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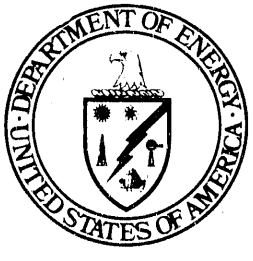
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Proceedings of the 1987 Socioeconomic Energy Research and Analysis Conference

May 21-22, 1987
Holiday Inn Capitol
Washington, D.C.

Sponsored by:
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August 1990



MASTER

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PREFACE

The energy crisis of the 1970's left the United States with a legacy of increasing government involvement in supply-related decisions and a new sensitivity to environmental quality concerns. The increasingly complex nature of the energy industry presents all its decisionmakers with an extremely challenging situation because of its unpredictable supply, demand, and price trends; its international breadth; and the complexities of its national and regional perspectives. Furthermore, attempts to determine any long-term realities of the energy situation are compounded by economic trends, demographic factors, energy costs, and value changes as our national and international resource problems accelerate. The situation is intensified further as various energy strategies, solutions and alternatives, and research and development on new technologies become more dependent on costs, market penetration feasibility, and political considerations. As a result, planning, and policy development must be incorporated into the formulation of a national strategy for all segments of the population. This necessitates the development of fluid methods to analyze and interpret the economic and social impacts of the extremely complex and dynamic energy environment.

The Department of Energy (the Department) convened the first Socioeconomic Energy Research and Analysis Conference in May 1987, in the spirit of constructive dialogue and mutual concern about numerous energy issues and problems. The objective was to provide a national forum for illuminating specific energy and related socioeconomic issues of our nation and discussing realistic approaches to energy policy assessments. This action was based on the Department's commitment to lead the way in developing a pragmatic framework for energy policy determinations, by incorporating constructive policy impact assessment methods into the decisionmaking process.

In this rapidly developing industry with high energy technologies, a strong Federal role and targeted government programs are essential for the development and integration of minorities into various industry segments. Furthermore, a responsive energy program for all segments of the population must be sensitive to (a) the impact of energy policies on the overall growth of the economy; (b) the differential impact of energy policies on various industries; and (c) the pattern of change in the structure of the social environment.

The Office of Minority Economic Impact at the Department, through its statutory authority, has the role of determining specific energy policies and programs which are needed to significantly enhance the social and economic conditions of minorities. As the focus on energy issues changes, this Office will play a multi-purpose role in addressing distributional inequities by:

- identifying policy options which will soften the impact of the adverse effects on minorities and the low-income population;

- assisting minority educational institutions and businesses through relevant technical assistance programs which will enable them to participate in the decision-making process of long-term energy supply and price; and

- facilitating and coordinating the efforts of these groups with those of Federal departments and agencies, in the effort to involve minority workers and businesses in the energy production industry segments.

The socioeconomic researchers and energy policy analysts who presented papers or participated in this national forum assisted the Department's efforts to build an energy structure which is truly responsive to the needs of the various population segmets of our nation. The conference participants were also given the opportunity to critique some unique energy policy assessment methodologies which have been conducted mainly at Argonne National Laboratory, under the sponsorship and guidance of the Research and Education Division of my Office. Judging from the papers which were presented at the conference, it appears that our efforts will have to continue to focus on the inescapable reality that there is an impacted network of economic and social problems, and that this network will exist as long as the demand for our energy resources continue to exceed the supply. The Department will continue, therefore, to explore new approaches and methods of analyzing the significant interactions of energy and the economy.

I would like to express sincere gratitude to the researchers and other individuals who presented papers or participated in any way in this first national forum to discuss energy and socioeconomic issues. I must apologize for the unfortunate delay in publishing the proceedings of the conference. However, I would like to assure each of you that your contributions were invaluable to the Department's effort to generate public discussions regarding socioeconomic issues which have been generated by the energy situation. Your contributions provided the option for the Department to address the phenomenal technical complexities of the industry and the related economic issues, in the context of the social and political components of energy policy. A realistic understanding of these issues is important to our national energy security objectives and increased world competitiveness for our nation.

Melva G. Wray
Director
Office of Minority Economic Impact
U. S. Department of Energy

Conference Agenda: Friday, May 22

9:00 Plenary Session *Chairperson: Michael J. Meshenberg, Research Conference Coordinator, Argonne National Laboratory*

Relating Energy Consumption to Utility Forecasting and Economic Development

Moderator: John Tucker, Special Assistant to the Chairman, Atlanta Gas Light Company

James K. Davis, Vice President for Corporate Relations, Georgia Power Co. • Johnny Ford, Mayor, Tuskegee, Alabama • Charles Baxter, Director, DOE New York Support Office • Norman F. Sather, Deputy Director, Energy and Environmental Systems Division, Argonne National Laboratory

10:15 Concurrent Sessions

TRACK 1: END-USER CONSUMPTION AND EXPENDITURE PATTERNS (continued)

Session 1.3: Utility Estimation of Customer Energy Patterns

Utility Survey Results: Beyond the Energy Forecast
Karen Buglass, Boston Edison Company

Energy Consumption, Appliance Holding, Housing, and Demographic Characteristics of Target Groups in the PG&E Service Territory
Lisa A. Skumatz, Pacific Gas and Electric Company

Least-Cost Electric Utility Planning: A Preliminary Assessment of Its Implications for Blacks and Hispanics
James A. Throgmorton, University of Iowa

TRACK 3: ECONOMIC DEVELOPMENT AND INDUSTRIAL PARTICIPATION

Session 3.1: Minority Energy Employment and Business Participation

Minority Employment in the Energy Sectors of the U.S. Economy: Projections for the 1990s
Adam Rose, West Virginia University; Brian Stevens, Illinois State University; and Gregg Davis, Northeast Louisiana University

Employment and Business Impacts: Minority Employment in the Energy Industry
Larry M. Blair, Oak Ridge Associated Universities

Minority Participation in New Energy Technologies: A Case Example of Electric Heat Pumps and Packaged Cogeneration Systems
Arvind P.S. Teotia, Argonne National Laboratory

12:00 Lunch (Individually Arranged)

1:45 Concurrent Sessions (continued)

Session 1.4: Transportation Energy Consumption and Expenditure Patterns

A Model to Assess the Relative Impact of Policy in Transportation Energy Expenditures
Danilo J. Santini and Anant Vyas, Argonne National Laboratory

Racial and Demographic Differences in Household Travel and Fuel Purchase Behavior
Marianne Millar, Argonne National Laboratory

Session 3.2: Energy and Economic Development

Energy Efficiency in Rental Housing
Joseph Laquatra, Cornell University

Leveraging Oil Restitution Funds for Minority Economic and Community Development
Lisa Posner, Consumer Energy Council of America Research Foundation

2:45 Session 1.5: Residential Energy Consumption in Developing Countries

Comparison of Urban Residential Energy Consumption in India, Brazil, and Costa Rica
Gerald W. Sazama, University of Connecticut

A Formal Approach to Analyzing the Household-Sector Fuel Transition: The Case of Zimbabwe
Richard N. Hosier and Jeffery Dowd, University of Pennsylvania

Session 3.3: DOE's Minority Energy Research Services

Using the Minority Economic Impact Bibliographic Data Base and Clearinghouse Services
Cynthia J. Booze, U.S. Department of Energy

Office of Scientific and Technical Information Automated Retrieval System
Speaker to be named, U.S. Department of Energy

3:45 Break

4:05 Plenary Session

Trends in Energy Consumption and Expenditures for Low-Income and Minority Households from 1973 to 1985
David Carroll and James McBride, Response Analysis Corporation

The Next Steps for MI's Socioeconomic Research Program
Georgia R. Johnson, Senior Economist, DOE Office of Minority Economic Impact

4:45 Conference Adjournment

Conference Agenda: Thursday, May 21

7:30 **Registration and Continental Breakfast**

8:30 **Plenary Session** *Chairperson: Georgia R. Johnson, Senior Economist, DOE Office of Minority Economic Impact*

Focus of Conference *Hon. Raymond G. Massie, Director, DOE Office of Minority Economic Impact*

Welcoming Remarks *Hon. John Herrington, Secretary of Energy (invited) • Member, U.S. Senate • Hon. Harris Fawell (Ill.), U.S. House of Representatives*

9:15 **Plenary Session** *Moderator: Lynda T. Carlson, Director of Energy End Use, DOE Energy Information Administration*

A Conceptual Framework for Minority Energy Research

Dorothy K. Newman, Director, Housing Foundation, Community Housing & Resources, Inc. • Lenneal Henderson, Professor, School of Business and Public Administration, Howard University • William P. O'Hare, Director of Policy Studies, Population Reference Bureau, Inc.

Overview of MI's Residential Energy Consumption and Expenditure Programs

Georgia R. Johnson, Senior Economist and Research Program Manager, DOE Office of Minority Economic Impact • David A. Poyer, Principal Investigator, Minority Energy Consumption and Expenditure Program, Argonne National Laboratory

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10:45 **Concurrent Sessions**

TRACK 1: END-USER CONSUMPTION AND EXPENDITURE PATTERNS

Session 1.1: Residential Energy Consumption and Expenditure Patterns

National Patterns of Energy Demand and Expenditures by Hispanics
David A. Poyer, Argonne National Laboratory

Residential Energy Consumption and Expenditure Patterns of Black versus Nonblack Households in the United States
Anant Vyas, Argonne National Laboratory

Residential Energy Consumption and Expenditure Patterns of Low-Income Households in the United States
Edward Vine, Lawrence Berkeley National Laboratory

TRACK 2: SOCIOECONOMIC ENERGY MODELING AND EXPENDITURE PATTERNS

Session 2.1: Modeling Fuel Price Changes

The New Gas Industry and the Low-Income Consumer
Anne V. Roland, American Gas Association

An Assessment of the Potential Impacts of Rapid Oil Price Increases on California Revenue Requirements and Hardship Programs
John Rozsa and Dennis Eoff, California Energy Commission

The Impact of Electric Rates on Low-Income Consumers
Arie P. Schinnar, Lisa Wood, David Shin, and Mark Bernstein, Wharton School, University of Pennsylvania

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12:45 **Lunch** *Speaker: Hon. Arturo Gandara, former California Energy Commissioner*

2:00 **Concurrent Sessions (continued)**

Session 1.2: Low-Income Weatherization and Energy Assistance

Effects of Energy Savings on Household Expenditures of Low-Income Weatherization Program Participants
Roberta W. Walsh, University of Vermont

Preliminary Findings on Thermal Performance of Zone Heating in Low-Income Households with Payment Troubled Utility Customers
John R. McBride and Brian Castelli, National Center for Appropriate Technology

Do Residential Energy Audits Contribute to Reduced Energy Consumption?
Subodh E. Mathur, District of Columbia Public Service Commission

Session 2.2: Application and Assessment of Socioeconomic Energy Data Base and Modeling Tools

Health Consequences of Residential Energy Conservation: A Study of Nonmetropolitan Households in Upstate New York
Peter S.K. Chi and Joseph Laquatra, Cornell University

Energy Data Needs for Policy Analysis
Joe Roop, Pacific Northwest Laboratory; Barry McNutt and Margaret Podolak, DOE Office of Policy, Planning, and Analysis

Review of EIA's RECS Survey and a Comparison of Energy Consumption and Expenditure Patterns among Age Groups: Focusing on the Elderly
Marty Johnson, DOE Energy Information Administration

3:45 **Break**

4:00 **Concurrent Sessions (continued)**

Session 1.2 (continued)

Profiles of RCS and Non-RCS Participants by Demographics, Housing, and Energy Conservation Characteristics
Phyllicia A. Faunteroy, District of Columbia Public Service Commission

Alternatives to the California Energy Baseline Program
David Gamson, California Public Utilities Commission

Designing and Developing an Energy-Related Program for Public Housing Residents and Renters
Allison Bryant, The Assignment Group

Session 2.2 (continued)

The Family Life Cycle and Changing Patterns of Energy Efficiency in the United States
Robert M. Wirtshifter, University of Pennsylvania, and Lester Baxter, California Energy Commission

A Disaggregate Analysis of Black-Nonblack Differences in Residential Energy Consumption
Dee Wernette, Argonne National Laboratory

Using the Minority Energy Assessment Model to Analyze Electricity Demand by Black and Nonblack Households within a Linear Expenditure System Framework
David A. Poyer, Argonne National Laboratory

5:30 **Adjourn**

FOCUSING ON THE BIG PICTURE: NATIONAL TRENDS AND MINORITIES AS ENERGY CONSUMERS

DOROTHY K. NEWMAN

FOCUSING ON THE BIG PICTURE: NATIONAL TRENDS AND MINORITIES AS ENERGY CONSUMERS

Dorothy K. Newman
Director, Housing Foundation
Sanibel, Florida

As the grandmother of the national survey of household energy consumption, I take a natural and, of course, excusable quasi-proprietary interest in it. When the very first questionnaire was in the drafting stage, my small crew of investigators received solicited and unsolicited views about the household energy behavior of minorities and the poor. These views often resembled cliches at the turn of the century when people said "Why provide those blacks, greenhorns (you name it) with a bathtub; they will only store coal in it." The story going around in 1973 was that poor folks and especially blacks, used lots more fuel in their homes than anyone else because they lived in drafty shacks or they liked it real warm, coming from the South as they did. They used more gasoline, too, the word went, because they preferred big classy cars. Anyone can see, they said, that the streets of the ghetto were lined with Cadillacs.

It was a revelation, and, in fact, caused quite a stir, when we came out with our initial findings, entitled "Let Them Freeze in the Dark." This catchy title was lifted from an editorial in a 1973 issue of Science because it conveyed so well the energy situation of poor and black households at that time. Poor and black households, we found, used much less energy at home and in their cars than others, and paid more per unit for it. When they had an automobile (and only 55 percent of blacks at that time did), they drove fewer miles, used less gasoline, and had bought their cars used. In 1973 their cars were at least 5 years old and were mostly standard or compact models.

Cliches die hard, and if only to prevent them from resurfacing, I have been happy to see that the national surveys have been repeated. The several sets of basic data now available provide a goldmine of information, and do far more than dispel myths. They increase understanding, alert policy makers to significant shifts, and identify important trends and variations in energy consumption.

Actually, the basic relationships in household energy consumption have remained remarkably stable. Poor and minority households continue to use less energy than others, with the difference being greatest for electricity. Electricity is the fuel of more discretionary use than oil and natural gas, which are needed for heating. In general, among minorities as well as others, the greater the household income, the more energy households use and the more extensive their conservation measures. The better-off households are able to afford to install energy saving features. Their energy conservation is incidental to saving money, but, while

saving that money, they spend for so-called energy saving appliances, appliances that save human energy but expend more of the kind we are talking about. Whether poor or well off, black or Hispanic, the larger the household, and therefore, when it is in the middle child-rearing years, the more energy it consumes. Energy use is lowest among the most youthful householders, usually one or two people, increases into the middle years, and falls among the elderly. Elderly minority households are likely to use less energy than almost anyone else because their households tend to be small and they have less money to spend.

In later sessions this conference will develop what lies behind swings and basic relationships in energy usage. I have been much too simplistic in this thumbnail sketch and the state of the art has improved since my day. My role here today is not to go into the intricate tapestry of energy usage. I leave that to your experts.

My objective is to step back and look at exterior conditions--what has happened, is happening now, or may happen in the foreseeable future that could influence energy consumption among black households.

I do not presume to analyze outside influences on Spanish speaking minorities, because they are so diverse in origin, culture, residence, and economic circumstance. Also, I do not factor in any disasters that mandate draconian measures.

Among the most influential circumstances are those that have to do with where people live, what kinds of structures they live in, and how much money they have at their disposal.

GEOGRAPHY

The dramatic migration of blacks from South to North, beginning in the 1940s, was the largest single migration within the country of any group in United States history. It halted a decade ago leaving more than half of all blacks still living in the South. The Southeast, where most Southern blacks live and where no other group is so heavily concentrated, is the nation's recent and current growth area both in population and employment. Degree days are relatively low there, thus influencing energy consumption on the down side among black households.

An agreeable offset, in human terms, however, is the distinct possibility of improving economic circumstances among blacks in the Southeast as they move into new job openings. The unemployment rate in the Southeast is now the lowest in any of the Nation's geographic regions except for New England. Many of the new jobs are in lower paying occupations, of course, as in the Nation as a whole, but data over time show that, regardless, those who work full time all year are the best off. The result is a stable, perhaps growing, black population in the Southeast in improving economic circumstances. Depending on the weights used, I might say, on balance, that the regional shifts in residence alone could leave blacks at about the same volume of BTU consumption into the near future, but at higher levels of satisfaction.

METROPOLITAN

Another significant geographic trend is the reversal of the 1970s movement away from metropolitan areas. Metropolitan areas are gaining a little now and central city population has been stabilizing. Unemployment rates in metro areas have dropped below those in nonmetropolitan areas for the first time in decades. Blacks are the most heavily concentrated and fastest growing population in metropolitan areas. Eighty-one percent of all blacks live in metropolitan areas now after a steady rise over the past three decades from 56 percent in 1950. Blacks are concentrated in the central cities of metropolitan areas where unemployment is greatest, but the influx into central cities has halted, and instead a steady stream of blacks has been moving into the urban fringe. By 1980 almost one-fourth of all blacks lived in metropolitan suburbs. The entire shift took place in the decade of the 70s.

A brightening economic future for cities and metropolitan areas should improve the economic circumstances of blacks and lead to expanding energy consumption per household. Furthermore, as blacks move increasingly into the fringe of metropolitan areas they will be caught up into the fastest growing and largest journey to work-- nexus the one that takes place within the suburbs of metropolitan areas. The largest rates of such work trips, in fact, are in the major suburban regions with greatest concentration of blacks, such as Atlanta, Washington, and Philadelphia.

Workers who both live and work in the suburbs account for the biggest share of all journey to work trips, and they go almost exclusively alone, by car, using lots of gas and oil. Workers who live and work within the central cities are the second largest group of commuters and blacks are most likely to be in this group, which could grow with improvements in central cities' attractions. Also, the move to residences in the fringe of metropolitan areas is doubtless accompanied by rising incomes, and therefore, increased energy consumption in the home as well as on the road. It appears, then, that metropolitan trends will, on balance, tend to increase black households' energy consumption.

THE STRUCTURE

As an increasing proportion of blacks have moved into the fringe of metropolitan areas they have occupied newer and larger dwellings with more energy using amenities. They have had to commute more in their own cars also, and increasingly, therefore, they have added to their energy consumption.

Those left in the central cities of metropolitan areas, the majority, however, are chiefly tenants and occupy small units in multifamily structures. Actually, the percentage of blacks who are tenants has not declined much in 20 years. By the 1980s, less than half (44 percent) were homeowners, whereas about 70 percent of whites were. As tenants, blacks have little control over significant energy conservation measures that require rehabilitation work.

The housing stock as a whole has not changed much for most black occupants, except to become older. Gentrification undertaken in the central cities is mostly for affluent whites.

While it is true that in recent years half the new home construction has been taking place in the South, where only one third of all U.S. households live, most of the new housing is not being occupied by blacks. In fact, the most immutable of the forces affecting energy consumption is the housing stock, which increases only fractionally each year. New units made up about two percent of the total in the 1980s and new structures are similar to the old in local areas. Design shifts are rare, and exterior materials have not changed much within regions in over 40 years.

The only significant impact on energy usage in the housing stock depends on public policy shifts toward much more extensive assistance with rehabilitation of older structures. Trends that materially affect blacks' energy consumption originate outside the structures they live in, barring of course the influence of such efforts as the Low Income Energy Assistance Program (LIEAP).

MONEY, WORK, AND THE BLACK CONSUMER

The most direct influence on energy consumption is income, yet the gross data tell us that median household income, whether among blacks or whites, has scarcely changed in 20 years (in constant 1984 dollars). The peak was in 1973, when black incomes were 13 percent higher than in 1984. White incomes were 9 percent higher. The median income of black households has fluctuated within the narrow range between 57 and 60 percent of white household income throughout the past two decades.

Looking closely, we see some variations within the whole. For instance, black, like white households, who are at the upper deciles of income have been gaining as a proportion of the total and those at the bottom have been losing. There appears to be a thinning of the middle income groups. The black middle-income group has less of the income stream, and so has less to spend for energy or anything else.

Equally interesting is an impressively sharp decline in the poverty rates among the black elderly, who, while remaining the poorest of the poor, are beginning to gain the benefits of FDR's legacy in social security payments. The fastest growing age group now is the elderly, and most particularly those over 70. While blacks average five years less life expectancy than whites, they too are living longer and healthier lives. This is a continuing group of energy consumers.

The elderly are virtually shut out of the work force now, but as soon as the baby-boom crop becomes elderly, early in the next century, about 2010, the birth-dearth generation coming up will need help in keeping the economy going. The black elderly and all black workers will have vital roles in the kinds of expansion that will have taken place in industry and the labor force-- in services, financial and retail businesses, and in transportation, where their participation has been greatest in the past. Also, while manufacturing is losing some ground in proportion to the rest, it still is the second largest employer and accounts for 1 in 5 of all jobs. Half of all blacks work in these five sectors. They will be available as experienced workers, as youthful recruits become scarce in the early 2000s. I think we can predict that

in those years black unemployment will drop, black household incomes will increase, and opportunities for blacks will penetrate into a wider spectrum of industry and occupations. The gap between black households' energy consumption and that of whites could narrow substantially. In fact, increasing labor force participation will have substantial energy consequences that will involve all groups and influence all sectors. Labor saving devices in the home, multi-earner families, possibly longer hours and shift work, all will expand total energy consumption per household, at least until the baby boomlet of today works its way into the labor force of the mid and later 2000s.

The crisis of scarcity in the labor force could have the happy consequence of reducing discrimination in the work place. Let us hope that we manage our energy future well enough to take advantage of that.

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THE INCREASING COMPLEXITY OF MINORITY STATUS

WILLIAM P. O'HARE

THE INCREASING COMPLEXITY OF MINORITY STATUS[1]

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Any analysis of the impact of energy policies on minorities must address implicitly or explicitly the sociological meaning of minority status and I submit that the meaning of minority status has become more complex over the past twenty five years and it promises to become even more complex in the next twenty-five years. This growing complexity must be taken into consideration as we develop a conceptual framework for future energy research on minorities.

Why do we group people on the basis of race and ethnicity rather than eye color or weight or any one of numerous other characteristics that we could use? To some extent current use of minority status as a relevant category for analyses is based on past research. In many cases minority status or race is used in analysis today simple because it has been used so often, in previous socioeconoic research and it has often proved successful in improving the explanatory power in our models.

However, as times change it is important for those of us in the research community to stop and ask ourselves if old concepts and old variables have retained their meaning

Why did researchers begin using race, ethnicity or minority status in socioeconomic research in the first place? Earlier researchers used minority status as a surrogate measure for a common set of experiences which were cumbersome to describe. In 1960, for example, nearly all nonwhites shared at least a couple of important characteristics. The vast majority of nonwhites were black and the vast majority of blacks were poor or grew up in poor families. In 1960, 7 out of 10 minorities were blacks and 55.1 percent of all blacks had incomes below the poverty line. But just as important, recently analyzed data from the 1940 census shows that 95 percent of blacks lived in families with earnings below today's poverty line (adjusted for inflation), which means that almost all blacks in 1960 had grown up poor. Furthermore,

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[1]Presentation made at the "Socioeconomic Energy Research and Analysis Conference," sponsored by the U.S. Department of Energy, Office of minority Economic Impact, held May 21-22, 1987, Washington, D.C.

most blacks had experienced the discrimination of separate schools and government-sanctioned segregation in major social institutions.

Similar data on the poverty of Hispanics, the bulk of the nonblack minorities, is not available, but it is a pretty safe bet that the level of Hispanic poverty during this period was not too dissimilar from that of blacks.

Consequently, in 1960 researchers could use minority status as a surrogate measure for a common set of experiences (poverty and racial discrimination) with a fair degree of confidence that most people in the group had shared these experienies. Minorities were relatively homogeneous in terms of race/ethnicity and economic background. We must now ask ourselves if race and ethnicity still reflect a common set of experiences and more importantly are they likely to continue to be useful variables in future research.

Certainly some conditions that were present 25 years ago have changed. Minorities are a larqer share of the total population and blacks are a much smaller share of the minority population. Also the economic diversity of minorities has increased dramatically.

First, lets look at some of the demographics. In 1960, minorities made up just 15.2 percent of the total population (see Table 1), but by 1985 minorities accounted for 22.1 percent of the population. Census Bureau projections suggest that minorities will comprise 29.1 percent of the population by the year 2010.

In 1960, blacks made up 69.1 percent of the minority population, but by 1985 that figure had fallen to 55.1 percent (see Table 1). By 2010, blacks will make up less than half (48.5 percent) of the minority population.

In other words, the minority population will become larger, in both absolute and relative terms, and even more diverse in the future as Hispanics, Asian-Americans and other minorities populations increase faster than blacks.

The economic status of minorities has also changed. Average income in some of the minority groups (such as Japanese-Americans) is higher than average income among whites. Although the median family income of blacks is still far lower than that of whites, these differences often disappear when one controls important factors other than race. Among young (age 25-44) families with similar characteristics (married-couple families in the Midwest with a wife or the paid labor force) median income for blacks was actually higher than that for whites in 1980.

Table 3 shows key socioeconomic indicators for a variety of groups who are part of the minority population. It is clear that there is substantial inter-group variation among this racial and ethnic subpopulations. The last column of Table 3, indicates that at least on one energy-related variable, use of public transportation for the journey to work, the minority population is far from homogeneous. Puerto Ricans use public transportation for the worktrip

at seven times the rate of American Indians. Does it make sense to lump these groups into one category we call minorities?

Minorities are not as homogeneous today as they were in 1960, and minority status is less likely to reflect a common set of experiences. The heterogeneity of minorities promises to increase over the next few years as Hispanics and Asian Americans dominate the immigrant stream.

What does this mean for researchers examining the impact of energy policies on minorities? A proper framework for future research in this area must accommodate the increasing complexity of minority status by demonstrating sensitivity to differences between minority groups and increased socioeconomic differences within the minority population. It means that researchers must look at more than race and ethnicity to sort out the impact of minority status. For example, we can expect energy policies to affect middle-class suburban blacks differently than poor blacks living in central city ghettos and we can expect energy policies to affect the relatively affluent Japanese-Americans differently than low-income Mexican-Americans.

This reconceptualization of meaning of minority status provides a major challenge for energy researchers. Analyzing current and future databases in ways which are sensitive to the increasing heterogeneity of the minority population will require careful consideration of possibilities. For example, most researchers would agree that examining the impact of minority status and socioeconomic characteristics simultaneously is advantageous, but the decreased reliability due to smaller cell sizes which would result from this approach is also an important consideration.

Since nonblack minorities are relatively small groups, most sample surveys do not gather data on enough members of each group to provide reliable estimates of those groups. This poses a particularly difficult data collection problem for those interested in minority energy research. In order to in increase the overall sample sufficiently to provide an adequate number of each minority group for analysis would be extremely costly. Another approach, gathering separate samples for minority groups of interest, would also be costly.

The major challenge facing minority energy researchers in the 1990s will be balancing the need to treat various minority groups independently, with the constraints on data collection and analysis posed by typical funding levels for energy research projects.

Table 1. Race and Ethnic Composition of the U.S. Population 1982, 1990 and 2000

(Figures in millions)

	1960		1985		2010	
	Number	%	Number	%	Number	%
Total	180.7	100	238.6	100	283.2	100
White Non-Hispanic	153.2	84.8	185.8	77.8	202.6	71.5
Minorities	27.5	15.2	52.8	22.1	82.5	29.1

SOURCE: U.S. Bureau of the Census, Current Population Reports, Series P-25, No. 995, "Projections of the Hispanic Population : 1983 to 2080", Tables P and AA, U.S. Government Printing Office, Washington, D.C. November 1986 and figures for 1960 are taken from The Demographic and Socioeconomic Characteristics of the Hispanic Population in the United States: 1950-1980, report to the Department of Health and Human Services, submitted by Development Associates and the Population Reference Bureau, October 30, 1981, and 1960 Census of Population

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Table 2. Population Distribution Across Minority Groups, 1960-2010
(figures in millions

	1960		1985		2010	
	Number	Percent	Number	Percent	Number	Percent
Minorities	27.5	100	52.8	100	82.5	100
Black	19.0	69.1	29.1	55.1	40.0	48.5
Spanish Origin	6.9	25.1	17.3	32.8	30.8	37.3
Other Races	1.6	5.8	6.4	12.1	11.7	14.2

SOURCE: U.S. Bureau of the Census, Current Population Reports, Series P-25, No. 995, "Projections of the Hispanic Population : 1983 to 2080", Tables P and AA, U.S. Government Printing Office, Washington, D.C. November 1986 and figures for 1960 are taken from The Demographic and Socioeconomic Characteristics of the Hispanic Population in the United States: 1950-1980, report to the Department of Health and Human Services, submitted by Development Associates and the Population Reference Bureau, October 30, 1981, and 1960 Census of Population

Table 3. Selected Socioeconomic Characteristics of the U.S. Population in 1980 by Race and Ethnicity

GROUP	Median Household Income	Percent in Poverty	Percent in Service Jobs	Percent of Families Headed by A Female	Percent Using Public Transit*
U.S. Average.....	$16,841	12.4	12.9	13.9	6.4
Non-Hispanic Whites..	17,814	8.9	11.5	10.6	4.6
Non-Hispanic Blacks..	10,959	29.8	23.1	37.2	17.6
Mexicans.....	13,823	23.3	16.2	15.9	6.4
Puerto Ricans.....	10,075	36.3	16.5	34.8	31.2
Cubans.....	16,043	13.2	12.4	14.2	10.5
American Indians.....	12,227	27.5	18.0	22.9	4.5
Eskimos.....	12,344	28.8	23.8	21.3	6.7
Aleuts.....	16,825	19.5	17.9	17.4	7.2
Japanese.....	22,517	6.5	12.8	11.9	8.2
Chinese.....	19,561	13.5	18.6	8.5	20.6
Filipinos.....	21,926	7.1	16.5	11.8	14.0
Koreans.....	18,145	11.7	16.5	10.8	10.1
Asian Indians.....	20,598	9.9	7.8	5.7	17.3
Vietnamese.....	12,549	35.5	15.3	14.8	9.5
Hawaiians.....	16,593	15.8	21.7	21.3	8.0

SOURCE: U.S. Bureau of the Census, 1980 Census of Population, PC80-1-C1, U.S. Summary, Tables 161, 163, 164, 165,167, 169, 170 and 171

*Percent using public transportation for the journey to work.

THE SOCIOECONOMIC BASES OF ENERGY POLICY: A HOUSEHOLD/INSTITUTIONAL APPROACH

DR. LENNEAL J. HENDERSON

THE SOCIOECONOMIC BASES OF ENERGY POLICY: A HOUSEHOLD/INSTITUTIONAL APPROACH

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Socioeconomic dimensions of energy events and policies pose both normative and empirical challenges to American Public Policy-makers. Normatively, energy policies which seek to enhance supply, curtail demand, or foster changes in the mix of primary fuels used in the household, commercial, industrial and transportation sectors raise fundamental questions about the ethics of resource distribution and redistribution in American society. No policy is without ethical import and consequence.[1]

Empirically, it is doubtful that sufficient data exist or are properly configured to measure and evaluate the full meaning of America's energy dilemmas to all income groups and most institutions operating in American society. Although theoretical models purporting to assess the socioeconomic dimensions of energy policy continue to proliferate with varying levels of sophistication, these models are seldom able to reliably examine the multidimensional and subtle demographic, economic, social ethnic, racial and behavioral variables associated with energy developments and policies.[2] A salient issue examined in this paper is the extent to which these models interrelate household and institutional energy consumption and expenditure behavior.

A curious void in the research on the socioeconomic consequences of energy policy are the known effects of energy costs and supply on social service, governmental and business

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[1]Lenneal J. Henderson, "Energy Policy and Public Administration: A Social Systems Perspective," The Howard Law Journal, V. 24, N. 2, 1981, p. 211.

[2]See, for example, David Poyer, et al, The Minority Economic Assessment Model (Argonne, Illinois: Argonne National Laboratory, 1988).

institutions serving neighborhoods and rural areas throughout the income continuum.[3] Do these institutions pass on the costs of energy or the costs of substituting higher price for lower price fuels to consumers, taxpayers or those dependent on them for a variety of social services? What are the behavioral and organizational dynamics which accelerate or retard such passthroughs? How do energy cost affect the quality and quantity of services from various institutions to a variety of households?

Conversely, how do changes in energy costs or fuel supplies influence the relationship of households to various institutions? Does a rapid rise in the cost of electricity or natural gas precipitate reductions in household disposable incomes which reduce or constrict consumer choices, affect levels of charitable giving or exacerbate household tax problems? Fundamentally, the issue is the effect of energy policy on the delicate web of interdependency of households and institutions.[4]

This paper, therefore, addresses three aspects of the household/institutional interdependency approach to energy policy analysis: (1) The relationship of household/institutional relationships in socioeconomic assessment; (2) Empirical issues in the measurement of household/institutional relationships; and (3) the policy implications of research on the interrelationships of households and a variety of institutions, particularly for energy policy.

INSTITUTIONAL ANALYSIS AND SOCIOECONOMIC ASSESSMENT

Olsen defines "social" to include all realms of human affairs: demographic, economic, organizational, community, familial, political, cultural and others. Social impacts are alterations in people's living conditions (or lifestyles) that occur in conjunction with a new policy or program and that are seen as significant social events.[5]

New or altered policies or programs affect socioeconomic status. Socioeconomic status includes such variables as income, occupational status, home ownership, age, race, ethnicity, gender, geographical in such institutions as churches, fraternal organizations, professional organizations and civic and community organizations.

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[3]See, for example, The National Academy of Sciences, Energy Consumption Measurement: Data Needs for Public Policy (Washington, D.C., (1979).

[4]Lenneal J. Henderson, "Energy, Urban Policy and Socioeconomic Development," The Urban League Review, 1978.

[5]Marvin E. Olsen, "Assessing the Social Impacts of Energy Conservation," in Karen M. Gentemann, ed., Social and Political Perspectives on Energy Policy (New York: Prager, 1981), p. 66.

In a system of social stratification, socioeconomic status is a combination of various social and economic indices of rank that are used in research studies.[6] These studies tend to focus on the distribution and redistribution of financial, occupational, educational, informational and other resources among various groups in the social strata. These groups are defined by demography, geography, income source and standard of living.[7] As Rosa, Machlis and Keating argue:

> Energy, though fundamentally a physical variable, penetrates significantly into almost all facets of the social world. Lifestyles, broad patterns of communication and interaction, collective activities, and key features of the social structure and change are conditioned by the availability of energy, the technical mans for converting energy into usable forms, and ways energy is ultimately used.[8]

The implications of this statement is that patterns of energy consumption and expenditure occur not just in households, not just in various business, health, educational, governmental and other institutions but in the interaction of household and institution. The "broad patterns of communication and interaction, collective activities and key features of the social structure," imply individuals and families obtaining goods and services from a variety of institutions and, conversely, institutions obtaining financial and other resources for such goods and services. The availability, cost and utilization of various energy sources can affect the flow and distribution of goods, services and money between households and businesses, non-profit organizations, public agencies and religious and fraternal organizations. Figure I portrays the nature of the household/institutional interaction pattern.

In the zone of exchange between households and a variety of institutions, goods, services, information, education, health care, employment, status and technical assistance are provided largely by the institutions in exchange for money (consumer costs) or, for federal, state or local government, taxes or other revenues.

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[6]George A. Theodorson and Achilles G. Theodorson, A Modern Dictionary of Sociology (New York: Thomas Y. Crowell Company, 1981), p. 399.

[7]Henderson, op. cit., Howard Law Journal, p. 212.

[8]Eugene A. Ross, Gary E. Machlis and Kenneth M. Keating, "Energy and Society," in W. Richard Scott and Judith Blake, eds., Annual Review of Sociology, Volume 14, 1988, p. 149.

A key socioeconomic issue is the extent to which significant changes in energy cost or supply affects interactions occurring in the zone of exchange. A rapid increase in the cost of gas, electricity, coal or nuclear fuel may induce an institutional provider such as a utility company or a health care institution to increase the cost of its goods or services to households. Such an increase, multiplied by the number of households experiencing such an increase, tends to reduce household disposable income available for the purchase of other goods and services in the zone of exchange.[9] Institutions affected by such reductions either respond by reducing the level of goods and services available and/or increasing the price of such goods and services to the household. Depending upon the income levels and sources available to the household, such price increase can be regressive or progressive: regressive if responsive price increases significantly exceed increases in available income in the household; progressive if price increases generally parallel or fall behind household income increases.

THE MEASUREMENT OF THE HOUSEHOLD/INSTITUTIONAL INTERDEPENDENCY

Five major issues exist in the measurement of the household/institutional interdependency in the socioeconomic analysis of energy policy;

(1) The impact of energy developments and policies on the type of household/institutional interaction;

(2) The impact of energy developments and policies on the level of interaction between households and institutions;

(3) The distributional or redistributional impacts of energy policies on the ability of households of varied income status to interact with various types of institutions of their choosing;

(4) The distributional or redistributional impacts of energy policies on the ability of varying types of institutions to interact with other types of institutions or households of their choosing; and

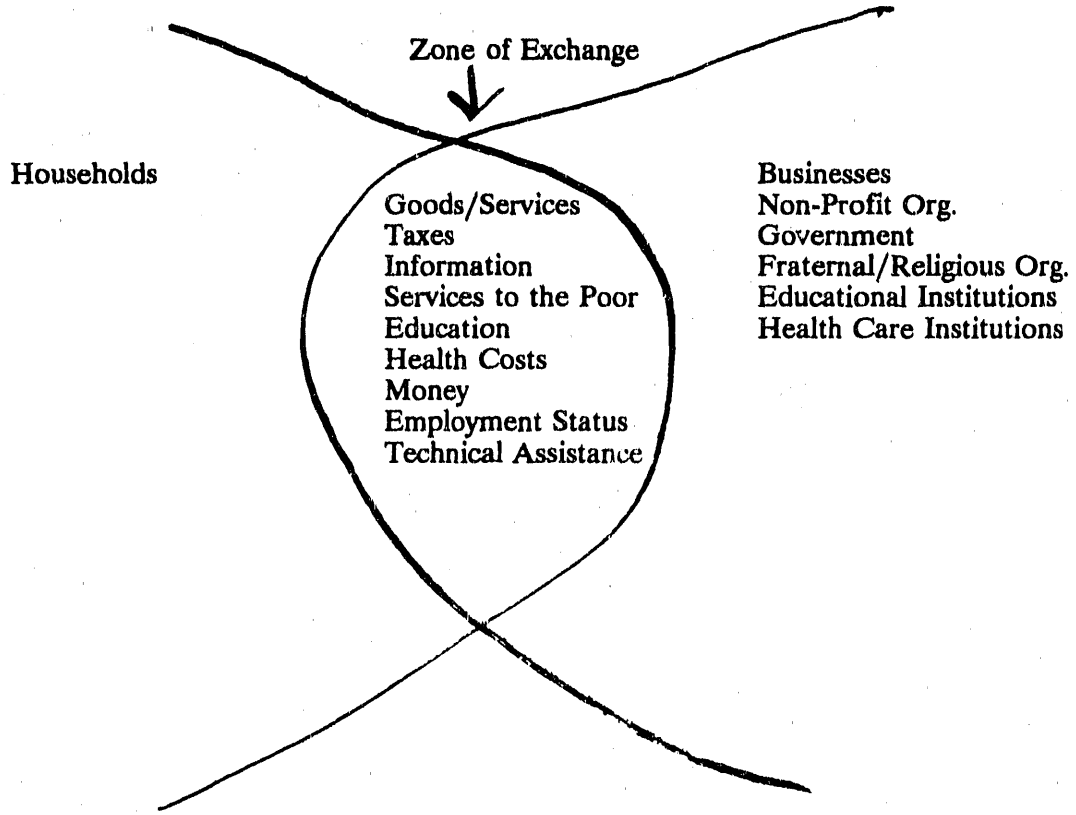
(5) The most appropriate modes or correct distortions, problems and dislocations in household/institutional interactions.

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[9]See, Lenneal J. Henderson, Testimony provided before the District of Columbia Public Service Commission on behalf of the District of Columbia Natural Gas Company, Formal Case 889, January 10, 1990, p. 17.

Figure I

Household/Institutional Interaction in the Energy Policy Context



TYPES OF HOUSEHOLD/INSTITUTIONAL INTERACTIONS

The measurement of the type of household/institutional interaction is depicted in Figure II. Households purchase goods and services from business, health care institutions, educational institutions and public agencies. They also receive goods and services, either in exchange for money, or as a result of social policy, from such institutions.

Institutions serve a variety of types of households: varying in income, home ownership and other socioeconomic characteristics. Depending upon the characteristics of the households, institutions configure and price their goods and services or determine the level of pro bono goods and services they provide to households.

A key measurement issue is the needs to determine what proportion of total household income is derived directly and indirectly from:

(1) Gainful employment in a corporate, public, non-profit or other institution;

(2) Transfer or income maintenance programs such as Aid to Families with Dependent Children (AFDC), Food Stamps, Social Security, Veterans' Benefits or other sources;

(3) Agencies providing in-kind services such as food, clothing, furniture.

Such a calculation suggests the degree of interdependency of households on various types of institutions. Subsequently, inferences about the degree of vulnerability of the household to any adverse economic development in an institution providing income can be made. If rapid escalation in electricity, natural gas or other energy costs force a reduction an austerity in institutional costs, employment retrenchment, service reduction and other consequences may result. If households, particularly low and moderate income households experience such institutional reductions in a good or service, they may seek support from public or social service programs such as the Low-Income Household Energy Assistance Program (LIHEAP).[10]

ENERGY POLICY AND HOUSEHOLD CHOICES

The nature of energy policy intervention affects the distribution and redistribution of household capability to choose the institutions from whom they will obtain energy and the quantity of energy resources they can obtain. For example, the District of Columbia Public Services Commission, in Formal Case 813,[11] determined that the load characteristics of master-metered apartment buildings in the District of Columbia resembled those of single-family dwellings to a much greater extent than commercial buildings. The Commission also wished to assist tenants in the District of Columbia, who constitute two-thirds of the households in the city, by placing master-metered apartment buildings on a residential rate. This decision was considered temporary by the Commission. They wanted to be sure that tenants benefitted from their decision.

The problem was that the meaning of "benefit" was not clearly defined. If apartment owners experienced a reduction in energy costs resulting from placement on a residential, instead of a commercial rate, how could such reductions benefit tenants? Were cost reductions automatically passed through to tenants?

Tenant groups argued that they should be provided with a range of choices for using the anticipated savings derived from placement on a residential rate. Some tenants expected that energy conservation actions would be taken by owners to further avoid,if not reduce, electricity costs. Others expected direct reductions in rent, despite rent control policies in the District of Columbia.[12]

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[10]It should be noted that LIHEAP payments go directly to the utilities or fuel companies on behalf of the household, thus reflecting an institutional approach to resolving a household energy problem.

[11]District of Columbia Public Service Commission, Formal Case 813, December 17, 1984.

[12]See, District of Columbia Office of Planning, Indices, A Statistical Guide to Services in the District of Columbia (Washington, D.C.; July 1989).

Figure II

Types of Levels of Household/Institutional Interdependencies Affected by Energy Policies

Households		Institutions	
1.	Type of Institutional Transaction - Business - Social Service - Health Care - Education - Federal, State, Local Government	1.	Types of Households - Low-Income - Moderate-Income - High-Income - Home Owners - Tenants - Transient Households
2.	Level of Institutional Dependency - % of Income Expended on Good/Service - % of Income, Good or Service Supplied by Institutional Type - Frequency of Transactions with Institutional Type - Number and % of Family Members Dependent on Institutional Type for Income, Goods, Services - % of Household Income Paid in Federal, State, Local Taxes	2.	Level of Household Interaction - % of Gross Receipts from all Households - % of Charitable Support or Donations Received by Households - % of Total Revenues Received from Households in Federal, State or Local Jurisdiction - % of Total Institutional Income Obtained from other Institutions (Government, Foundations, etc.) to Support Household Needs

This type of policy intervention by the District of Columbia Public Service Commission was well-intentioned buy achieved few direct benefits for tenants. Cost reductions experienced by owners were generally used to address increases in other building operating costs such as natural gas, maintenance, and labor.

ENERGY POLICY AND INSTITUTIONAL ENERGY CHOICES

Just as household energy choices can be enhanced or impeded by energy policy-making, institutional choices can also be affected. The location of energy-producing facilities, the utilization of fossil and alternative fuels, the choice of heating, cooling, cooking, boiler, or manufacturing technology, the choice of energy conservation strategy and other energy choices made by business, government, health care, educational and non-profit agencies can be influenced by energy policy.

A recent policy emphasis on Integrated Energy Least Cost Planning (ILCP) encourages electric and natural gas utilities to work with households and institutions to make more energy efficient choices. The ILCP process clearly seeks to influence the way in which energy is used by social systems. As Eric Hirst and others have indicated, utilities and utility commissions solicit and utilize the advice and technical assistance of consultants to determine whether heat pumps, high-efficiency furnaces, efficient refrigeration and other technologies used by commercial and industrial institutions throughout the utility jurisdiction can result in significant reductions in natural gas or electricity baseloads. These "demand-side" programs are aimed at achieving higher levels of efficiency while precluding the need for expensive additions to electric generating capacity or purchase of natural gas.

The ILCP process involves extensive consultation with a variety of affected public and private institutions. Cooperating institutions consult with a variety of equipment suppliers and consultants capable of providing them with the best range of options for energy efficiency.[13]

However, the public utility commissions and electric and natural gas utilities pursuing the ILCPs are aware of the socioeconomic impact of institutional energy choices. For example, the District of Columbia Public Service Commission has established a Load Research Advisory Group (LRAG), consisting of the utilities, Commission staff, the District of Columbia Energy Office and various citizen organizations to monitor the development and implementation of ILCP. A key component of the process has been the inclusion of the District of Columbia Natural GAs Company (DCNG).[14] This analysis is aimed at assessing the socioeconomic

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[13]Eric Hirst, "Guidelines for a 'Good' Integrated Resource Plan," Public Utility Fortnightly, v. 125, n. 7, pp. 18-14.

[14]District of Columbia Natural Gas Company, Least Cost Plan (Washington, D.C.: June 1990), pp. 54-58.

consequences of both households and institutional energy efficiency choices. Once the consequences are determined, DCNG recommends to the LRAG, or to the Commission, appropriate mitigation or intervention strategies to facilitate institutional and household choice.

The ILCP process is therefore aimed at achieving energy efficiency so that the benefits are realized by both participating households and institutions. The concern that externalities or unanticipated costs of energy efficiency choices should not adversely affect either households or institutions, particularly lower income households and small institutions.

However, the measurement of household and institutional socioeconomic impacts is not simple. For example, the hypothesis that energy costs, on the one hand, and benefits derived from energy efficiency, on the other, automatically pass through from business, government and social service institutions to consumer households may be tested by:

(1) Determining through interviews with households or institutional leaders whether they are aware of energy cost increases or benefits;

(2) How and to what extent such energy costs impact upon them;

(3) How long pass through of energy costs impacts to households actually takes; and

(4) Whether energy cost savings or avoidance are absorbed by increases in other price factors.

Factor analyses of institutional operating expenses may be necessary to isolate the status and impact of energy costs. Moreover, such intervening variables as seasonal fluctuations in energy costs, inclement or unusual weather or expansion of contractual or general market forces is necessary to isolate energy cost behavior and the impacts of such costs on the social system.

Appropriate modes of policy intervention must rest firmly upon such analyses. Inadvertent regressivity in energy policy can exacerbate socioeconomic response to such policies. The delicate web of interrelationships between households and institutions, particularly in lower-income neighborhoods, can be disrupted by energy efficiency initiatives which rely upon expensive up-front investments in energy equipment such as heat pumps, gas chillers, efficient furnaces and refrigerators, attic insulation, and timers. Payback periods for such investments vary with usage and with the overall financial condition of the household or institution. Moreover, investment in equipment without improvements to building envelopes may result in significant energy technology investments without a necessary avoidance of costs.

It is also essential that "socioeconomic" include all income groups among households and all sizes and types of institutions. There are three essential reasons for this "social systems" approach:

(1) Household/institutional interactions impact most income strata and many types of institutions not directly transacting in the zone of exchange;

(2) Energy distribution is not segmented by socioeconomic status. Utility companies tend to define service jurisdiction on a geographic, not a socioeconomic basis; and

(3) Policy intervention to assist in or support one income group or institutional type will invariably affect other non-targeted income groups on institutional types.

Consequently, the term "socioeconomic" is not a synonym for low-income. Nor is it a rubric for "household." It includes all key elements of a given social system, including interactions and interdependencies among the elements of that social system. The socioeconomic bases of energy policy are therefore firmly rooted in the social system and are ultimately adjudged to be effective or defective by the social system.

(Revised June 1990)

OVERVIEW OF MI'S RESIDENTIAL ENERGY CONSUMPTION AND EXPENDITURE PROGRAM

GEORGIA R. JOHNSON

OVERVIEW OF MI'S RESIDENTIAL ENERGY CONSUMPTION AND EXPENDITURE PROGRAM

Georgia R. Johnson

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Section 211 of the Department of Energy (DOE) Organization Act (42 USC 7141) directs the Office of Minority Economic Impact (MI) to conduct an on-going research program with the assistance of the Energy Information Administration and other appropriate federal agencies to determine the impact of national energy programs, policies, and regulations on minorities. This will enable the Director of MI to develop and recommend to the Secretary of Energy relevant policies to assist minorities and minority business enterprises alleviate any negative impacts resulting from such energy actions.

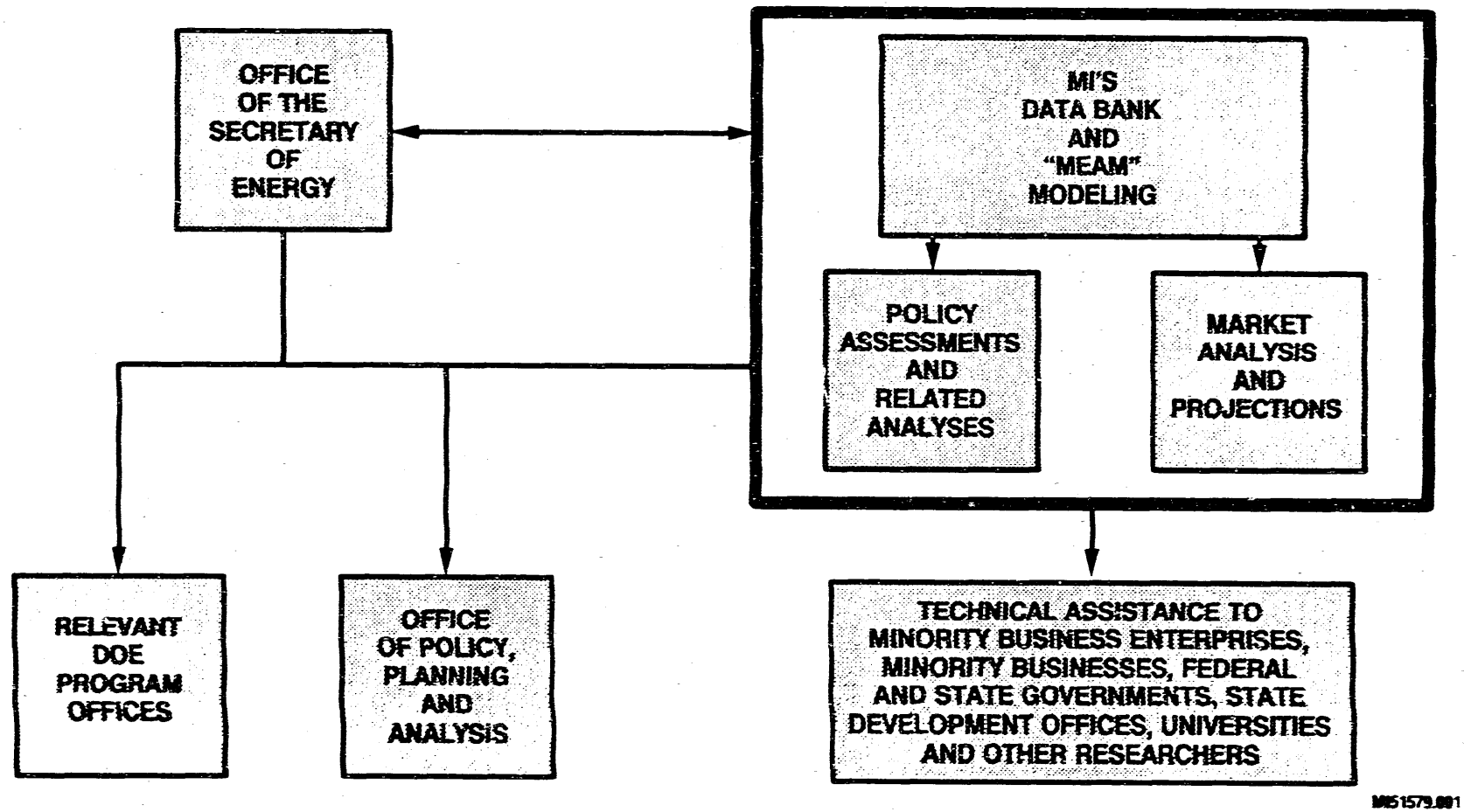
In directing MI to assess how minorities cope with the disproportionate financial impact of higher energy prices, the legislative mandate requires a determination of the equity effects of policies and regulations on individuals and communities. If energy policies and programs result in higher prices, this will generate increases in the direct energy expenditures of households and increases in the overall energy costs for producing all goods and services. However, since energy consumption cannot be reduced in the short-run, appropriate assessments must be made, so that energy policy alternatives and strategies can be established and implemented. Such alternative strategies must focus on decreasing prices and the overall national energy consumption.

Energy has a major influence on economic activity. The relationship of energy prices, policies, regulations, and programs to family and household income is highly complex. Energy pricing impacts not only the purchasing power of consumers, but it also impacts household conservation, research and development, the commercialization of energy technology, and the development of energy supplies through exploration and investments, the acquisition of petroleum stockpiles, and the viability of all industries which are dependent on energy. Accordingly, energy pricing has enormous consequences for the overall economy of the Nation.

In order to address MI's legislative mandate, specific determinations must be made about the extent to which energy prices impact economic activity. Energy is a necessary input to the supplies and the development of all sectors of the economy. Energy is also the most single

Figure IA

FUNCTIONAL INTERRELATIONSHIPS OF MI'S RESEARCH PROGRAM



factor which influences economic activity. Accordingly, economic and energy policy decisions must constantly be made and readjusted. However, the energy problems and solutions must be determined within the context of relevant social interactions and equity. For example, decisionmakers must assess and establish a policy of market pricing of various energy sources in order to minimize negative impacts; as they attempt to stabilize energy prices and establish a rational energy policy.

Studies from the Residential Energy Consumption Survey (RECS) indicate that minority households generally spend a disproportionate share of their income on residential energy and this share tends to grow disproportionately as energy prices increase. This situation retrogresses because, even though minority households consume less energy than higher income households, minorities have fewer discretionary energy options and usually lack the resources to participate in energy consumption--either behavorially or through investments. To compound the situation, minority and lower income households are subjected to inverted rate structures for their utilities because the changes or rates decline with larger quantities of energy consumed. Accordingly, legislation which addresses energy impact assessments specifically requires systematic evaluations of policy changes which are linked closely to energy price behavior.

OBJECTIVES OF THE SOCIOECONOMIC ENERGY RESEARCH AND ANALYSIS PROGRAM

In order for MI to address its legislative mandate, a determination of the extent to which energy prices impact economic activity is essential. A specific quantitative framework had to be designed to enable socioeconomic researchers and policy-makers to realistically deal with the complex issues of unprecedented rising energy prices since the 1970's and the resulting impact on energy consumption and disposable income. These major objectives necessitated the design and development of specific research tasks which will facilitate massive comparative data and other information and policy impact assessments and analyses, to enable comparisons of the energy consumption and expenditure patterns versus other population segments. In addition, the development of technical market analyses and projections on selected energy technologies will fulfill other provisions of MI's legislation to provide focused technical assistance to minority business entrepreneurs in the U.S. Effective quantification of such dynamic socioeconomic factors and their related policy assessments are best estimated by the development of econometric models, through the utilization of representative national and regional data.

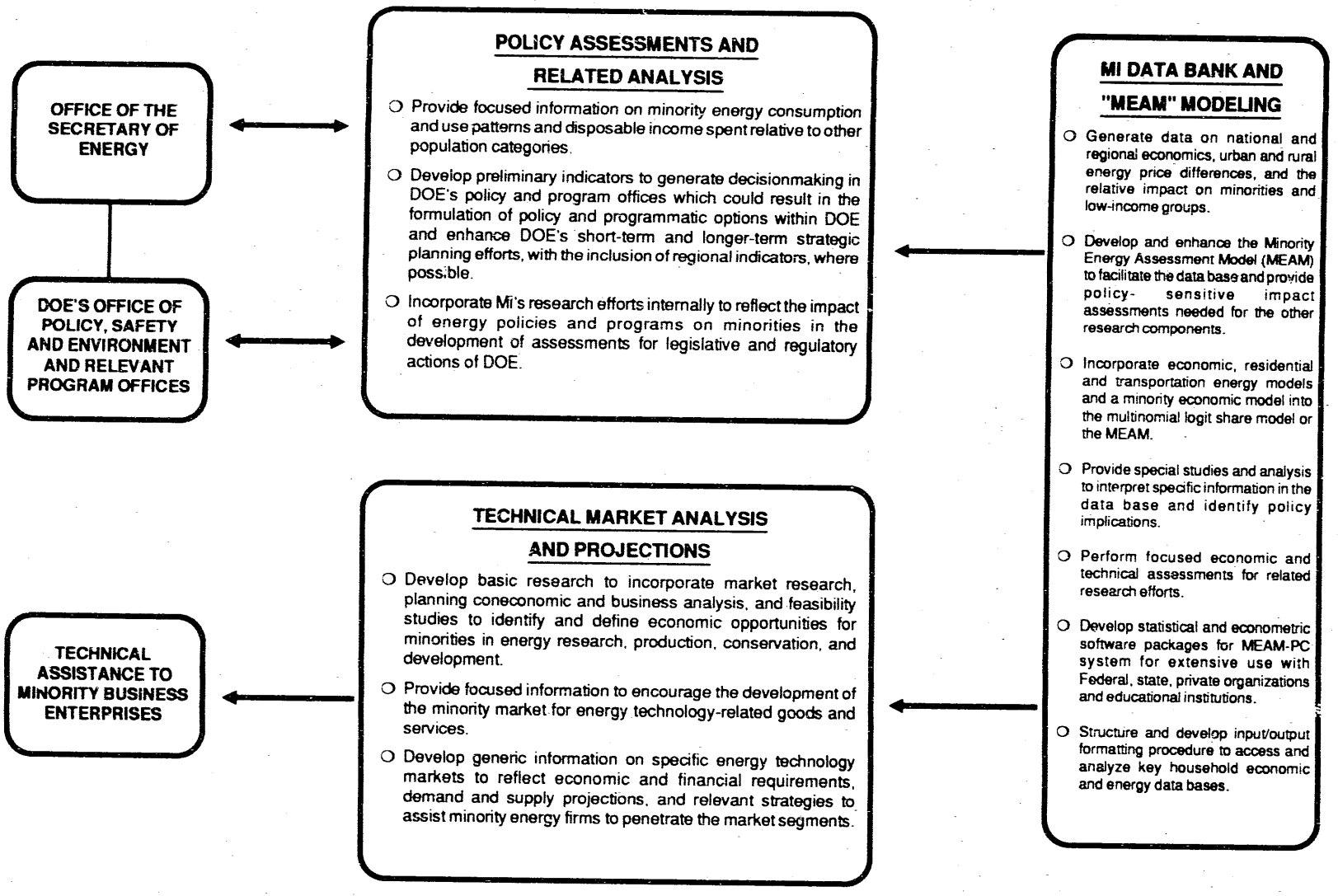
Accordingly, the three major tasks of the Socioeconomic Energy Research and Analysis Program (SERAP) are:

A. The Development of A Socioeconomic Data Base and the Minority Energy Assessment Model

B. The Development of Energy Policy Assessments and Related Analyses

Figure IB

FUNCTIONAL INTERRELATIONSHIPS OF MI'S SOCIOECONOMIC RESEARCH AND ANALYSIS PROGRAM



Prepared by: Office of Minority Economic Impact
Minority Energy Information Clearinghouse

C. Technical Market Analyses and Projections

The long-range goals of this SERAP are to:

1. Enhance the capabilities of the policy-sensitive Minority Energy Assessment Model (MEAM) by improving the level of minority representation in the data bank, enhancing the overall regional characteristics of the socioeconomic and energy consumption information for comparative purposes, and improving the macroeconomic components to this policy tool;

2. Extend the utilization of analyses of specific indicators of minority consumption and use patterns relative to other population categories, at the regional level, for use in the development of assessments for policy and program options and legislative and regulatory actions of DOE and other Federal agencies;

3. Increase the participation of minorities and minority communities in energy-related activities by:

   (a) developing characterizations of options for economic and planning analyses in energy technology markets; and

   (b) enhancing the development of market research and projections and other technical assistance which will facilitate the transfer of information relating to specific economic opportunities for minority entrepreneurs and minority communities;

4. Augment MI's unique minority data base system and the MEAM to more accurately forecast residential and transportation energy demand by incorporating the latest theoretical developments in applied econometric and microeconomic analyses for policy assessments;

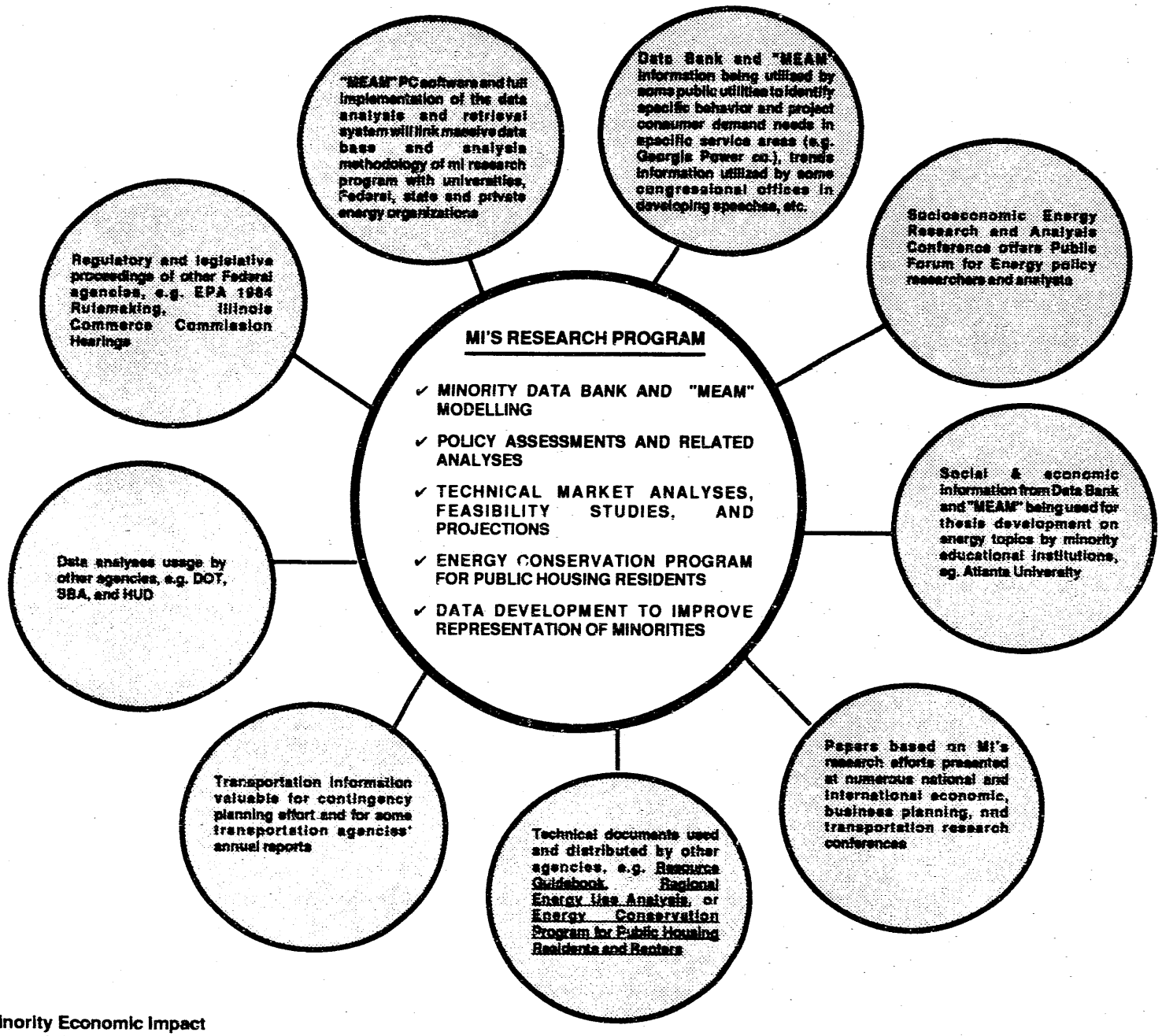
5. Develop a MEAM-PC system and integrate it with existing statistical and econometric software packages which are currently accessible to other energy policy researchers; and

6. Structure and develop a unique statistical input/output formatting procedure for users of national survey data and massive data bases--facilitating a new capability to assess, report, and analyze key household, economic, and energy data by population subgroups; through the integration of national survey information.

The specific objectives of the SERAP are directly related to the functional interactions of MI to other offices within DOE. These interrelationships are summarized in Figures IA and IB.

Figure II

MI'S SOCIOECONOMIC RESEARCH AND ANALYSIS PROGRAM EXTERNAL INTERRELATIONSHIPS



Prepared by: Office of Minority Economic Impact
Minority Energy Information Clearinghouse

In Figure II, some of the applications of the efforts generated through the SERAP are delineated. The specific sub-tasks of the multi-faceted SERAP are shown in Figure III.

Through MI's sponsorship of specific research tasks conducted mainly by a multi-disciplinary staff at Argonne National Laboratory at Argonne, Illinois, a multi-nomal logit model called the Minority Energy Assessment Model (MEAM) is being developed to address MI's on-going research mandate. The MEAM was designed and is constantly being refined, modified, and enhanced to improve its analytical power and precision and to facilitate the quantitative methods which are essential for effective energy policy development processes.

THE MINORITY ENERGY ASSESSMENT MODEL

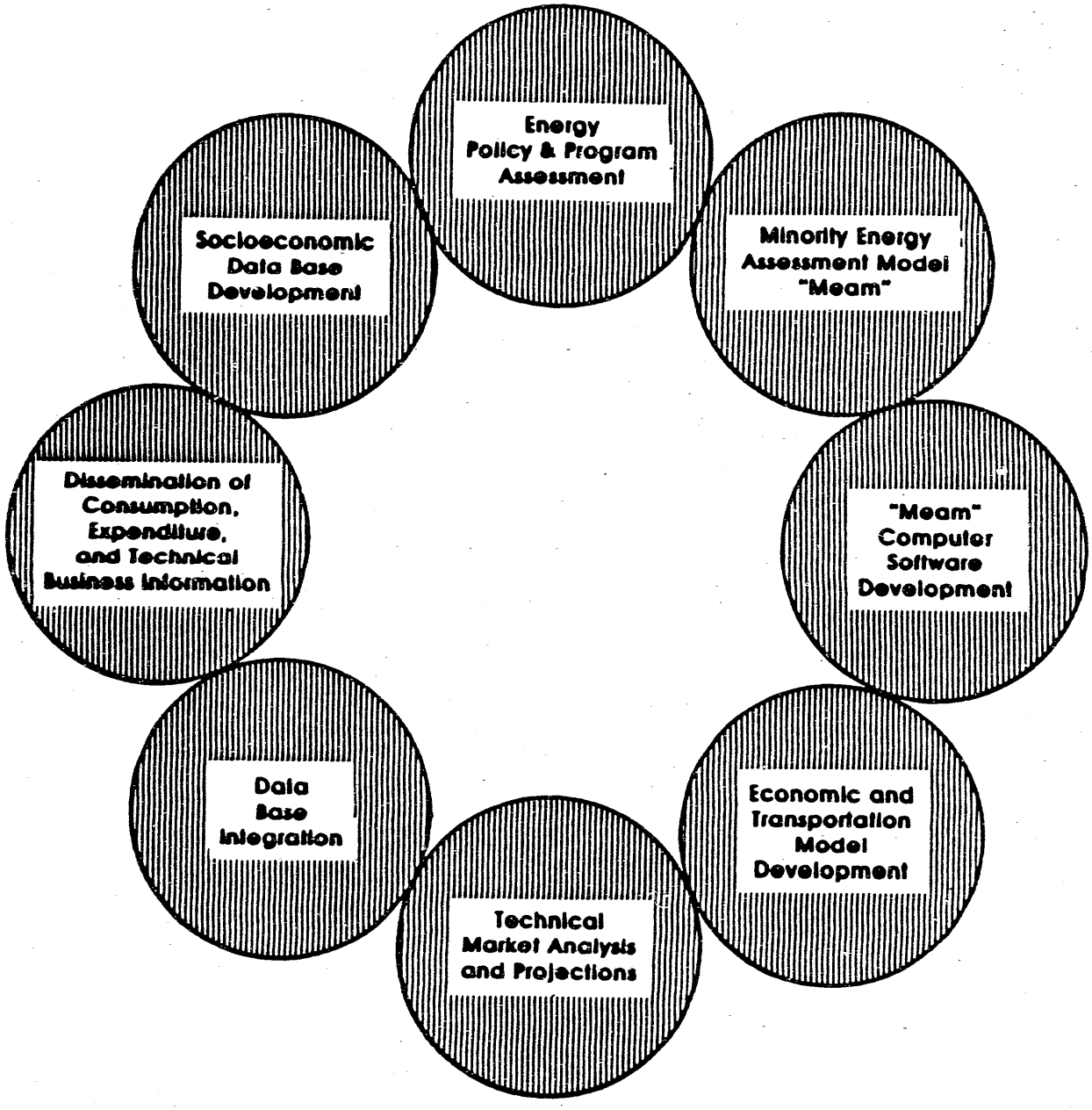
Figure IVA shows a simplistic concept of the MEAM. The MEAM estimates the fuel consumption and expenditure patterns for selected minority groups, compared to other population segments. For each minority group (mainly Blacks, Hispanics, the elderly, and the poor) expenditures are estimated separately for natural gas, electricity, fuel, oil, and liquefied petroleum gas (LPG). The MEAM also estimates the impact of the changing fuel prices on the economic well-being of minority households, as measured by changes in consumer surplus. The estimates are determined at the National level and are also disaggregated for each of the four the Census regions. Figure IVB simply indicates the approach of the quantification of the MEAM.

The MEAM Demand Model is characterized by a set of fuel demand equations which are estimated for each minority group, and for each Census region. Four separate equations estimate the demand for electricity, natural gas, fuel, oil, and LPG for each minority group, in each Census region. For each equation, the amount of fuel demanded by each household is stipulated to be a function of specific income, price, and socioeconomic variables. These are:

- real income of the household
- type of fuel used
- average price of fuel paid by the household
- number of heating degree days
- number of cooling degree days
- family size
- number of persons per room
- age of home structure
- number of rooms air conditioned
- fuel use

Figure III

Socioeconomic Energy Research and Analysis Program



May 1987

In Figure II, some of the applications of the efforts generated through the SERAP are delineated. The specific sub-tasks of the multi-faceted SERAP are shown in Figure III.

Through MI's sponsorship of specific research tasks conducted mainly by a multi-disciplinary staff at Argonne National Laboratory at Argonne, Illinois, a multi-nomal logit model called the Minority Energy Assessment Model (MEAM) is being developed to address MI's on-going research mandate. The MEAM was designed and is constantly being refined, modified, and enhanced to improve its analytical power and precision and to facilitate the quantitative methods which are essential for effective energy policy development processes.

THE MINORITY ENERGY ASSESSMENT MODEL

Figure IVA shows a simplistic concept of the MEAM. The MEAM estimates the fuel consumption and expenditure patterns for selected minority groups, compared to other population segments. For each minority group (mainly Blacks, Hispanics, the elderly, and the poor) expenditures are estimated separately for natural gas, electricity, fuel, oil, and liquefied petroleum gas (LPG). The MEAM also estimates the impact of the changing fuel prices on the economic well-being of minority households, as measured by changes in consumer surplus. The estimates are determined at the National level and are also disaggregated for each of the four the census regions. Figure IVB simply indicates the approach of the quantification of the MEAM.

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- real income of the household
- type of fuel used
- average price of fuel paid by the household
- number of heating degree days
- number of cooling degree days
- family size
- number of persons per room
- age of home structure
- number of rooms air conditioned
- fuel use

— for space heating

— for water heating

These variables facilitate the estimation of both income and price elasticities for each fuel. For each fuel also, two structural equations --a price equation and a household demand equation --are used by the MEAM. In order to eliminate potential errors as a result of employing average fuel prices (which are inversely related to the quantity consumed) rather than marginal prices, a three-stage least squares estimation procedure has been incorporated into the model. Pooled cross-section data, mainly from the Energy Information Administration's (EIA) Residential Energy Consumption Surveys data for five years,[1] provide the basis for the estimated equations. Projections are generated with the MEAM to determine future distribution trends of energy expenditures for the minority groups, by fuel types. These projections also incorporate variables relating to income levels, fuel prices, and socioeconomic characteristics. Data sources for the projections and the MEAM are as follows:

BASIS OF MEAM PROJECTIONS

VARIABLES	INFORMATION SOURCES	MEAM APPLICATIONS TO INFORMATION
Income Levels	DRI's United States[2] Macroeconomic Model	• Uses income projections from the Macroeconomic Model to estimate changes in average household income levels. • Models impact of changes in income on the quantity of fuel consumed, using a distributed log function.
Fuel Prices	DIR's U.S. Energy Model	• Uses fuel price projections from the Economic Model. • Models the impact of changes in producer fuel prices on prices paid by consumers for end-use energy products by applying a distributed log function.
Socioeconomic Assumption[3]	EIA/RECS Data	• Utilizes assumptions made in the basic "MEAM" demand model (form separate equations estimating demand for the form fuel types) to make projections. — changes in ratio of household heating, — changes in ratio of end-use energy products, — changes in fuel efficiency of housing units, utilizing trend in ratio of distribution of households vs. age of homes over the period of projection.

Since the DRI income projections for the U.S. is applied by the MEAM to all population sub-groups, the MEAM is currently being modified to correct for this deficiency. A Minority Economic Model (MEM) is being developed to more accurately estimate the relationships among changes in the income of specific minority groups, changes in total income, and relevant demographic and macroeconomic variables. The MEM will utilize historical data on incomes, wealth, and employment of minority groups to (a) determine relationships to major economic indicators, and (b) project the incomes of minority groups for each year, between 1985 and 2005. The estimation methodology of the MEM will be consistent with the MEAM and the MEM will be incorporated into the basic MEAM demand model.

Data for the major portion of the research work performed under the SERAP is generated extensively from major energy-related data bases such as the Residential Energy Consumption Surveys, the Annual Housing Surveys, the Public Use Micro Sample, the Consumer Expenditure Surveys, the Nationwide Personal Transportation Surveys, and none recently, the Survey of Income and Program Participation. Other research efforts have involved occasional grant awards for unique projects which relate to the specific objectives of the overall program and which have resulted in the development of unique analyses and other information for use in specific segments of the energy end-use market. The MEAM's sub-model components--residential energy model, transportation energy model, and minority economic model--are updated periodically and their technical development enhanced, in order to facilitate relevant energy policy impact assessments in a timely fashion.

Figure IVA

OFFICE OF MINORITY ECONOMIC IMPACT ASSESSMENT MODEL (MEAM)

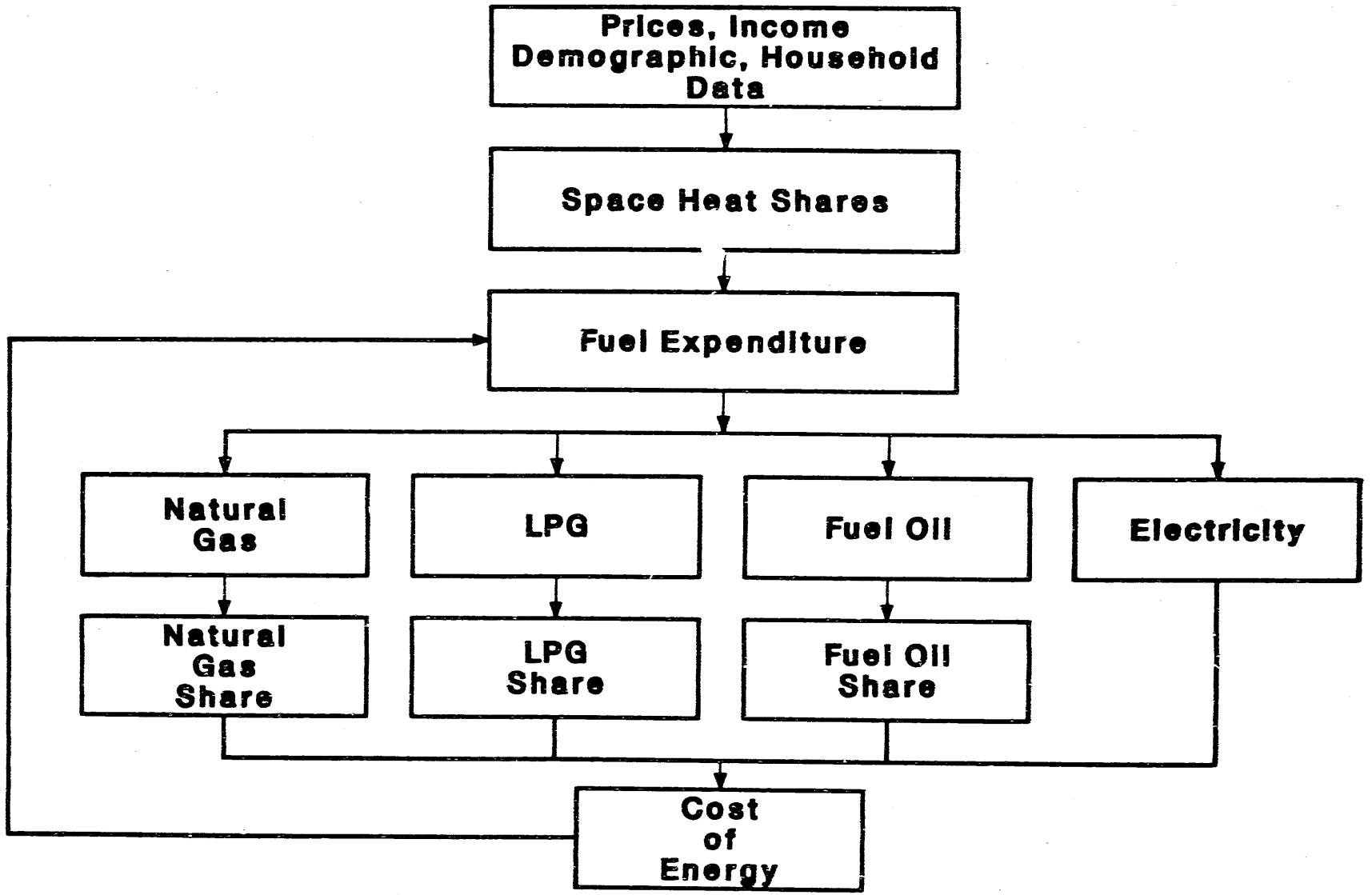
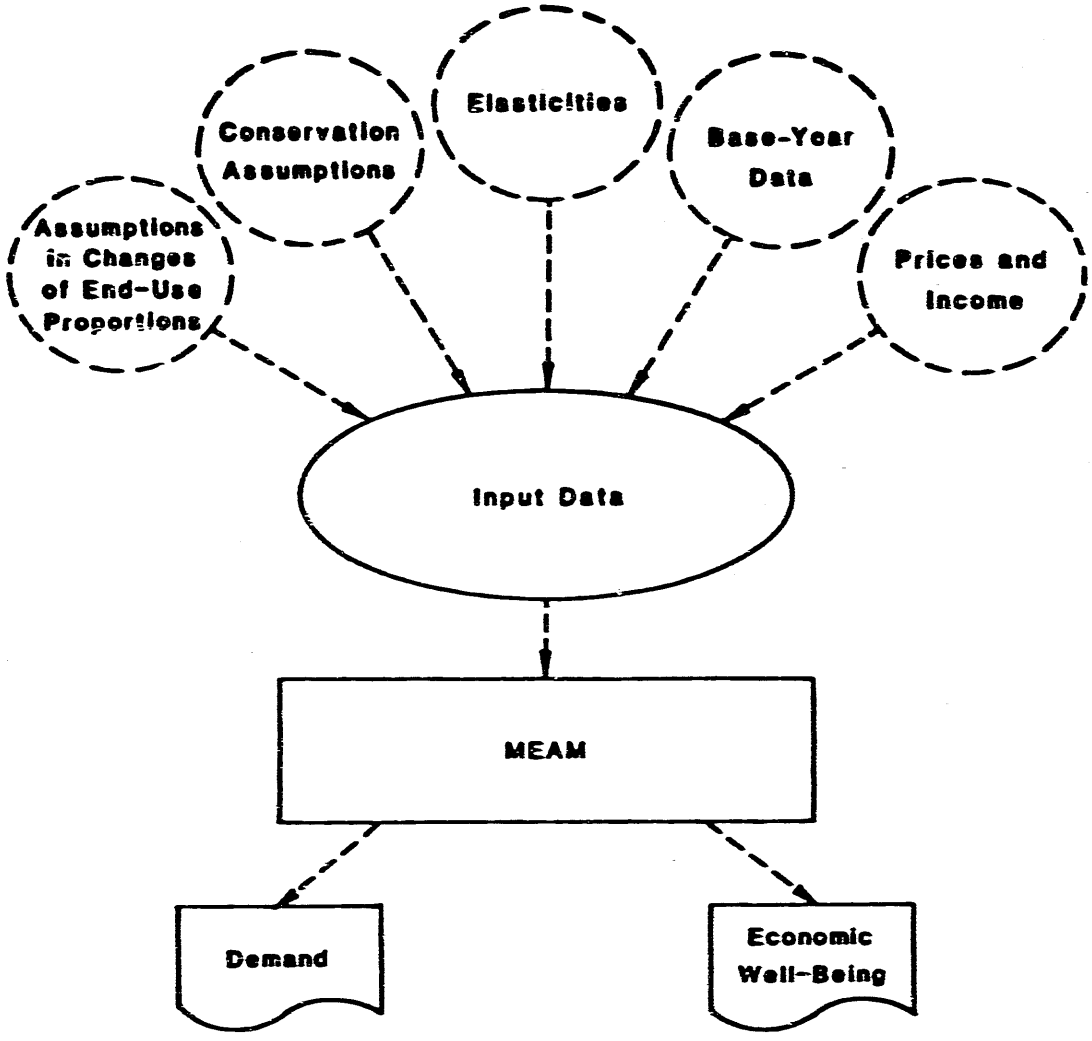


Figure IVB


Conservation Assumptions
Elasticities
Base-Year Data
Assumptions in Changes of End-Use Proportions
Prices and Income
Input Data
MEAM
Demand
Economic Well-Being

REFERENCES

1. RECS Survey data information is for 1978/79, 1979/80, 1980/81, 1981/82, 1982/83. Data for 1984/85 is being incorporated into the MEAM (at time of publication). The RECS includes data on 5,000 - 6,000 households in the U.S. and includes data for 12 month periods on housing characteristics, fuel use, energy use and expenditures, and socioeconomic data.

2. Data Resources, Incorporated.

3. Socioeconomic Variables such as average family size per household and number of rooms occupied per person, are usually hold constant over the period of the projections, at the base year levels.

ELECTRIC UTILITIES AND CORPORATE SOCIAL RESPONSIBILITY: CREATING AN ENVIRONMENT THAT PROVIDES FOTH SERVICE AND OPPORTUNITY

JAMES K. DAVIS, JR.

ELECTRIC UTILITIES AND CORPORATE SOCIAL RESPONSIBILITY: CREATING AN ENVIRONMENT THAT PROVIDES BOTH SERVICE AND OPPORTUNITY

James K. Davis, Jr.
Vice President

Corporate Relations
Georgia Power Company

One of the quandaries those of us in the electric utility business have found ourselves in over the years is the struggle to identify the "average" customer.

It's like describing the "average" football, basketball or baseball fan -- there is little to link him with another fan except the favorite team.

All the other factors -- the level of intensity of his or her fanaticism, the number of games attended, or even the amount of money wagered on the team varies extensively.

So, too, do the characteristics of what we call the "average" electric customer. Those differences become even more pronounced when you consider the "average" low-income customer. The variations often defy traditional logic.

For instance, studies done by Georgia Power's economic and market research department show that low income customer's - those earning less than $10,000 a year -- use less energy on average, with 16 percent using about 488 kWH a month.

However, not all low income customers are low users. In fact, studies show that 20 percent of our low-income customers use from 651 to 1,000 kWH a month, and 10 percent use from 1,001 to 1,500 kWh monthly.

But the results of other research examining the electricity use patterns of low-income customers tends to be more predictable:

— a greater percentage live in multi-family homes;

— their homes tend to be smaller;

— they tend to own fewer appliances;

— they generally do not have air conditioning;

— they have taken fewer conservation steps;

— they are more likely to have electric water heating;

— they are almost as likely to have electric heat;

— they tend to be either older or younger;

— they are less well-educated; and

— they have a higher percentage of homes where the female is head of the household.

The social -- and economic -- implications of this customer profile are enormous, particularly when they deal with the affordability of our product, electricity.

We have, in previous years, proposed to our state public service commission a rate for the elderly and for those living on fixed incomes.

However, our position has been that the state must certify those who qualify for that rate, and up to this point, the state has yet to tackle the assignment.

Quite frankly, Georgia Power is hesitant to take on sole responsibility for both designing such a rate and then certifying customers for it because we feel that responsibility is best handled by a social service agency -- not a regulated, for-profit electric utility.

What we have tried to do is to produce an available and reliable product at the lowest cost possible, and propose a residential rate that is fair to everyone--based on usage.

That doesn't mean, however, that there aren't other initiatives Georgia Power -- and electric utilities like it can't undertake to assist economically disadvantaged customers and the communities in which they live.

Georgia Power has been a corporate presence in the communities it serves in 153 of the state's 159 counties for more than 50 years. Before that, the Company's corporate predecessors had been involved in Georgia for more than 50 years.

Our historical efforts include:

— A rural lines program in the late 1920s, at least eight years before the Rural Electrification Administration was created. These lines brought the benefits of electricity to rural Georgia, providing many special services to farm customers to help them improve their quality of life and economic welfare through the innovative and efficient use of electricity.

— A rural development program in the late '40s and early '50s that helped to revitalize Georgia's declining farm economy and eliminate severe soil erosion problems that were being experienced statewide.

— Georgia Power's Better Home Towns program following World War II, which was credited with revitalizing the state, making scores of Georgia towns better places to live and attracting industries to provide jobs for returning war veterans.

To date, our economic development department has been responsible for coordinating the location of hundreds of businesses and industries in Georgia.

With the reductions of Federal funding of numerous educational, cultural and social service programs beginning in the early '80s, public attention was focused on American businesses to take on a greater role in providing resources.

What Georgia Power -- and many electric utilities -- have come to realize is that the way private enterprise responds may determine the course of business success and regulation well into the 21st century.

So in addition to the historical types of services we as a Company had been providing, we designed other programs to meet the goals of corporate social responsibility, which is a part of our business plan.

Since the needs of society fluctuate based on the economy, governmental actions and global politics, we periodically review our social investments and adjust them to meet current needs.

One move the Company has made is to eliminate the requirement for an initial deposit to begin service.

Although the procedure had little effect on many customers, it was an irritant to all, and particularly devastating for low-income customers, who were sometimes overwhelmed with the costs of moving and setting up utility service.

Other programs directed particularly to low-income and elderly customers include:

— Project Share, a joint venture of the Salvation Army and Georgia Power to address the energy-related needs of low-income Georgians. The emergency needs this program covers include food, shelter, clothing and utility bills. Georgia Power customers make pledges to this program which are matched by the Company on a dollar-for-dollar basis. In 1987, more than $1 million was pledged to the program. This could mean $2 million dollars for Project Share this year.

— Lending a Helping Hand is a joint venture with Enercom, a subsidiary of Equifax, Incorporated, and Georgia Power to hire senior citizens to weatherize and install smoke alarms in other senior citizens' homes. The work involves caulking, weather-stripping, replacing broken windows and worn thresholds to reduce air infiltration. More than 30,000 homes have been weatherized.

— Georgia Power operates neighborhood communications programs in certain Atlanta areas where factors such as income, education, language and transportation have

made it difficult for customers to communicate adequately with the Company -- or to get to Company offices.

— Extended payment arrangements are worked out with customers if paying a total bill on time presents a financial hardship. Arrangements are made in advance on an individual basis.

— If customers cannot pay their bills, Company employees will refer them to various social service agencies that might be able to give them financial assistance.

— Georgia Power's marketing representatives evaluate conservation needs and recommend the most cost-effective energy-saving measures to homeowners and apartment dwellers.

— The Company -- in cooperation with the Atlanta Regional Commission -- donated 800 electric fans to needy elderly residents in 1986. Included with the fans was information on heat stress and the efficient use of electricity. Georgia Power also provides other programs to senior citizen organizations on how to cope with heat and cold stress situations. The instruction also includes measures on helping prevent hypothermia and hyperthermia.

— Each summer disadvantaged youth are employed and placed in positions throughout Georgia Power according to their experience, education and skills. This program not only provides jobs and experience, but also weekly enrichment classes.

The Company also provides financial support to summer day camps for disadvantaged youth throughout the state. Learning programs and outings for participants are conducted weekly.

These are just a few of the many ongoing programs which are supported by our Company. Most of them are coordinated by our employees, who are especially sensitive to the needs of the communities which benefit from them.

This sensitivity has developed around a slogan coined to describe Georgia Power many years ago: "A citizen wherever we serve."

It is this part of our corporate culture -- being good stewards in the communities where we do business -- that keeps us close to the customer we talked about earlier. After all, we are in the business to serve all customers. As long as we have regulatory agencies, rates will always be consistent within classes -- whether residential, commercial or industrial

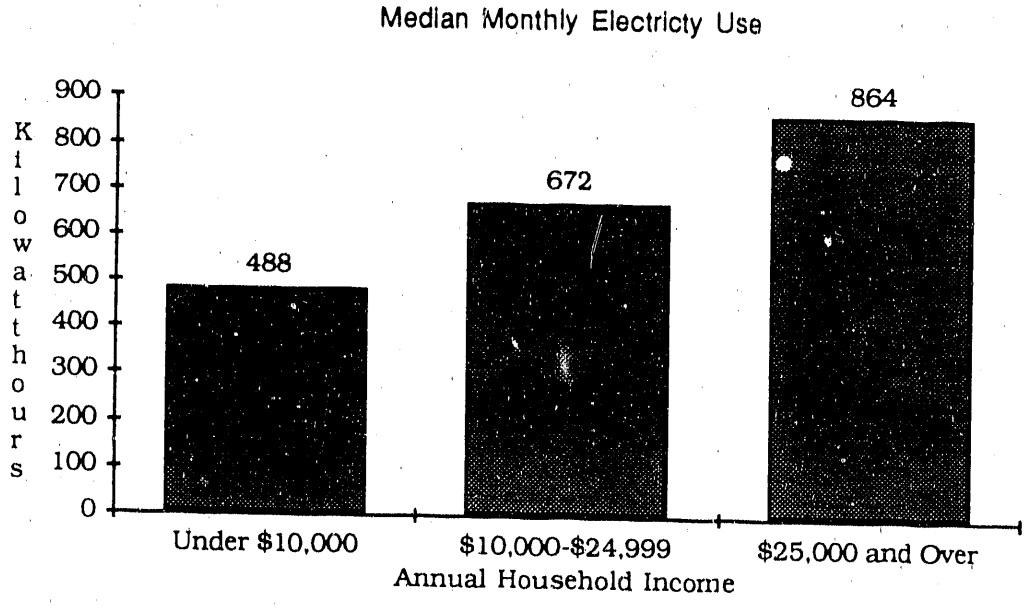
And I believe that's fair.

What we have pledged to do, however, is make it easier for lower income customers to enjoy the same level of service as others, whether through referral to social service agencies; weatherization to reduce consumption; or programs designed to create jobs.

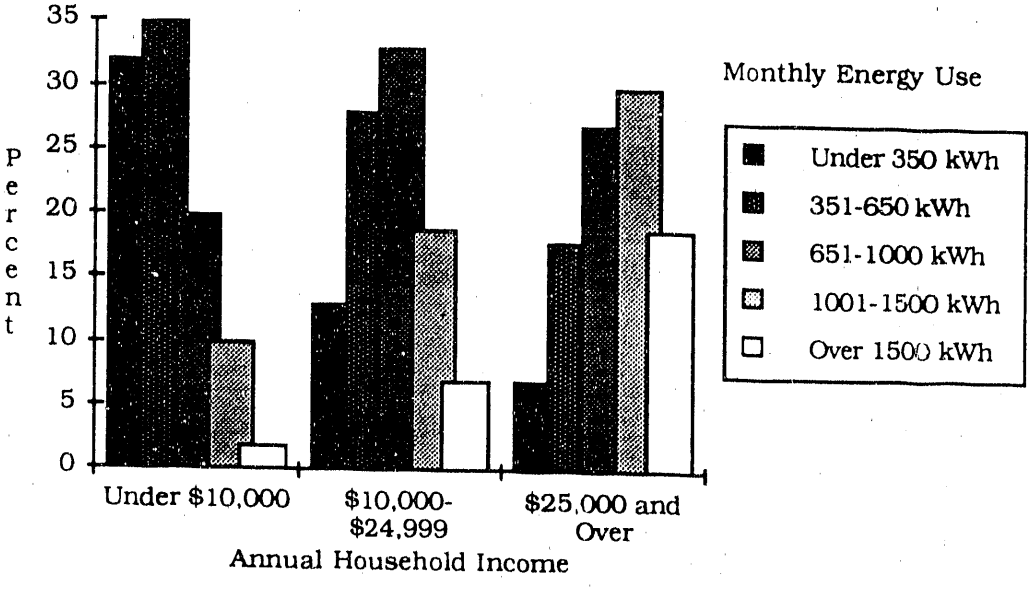
In this new age of corporate social responsibility, there must be a revival of caring for and about those who created the need for utilities and who will ultimately ensure our survival: the customer.

- **Low income customers use less energy on average**

- They have lower use on average

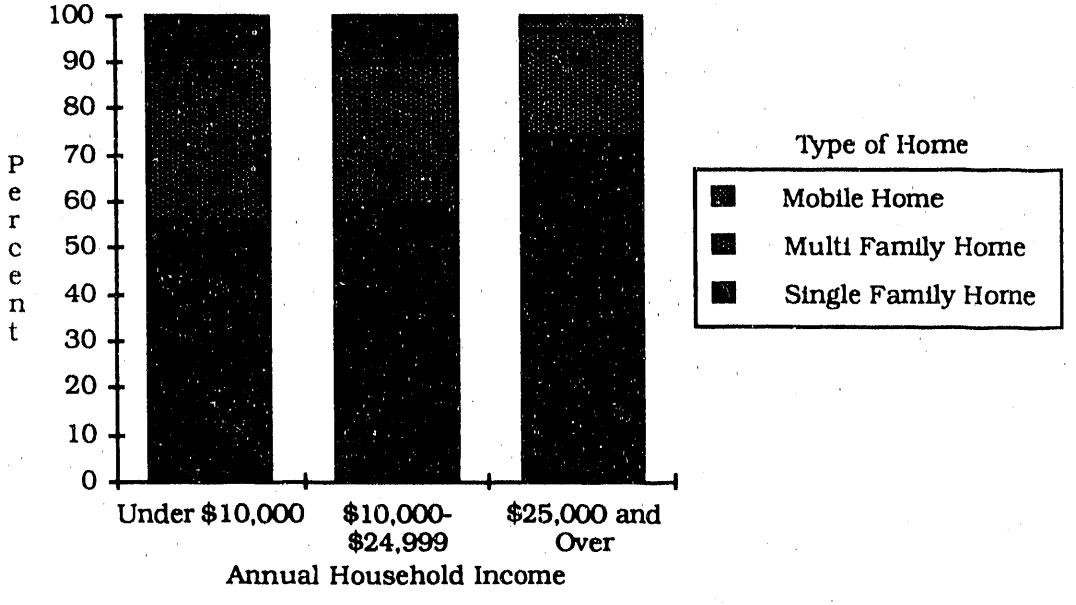


- But not all low income customers are low users

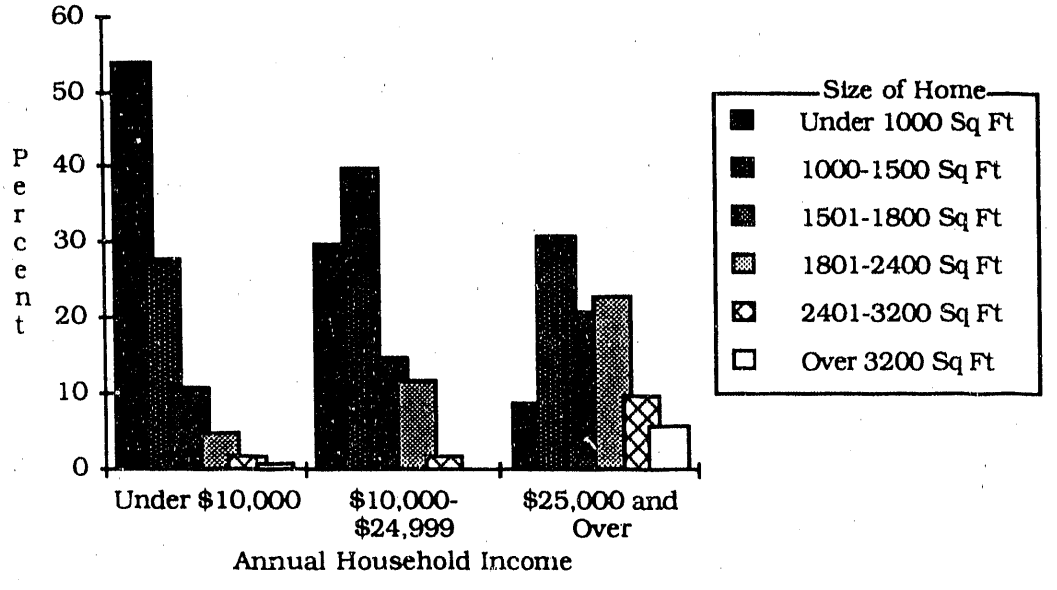


- **Many factors dispose low income customers to using less energy**

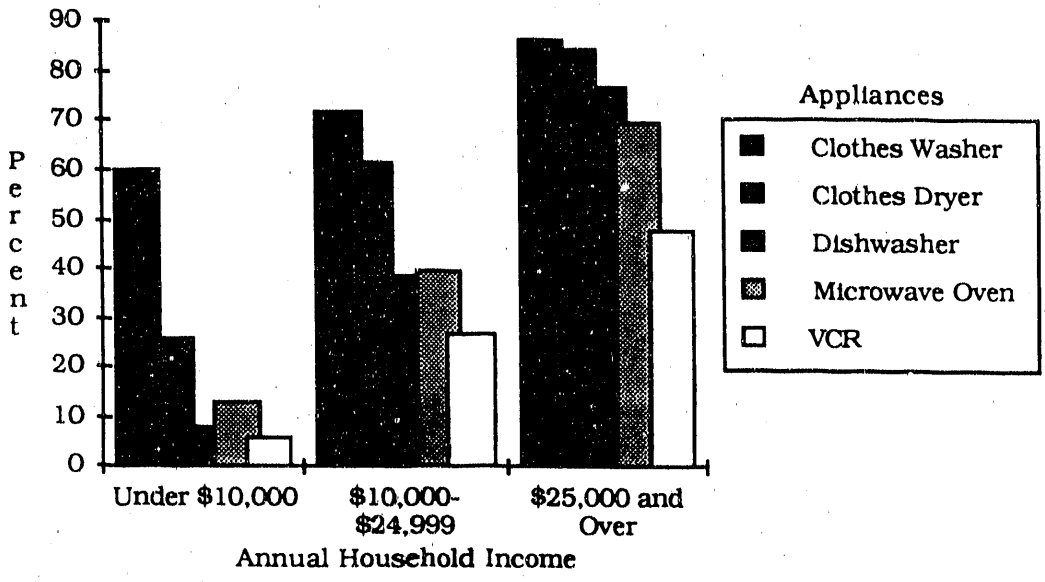
- A greater percentage live in multi-family homes



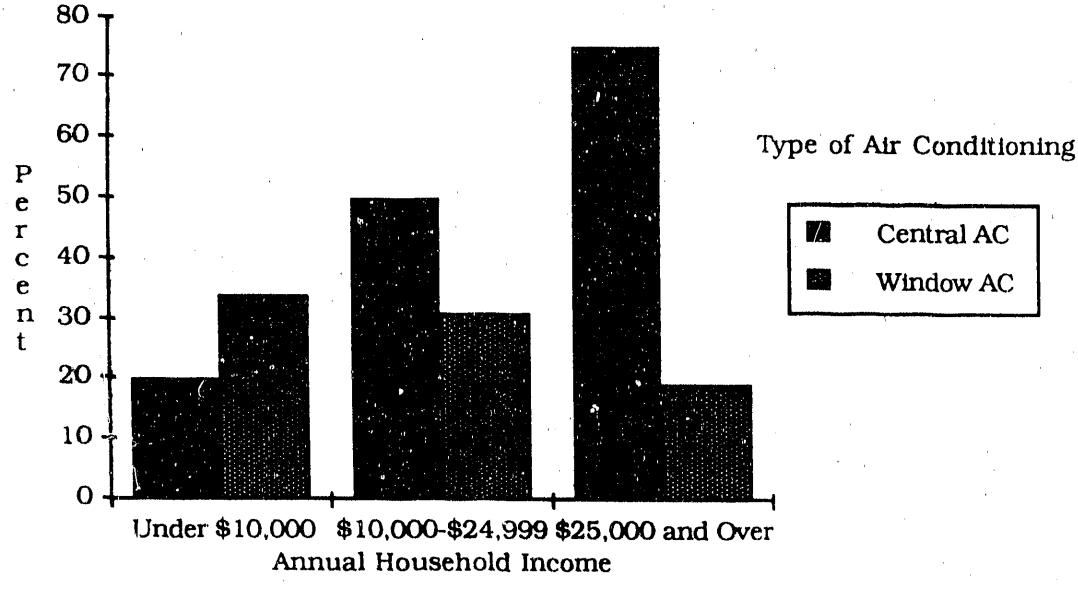
- Their homes tend to be smaller



- They tend to own fewer appliances

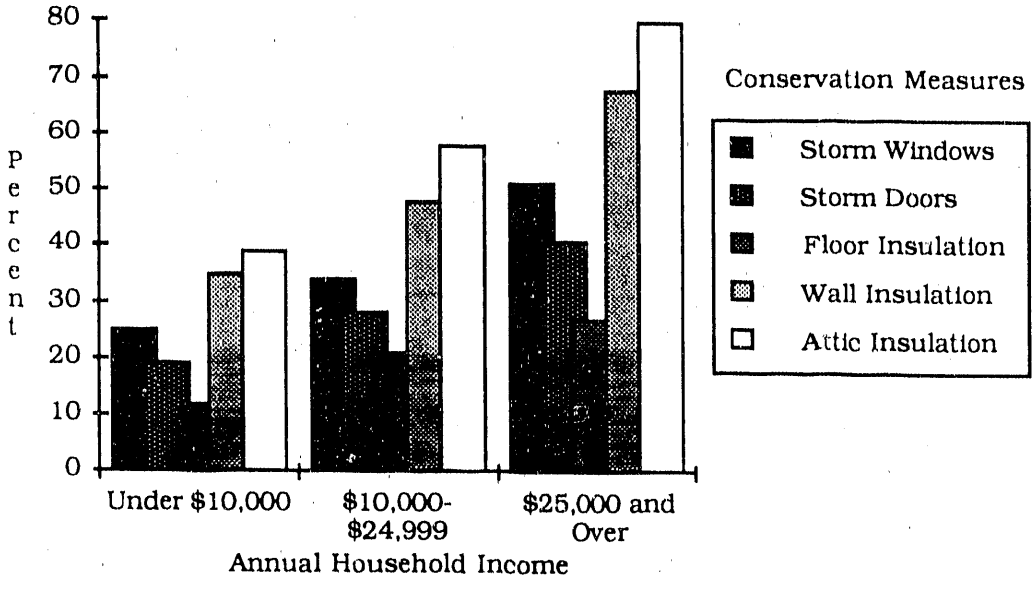


- They generally do not have air conditioning

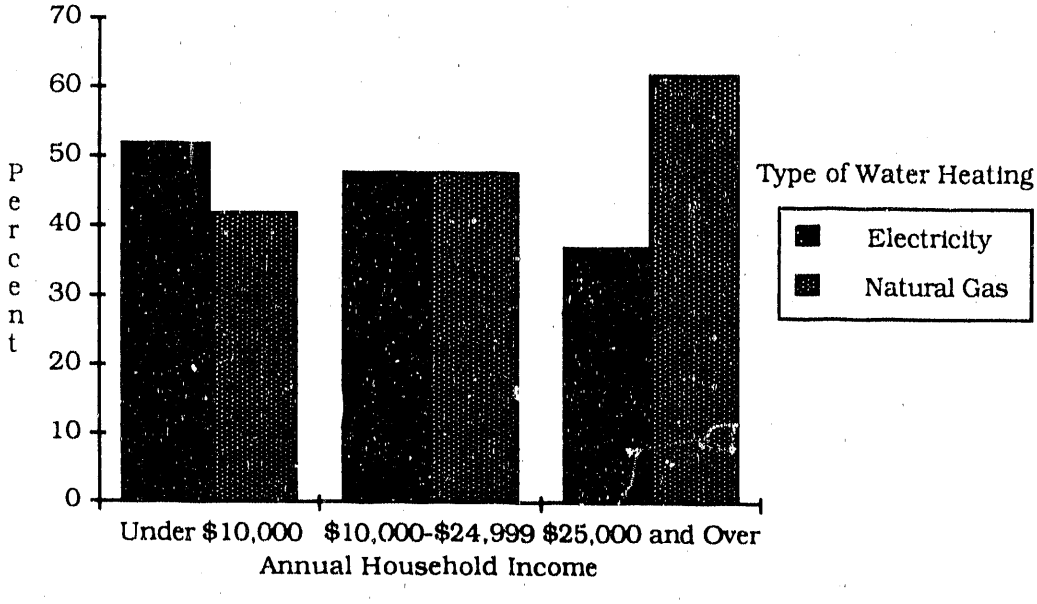


- **They are less likely to be able to control their energy costs**

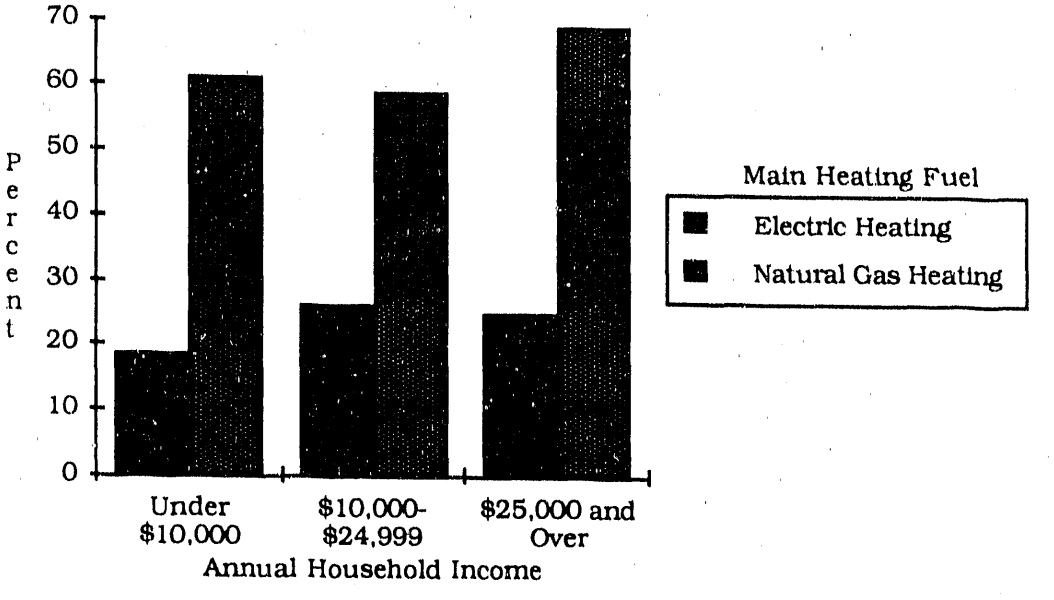
- They have taken fewer conservation steps



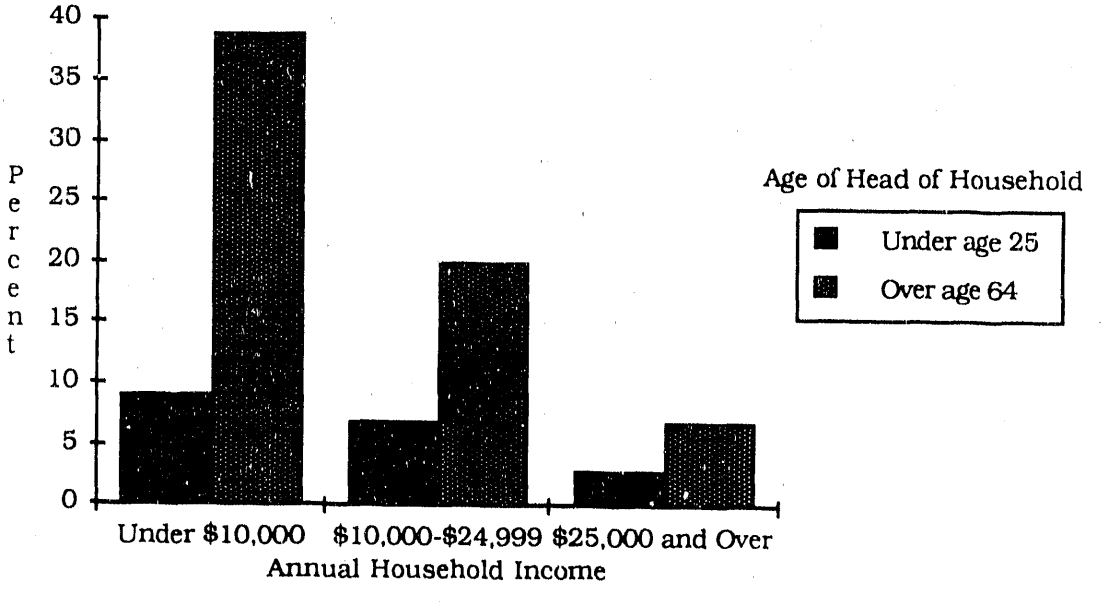
- They are more likely to have electric water heating



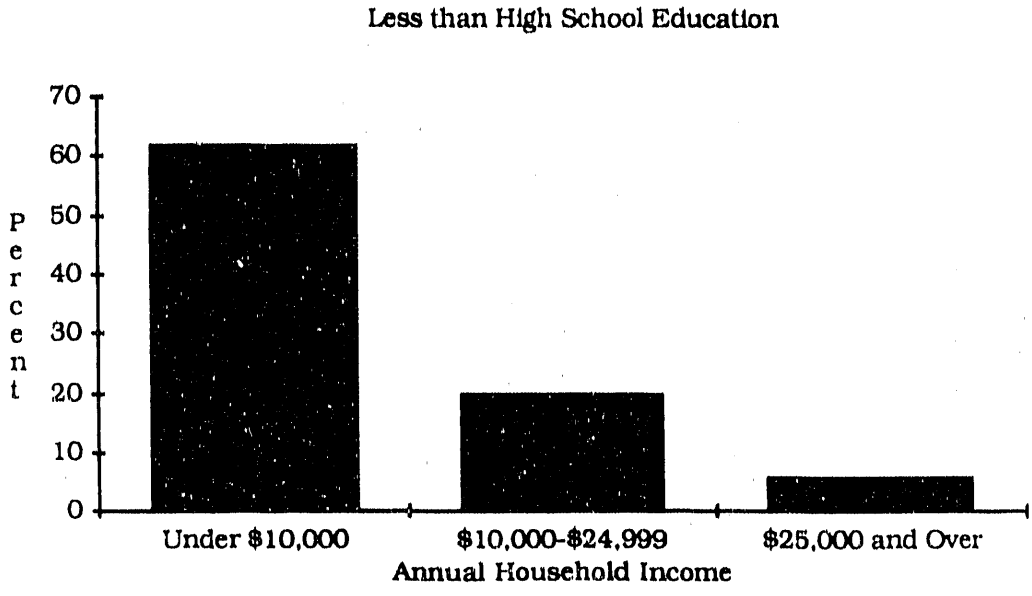
- They are almost as likely to have electric heat



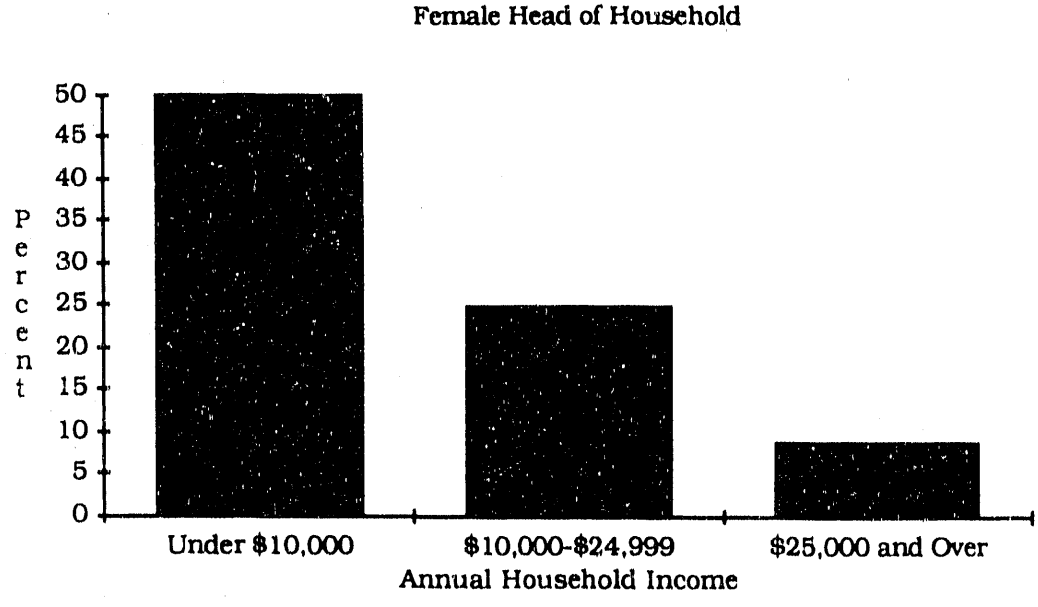
- They tend to be either older or younger



- They are less well educated



- They have a high percentage of female headed households



- **A profile of customer characteristics by annual Household Income**

Customer Characteristics by Annual Household Income

	Under $10,000	$10,000-$24,999	$25,000 and Over
	kWh	kWh	kWh
Median Monthly Electricty Use	488	672	864
	%	%	%
Percent of Customers	16	31	52
Monthly Electricity Use			
Under 350 kWh	32	13	7
351-650 kWh	35	28	18
651-1000 kWh	20	33	27
1001-1500 kWh	10	19	30
Over 1500 kWh	2	7	19
Home Type			
Single Family Home	56	59	74
Multi Family Home	33	31	23
Mobile Home	11	10	3
Home Ownership			
Own	46	56	74
Rent	54	44	26
Size of Home			
Under 1000 Sq Ft	54	30	9
1000-1500 Sq Ft	28	40	31
1501-1800 Sq Ft	11	15	21
1801-2400 Sq Ft	5	12	23
2401-3200 Sq Ft	2	2	10
Over 3200 Sq Ft	1	0	6
Energy Conservation Measures			
Storm Windows	25	34	51
Storm Doors	19	28	41
Power Attic Ventilator	1	9	24
Attic Fan	8	17	31
Floor Insulation	12	21	27
Wall Insulation	35	48	68
Attic Insulation	39	58	80
Appliances			
Clothes Washer	60	72	87
Clothes Dryer	26	62	85
Dishwasher	8	39	77
Microwave Oven	13	40	70
VCR	6	27	48
Water Heating			
Electricity	52	48	37
Natural Gas	42	48	62
Heating and Air Conditioning			
Central AC	20	50	75
Window AC	34	31	19
Electric Heating	19	26	25
Natural Gas Heating	61	59	69
Demographics			
Head of Home under age 25	9	7	3
Head of Home over age 64	39	20	7
Less than High School Education	62	20	6
Female Head of Household	50	25	9

RELATING ENERGY CONSUMPTION TO UTILITY FORECASTING AND ECONOMIC DEVELOPMENT

CHARLES F. BAXTER

RELATING ENERGY CONSUMPTION TO UTILITY FORECASTING AND ECONOMIC DEVELOPMENT

Charles F. Baxter

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New York, New York 10278

In a few short months, the Department of Energy will celebrate its tenth anniversary. Since the Department's creation, the nation has experienced some dramatic changes in its perception of utility forecasting and economic development.

To focus more on this subject, we need to examine some typical data produced during the early 1970's, at the peak of the energy disruption and compare those forecasts with subsequent actual events.

(CHART NUMBER 1)

The information presented in chart number 1 was compiled during the early 1970's and depicts total U.S. Energy consumption, in quadrillion British Thermal Units (Quads), by years, from 1850 to 1990. An initial inspection of the data and the shape of the curve that it produces suggests a simple positive exponential curve with a slight break occurring about 1950, probably due to the change in the use of automobiles following World War II. However, a closer look and analysis of the data reveals some startling points to consider. For example, from 1850 to 1950, a period of one hundred years, the energy consumption in the United States rose by only 30 quads, but during the next 20 years, the energy consumption doubled to 70 quads. The forecast in 1970 further predicted an increase of 40 quads during the next 20 years. As expected, a forecast of this magnitude, created much consternation for both sides of the energy supply and demand world. The key questions were, what would we use, where would we get it, and how much would it cost to produce?

There were those who insisted on immediate and forceful government remedies to stem the tides of rampant energy consumption, while conversely, others cried out for new and extensive production of energy to enhance economic development and growth.

(CHART NUMBER 2)

What actually happened? The unexpected and rapid increases in fuel costs, from an average of $2.00 per million BTU's, pre-1970, to prices of $5.00 and higher, forced many energy

CHART 1

TOTAL U.S. CONSUMPTION

(DATA COMPILED IN 1974)

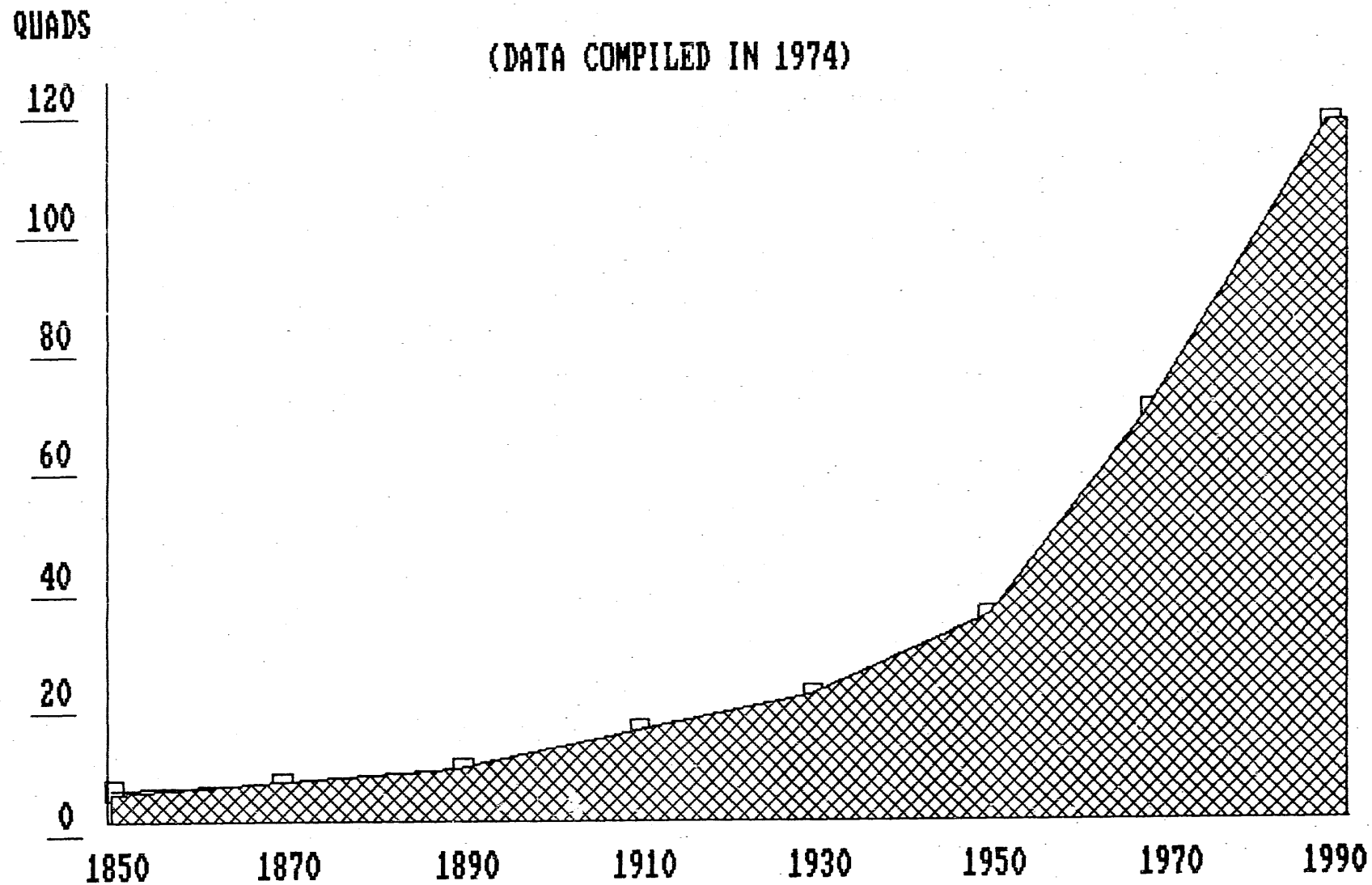
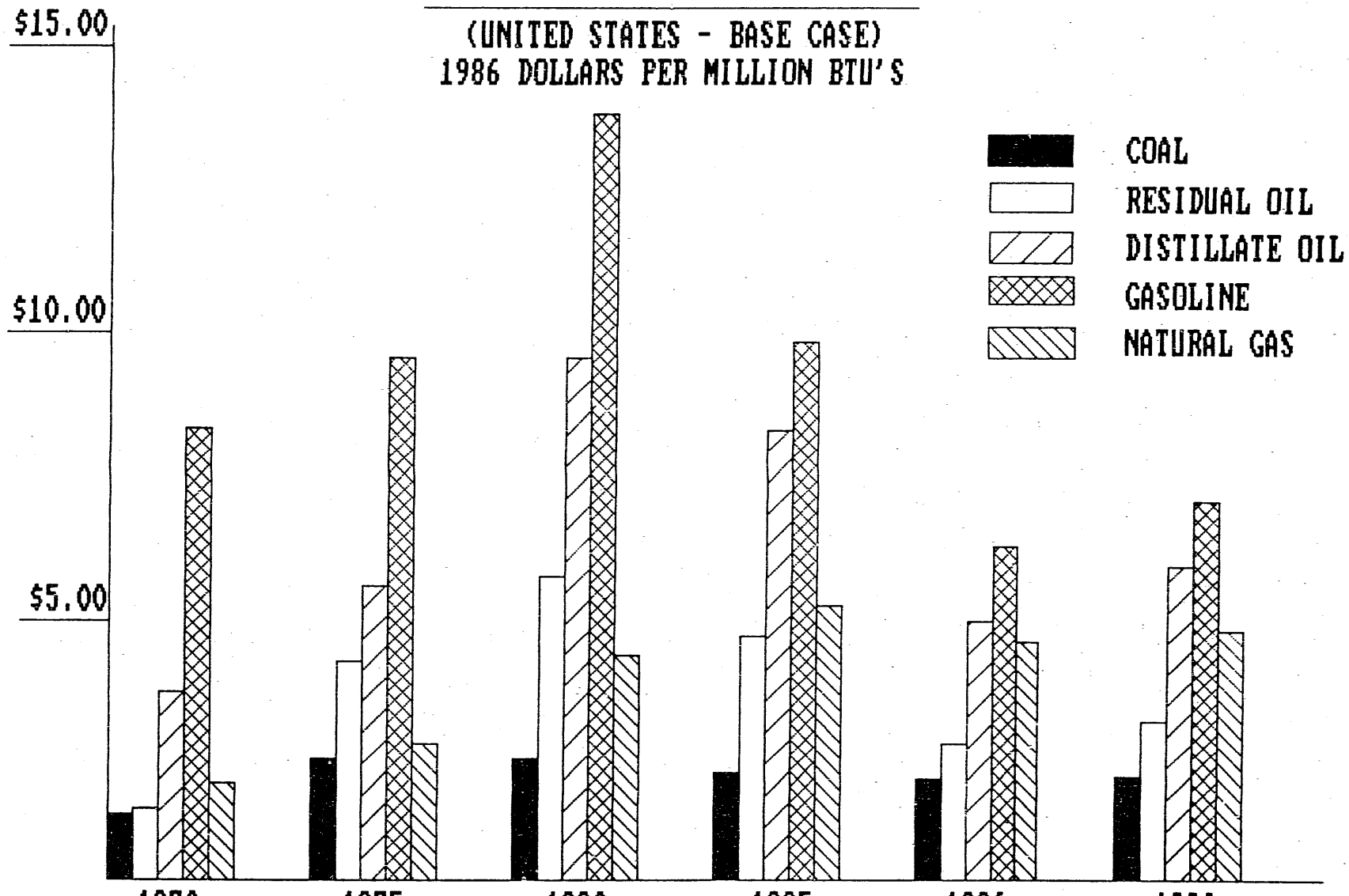


CHART 2
AVERAGE FUEL PRICE TO ALL USERS
(UNITED STATES - BASE CASE)
1986 DOLLARS PER MILLION BTU'S



SOURCE: DOE/EIA 0383 (86) 2/11/87

consumers to cut back drastically. Old and inefficient manufacturing plants became difficult to operate and still produce a profit, thus many were shut down and closed. Many workers were laid off and some jobs lost to the local communities forever. A new era of energy consciousness had arrived.

This sudden economic upheaval, created in part because of higher energy costs, brought forth an urgent need for cheaper fuels and more efficient ways of during business. At the outset, energy conservation was conceived as the first line of defense against rapidly rising energy costs. However, it was clear that conservation alone could not supply new energy needs for economic growth but that new production would be required also.

Toward this end, new and innovative ideas were sought which could meet the energy requirements of growth and progress. One concept considered, which is used widely in Europe, was the development and implementation of cogeneration and district heating systems. District heating, once common in the United States around the turn of the century, utilizes a central boiler to produce steam or hot water which is then pumped through miles of underground pipes to supply heat to a large number of buildings. The same system may, where needed, provide chilled water for cooling in the summer by using absorption chillers. Newer systems, known as cogeneration systems, also simultaneously produce electricity.

Why cogeneration and district heating? Let us now take a different look at data collected in the 1970's forecasting U.S. energy consumption.

(CHART NUMBER 3)

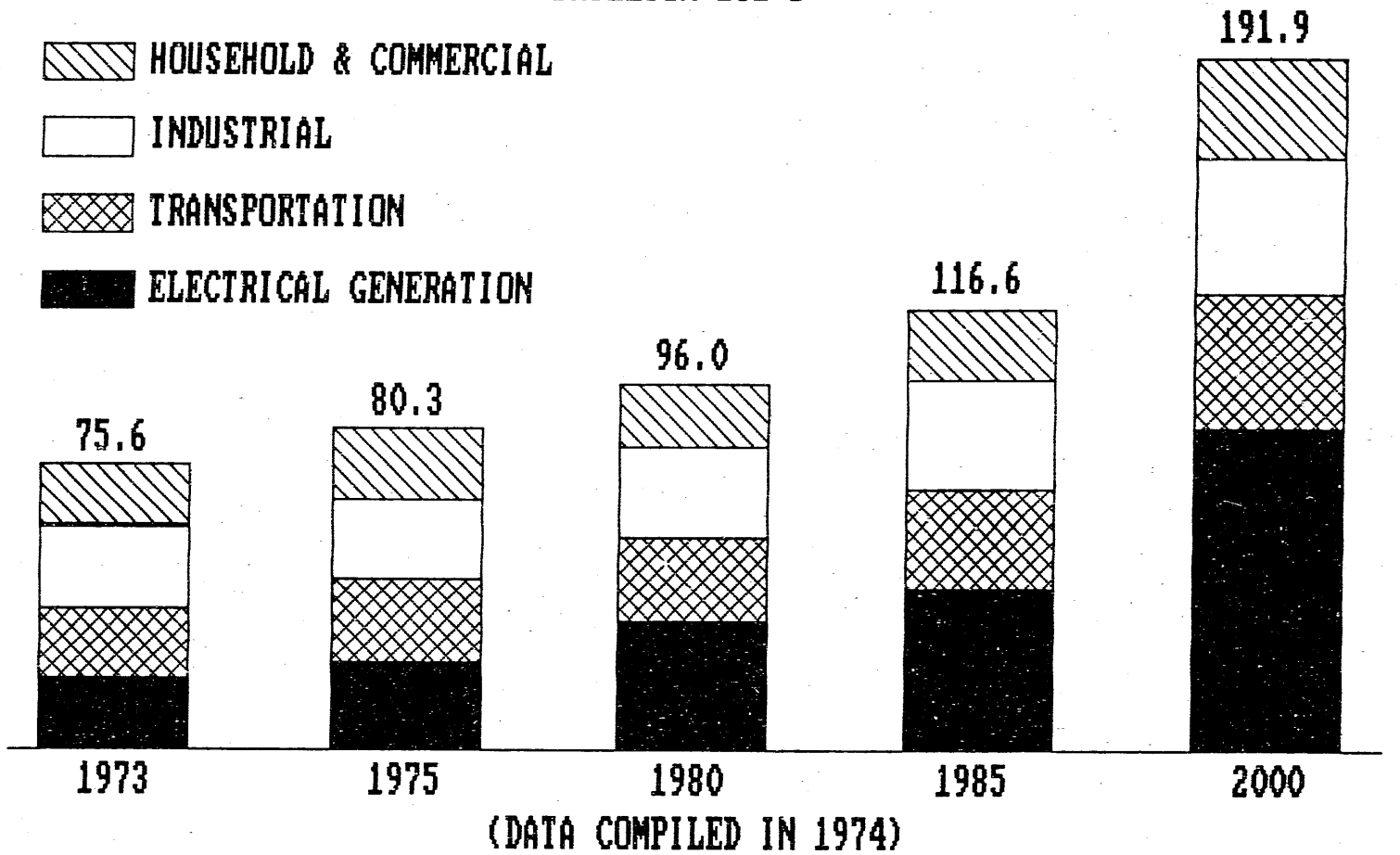
Chart number 3 suggests that the electrical generation sector was expected to grow at a much faster rate than all of the other sectors. At that time, the sector was growing at an annual rate of 7 - 10 percent per year. Additionally, because of thermodynamic limitations, only about 30 percent of the fuel value is converted into useful energy and the rest is wasted. Much of this "waste" energy could be used to provide heating and cooling for the residential and commercial sector, if the the user density is appropriate.

One of the first municipalities bold enough to take that initial step in the direction of an innovative state-of-the-art district heating system was Trenton, capital city of New Jersey. The Trenton facility is one of the first new district heating plants to be installed in fifty years. Conceived during the late 1970's, the project is aimed at reducing energy costs and revitalizing the downtown area of the city. The $40 million facility uses diesel generators to produce electricity which is sold to the local electric utility. Heat form the diesels is recovered and transported through nine miles of insulated piping to service 55 downtown buildings which included all state offices, the county courthouse, the state prison and many commercial users.

The system to date has saved the state government several millions of dollars. For example, an old boiler in the State House that needed major repairs was junked completely and eliminated. In three new state office buildings, boiler rooms were not even installed and the cost of operating older and inefficient boilers in other buildings was eliminated.

CHART 3

UNITED STATES ENERGY CONSUMPTION
BY SECTOR
1973 - 2000
QUADRILLION BTU's



(DATA COMPILED IN 1974)

The Trenton project, which was directed at cutting energy costs, has indeed succeeded and perhaps a little too well, The system has reduced the energy use in the 55 buildings to a degree far greater than had been anticipated and the expected revenue payments for energy are not covering the utility's development costs and investments. Based upon earlier utility forecasts, the energy savings were expected to be about 25 percent of normal consumption, however, the actual savings, due to unexpected higher efficiencies and less waste, turned out to be 50 percent or double the original projections.

This case history now brings us back to the topic of discussion "Relating Energy Consumption to Utility Forecasting and Economic Development". When the cost of fuel is low, as was the case pre-1975, there is little, if any, incentive to spend money for energy conservation and improved operating efficiencies. For three decades following World War II, utilities were forecasting annual energy growth rates of 7 - 10 percent, which tended to track the nation's growing GNP. Since the early 1980's, there has been little direct correlation between the consumption of total energy and economic development. Why? There is a lot more to energy efficiency and conservation than most people would have imagined and the population has learned to replace and substitute energy consumption where possible.

(CHART NUMBER 4)

The 1970 national energy consumption forecasts did not hold any significant reductions in use occurred. During 1985 the nation did not consume the 116 quads of energy as predicted, but used only 80 quads. Increased energy costs have forced major improvements in the transportation sector and accelerated innovations in the industrial sector to achieve even greater efficiencies which have reduced the growth rates appreciably.

However, from 1970 to 1983, the nation's Gross National Product (GNP), in constant (1972) dollars did increase by a factor of approximately 1.5 ($1086 billion to $1535 billion). Concurrently, the electric utilities total consumption of fuel to produce electricity also rose from 16.3 quads to 25.0 quads, also by a factor of 1.5.

(CHART NUMBER 5)

Thus it seems clear that while the nation's consumption of oil and gas has been largely "decoupled" from GNP, that the electric utility's fuel demand and energy consumption has continued to track or grow at the same pace as the nation's economy.

It would be improper to relate energy consumption to utility forecasting, but there seems to be a definite relationship between utility forecasting and economic development.

CHART 4
UNITED STATED TOTAL ENERGY CONSUMPTION
(QUADRILLION BRITISH THERMAL UNITS)
BASE CASE FORECASTS
1950 - 2000

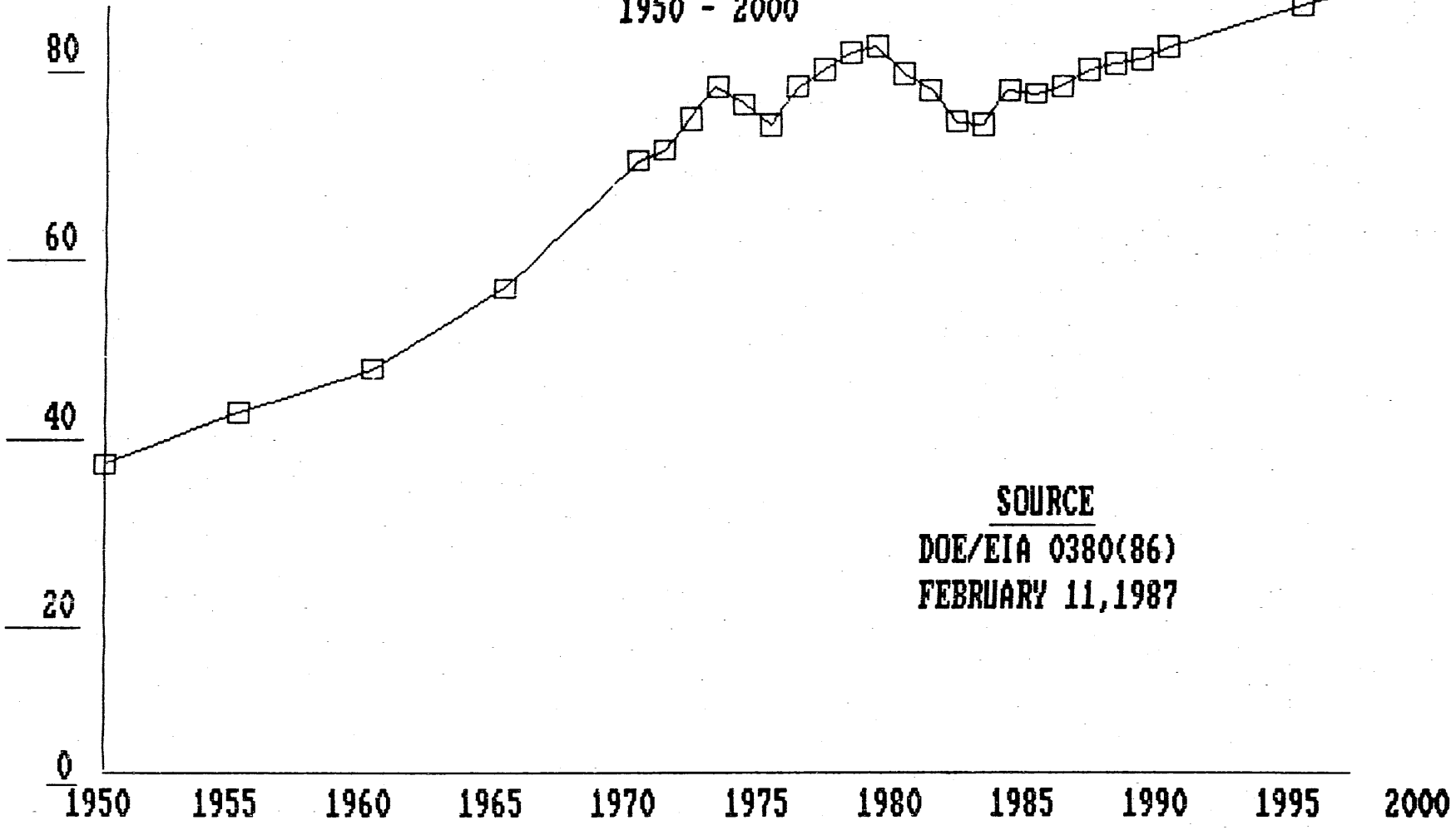
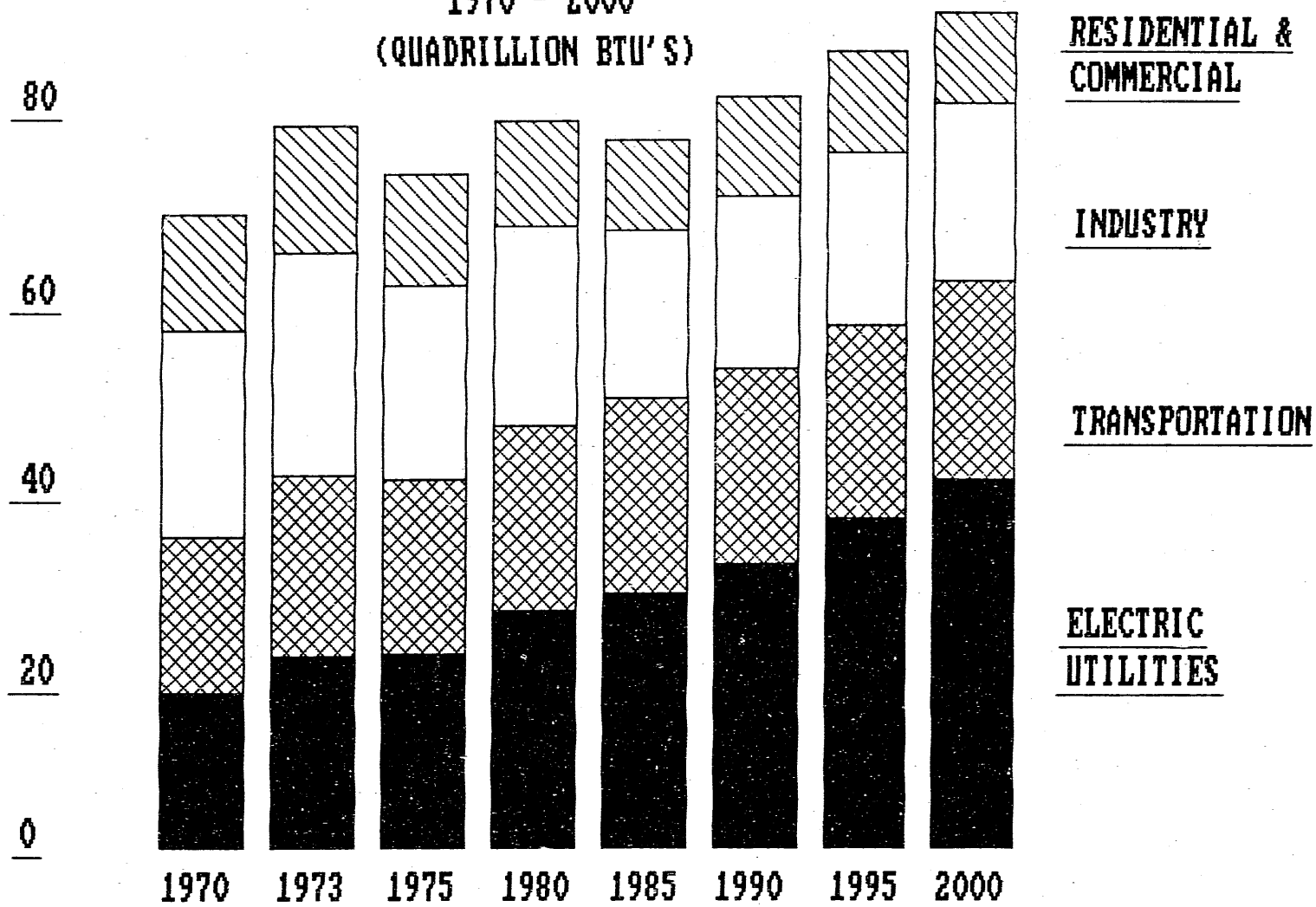


CHART 5

UNITED STATES PRIMARY ENERGY CONSUMPTION BY SECTOR

1970 - 2000

(QUADRILLION BTU'S)



SOURCE: DOE/EIA 0383 (86) 2/11/87

TRENDS IN ENERGY CONSUMPTION AND EXPENDITURES FOR LOW INCOME HOUSEHOLDS FROM 1973 TO 1985

JAMES McBRIDE, DAVID CARROLL, AND RENEE DONAHEY

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Princeton, New Jersey

The national and global events that have contributed to dramatic changes in energy supplies and energy prices over the last two decades are well documented. In the seventies, oil supply restrictions, oil and natural gas price deregulation, environmental restrictions on burning coal, and increasing problems in the development of nuclear power plants all contributed to higher energy costs. Subsequently, oil prices have fallen, due in part to declining demand, and have resulted in lower retail prices for gasoline and fuel oil, as well as reduced natural gas and electricity rates.

These price fluctuations have resulted in significant changes at the household level. Households responded to rising prices and supply problems by changing heating fuels, lowering indoor temperatures, buying smaller cars, investing in household conservation measures, and undertaking a host of other actions. Recently, prices for many types of energy have stabilized, and actually have fallen in some cases. It is less clear what impact this has had and will have on households. Have they continued to reduce consumption, or have they begun to shift back to an "energy consuming" mentality?

The purpose of this paper is to provide a context for the analysis of current residential energy consumption patterns by showing the way that patterns have changed in the past due to price and supply shifts. It examines trends in consumption and expenditures at the household level to quantify the changes that have taken place. Then it documents household energy use changes and reviews how energy use changes have translated into changes in consumption and expenditures. In all of the analyses, special attention is given to the differential impact for low income households, considering how these households compare with the rest of the population and assessing the relative hardship caused by expenditure trends.

The discussion of household consumption is separate from the discussion of consumption for transportation. One reason is that the data files available for analysis of transportation consumption do not match household consumption files in terms of time periods or households. The second reason is that consumption patterns are quite different for transportation than they are for household consumption.

For analysis of household consumption, we used public use data tapes from three residential energy consumption surveys that were evenly spaced over time, the 1972-73 Washington Center for Metropolitan Studies Liefstyles and Household Energy Consumption Survey (WCMS), the 1978-79 National Interim Energy Consumption Survey (NIECS), and the 1984-85 Residential Energy Consumption Survey (RECS). For analysis of residential transportation energy Consumption, we used published data on the WCMS Survey for 1972-73, published data on the DOE Household Transportation Panel for 1980, and the Residential Energy Consumption Transportation Survey (RTECS) public use data tape for 1985.

We wish to acknowledge the extent to which our work was influenced by the ideas and concepts developed in The American Energy Consumer (Newman and Day, 1975). This comprehensive analysis of energy consumption patterns in 1972-73 reported on the data gathered in the first WCMS survey. It served as a basis for much of our thinking about this subject.

SECTION I - HOUSEHOLD ENERGY CONSUMPTION AND EXPENDITURE PATTERNS

Both consumption and expenditures have shifted dramatically. Table 1.1 shows overall trends from 1972-73 to 1984-85 for four income groups. In addition to gross consumption and expenditure figures, it includes information on the percent change in consumption and expenditures from 1972-73 and on the percent of income that is spent on residential energy.

Consumption has fallen for all groups, though it has fallen by only half as much for the low income households as for the non-low income households. As a result, the difference in consumption between groups has become considerably smaller. In 1972-73 the highest income class used 77 percent more energy than the lowest income class, while in 1984-85 the figure was only 47 percent.

Expenditures, on the other hand, have risen both in nominal and real terms. For low income households, residential energy expenditures rose by 240 percent. For the other three income groups, increases were from 180 percent to 210 percent. Over the period 1973 to 1985, the consumer price index rose by only 142 percent. Over the same time period, mean family income rose by 141 percent.[1]

As noted earlier, prices have fallen for various fuels in the 1980's. For purposes of this review, we have merely discussed the change from 1978-79 to 1984-85. While prices, and therefore expenditures, rose during this time, it is possible that prices peaked in real terms some time

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[1] Source: Computed from Money Income and Poverty Status of Families and Persons in the United States: 1985, Current Population Reports, Series P-60, No. 154.

between these two time periods. Further, it is possible that consumption actually hit a minimum level some time in the eighties. These questions can only be answered by looking at additional data files.

Gross energy prices can be derived from expenditure and consumption means. Prices rose over 300 percent for all income groups. Surprisingly, energy prices rose the least for the low income group. Newman and Day (1975) found that in 1972-73 the low income group consistently paid more for electricity and utility gas. They suggested that declining block tariff pricing brought this about; low income households paid more per unit because they consumed less. From the 1984-85 data, it appears that this pattern no longer holds true, though it is unclear why the change has occurred.

The net effect of all these changes has been an increase in the percent of income spent on energy for all groups over the time period 1972-73 to 1984-85. Our estimates show that in 1984-85, households in the low income group spent an average of 14.9 percent of their income for residential energy, up from 11.0 percent in 1972-73.[2]

SECTION 2 - THE SOCIOECONOMIC IMPACT OF EXPENDITURE TRENDS

One of our principal interests in analyzing expenditures is to determine the extent to which the poor are spending a disproportionate share of their income for energy consumption. The summary Table 1.1 furnishes useful descriptions of the levels and patterns of consumption and expenditures over a nearly fifteen year span. This table summarizes the relative position of low income households compared with other income groups in unmistaksble terms: average percent of income for energy expenditures among the poor is 2.5 to 6 times that for other income groups.[3] This relationship among income groups has persisted over time, while the overall percentage of income for energy has itself risen by 30 to 40 percent over the 1972-1985 period, almost independently of income level.

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[2]It is important to note that our analysis does not include all household energy expenditures. We have excluded households using LPG as a main or supplemental heat from this analysis. In addition, we do not collect data on expenditures for a range of fuels including wood and coal.

[3]This is obviously an artifact of our decisions in defining the four income classes that we use. If the low income group were divided further into groups of less than 75 percent of the poverty line and 75-125 percent of the poverty line, percent of household income spent on home energy would probably be 2 times greater for the lowest income subgroup. It is nevertheless, a useful characterization of the overall tabulations.

Distribution of Percent of Income Spent on Energy

The percentages of income for energy expenditures that appear in Table 1.1 are no more than average expenditures for different income levels and use classes. There is no way to approximate the extent to which households have energy expenditures as a share of income that exceed some "acceptable threshold" from this table. Therefore, a more detailed analysis of the trend in share of income devoted to utilities is needed.

The obvious means for examining the variability in share of income for utility expenditures is to look at the actual distributions of percent of income for energy. We have produced distributions, by income class, and for a variety of use classes that parallel Table 1.1. (Figures 2.1-2.3). In most cases these distribution are skew symmetric, and common sense is sufficient to characterize large areas within the tails of these distributions as representing either "acceptable" or "unacceptable" expenditures as a share of income. Consider, for example, the distribution in Figure 2.1, corresponding to Table 1.1 for consumption of all fuels by low income households. Clearly income share in the 1-8 percent or 1-10 percent range represents acceptable expenditures, and in the range 25 percent, unacceptable expenditures.

As a next step, and in order to be able to make systematic comparisons across income levels and over time, we adopted the same percentage of income threshold levels that Wayne Hoffman used in 1979 to make calculations for households below the poverty line.[4] We use two threshold levels to define households "in need." Households whose energy expenditures as a share of income exceed the lower level are said to be in "moderate need"; and the higher level, in "extreme need". We define one set of threshold levels for heating fuel expenditures, and a second set for total home fuel expenditures.

The definitions are as follows:

Main Heating Fuel Expenditures

Extreme Need - expenditures at least 12 percent of income.
Moderate Need - expenditures at least 6 percent of income.

Total Home Energy Expenditures

Extreme Need - expenditures at least 25 percent of income.
Moderate Need - expenditures at least 14 percent of income.

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[4]Hoffman, W. (1979) "Energy Need Among Low Income Households: State Specific Estimates Using Several Alternative Measures." Washington, D.C, Urban Institute Working Paper 1197-5.

While these criteria are in some sense arbitrary, they are reasonable from two perspectives. First, in 1979, households spent about 3.5 percent of their income on main heating fuels and 7 percent on total home fuel expenditures. For a household to be in "extreme need" requires that it spend nearly four times the average share of income on heating fuels and three times the average share on all home energy.

Second, inspection of Table 2.1 shows that the threshold levels we have used are also reasonable by virtue of how they apportion the different income classes to the defined need classes. Extreme need households are, almost without exception, low income households. Moderate need households are almost without exception, low income and lower middle income households; and the lower middle income class is increasingly represented within moderate need households as we move from 1972 to 1985.

Table 2.1 is an important one. Classification by needs level is shown for total fuel expenditures, and for the households that use utility gas as a main heating fuel (Figures 2.1 and 2.2). We also restricted the classification for total fuel expenditures to elderly headed households; but as the figures show, no meaningful distinction is apparent between elderly and non-elderly headed households for any income level (Figure 2.3). This table shows clearly how the poor (and the lower middle income class) have been increasingly disadvantaged by rising energy prices over the past fifteen years. Extreme need households have doubled, and the percentage of low income households in extreme need now varies between 20 and 40 percent, depending upon the user class. Low income households in moderate need have increased by 50 percent since 1972, and now include between 60 and 75 percent of all low income households (again varying by user class). There has also been & "leakage" of moderate need households into the lower middle income class. Very few lower middle income households were classified as in moderate need in 1972; but 10 to 20 percent of that income group is now so classified. Clearly, that fraction of the total population for which rising energy prices represent a genuine burden has increased.

As discussed in Appendix A, there are several cautions that should be expressed in connection with the tabulations and interpretations just described. The three sets of survey data used were not weather adjusted to a normalized degree day standard, the income class definitions used were close, but not in perfect agreement between surveys, and the NIECS and RECS data used imputed data for both consumption and income. Although there may be some bias in estimating changes over time as we have, our belief is that any bias is small and that the percentage levels for extreme and moderate need households are generally correct given our choice of threshold values. In fact, for the three user classes that appear in Table 2.1, any bias in estimating changes over time for 1972-73 versus 1984.85 are likely to be in a the direction of underestimating the percentages of those in need for 1984-85. The low income class for the RECS 1984-85 period includes the poorest 22.5 percent of the sample, whereas the WCMS low income class includes only the poorest 17.5 percent of its sample. Thus WCMS likely has a poorer low income class than RECS, and any RECS estimates of need are likely underestimated.

Impact of Federal Energy Assistance Programs

It is important to note that the Low Income Home Energy Assistance Program provides assistance to a substantial number of low income households. In FY 1985, the program provided heating and cooling assistance to approximately 6.8 million households. The average benefit was about 240 dollars.

Our low income group includes households that are below 125 percent of the poverty line. LIHEAP benefits are available to households up to 150 percent of the poverty line or 60 percent of state median income. CPS data shows that about 85 percent of LIHEAP recipients had incomes below 125 percent of the poverty line. Thus, LIHEAP serves about 30 percent of those households that we classify as low income.

Using these totals, we can estimate that, for all low income households, the average percent of income spent on energy, net of LIHEAP benefits, is reduced to approximately 13.6 percent.

SECTION 3 - FUEL SPECIFIC DIFFERENCES IN TRENDS

Aggregate consumption and expenditure figures are useful, since they show the net effect of changes that have taken place. However, by looking more carefully at separate fuels and separate uses of fuels, we can get a better indication of the contribution of a number of different changes to the net change.

We start by looking at the three main fuels, electricity, utility gas, and fuel oil. Table 3.1 shows the mean consumption and expenditures of each fuel by those households that use the fuel. The change in consumption varies substantially by fuel type. Consumption of fuel oil changed most dramatically, falling by an average of approximately 55 percent per household. Utility gas consumption fell by an average of 33 percent and electricity consumption fell by only about 3 percent. In all cases, consumption for the low income group fell by a smaller amount than for the other three groups, and consumption of electricity actually rose.

These patterns suggest that somewhat different factors are contributing to changes in consumption for each of the three fuels. There appears to be a decrease in the incidence of use of fuel oil and utility gas, however a decline in the number of households using a fuel should have no effect on the average consumption by those using the fuel. Rather, we have found that this pattern of change is due primarily to changes in the incidence of major end uses for each fuel, as well as differences in the way consumption has changed for these end uses.

Below, we consider each end use, and the factors that are likely to bring about increases or decreases in the consumption of the fuel. There are two kinds of changes that take place. First, improved efficiency in the use of fuels for an end use has resulted in downward pressure on consumption means. At the same time, increased utilization of fuels for particular end uses, has resulted in upward pressure on consumption means. Finally, major shifts in end uses from one fuel to another cause downward pressure on one fuel and upward pressure on

the other. Our review of efficiency and utilization changes helps to show why the fuel specific trends we have seen took place.

SECTION 4 - SPACE HEATING AND WATER HEATING CONSUMPTION TRENDS

Much of the focus on conservation over the last decade has been on reducing consumption of energy for space heating. As the single largest component of the energy consumption budget for most households, it is the most easily addressed in a comprehensive way. Further, we will show that it appears that this focus has resulted in reduced space heating consumption.

In many instances, households use the same fuel for water heating as they do for space heating. As a result, it is difficult in this analysis to separate out changes in consumption for this end use. We review statistics on main water fuels and though we can discern little in the way of significant changes, we believe it is likely that some portion of the changes in consumption attributed to space heating through our aggregate analysis are most likely due to increased water heating efficiency.

Consumption Levels of Main Heating Fuels

For each fuel, Table 4.1 shows the mean consumption per household for those households that use the fuel as a main heating fuel. In all cases, Consumption fell dramatically from 1972-73 to 1984-85. Moreover, unlike the pattern in Table 3.1 above, the percentage reduction in consumption was much closer for the three fuels. Consumption reductions were 30 to 35 percent for electricity and utility gas, and closer to 40 percent for fuel oil. Again, the low income households had the smallest reductions in most cases, but the discrepancy for electricity was far smaller than we saw above.

A few important findings are suggested by comparing table 4.1 to table 3.1. First, the smaller fall in consumption of electricity in table 3.1 is probably not caused by failure to improve the efficiency of electric space heating. Rather, if we look at the percent of households space heating with electricity, we see that it almost doubled from 1972-73 to 1984-85. Since almost all households use electricity, adding this end use would have an impact on the average consumption per household using electricity.

Second, while the percentage of households using fuel oil has not fallen substantially, the percentage using it as a main heating fuel has declined by about 33 percent. In 1972-73, over 90 percent of all households using fuel oil, used it as the main heat. In 1984-85, the number was closer to 70 percent. Two factors are likely to have contributed to this. A large number of fuel oil households currently use a wood stove or portable kerosene heater as the main heating source and keep the fuel oil system as a backup. In addition, kerosene usage is included in the fuel oil figures and a substantial number of households now use kerosene for supplemental heat. Both of these factors would result in reduced average consumption and may account for a large part of the differential in consumption reduction over households that heat with natural gas.

The combination of these factors with findings relating to appliance utilization and space cooling incidence, go a long way toward explaining the discrepancies noted in the analysis of aggregate tables.

Impact of Heating Degree Days on the Reduction in Space Heating Consumption

The single most important factor in space heating consumption is the number of heating degree days experienced by the household. Before looking at the other factors that could contribute to a reduction in consumption, it is important to examine degree day changes. If there were significantly more degree days in 1984-85 than in 1972-73, then our 1984-85 consumption figures would be overstated, meaning that we would understate the effect of conservation and overstate the percent of income spent on household energy consumption.

The direction of change in average degree days varies by main heating fuel (Table 4.1). For electric main heaters, heating degree days averages were substantially lower in 1984-85 than they were in 1972-73 for all groups except the low income. Given the large shift into electric space heating, it is not surprising to see such a large change would take place. For example, it is possible that the households shifting into electric main heat live in warmer areas than the households that heated with electricity in 1972-73. The fact there was not a change in average heating degree days for low income households suggests one more reason why consumption of electricity by low income households has not fallen by as much as consumption for other groups.

For utility gas main heaters, the changes are much smaller with the exception of a sizable decrease in degree days for the high income group. Degree days for fuel oil main heaters uniformly rose, with a sizable increase for upper middle income households. In all cases, degree day changes are less than 10 percent and given the mixture of increases and decreases, we expect that the net effect on our mean total consumption and percent of income figures is small.

The National Oceanic and Atmospheric Administration (NOAA) reports population weighted totals for average degree days. On average, the 1972-73 season was the 23rd coldest, the 1978-79 was the 3rd coldest, and the 1984-85 season was the 34th coldest.[5] While these rankings do not always translate directly into demand for space heating, they do serve as a further indication that the 1984-85 period was one in which there is likely to have been the lowest demand.

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[5] State, Regional, and National Monthly and Seasonal Heating Degree Days - Weighted by Population (1980 Census), June 1931 to June 1985, National Oceanic and Atmospheric Administration, Historical Climatology Series 5-1, Asheville, N.C., November, 1985

Water Heating Fuel Changes

Water heating patterns are much less clear. Again, this is partly due to the fact that water and space heating fuels overlap. However, it is also due to the fact that the statistics generated from the survey data on water heating are so erratic that we doubt their validity.

In WCMS, about 6 percent of households indicated that they did not know their water heating fuel, including 12 percent of the low income group. One data collection procedure used in the RECS data gathering effort is a rental agent survey. This assists in the collection of information on main heating and water fuel for households in large apartment buildings.

The erratic movement of percentages over time suggests that lack of knowledge, rather than real changes, has resulted in the movement shown, especially given the stability of the aggregate totals.

SECTION 5 - APPLIANCE AND SPACE COOLING CONSUMPTION TRENDS

As noted above, fuel consumption has generally dropped in the decade since the WCMS study was conducted. One remarkable exception is that overall consumption of electricity has increased by almost 20 percent for low income households since 1973 (Table 3.1). This is in spite of the fact that low income households using electricity as their main space heating fuel have decreased consumption by over 30 percent. The incidence of electricity as a main heating fuel has doubled for low income households. However, since electric space heating has doubled in all income groups, the rise in incidence cannot entirely explain the rise in consumption.

Changes in consumption can be more clearly understood by excluding households that use electricity as their main heating fuel. Average annual mmBTU consumption of electricity for low income households that do not use electricity as their main heating fuel can be easily derived from Tables 3.1 and 4.1. For this group of households, consumption rose from about 45 mmBTU's in 1973 to 60 mmBTU's in 1985, or over 30 percent. Since the prevalence of electric water heating has not changed significantly for these households and the number of persons in these households has remained relatively constant, water heat cannot be assumed to be a contributor to the rise in consumption.

The dramatic rise in electricity consumption is probably due to increases in the incidence of appliances and space cooling. Although many poor households had refrigerators, washers, and televisions in 1973, they were less likely to have these appliances than were other income groups (Table 5.1). Further, they often had less modern versions. Black and white TV's, manual defrost refrigerators and freezers, and wringer washers use significantly less energy than their more advanced counterparts.

Low income households were three times more likely to own a frost-free refrigerator in 1985 than they were in 1973. Seventy-five percent of low income households had a color TV in 1985, whereas, less than 30 percent had one in 1973. Only 1 percent still have wringer

washers; 82 percent have automatic clothes washers. Although the incidence of appliances has risen for all income groups, the low income households have had the greatest gains. The major reason for their dramatic growth rate is that their baseline is so low.

From the above, one would expect a substantial change in appliance-related consumption for low income households and a smaller change for other households. Appliance indexes for electricity and utility gas were constructed to measure this change (Appendix B). An estimate of annual consumption in BTU's for each appliance was calculated. Estimates were adjusted for number of household members and other factors relating to consumption. Finally the estimates were summed across the appliance stock of each household. Note that the index used does not account for changes in the efficiency of appliances. Given expected gains in efficiency, the index probably rose slightly more than actual consumption.

Average values of the electric appliance index for each income group from each survey are presented in Table 5.2. The electric index for the three non-poor groups remained relatively stable. While these groups increased their appliance stock, the increase was not dramatic. Further, these groups all had fewer household members in 1985 than in 1973 (Table 6.1). As expected, the expanded appliance stock for low income households is reflected by a 27 percent increase in the electric index between 1973 and 1985.

Part of the change in the electric index may be due to changes in the use of utility gas appliances. The index for utility gas generally dropped reflecting a decrease in the average incidence of utility gas appliances. Since electric appliances can be substituted for utility gas appliances (though the reverse is not always true), part of the rise in the electric index may be attributed to the fall in the utility gas index.

Although the percent change in the electricity index for low income households is rather large, it does not explain the 30 percent rise in electricity consumption noted earlier. A final component is necessary; the incidence of space cooling. The number of low income households with air conditioning has almost doubled since 1973. This is true in both the warmest and coolest areas (Table 5.3). Low income households were more likely to have central air conditioners in 1985 than in 1973, with incidence rates of 18 percent and 5 percent respectively. In addition, 28 percent of low income households now have window air conditioning units as compared with only 18 percent in 1973. The incidence of air conditioning has increased for all income groups. Since air conditioning was more common among the other three groups in 1973, the increases for the non-low income groups were smaller than the increases for the low income group. Further, electric air conditioners consume a great deal of energy. It is not unreasonable that doubling their usage would cause a substantial rise in over-all consumption and may be one reason why consumption of electricity did not decline for non-poor income groups as much as their consumption of other fuels did.

SECTION 6 - UNDERSTANDING HOUSEHOLD ADJUSTMENT TO RISING ENERGY PRICES

Families react to rising energy bill in a variety of ways. They can improve the weatherization of their units, replace inefficient equipment, lower their thermostats, reduce their use of air conditioning, or take any of a number of other actions. Or, they may do nothing at all.

Our particular interest is in the energy situation of low income households and their response to rising energy prices. We have examined one dimension of this situation already. Low income households have little discretionary income, so faced with disproportionate increases in energy costs there is both a much stronger incentive to make adjustments and also a much greater likelihood of falling into the categories that we have termed "moderate" and "extreme need." What adjustments have the poor made; how successful were these adjustments -- both in obsolute terms and relative to those made by the more affluent? There are a number of demographic, behavioral, and weatherization comparisons across surveys that may help to explain how the poor have responded to rising energy prices in the last fifteen years.

Demographics

From 1973 to 1985, our data shows that the average household size has decreased by 15 to 20 percent for every group except the low income group (Table 6.1). Low income households have, in fact, increased in average size. For all but the low income households, there has been a very significant redistribution of household size. Among the more affluent income classes, 20 percent of all households included 5 or more persons in 1972; by 1985 only 10 percent were that large. Correspondingly, the fraction of single person households doubled for these groups, from 10 percent in 1972 to 20 percent in 1985. During this period, low income households experienced virtually no change in the distribution of household size--if anything, there was a slight displacement in the direction of larger household sizes.

Low income and lower middle households have continued to include a disproportionately high percentage of the elderly. The percentage of elderly headed low income households was reduced from 45 percent in 1972 to 32 percent in 1985. About 30 percent of low and lower middle income households are now elderly headed; less than 10 percent of the remaining income classes were, or are, elderly headed. The poor are also unique by having experienced a significant increase in the percentage of families with children at the same time all other income groups have seen a decline in this family type.

It is difficult to systematically study the effects of demographic shifts and changes of the sort just described on energy consumption. Even with high quality survey data such as RECS, some relationships are elusive because of the multicollinearity of the data. It is difficult, for example, even after developing elaborate end use models, to specify a precise relationship for something that should be straightforward likethe relationship between energy consumption for water heating and household size. Other factors in the household energy equation such as consumption for cooling are even less well understood. Despite these difficulties, it is still useful to speculate concerning the interplay between the demographic shifts noted above, and

the trends in consumption that we have described and that form the basis for our major tables (Tables 1.1, 3.1, and 4.1).

The average decline in household size for non-poor households over the period 1973 to 1985 was about 0.6 members. While current end use models incorporate demographic information imperfectly, there are a number of end use terms that appear to relate statistically to household size. Water heating and cooking, which account for about 20 percent of consumption, are prominent examples. Consumption for some other uses, such as refrigerators and TV's, probably relates to household size since it relates to frequency of use, though our models have not been able to statistically discern the relationship. Depending on the proportionality factor for household size, the 0.6 member decline is likely to result in a 12 to 20 percent reduction in energy consumed for these end uses, or a net reduction of 4 to 6 percent in total consumption for the non-poor household groups.

Weatherization

We have limited our focus in describing the extent to which units have been weatherized or undergone other conservation actions, and in assessing the changes in incidence of energy saving features over time. The data collected by the WCMS survey was significantly less detailed than in the two later surveys, and there is a less than perfect correspondence between the two later surveys. For this reason, our discussion focuses on the presence of several basic and easily measured features that make a structure's envelope more tight.

We review the following three measures: the presence of storm windows, storm doors, and ceiling or wall insulation. WCMS data provides detailed information with respect to windows, but simply records the presence of "some" storm doors and "some" insulation. We have restricted the tabulations of incidence to single family units, since data was only collected for single family units and mobile homes in NIECS and RECS, and we believe that WCMS significantly underrepresented mobile homes (Table 6.2).

Incidence is tabulated for these two combinations of the three measures:

All Measures - occurs when some of each one of the three weatherization measures exists; i.e., there must be some storm windows AND some storm doors AND some insulation.

No Measures - occurs when none of the three measures is present.

As one would expect, there is sharp variation in the extent of weatherization depending on the climate. This variation is so severe that we have furnished tabulations within four regions that were constructed on the basis of aggregate heating degree days for the appropriate survey year. What sort of adjustment have the poor made? The figures in Table 6.3 furnish the basis for a partial answer. The incidence of energy saving features along several dimensions is striking. For any income class and survey period, the incidence of weatherization features increases dramatically with severity of climate. Within any given climate area, incidence

increases dramatically with income, except that the upper middle and high income classes have identical incidence patterns.

In absolute terms, the adjustments by the poor have been substantial. An additional 25 percent of the low income single family housing stock in warm and cold regions was added to the group of units that incorporated all three weatherization measures during the period from 1973 to 1985. This was only slightly less in the very cold region (20 percent). In the warm regions, nearly 40 percent of the housing stock shifted out of the no measures group.

Relative to adjustments made by the more affluent classes, those made by the poor have been modest. The well off have made large absolute gains, starting at both low and high levels of weatherization incidence in 1973. These gains match those for the poor, even though their initial levels of weatherization are high.

NIECS and RECS collect detailed information on conservation investments that have no counterpart in the WCMS database. A set of tabulations taken from NIECS furnishes additional information on the type and extent of ongoing adjustments. It is important to remind ourselves that Table 6.3 discussed above, classifies buildings according to the presence or absence of weatherization features. The increased incidence in weatherization measures documented by this table is the end result of a variety of actions such as removal of less efficient units from the housing stock, dwelling switching by renters (roughly 30 percent of the poor single family households are renters), and owner initiated weatherization investments. We have no way of knowing what mix of these actions occurred.

Table 6.4 is concerned with this last named action. It shows the percentage of households, by income, that made various weatherization investments in 1977. Overall, 36 percent of all households made some weatherization improvement during that year, compared with only 24 percent of households in the lowest income class. There is not a great difference between income classes for inexpensive insulating improvements. But there is a large gap between the lowest and all remaining income classes for all other types of improvements. Comparable data from RECS show the same pattern. Again, available evidence suggests modest housing adjustments by low income households to energy price increases - but this time at a much reduced level relative to those actions undertaken by the more affluent.

Short-term Adjustments

Short term adjustments are primarily behavioral changes, such as closing off rooms in the winter, using a supplementary heating source in conjunction with the main heating source, and adjustment of day and/or night temperature.

The only one of these changes for which comparable data exists across the studies is temperature control (Table 6.5). For both day and night, and across income classes, there has been a reduction in the temperatures at which persons normally keep their homes during the past 15 years. There is clearly an income effect, however, on the magnitude of the reductions.

In 1973, the distributions for day temperatures were virtually identical across income classes. Since that time, all income levels have adjusted downward; but only one-third of the poor have moved to less than 70^0, and 55 percent of the upper middle and high income group have. Fifteen years ago, low income households had a unique distribution of night temperatures, concentrating much more heavily below 65^0. That distribution has remained constant over time, while the more affluent have doubled and tripled their fraction below 65^0

SECTION 7 - TRANSPORTATION ENERGY CONSUMPTION AND EXPENDITURE TRENDS

Trends in transportation energy consumption and expenditures show some surprising changes from 1973 to 1985. Between 1973 and 1980, average consumption increased for the two lower income groups, while it fell for the two higher income groups (Table 7.1). Between 1980 and 1985, consumption rose for all groups, though it did not reach 1973 levels for the two higher income groups.

Expenditures, on the other hand, rose dramatically for all groups between 1973 and 1980, and by a much smaller amount between 1980 and 1985. The net result was a dramatic increase in the percent of income spent on gasoline for all groups between 1973 and 1980, and then a decline between 1980 and 1985, though 1985 levels were still above 1973 levels by 50 percent for the highest income group and by almost 150 percent for the lowest income group.

The difference in consumption by income group is more substantial than for residential energy consumption, with high income households consuming twice as much gasoline as low income households in 1985. However, as with residential energy consumption, the gap between the high income and low income has narrowed, going from a ratio of 3 to 1 in 1973 to a ratio of 2 to 1 in 1985.

Of course, a significant factor in the these consumption and expenditure patterns is that gasoline prices rose to their highest levels in the early 1980's and have declined since. It is not surprising, then, that the high income households cut back on consumption by 1980 and then increased again in 1985. The increase in consumption by the low and lower middle income classes is more puzzling.

Table 7.2 gives some insight into the trends. Annual mileage increased for the low income group between 1973 and 1980, while it decreased for all other groups. At the same time, while average efficiency increased by over 15 percent for the high income group, it actually fell for the low income group. In 1973, low income households actually had the most efficient vehicles. Newman and Day concluded that this was because they tended to own older cars which were smaller and thus more energy efficient than new cars. By extension, one would expect that in 1980, most of the low income households now owned the inefficient cars that had been built in the early seventies. Thus, the combination of increased mileage and lower efficiency brought about the disproportionate increase in consumption and expenditures by low income households.

Between 1980 and 1985, all income groups both increased annual mileage and average efficiency of vehicles. Given falling prices, this change is not surprising. However, it is interesting to note that prices in 1985 were still higher in real terms than prices in 1973, yet average mileage rose substantially above 1973 levels.

At this point it would be useful to have information on why l income households have increased annual mileage and vehicle ownership, when these expenditures represent such a large part of annual income. Likely explanations include the movement of jobs and shopping from the center city to suburban locations, as well as the movement of low income households to areas not served by public transportation. However, our data files do not have information that would allow us to quantify these changes.

SECTION 8 - SUMMARY AND SUGGESTIONS FOR RESEARCH

The purpose of this analysis was to provide an overview of consumption and expenditure changes for households between 1973 and 1985, and to develop some information on what factors contributed to those changes. In particular, it focused on low income households and the disproportionate impact of price changes on these households.

Summary of Trends

For households, in general, residential energy consumption has fallen by 30 to 40 percent, while expenditures have risen by over 200 percent. As a result, the percent of income that is spent on residential consumption has risen by 30 to 40 percent.

From aggregate tables, it appears that a significant part of the fall in consumption was due to reductions in space heating consumption. Households in all income groups show substantial increases in weatherization measures and significant reductions in indoor temperatures.

Consumption appears to fall little or not at all for appliances and space cooling. This probably results because decreases in consumption due to efficiency were offset by increased incidence.

Consumption for transportation appears to have fallen very little. Despite efficiency improvements, price increases resulted in substantial increases in expenditures.

Trends for low income households were different from the general population in several respects. Consumption fell by only half as much as for other income groups. This was offset somewhat by the fact that prices did not rise as fast for low income households. The net effect was that low income households spent approximately 15 percent of their income on energy in 1984-85.

Space heating consumption decreases appear to be close to those for other income groups. However, while low income households have undertaken low-cost weatherization measures

and have lowered indoor temperatures, they have done so at a lower rate than other income groups. Moreover, there is evidence that they have lagged substantially in the installation of higher cost measures.

Appliance and space cooling consumption appears to actually have risen for low income households over the time period. This is probably due to the significant increases in incidence of appliances and space cooling for these households.

Transportation expenditures have increased more for low income households than for other groups, due to rising incidence and increased mileage, along with reduced vehicle efficiency.

Suggestions for Further Research

The tables here are an imprecise way of measuring trends. A more thorough analysis would develop end use models and actually compute consumption attributable to each end use. In addition, it is important to get a more precise assessment of how weather affects these trends. Overall, however, we feel that such an analysis would be likely to result in many of the some general findings.

What is more critical, we feel, is to develop information on the socioeconomic impact of these expenditure increases. Our estimates indicate that, on average, low income households are spending close to 30 percent of their income on household and transportation energy consumption expenditures. This immediately brings to mind a range of questions.

- What percent of these households pay these expenses directly, and what percent have them included in the rent?
- How do these percentages change when we look at even lower income households (e.g. less than 75% of the poverty line)?
- What types of expenditures are being squeezed out by the rising share of income spent on energy?

We also found that low income households are less likely to take actions to reduce space heating consumption, have increased appliance holdings and space cooling, and have increased transportation expenditures. Investigation of these issues would include:

- Analysis of the actions taken by low income homeowners vs. renters;
- Investigation of appliance acquisition decisions;
- Use of vehicles by low income households; and
- Analysis of low income weatherization programs.

Finally, it is likely that some number of households are responding to these increases by turning to federal programs or by failing to pay utility bills. Above we noted that the LIHEAP program reduces consumption by about 25 percent for those households that participate, reducing the average percent of income spent on energy by all low income households to about 14 percent. No comprehensive national data exists on problems associated with utility arrearages and utility disconnects.

APPENDIX A - DATA QUALITY ISSUES

Data Resources

For analysis of household consumption, we used public use data tapes from three residential energy consumption surveys that were evenly spaced over time. The Lifestyles and Household Energy Use surveys were funded by the Ford Foundation through the Washington Center for Metropolitan Studies and covered the time periods of 1972-73 and 1974-75. The National Interim Energy Consumption Survey (NIECS) and the Residential Energy Consumption Surveys (RECS) were funded by the U.S. Department of Energy, Energy Information Agency. NIECS covers the time period 1978-79 and the RECS series covers the time periods 1980-81, 1981-82, 1982-83, and 1984-85.

Each of these surveys used a national sample and collected detailed information on household energy use. In addition, all three collected actual fuel consumption and expenditure data from household energy suppliers, dramatically improving the quality of this data over self-reported information. This detailed information is necessary to examine how consumption and expenditure patterns have changed for different income groups.

We selected three data files for our analysis: the 1972-73 WCMS data, the 1978-79 NIECS data, and the 1984-85 RECS data. The 1972-73 file may be looked at as a baseline. While energy prices outpaced inflation in the early seventies, the most dramatic price changes took place starting in late 1973. The 1978-79 file actually covers a time period when price and supply shocks were taking place. Finally, the 1984-85 data is the most recent national energy consumption data available.

Not all of the information collected in the WCMS study was included on our data tape. Where information was missing, we made use of tabulations that were published in the American Energy Consumer, by Newman and Day (1975). In addition, this publication was an excellent resource for assisting us in thinking about how to describe energy use. We owe a substantial debt to the authors for their contribution to our research.

In addition, we made use of tabulations published in Energy Consumption and Structure of the U.S. Residential Sector: Changes Between 1970 and 1984, by Meyers (1986). This excellent overview of aggregate consumption changes assisted us in assessing the reasonableness of our findings.

For analysis of transportation consumption, we used public use data for 1985, and publications for 1980 and 1972-73. The WCMS study gathered data on use of vehicles. Newman and Day developed consumption estimates from this information. Our data file did not include this information, thus most of our information is taken directly from tables they developed for The American Energy Consumer. The Energy Information Agency of DOE conducted the Household Transportation Panel from June 1979 to December 1980. We used statistics published in the report Consumption Patterns of Household Vehicles, June 1979 to December

1980, for our 1980 figures. We used the public use data file from the 1985 Residential Transportation Energy Consumption Survey (RTECS) for our 1985 figures.

In developing comparisons among statistics for the three time periods, we looked carefully at data definitions. This process was made easier by the fact that there was a substantial overlap in the instruments for the three studies.

Sample Sizes and Estimated Sampling Errors

The WCMS survey had a smaller sample than the NIECS and RECS surveys. As a result, differences between this file and the other two are less likely to be statistically significant than between the two later surveys.

Table A.1 shows the unweighted and weighted sample counts for the three household data files by income group.

Each of these three studies was done with a different sample. While all three used area probability sampling procedures to develop a stratified and clustered sample, different optimization decisions were made for each. This means that each sample may be more efficient with respect to estimation of some variables and less efficient with respect to others.

For our purposes here, it is adequate to give average estimates of variances for each of our groups. Table A.1 shows approximations the standard error for survey percentages by income group and the standard errors for mean mmBTU consumption amounts. Most of the consumption trends are robust, despite the problems of comparing three different data files.

Table A.2 shows the weighted and unweighted sample counts for the transportation data files. It also shows the standard errors for mean mmBTU consumption amounts. The differences in consumption are not robust, but the resulting changes in expenditures due to rising prices are robust.

Non-Sampling Error

The survey instruments for the three surveys are similar to one another. However, there have been significant changes in data gathering and data preparation procedures over time. The following are some of the most significant factors:

- Fuel oil data was gathered using self-reports in WCMS, while actual billing information was gathered for NIECS and RECS.
- NIECS and RECS data files have imputed values for 100 percent of the variables we considered in the analysis. Missing information was excluded from WCMS tables.

- Consumption was imputed for all households in NIECS and RECS. WCMS consumption means are probably biased upwards, since data is more likely to be collected from households with higher consumption.
- Consumption figures are poor for households in large apartment buildings for all files. Rental agent and master meter surveys for RECS have improved this data somewhat, though it is still unclear how reliable imputation estimates are for these households.
- Data cleaning procedures are improved for NIECS and RECS because of experience with the data.
- Changes in weighting procedures have taken place, including changes that increased the weights of single person households.

Most of these changes have resulted in data that is less likely to have substantial non-sampling error. In some cases, then, it is possible that the tables show a change, but that the change was really in our ability to measure the particular statistic rather than in the statistic itself.

Comparing Sub-Groups Over Time

The most significant problem in this analysis is establishing precise subgroup definitions over time. Failing to do so would mean that changes for a particular income group over time may result from changes in the group's definition, rather than from actual changes in the group itself.

In developing income classifications, we focused on the low income group. Because the income questions included relatively broad ranges, we were unable to exactly match the percentage of the population in this group for the three time periods. Instead, we chose to have a consistent bias. The low income group includes 15 percent of the households in 1972-73, 18 percent in 1978-79, and 22 percent in 1984-85. This does not mean that the low income population has been growing since 1972. It means that the way we have defined low income households for our analysis has resulted in a growing percentage of households being classified as low income. For precise estimates of the number of low income households, a survey such as the CPS should be used.

Consumption rises with income and the percent of income spent on energy falls with income. Thus, the biases in our tables are that consumption for the low income group has probably fallen more than we have estimated and the percent of income spent on energy has probably risen more than we have estimated. We should point out, however, that consumption for the lower middle income group has actually fallen below consumption for the low income group. This means that it is unlikely that the consumption bias is very large.

APPENDIX B - APPLIANCE INDICES

The appliance indices were computed using equations from conditional demand models estimated on the 1980-81 RECS data tape. The conditional demand models were developed for imputation purposes, and not specifically designed for the purpose of developing an accurate appliance index. As such, there may be some biases in the indices used.

Electric Appliance Index

Annual mmBTU's	Appliance	Adjustment Factor
1.77	TV color	NA
0.50	TV B&W	NA
1.73	Cooking	NA
0.80	Washer	SQRT(# HH MEMS)
1.50	Dishwasher	SQRT(# HH MEMS)
1.83	Dryer	SQRT(# HH MEMS)
1.44	Lights	# HH MEMS
2.80	Frost Free Refrigerator	1+.04*SQRT(# CDD65)
1.37	Manual Def Refrigerator	1+.04*SQRT(# CDD65)
2.17	Frost Free Freezer	1+.04*SQRT(# CDD65)
1.47	Manual Def Freezer	1+.04*SQRT(# CDD65)

Utility Gas Appliance Index

Annual mmBTU's	Appliance	Adjustment Factor
5.30	Cooking	SQRT(# HH MEMS)
1.86	Gas Light	# Rooms
2.01	Dryer	SQRT(# HH MEMS)

Households are counted as only having one of each particular appliance. In addition, households are counted as only having one of the refrigerator type and one of the freezer types.

ENERGY AND EQUITY

ARTURO GANDARA

ENERGY AND EQUITY

Arturo Gandara

Energy Consultant
and Former California Energy Commissioner

Good afternoon. As the program indicates I will be making a few comments on energy and equity but before I begin let me express my congratulations to the Office of Minority Economic Impact for putting together this conference. I have had a long-standing interest in this research area and can fully appreciate the contribution that this conference will make to the field. You all know as well as I do that the research literature in this area is scattered among various disciplines and is difficult to gather. More difficult, however, is to gather together the various active researchers so that an interdisciplinary dialogue may be held that will provide appropriate peer scrutiny of past and current research efforts. The inevitable outcome of such a dialogue and interaction is the refinement of thinking and the generation of new research ideas. Because I believe that there is much to explore in this area, I hope that in future years one will be able to look back and refer to this conference as the First Annual Socioeconomic Energy Research and Analysis Conference.

I have spent the past twelve years of my professional life in the energy area. I spent six years conducting energy policy research and the following six in public service in the administration of energy policy. I, therefore, had the full spectrum of experience ranging from identifying a policy area ripe for research, developing a research design, collecting data, evaluating it, and deriving policy recommendations. Later, as a public official, I had the rare privilege and opportunity to begin where my research efforts left off. That is, upon receipt of others' policy recommendations, reviewing the research evidence, weighing the testimony, balancing the private interests, and rendering a decision that would, hopefully, advance the public interest.

Today I am going to talk about some thoughts regarding energy and equity that have come to me during the course of those twelve years. One might call them reflections on policy research and public policy decisionmaking. Since I am assuming that one of the objectives of your efforts is for your research to have some public impact perhaps such ruminations will be helpful to you.

But before I get ahead of myself let me define what I mean by equity. Equity is first and foremost concerned with fairness. To be equitable is to be fair. In the law it is often said that, "To receive equity one must do equity." That is to receive justice one must be just. Once one enters the arena of what is just and what is not, one has entered the realm of normative values that requires a vision of what ought to be. But not everybody has the same vision. Therefore,

there will be differences over what is just and equitable. Nonetheless, without expecting full and detailed agreement over what is fair one can say that equity connotes a basic sense of fairness. How do we begin to address the issue of equity in an area as broad as energy? What shall one be fair about? To whom shall one be fair?

Perhaps the most obvious place to start is with that equity that concerns this conference - class equity. It always sounds a bit strange and uncomfortable to refer to class in a democratic and equalitarian society but that really is what we are dealing with when we refer to the low-income, minority, and disadvantaged. To be sure not all minorities are low-income or disadvantaged nor will any particular low-income person remain low-income throughout his life but it is the case more often than not.

As we all know the price shocks of the '70s resulted in higher energy prices for everyone. For the lower-income this was yet another problem in an already difficult life. Although their energy consumption was low compared to their more affluent fellow citizens we knew that as a percentage of their disposable income their burden was greater and worsening with the energy price increases. The response to this situation was an add-on to the typical financial assistance programs for the low-income, that is an energy assistance program that provided funds to pay for higher energy bills.

As with other low-income assistance programs we are generally not content with income supplements as a way of life so a second order response is to offer programs that will result in some structural change in their lives...such as job training. The analogous counterpart in this instance was the low-income acceptable to merely institute an income transfer payment but that a permanent structural inroad had to be made on energy consumption thus lowering the need for financial assistance.

There were, of course, many variations on both strategies but I will not review those since for our purposes this is the type of response that does not pose many problems from an equity point of view. It operates basically on a deficit model; that is, a targeted group is experiencing a deficit and a compensatory or remedial program is developed. The intent is to mitigate an immediate adverse affect. While there may be issues with respect to eligibility, how large the payment should be, the extent of services provided and so on, on the whole the concept is accepted as fair and appropriate, not unlike emergency relief.

Another characteristic of this class equity category is that the recipients are at the end of a long casual chain of events over which they have little control and rarely any input. They literally wait to be affected and similarly wait for relief. But more on this later.

In addition to class equity, the energy crisis also brought forth demands for technological equity. This was a call for fair treatment of what some perceived as underprivileged technologies, neglected technologies at best. The fossil-fuel industry, principally oil, had been the recipient of depletion allowances and investment tax credits. The nuclear industry had been a governmentally favored, subsidized, and promoted technology. Gas has been regulated such that its pricing promoted consumption. Electricity from utilities with central

generating facilities was likewise favored. It was now felt that the time had come to be technologically fair. This effort had two dimensions to it, however.

Some seekers of equity called for an end to technological bias. As the saying usually goes the call was for a level playing field. I have heard that so often from so many quarters that I have nearly come to the conclusion that nobody really wants a level playing field. Rather they want the bumps redistributed. But there were many sincere people who felt that if all technologies were allowed to compete, unsubsidized, that the result would be a more diverse and lesser cost energy system. Thus in addition to being technologically fair it would also be economically sound.

There were other seekers of technological equity, however, who preferred the deficit model discussed before and who felt that fairness demanded not only a reduction or end to the subsidization of some technologies but that a compensatory, remedial, subsidized effort directed at neglected or disadvantaged technologies should be undertaken. In otherwords, the bumps ought to be redistributed. This latter view prevailed and substantial program efforts and dollars were poured into alternative energy technologies, and renewable energy technologies. A preferred technology status was conferred.

In contrast to the general consensus with respect to class equity, that it was fair and just to render equitable relief, there was no such agreement on technological equity. The result was closer to technological war. Because of the momentum generated by the embargos, price shocks, and the implicit failure of the existing structure to protect against the adverse effects, formerly neglected and disadvantages technologies were given their opportunity. Existing energy institutions settled down to a long struggle and at opportune times made-counter-advances. These battles still continue.

There also emerged another type of equity concern that I shall call auto-equity. No, not auto as in automobile but auto as in referring to the self. In otherwords, self-equity. This was a view that we needed to be fair with ourselves and in doing so we would be fair to others. A related component was that others needed to be fair with us in return. In fact, they were in some instances obligated to do so. I place most of the non-remedial voluntary conservation in this category and definitely all the mandated energy conservation efforts.

In this view it was seen as unfair if one consumed energy in excess of that which was necessary to maintain the same level of comfort in heating, cooling, and light. Therefore, one would be fairer if such surplus consumption was eliminated. It was a short next step to demand equity from others if in fact such excess consumption was widespread. Thus came the development of appliance standards, residential building standards, and mandatory retrofit efforts. What could be more fair than a conservation standard which required compliance with a minimum threshold from everyone? If someone wished to conserve beyond that certainly that opportunity would still be there.

There were, and are, other equity concerns that intersect or incorporate the ones we have enumerated. These are not particular to energy but they were accentuated by the energy crisis and the manner in which it was addressed. One of these which had considerable prominence

was intergenerational equity, a concern over fairness to future generations. The energy crisis brought to the forefront the more general issue of resource depletion and responsibilities that this generation had as a trustee or guardian for future generations.

This equity concern reinforced the auto-equity and technology equity concerns because it added a long-term temporal dimension. With respect to auto-equity, although compliance with a minimum energy standard was good it would be better to minimize energy consumption. With respect to technological equity one should now internalize as many future costs as possible so that a true equitable balancing could be achieved. Thus nuclear power should internalize decommissioning and high-level nuclear waste disposal. Cogeneration, although preferred because of its efficiency, should internalize its resource depletion aspects. Obviously, intergenerational issues could be raised in just about every choice that was being made.

If this were not enough, we were also being asked to address concerns of international equity. Some countries were producer countries and some were consuming countries. Among the consuming countries were those that were more dependent on vulnerable sources of energy. To meet concerns of oil disruptions the International Energy Agency was formed. It created a complex method of allocating supply rights and obligations in case of an oil disruption and it coordinated vulnerability reduction efforts. There were other less well coordinated responses to these concerns of transnational energy equity. For example, energy choices of some countries were depositing acid rain in others. Nuclear fuel cycles varied with respect to basic fuel choices thus creating new dependencies while liberating these countries from other fuels considered more politically unstable.

Quite clearly, it was getting more difficult to balance the equities. It was also difficult to discern the issues much less compare the options. Within this discussion we have come a considerable distance from the class equity we started with. To what purpose? How does this taxonomy of equity concerns assist us in this conference? First, I hope that as important as the work to be presented here is, that we keep the words of Garrett Hardin in mind, "Data generation...serves both good and bad ends. Whenever we are in trouble we are apt to call in the computers to spew out rolls of computer sheets much as an octopus pours forth a cloud of ink to hide its panic. . . Thus do we act when we are troubled: we multiply data instead of looking for insights."

Second, I hope that this discussion of equity categories has reminded us that class equity concerns are at the end of the pipeline. As long as the low-income, minority, and disadvantaged (along with those who research this area) confine themselves to a deficit model and development of compensatory programs, the group will not break out of its policy recipient status.

Instead armed with the data and insight you all are generating this socioeconomic group should assert its interests in the other equity debates I have outlined. There is where the vital decisions are being made that will affect this group. You as researchers can assist in this advocacy.

There are many questions that need to be raised at appropriate times in order for this affected group to gain greater control over the energy dimension of their lives.

For example, let's take the area of international equity. The stated federal response to an oil disruption is to let prices rise until it hurts so much that people will diminish purchases of oil and petroleum products. Obviously, without doing anything else there will be disproportionately adverse effects on the low-income. Critics have demanded a recycling of revenues that would otherwise accrue rather rapidly to the federal treasury. This recycling should go back directly to the people who will be paying the high prices to avoid an adverse economic impact that will result in increased unemployment and a substantial demand on local and state social services. In otherwords while the policy may be an efficient allocator of a scarce commodity, the time lag involved in the recycling if not adequately planned will wreak severe consequences on those least able to bear it because they are low-income, lack good employment skills, and in general are more vulnerable.

Similarly, the clarification on the drawdown policies of the Strategic Petroleum Reserve has not been forthcoming. In fact there has been foot-dragging in the filling of the Reserve at a time when oil has been incredibly cheap. If the SPRO is to be effective it must be released early on in a disruption yet open questions still remain. The debates in this area get quite esoteric with considerations of national security, allied relations and so forth but the needs and desires of those that will take it on the chin the hardest need to be put forth more aggressively.

Before I leave you with an impression, however, that it is only government that has not fully heard the equity issues involved let me say that it has been a particular disappointment of mine that on occasion major organizations who serve as spokesman for their comm[illegible]ues have taken inadequately informed positions. One example will suffice from the category of intergenerational equity. Let me choose my own ethnic group, Hispanics, to make the point. In California one of the most controversial energy issues is off-shore oil drilling. Because one of our major concerns as a community is jobs, proponents of oil drilling expansion have appealed to this need by linking jobs to such expansion. Notwithstanding that in this capital intensive industry few jobs will be directly forthcoming to a community that has few skills in the area, a number of Hispanic organizations have endorsed such off-shore expansion in a belief that a general economic expansion will benefit the community and that off-shore drilling is necessary for that economic expansion.

Now, I am not necessarily against such oil-drilling expansion, in fact I am not saying where I stand on this issue since this is not a forum for that purpose, but it pains my analytical conscience to see these positions taken with less than an informed debate about the likely effect on the community. Nowhere in the debate was there a concern over intergenerational effects which for those of you familiar with the demographic changes in California, Hispanics should have a high degree of concern about.

In the auto-equity category I was in the midst of the appliance standards and residential building standards debate. If you can believe it the interest of the low-income community

was asserted in the former case by the appliance manufacturers and in the latter case by the building industries association. In both instances they asserted that the low-income community was more concerned about the lowest initial acquisition cost rather than the lowest life-cycle cost. Regrettably appliance standards were characterized as anti-consumer and anti-low-income. With respect to building standards, the characterization was that such action would eliminate affordable housing. In neither instance did anybody really know the consumer interest purchase behavior. Yet, indisputably, such standards do raise initial acquisition costs and I can tell you that from personal experience that in the absence of consumer information it was easier for the opponents of standards to place a claim on the representation of the low-income. But carefully omitted was the fact that over the ownership lifetime of the appliance or home much higher energy bills would result.

With respect to technological equity, the low-income likewise have a vital interest. Many of the preferred technologies were promoted not only by federal and state funds collected from general tax revenues but by tax credits. Cost-effective technologies such as solar and wind were accelerated by generous tax credits that were essentially cross-subsidies from non-participants to participants. The non-participants included not only households in the same income categories but across all income categories.

Similarly, the technology choices for electricity generation affected the low-income as ratepayers. While the variety of baseline rates differ, to the extent that tariffs reflect the true costs of technological choices any use of the utility system to experiment with various technologies has a cross-subsidy effect that differs little from tax credit subsidization, except that it will be accomplished through rate tariffs instead.

A more contemporary technological equity issue is the issue of an import tax on oil. In essence the falling price of oil has had a negative effect on the oil industry and the effect of an import tax would be to set a floor on the price of oil within the country. The other effect is that if oil is made more expensive consumers will purchase less. Other discussions of how to achieve the same effect include a tax of on the sale of petroleum products. This way government, state and local, will capture the economic rents rather than the domestic oil industry. In either case the final sale price to the consumer will go up and the effect is a regressive tax which places a greater burden on the low-income.

There are, of course, many other issues but my point is not to enumerate them. My point is in fact that to pursue equity for the category or class of people that this conference is principally concerned about we have to extend our interests and research beyond the narrower class equity problem. That is not to say that the difficult task of the more immediate problem is not appreciated or unnecessary. On the contrary it is an indispensable first step, I just urge you not to stop there. Let's take Garret Hardin's advice and armed with such data analysis look for insights as to how to affect the larger decision making spheres so that the interests of this under-represented or unrepresented class are asserted.

This year we celebrate the Bicentennial of the Constitution. It is appropriate to note that embodied in the Constitution is the philosophy of how governmental decisions will be made.

The Constitution rejected decisionmaking by divine right. That is it reflects the distrust of decisions from a proclaimed true source. Instead it opted for decisions to be made by representative debate. The Constitution expresses a faith that the public interest will emerge from a vigorous contestation of a constellation of interests. Our courts, legislatures, and administrative agencies use the same decisionmaking model. However, in order for the model to function correctly, that is for the true public interest to emerge, all interests must be represented and represented equally.

This conference is a vital part of establishing a foundation for such representation by increasing our understanding of an affected interest group. I urge you to keep in mind that if we desire change to be forthcoming from this increased understanding, we need to assert it beyond the end of the long causal chain that resulted in the problems we are discussing. Our increased understanding should lead us to preventative strategies in avoiding adverse effects as well as developing remedial programs for those adverse effects that cannot be avoided.

NATIONAL PATTERNS OF ENERGY DEMAND AND EXPENDITURES BY HISPANICS

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NATIONAL PATTERNS OF ENERGY DEMAND AND EXPENDITURES BY HISPANICS*

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INTRODUCTION

The paper is based on ongoing research, at Argonne National Laboratory, being done for the Office of Minority Economic Impact (MI) of the U.S. Department of Energy. Under its legislative mandate MI is required to assess the impact of government policy, programs, and actions on U.S. minorities. In line with this mission Argonne is currently involved in characterizing and analyzing the patterns of energy demand and expenditures of minorities. A major barrier associated with this task is the availability of sufficient data. With the possible exception of blacks, analysis of the patterns of energy demand for most minority population categories is all but impossible because of small sample sizes. The major source of residential energy consumption data, the Residential Energy Consumption Survey, only collects data on 5,000 to 7,000 households. For many minority population categories, this number of observations make any meaningful statistical analysis at least at the regional Census level practically impossible, with any further refinement of the analysis becoming even more difficult.

In this paper our primary purpose is to describe the patterns of energy demand for Hispanics and nonhispanics but ancillary to that briefly present one possible solution to the data availability problem.

METHODOLOGY

In order to expand the scope of our analysis of minority energy consumption, we have proposed the use of regression analysis techniques and data pooling. Very simply, the statistical efficiency associated with our estimates, with the use of more information, is improved. The standard

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errors associated with our statistical estimates of energy consumption and expenditures are lowered.

This analysis entails the pooling of three data files compiled by the Energy Information Administration (EIA) of the U.S. Department of Energy (EIA 1982, 1983, and 1985). The pooled data file provides us with a substantially larger data set for Hispanic households. In a previous study (Poyer and Wernette 1986) we were unable to make any meaningful statistical inference with respect to energy consumption by Hispanics in the Northcentral Census Region because of a lack of data, with only 24 data points being available in EIA's RECS1 data file (EIA 1982). In our pooled data set that number is increased to 82.

The issue which immediately emerges is how do we appropriately use our additional observations on Hispanic households. Because of variation in the sampling structure from year to year, the use of the sampling weights associated with each observation to derive statistical inferences about the population would be inappropriate. If however the structure of energy demand is relatively stable over the time period in which the data is pooled, regression analysis can be used to derive an instrumental estimate of energy demand and energy expenditures. The selection of instruments used to specify our regression equation is linked to their availability in a more extensive data file. In our case the Hispanic and nonhispanic population categories were characterized using the 1980 Annual Housing Survey (Bureau of the Census, 1983). In comparison to RECS1's 24 Hispanic observations in the Northcentral Census region, we were able to obtain 202 observations on Hispanic households. As a result we are able to obtain more efficient estimates of the instruments, which are to be used to estimate the energy demand and expenditures in 1980 for Hispanic and nonhispanics.

The estimated regression equation, obtained by using the pooled EIA data files, and the estimated values for our instruments, obtained by using the 1980 AHS data file, are used to estimate energy demand and expenditures for Hispanic and nonhispanics at the national and regional Census level. It might be mentioned parenthetically that with our regression approach the variances associated with our estimates can be determined thereby allowing us to determine a confidence bound around our estimate and to also test for differences in energy demand and expenditures for Hispanic and nonhispanic households.

In the next section we discuss in detail the relative patterns of energy demand and energy expenditures of Hispanic and nonhispanic households.

HISPANIC PATTERNS OF ENERGY DEMAND AND EXPENDITURE

Our ultimate objective is to be in a position where we can in a logically coherent way assess the relative impact of energy policy on the economic welfare of Hispanics. A prerequisite step in that direction requires an understanding of the size, and composition of energy relevant household characteristics of Hispanics. Consequently, this brief paper which describes the relative patterns of energy demand and expenditures, by Hispanics, serves as an important point of departure.

Hispanics are individuals identifying themselves on Census forms as of "Mexican, Mexican-American, or Chicano; Puerto Rican; Cuban; or other Spanish Origin. Persons in the other Spanish category include those from Spain, the Spanish-speaking countries of Central or South America, or persons identified generally as Spanish, Spanish-American, Hispano, Latino, etc" (Bureau of the Census, Sept. 1983 p. 2). Hispanic status is an ethnic status independent of race. Hispanics may be of any race. In the 1980 Census 58% of Hispanics classified themselves as white, 3% black, and 41% as "other" (Kasarda, 1984). In 1980 approximately 60% of all Hispanics were Mexican-Americans, 14% were Puerto Rican, 6% were Cuban, and 20% were "other" Hispanic (Bureau of the Census, 1982).

Despite differences in race and national origin, Hispanics do share some characteristics which make them more than just a statistical category. Most Hispanics (about 75%) report speaking Spanish in the home, and the vast majority (about 85%) are Roman Catholic (Jaffe et al, 1976). As a group Hispanics are also experiencing rapid growth in numbers, due to both high fertility rates and to immigration. At the national level as of 1980, there were 4.1 million Hispanic households in the United States (Bureau of the Census, 1983). Of this number 74% were located in the South and West census regions compared to only 52% of nonhispanic households. Hispanics typically have larger families about 3.3 versus 2.6 for nonhispanics. In general they are poorer with almost 30% falling below the 125% poverty line compared to 18% of the nonhispanic population. Furthermore Hispanics are less likely to live in single family homes, to own their homes, or to live in a home built after 1974. In regard to fuel and electricity use, Hispanics are somewhat more likely to use natural gas and less likely to use electricity for space heating. Finally at the national level Hispanics are much less likely to have air conditioning (Bureau of the Census, 1983).

Now with these preliminaries in hand we will precede with our discussion of energy demand and energy expenditures for Hispanic and nonhispanic households. We will first describe demand and expenditures at the national level and then at regional Census level.

NATIONAL ENERGY DEMAND AND EXPENDITURES

In Table 1 is shown the list of variables specified in the energy demand and expenditure regression equations. The same equations were specified for both Hispanic and nonhispanic households. It should be noted that our regression equation has been specified primarily for the purpose of describing the patterns of energy demand and expenditure for Hispanics and nonhispanics. Even though there is some clear analytic content, the regression equations referred to in the paper can at best be considered a reduced form equation which does not give the structural demand relationships. It is of course necessary to describe energy demand in terms of prices and income if the economic welfare implications of public policy are to be determined. This is not my intent in this paper.

Estimates for energy demand and expenditure at the national and regional level are determined using the same set of equations. Energy demand and expenditure equations were estimated separately for Hispanic and nonhispanic households. These equations were then used to

determine national and regional demand and expenditure estimates for Hispanic and nonhispanic households.

The coefficient estimates are shown in Table 2. The coefficient estimates for the Hispanic and nonhispanic demand equations are, with a few exceptions, remarkably similar. The estimates for all four of the heating load variables are almost identical. The most prominent exception, to the strong similarities in the estimates, is the coefficient estimate for the Northeast dummy variable which is twice as large for Hispanic households.

The difference in energy demand at the national level (see Table 3) is primarily explained by the regional distribution of the Hispanic and nonhispanic population categories. As mentioned earlier better than 70% of the Hispanic population is located in the South and West Census regions, compared to only a little more than 50% of nonhispanics. As a result energy demand to meet heating load requirements is much higher for nonhispanics. Also because of the higher incidence of air conditioning on the part of nonhispanics, their cooling load requirement is higher.

Other factors pulling down the average level of energy demand by Hispanics are poverty status, type of home, and home ownership. On the other hand factors pushing up the average level of energy demand by Hispanics are average family size, and housing stock vintage. Home ownership, single family home occupancy, and family size are positively related to energy demand, whereas poverty status and living in newer homes are negatively related (see Table 2).

On the expenditure side, in step with relative levels of demand, nonhispanics spend more for energy. The reasons for this are the same as those in the case of energy demand. Again the primary reason is the regional distribution of the Hispanic and nonhispanic population categories. At the regional level Hispanics, as at the national level, consume less energy and spend less on energy, with just one exception. Hispanics spend slightly more on energy in the Northeast. However, at the regional level when compared to the national level, the relative differences in demand for and expenditure on energy are in most cases smaller.

NORTHEAST CENSUS REGION

Of the four Census regions, the pattern of energy demand and expenditure for Hispanics, in the Northeast, gives rise to the greatest concern. A sizable proportion of the Hispanic population fall beneath the 125% poverty line (over 40%), live in multifamily homes (over 80%), and are renters (over 80%). Despite this Hispanics still consume nearly as much energy and spend more on it than do nonhispanics. Certainly the welfare implications associated with higher energy prices, and in particular fuel oil, would be severe. Only in the northeast do we find Hispanics either consuming more or spending more for energy.

NORTHCENTRAL CENSUS REGION

In the Northcentral Census region the marginal influences associated with type of living quarters, homeownership, and the incidence of fuel oil and electric heat play an important role in explaining the difference in energy demand and expenditure between Hispanics and nonhispanic households.

The level of energy demand and expenditure for Hispanics is pulled down because of a lower incidence of single family home occupancy, homeownership, and fuel oil and electric heat. The variation in expenditure is in large part explained by the last factor. The marginal difference associated with fuel oil heat constitutes more than thirty percent of the total difference in energy expenditures between Hispanics and nonhispanics.

SOUTH CENSUS REGION

In the South Census region, as in the Northcentral region, the marginal influences associated with homeownership, and the incidence of fuel oil heat explain a sizable portion of the overall difference in energy demand and expenditure. The reduction in the relative gap in energy demand and expenditures, by Hispanics and nonhispanics, in the South, when compared to those In the Northcentral, is explained by the comparatively equal use of electric heat in the South.

WEST CENSUS REGION

In the West Census region, the use of electric heat explains, in large part, the relative differences in energy demand and expenditures. Since, Hispanics use electricity for heat less frequently, the difference in energy expenditures is relatively larger than it would be if its frequency of use were more equal.

SUMMARY

In general Hispanics consume and spend less on energy than do nonhispanics. However, one must be cautious in inferring that energy is not as important in the Hispanic budget. Income and price are conspicuously absent in our discussion of energy demand. In order for inferences to be made with respect to the welfare implications of energy policy these variables must be explicitly taken into account. Given the overall poverty status of Hispanics when compared to nonhispanics, the proposition that energy is not as important in the Hispanic budget is at best problematic.

In fact the Hispanic pattern of energy demand and expenditure in the Northeast leaves open very little doubt as to their vulnerability to energy price changes. If not for the difference in the magnitude of the coefficient of the Northeast regional dummy variable, energy demand and expenditure would be substantially less in the Northeast Census region. Therefore a much higher level of demand and expenditure prevails, in the Northeast, than would otherwise be the case for Hispanics. It is our surmise that this fact would certainly be reflected in much

different price and income elasticities for Hispanic and nonhispanic households in the Northeast, with the income effect dominating in the case of Hispanics.

In the other three regions the variation ln energy demand is for the most part explained by demographic and household characteristic differences. Very often either a difference in the incidence of use of fuel oil and electric heat contribute a substantial amount to the overall difference. However, income related factors such as home ownership, and single family home occupancy also contribute to explaining some of the differences.

TABLE 1 Instruments Used To Estimate Energy Demand And Expenditures For Hispanic And Nonhispanic Households

Intercept term (INT)
Cooling degree days if air conditioning is used (CDD)
125% below the poverty line dummy variable (POOR)
Northeast Census region dummy variable (NE)
Northcentral Census region dummy variable (NC)
South Census region dummy variable (SO)
Homeowner dummy variable (OWN)
Family size (SIZE)
Family size squared (SIZE2)
Home built 1940 to 1974 dummy variable (AGE1)
Home built after 1974 dummy variable (AGE2)
Located in an urban area dummy variable (CITY)
Single family home dummy variable (HOME1)
Other than either a single or multifamily home dummy variable (HOME2)
Heating degree days: natural gas is used for space heating (HEAT1)
Heating degree days: LPG is used for space heating (HEAT1)
Heating degree days: fuel oil is used for space heating (HEAT3)
Heating degree days: electricity is used for space heating (HEAT4)

TABLE 2 Coefficient Estimates Of The Instruments For The Energy Demand And Expenditure Equations

	Hispanic		Nonhispanic	
Coefficient	Demand	Expenditure	Demand	Expenditure
INT	4.52	-12.53	2.54	-39.70
	(7.51)	(59.85)	(2.06)	(16.57)
CDD	0.006	0.135	0.008	0.133
	(0.002)	(0.017)	(0.0006)	(0.004)
POOR	-5.61	-57.08	-5.84	-75.54
	(3.42)	(27.26)	(1.08)	(8.66)
NE	31.42	725	14.79	451
	(5.38)	(42.85)	(1.29)	(10.38)
NC	8.98	155	7.95	167
	(5.33)	(42.43)	(1.16)	(9.35)
SO	5.05	152	5.55	175
	(3.85)	(30.65)	(1.11)	(8.94)
OWN	9.57	109	14.07	122
	(3.51)	(27.97)	(1.08)	(8.68)
SIZE	10.27	83.08	13.14	125
	(2.62)	(20.90)	(0.78)	(6.25)
SIZE2	-0.42	-3.20	-0.40	-3.46
	(0.28)	(2.24)	(0.10)	(0.80)
AGE1	-7.88	-16.89	-8.49	-9.37
	(3.50)	(27.91)	(0.91)	(7.33)
AGE2	-14.75	-53.40	-16.80	-44.08
	(5.45)	(43.38)	(1.37)	(11.04)
CITY	10.67	36.44	11.21	45.66
	(3.27)	(26.07)	(0.90)	(7.21)
HOME1	26.88	161	21.63	118
	(4.20)	(33.43)	(1.26)	(10.16)
HOME2	13.30	64.45	3.91	-11.38
	(6.23)	(49.65)	(1.64)	(13.23)
HEAT1	0.012	0.038	0.013	0.037
	(0.0008)	(0.006)	(0.0002)	(0.002)
HEAT2	0.011	0.109	0.009	0.08
	(0.002)	(0.015)	(0.0004)	(0.003)
HEAT3	0.012	0.082	0.012	0.10
	(0.001)	(0.009)	(0.0002)	(0.002)
HEAT4	0.0023	0.033	0.0027	0.034
	(0.001)	(0.008)	(0.0003)	(0.002)

Standard errors are reported in the parenthesis.

TABLE 3 1980 AHS Values Of The Instrumental Variables At The National Level

Variable	Hispanic	Nonhispanic
A/C System Present (%)	40.9	58.2
Below 125% Poverty (%)	29.7	18.3
Living in Northeast (%)	18.8	21.6
Living in Northcentral (%)	7.4	26.9
Living in South (%)	33.1	33.0
Homeowners (%)	42.4	66.9
Average Household Size[a]	3.3	2.6
Homes Built 1940-1974 (%)	58.7	58.1
Homes Built After 1974 (%)	8.7	11.8
Living in Urban Area (%)	91.3	77.2
Single Family Home (%)	52.0	65.3
Multifamily Housing (%)	42.0	26.0
Natural Gas Heat (%)	63.6	54.9
LPG Heat (%)	3.6	5.4
Fuel Oil Heat (%)	13.3	18.8
Electric Heat (%)	14.7	17.9

[a]For households with seven or greater members, the household size was assumed equal to seven.

Source: Bureau of the Census 1983.

TABLE 4 1980 AHS Values Of The Instrumental Variables In The Northeast Census Region

Variable	Hispanic	Nonhispanic
A/C System Present (%)	28.8	46.8
Below 125% Poverty (%)	41.9	16.7
Homeowners (%)	16.4	62.9
Average Household Size[a]	3.03	2.63
Homes Built 1940-1974 (%)	31.9	46.2
Homes Built After 1974 (%)	3.2	5.7
Living in Urban Area (%)	97.7	85.8
Single Family Home (%)	11.7	51.4
Multifamily Housing (%)	84.0	38.9
Natural Gas Heat (%)	34.5	40.6
LPG Heat (%)	0.2	0.7
Fuel Oil Heat (%)	62.3	49.7
Electric Heat (%)	2.7	6.8

[a]For households with seven or greater members, the household size was assumed equal to seven.

Source: Bureau of the Census 1983.

TABLE 5 1980 AHS Values Of The Instrumental Variables In The Northcentral Census Region

Variable	Hispanic	Nonhispanic
A/C System Present (%)	47.9	60.0
Below 125% Poverty (%)	28.3	19.3
Homeowners (%)	45.0	70.7
Average Household Size[a]	3.13	2.62
Homes Built 1940-1974 (%)	35.9	52.5
Homes Built After 1974 (%)	4.3	9.7
Living in Urban Area (%)	91.3	76.2
Single Family Home (%)	41.6	70.7
Multifamily Housing (%)	55.5	23.4
Natural Gas Heat (%)	86.5	70.2
LPG Heat (%)	2.9	6.4
Fuel Oil Heat (%)	5.1	12.1
Electric Heat (%)	4.6	9.9

[a]For households with seven or greater members, the household size was assumed equal to seven.

Source: Bureau of the Census 1983.

TABLE 6 1980 AHS Values Of The Instrumental Variables In The South Census Region

Variable	Hispanic	Nonhispanic
A/C System Present (%)	64.3	77.2
Below 125% Poverty (%)	29.3	20.6
Homeowners (%)	52.8	69.1
Average Household Size[a]	3.33	2.63
Homes Built 1940-1974 (%)	71.6	65.9
Homes Built After 1974 (%)	12.3	15.4
Living in Urban Area (%)	87.0	67.5
Single Family Home (%)	65.1	71.3
Multifamily Housing (%)	27.7	18.4
Natural Gas Heat (%)	56.6	45.8
LPG Heat (%)	6.3	9.2
Fuel Oil Heat (%)	2.1	12.1
Electric Heat (%)	28.8	29.0

[a]For households with seven or greater members, the household size was assumed equal to seven.

Source: Bureau of the Census 1983.

TABLE 7 1980 AHS Values Of The Instrumental Variables In The West Census Region

Variable	Hispanic	Nonhispanic
A/C System Present (%)	26.1	35.2
Below 125% Poverty (%)	24.6	14.6
Homeowners (%)	45.4	62.3
Average Household Size[a]	3.42	2.44
Homes Built 1940-1974 (%)	64.7	66.2
Homes Built After 1974 (%)	9.1	15.6
Living in Urban Area (%)	91.7	86.0
Single Family Home (%)	61.8	62.6
Multifamily Housing (%)	31.3	27.7
Natural Gas Heat (%)	78.5	65.3
LPG Heat (%)	3.2	2.8
Fuel Oil Heat (%)	1.2	4.6
Electric Heat (%)	10.6	22.8

[a]For households with seven or greater members, the household size was assumed equal to seven.

Source: Bureau of the Census 1983.

TABLE 8 1980 Energy Demand And Expenditure Estimates For Hispanic And Nonhispanic Households

	Hispanic		Nonhispanic	
Census Region	Demand (10^6 BTU)	Expenditures (Dollars)	Demand (10^6 BTU)	Expenditures (Dollars)
Northeast	142 (4.41)	1382 (35.15)	149 (1.38)	1339 (11.10)
Northcentral	138 (4.73)	817 (37.68)	147 (1.25)	977 (10.04)
South	91 (3.82)	838 (30.45)	104 (1.38)	947 (11.12)
West	101 (2.22)	573 (17.70)	104 (1.32)	617 (10.64)
National	107 (1.79)	809 (14.23)	123 (1.13)	958 (9.12)

Standard errors are reported in the parenthesis.

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RESIDENTIAL ENERGY CONSUMPTION AND EXPENDITURE PATTERNS OF BLACK AND NONBLACK HOUSEHOLDS IN THE UNITED STATES

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RESIDENTIAL ENERGY CONSUMPTION AND EXPENDITURE PATTERNS OF BLACK AND NONBLACK HOUSEHOLDS IN THE UNITED STATES

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ABSTRACT

Residential energy consumption and expenditures by black and nonblack households are presented by Census region and for the nation based on the Energy Information Administration's 1982-83 Residential Energy Consumption Survey (RECS). Black households were found to have significantly lower levels of electricity consumption at both the national and regional level. Natural gas is the dominant space heating fuel used by black households, Natural gas consumption was typically higher for black households. However, when considering natural gas consumption conditional on natural gas space heating no significant differences were found.

INTRODUCTION

This paper compares residential energy consumption and expenditure patterns of black households to those of nonblack households. Work reported here was performed for the U.S. Department of Energy's Office of Minority Economic Impact. This particular work was a part of a research program directed toward determining energy consumption and expenditure patterns of minority groups as opposed to other groups and identifying areas where energy policies would have adverse impacts on minority groups. The program has documented patterns of energy consumption and expenditure patterns of minority groups.[1-5] An analytical framework for measuring the impacts of energy prices and policies on these minority groups has been developed.[6-7] As such the analysis presented in this paper represents, in part, a continuance of research work conducted over the last four years. Furthermore, it represents the first time the Energy Information Administration's RECS-3 data has been used to comparatively assess the patterns of energy consumption and expenditure of black and nonblack households.[8]

PURPOSE

The purpose of this paper is to compare the patterns of energy consumption and expenditure by black and nonblack households at three levels. First, total consumption and expenditures are compared, Electricity, natural gas, and fuel oil consumption and expenditures are summed for this comparison, Second, consumption and expenditures by fuel-type are compared, The three major fuel types electricity, natural gas, and fuel oil are considered individually. Finally, because of space heating's relative importance, the consumption and expenditures of electricity, natural gas, and fuel oil are individually compared for households in which they are the primary space heating fuel.

APPROACH

The analysis presented in this paper is primarily expository in nature. Patterns of energy consumption and expenditures for black and nonblack households are presented in tabular form. Levels of consumption and expenditures are reported both at the regional (census) and national levels. Standard errors for mean consumption and expenditures are reported. Statistical tests were performed to determine significant differences between the mean consumption and expenditures on energy by blatk and nonblack households.

As mentioned earlier, the 1982-83 Residential Energy Consumption Survey (RECS3), the latest available survey, is used in the analysis presented here.[8] The survey includes 4660 randomly selected households that form a representative national sample. The survey was conducted in two steps; 1) household information and Fuel-type obtained through a home interview and 2) energy consumption and expenditure information obtained from the household's energy supplier(s).

In our analysis households are classified on the basis of the race of the head of household. All households whose heads are reported to have black racial origin, including those reporting black racial and Hispanic ethnic origin, are treated as black households. All other households are grouped as nonblack households.

TOTAL ENERGY CONSUMPTION AND EXPENDITURES PER HOUSEHOLD

Geographic Distribution of Households

Since wide variations exist in weather patterns between the census regions the annual energy consumption of a household is significantly affected by its location. As a result differences in geographic distribution of black and nonblack households play an important role in explaining differences in their overall pattern of energy consumption and expenditures.

Table 1 summarizes the distribution of black and nonblack households by census region. A majority (51%) of black households are located in the South region. Midwest (North Central) and Northeast regions each contain about 20% and the West region has less than 10% of all black households. In comparison only 31% of all of nonblack households are located in the

South. At the other extreme, a substantially greater portion of all nonblack households is in the West region. Besides geographic distribution other household characteristics also play a role in influencing patterns of energy consumption and expenditures of black and nonblack households, According to the 1980 census, 55.6% of all black households occupied rental units as compared to 33.2% of nonblack households. The distribution of housing stock by age is different for black and nonblack households. A small percentage (17.9%) of all black

TABLE 1 Geographic Distribution of Black and Nonblack Households(%)

Census Region	Black	Nonblack
Northeast	19.5	21.8
Midwest	20.2	26.4
South	51.0	31.2
West	9.3	20.6

households live in homes built after 1969, 54.5% live in homes built between 1940 and 1969, and 27.6% live in homes built before 1940. The comparative percentages for nonblack households are 26.4, 48.0, and 25.6 respectively. Therefore, blacks typically live in older homes. Closely related to the distribution of households between renter and owner occupied housing is the type of structure. In terms of single family versus multifamily housing, 54.7% of black households occupied single family units as compared to 74.8% of the nonblack households.[9] Finally, black households have lower median income. According to the current population reports the median 1982 income of black households was only 57% of that for white households and 59% of the median income of all households.[10]

Total Energy Consumption and Expenditure

Total energy consumption and expenditures are the overall averages of all residential energy consumed and paid for per household. Table 2 summarizes average energy consumption and expenditures by region and nation. As can be seen from the table the values are very similar. Energy consumption differences for the Midwest region and the South are marginally significant with statistics of 1.7 and 1.8 respectively. Typically black households consume slightly more energy but do not spend more on it. As we will see shortly this is primarily due to differences in the composition of fuel demand. Due to the disproportionate use of electricity for space heating and air conditioning, differences in efficiency at the point of end-use, and differences in pricing of various fuel-types, no significant differences are observed between black and nonblack households expenditures even though blacks consume slightly more energy.

In large measure the difference in the per unit cost of energy paid by black and nonblack households is explained by the difference in the composition of fuel demand. In all cases, the per unit cost of energy is lower for black households, where the average energy prices id

TABLE 2 Total Energy Consumption and Expenditures by Black and Nonblack Households[a]

Region	Black		Nonblack	
	Consumption (10^6 Btu/hh)	Expenditures ($/hh)	Consumption (10^6 Btu/hh)	Expenditures ($/hh)
Northeast	127 (7.9)[b]	1385 (85.9)	127 (3.8)	1412 (42.4)
Midwest	140 (8.7)	1089 (67.5)	124 (3.2)	1074 (27.9)
South	100 (4.3)	1020 (43.9)	91 (2.3)	1065 (26.6)
West	93 (7.6)	716 (58.7)	86 (2.6)	735 (22.1)
National	113 (3.7)	1077 (35.5)	107 (1.8)	1075 (18.3)

[a]During the period April, 1982 to March, 1983.
[b]Numbers in parenthesis represent standard errors.

paid by black households are 10.91, 7.78, 10.20, and 7.70 $/10^6$ Btu in the Northeast, Midwest, South, and West census region respectively. The corresponding prices for the nonblack households are 11.12, 8.66, 11.70, and 8.55. The national average energy prices paid are 9.53 for black households and 10.05 for nonblack households.

Energy Consumption and Expenditures by Fuel-type

Average energy consumption and expenditures are shown for each group by Fuel type in Tables 3-5. The three major Fuel-types or energy sources looked at in this paper -- electricity, natural gas and fuel oil account for over 90% of all household energy consumption. We will now consider each fuel separately.

Electricity: Average electricity consumption and expenditures for black andnonblack households are summarized by region and for the nation in Table 3. As can be seen black households use considerably less electricity than nonblack households. The differences in consumption and expenditures are statistically significant for each region and the nation. The

this overall analysis showed high natural gas energy consumption by black households and high electricity use by nonblack households. An analysis of energy use by the major residential end use category, space heating, will provide additional insight into the pattern of energy consumption and expenditures. In this section first the share of households by space heating fuel is presented followed by comparisons of consumption and expenditures for the primary space heating fuels. Therefore, the values reported in Tables 6-8 are conditional on the fuel being used for space heating. It should be noted however that the values include consumption for all end-uses and not only the space heating.

Space Heating Shares

Figure 1 shows space heating shares of households by Fuel-type for the two groups. The other category of fuel primarily includes liquid petroleum gas, and wood. With the exception of the Northeast region the percent of nonblack households using electricity for space heating is larger. The South region is the only other region to have a reportable share of black households who use electricity for space heating.

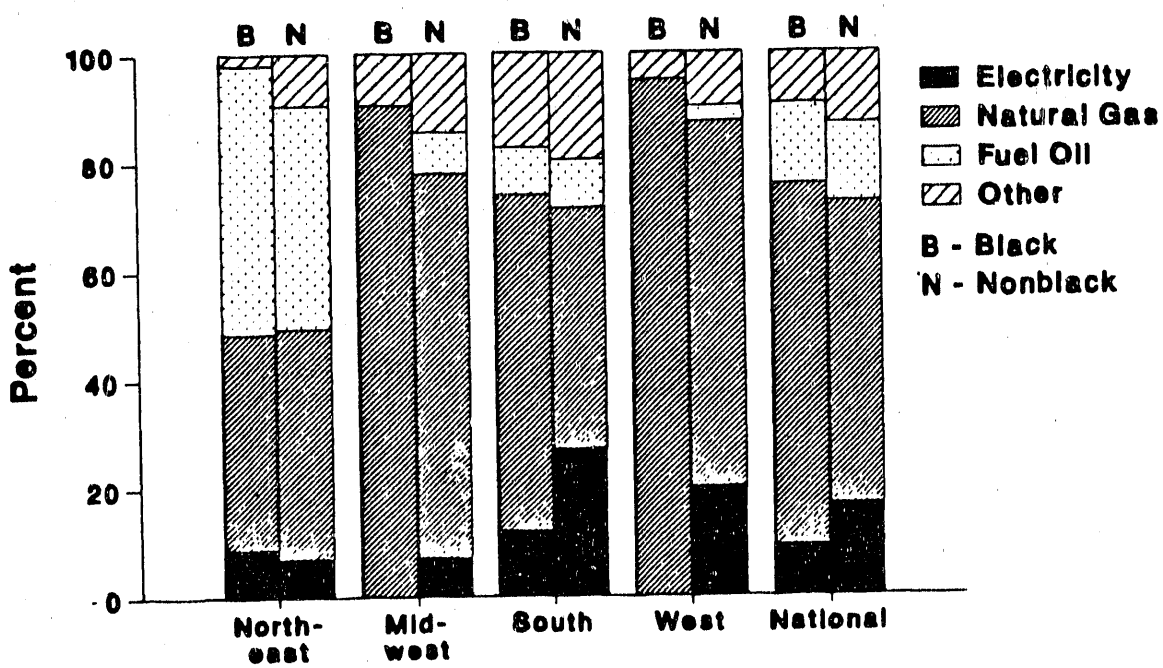


FIGURE 1 Household Shares by Space Heating Fuel-type for Black and Nonblack Households[a]

[a]Percent of Households During April, 1982 to March, 1983.

TABLE 4 Natural Gas Consumption and Expenditures by Black and Nonblack Households[a]

Region	Black		Nonblack	
	Consumption (10^6 Btu/hh)	Expenditures ($/hh)	Consumption (10^6 Btu/hh)	Expenditures ($/hh)
Northeast	59 (4.1)[b]	448 (30.9)	55 (1.6)	395 (11.8)
Midwest	115 (7.9)	606 (41.8)	79 (2.1)	412 (10.7)
South	55 (2.6)	321 (15.1)	37 (1.0)	204 (5.3)
West	75 (7.0)	370 (34.8)	54 (1.6)	262 (7.9)
National	70 (2.4)	407 (14.2)	55 (0.8)	312 (4.7)

[a]During the period April, 1982 to March, 1983.
[b]Numbers in parenthesis represent standard errors.

TABLE 5 Fuel Oil Consumption and Expenditures by Black and Nonblack Households[a]

Region	Black		Nonblack	
	Consumption (10^6 Btu/hh)	Expenditures ($/hh)	Consumption (10^6 Btu/hh)	Expenditures ($/hh)
Northeast	49 (3.4)	412 (28.8)	43 (1.0)	366 (8.1)
Midwest	-	-	7 (0.1)	61 (1.1)
South	6 (0.3)	53 (2.2)	6 (0.1)	50 (0.9)
West	-	-	2 (.04)	16 (0.4)
National	14 (0.4)	115 (3.1)	14 (0.2)	115 (2.1)

[a]During the period April, 1982 to March, 1983.
[b]Numbers in parenthesis represent standard error.

TABLE 6 Electricity Consumption and Expenditures by Black and Nonblack Households Reporting Use of Electricity for Space Heating[a]

Region	Black		Nonblack	
	Consumption (10^6 Btu/hh)	Expenditures ($/hh)	Consumption (10^6 Btu/hh)	Expenditures ($/hh)
Northeast	37 (6.6)[b]	777 (137)	49 (4.9)	1130 (112)
Midwest	-	-	65 (5.0)	1029 (79.2)
South	49 (5.9)	912 (108)	57 (3.1)	1013 (54.7)
West	-	-	48 (3.2)	655 (43.9)
National	48 (4.8)	866 (86.6)	55 (2.3)	939 (38.5)

[a]During the period April, 1982 to March, 1983.
[b]Numbers in parenthesis represent standard errors.

TABLE 7 Natural Gas Consumption and Expenditures by Black and Nonblack Households Reporting Use of Natural Gas for Space Heating[a]

Region	Black		Nonblack	
	Consumption (10^6 Btu/hh)	Expenditures ($/hh)	Consumption (10^6 Btu/hh)	Expenditures ($/hh)
Northeast	120 (12.4)[b]	842 (86.7)	115 (4.9)	807 (34.7)
Midwest	125 (8.6)	661 (45.6)	110 (3.5)	573 (18.3)
South	85 (4.9)	494 (28.7)	79 (2.8)	437 (15.3)
West	79 (7.4)	390 (36.7)	75 (2.6)	362 (12.7)
National	100 (4.3)	566 (24.3)	95 (1.8)	526 (10.0)

[a]During the period April, 1982 to March, 1983.
[b]Numbers in parenthesis represent standard errors.

As alluded to earlier, a large percent of black households use natural gas for space heating fuel. In the West, Midwest, South, and Northeast 95%, 90.6%, 61.8% and 39.5% of all black households use natural gas for space heating. At the national level 66.4% of all black households use natural gas for space heating compared to 55.5% for nonblack households.

Fuel oil is most commonly used for space heating in the Northeast region. Approximately 49.5% of all black households in the Northeast region use it for space heating whereas 41.1% of all nonblack households use it for space heating in that region.

TABLE 8 Fuel Oil Consumption and Expenditures by Black and Nonblack Household Reporting Fuel Oil Use for Space Heating[a]

	Black		Nonblack	
Region	Consumption (10^6 Btu/hh)	Expenditures ($/hh)	Consumption (10^6 Btu/hh)	Expenditures ($/hh)
Northeast	97 (10.3)[b]	819 (86.8)	101 (4.0)	852 (34.1)
Midwest	-	-	89 (7.4)	733 (60.8)
South	60 (10.3)	516 (87.7)	61 (4.3)	520 (36.4)
West	-	-	60 (10.9)	513 (93.4)
National	86 (7.2)	731 (60.7)	90 (2.4)	758 (20.5)

[a]During the period of April, 1982 to March, 1983.
[b]Numbers in parenthesis represent standard errors.

Energy Consumption and Expenditures Based on Space Heating Fuel

Electricity: Average electricity consumption and expenditures when it is used for space heating by the two groups are presented in Table 6. Once again, we reiterate that the consumption values include electricity consumed for all end-use categories. Average electricity expenditures in the Northeastern region differ significantly between the two groups. All other differences are statistically insignificant.

Natural Gas: Average energy consumption and expenditures by the households reporting natural gas as the primary space heating fuel are shown in Table 7. Compared to the significant differences observed in the analysis of natural gas consumption by all households (see Table 4), the differences here are insignificant with the exception of expenditures in the Midwest region. This implies that the overall difference in natural gas consumption is in part explained by differences in its use for space heating.

Fuel Oil: Average consumption and expenditures for households using fuel oil for space heating are tabulated in Table 8. The differences, in those regions where data were adequate, in the level of consumption and expenditures are statistically insignificant.

SUMMARY AND CONCLUSIONS

A description of residential energy consumption and expenditures by black and nonblack households is presented in this paper.

Our analysis offers the following conclusions:

- Total residential energy consumption and expenditures of black households at both the national and regional levels are not significantly different.
- Because of a lower incidence of use of electricity for space heating and air conditioning, electricity consumption and expenditures of black households are significantly lower both at the national and regional levels.
- When shares of households by various primary fuels for space heating are compared, black household show significantly higher incidence of use of natural gas for space heating.
- Natural gas consumption and expenditures when compared over all households are significantly higher for black households, primarily due to higher incidence of its use for space heating by blacks.
- When looking at natural gas consumption and expenditures conditional on its use for space heating, significant differences are only observed in the Midwest where both consumption and expenditures are higher for blacks.

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RESIDENTIAL ENERGY CONSUMPTION AND EXPENDITURE PATTERNS OF LOW-iNCOME HOUSEHOLDS IN THE U NITED STATES

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RESIDENTIAL ENERGY CONSUMPTION AND EXPENDITURE PATTERNS OF LOW-INCOME HOUSEHOLDS IN THE UNITED STATES

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ABSTRACT

The principal objective of this study is to compare poor and non-poor households to see whether the two groups are similar or different with respect to energy consumption and expenditures, housing characteristics, and energy-related behavior. We based our study on an analysis of a national data base created by the U.S. Department of Energy, the 1982-83 Residential Energy Consumption Survey (RECS). RECS includes detailed information on individual households: demographic characteristics, energy-related features of the structure, heating equipment and appliances, recent conservation actions taken by the household, and fuel consumption and costs for April 1982 - March 1983. We found a number of statistically significant (as the 0.05 level) differences between the two income groups in terms of demographics, heating/cooling/water heating systems, appliance saturation, the thermal integrity of their home, energy conservation behavior, energy consumption, energy expenditures, and the percentage of income spent on energy costs. These differences suggest different approaches that might be taken for targeting energy conservation programs to low-income households. Sine the poor spend about 25% of their income on energy expenditures, compared to 7% for the non-poor, informational, technical, and financial assistance to low-income households remains an urgent, national priority.

INTRODUCTION

The energy needs of low-income households have been the focus of several state and federal government and utility programs since the early 1970s, when the cost of energy increased dramatically for all income groups and when scarcities and occasional shortages of fuels occurred. During the mid-1980s, however, these financial, informational, and technical programs have plateaued or decreased in their level of effort, partially due to state and federal

budget constraints and also to the stabilization of the price of oil. For example, funding levels for the U.S. Department of Energy's (DOE) Weatherization Assistance Program (WAP), one of the primary assistance programs for low-income households, were $190 million for Fiscal Year 1984, $191 million for 1985, and $190 million for 1986 (1). Moreover, in its FY 1987 budget proposal, the administration proposed no funding for WAP, in part pointing to the states' receipt of almost $2.1 billion in Exxon oil overcharge funds, as justification for its position (1). When the oil overcharge funds run out, the future of this program and other conservation programs may be in jeopardy, severely impacting the energy situation of low-income households.

While average household energy consumption stabilized in the early 1980s, the price of energy increased, resulting in an increase in energy expenditures for all households: for example, relative to 1970, the average price in 1984 was 3.4 times higher for electricity, 5.6 times higher for natural gas, and 6.2 times higher for distillate fuel (2). Accordingly, the energy burden (percentage of income spent on residential energy costs) of the poor has also been increasing: for example, the average residential energy expenditure by a poor household was 10.9% of household income in 1978-79 and rose to 13% in 1980-81 (3). The services provided by the energy sector (for heating, cooking, washing, etc.) are necessities, and, if the cost of providing these services increases, a higher proportion of the budget of low-income houses will be spent on these services. Some expect that poverty level families will either have to go into debt to purchase basic essentials or do without (4). Also, some destitute families reportedly have forsaken food and medical care to pay escalating electric and home heating bills (4).

Successful development and implementation of energy conservation programs for low-income households requires a detailed understanding of how energy is used in homes, the factors that influence energy consumption and energy burden, and the conservation measures adopted by households. Such information can be used to more carefully target conservation programs to low-income groups and to ensure that these programs offer the services needed by low-income households for them to conserve energy. Accordingly, this paper examines low-income households in detail by analyzing a national data base recently created by DOE, the 1982-83 Residential Energy Consumption Survey (RECS). This data base represents one of the most comprehensive and most recent, publicly available compilation of data on households in the country.* We analyze the patterns and differences in the use and cost of energy and in energy-related measures for poor and non-poor households in the country. In addition to statistically testing for differences between the poor and non-poor on these variables, we

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* The only other published national study of low-income households was conducted on an earlier RECS data base [5]. Studies of low-income households in more localized settings have been conducted in California[6] and Decatur, Illinois [7].

construct predictive models of energy consumption and energy burden for each income group. In the concluding section, we make policy recommendations, based on the findings from our models, for targeting energy conservations programs to low-income households.

This paper is organized into four sections. We first discuss how the data were collected, the kind of data analyzed, and the types of statistical tests used. The second section reviews the patterns and differences in energy-related characteristics and energy consumption and expenditures of poor and non-poor households. In the third section, we present models of energy consumption and energy burden for poor and non-poor households and discuss the principal determinants of energy consumption and burden for the two income groups. The concluding section summarizes the key statistical findings and makes recommendations for targeting low-income households in energy conservation programs.

METHODOLOGY

RECS is based on a multistage probability sample of housing units, and it provides data on energy consumption and expenditures for the 12-month period of April through March. RECS has been conducted annually, starting with the data collection for April 1978 to March 1979.* For the 1982-83 survey, of the 5, 903 housing units chosen to be in the sample, 5,272 were eligible housing units, and the response rate for this survey was about 90% (9). The sample size analyzed for this paper was 4660 households, representing all 50 States in the U.S., except Alaska and Hawaii. Most (95% of the sample) of the households were personally interviewed during the Fall of 1982, and for the remaining 5% of the sample, mailed questionnaires were used. Detailed information on sample design and data collection is provided in Appendix A of the RECS report (9).

For our analysis, we divided the sample into "poor" and "non-poor" groups, using the U.S. Bureau of Labor and Statistics' definition of the actual poverty level in 1983, which considers income and family size. An individual living alone and with an annual income less than or equal to $4860 (the threshold level) was classified as poor. For those households with two or more members the threshold level was increased by an additional annual income of $1680 for every added member. Those households above the threshold level were placed in the non-poor group. The threshold levels are presented in Table 1 for the income and family size variables used in the RECS data base.

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* The results of a more recent RECS (for 1984-85) have recently been published, and a publicly available 1984-85 RECS data tape is expected to be released during the Summer of 1987 [8].

Table 1. Threshold Levels Used for Defining the Poor

Household Members	Household Income (1983)
1	Less than $5,000
2	$5,000 - $6,999
3	$7,000 - $7,999
4	$8,000 - $9,999
5	$10,000 - $11,999
6	$10,000 - $11,999
7	$12,000 - $14,999
8	$15,000 - $16,999
9	$15,000 - $16,999
10 or more	$17,000 - $19,999

We structured our analysis of the RECS data to reflect and assist ongoing energy research, program, and policy initiatives at DOE and at the national research laboratories. Currently, DOE addresses many residential energy issues by focusing on the type of dwelling, for example, single-family and multi-family homes. In our analysis of the RECS data, we used five housing types: mobile homes, single-family detached houses, single-family attached houses, buildings with 2-4 units, and building with 5 or more units. In this way, those interested in a particular housing type can focus on selected sections of the tables of results that are of special interest to them.

We included the following variables for analysis: demographic characteristics (e.g., race, marital status, and size of household), fuel use (including space heating, cooling, and water heating), energy consumption and expenditures (by individual fuels and total fuels), house type, type of heating and air-conditioning equipment, thermal integrity of the house, appliance ownership, and energy conservation improvements and behavior. Information concerning the housing unit was collected through personal and mail interviews and adult residents. Data concerning energy consumption (fuel use and prices) were obtained from fuel records (electricity, natural gas, fuel oil/kerosene, and liquid petroleum gas) maintained by the household's utilities and fuel suppliers. DOE also added information on annual heating and cooling degree days to each household record.

The sample estimates were weighted by DOE to permit the expansion of the RECS data to the total housing stock. Each housing unit was assigned to "base" weight, the inverse of the probability of selection for the housing unit. The official population values that were used to adjust the RECS estimates were from the Current Population Survey conducted by the U.S. Bureau of the Census. Detailed information on the weighting procedure are provided in Appendix A of the RECS report [9], and a discussion of the limitations of the weighting procedure is presented in another DOE report [10]. We present the results of our analysis in a series of tables, and the percentages in the tables are for the weighted sample. We used the unweighted sample for performing the statistical analyses.

For statistical analysis, we used the appropriate statistical tests and procedures contained in the Statistical Package for Social Sciences X (SPSS-X). For performing significance tests, we used the Chi-square statistic for comparing two nominal variables, as well as for comparing variables with nominal and ordinal levels of measurement. A significance level of 0.05 was used to decide whether the relationship was significant or not. For statistically significant variables involving nominal measurement, Cramer's V values were computed to examine the degree of relationship between the variables. However, since most of these values turned out to very low and virtually negligible, Cramer's V values were excluded from the tables.

Gamma was computed to measure the strength of association of significantly related ordinal variables. Gamma is 'proportionate reduction in error' measure which is concerned with the rank ordering of pairs of cases on one variable and is used to predict the rank order on the other variable. It is a symmetrical measure of association with limiting values of -1.0 (negative association) and +1.0 (positive association). A zero Gamma represents to association between the variables, indicating that knowledge of the ranking of pairs on one variable is not useful in predicting rank order on the other variable. Gamma values which were 0.40 and higher were included in the tables, otherwise, they were deleted.

The analysis of variance (Anova) test was used with interval and nominal or ordinal variables to test the differences among the means of the samples. For a single independent variable, a one-way Anova was used, while a two-way Anova was computed with two or more independent variables. A significance level oof 0.05 was chosen for the analysis.

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We used stepwise multiple regression analysis to construct energy consumption and energy burden models for poor and non-poor households, so that we could identify those significant variables that helped explain the variation in energy consumption and energy burden in these households. These models are described in detail near the end of this paper.

RESULTS

Distribution of Households

The poor comprise less than 10% of the total households in the country (Table 2). The poor and non-poor occupy similar housing types (over 50% of both groups live in single-family detached units); however, more poor households live in buildings with 5 or more units than the non-poor (23% and 15%, respectively), and there is a statistically significant relationship between house type and income group (Table 3).

Table 2. Distribution of Households by Income Classification

Income Classification	Number of Households	Percent
Poor	7,471,248	9.0
Non-poor	75,878,501	91.0
Total	83,349,749	100.0

Table 3. Distribution of Households by Housing Type and Income Classification

(Percentage of Households)

Housing type	Income Classification		
	Total	Poor	Non-Poor
Mobile home	4.5	6.3	4.3
Single-family detached	64.2	51.8	65.4
Single-family attached	4.6	4.0	4.7
Buildings with 2-4 units	12.1	15.0	11.9
Buildings with 5 or more units	14.6	22.9	13.7

Based on Census regions, about 20 to 25% of the poor and non-poor live in the Northeast and Northcentral U.S,; however, there are statistically significant differences in the other regions of the U.S.: about 40% of the poor (versus 33% for the non-poor) live in the South while only 16% of them live in the West (versus 20% for the non-poor) (Table 4). When controlling for house type, the differences between the two income groups are not statistically significant except in single-family detached houses.

Demographic Characteristics

While more than 50% of both the poor and non-poor own their home, there is a statistically significant relationship between home ownership and income: the non-poor are more likely to homeowners than the poor (Table 5). When housing type is taken into account, the relationship between home ownership and income is statistically significant only in mobile homes and buildings with 5 or more units: in the former, the non-poor tend to be homeowners, and in the latter, the poor are more likely to renters.

Table 4. Distribution of Households by Housing Type, Income Group, and Census Region (Percentage of Households)

Household characteristics	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Region	*				*							
Northeast	20.9	21.6	11.1	10.0	12.0	16.6	67.1	48.2	30.9	34.9	29.0	28.7
Northcentral	23.8	25.7	29.4	16.9	23.0	27.3	13.4	15.6	25.1	25.2	25.2	25.1
South	39.6	33.1	47.6	48.8	46.6	37.6	-	11.5	32.8	22.4	33.0	23.1
West	15.7	19.6	11.9	24.4	18.4	18.5	19.5	24.8	11.2	17.6	12.9	23.0

*Significant at 0 05 level using Chi-square test.

Table 5. Household Characteristics by Housing Type and Income Classification (Percentage of Households)

Household characteristics	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Dwelling owned/ rented	*		*								*	
Own	50.6	65.9	65.8	81.4	79.0	84.4	62.7	71.0	17.8	21.6	1.7	9.2
Rent	46.9	32.1	20.5	18.6	18.0	13.4	37.3	26.9	82.2	76.5	98.3	88.7
Rent-free	2.4	2.0	13.7	-	3.1	2.1	-	2.1	-	1.9	-	2.2
Year house built	*		*		*							
Before 1940	38.2	27.3	-	-	46.4	26.3	43.0	30.3	50.3	50.7	21.2	19.6
1940-1959	23.6	24.5	30.1	3.4	27.8	30.2	25.1	21.3	17.1	17.3	16.3	10.9
1960-1969	17.3	20.2	5.8	24.2	12.3	20.2	10.9	15.0	19.8	16.1	31.0	23.7
1970-1979	18.9	24.5	64.2	67.1	13.4	20.3	20.9	31.1	7.8	12.2	25.7	39.3
1980-1983	2.1	3.6	-	4.9	-	3.0	-	2.3	5.0	3.8	5.9	6.5
Number of household members	*(-0.53)		*(-0.57)		*(-0.54)				*(-0.40)		*(-0.45)	
1	53.8	20.0	53.6	17.8	46.6	13.1	66.0	19.2	53.4	28.4	68.6	46.4
2	29.6	31.6	35.9	35.4	32.5	31.6	11.2	28.8	30.5	32.3	23.9	30.5
3	3.0	17.6	1.3	23.0	4.5	18.7	-	19.3	1.8	16.4	1.6	10.9
4	8.4	17.8	3.9	13.5	10.6	21.1	9.1	15.4	9.9	13.7	3.7	7.4
5	2.9	7.8	4.1	6.4	3.7	9.7	6.2	9.3	3.5	4.5	-	2.0
6	1.2	2.9	1.2	2.5	0.8	3.2	-	4.2	1.0	2.0	2.3	1.6
7	0.8	1.2	-	0.9	0.9	1.2	7.5	2.5	-	1.4	-	0.5
8	0.2	0.6	-	-	0.5	0.7	-	0.5	-	0.3	-	0.4
9 or more	-	0.6	-	0.4	-	0.7	-	0.8	-	1.0	-	0.2

*Significant at 0.05 level using Chi-square test. The figures in parentheses are Gamma values ranging from -1.0 (negative association) to +1.0 (positive association). Gamma is a measure of association.

Table 5. Continued.

Household characteristics	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Marital status of household head	*		*		*		*		*		*	
Now married	29.2	64.8	32.0	71.1	38.0	74.9	11.6	55.9	20.5	44.0	17.1	35.7
Widowed	39.0	11.3	27.8	10.8	39.7	10.7	48.6	14.0	34.3	13.4	41.8	11.1
Divorced/ separated	16.0	13.7	20.6	16.8	11.7	9.3	30.6	24.3	13.3	21.1	23.5	22.8
Never married	15.9	10.3	19.7	2.3	10.5	5.0	9.2	5.8	31.9	21.5	17.6	29.4
Race of household head	*				*						*	
White	75.5	86.2	96.1	94.2	78.3	89.4	85.9	73.4	68.1	78.3	66.2	79.6
Black/Negro	22.9	11.6	3.9	5.8	20.0	8.9	14.1	21.7	31.4	18.5	30.8	16.5
American Indian	0.1	0.3	-	-	0.1	0.4	-	-	-	0.3	-	0.1
Asian/Pacific	1.1	1.7	-	-	0.7	1.1	-	3.6	0.5	2.6	2.9	3.8
Other	1.4	0.2	-	-	0.8	0.2	-	1.2	-	0.4	-	-
Education	*		*		*				*		*	
No schooling	1.5	0.5	6.3	-	2.1	0.4	-	0.7	-	0.8	-	0.9
Elementary school	12.4	3.6	4.5	4.2	15.1	3.5	-	4.0	11.7	5.5	11.2	2.3
Junior high school	21.7	7.4	19.6	11.9	27.1	7.6	24.8	6.9	15.1	6.8	13.5	5.8
Some senior high school	18.7	14.5	32.3	17.5	19.2	13.9	35.8	19.9	22.0	16.3	8.6	13.1
Completed high school	27.7	36.4	16.4	47.3	21.9	37.5	30.2	35.1	25.6	30.4	46.9	33.5
Some college	12.4	19	14.0	13.2	18.4	19.0	18.7	20.2	20.5	21.2	12.8	18.9
Completed college	4.5	12.7	1.3	3.7	3.4	12.3	9.2	9.1	5.4	13.4	6.6	17.7
Graduate education	1.0	5.8	-	2.6	0.4	5.8	-	4.1	5.7	5.5	-	7.9

*Significant at 0 05 level using Chi-square test

Table 5. Continued.

Household characteristics	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Income sources (1983)												
Paid employment	28.7*	73.4	14.3*	70.7	27.5*	73.7	68.6	75.0	35.7*	73.2	23.5*	73.0
Received income from AFDC	5.6	3.2	15.0	2.3	4.7	2.5	14.0	4.0	9.0	6.8	1.4	2.3
Received income from SSI	16.9*	3.8	4.7	4.3	16.8*	33.4	8.5	7.4	10.4	5.6	28.1*	2.6
Received other public aid	7.1*	1.8	20.7	3.2	3.2*	1.5	14.4*	2.6	9.4	2.8	8.8*	1.2
Received food stamps	26.4*	6.4	42.1*	7.0	25.4*	5.1	7.7	9.5	29.6*	12.6	25.6*	4.6
Received social security	67.0*	31.0	67.2*	28.6	74.3*	32.4	51.1	34.9	50.3*	26.7	65.1*	28.9
Received unemployment benefits	2.6*	8.9	-	14.3	3.0*	9.0	2.3	3.3	1.0*	9.2	3.5	8.6

*Significant at 0.05 level using Chi-square test

The homes occupied by the poor and non-poor are mostly old, constructed before 1940, and very few of the homes (2% and 4% for non-poor, respectively) are relatively new (constructed between 1980 and 1983) (Table 5). The main exception to this finding is for mobile homes, in which ove 60% of both income groups reported the year of construction to be between 1970 and 1979. There is a statistically significant relationship between income and the age of the home: compared to the non-poor, poor households tend to occupy homes built before 1940, and this is particularly true in single-family detached houses. The poor are also more likely to live in older (1940-59) mobile homes than the non-poor.

A majority (more than 85%), of both the poor and non-poor have relatively few household members (1 to 4), and only 5% of the poor and 13% of the non-poor have 5 to 8 members in their household (Table 5). The relationship between size of household and income is statistically significant: the poor tend to have fewer household members than the non-poor. Moreover, the Gamma (measure of association) value of -0.53 indicates a relatively strong association between the two variables and implies that the more poor the respondents are, the smaller the size of the household. When taking housing type into account, the relationship between size of household and income remains statistically significant across all house types, except in single-family attached units.

A large percentage (39%) of the poor are widoowed, followed by the 'now married' category (29%). On the other hand, a majority (65%) of non-poor are 'now married,' followed by the 'divorced/separated' category (14%) (Table 5). The relationship between the marital status of the head of the household and income is statistically significant: the non-poor tend to be currently married while the poor are widowed. When taking housing type into account, the relationship between the marital status of the head of the household and income remains statistically significant across all houses types.

A majority of the poor (76%) and non-poor (85%) are white (Table 5). However, the relationship between the race of the head of the household and income is statistically significant: compared to the non-poor, a greater percentage of the poor is black, and this is particularly ture in single-family detached houses and in buildings with 5 or more units.

The relationship between the education of the head of the household and income is statistically significant: the non-poor are better educated than the poor (Table 5). In fact, over 50% of the poor to not complete a high school education. In contrast to 26% for the non-poor. Also, almost 38% of the non-poor have some education beyond high school (versus 18% of the poor), and almost 14% of the poor do not go beyond elementary school (versus 4% of the non-poor). This relationship remains statistically significant across all house types, except in single-family attached units.

The two income groups rely on different sources of income (Table 5). About 73% of the non-poor, but 29% of the poor derive their income from paid employment (statistically significant). The poor depend more heavily on other income sources (e.g., income from Aid to Families with Dependent Children (AFDC), Social Security Income (SSI), food stamps, social security, and other public aid) than the non-poor. After accounting for house type, the

relationship remains statistically significant in many cases (especially in single-family detached houses and in buildings with 5 or more units). The one exception to this dependency is unemployment benefits (related to paid employment) in which a greater percentage of the non-poor (9%), compared to the poor (3%), use these benefits as a source of income.

Heating Fuels

More than 50% of the poor and non-poor use piped (natural) gas as their main home heating fuel (Table 6). The second most used main fuel for heating homes in fuel oil (16%) for the poor and electricity (16%) for the non-poor, and about 7% of each group use wood as their principal home heating fuel. There is no statistically significant relationship between type of heating fuel and income; however, when controlling for house type, a statistically significant difference occurs in mobile homes and in single-family attached houses. In the former, the poor tend to use more electricity and less liquid petroleum gas (lpg) than the non-poor, and, inn the latter, the non-poor use less electricity and more lpg than the non-poor.

There is a statistically significant relationship between the use of secondary home heating fuels and income: about 21% of the poor use a secondary source, while almost 37% of the non-poor use such a source (Table 6). The poor tend to use electricity and wood equally (about 10%) as a secondary source, while the non-poor tend to use wood (24%) and some electricity (10%) as backup heat. Differences between the two groups are statistically significant in only only housing type: almost one-half of the non-poor use secondary heating fuels in single-family detached houses, while the poor use only 33%.

Heating Equipment

About 33% of the poor and 50% of the non-poor use central heating systems, followed by gas/oil heaters for the poor (19%) and radiators for the non-poor (15%) (Table 7). There is a statistically significant relationship between heating equipment and income: in contrast to the poor, the non-poor tend to use central units. When controlling for house type, significant differences between the two income groups remain in single-family units. In single-family detached dwellings, over 50% of the non-poor use central units, and one-third use gas/oil heaters. Also, twice as many of the poor than non-poor use pipeless furnaces. In single-family attached dwellings, the percentage of poor and non-poor using central units is about the same (46%); however, one-quarter of the poor use pipeless furnaces versus 9% of the non-poor. There are no statistically significant differences between the two income groups in the other housing units.

The non-poor are more likely to use secondary home heating equipment than the poor, and this difference (39% vs. 25%) is statistically significant (Table 7). The most common type of secondary home heating equipment is a fireplace (16%) for the non-poor and a portable electric heater (7%) for the poor. When house type is controlled for, the relationship between income and secondary home heating equipment is no longer statistically significant, except in the single-family detached housing. In this type of construction, almost one-half of the non-poor use secondary home heating equipment (compared to 38% of the poor).

Table 6. Fuel Use by Housing Type and Income Classification

(Percentage of Households)

Fuel use	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Main home heating fuel			*		*							
Piped gas	54.7	57.1	33.8	28.7	54.6	57.3	63.8	69.5	62.1	69.5	54.4	50.4
Electricity	13.9	16.2	42.9	20.9	5.8	13.5	11.7	16.4	5.8	11.4	28.9	31.4
Fuel oil	16.2	13.3	11.6	11.6	16.2	12.4	12.7	9.2	23.5	15.7	15.7	17.3
Lpg	7.2	4.3	6.3	26.4	12.2	4.5	11.7	1.9	-	0.8	-	0.1
Coal/kerosene	1.7	1.9	5.4	3.8	1.5	0.8	-	0.7	4.1	1.4	-	0.4
Wood	6.2	6.8	-	8.6	10.7	9.6	-	1.7	4.5	0.5	-	-
Others	-	0.1	-	-	-	0.3	-	-	-	0.1	-	-
No fuel used	-	0.2	-	-	-	0.1	-	0.5	-	0.7	-	0.5
Secondary home heating fuel												
Use	21.4*	36.8	6.3	28.0	33.2*	47.0	27.4	28.2	9.6	17.4	9.6	17.4
Piped gas	1.0	1.1	-	-	1.4	1.4	-	-	1.7	0.8	-	0.2
Lpg	1.8	0.9	-	3.6	3.2	1.0	-	1.1	-	-		-
Fuel oil	0.8	1.6	-	1.0	1.4	2.1	-	-	-	0.4	-	0.8
Kerosene	1.0	2.0	-	4.6	1.8	2.1	-	3.4	-	1.2	-	0.4
Electricity	10.3	9.8	-	10.1	13.7	10.7	7.7	9.6	10.0	9.7	4.7	5.0
Wood	9.3	23.6	13.6	9.6	13.7	31.2	15.4	16.4	1.7	6.8	1.2	3.1
Coal	0.5	0.2	-	-	0.9	0.3	-	-	-	-	-	-
Others/unknown	75.6	60.7	86.4	71.4	63.9	51.1	76.9	69.9	86.7	8.1	94.2	90.4

*Significant at 0.05 level using Chi-square test

Table 7. Heating Equipment by Housing Type and Income Classification
(Percentage of Households)

Heating equipment	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Main home heating equipment	*				*		*					
Hot water pipes	1.6	1.7	-	-	1.0	1.2	-	4.1	-	1.1	4.8	4.3
Radiators	16.6	16.1	-	0.3	3.8	8.6	17.5	25.3	30.7	30.1	40.7	34.7
Central warm air	32.7	48.9	62.8	71.2	33.4	54.0	46.1	46.3	30.0	38.5	22.2	27.3
Heat pump	3.3	4.5	5.9	4.7	2.3	4.4	-	1.3	-	3.0	7.7	6.3
Electric wall	5.3	6.0	-	0.7	2.2	4.6	11.7	8.3	0.8	4.6	15.4	14.9
Gas/oil heater	19.1	6.6	11.7	3.7	30.1	7.5	-	3.5	12.1	9.2	4.4	2.3
Wood/coal stove	5.5	6.4	-	8.6	9.3	9.1	-	1.5	4.5	0.5	-	-
Portable electric heater	1.6	0.9	2.5	2.8	0.7	1.0	-	0.8	3.9	0.4	-	-
Portable kerosene heater	-	0.3	-	3.5	-	0.1	-	-	-	0.5	-	-
Cooking stove	0.6	0.5	-	0.9	-	0.4	-	0.4	4.0	1.2	-	0.4
Pipeless furnace	12.8	8.6	5.2	3.6	16.1	8.3	24.7	8.5	14.9	11.0	4.7	9.8
Fireplace	0.6	0.4	-	-	1.2	0.6	-	-	-	-	-	-
Other	0.3	0.1	5.1	-	-	0.2	-	-	-	0.1	-	-

*Significant at 0 05 level using chi-square test

Table 7. Continued.

Heating equipment	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Secondary home heating equipment												
Use	25.0*	38.9	8.3	30.9	38.2*	48.6	35.2	30.1	10.2	28.9	8.2	13.5
Hot water pipes	-	0.1	-	-	-	0.2	-	-	-	-	-	-
Radiators	0.3	0.4	-	-	0.5	0.5	-	-	-	0.2	-	0.4
Central furnace	1.3	2.3	-	5.5	2.3	3.0	-	-	-	0.4	-	-
Heat pump	0.3	0.3	-	-	0.5	0.4	-	-	-	-	-	-
Built-in Electric unit	4.0	2.7	-	0.5	5.5	5.2	-	1.1	-	1.6	4.7	1.9
Pipeless furnace	-	0.4	-	-	-	0.4	-	1.1	-	-	-	-
Room heaters	2.5	1.5	-	0.5	4.6	2.0	-	-	-	1.0	-	-
Heating stove	4.3	5.0	8.1	4.5	6.3	6.7	-	4.0	-	0.6	-	-
Fireplace	4.8	16.2	4.5	5.0	7.3	21.0	7.7	11.3	1.7	6.2	-	2.9
Portable electric heater	6.5	8.3	-	9.0	6.8	8.7	15.4	6.0	10.0	7.6	3.5	5.6
Portable kerosene heater	1.5	2.9	-	4.0	2.7	3.5	-	4.0	-	1.0	-	0.4
Cooking stove	2.8	1.1	-	1.5	3.2	0.7	7.7	0.8	3.3	0.3	1.2	1.3
Other/unknown	74.8	59.6	88.4	69.3	59.9	49.6	69.2	68.8	85.0	78.0	90.7	87.5

*Significant at 0.05 level using Chi-square test.

There is a statistically significant relationship between income and central air-conditioning equipment: in contrast to the poor, the non-poor tend to have central air-conditioners (29% and 16%, respectively), and this is particularly evident in single-family dwellings and in buildings with 2-4 units (Table 8). However, in contrast to the total sample, the non-poor are more likely to have a window air-conditioner than the poor in buildings with 2-4 units (36% and 21%, respectively). More than 90% of the poor and the non-poor have only 1-2 window air-conditioners, and there is no statistically significant difference between the two groups, even after controlling for house type.

Wood Use

A similar percentage of poor (30%) and non-poor (33%) purchased wood during the year before the survey was taken (Table 9), and there is no statistically significant difference between the two groups. However, the non-poor are almost twice as likely to have burned wood the previous year than the poor (27% and 14%, respectively). This difference is statistically significant, and after controlling for house type, it remains significant in single-family detached dwellings. In terms of usage, which is always difficult to respondents to accurately remember, more than 50% of both the poor and non-poor burned one cord of wood or more during the previous year. No statistically significant difference is evident, even after controlling for house type.

Water Heating Fuel Use

Both the poor (57%) and non-poor (56%) use piped natural gas as their principal fuel source for heating water (Table 10). Electricity is the second most common water heating fuel, for 29% of the poor and 32% of the non-poor. However, there is a statistically significant relationship between the fuel used for water heating and income. There is a greater use of lpg by the poor than the non-poor (6% and 4%, respectively), and this difference is especially marked in single-family dwellings. A very small percentage of both the poor (1%) and non-poor (2%) use a secondary water heating fuel, and this fuel is usually lpg or wood for the poor, and electricity or wood for the non-poor. When housing type is taken into account, there is no significant relationship between fuel type and income.

Appliance Saturation

Almost every poor and non-poor household have at least one refrigerator in their house, irregardless of dwelling type (Table 11). Of the few households that have more than one refrigerator, the non-poor tend to have more than one (14%), compared to the poor (6%), and this difference is statistically significant. This difference is particularly evident in single-family detached dwellings. However, in single-family attached dwellings, the poor tend to have more than one refrigerator, compared to the non-poor. Almost every poor and non-poor household has at least one freezer, with a small percentage having more than one (Table 11). There is no statistically significant relationship between income and number of freezers, even after controlling for house type. Almost every household has an oven, but there

Table 8. Air Conditioning Equipment and Fuel Use by Housing Type and Income Classification (Percentage of Households)

Air conditioning equipment and fuel use	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Air conditioning (A/C)												
Central A/C	16.2*	29.2	20.7	24.0	12.4*	31.0	-*	29.1	11.9	14.7	29.1	34.4
Central A/C fuel												
Electricity	99.4	97.1	100.0	100	98.4	97.8	-	96.4	100.0	97.2	100.0	94.0
Piped gas		2.9	-	-	-	2.2	-	3.6	-	2.8	-	6.0
Lpg	0.6	-	-	-	1.6	-	-	-	-	-	-	-
Window/wall A/C	34.8*	30.7	30.5	25.9	39.9*	29.8	63.6*	27.3	21.1*	35.8	32.7	28.5
Number of window/wall A/C												
1-2	98.8	92.0	100.0	98.5	98.0	91.2	100.0	82.6	100.0	93.2	100.0	95.4
3-4	1.2	7.0	-	1.5	2.0	7.3	-	14.5		-	6.0	-
5 and above		1.1	-	-	-	1.0	-	2.9	-	0.8	-	1.0

*Significant at 0 05 level using Chi-square test

Table 9. Wood Consumption by Housing Type and Income Classification (Percentage of Households)

Wood consumption	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Wood purchased in past year	30.4	33.4	-	18.4	32.6	32.7	-	55.3	43.5	35.0	-	62.8
Wood burned in past year	13.9*	26.9	6.3	14.7	23.1*	37.4	16.5	12.0	5.2	6.8	0.5	3.2
Amount of wood burned in past year												
Less than one cord	34.7	44.7	59.8	29.0	31.8	43.4	84.8	51.6	13.2	61.7	100.0	96.9
One cord or more	65.3	55.3	40.2	71.0	68.2	56.6	15.2	48.4	86.8	38.3	-	3.1

*Significant at 0 05 level using chi-square test.

Table 10. Water Heating Fuel Use by Housing Type and Income Classification (Percentage of Households)

Water fuel use	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Main water heating fuel	*				*		*					
Piped gas	56.7	56.4	22.3	23.8	48.8	55.4	76.6	74.6	64.9	72.4	58.4	54.1
Lpg	6.1	3.8	11.7	17.4	9.9	4.3	11.7	0.4	-	1.3	-	0.1
Fuel oil	6.9	6.7	3.8	0.3	3.2	4.6	-	2.4	16.8	9.7	14.6	16.8
Electricity	28.6	32.1	62.3	58.6	35.6	34.2	11.7	22.2	16.0	16.2	27	28.9
Wood	0.4	0.4	-	-	0.6	0.7	-	-	-	-	-	-
Coal/coke/kerosene	0.3	0.1	-	-	-	0.2	-	-	2.2	0.2	-	-
Other	-	0.4	-	-	-	-	0.7	-	-	0.4	2.2	-
No fuel	0.9	0.1	-	-	1.8	0.1	-	-	-	0.3	-	-
Secondary water heating fuel use	1.2	1.8	-	1.0	2.0	2.0	100.0	-	0.9	0.4	-	1.9
Piped gas	11.4	14.3	-	29.5	-	4.2	-	49.2	100.0	-	-	47.1
Lpg	29.1	8.7	-	-	32.9	11.2	-	8.0	-	-	-	-
Fuel oil	-	12.4	-	-	-	4.5	-	42.8	-	68.3	-	48.0
Kerosene/coal	-	4.5	-	-	-	5.1	-	-	-	-	-	-
Electricity	10.5	39.6	70.5	11.8	46.9	-	-	-	-	-	4.9	
Wood	23.2	15.9	-	-	26.2	21.9	-	-	-	-	-	-
Other	25.8	4.5	-	-	29.1	6.1	-	-	-	31.7	-	-

*Significant at 0 05 level using Chi-square test

Table 11. Appliance Use by Housing Type and Income Classification (Percentage of Households)

Appliance use	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Use refrigerator	**99.9**	**99.7**	**100.0**	**100.0**	**100.0**	**99.8**	**100.0**	**100.0**	**99.0**	**99.0**	**100.0**	**99.8**
Number of refrigerators used	*(- 0.43)				*		*(- 0.53)					
One	94.1	85.9	100.0	89.8	90.8	81.8	73.3	88.9	100.0	95.1	100.0	99.0
Two	5.5	13.4	-	9.6	8.5	18.5	26.7	11.1	-	4.6	-	1.0
Three or more	0.4	0.6	-	0.5	0.7	0.8	-	-	-	0.3	-	0.1
Number of freezers used												
One	91.3	91.3	100.0	96.7	89.9	90.3	100.0	99.4	91.7	99.1	100.0	100.0
Two	8.7	8.4	-	2.3	9.4	10.1	0.6	-	8.3	0.9	-	-
Three or more	-	0.3	-	-	-	0.3	-	-	-	-	-	-
Number of ovens used	*(- 0.53)				*(- 0.53)		*(- 0.53)					
One	87.3	69.1	91.8	74.4	84.4	61.9	75.1	70.4	88.5	85.9	95.2	89.5
Two	11.4	27.8	8.2	24.3	13.1	33.8	24.9	28.9	11.5	12.6	4.8	10.5
Three or more	1.3	3.1	-	1.3	2.4	4.3	-	0.7	-	1.5	-	-

*Significant at 0.05 level using Chi-square test. The figures in parentheses are Gamma values ranging from -1.0 (negative association) to +1.0 (positive association). Gamma is a measure of association.

Table 11. Continued.

Appliance use	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Electric range (stove top or burner)	43.3*	54.3	44.5	34.2	44.2*	60.5	44.6	33.3	24.0	36.1	53.7	53.8
Gas range (stove top)	56.6*	45.6	55.5	65.1	55.9*	39.6	55.4	66.7	75.0	63.4	46.8	45.6
Automatic clothes washer	48.0*	71.2	52.0*	73.8	66.6*	87.5	50.4*	80.6	40.5	43.7	9.5	13.4
Wringer clothes washer	7.0*	2.6	-	1.5	10.5*	3.4	7.7	3.0	4.1*	1.0	2.7*	0.6
Dishwasher	12.1*	38.5	11.1	20.9	11.7*	43.9	26.3	40.0	6.2*	20.7	14.6*	32.9
Electric clothes dryer	27.3*	47.2	45.6	57.2	40.2*	59.9	30.0	40.7	11.4	21.1	3.2	8.5
Gas clothes dryer	7.9*	15.2	-	5.5	13.4*	18.9	6.2	24.3	-*	10.3	3.1	1.7
Dehumidifier	3.0*	9.6	-	1.0	4.9*	13.5	10.9	5.2	-	4.0	-	0.5
Humidifier	5.7*	14.2	-	9.3	7.5*	18.3	-	7.6	5.6	5.9	4.3	5.8
Evaporative cooler	1.9*	4.5	5.2	16.2	3.0	5.0	-	6.4	-	1.8	0.3	0.1
Whole house cooling fan	6.5	7.9	-	0.8	9.2	11.0	34.1	6.0	2.5	3.5	-	0.2
Ceiling fans	27.2	28.2	12.3	24.0	34.3	30.8	31.6	31.8	24.3	26.9	16.6	17.3
Black and white television	47.4	46.4	45.3	48.7	46.0	47.6	55.4	47.4	63.5*	45.0	41.4	41.0
Color television	71.4*	86.1	64.2	79.1	75.4*	89.9	83.1	87.3	52.6*	77.5	74.6	77.1
Outdoor piped gas grill	1.3*	3.9	-	0.5	1.7	5.1	-	4.5	-	1.7	1.7	0.9
Outdoor lpg gas grill	1.8*	8.3	-	3.8	2.2*	10.9	-	8.2	3.3	2.4	0.5	1.7
Outdoor gas light	0.9	1.8	-	0.3	2.3	1.7	0.7	-	1.4	-	0.1	-

*Significant at 0.05 level using Chi-square test

is a statistically significant relationship between income and number of ovens (Table 11). The non-poor are more likely to have more than one oven (31% and 13%, respectively), particularly in single-family dwellings.

The proportion of households having other appliances were low (Table 11); however, statistically significant differences between the two income groups occasionally occur. For example, the non-poor are more likely than the poor to have electric ranges (54% versus 43%, respectively), automatic clothes washers (71% versus 48%), dishwashers (39% versus 12%), electric clothes dryers (47% versus 27%), gas clothes dryers (15% versus 8%), dehumidifiers (10% versus 3%), humidifiers (14% versus 6%), evaporative coolers (5% versus 2%), color televisions (86% versus 71%), outdoor piped gas grills (4% versus 1%), and outdoor lpg gas grills (8% versus 2%). In contrast, the poor are likely than the non-poor to have gas ranges (57% versus 46%, respectively) and wringer clothes washers (7% versus 3%). When accounting for house type, many of these relationships remain statistically significant in single-family detached dwellings, but, in the other house types, most of the differences are no longer statistically significant.

Thermal Integrity of Home

Thermal integrity refers to those house characteristics (e.g., storm windows and doors, and insulation properties of walls, ceilings, attics, and floors) that limit the amount of heat that enters and leaves a house, and, therefore, give us an idea about the thermal performance of the house. About 40% of the poor and 50% of the non-poor have sliding glass storm doors (usually, one) (Table 12). Compared to the poor, the non-poor are more likely to have one or more sliding glass storm doors, but when controlling for house type, this statistical significance disappears in all house types except in single-family detached houses. Almost 60% of the poor and 50% of the non-poor have storm windows, but the poor tend to have more storm windows than their counterparts (Table 12). When controlling for house type, however, this statistically significant difference disappears in all house types except one: in single-family detached houses, the poor are more likely to have at least one storm window.

About 54% of the non-poor tend to have either all or some of their walls insulated compared to 36% of the poor (Table 12), and this difference is statistically significant. However, when house type is controlled for, these statistically significant differences disappear. There is a statistically significant relationship between income and the presence of attic/roof insulation (43% of the poor and 64% of the non-poor) (Table 12).

However, when controlling for house type, the poor are more likely to have roof insulation than the non-poor in single-family homes. Most of those reporting the presense of roof insulation have 96-100% of their roof insulated.

Temperature Regulation and Thermostat Settings

There are several ways households can regulate the temperature in their home during the winter: open and close windows and/or doors, open and close hot air vents, turn heaters

Table 12. Thermal Characteristics by Housing Type and Income Classification (Percentage of Households)

Thermal characteristics	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Number of sliding glass storm doors	*(- 0.52)				*(- 0.59)							
None	61.7	50.1	-	70.0	71.0	43.5	11.2	56.4	100.0	69.3	56.5	66.2
One	33.0	39.7	100.0	27.3	27.5	45.0	88.8	33.7	-	18.4	30.4	28.1
Two or more	5.4	10.3	-	2.8	1.5	11.4	-	10.0	-	12.1	13.1	5.7
Number of storm windows	*				*							
None	43.1	54.3	41.9	54.8	44.6	53.5	37.2	53.2	36.0	37.5	23.4	38.6
1-6	10.7	14.5	10.3	3.7	9.9	2.8	6.2	7.2	6.1	14.9	18.4	14.6
7-12	23.1	18.7	23.5	28.4	39.0	26.9	25.5	20.8	25.9	21.4	17.0	21.8
13-18	16.3	10.0	17.0	13.3	6.5	14.2	21.6	15.1	22.1	17.1	27.2	16.3
19 or more	6.8	2.5	7.3	1.2	-	1.3	9.5	3.8	10.0	9.1	14.0	8.6

*Significant at 0.05 level using Chi-square test. The figures in parentheses are Gamma values ranging from -1.0 (negative association) to +1.0 (positive association). Gamma is a measure of association.

Table 12. Continued.

Thermal characteristics	Housing Type by Income Classification							
	Total		Mobile home		Single-family detached		Single-family attached	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Presence of wall insulation	*							
None/No answer	63.9	46.2	8.1	4.8	41.0	24.4	51.0	33.8
All	30.7	44.9	81.0	88.2	49.5	62.7	45.6	50.5
Some	5.4	9.0	10.8	7.1	9.5	12.9	3.4	15.7
Attic/roof insulation	42.7*	63.6	84.2	91.4	87.5*	72.4	81.6*	52.1
% Roof Insulation	*				*			
Don't know	6.0	4.1	-	2.8	6.9	4.3	-	1.8
Less than 5%	2.2	1.7	-	2.2	1.8	1.4	19.2	5.4
5%-33% insulated	1.0	1.7	-	-	1.1	1.5	-	6.4
34%-66% insulated	1.6	3.0	-	1.6	1.8	2.9	-	5.9
67%-95% insulated	2.8	5.6	-	4.8	3.3	5.9	-	1.1
96%-100% insulated	86.4	84.0	100.0	88.6	85.0	84.0	80.8	79.4

*Significant at 0 05 level using Chi-square test.

(radiators) on and off, adjust fuel usage, and/or use the oven (stove or range) to heat the home (Table 13). The primary means of regulating temperatures in the home for both the poor and non-poor is turning the heater on and off (60% and 50%, respectively). There are statistically significant differences between the poor and the non-poor: the latter are more likely to adjust the heater and fuel usage of wood and coal stoves. When controlling for house type, these differences remain statistically significant in only single-family detached houses. It is interesting to note that about 10% of each group use their ovens (stoves, ranges) to control indoor temperatures, and in mobile homes, this percentage increases to 23% for the poor and 32% for the non-poor.

One of the most effective and least expensive means of reducing household energy use is through thermostat management [12]. About 82% of the non-poor and 61% of the poor have thermostats, and this difference remains statistically significant in all house types (Table 13). For those households with thermostats, both the poor and the non-poor set similar thermostat temperatures for three difference time periods (when someone is home during the day, when the house is vacant during the day, and at night) (Table 14). However, thermostat settings do change for both groups during these time periods. When someone is home during the day, during the winter, the thermostat is usually set around 70 ^{o}F or about. However, when nobody is home during the day, many of the poor (26%) and non-poor (19%) turn their heat off, and many others set their thermostats in the low 60s (^{o}F). At night, temperature setback is less severe; however, many of the poor (21%) and some of the non-poor (13%) do keep their heat off, and about 20% of each group set their thermostat at 63 ^{o}F or below.

Energy Audits

In the last ten years, energy audits have become one of the most important components of energy conservation programs in trying to influence households to invest in energy-efficient improvements. However, not all households have participated in energy audits. In the RECS survey, residents of single-family houses and mobile homes were asked about their reasons for participating or not participating in energy audits (Table 15). Only 4% of the non-poor and 2% of the poor received an energy audit during the past year, and the difference between the two income groups is not statistically significant. A greater percentage of the poor have had energy audits in mobile homes than in single-family homes, and vice versa for the non-poor, but there are no statistically significant differences.

Households receiving an audit were asked which of the following reasons were important to them for requesting the audit: high fuel bills, uncomfortable home, planning other improvements at the same time, recommendation of audit by friends or neighbors, or inexpensive cost of audit (in come cases, audits are free or low-cost). A very high percentage of the poor (88%) and the non-poor (69%) felt that high fuel bills were very important for them in requesting an audit. However, about 16% of the poor in single-family detached houses and over 20% of the non-poor in mobile homes and single-family detached houses indicated that high fuel bills were not important, suggesting that noneconomic factors are important in requesting an audit. For example, the comfort of the house was very important for requesting an audit for 35% of the poor and 11% of the non-poor. Comfort may be more important for

Table 13. Temperature Regulation and Thermostats by Housing Type and Income Classification (Percentage of Households)

Thermostat and temperature control	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Methods of controlling temperature												
Open/close doors and/or windows	34.6	34.5	23.3	39.6	29.5	26.5	37.8	17.1	20.3	37.8	57.9	56.1
Opene/close hot air vents	1.8	4.3	-	2.4	1.9	3.5	-	-	2.9	9.7	1.4	3.2
Turn heater on/off	59.4*	50.0	94.1	66.2	83.0*	58.5	51.3	71.6	37.4	43.7	23.4	29.6
Turn radiator on/off	3.7	7.4	-	-	-	0.7	-	12.6	9.4	11.3	8.0	21.1
Adjust fuel use	10.5*	18.5	24.3	20.6	15.6*	31.0	-	11.6	9.1	3.3	-	-
Using oven/stove/range	11.3	9.4	23.3	31.6	7.9	7.8	-	-	17.4	14.6	12.8	7.8
Other	-	0.6	-	-	-	0.4	-	-	-	-	-	1.6
Have thermostat	61.2*	81.8	77.7*	87.4	62.1*	84.7	77.1*	89.2	50.5*	75.2	58.7*	69.1

*Significant at 0 05 level using Chi-square test

Table 14. Room Temperature by Housing Type and Income Classification (Percentage of Households)

Room temperature	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Daytime temperature when someone is at home												
Unknown/no answer	11.0	5.5	-	3.2	11.6	3.4	-	2.3	11.0	10.5	14.9	12.7
Heat turned off	3.4	2.1	-	-	2.8	1.6	-	3.9	6.2	4.5	4.2	2.7
Heat turned on	85.7	92.4	100.0	96.8	85.7	95.0	99.0	93.8	82.7	85.0	80.9	84.6
63 °F and below	3.9	5.4	1.5	2.8	2.8	5.0	6.5	6.3	7.2	5.3	4.6	8.0
64-66 °F	13.4	12.1	17.4	16.0	12.3	12.5	16.9	12.7	13.4	13.7	14.1	7.4
67-69 °F	14.6	24.5	26.9	18.2	16.9	27.8	31.3	27.0	11.0	22.3	5.3	11.8
70 °F	26.7	25.7	21.0	34.4	29.5	25.4	22.0	26.5	25.4	21.2	23.4	28.1
71 °F and above	27.1	24.7	33.2	25.4	24.2	24.3	23.2	21.3	25.7	22.5	33.6	29.3
Daytime temperature when no one is at home												
Unknown/no answer	9.1	4.7	-	0.4	7.1	2.7	-	2.3	10.0	9.4	17.2	12.1
Heat turned off	26.4	18.6	26.7	26.7	31.3	16.9	26.0	19.0	14.5	19.5	23.2	23.4
Heat turned on	64.4	76.7	73.2	72.9	61.7	80.4	73.9	78.7	75.6	71.1	59.6	64.6
63 °F and below	18.9	24.9	25.6	30.6	20.4	26.5	9.2	27.2	21.5	21.0	13.5	17.7
64-66 °F	16.5	17.2	9.9	19.5	14.9	18.5	30.6	17.4	19.4	16.6	17.7	11.1
67-69 °F	8.3	13.1	6.4	5.5	9.9	15.0	13.4	11.8	7.2	12.3	5.3	7.7
70 °F	9.6	11.4	18.3	6.8	9.9	11.4	-	14.3	11.1	9.5	7.3	13.7
71 °F and above	11.1	10.1	13.0	10.5	6.6	9.0	20.7	8.0	16.4	11.7	15.8	14.4

Table 14. Continued.

Room temperature	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Pocr	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Night time temperature												
Unknown/ no answer	8.0	5.1	-	0.8	6.2	2.9	-	4.5	10.9	10.2	14.5	12.6
Heat turned off	21.4	12.8	18.2	14.2	26.6	11.5	19.5	14.5	8.5	13.9	19.3	17.6
Heat turned on	70.6	82.2	81.8	85.0	67.1	85.6	80.5	80.9	81.4	76.9	66.3	69.8
63 °F and below	20.0	23.1	9.9	26.1	20.1	25.5	24.9	27.3	20.7	17.6	21.2	14.2
64-66 °F	17.1	19.5	24.3	23.0	16.6	20.6	13.7	15.5	18.4	17.1	15.9	16.7
67-69 °F	14.7	16.7	22.8	19.5	15.6	18.2	35.2	18.2	14.9	17.5	6.6	9.9
70 °F	10.0	12.6	11.8	14.4	10.6	12.2	-	12.8	15.2	11.6	6.4	14.7
71 °F	8.8	10.3	13.0	11.0	4.2	9.1	6.7	7.1	12.2	13.1	16.2	14.3

Table 15. Energy Audit by Housing Type and Income Classification
(Mobile homes and single-family units only)
(Percentage of Households)

Energy audit	Housing Type by Income Classification							
	Total		Mobile home		Single-family detached		Single-family attached	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Energy audit performed in past year	2.2	3.8	5.1	3.2	2.0	3.9	-	2.9
REASONS FOR AUDIT								
High fuel bills								
Very important	88.1	69.0	100.0	71.2	84.5	67.3	100.0	-
Somewhat important	-	7.7	-	-	-	8.6	-	-
Not a reason	11.9	21.1	-	28.8	15.5	21.8	-	-
No answer	-	2.1	-	-	-	2.3	-	-
Home uncomfortable								
Very important	34.8	11.0	100.0	-	14.8	12.2	-	-
Somewhat important	-	15.8	-	25.3	-	11.9	79.1	-
Not a reason	65.2	65.1	-	53.1	85.2	68.1	20.9	-
No answer	-	8.1	-	21.6	-	7.8	-	-

Table 15. Continued.

Energy audit	Housing Type by Income Classification							
	Total		Mobile home		Single-family detached		Single-family attached	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Planning other improvements								
Very important	-	12.7	-	17.0	-	11.5	-	-
Somewhat important	-	9.2	-	-	-	9.8	-	-
Not a reason	100.0	70.0	100.0	61.4	100.0	71.6	100	78.4
No answer	-	8.1	-	21.6	-	7.8	-	21.6
Friends/neighbors recommended it								
Very important	-	6.5	-	-	-	7.2	-	-
Somewhat important	-	13.7	-	-	-	14.4	-	14.4
Not a reason	100.0	72.5	100.0	78.4	100.0	71.4	-	85.6
No answer	-	7.4	-	21.6	-	7.0	-	-
Audit was a bargain								
Very important	-	31.1	-	17.0	-	33.2	-	6.9
Somewhat important	-	11.3	-	25.3	-	11.1	-	-
Not a reason	100.0	49.6	100.0	36.1	100.0	48.9	-	93.1
No answer	-	8.1	-	21.6	-	7.8	-	-

Table 15. Continued.

Energy audit	Housing Type by Income Classification							
	Total		Mobile home		Single-family detached		Single-family attached	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
REASONS FOR NOT REQUESTING ENERGY AUDIT	*				*			
Utility doesn't offer energy audits	4.5	3.4	11.8	3.1	3.3	3.6	8.6	1.4
Have enough energy conservation items	8.4	12.8	9.0	6.5	8.2	13.6	10.9	6.8
Don't need outside advice	12.5	13.3	8.4	16.8	11.4	13.0	32.4	14.3
Audit costs too expensive	6.9	3.2	5.7	6.2	7.0	2.9	7.5	3.7
Planning on moving soon	0.6	0.7	6.2	1.2	-	0.7	-	-
Just moved in	2.0	4.2	-	4.4	1.7	4.2	9.2	4.4
Renting residence	9.0	6.8	15.2	6.3	8.4	6.3	7.7	14.7
Audit not worthwhile	5.9	6.6	9.8	3.7	6.0	6.9	-	4.5
Never heard about it	44.2	37.6	33.8	44.4	47.1	37.0	23.5	39.9
Had prior audit	0.6	1.8	-	0.5	0.7	2.0	-	0.5
Never thought of it	4.1	7.3	-	6.6	4.9	7.4	-	6.0
Planning to do it	0.4	1.3	-	-	0.5	1.3	-	2.5
Other reasons	0.3	0.3	-	-	0.3	0.4	-	1.2
No answer	0.5	0.4	-	0.2	0.5	0.5	-	0.2

*Significant at 0.05 level using Chi-square test

low-income groups, particularly in mobile homes, and to a lesser extent, in single-family attached homes. Planning other improvements, recommendations by friends or neighbors, and the minimal cost of the audit were not considered to be important reasons by both the poor and non-poor.

For these households not receiving an audit, a list of possible reasons for not participating in an audit was presented to them. The most common reason for not requesting an audit for both the poor and non-poor was that they had never heard about audits (44% and 38%, respectively) (Table 15). About 13% of both income groups also indicated that they did not want an audit because they didn't need outside advice. There is a statistically significant difference between the two income groups, especially in single-family detached homes. In these homes, the non-poor are more likely to be recent occupants, have enough energy conservation measures, have had a previous audit, or have never thought about getting an audit. In contrast, the poor are more likely to renters, think that the audit costs are too expensive, or have never heard about an audit.

Energy Conservation Improvements

Respondents were asked a series of questions about specific energy conservation improvements taken since 1980 (Table 16). Over 20% of the non-poor added caulking and weatherstripping to their home; over 10% installed plastic sheets over windows, and insulated their roofs and ceilings; and over 5% placed insulation around their hot water tank and pipes, added shutters, drapes, or reflective film around their windows, insulated their walls, or added a woodburning stove. In comparison, over 10% of the poor added caulking and weatherstripping to their home, and over 5% insulated their roof/ceiling, or installed plastic sheets over windows. The poor and non-poor were alike in their energy conservation improvements taken since 1980, although there are some statistically significant differences between the two income groups: the non-poor are more likely to have installed closeable shutters, insulating draps, and reflective film, and added caulking and weatherstripping; these differences remain statistically significant in only single-family detached houses. In summary, the poor have been less active in installing energy conservation improvements than the non-poor since 1980.

Energy Consumption

In 1982-83, the poor's annual electricity consumption of 10 mBtu (million Btu) per household was less than the non-poor's consumption of 26 mBtu per household, and this difference is statistically significant (Table 17).* When housing type is controlled for, the difference is no longer statistically significant; however, the non-poor continue to use more electricity than their counterparts in all house types. The non-poor's annual consumption of piped natural gas is also greater compared to the poor: 78 mBtu per household and 72 mBtu per household,

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*All Fuels were transformed into Btus (British thermal units) by DOE [9].

Table 16. Energy Conservation Improvements/Installations Since September 1980 by Housing Type and Income Classification
Mobile homes and single-family units only
(Percentage of Households)

Conservation improvements	Housing Type by Income Classification							
	Total		Mobile home		Single-family detached		Single-family attached	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Add clock thermostat	0.8	3.8	-	2.0	1.0	3.8	-	5.1
Flame retention head burner added	1.1	1.0	-	0.9	1.3	0.9	-	1.2
Automatic flue door added	-	1.7	-	0.2	-	1.9	-	0.6
Spark ignition added	0.5	2.4	-	2.3	0.6	2.4	-	2.5
Insulation around heating and/or cooling ducts	1.5	2.8	-	5.4	0.7	2.7	14.0	2.0
Insulation around the hot water and/or cooling pipes	-	5.1	-	6.3	3.7	5.2	14.0	3.6
Insulation around the hot water heater	4.7	7.9	5.5	7.2	5.5	7.8	-	9.4
Closeable shutters, insulating drapes, reflective film added	1.3*	7.5	4.1	9.4	0.8*	7.1	2.6	9.0

*Significant at 0 05 level using Chi-square test

Table 16. Continued.

Conservation improvements	Housing Type by Income Classification							
	Total		Mobile home		Single-family detached		Single-family attached	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Plastic sheets added over windows or other openings	9.9	13.7	16.4	17.9	9.8	13.5	-	11.7
Caulking added	13.5*	28.6	8.5	13.7	14.6*	29.8	21.2	25.6
Weatherstripping around windows or doors	12.3*	21.4	7.8	16.4	10.0*	21.8	49.4	21.8
Heat pump added	-	0.6	-	0.4	-	0.7	-	-
Woodburning stove added	3.4	5.8	-	7.1	4.0	6.1	-	1.8
Roof/ceiling insulated	6.3	12.6	5.1	8.6	6.9	12.8	-	12.5
Outside walls insulated	2.5	5.8	-	3.0	3.0	6.3	-	2.8
Floor insulated	1.2	4.2	-	3.0	0.7	5.0	10.9	2.9

*Significant at 0 05 level using Chi-square test

Table 17. Average Annual Fuel Use by Housing Type and Income Classification
(Million Btu per household)
(1982-83)

Fuel use	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
(1) Electricity	20**	26	29*	30	23*	34	17*	26	14*	21	19*	22
(2) Piped gas	72**	78	78	66	88	102	92	94	59	78	42	53
(3) Fuel oil	86	69	73	32	75	77	100	74	90	87	94	82
(4) Lpg	20	41	13	36	35	43	62	40	2	21		64
Total (1&2&3&4)	86**	106	71	72	95	114	106	112	86	100	65	74

*Significant at 0 05 level using Analysis of Variance (ANOVA) test.

**Significant at 0 05 level using ONEWAY Analysis of Variance (ANOVA) test.

respectively. This difference is statistically significant and remains so after controlling for house type. The exception to the above trend is that the poor use more natural gas in mobile homes than the non-poor.

In contrast to the above fuels, the poor use more fuel oil (86 mBtu per household) than the non-poor (69 mBtu per household), but this difference is not statistically significant. However, when house type is controlled for, differences between the two income groups are statistically significant for all house types: the poor have higher consumption of fuel oil in all house types. However, the non-poor consume more liquid petroleum gas (lpg) than the poor: 41 mBtu per household and 20 mBtu per household, respectively, but this difference is not statistically significant. The poor use more lpg in single-family attached buildings and buildings with 2-4 units, but use less lpg in the other house types (no statistically significant differences).

We calculated total fuel consumption for both poor and non-poor households by adding the consumption of the four fuel types described above. For total consumption, non-poor households consume 22% more energy than poor households (105 mBtu and 86 mBtu, respectively), and this difference is statistically significant. When taking house type in to account, the differences between the two income groups are not statistically significant.

Because we thought energy consumption might be strongly affected by the size of the home, we divided fuel consumption by square footage of the home (Table 18) [7]. The poor have a greater (22% more) total consumption per square foot than the non-poor (0.089 mBtu/ft^2 per household and 0.073 mBtu/ft^2 per household, respectively), and this difference is statistically significant for all households, but the statistical difference disappears when house type is taken into account. For individual fuels, the poor and non-poor consume the same amount (mBtu per square foot per household) of electricity and lpg, but the poor use significantly more piped natural gas and fuel oil than their counterparts. When house type is taken into account, there is a statistically significant difference between the two income groups in electricity consumption and natural gas, however, the relationship is not consistent.

Energy Expenditures

In 1982-83, the non-poor paid $541 per household for their annual electricity consumption while the poor paid $424 per household (Table 19). This difference is statistically significant, and when house type is controlled for, the differences between the two income groups continues to be statistically significant. For piped natural gas, the non-poor spend more than the poor ($460 per household and $419 per household, respectively), and this difference is statistically significant. However, the differences are no longer statistically significant after accounting for house type.

In contrast to the above fuels, the poor pay more for fuel oil than the non-poor ($733 per household and $586 per household, respectively), but the difference is not statistically significant, even after controlling for house type. For lpg, the non-poor pay more than the

Table 18. Average Annual Fuel Use Per Home Area by Housing Type and Income Classification (Million Btu/ft^2 per household) (1982-83)

Fuel use	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
(1) Electricity	0.022	0.021	0.042*	0.036	0.017*	0.019	0.013*	0.017	0.016*	0.021	0.032*	0.029
(2) Piped gas	0.072**	0.062	0.102*	0.076	0.067*	0.054	0.050*	0.054	0.076*	0.081	0.073*	0.073
(3) Fuel oil	0.086**	0.051	0.152	0.045	0.049	0.033	0.049	0.043	0.104	0.076	0.158	0.118
(4) Lpg	0.030	0.032	0.032	0.048	0.029	0.028	0.045	0.029	0.001	0.023		0.084
Total (1&2&3&4)	0.089**	0.073	0.129	0.089	0.071	0.061	0.063	0.067	0.106	0.101	0.112	0.103

*Significant at 0.05 level using Analysis of Variance (ANOVA) test

**Significant at 0.05 level using ONEWAY Analysis of Variance (ANOVA) test

Table 19. Average Estimated Cost of Fuel Use by Housing Type and Income Classification
(Dollars per household)
(1982-83)

Fuel use	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
(1) Electricity	424**	541	549*	563	442*	647	414*	563	296*	467	419*	467
(2) Piped gas	419**	460	395	320	467	554	599	609	363	484	272	334
(3) Fuel oil	733	586	631	281	647	598	849	626	750	731	787	694
(4) Lpg	194	391	151	339	329	398	456	415	35	245	-	558
Total (1&2&3&4)	852**	1,068	822	867	904	1,137	1,034	1,151	796	996	746	833

*Significant at 0.05 level using Analysis of Variance (ANOVA) test.

**Significant at 0.05 level using ONEWAY Analysis of Variance (ANOVA) test.

Table 20. Average Estimated Cost of Fuel Use Per Home Area by Housing Type and Income Classification (Dollars/ft^2 per household) (1982-83)

Fuel use	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
(1) Electricity	0.45**	0.42	0.82*	0.68	0.34*	0.36	0.31*	0.36	0.35*	0.47	0.71*	0.63
(2) Piped gas	0.42**	0.36	0.80*	0.38	0.36*	0.29	0.32*	0.34	0.46*	0.50	0.48*	0.48
(3) Fuel oil	0.74**	0.43	1.31	0.39	0.43	0.28	0.42	0.36	0.87	0.64	1.33	0.99
(4) Lpg	0.30	0.31	0.37	0.46	0.29	0.26	0.40	0.31	0.02	0.27	-	0.73
Total (1&2&3&4)	0.91**	0.76	1.39*	1.09	0.68*	0.62	0.66*	0.69	0.97*	1.00	1.28*	1.16

*Significant at 0 05 level using Analysis of Variance (ANOVA) test

**Significant at 0 05 level using ONEWAY Analysis of Variance (ANOVA) test

poor ($391 per household, respectively, and the only exception in the house types is for single-family attached where the poor pay $456 per household and the non-poor pay $415 per household. However, none of the lpg differences are statistically significant.

We calculated total fuel expenditures for both poor and non-poor households by adding the expenditures of the four fuel types described above. The non-poor spent 25% more than the poor in their total annual fuel expenditures ($1,068 per household and $852 per household, respectively), and this difference is statistically significant. When house type is taken into account, the differences in total expenditures are not statistically significant.

As in the previous section on energy consumption, we divided fuel expenditures by square footage of the home (Table 20). The poor spent 20% more dollars per square foot than the non-poor. This difference is statistically significant, and the differences between the two income groups in each housing type are statistically significant. For individual fuels, the poor spend more money per square foot on electricity, piped natural gas, and fuel oil than the non-poor (all statistically significant differences).

Energy Burden

The percentage of income spent on residential energy (the "energy burden") was calculated by taking each household's total energy expenditures for 1982-83 and dividing that by the family's income in 1983. Because RECS collects income data in categories (i.e., a family's income is known only by a range), we used category mid-points when dividing expenditures by income. For example, $6,000 was used for each household in the category $5,000 to $6,999 (Table 21). Thus, the energy burden experienced by the households is a "crude" indicator of how much an impact energy expenditures has on their livelihood.

The energy burden is significantly higher for the poor than for the non-poor for all households and for all regions of the country (Table 22). The average energy burden is 24% for the poor

Table 21. Assigned Income Values

Household Income (1983)	Assigned Value
Less than $5,000	$2,500
$5,000 - $6,999	$6,000
$7,000 - $7,999	$7,500
$8,000 - $9,999	$9,000
$10,000 - $11,999	$11,000
$12,000 - $14,999	$13,500
$15,000 - $16,999	$16,000
$17,000 - $19,999	$18,500
$20,000 - $24,999	$22,500
$25,000 - $34,999	$30,000
$35,000 or more	$50,000

versus 7% for the non-poor, and the poor's energy burden ranges from a low of 16% in the West to a high of 33% in the Northeast. When house type is taken into account, the impact of house type is not statistically significant except in the West.

Determinants of Energy Consumption and Energy Burden

There is a considerable amount of variation in energy consumption and energy burden among poor and non-poor households, and it is important to try to explain this variation for both income groups and to identify the significant determinants of energy consumption and energy burden. Similar to a previous analysis of an earlier RECS data base, we examine energy consumption as a function of its capital stock (the structure in which people live and the energy-using equipment they own), the energy intensiveness of that stock, and the ways in which the household uses that stock [12]. These factors are also influenced by climate and demographic characteristics of the household which are also included in our analysis. We structured our analysis of energy consumption and energy burden in ten analytical blocks, similar to the organization of the results presented in this paper: (1) demographic characteristics (e.g., family size, sex, age, education, and marital status of head of household, home ownership, and number of adults, children, and teenagers); (2) fuels and equipment (e.g., heating fuels, hot water fuels, heating and cooling equipment, and wood-related equipment and usage); (3) appliance saturation; (4) thermal integrity of home (e.g., wall and ceiling insulation); (5) thermostat settings for three conditions (described above) and temperature regulation (e.g., opening and closing windows and doors); (6) energy conservation improvements (e.g, adding time clocks and water heater insulation, or buying a new water heater or air-conditioner); (7) heating problems encountered in past year (e.g., power outages); (8) sources of financial assistance for paying energy bills (e.g., vouchers and governmental assistance); (9) income sources (e.g., wages, social security, and food stamps); and (10) house characteristics (e.g., house type, total floor area, area of heated space, age of home, regional location, and number of heating and cooling degree days (at base $65^{\circ}F$)). Dummy variables were used in many cases (e.g., type of heating equipment, type of water heating fuel, and marital status). Fuel prices were not used in these models because marginal fuel prices were not available, and average fuel prices could only be calculated by dividing total fuel consumption by total fuel expenditures, and this product would be highly colinear with the dependent variables used in our analyses. The level of significance used for including independent variables in the equations was set at 0.05.

We developed separate regression equations for the poor and non-poor, and two types of dependent variables were used (untransformed and transformed (the natural log)). The model using the logarithmic transformation of dependent variable was used in order to correct some of the violations in the assumptions used in conducting multiple regression analysis.* This

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* For example, the variance of the differences (errors) between estimated and actual energy consumption was not constant (the heteroscedasticity problem) when the untransformed dependent variable was used. This problem disappeared when the logarithmic form was used.

transformation usually resulted in better fits of the regression equations. We first ran separate regression equations on the logarithmic form of the dependent variable in each of the ten blocks for the poor and non-poor. The statistically significant independent variables resulting from these analyses were placed together in a total of four equations for estimating total energy consumption and energy burden for the poor and for the non-poor. Ten independent variables were statistically significant in explaining one-half (the multiple correlation coefficient (R^2) was 0.50) of the variation in total energy consumption for poor households when the logarithmic form of the dependent variable was used (Table 23, Model I). These variables included the type of principal home heating fuel (electricity or fuel oil), type of hot water fuel (natural gas or fuel oil), type of home heating equipment (wood or coal stove, or fireplace), use of an automatic clotheswasher, number of people in the household, the area of the home (heated and unheated areas), and whether the household was located in the Northcentral region of the U.S.

Because of the difficulty in interpreting logarthmic dependent variables, the statistically significant independent variables (and their associated dummy variables, where appropriate) were placed in a multiple regression equation where the dependent variable was untransformed (Table 23, Model II). The amount of variation in total consumption explained was 50%, and many of the variables from the first model remain statistically significant.

We conducted a similar analysis for the non-poor and obtained a larger number (19) of statistically significant variables in determining 57% of the variation in total energy consumption (Table 24, Model I). These variables included type of hot water fuel (natural gas, fuel oil, lpg, and electricity), type of home heating equipment (wood or coal stove, fireplace, electric wall units, heat pump, and pipeless furnace), use of an automatic clotheswasher, number of window/wall air-conditioners, presence of a thermostat, number of people in the household, the heated area of the home, the number of rooms in a home, the age of the house, the number of heating degree days, and the location of the home (Northcentral or South region).. When these variables (and their associated dummy variables, where appropriate) were placed in a multiple regression equation where the dependent variable was untransformed (Table 24, Model II), the amount of variation in total energy consumption was reduced to 51%.

We conducted a similar type of analysis for poor and non-poor in explaining the variation in the total energy burden, and encountered different levels of success for the two income groups. (Table 25). For the non-poor, we were unable to create an equation with any statistically significant variables, and, therefore, no results are presented.* For the poor, we were able to explain 53% of the variation in total energy burden when the logarithmic form of the dependent variable was used (Table 25, Model I). The thirteen statistically significant

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* In each of the blocks analyzed, statistically significant variables were discovered; however, when these variables were combined, their statistical significance disappeared.

Table 22. Percentage of Income Spent on Household Energy
(In percent)

Region	Housing Type by Income Classification											
	Total		Mobile home		Single-family detached		Single-family attached		Buildings with 2-4 units		Buildings with 5 or more units	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
All regions	24**	7	23	7	23	6	28	9	25	9	24	6
Northeast	33**	9	40	9	32	8	31	12	32	11	33	8
Northcentral	24**	7	19	6	26	7	38	7	28	10	20	6
South	23**	7	21	7	23	7	-	7	20	7	26	7
West	16**	4	23*	5	16*	4	11*	5	17*	4	13*	4

*Significant at 0 05 level using Analysis of Variance (ANOVA) test

**Significant at 0.05 level using ONEWAY Analysis of Variance (ANOVA) test

Table 23. Determinants of Energy Consumption for Poor Households

I. Dependent variable = log (total energy consumption (mBtu))

* Main home heating fuel is electricity
* Main home heating fuel is fuel oil
* Main hot water fuel is natural gas
* Main hot water fuel is fuel oil
* Main home heating equipment is a wood or coal stove
* Main home heating equipment is a fireplace
* Use an automatic clotheswasher
* Number of people in household
* Area of home
* Live in the Northcentral region

* Significant at the 0.05 level

Adjusted R^2 = 0.50

II. Dependent variable = total energy consumption (mBtu)

	Regression coefficient (b)
Main home heating fuel is natural gas	14.90
Main home heating fuel is lpg	-0.34
* Main home heating fuel is fuel oil	33.32
Main home heating fuel is electricity	-6.92
* Main hot water fuel is natural gas	42.55
* Main hot water fuel is lpg	35.91
* Main hot water fuel is fuel oil	53.22
Main hot water fuel is electricity	24.29
Main home heating equipment is hot water pipe	1.52
Main home heating equipment is radiator	5.04
Main home heating equipment is central warm air	9.05
Main home heating equipment is heat pump	13.73
Main home heating equipment is electric wall unit	4.86
Main home heating equipment is pipeless furnace	12.04
Main home heating equipment is gas or oil heater	8.46
Main home heating equipment is wood or coal stove	-24.16
Main home heating equipment is fireplace	-0.78
* Use an automatic clotheswasher	8.10
* Number of people in household	6.63
* Area of home	0.02
Live in the Northeast region	9.87
* Live in the Northcentral region	20.31
Live in the South region	5.85
Constant	-19.15

* Significant at the 0.05 level

Adjusted R^2 = 0.50

Table 24. Determinants of Energy Consumption for Non-poor Households

I. Dependent variable = log (total energy consumption (mBtu))

* Main hot water fuel is natural gas
* Main hot water fuel is fuel oil
* Main hot water fuel is lpg
* Main hot water fuel is electricity
* Main home heating equipment is a wood or coal stove
* Main home heating equipment is a fireplace
* Main home heating equipment are electric wall units
* Main home heating equipment is an heat pump
* Main home heating equipment is a pipeless furnace
* Use an automatic clotheswasher
* Number of window/wall air-conditioners
* Thermostat is present
* Number of people in household
* Heated area of home
* Number of rooms in home
* Age of house
* Live in the Northcentral region
* Live in the South region
* Number of heating degree days

* Significant at the 0.05 level

Adjusted R^2 = 0.57

Table 24 continued. Determinants of Energy Consumption for Non-poor Households

II. Dependent variable = total energy consumption (mBtu)

	Regression coefficient (b)
* Main hot water fuel is natural gas	54.76
* Main hot water fuel is lpg	36.43
* Main hot water fuel is fuel oil	54.84
* Main hot water fuel is electricity	28.66
Main home heating equipment is hot water pipe	20.77
* Main home heating equipment is radiator	27.02
* Main home heating equipment is central warm air	18.39
Main home heating equipment is heat pump	-1.31
Main home heating equipment is electric wall unit	-4.60
Main home heating equipment is pipeless furnace	7.01
Main home heating equipment is gas or oil heater	17.40
* Main home heating equipment is wood or coal stove	-32.50
Main home heating equipment is fireplace	-1.52
* Use an automatic clotheswasher	6.55
* Number of window/wall air-conditioners	3.55
* Thermostat is present	9.77
* Number of people in household	5.35
* Heated area of home	0.02
* Number of rooms in home	5.10
* Age of house	-2.73
Live in the Northeast region	2.50
* Live in the Northcentral region	9.45
* Live in the South region	8.23
* Number of heating degree days	0.004
Constant	49.95

* Significant at the 0.05 level

Adjusted $R^2 = 0.51$

Table 25. Determinants of Energy Burden for Poor Households

I. Dependent variable = log (total energy burden (%))

* Main home heating fuel is fuel oil
* Main home heating equipment is wood or coal stove
* Have central air-conditioning
* Bought a new heating system since Sept. 1980
* Added floor insulation since Sept. 1980
* Married
* Number of people in household
* Received income from AFDC
* Age of respondent
* Live in the Northeast region
* Live in the Northcentral region
* Live in the South region
* Number of heating degree days

* Significant at the 0.05 level

Adjusted $R^2 = 0.53$

Table 25 continued. Determinants of Energy Burden for Poor Households

II. Dependent variable = total energy burden (%)

	Regression coefficient (b)
Main home heating fuel is natural gas	-0.05
Main home heating fuel is lpg	-0.03
Main home heating fuel is fuel oil	0.06
Main home heating fuel is electricity	-0.08
Main home heating equipment is hot water pipe	-0.05
Main home heating equipment is radiator	-0.02
Main home heating equipment is central warm air	0.01
Main home heating equipment is heat pump	0.04
Main home heating equipment is electric wall unit	0.001
Main home heating equipment is pipeless furnace	-0.01
Main home heating equipment is gas or oil heater	-0.002
Main home heating equipment is wood or coal stove	-0.10
Main home heating equipment is fireplace	-0.01
* Have central air-conditioning	0.06
Bought a new heating system since Sept. 1980	-0.001
* Added floor insulation since Sept. 1980	0.23
* Married	-0.18
* Divorced	-0.06
* Widowed	-0.06
Number of people in household	
* Received income from AFDC	-0.11
* Age of respondent	0.002
* Live in the Northeast region	0.10
Live in the Northcentral region	0.04
* Live in the South region	0.05
Number of heating degree days	
Constant	0.20

* Significant at the 0.05 level

Adjusted $R^2 = 0.42$

variables included main home heating fuel (fuel oil), main home heating equipment (wood or coal stove), use of central air-conditioning, installation of a new heating system since 1980, addition of floor insulation since 1980, whether person was married, number of people in household, whether they received income from AFDC, the age of the respondent, the location of the home (Northeast, Northcentral, or South region), and the number of heating degree days. When these variables (and their associated dummy variables, where appropriate) were included in the regression equation with the untransformed dependent variable, the amount of variation explain dropped to 42%, and some of the independent variables lossed their statistical significance (Table 25, Model II).

The equations developed here represent exploratory work and should be regarded as initial effort in using the RECS data. Additional analysis is likely to be fruitful by stratifying the data by region, housing type, primary heating fuel, etc. and developing separate equations for each stratum. Also, it would be useful if a measure of wood consumption (in mBtu) could be included in total consumption since 6-7% of both income groups ue wood as their primary heating fuel and an additional 9-24% use wood as a secondary heating fuel.

Because of time constraints and concern for maintaining a large sample size for poor households, we decided to use all the households in the RECS sample. However, we could have excluded cases if we were more stringent about the quality of the data or about certainresponses. For example, we could have dropped respondents: with mail questionnaire responses, whose main and secondary space fuels were imputed, who live in multi-family units, who were outliers on selected variables (e.g., energy use and floor area), who used wood as a primary heating fuel, whose energy costs were included in their rent or whose fuel consumption was estmated (rather than based on actual readings). If we had filtered the data in this manner and had a large enough sample size for low-income households, we would expect to explain a greater amount of variation in our dependent variables.

SUMMARY AND CONCLUSIONS

The principal objective of this study is to compared poor and non-poor households to see whether the two groups are similar or different with respect to energy consumption and expenditures, housing characteristics, and energy-related behavior. We based our study on an analysis of a national data base created by the U.S. Department of Energy, the 1982-83 Residential Energy Consumption Survey (RECS). We found a number of statistically significant (At the 0.05 level) differences between the two income groups, suggesting different approaches that might be taken for improving the targeting of energy conservation programs to low-income households. We've organized the following discussion of the results into eight sections: demographics, heating/cooling/water heating, other appliances, thermal integrity, energy conservation behavior, energy consumption, energy expenditures, and energy burden (Table 26).

Compared to the non-poor, the poor are mor likely to live in multi-family housing, reside in the South, rent their home, live in very old (pre-1940) housing stock, have smaller households,

Table 26. Summary Table of Significant Variables

	Total	Housing Type				
		Mobile home	Single-family detached	Single-family attached	Buildings with 2-4 units	Buildings with 5 or more units
Demographics						
Type of home	*					
Location (Region)	*		*			
Own/rent home	*	*				*
Age of home	*	*	*			
Number of people in home	*	*	*		*	*
Marital status	*	*	*	*	*	*
Race	*		*		*	
Education	*	*	*		*	*
Paid employment	*	*	*		*	*
Received SSI income	*		*			*
Received public aid	*		*	*		*
Received food stamps	*	*	*		*	*
Received social security	*	*	*		*	*
Received unemployment benefits	*		*		*	
Heating/Cooling/ Water Heating						
Main heating fuel		*	*			
Uses secondary heating	*		*			
Main heating equipment	*		*	*		
Uses secondary heating equip.	*		*			
Central air-conditioner	*		*	*		
Window air-conditioner	*		*	*	*	
Burned wood last year	*		*			
Main water heating fuel	*		*	*		
Have thermostat	*	*	*	*	*	*
Other Appliances						
Number of refrigrerators	*		*	*		
Number of ovens	*		*	*		
Electric range	*		*			
Gas range	*		*			
Automatic clothes washer	*	*	*	*		
Wringer clothes washer	*		*		*	*
Dishwasher	*		*		*	*
Electric clothes dryer	*		*		*	
Dehumidifier	*		*			
Humidifier	*		*			
Evaporative cooler	*					
Black and white TV					*	
Color TV	*		*		*	
Outdoor piped gas grill	*					
Outdoor lpg gas grill	*		*			

Table 30 continued. Summary Table of Significant Variables

	Total	Housing Type				
		Mobile home	Single-family detached	Single-family attached	Buildings with 2-4 units	Buildings with 5 or more units
Thermal Integrity						
Number of sliding glass storm doors	*		*			
Number of storm windows	*		*			
Wall insulation	*		*	*		
Attic/roof insulation	*					
Percent of roof insulated	*		*			
Conservation Behavior						
Turn heater on/off	*		*			
Adjust fuel use	*		*			
Installed shutters/drapes/film	*		*			
Added caulking	*		*			
Added weatherstripping	*		*			
Reasons for no audit	*		*			
Energy Consumption						
Electricity	*	*	*	*	*	*
Gas	*	*	*	*	*	*
Fuel oil	*					
Total	*					
Energy Expenditures						
Electricity	*	*	*	*	*	*
Gas	*	*	*	*	*	*
Fuel oil	*					
Total	*	*	*	*	*	*
Energy Burden						
All regions	*					
Northeast	*					
Northcentral	*					
South	*					
West	*	*	*	*	*	*

be single, be black, have less education, and be more dependent on outside sources of financial assistance. Although there is no consistent relationship in the interaction between housing type and income for these demographic variables, the type of housing does significantly impact on all of these variables.

Compared to the non-poor, the poor tend to have different main and secondary heating equipment, have more window/wall cooling units, and use different fuels to heat water. On the other hand, the poor are less likely to use secondary heating, have central air-conditioning, burn wood, and have a thermostat to regulate the temperature in their homes. House type does have a significant impact on all of these variables: in particular, the main heating fuel used by the poor is statistically different than the non-poor mobile homes and single-family detached housing; however, when house type is not accounted for, differences between the poor and non-poor are not statistically significant. The two income groups are alike in the fuel used for air-conditioning (electricity), the number of window air-conditioners (1-2), the amount of wood burned in the previous year, and in their use of secondary water heating (1-2%).

The poor are more likely to have gas ranges and wringer clothes washers than the non-poor. However, the poor are less likely to have more than one refrigerator or oven, electric ranges, automatic clothes washers, dishwashers, electric or gas clothes dryers, dehumidifiers, humidifiers, evaporative coolers, color televisions, outdoor piped gas grills, and outdoor lpg gas grills. House type has a significant impact on many of these variables (especially, in single-family detached housing).

Compared to the non-poor, the poor are more likely to have more than one storm window, but they are less likely to have more than one sliding glass storm door and insulation in their walls or attics. Also, the poor are less likely to have added caulking, weatherstripping, or window shutters and drapes. Poor households expressed different reasons than the non-poor for not having an energy audit: they are more likely to think that audit costs are too expensive, to have never heard about an audit, or to be renters. This was particularly true in single-family houses.

The poor used and spent less on electricity and natural gas than the non-poor. However, when these figures were standardized (divided by area of home), the poor used and spent more on energy than their counterparts. This was also true for total consumption and expenditures. In terms of total energy consumption (mBtu), the non-poor consumed 22% more energy than the poor, but in terms of total energy consumption per square foot (mBtu per ft^2), the poor consumed 22% more energy than the non poor. In terms of total energy expenditures, the non-poor spent 25% more dollars than the poor, but in terms of total energy expenditures per square foot, the poor spent 20% more dollars than the non-poor.

The percentage of income spent on energy was much higher for the poor (24%) than for the non-poor (7%), and this was evident in all regions of the country. In the West, house type did have an additional significant impact on energy burden.

Approximately half the variation in energy use in low-income households can be explained with a regression model that includes 10 independent variables. The key determinants of total energy consumption in low-income households are: the type of principal home heating fuel (electricity or fuel oil), type of hot water fuel (natural gas or fuel oil), type of home heating equipment (wood or coal stove, or fireplace), use of an automatic clotheswasher, number of people in the household, the area of the home (heated and unheated areas), and whether the household was located in the Northcentral region of the U.S.

Approximately half of the variation in energy burden for poor households can be explained with a regression model that includes 13 independent variables. The key determinants of energy burden in low-income households are: main home heating fuel (fuel oil), main home heating equipment (wood or coal stove), use of central air conditioning, installation of a new heating system since 1980, addition of floor insulation since 1980, whether person was married, number of people in household, whether they received income from AFDC, the age of the respondent, the location of the home (Northeast, Northcentral, or South region), and the number of heating degree days.

In conclusion, the energy burden of the poor is very large as energy costs account for almost one-quarter of their household income. However, energy conservation programs targeted to the key determinants affecting energy consumption and energy burden can help improve the economic and energetic situation of low-income households. For example, program resources might be focused on households with fuel oil as their main heating fuel, large households, and houses located in colder climates. Also, if audits are to continue as a primary mechanism in assisting low-income households, then the benefits of improved comfort, as a result of improved energy efficiency, should be emphasized to low-income households as part of the audit marketing process. Finally, the results presented in this paper are "snapshorts" taken over one period of time 1983-84). A longitudinal analysis of low-income households and their energy consumption and burden is needed to provide a more comprehensive and dynamic picture. This need will become ever more urgent if the cost of energy begins to escalate as it did in the 1970s.

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EFFECTS OF ENERGY SAVINGS ON HOUSEHOLD EXPENDITURES OF LOW-INCOME WEATHERIZATION PROGRAM PARTICIPANTS

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EFFECTS OF ENERGY SAVINGS ON HOUSEHOLD EXPENDITURES OF LOW-INCOME WEATHERIZATION PROGRAM PARTICIPANTS [1]

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INTRODUCTION AND OVERVIEW

The primary purpose of the Low-Income Weatherization Program (LIWAP) is to reduce the energy consumption of low-income households by providing materials and labor necessary to increase efficiency of heating and cooling in dwelling units. This has the effect of improving thermal comfort and healthful living conditions for program participants. A further effect of the induced energy savings is a shift in expenditure from energy to other household expenditure categories. The direction and magnitude of this effect has implications for examining the economic well-being of participating households, as well as analyzing broader macroeconomic effects, such as net energy consumption and employment impacts in affected economic sectors. [2]

The focus of this study is limited to estimating the change in consumption of goods and services, including energy, in budgets of LIWAP-eligible households. The estimates were derived using an average percentage of energy savings per household, applied to incomes of a national sample matched with LIWAP eligibility characteristics. The effective reduction in expenditure on energy for heating and cooling was estimated as a 13.4% income "gain", consistent with the national energy savings average attributed to the 1980-81 program by the U.S. Department of Energy (Peabody, 1984). A basis for estimating changes in expenditures resulting from the achieved savings was made by expanding the pre-weatherization used

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[1]Funded in part by Vermont Agricultural Experiment Station (Batch Project #370). Aggregation of Consumer Expenditure Survey data used in this study was completed under the direction of William Crown, Beller Graduate School, Brandeis University, Waltham, MA.

[2]For a more detailed discussion of economic effects, including those induced by program expenditures for labor and materials, see Walsh and Crown, 1986.

composition and level of expenditures of eligible households, using data from the 1980-81 Bureau of Labor Statistics' Consumer Expenditure Interview Survey (CEIS) (U.S. Department of Labor, 1985). Regression analysis was to estimate the marginal propensities to consume (MPC's) in broadly defined categories of expenditures, given post-weatherization savings.

This paper reports the detail of the methodology, including approaches taken to address data quality issues and presents highlights of the preliminary results. Limitations in interpretation of the findings are discussed, followed by some general conclusions drawn from the study.

METHODS

Data Sources and Household Sample Size

The Interview component of the 1980-81 Consumer Expenditure Survey conducted by the U. S. Department of Labor, Bureau of Labor Statistics, was used as the data source for baseline expenditures of LIWAP-eligible households. This Survey reports household income and expenditures classified by socio-economic variables and is the most detailed source of this information available. It covers over 500 expenditure categories collected quarterly from a sampling of 4950 households, mainly in urban areas. For purposes of this study, expenditures were aggregated into 21 commodities (see Table 1) and totaled to give annual expenditures.

Table 1. Aggregated Commodity Groups From Consumer Expenditure Interview Survey

1. Food
2. Alcoholic beverages
3. Total housing (includes categories 4-9)
4. Owned dwelling
5. Rented dwelling
6. Other lodging
7. Natural gas
8. Electricity
9. Fuel oil and other fuels
10. Apparel
11. Transportation
12. Health insurance
13. Medical services
14. Drugs and medical supplies
15. Entertainment

16. Personal care
17. Reading
18. Education
19. Tobacco and smoking
20. Miscellaneous
21. Personal insurance and pensions

The first step was to extract LIWAP-eligible households -- i.e., those having before-tax income less than or equal to 125% of the 1980 poverty thresholds (U.S. Department of Commerce, 1982). These income thresholds were based on sex and age of household head, family size, number of children under 18, and farm or nonfarm residence. (A farm household in the CEIS was defined as one with non-zero farm income.) This step resulted in a sample size of 1381 households. Other variables extracted from the CEIS data file were race of the household head, geographic region[3] and type of fuel used for heating and cooling.

The CEIS does not disaggregate household energy expenditures by type of use. Therefore, next step was to estimate pre-weatherization household expenditures for heating and/or cooling only. The Residential Energy Consumption Survey (RECS) (U.S. Department of Energy, 1982) provided average household expenditures for various fuels for heating and cooling for the 1980-81 period. For natural gas, LP gas, and fuel oil or kerosene, the RECS reports expenditures by main heating fuel and region; electricity expenditures are reported by main heating fuel, cooling fuel, and region. Expenditures for households with income under 125% of poverty level were for assumed for households from the CEIS data file for which region was unknown (i.e., "rural"). These figures were used to estimate what percent of a household's expenditures for natural gas, electricity, or other fuels was related to heating or cooling, based on region and fuel used for heating or cooling.

For example, within a region, the average electricity expenditure for households with electricity not as main heating fuel, and no air conditioning, was assumed to be a baseline expenditure for households in that region. Subtracting this value from the average electricity expenditure for households with electricity as main heating fuel and having air conditioning would yield an estimated expenditure for heating and cooling. This could then be expressed as a percent of the electricity expenditure for these households. Applying these percentages to the expenditure data from the CEIS yielded an estimated energy expenditure for heating and cooling for each household. This expenditure could be estimated for only 1075 households. The remaining households were missing either heating or cooling fuel, or fuel expenditures.

Some households had extremely high values for some expenditure categories. Regression diagnostics, including studentized residuals and Cook's distance, were examined to identify any cases which would be unduly influential in regression analysis (Belsey, et. al., 1980).

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[3]Region was unknown for rural households (population <75,000).

Eleven households which failed several of the tests were omitted, reducing the final sample size to 1064 households. A demographic breakdown is shown in Table 2.

Table 2. Demographic Variables of Households In Sample

Variable	N
Sex of Household Head	
Males	575
Females	489
Age of Household Head	
Less than 60	551
60 and over	513
Race of Household Head	
White	872
Non-white	192
Family Size	
1 person	342
2 persons	288
3 persons	138
4 persons	138
5 or more persons	158
Region	
Rural (less than 75,000)	157
Northeast	240
Midwest	255
South	278
West	134
TOTAL	1064

Estimation of Marginal Propensities to Consume

In order to estimate the impact of the LIWAP savings on consumer spending, it was necessary to model the relationship between spending and income, adjusting for demographic variables. Total expenditure was used as a proxy for income for two reasons. First, many CEIS respondents reported negative or zero before-tax income. Second, total expenditures may in fact be a better indicator of "permanent income," than income in a given year (Chen and Chu, 1982).

Ordinary Least Squares was used to regress expenditures for each of the 21 commodities on total expenditure, various demographic variables, and the interactions of the demographic variables with total expenditure. Accordingly, the model for the ith commodity is as follows:

$$Y_i = B_{i0} + B_{i1}X_1 + B_{i2}X_2 + \ldots + B_{i61}X_{61}$$

where,

Commodity i= 1, . . . 21

Y_i = Household expenditure for ith commodity

X_1 = Household total expenditure

X_2 = 1 if Household head female, 0 otherwise

X_3 = 1 if Household head aged 60 or more, 0 otherwise

X_4 = 1 if Household head non-white, 0 otherwise

X_5 = $\log_{10}$ family size

X_6 = 1 if Household in Northeast, 0 otherwise

X_7 = 1 if Household in Midwest, 0 otherwise

X_8 = 1 if Household in South, 0 otherwise

X_9 = 1 if Household in West, 0 otherwise

Variables X_{10} through X_{17} are interactions of total expenditure (X_1) with the eight demographic variables (X_2 through X_9), variables X_{18} through X_{39} are two-way interactions among the demographic variables, and variables X_{40} through X_{61} are three-way interactions of total expenditures with the demographic variables. The interactions were included to allow the relationship between expenditure and "income" to vary across demographic categories. The model was fit in a stepwise fashion, i.e., only those variables which contributed significantly (at .05 level) to the regression were entered into the model.

The marginal propensity to consume (MPC) for commodity i, (i.e. the change in expenditure for commodity i per unit change in "income") is the partial derivative of Y_i with respect to X_1. For example, the MPC for commodity i for a household with a female head of household, aged less than 60, white, with family size 2, living in the Northeast would be:

$B_{i1} + B_{i10} + B_{i13}\log(2) + B_{i14} + B_{i48}\log(2) + B_{i49} + B_{i58}\log(2)$

where B_{i14} is the coefficient of northeast Total Expenditure, B_{i48} the coefficient of Sex X $\log_{10}$(family size) X Total Expenditure, B_{i49} the coefficient of Sex X Northeast X Total Expenditure, and B_{i58} the coefficient of $\log_{10}$(family size) X Northeast X Total Expenditure (assuming all terms in the model). The MPC's sum to 1 over the 21 commodities, for each combination of the demographic variables.

Effect of LIWAP Savings on Spending Patterns

For each household, the average 13.4% estimated savings under the program (Peabody, 1984) was calculated using the previously estimated energy expenditure. The effect of this savings on the ith commodity was calculated as the product of the savings and the marginal propensity to consume the itn commodity.

RESULTS

Marginal Propensities to Consume

The MPC for each commodity was heavily dependent upon the demographic characteristics of the household (sex, age, and race of the household head; family size and region). Value ranges of MPC's for some commodity groups were more affected by these variables than others. The following are examples of these variations.

- Food ranged from .083 for a white household head living alone in the west, to .277 for a female, non-white, age 60 or over, with family size of seven, living in the West.

- Owned dwelling ranged from .024 for a nonwhite household head, age 60 or over, with a family size of five, not living in the south, to .245 for a white household head, age less than 60 with family size of seven, living in the South.

- Transportation ranged from .058 for a female, age less than 60, with family size of six, living in the South, to .545 for a female household head with family size of nine, living in the Midwest.

Average Estimated Savings and Increased Expenditures

The average estimated savings under the program for various household categories are shown in Table 3. The mean estimated savings for the 1064 households was $52.

The average increased expenditures for the 21 communities due to savings from the program are shown in Table 4. Most of the savings would be spent on transportation or categories of expenditures which comprise total housing. Expenditures on food, apparel and entertainment would also increase. The remaining categories would show little increase in expenditures.

Differences in increased expenditures for some of the major commodities by sex, age, race, and region are shown in Figures 1 through 4, respectively. For purposes of presentation clarity, medical services and drugs are combined, as are the three fuel commodities. Table 3. Mean Estimated LIWAP Savings by Demographic Variables

Table 3. Mean Estimated LIWAP Savings by Demographic Variables

Variables	Savings ($)
Sex of household head	
Males	57
Females	46
Age of household head	
Less than 60	54
60 and over	50
Race of household head	
White	55
Non-white	39
Family Size	
1 person	39
2 persons	55
3 persons	57
4 persons	64
5 or more persons	62
Region	
Rural (< 75,000)	43
Northeast	88
Midwest	50
South	45
West	17
ALL HOUSEHOLDS	$52

Some specific results shown in these figures are worthy of note. Figure 1 shows that the increase in expenditure for apparel, education and fuels does not differ between males and females, even though the expected savings is less for females. In Figure 2, it is evident that household heads age 60 and over would spend proportionately more on housing, medical services and fuels, but less on education. Figure 3 reveals that, despite lower estimated savings, nonwhites would spend more on apparel and proportionately more on fuels. Figure 4 shows that Midwesterners would spend more of their savings on transportation than program participants in other regions.

Figure 1. Mean Increase in Expenditure per Household Based on Mean Energy Savings By Sex of Household Head

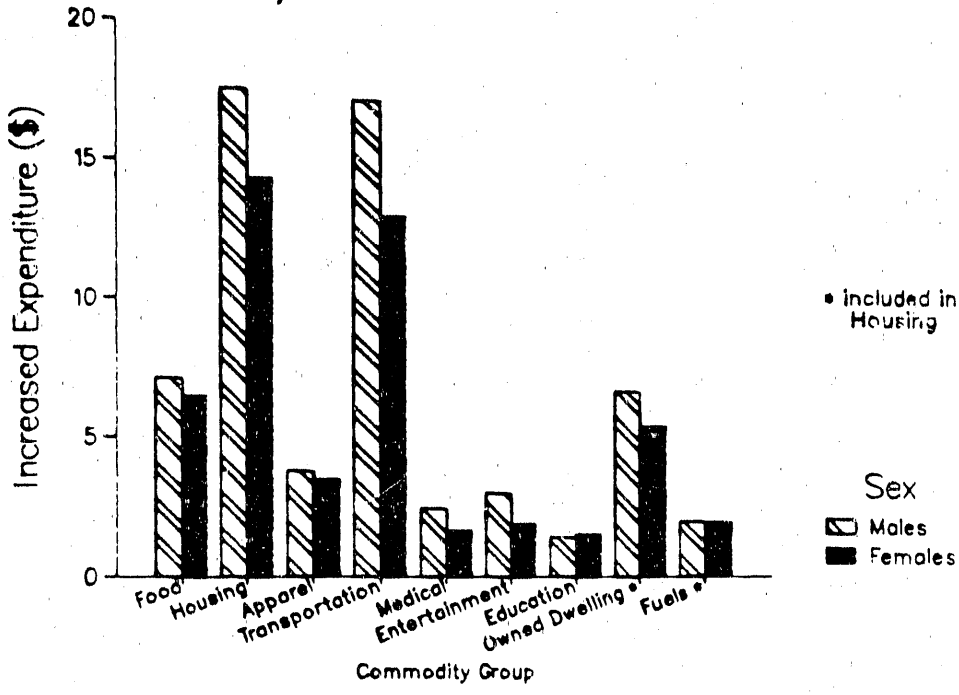


Figure 2. Mean Increase in Expenditure per Household Based on Mean Energy Savings By Age of Household Head

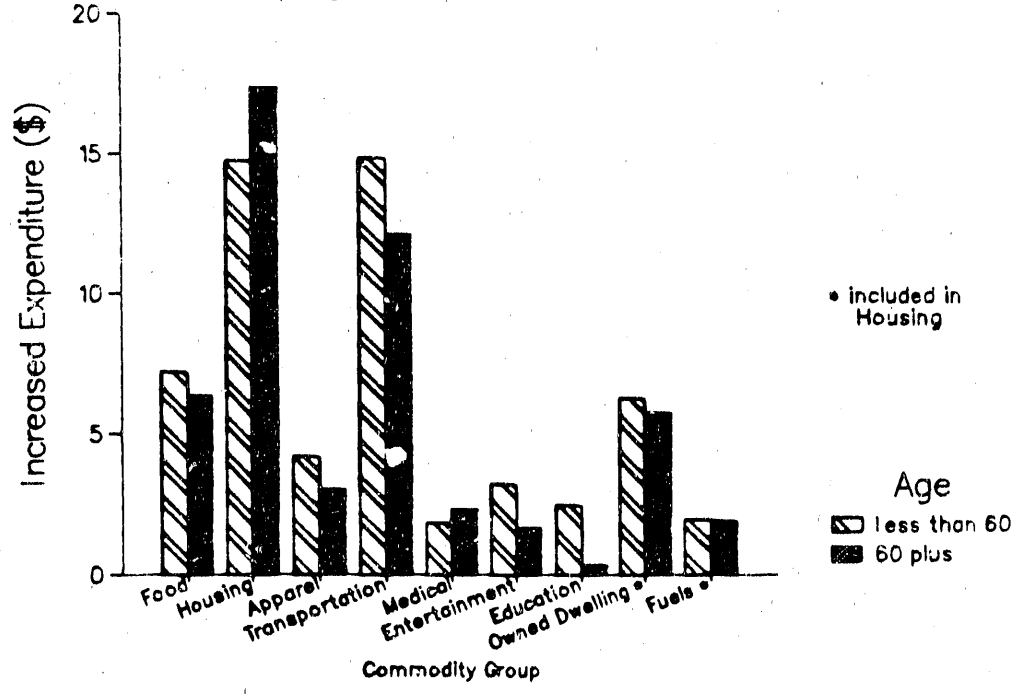


Figure 3. Mean Increase in Expenditure per Household Based on Mean Energy Savings By Race of Household Head

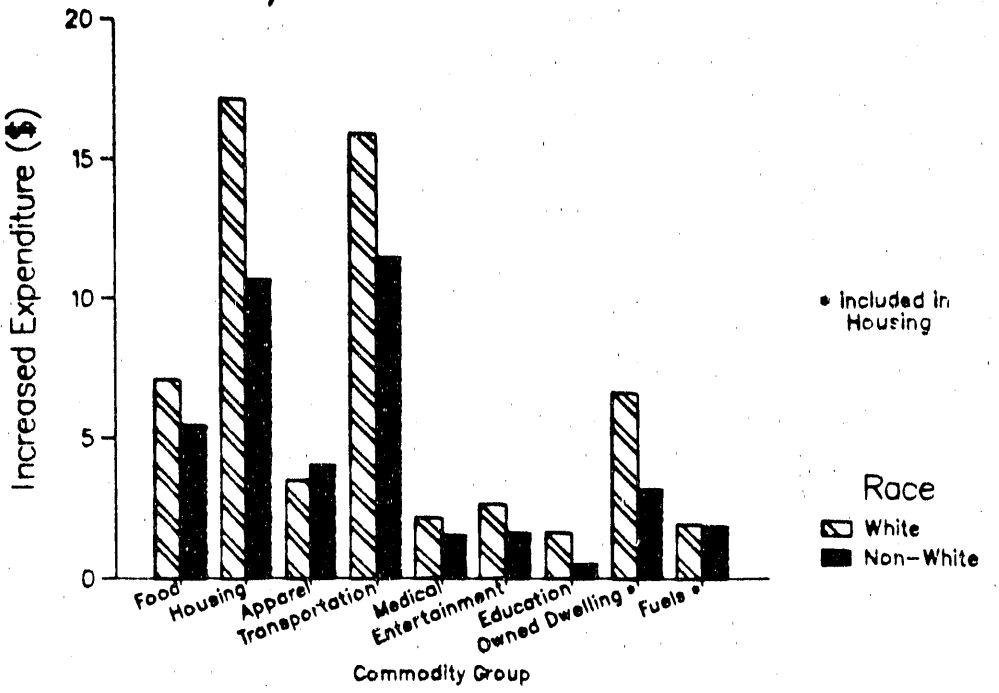


Figure 4. Mean Increase in Expenditure per Household Based on Mean Energy Savings By Region of Residence

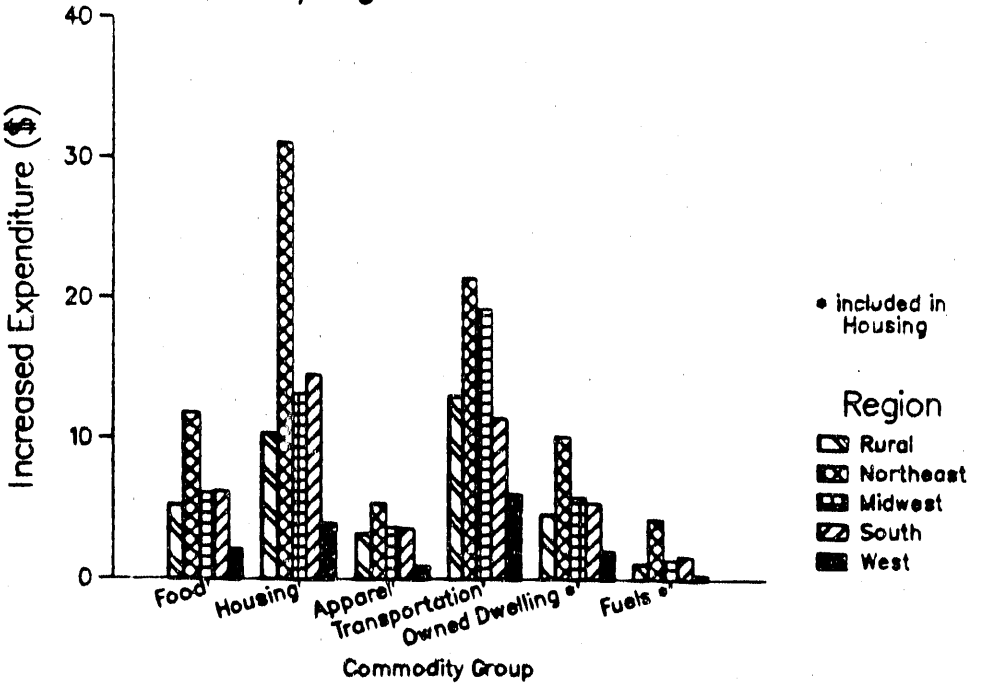


Table 4. Mean Increased Expenditure Due To LIWAP Savings

Commodity Group		Mean Increase ($)
1.	Food	6.82
2.	Alcoholic beverages	.82
3.	Total housing	16.01
4.	Owned dwelling	6.04
5.	Rented dwelling	.38
6.	Other Lodging	1.03
7.	Natural gas	.32
8.	Electricity	1.04
9.	Fuel oil and other fuels	.58
10.	Apparel	3.64
11.	Transportation	15.12
12.	Health insurance	.40
13.	Medical services	1.83
14.	Drugs and medical supplies	.24
15.	Entertainment	2.48
16.	Personal care	.75
17.	Reading	.41
18.	Education	1.45
19.	Tabacco and smoking	.07
20.	Miscellaneous	.86
21.	Personal insurance and persions	.70
TOTAL*		$52.00

*Total housing includes commodities 4 through 9.

DISCUSSION

As noted in the introductory section of this paper, the researchers view these results as preliminary; therefore, caution should be exercised in interpretation of the findings. Due to the nature of the data, some refinement in the methodology may be needed. Moreover, the research reported here is the first part of a continuing project and was conducted in such a way as to enable estimation of broader economic impacts. Some aspects of the results affected by these conditions are addressed below.

First, because of the high incidence of zero reporting in many categories of expenditures among the low-income CEIS respondents constituting the sample in this study, the Tobit model (Tobit, 1958) may be a more suitable technique than regression alone. As reported in the literature, household consumption data are among those which are characterized by observations clustered at zero and to which Tobit analysis is often applicable (Wagner, 1985). (An effort was attempted to incorporate Tobit in this preliminary manipulation of the data, but results were inconclusive.)

A second point also related to the CEIS data base is its reliance on respondents recall. It was recognized early in household energy expenditure analysis that the household's energy supplier is a more reliable source for this information. The Residential Energy Consumption Survey (RECS) of the U.S. Department of Energy uses this preferred method; however, inconsistencies between the RBCS and the CEIS precluded incorporating household energy expenditure data based on supplier records for purposes of this study.

Finally, it should be emphasized that the unit of reporting effects of energy savings is based on the 13.4% used, not on a per-dollar basis. This was intentional because of the researchers' plan for a follow-up study to use these results to estimate impacts on affected economic sectors. Accordingly, any interpretation of these results to a savings level other than 13.4% should take this fact into account.

CONCLUSIONS

In addition to their usefulness in conducting further analysis, these results may be viewed independently for their contribution to understanding the nature of the improved economic wellbeing of LIWAP participants. This study does not suggest that energy savings resulting from the program produces a change in households' level of living which differs from savings emanating from any other source. Its contribution lies in (a) recognizing that the socio-economic composition of households is an important determinant of shifts in expenditure when a change in income is realized and (b) targeting socio-economic characteristics of LIWAP-eligible households as a basis for estimating that change.

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PRELIMINARY FINDINGS ON THERMAL PERFORMANCE OF ZONE HEATING IN LOW-INCOME HOUSEHOLDS WITH PAYMENT TROUBLED UTILITY CUSTOMERS

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1. INTRODUCTION

A combination of economic, demographic and climatic factors have led to especially burdensome energy costs for low-income residents of Pennsylvania. This, in turn, has led to arreagages of more than $90 milllon per month for utilities, and an increasing demand for government assistance.

In response, the Commonwealth of Pennsylvania is exploring an innovative approach, the Critical Needs Weatherization Research Project (CNWRP), as an alternative to current weatherization and assistance programs. The project was developed by the Commonwealth

of Pennsylvania Governor's Energy Council with funding from the Pennsylvania Department of Public Welfare, the Gas Research Institute, Columbus Gas of Pennsylvania, and the Philadelphia Gas Works. The National Center for Apprpriate Technology is the prime contractor for the project.

The project is testing the effectiveness of a 40,000 Btu, zone, natural gas heater combined with "house doctor" infiltration control, ceiling insulation, and resident education to reduce energy costs. Data from comprehensive monitoring installations is being analyzed along with the observations of residents in project homes.

While data analysis is preliminary, the initial results are encouraging. Energy use is being analyzed based on whether normalized comparisons of heater and central furnace gas consumption. Based on preliminary data, the heaters appear to be using from 19 percent to 60 percent less gas to maintain acceptable comfort levels. Twenty-five homes are being studied, and of those, mid-way through the project, 10 participants prefer the zone heater to the central furnace, eight accept the zone heater with some qualifications, and seven prefer their central furnaces.

One important aspect of the project is the specific observations of the project participants, each with unique circumstances and needs. Their observations, after 3 months of the project, as well as early results of the technical monitoring, are presented in the following paper.

2. BACKGROUND

For more than a decade, the federal government has been addressing the special energy related needs of low-income people through two major programs. These two programs are now called the Low-Income Home Energy Assistance Program (LIHEAP), administered by the Department of Health and Human Services (HHS), and the Weatherization Assistance Program (WAP), administered by the Department of Energy (DOE).

2.1 low Income Home Energy Assistance Program (LIHEAP)

LIHEAP was established on a nationwide basis in 1975 under the Community Services Administratin (CSA) and was transferred to HHS in 1981 after CSA was abolished. It was designed to supplement other cash assistance programs in recognition of the critical impact that rising fuel costs were having on low-income people. LIHEAP eligibility has been expanded over the years to the point that currently households living within 150 percent of the federal proverty level can receive assistance. Under existing LIHEAP regulations, states can use up to 15 percent of their annual allocation to provide weatherization services.

2.2 Weatherization Assistance Program (WAP)

In 1975, Congress also authorized the CSA to operate the Emergency Energy Conservation Services Program. In 1976, the DOE began to operate its own Weatherization Assistance Program as authorized by the Energy Conservation and Production Act (ECPA). The DOE

WAP continued and expanded upon the CSA Weatherization Program until by 1979 DOE was the principal provider of weatherization funding. Under DOE, the WAP has grown both in terms of technical sophistication and number of dwelling units served. Current DOE regulations allow a state to make eligibility for weatherization consistent with LIHEAP. These regulations also permit a state to spend an average of $1,600 per dwelling unit on weatherization with 40 percent of the funding allocated for materials and 60 percent for labor and administration.

2.3 Penetration And Effectiveness

A 1984 study prepared by the National Consumer Law Center (NCLC) determined that LIHEAP had served about 6.9 million households, about 36 percent of those eligible nationally. 1 Well over one-half of the households participating in LIHEAP had incomes less than $6,000, and in 32 states the LIHEAP benefit covered less than 25 percent of a low-income household's energy bill. The need for LIHEAP is documented by another NCLC study of utility companies which estimsted that 1.8 million households lost their utility service in 1984. 2 Nationally, this survey found that the number of households in significant arrears increased by 21 percent from 1982 to 1984.

Federal funding for weatherization remained essentially constant from 1980 to 1986 at about $200 million per year. For 1987, weatherization funding was cut by nearly 40 percent, in part due to the availability of Oil Overcharge funding. During the first 7 years of the federal weatherization program, at most, about 8 percent of all eligible homes were weatherized. 3 It is likely that WAP penetration levels have remained low due to expanded criteria for eligibility in recent years. Utilities and other local nonprofit groups not associated with the federal WAP have also begun to offer weatherization programs in recent years. These programs have been growing in popularity as a supplement and partial replacement to the WAP. Notwithstanding a recent general decline in energy prices, low-income Americans come to depend more and more on government, utility and community assistance to acquire and continue energy services.

From an energy savings perspective, the various weatherization programs generally have not been as effective as anticipated. Engineering calculations, energy audits and carefully designed pilot/demonstration programs all indicate thst the weatherizatlon of low-income homes should provide substantial energy savings. For example, the National Bureau of Standards conducted a weatherization demonstration project in which building shell (ceiling, walls, etc.) and heating system retrofits were installed in over 200 low-income houses at 12 sites across the United States. 4 Those homes which received both building shell and heating system retrofits achieved an average of 41 percent reduction in space heating fuel consumption at an average cost of $1,862 per house (1980).

While most homes receiving assistance from the WAP typically were not weatherized to the levels of the NBS study, expectations of 20 to 25 percent energy savings from weatherization were common. Unfortunately, these expected savings were rarely realized in practice. In 1984, the U.S. Energy Information Administration (EIA) conducted an evaluation of the

WAP. 5 Their study indicated that the WAP saved almost 14 percent of a home's heating energy. A detailed evaluation conducted in 1984 of the Low Income Weatherization Program operated by the Wisconsin Department of Health and Social Services determined that overall heating energy savings due to weatherization were on the order of 6 to 10 percent. 6 Typical investments in the homes studied were about $700 per house for materials and $2,250 in total, including labor, program support and administration.

A 1986 study of the Minnesota Weatherization Program showed an average savings per house of 7.1 percent in total natural gas consumption for a sample of 221 houses. 7 The total program cost in Minnesota was $1,450 per house. Other studies from all over the United States indicatee savings from weatherization in the 5 to 15 percent range.

2.4 Alternative Approaches

The traditional weatherization approach relies on ceillng, wall and basement insulation, storm windows, and caulking and weatherstripping to reduce a home's overall heat loss, as well as various furnace retrofits and tuning to improve the efficiency of the home's heating system. As weatherization technology has grown in sophistication, several alternative approaches have also been developed. Two interesting alternatives are "house doctor" weatherization and the "warm room" approach.

"House doctor" weatherization is a high technolgy instrumented audit approach to infiltration reduction. Trained technicians use sophisticated equipment, such as blower doors (large calibrated fans used to pressurize and depressurize a home) and infrared cameras to detect heat loss pathways which are usually not identified or corrected in traditional home weatherization. "House doctor" weatherization has the potential to reduce air infiltration in homes to very low levels and often can save significant amounts of energy when applied to low-income people's homes.

The "warm room" or "comfort zone" approach to weatherization is to some degree a return to the space heating technology of years past. 8 With the "warm room" approach the temperature in less frequently used areas of a home is reduced while vital living areas are maintained at comfortable temperature levels. A "warm room" can be implemented by closing off hot air registers and turning off or covering radiators to zone the existing heating system, or by installing supplemental space heaters and turning down the central furnace. Doors are closed and/or insulating curtains are hung to separate the warm zone from the rest of the house. The warm zone may also be structurally altered by installing insulation, storm windows and other weatherization materials. When using this approach, care must be taken to ensure that pipes do not freeze or that other structural damage does not occur in the cool zone.

3. THE CRITICAL NEEDS WEATHERIZATION RESEARCH PROJECT

The Commonwealth of Pennsylvania, because it is a populous and cold climate state, is the second largest state recipient of both LIHEAP and WAP funding. In fiscal year 1986, Pennsylvania received 6.72 percent of the Federal LIHEAP allocation and 6.74 percent of the federal WAP funding. Pennsylvania also received 4.61 percent of the recently allocated Exxon oil overcharge funds. 9

Unfortunately, the need for low-income energy assistance still is substantially greater than the funding available to the Commonwealth of Pennsylvania. Pennsylvania was hit especially hard by the recession of the early 1980's and the collapse of basic industries such as steel and certain chemicals. In late 1985, Pennsylvania's unemployment level was still more than 1 percent higher than in 1979. 10 At an average of $1,145 per year for low-income Pennsylvania households, annual energy costs represent about 16 percent of a poverty level budget. 11 However, during cold winter months this percentage can increase to 30 to 40 percent or more. For an average month in 1982, over 940,000 Pennsylvania residential utility customers were behind on their bill payments. This arrearage represents, in total, over $90 million per month. Utility shutoffs in Pennsylvania average about 85,000 per year. 12

LIHEAP reaches about 35 percent of the estimated statutory eligible population in Pennsylvania and typically provides $200 to 300 per year in benefits. Pennsylvania has weatherized more than 200,000 homes, a substantially greater level than many other states. However, this still probably represents less than 20 percent of all eligible dwelling units. Also, there is no reason to believe that weatherization is saving any more energy in Pennsylvania than elsewhere in the United States. The combination of these factors has led the Commonwealth of Pennsylvsnia to seek other innovative approaches to reduce low-income energy costs.

One such innovative approach is the Critical Needs Weatherization Research Project (CNWRP). The CNWRP is sponsored by the Commonwealth of Pennsylvania Governor's Energy Council, The Gas Research Institute, Columbia Gas of Pennsylvania, and The Philadelphia Gas Works. The National Center for Appropriate Technology (NCAT) is the prime contractor for CNWRP. The CNWRP seeks to demonstrate the potential for reducing heating costs by using a high efficiency, natural gas space heater in place of a home's existing central furnace, coupled with "house doctor" infiltration control and ceiling isulation where less than R-19 is currently present. The project departs from the "warm room" concept in that the high efficiency heater provides heat to most areas of the house. The CNWRP also seeks to demonstrate that this approach can be used effectively to reduce utility bill arrearages from payment troubled residential customers. One of the most imprtant characteristics of the project is that its principal objective is the reduction of energy costs.

3.1 Experimental Design

Twenty-five low-income families, 15 in Pittsburgh and 10 in Phlladelphla, were selected to participate in the CNWRP. Potential participants were selected by local social service delivery agencies in consultation with the local gas utility. Selection criteria included a substantial utility bill arrearage along with a willingness to cooperate. The potential participants' homes were then screened by engineering personnel from NCAT to determine the feasibility of zone heater installation. The project was then described in detail to the residents who signed an access agreement and memorandum of understanding if they agreed finally to participate.

When the project began, each participating household was interviewed. The entry interview was used to obtain information about the household members, such as, how many people live in the home, their ages and how much time they spend at home. Changes in household status between the present and recent past were also identified. The entry interview also attempted to document the energy lifestyle of the participants at the start of the project and the household income and budget. The priority that participants placed on paying various bills was estimated using a Q-Sort technique. The participants were also provided with a calendar upon which they could record important facts related to home energy consumption, such as, changes in daily routine, parties, overnight guests, and other such occurrences.

A building characteristics survey consisting of a thermal characteristics audit, a connected load inventory and an indoor air quality survey was conducted on each participating home. The thermal characteristics audit was designed to collect information on the thermal resistance of building shell components to calculate an overall building heat loss coefficient (UA). The building characteristics audit also recorded use and occupancy information, floor plan and elevation sketches, and a description of mechanical and heating systems. The connected load inventory was used to gather data on all gas and electrical appliances, such as, nameplate information and estimated use patterns. Similar information was also collected for all other energy appliances on site, such as, wood stoves and kerosene heaters.

At the start of the project, before any structural modifications were made, indoor air quality was measured. This audit was designed to collect data on potential sources of air pollution within the participants' homes. Where appropriate, recommendations on how to improve the indoor air quality of the dwelling were offered. Since the project involved the installation of a new combustlon device, a nitrogen dioxide (NO^2) sensor was installed in the kitchen of each dwelling for approximately one week at the start of the project to document current levels of that combustion related pollutant. A second NO^2 sensor was deployed for a similar time period at the height of the heating season to document any seasonal changes. A radon sensor was also installed in each home and left for a 3 to 4 month sampling period. The radon sensors were then collected and returned to the laboratory for analysis.

The critical needs technologies were installed in the participating homes during October 1986. A 40,000 Btu/hr, direct vented, natural gas space heater with electronic ignition and other high-efficiency features was installed in each home. In two-story homes, registers were

sometimes cut in the first floor ceiling to enhance heat transfer to the upstairs. In Pittsburgh, the space heaters were vented through an exterior wall. In Philadelphia, a custom designed mount was used so that the heater could be vented through a double-hung window. If the home did not have at least R-19 insulation in the ceiling, R-30 insulation was installed. During this period, technicians applied "house doctor" infiltration reduction measures to each home. Where necessary, water pipes were wrapped with insulation and/or heat tape to prevent freezing, since the basements often became unconditioned space when the zone heater was in use. Elementary hot water conservation techniques, such as, water tank insulatin, pipe insulation, and flow restricting shower heads were also installed if they were not present. The participants were also instructed in the use of the space heater and other simple conservation techniques and provided with a 24-hour telephone number which they could call to reprt any project-related problems.

A detailed plan to measure building thermal performance and energy consumption was prepared for each site based on the data obtained in the building characteristics survey. As specified in the measurement plan, utility grade gas flow meters were installed on all natural gas fueled appliances at each project site. The gas meters were equipped with transducers manufactured by Rockwell International to permit electronic data collection. A transducer was also installed on the main gas meter at each site to provide measurement redundancy. Within experimental error, if the meters are operating correctly, the sum of the individual submeter readings should equal the main reading for a given interval. Also, as, specified in the measurement plan, electronic temperature sensors were installed to measure temperatures at three interior and one exterior location. Data was collected through a remote, field data acquisition system. Hourly gas consumption for the main and each appliance (central furnace, zone heater, water heater, range, and dryer) along with hourly average interior and exterior temperatures are stored in the memory of the data acquisition system. Data stored on site are retrieved biweekly through a telephone modem connection with NCAT's central computers in Butte, Montana.

The effectiveness of the Critical Needs technologies was measured using two different approaches. For a given period of time, the home's energy consumption last year versus this year was to be compared. Also, the energy consumption of the space heater versus the central furnace was to be compared using a "flip-flop" or A-B test approach. In the A-B test mode, the home was heated using only the zone heater for a specified period of time. The zone heater was then turned off and only the central furnace was used to heat the home. The difference in consumption, adjusted for differences in outdoor temperature, between the two systems was then determined.

At the conclusion of the project in May 1987, an exit interview will be administered. This exit interview will follow up on many of the questions asked during the entry interview to determine if there were any major changes in household characteristics during the study. The interview will determine the current attitude of the participants' toward the project and attempt to evaluate project success from the participants perspectives. In particular, the interview will stress qualitative aspects of the project which cannot be determined by analyzing energy consumption data.

The final aspect of the project is the development of a sophisticated econometric evaluation model to estimate the long-term financial benefit of utility investment in energy conserving technologies in low-income households with arrearages. Pennsylvania utilities would use the model, which runs on IBM-PC compatible computers. The model is called PennLINK for Pennsylvania Low Income Energy Kalculator. It is a menu-driven, user-friendly, DOS executable object code. The household treatments evaluated by the model include a heating system program, a building shell program, a water heater program, a warm zone program, and combinations thereof. A 30-year time period is modeled. PennLINK is in the final stages of development and will be described in a paper to be presented at the Third International Energy conservation Evaluation Conference in Chicago, August 1987. 13

4. DESCRIPTION OF PARTICIPANTS

4.1 Philadelphia

The entry interviews of the 10 Philadelphia households were conducted from October 9 through October 21, 1986. At the time of the interviews, heaters had not been installed nor weatherizstion accomplished. In every case, the head of the household was interviewed. In all but one case, all adult members of the household were present. The adult household members range in age from 27 to 61 years old. The average age is 42 years. The households range in size from one to six persons; six houselds are three or more people. The average family size is 3.3, which is larger than the average for household, of all incomes in Pennsylvania. Only four of the 10 households are married-couple families. The other six households are headed by women. Racially and ethnically, five of the households are black, two are Hispanic, and three are non-Hispanic whites. Five of the households contain at least one person with a disability or chronic illness. The majority of the individual occupants report themselves to be in excellent or good health.

One-half of participating households are "working poor" with poorly paid jobs, while the rest depend on public assistance, social security disability payments, and Supplemental Security Income (SSI). Household incomes range from $206 to $1,125 per month. The average is a little over $8,000 per year.

4.2 Pittsburgh

The entry interviews in Pittsburgh were also conducted in October 1986. With one exception, at the time of the entry interview no heaters had been installed or weatherization accomplished. The adult who paid the household bills was present for the interview in every case. In four cases all family members were present. The average age of household heads in Pittsburgh is 48 years. The youngest household head is 31 years old, with only five heads of households under 40; the oldest is a widowed woman of 70 years. Most households in the Pittsburgh study group have three or more persons with the average size being 3.9. Nine of these households have children under 18 years; six have babies or preschoolers. Racially, three of the households are black, the remaining 12 are non-Hispanic whites. Of the 15 households

in Pittsburgh, eight have members reporting chronic illnesses or disabilities. In six of these eight households, the head of the household has the disability or illness.

Most of the Pittsburgh participants also are "working poor" with members in 9 of 15 households holding jobs, primarlly part-time, service industry type jobs. Two other household heads attend school. Seven of the 15 households are dependent to some degree upon public welfare. Household incomes range from a low of $250 per month to a high of $1,200. The average is $752 per month or about $193 per person. Several of the Pittsburgh participants can be described as "new poor," since one or more of the household members previously held high-paying jobs in steel or other basic industries.

4.3 Q-Sort Results

For the Q-Sort task, each head of household was given a set of cards. The name of a bill which might be paid periodically was printed on each card. The head of household was asked to sort (or rank) the cards in the order the bills would be paid. The results of these rankings are presented in Table 1.

Paying the mortgage or rent, the gas and electric utility bills, and buying groceries were ranked as the top three bills to be paid by households in both cities. That these families would rank the payment of their energy utility bills high may be attributable to the fact that they were already participating in a utility-based experiment, were delinquent on utility payments, and had every reason to believe that at least the natural gas utility would see the data.

The differences between the two cities are interesting, because those reflect differences in expectations, attitudes and lifestyles. For example, the suburban, "new poor" families in Pittsburgh ranked paying insurance, telephone bills, and giving to their church higher than the Philadelphia householders. The rankings from the inner-city, longer-term, low-income Philadelphia households had doctor and medical bills higher than those in Pittsburgh. Philadelphia participants also ranked transit fare and automobile repair costs more highly. Fares are understandable because inner-city Philadelphia has readily available mass transit. The higher importance of car repairs is not so discernible, since households in both cities rank paying car loans and gasoline about the same. Discretionary items-eating out, entertainment, clothes for adults, and pets--were ranked lowest in both cities.

5. HOUSING CHARACTERISTICS

5.1 Philadelphia

All of the houses in Philadelphia are two-story row houses typical of the city. All are located in inner-city neighborhoods. Eight of the homes are mid-row and two are end-row. Six of the homes are owner occupied and four are rentals. All of the households are quite stable, most having lived at their present location for five or more years. The floor plans of the homes are all quite similar. They average 5.4 rooms (range, 4 to 7 rooms).

Several of the dwellings have "shed" kitchens--cheaply constructed additions that are often unheated and uninsulated. Six of the ten families described their kitchen as uncomfortable in the winter. The homes range in size from 705 to 1,138 square-feet of conditioned space. All of the dwellings have basements (unconditioned when the zone heater is in use) ranging in size from 211 to 565 square-feet. The overall heat loss coefficient (UA) of the homes ranged from 282 to 676 Btu/hr-^{o}F. One of the homes was heated by a natural gas, hot water heating system; the remaining nine were heated with natural gas, forced-air furnaces. Seven of the homes reported using auxiliary heating systems (electric space heaters, kitchen range) during previous winters.

5.2 Pittsburgh

The 15 Pittsburgh homes are located in a wide variety of neighborhoods in the "South Hills" suburban area. They range from relatively large, comfortable and well-maintained suburban "ranch" types to smaller, single-family, older homes in traditionally working class neighborhoods. All but one of the Pittsburgh homes, a duplex, are single-family detached structures. The Pittsburgh homes range in size from 4 to 9 rooms with an average of approximately 6 rooms. They are a mixture of one- and two-story dwellings. All are owner occupied. The homes range in size from 801 to 1,818 square-feet of conditioned space. All but one of the homes have basements which range in size from 421 to 1,316 square-feet. Four of the homes also have attached garages. The overall heat loss coefficient (UA) for these homes range from 270 to 1,lOB Btu/hr-^{o}F. One of the homes is heated by a natural gas, gravity hot air, heating system. The remaining 14 are all heated by natural gas fueled, forced-air furnaces. Five of the households used auxiliary space heaters (primarily kerosene) in previous winters.

6. PRELIMINARY FINDINGS

Energy consumption and weather data for the 1986-87 heating season is still being collected. At this point, the comparison of the test homes' natural gas consumption this year versus last year is not complete. This comparison would provide a measure of the actual energy savings accomplished by each participant. The actual savings are expected to be somewhat less than theoretically achievable levels, because the choice of whether to use the the heater or the central furnace and at the levels of use was left entirely up to the participant. However, the A-B test provides at least a semi-quantitative measure of the theoretically achievable savings attributable tc the zone heater. Preliminary results of that test are reported here.

6.1 A-B Test Protocol

The A-B test was conducted during the week of January 25 through January 31, 1987, in Philadelphia, and February 1 through February 7, 1987 in Pittsburgh. Average temperatures in Philadelphia during the test period were approximately 25°F, while in Pittsburgh the following week temperatures averaged approximately 35°F. To initiate the test, NCAT staff engineers personally visited each house in the study, turned off the zone heater, and turned

on the central heating system, adjusting the thermostat to the "normal" setting suggested by the occupants. The staff engineers remained on site until they were sure that the central furnace was operating properly. They instructed the participants to operate their central furnace just as they did in the past before the zone heater was installed. After a period of at least 72 hours, the engineers returned to the site, turned off the central system by turning down the thermostat, and turned on the zone heater to the setting desired by the participants.

The average hourly natural gas consumption in cubic feet per degree day (base 65°F) was calculated from the measured hourly end-use energy consumption of the central furnace during the test period with the zone heater turned off (State B) and the hourly average outdoor temperature. This result was compared with the average hourly natural gas consumption of the zone heater and central furnace pilot light per degree day (Base 65°F) during a period when the central furnace was not operating (State A). The central furnace test period was a minimum of 72 hours, but for some sites additional periods of time when only the central furnace was operating were identified by scanning the measured data, resulting in State B test periods (not necessarily continuous) as long as 33 days. The 72-hour minimum State B test period was chosen as a compromise between the need to have representative data and the desire to minimize the additional fuel expense incurred by the low-income participants. The 72-hour test period also minimized the disturbance to the longer term experiment to determine the actual energy savings accomplished by the zone heater and weatherization measures. For several sites, the State B test period was the only time during the heating season when the central furnace operated, so the comparison period when only the zone heater and the central furnace pilot light operated (State A) would be much longer. The State A comparison periods used in this study ranged from a minimum of 12 days to typically, 60 to 75 days.

6.2 A-B Test Results

For 13 Pittsburgh sites, the difference between State B (central furnace) and State A (zone heater and central furnace pilot light) ranged from 19 to 56 percent, with State A averaging 42 percent less than State B. In the three sites with the lowest percentage difference between States B and A, the participants typically operated their zone heaters at substantially higher temperature settings than the other participants. For the 10 Philadelphia sites, State A consumption ranged from 33 to 60 percent less than State B, with State A averaging 48 percent less than State B.

No attempt was made to control the indoor temperature during either comparison period. Participants were instructed to control the zone heater at whatever setting they were comfortable with and to operate their central furnace at its normal setting. While the dwellings were undoubtedly operating under different heat loss regimes (different interior/exterior temperature differences due to heat stratification and distribution patterns) in the two comparison states, no attempt was made to adjust for this factor, since it was assumed that each state was "normal" for the heating system under study. The test results obviously could be distorted if the zone heater were operated at a lower than "normal" setting during the State A period and the central heater at a higher than "normal" thermostat setting during the State B period, but there was no evidence that this happened. In every case State B temperatures

appeared reasonable, while State A interior temperatures were typical of the entire study period.

6.3 Participant Characterization

The participants in the Critical Needs Weatherization Research Project were asked to characterize their heating system preference immediately after the A-B test was conducted. The results of this characterization are given in Tables 2 and 3.

In Pittsburgh, seven families absolutely preferred the zone heater over their existing central furnace. Another four families accepted the zone heater because it saved them money, while four families preferred the central furnace and would be unlikely to use the zone heater in preference to the central furnace. In three of the sites where the participants preferred the central furnace to the zone heater, inadequate heat distribution from the zone heater seemed to be the major problem. Two of the homes were probably too large to be adequately heated by the zone heater alone, and the third, although smaller, did not have a floor plan that was conducive to zone heating at the interior temperatures preferred by the residents. At the fourth site where the central furnace was preferred, the zone heater was not optimally located for heat distribution. The participants at this site also operated the zone heater at a low control setting which resulted in cool interior temperatures.

Three of the participants in Philadelphia unequivocally preferred the zone heater over the central furnace. Four more participants accepted the zone heater because it saved them money, while three participants preferred the central furnace. The zone heater was improperly located at one of the sites where the central furnace was preferred, and the floor plan inhibited heat transfer in another. The lack of ceiling insulation during much of the study period prior to the A-B test, coupled with communication difficulties with the Spanish-speaking residents, resulted in poor acceptance of the zone heater at the third site.

6.4 Expanded A-B Test Analysis

Participants were instructed not to use the zone heater and the central furnace at the same time to simplify data analysis, and many of them followed this advice. Hence, for at least seven of the project sites, 15 days or more of State B data are available for A-B analysis. These seven sites are shown in Table 4 and are examined in further detail below. Those sites which used only the zone heater all winter (except for the short A-B test period) will not be evaluated until the end of the heating season, so are not included in this discussion.

Site 4 is occupied by two people; a mother and her thirteen-year-old daughter. Both occupants are in school, the mother at night, the daughter during the day. They subsist entirely on public welfare.

The zone heater at Site 4 consumed 56 percent less gas compared with the central furnace, one of the largest potential savings of any site in the study. Site 4 is a 1,344 square-feet, two-story, wood frame home located in Pittsburgh. It has a 442 square-feet basement and an

unconditioned crawl space under the kitchen. The home has an overall heat loss coefficient (UA) of 887 Btu/hr-^{o}F. It previously was heated by a 160,000 Btu/hr, input rated, forced-air furnace. According to the technicians, Site 4 had the highest air infiltration rate after weatherization of any of the Pittsburgh homes in the study. Because of the high air infiltration rate, the zone heater initially had a difficult time maintaining comfortable temperatures on the second floor, with temperatures in the 50 to 60s^{o}F observed. The pipes under the kitchen also froze during a very cold and windy period. The first floor living area did remain comfortable throughut the winter and second floor temperatures improved when registers were installed in the first floor ceiling to facilitate heat transfer. Despite some inconvenience, the participants at Site 4 used the zone heater throughut much of the heating season and experienced an appreciable reduction in the cost of heating their home.

Site 5 is in Pittsburgh and is occupied by a mother and her 31-year-old son. Both receive disability payments which are their principal source of income. Both are home most of the time. Site 5 had the lowest difference between States A and B at 19 percent. Site 5 is a 1,665 square-feet, two-story home with a 460 square-feet basement which contains a 150,000 Btu/hr, forced-air furnace. It has an overall heat loss coefficient of 1,077 Btu/hr-^{o}F. It is the second largest home in the study. The participants initially felt that the zone heater inadequately heated their home and were reluctant to use it. They did not find the "warm room" approach to be acceptable and wanted their entire home heated to a comfortable 70°F+.

After registers were installed, the participants began to use the zone heater more frequently and by late winter were using it as their principal heat source. They did, however, maintain their zone heater at a very high control setting. As a result, temperatures in all rooms in the home were measured at warmer levels than when the central furnace was on. This comparison configeration was responsible for the relatively low percentage difference between the two heating systems.

Site 9 is occupied by a family of 11 persons supporting themselves through various jobs and welfare payments. Their total income is approximately $1,000 per month. Household members include a 16-month-old baby and several school-age children. Someone is at home almost continuously.

Site 9 is an 864 square-feet, two-story home with a 427 square-feet basement; it was built in 1936. It has an overall heat loss coefficient of 582.5 Btu/hr-^{o}F. The central furnace is a 125,000 Btu/hr forced-air model. The A-B test results indicate a 35 percent difference between the zone heater and the central furnace. Site 9 residents also were reluctant to use the zone heater. As the winter progressed, they used the zone heater more frequently, and it is now their principal heat source. The zone heater appears to be heating all rooms in the house adequately. Site 9 also seems to be achieving a substantial fuel cost reduction.

Site 16 is located in Philadelphia and is occupied by a single woman who subsists on a social security disability payment. She typically remains at home.

Site 16, like all Philadelphia homes in the study, is a two-story row house. It has 826 square-feet of floor area with a 306 square feet basement and an overall heat loss coefficient

of 349 Btu/hr-^{o}F. The existing furnace is an 80,000 Btu/hr forced-air system. The A-B test results indicate a 37 percent difference. The participant at this site likes the zone heater and has used it continually except for two relatively brief periods.

Site 18 in Philadelphia is occupied by three people, a mother and her two school-age sons. The head of the household is unemployed and subsists on public welfare. She is typically at home.

Site 18 is a 928 square feet two-story row house with a 350 square feet basement. It has an overall heat loss coefficient of 349 Btu/hr-^{o}F., the same as Site 16. The existing furnace is a 70,000 Btu/hr forced-air model. The A-B test results indicate a 43 percent difference in space heating consumption between the zone heater and the central furnace. The participants at Site 18 also like the zone heater and have used it continuously except for one three-week period at the time of the A-B test in February when there was confusion about which heating system to operate. The zone heater provides more than adequate comfort at this site and the occupants often turn the zone heater down because the house becomes too warm.

Site 23 in Philadelphia is occupied by a 5-person family: husband, wife and three school-age children. The adults are chronically unemployed and the entire family suffers from asthma. They subsist on public assistance. Except for the school children, the family typically remains at home.

Site 23 is a 907 square-feet, two-story row house with a 348 sguare-feet bssement. It has an overall heat loss coefficient of 487 Btu/hr-^{o}F. It is equipped with a 100,000 Btu/hr, natural gas fueled, forced-air furnace. The occupants describe the house as being cold, especially the front bedroom, and they have used the kitchen range as a heat source in past years. The ceiling of the home was uninsulated and remained so because of structural problems until early February 1987 when approximately R-20 was installed.

For most of the study period the participants at Site 23 used the zone heater during the day only. They would carefully turn off their central furnace during the day and turn it back on again when they went to bed at night. They felt that the zone heater did not keep the front bedroom on the second floor warm enough. Registers were installed to provide an additional heat transfer pathway into the front bedroom, but the occupants still felt that the room was not warm enough. Late in the project, only after the ceiling was insulated, the participants began to use the zone heater at night. Temperature data collected during this period indicated that the second floor ow is reasonably comfortable. The A-B difference measured during this period was 43 percent.

Site 25 is a three-person household consisting of a mother, daughter and school-age godchild. One member of the household is employed. They also receive public assistance.

Site 25 is an 887 square-feet, two-story, row house in Philadelphia. It has a 515 square-feet basement and an overall heat loss coefficient of 401 Btu/hr-^{o}F. The house is equipped with an 80,000 Btu/hr, forced-air furnace with electronic ignition. The A-B test data indicate a 51 percent difference between the zone heater and the central furnace. The zone heater provides

adequate comfort and according to the participants "saves lots of money." However, they also believe that the zone heater causes the air in the home to be too dry which may aggravate one of the occupant's chronic bronchitis. For this reason they sometimes use the central furnace at night.

7. PRELIMINARY CONCLUSIONS

Early results of the Critical Needs Weatherization Research Project are encouraging. The A-B test results indicate that there may be substantial potential for energy cost reduction through the use of zone heating techniques. Many of the sites are apparently capitilizing on much of that potential. Proper house selection (size and floor plan) and heater placement within the house appear to be the primary technical determinants that control occupant acceptance. The study team had a high level of contact with the participants, and this human factor seems to be at least as important as the technical factors in determining the success of a particular zone heating installation.

It must be stressed that the results reported here indicate only the potential, and to some extent, the "art of the possible" in energy cost reduction. They do not necessarily demonstrate what will actually happen in practice. The actual savings obtained by the participating households was a direct result of their willingness to use the zone heater instead of their central furnace, a decision entirely in their control.

To save significant amounts of money, some residents but by no means all, had to accept some reductions in comfort. Less than half of the Critical Needs participating families felt, without reservations, that the zone heater is an all-around better heating system than their existing furnace. The others used it, to a greater or lesser extent, because they believed they were saving money.

Critical Needs is an interactive technology. It requires participant involvement for success. It views education as the single most valuable energy conservation measure. If the Critical Needs approach is to be widely used as an alternative to existing weatherization practices, then attention must also be paid to participant selection. Significant administrative time will be required to evaluate potential participants to make sure they understand the technology and are willing to accept it. If participants are chosen carefully, the approach can result in substantial energy cost reductions.

TABLE 1

Q-Sort Results: Ranked Priority for Payment of Bills

Highest to Lowest Rank		Higher in	Higher in	About the Same
Philadelphia	Pittsburgh	Philadelphia	Pittsburgh	in Both Cities
Mortgage	Mortgage	Doctor	Insurance	Mortgage
Groceries	Natural Gas	Medicine	Telephone	Natural Gas
Natural Gas	Electricity	Transit Fares	Church	Groceries
Electricity	Groceries	Car Repair		Electricity
Doctor	Gasoline	Pets		Gasoline
Medicine	Telephone			Car Loan
Gasoline	Other			Kids Clothes
Transit Fares	Insurance			School Costs
Car Repair	Car Loan			Entertainment
Car Loan	Kids Clothes			Adult Clothes
Telephone	Medicine			Eat Out
Kids Clothes	School Costs			
School Costs	Transit Fares			
Other	Church			
Pets	Doctor			
Insurance	Car Repair			
Entertainment	Adult Clothes			
Adult Clothes	Eat Out			
Church	Entertainment			
Eat Out	Pets			

TABLE 2

A-B Test Results

Participant Characterizations

Pittsburgh

Site	Preference	Comments
1	Zone, saves money	Central heats house better; moisture problems
2	Central	Central furnace used at night; heats upstairs better
3	Zone, saves money	Central furnace used on very cold nights
4	Zone, saves money	Frozen pipes in exposed crawlspace
5	Central	Central furnace heats upstairs better
6	Zone, saves money	Central provides more even temperature distribution
7	Zone	House cold, drafty with central furnace
8	Zone	Zone heater more comfortable and convenient
9	Central	Better heat distribution
10	Zone	Zone heater more comfortable and convenient
11	Zone	Central furnace dusty
12	Central	Central provides better heat distribution
13	Zone	House too warm with central furnace
14	Zone	Central furnace dusty
15	Zone	Upstairs too warm with central furnace

TABLE 3

A-B Test Results

Participant Characterizations

Philadelphia

Site	Preference	Comments
16	Zone	Pipes froze with central heater
17	Zone, saves money	Some rooms cooler with zone heater
18	Zone	No problems
19	Central	Central furnace provides better heat distribution
20	Zone, saves money	Some rooms cooler
21	Central	Zone heater poorly located
22	Zone, saves money	Some rooms cooler
23	Central	Better heat distribution; dries clothes in basement
24	Zone	Some rooms cooler
25	Zone, saves money	Air too dry with zone heater

TABLE 4

Selected A-B Test Results

Site	Consumption State A ($Ft^3/DD_{\circ}F.$ base $65^{\circ}F.$)	Daily Average Temp. Range State A ($^{\circ}F.$)	# of Days	Consumption State B (C.F./hr.)	Daily Average Temp. range State B ($^{\circ}F.$)	# days State B	% Difference (A<B)
4	14.0	7.0-57.5	85	31.8	17.1-60.8	33	56
5	25.9	25.2-58.3	39	31.9	26.1-46.5	15	19
9	13.0	16.6-61.4	75	19.9	13.5-51.0	15	35
16	12.0	32.2-54.9	69	19.0	20.3-43.4	16	37
18	7.2	19.6-53.8	73	12.7	26.2-44.3	19	43
23	8.6	32.1-55.1	12	15.1	35.4-61.2	31	43
25	6.4	28.3-50.5	55	13.0	15.2-38.3	15	51

State A = Zone heater and central furnace pilot light

State B = Central furnace

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DO RESIDENTIAL ENERGY AUDITS CONTRIBUTE TO REDUCED ENERGY CONSUMPTION?

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DO RESIDENTIAL ENERGY AUDITS CONTRIBUTE TO REDUCED ENERGY CONSUMPTION?

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The purpose of this paper is to analyze the effect of residential energy audits on residential energy consumption. Two fundamental questions are addressed in the analysis:

* Do residential households reduce their energy consumption as a result of the audit?

* What is the impact on energy consumption of each of the various recommendations made to the households as a result of the audit?

Two separate models are used to address the two questions listed above. They will be referred to as the "net impact model" and the "recommendations model." Both of the models use the methodology of multiple regression analysis. At the end, the paper also proposes an analytical approach that could be used in a future analysis to strengthen and extend the results presented in this paper.

THE NET IMPACT MODEL

The net impact model[2] compares the pre-audit and post-audit energy consumption of a participant in the residential energy audit program in order to measure the impact of the audit on energy consumption. This change in a participant's energy consumption is not a true measure of the effect of the audit since it is possible that non-participants had also attained possible reductions over the same period on their own. The possible reductions attained by nonparticipants are viewed as trend changes in energy consumption. Hence, the model compares a participant's pre-audit/post-audit energy consumption change to a non-participant's energy consumption change over the same time period.

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[1] The opinions expressed by the author are his alone, and do not necessarily reflect the views of the District of Columbia Public Service Commission.

[2] This is an extension of the model used by the Potomac Electric Power Company (Pepco) in its report entitled "Energy Avoidance Analysis: District of Columbia" dated December 1986.

The difference between a participant's change and a non-participant's change is defined to be the net impact of the audit program on residential energy consumption.

The general form of the multiple regression equation corresponding to this model is:

$$ENERGY_i = a_1 + a_2(CDH_i) + a_3(CDHPART_i) + a_4(HDH_i) + a_5(HDHPART_i) + a_6(POSTAUDIT_i) + a_7(AUDITPART_i) + a_8(AUDCDH_i) + a_9(AUDHDH_i) + a_{10}(AUDCDHPART_i) + a_{11}(AUDHDHPART_i) + d_2(DUM_2) + d_3(DUM_3) + ... + d_n(DUM_n)$$

where:

i = subscript for an individual customer.

$ENERGY_i$ = monthly billing cycle energy per customer measured in millions of BTU (MBTU).

CDH_i = Cooling Degree Hours by monthly billing cycle.

$PART_i$ = dummy variable, with value = 1 for participants, and value = 0 for non-participants.

$CDHPART_i$ = CDH_ix$PART_i$. Interaction term designed to differentiate between participants and non-participants.

HDH_i = Heating Degree Hours by monthly billing cycle.

$HDHPART_i$ = HDH_ix$PART_i$. Interaction term designed to differentiate between participants and non-participants.

$POSTAUDIT_i$ = dummy variable, with value = 1 if month is post-audit, and value = 0 if month is pre-audit.

$AUDITPART_i$ = $POSTAUDIT_i$x$PART_i$. Interaction term designed to differentiate changes in pre-audit and post-audit energy use between participants and non-participants.

$AUDCDH_i$ = $POSTAUDIT_i$xCDH_i. Interaction term designed to differentiate effect of cooling degrees between pre-audit and post-audit periods.

$AUDHDH_i$ = $POSTAUDIT_i$xHDH_i. Interaction term designed to differentiate effect of heating degrees between pre-audit and post-audit periods.

$AUDCDHPART_i$ = $POSTAUDIT_i$xCDH_ix$PART_i$. Interaction term designed to differentiate effect of cooling degrees between pre-audit and post-audit periods and between participants and non-participants.

This equation has several notable features:

* The equation normalizes the residential energy consumption for the prevailing weather conditions.

* The equation tries to take account of household-specific characteristics that affect energy consumption by including a dummy variable for each household.

* The equation is designed to differentiate between participants and non-participants as well as for the pre-audit and post-audit periods for each and every variable that affects energy consumption, while combining the two groups and two periods in one equation. This makes it possible to conduct statistically valid tests across the two time periods and the two groups.

For participants, the equation implies:

$$\text{Pre-audit}\quad ENERGY_i = a_1\,[a_2 + a_3](CDH_i)\,[a_4\ a_4](HDH_i)$$

$$\text{Post-audit}\quad ENERGY_i = [a_1 + a_6\ a_7]\,[a_2 + a_3 + a_8 + a_{10}](CDH_i) + [a_4 + a_5\ a_9 + a_{11}](HDH_i)$$

Note that the household-specific dummy variable= have been ignored because they will cancel out in the calculation of the reduction.

$$\text{Participant Reduction} = \text{Pre-audit} - \text{Post-audit}\ ENERGY_i = -([a_6 + a_7] + [a_8 + a_{10}](CDH_i)\,[a_9 + a_{11}](HDH_i))$$

For non-participants, the equation implies:

$$\text{Pre-audit}\quad ENERGY_i = a_1\ a_2(CDH_i)\ \ a_4(HDH_i)$$

$$\text{Post-audit}\ ENERGY_i = [a_1 + a_6]\,[a_2 + a_8](CDH_i)\ \ [a_4 + a_9](HDH_i)$$

Note that the household-specific dummy variables have been ignored because they will cancel out in the calculation of the reduction.

$$\text{Non-participant Reduction} = \text{Pre-audit} - \text{Post-audit}\ ENERGY_i = -(a_6\ a_8(CDH_i) + a_9(HDH_i))$$

Hence, the net effect of the audit, which is the difference between the participant and non-participant reductions, is:

Net audit impact = Participant Reduction - Non-participant Reduction =

$$= -(a_7\, a_{10}(CDH_i) + a_{11}(HDH_i))$$

Thus, this net impact has been calculated after taking account of weather changes, household-specific characteristics, and possible trend reductions achieved by non-participants.

THE RECOMMENDATIONS MODEL

The recommendations model focuses on only the participants in the post-audit period. The model is based on the following ideas. If a particular recommendation (such as water tank insulation) was made to a household, then this should indicate a need for the measure. In other words, with all other things equal, a household to whom a recommendation was made should have higher energy use than a household to whom the recommendation was not made. Further, the implementation of the recommendation should indicate a decline in energy consumption. In other words, with all other things equal, a household that did implement a recommendation should have lower energy consumption than a household that did not implement the recommendation.

Within the group of participants, the other factors affecting energy consumption are cooling and heating degrees, the family size, the area and type of the dwelling, and the family income.

The general form of the multiple regression equation corresponding to this model is:

$$ENERGY_i = b_1 + b_2(CDH_i) + b_3(HDH_i) + b_4(FAMSIZE_i) + b_5(AREA_i)$$
$$+ b_6(TYPEHOME_i) + b_7(INCOME_i) + c_1(REC1_i) + e_1(IRECl_i)$$
$$+ \ldots + c_n(RECn_i) + e_n(IRECn_i)$$

where:

i = subscript for an individual customer.

ENERGYi = monthly billing cycle energy per customer measured in millions of BTU (MBTU).

CDH_i = Cooling Degree Hours by monthly billing cycle.

HDH_i = Heating Degree Hours by monthly billing cycle.

$FAMSIZE_i$ = Number of people in the household.

$AREA_i$ = Area of the dwelling in square feet.

$TYPEHOME_i$ = Type of home, i.e. single-family, apartment, etc. Represented by appropriately defined dummy variables.

$INCOME_i$ = Income of household.

$REC1_i$ = Dummy variable, with value = 1 if the first recommendation (e.g. storm windows) was made, value = 0 otherwise.

$IREC1_i$ = Dummy variable. with value = 1 if the first recommendation was made and implemented, value = 0 otherwise.

$RECn_i$ = Dummy variable, with value = 1 if the last recommendation (e.g. floor insulation) was made, value = 0 otherwise.

$IRECn_i$ = Dummy variable, with value = 1 if the last recommendation was made and implemented, value = 0 otherwise.

$b_1,\ldots, b_7, c_1,\ldots, c_n, e_1,\ldots, e_n$ = parameters to be estimated by multiple regression analysis.

In this multiple regression equation, a positive coefficient for a recommendation dummy variable indicates a need for the measure, and a negative coefficient for the implementation dummy variable indicates a reduction in energy consumption as a result of the implementation.

THE DATA

The data for the analysis relate to residential energy audits conducted by the Potomac Power Electric Company (Pepco) in Washington, D.C. The time periods involved are :

* Pre-audit period: October, 1983 - September, 1984

* Audits Conducted: October, 1984 - September, 1985

* Post-audit period: October, 1985 - September, 1986.

The energy consumption data are for both electricity and natural gas, where the latter data were obtained by Pepco from Washington Gas Light Company.

There are two types of audit that Pepco conducted: a professional audit,where a professionally trained auditor went to the customer's home, and a do-it yourself audit, where a customer mailed in a completed questionnaire to Pepco. While data are available for both types of audits, the greatest concern related to professional audits. Further, the number of do-it-yourself audits is relatively small. Hence, this analysis has focused on only the professional audits.

Pepco has also collected data on a selected group of non-participants. The number of households for which data are available is shown in Table 1. The table shows that data are available for 110 professional participants (of which 98 have gas space heating, and 12 are all-electric customers), 9 do-ityourself participants (of which 8 have gas space heating, and 1 is an all electric customer) and 103 non-participants (of which 85 have gas space heating, and 18 are all-electric customers).

THE RESULTS

The results of estimating the net impact model are shown in Table 2. The results show that the only statistically significant impact of the residential energy audit on energy consumption is on winter season electricity use by customers who have gas space heating. For all-electric customers, there is no statistically significant net impact on either winter season or summer season electricity use.

These results imply that the audits have been only marginally successful in achieving the aim of energy conservation since the winter season electricity consumption of gas heating customers is only a small part of total household energy consumption.

The results of estimating the recommendations model are shown in Tables 3 and 4. This model has been applied only to the 98 professional participants who have gas space heating. The reported results are based on regression equations from which the INCOME and TYPEHOME variables were dropped, because preliminary estimation showed that their coefficients were statistically insignificant.

For the winter season, based on the gas use equation, there are three measures whose implementation has led to energy reductions: wall insulation, weatherstripping, and storm windows. In additlon, for pipe insulation and thermostat settings, the need appears to have been correctly identified, but their implementation does not show any statistically significant energy reductions. The implementation of the storm doors, clock thermostat, replace the heating system, automatic pilot light, and window door film recommendations does show energy reductions, but the reductions are not statistically significant.

For the summer season, based on the electricity use equation, the implementation of the storm doors, storm windows, water tank insulation and automatic pilot light recommendations leads to statistically significant declines in energy use. In addition, the need for weatherstripping, pipe insulation, and thermostat settings appears to have been correctly identified, but their implementation does not lead to any statistically significant energy reductions. Finally, the implementation of the clock thermostat and wall insulation recommendations does show energy reductions, but they are not statistically significant.

In other words, the results show that only a limited number of the recommendations made as part of the energy audits are effective in reducing gas use in winter and electricity use in summer. In particular, the storm windows recommendation is the only one that is effective

in both the winter and summer seasons. These results may explain why the audits conducted by Pepco have not been very effective in reducing energy consumption.

FURTHER RESEARCH

The above results indicate that the residential energy audit program has been only marginally successful. However, the above analysis does not indicate the reasons for this phenomenon. An explanation would require two types of analyses: (1) A technical analysis that examines the nature of the audits and the recommendations made from an engineering point of view, and (2) An economic analysis that is based on a model of consumer behavior. This second type of analysis is explored in this section.

From an economist's point of view, each household is a producer of a commodity that can be labeled as COMFORT, which involves establishing a comfortable environment in the customer's residence. Each household is also a consumer of COMFORT. Thus, the economic analysis would be based on both consumer and producer theory.

The inputs for producing COMFORT are the energy used as well as the characteristics of the dwelling such as the amount of caulking, weatherstripping, insulation, etc. The relationship between these inputs (including energy used) and COMFORT would be described by a production function. Following economic theory, the household would find the cost-minimizing combination of inputs for producing different levels of COMFORT. There would be significant differences between the short-run and the long-run, since we expect some of the dwelling characteristics to be fixed in the shortrun. This cost-minimization would produce the usual cost curve, i.e. the cost of producing different levels of COMFORT.

Since the household is the producer as well as the consumer of COMFORT, the price of an additional unit of COMFORT is clearly the marginal cost of producing COMFORT. It is this price that the household uses in determining how much of COMFORT to produce and consume, based on the usual utility maximizing assumption.

This framework is likely to provide the theoretical foundations of analyzing why energy audits are not highly successful in reducing household energy use. For example, suppose that a household implements an audit recommendation that makes the home highly energy efficient. In turn, this reduces the cost of producing COMFORT, so that the price of comfort (as measured by the marginal cost) also comes down. In this situation, it would be usual to expect that the household would raise its level of COMFORT. Thus, the fall in energy consumption implied by the implementation of the recommendation would be, to some extent at least, be diminished by the rise in energy consumption implied by the raising of COMFORT.

There is some evidence that residential households view energy audits as means of saving energy and raising comfort, and not primarily as a means of saving the amount of money they spend on energy. Pepco's survey of audit participants found that more than 70% of the surveyed participants said that some of the purposes of the audits were to save energy and to

raise the level of comfort. However, only 60 % of the surveyed participants said that one of the purposes of the audits was to save money.

This analytical framework is also likely to be useful in providing significant insights about the customer's decision to implement or not the recommendations made by the auditor. The correct opportunity cost of implementing a recommendation includes the implicit value of the time spent by the customer. Even if the actual work is done by a contractor, a customer may have to spend a substantial amount of time in analyzing the recommendation, finding a suitable contractor, and supervising the work.

This time cost could be readily included in the economic model. The logit/probit regression technique is particularly suited for Yes/No types of decisions. A logit/probit regression equation derived from this analytical framework would be very useful in analyzing the factors that lead customers to not implement some of the recommendations.

Table 1 Number of Customers in the Analysis

Fuel type	Participants		Non-participants
	Professional	Do-It-Yourself	
Gas Heat	98	8	85
All Electric	12	1	18
Total	110	9	103

Notes: Gas heat refers to the customers who have gas space heating, while all electric refers to customers who have all electric homes.

Table 2 Net Impact of Residential Energy Audit Program

Fuel Type	Total Energy	Electricity Use	Gas Use
	WINTER SEASON		
Gas heat	1.21	0.21 *	1.01
All-electric	-1.03	-1.03	N/A
	SUMMER SEASON		
Gas heat	0.46	0.21	0.13
All-electric	0.56	0.56	N/A

Notes: The figures show the net impact (in million of BTUs per participating customer) of the residential energy audit program on energy consumption, after adjusting for weather, household-specific characteristics, and for trend changes in consumption exhibited by non-participating households. A positive sign indicates reduction in energy use, while a negative sign indicates a rise in energy consumption. An asterisk * indicates statistical significance at the 95 % confidence level, using a two-tailed test. For details of the estimating equation, see the text.

Table 3 Effect of Specific Audit Recommendations on Energy Use

(Gas Heat Professional Participants Only)

WINTER SEASON

	Total Energy	Electricity Use	Gas Use
Storm Windows			
Recommendation	3.23 *	-0.03	3.11 *
Implementation	-2.56 *	-1.04 *	-2.26 *
Storm Doors			
Recommendation	0.35	0.22	0.26
Implementation	-0.36	0.74 *	-0.17
Caulking			
Recommendation	0.72	-0.49	0.74
Implementation	1.85 *	0.03	1.68 *
Weatherstripping			
Recommendation	3.33 *	1.11 *	3.33 *
Implementation	-3.24 *	-0.97 *	-2.84 *
Duct Insulation			
Recommendation	2.62	-0.25	2.08
Implementation	N/A	N/A	N/A
Pipe Insulation			
Recommendation	6.64 *	0.46	5.95 *
Implementation	-3.39	-0.52	-2.54
Water Tank Insulation			
Recommendation	-2.38 *	-0.24	-2.41 *
Implementation	-0.17	-0.50	0.01
Clock Thermostat			
Recommendation	0.59	-0.75 *	0.59
Implementation	-0.87	-0.63	-1.16
Replace Heating System			
Recommendation	0.86	0.10	0.73
Implementation	-1.92	-0.23	-2.20
Flue Vent Damper			
Recommendation	1.75	-0.66 *	1.24
Implementation	0.47	0.30	0.42

Table 3 Effect of Specific Audit Recommendations on Energy Use (Continued)

(Gas Heat Professional Participants Only)

WINTER SEASON

	Total Energy	Electricity Use	Gas Use
Auto Pilot Light			
Recommendation	0.46	-1.75 *	0.28
Implementation	-1.27	-0.22	-0.40
Window Door Film			
Recommendation	-0.70	-0.05	-0.69
Implementation	1.36	2.00 *	-0.13
Thermostat Setting			
Recommendation	3.61 *	1.22 *	3.23 *
Implementation	0.65	0.12	0.33
Wall Insulation			
Recommendation	1.42	-0.17	1.60 *
Implementation	-4.17 *	-0.33	-4.52 *
Ceiling Insulation			
Recommendation	-2.47 *	-1.07 *	-2.43 *
Implementation	6.10 *	1.89 *	5.53 *
Floor Insulation			
Recommendation	1.79 *	-0.47	1.30
Implementation	1.77	0.29	2.07

Notes: The estimated coefficients measure the changes in million BTUs. A positive sign for a recommendation coefficient indicates the extra energy used by a customer for whom the measure was recommended as compared to a customer for whom the recommendation was not made. A negative sign for an implementation coefficient shows the fall in energy use resulting from the implementation of the recommendation. An asterisk * denotes statistical significance at the 95 % confidence level, using a one-tailed test. For details of the estimating equation, see the text.

Table 4 Effect of Specific Audit Recommendations on Energy Use

(Gas Heat Professional Participants Only)

SUMMER SEASON

	Total Energy	Electricity Use	Gas Use
Storm Windows			
Recommendation	0.31	0.07	0.16
Implementation	-0.55	-1.09 *	0.28
Storm Doors			
Recommendation	0.42	0.59 *	-0.11
Implementation	-0.71 *	-0.47 *	-0.28
Caulking			
Recommendation	-1.10 *	-0.94 *	0.12
Implementation	0.78 *	0.83 *	-0.19
Weatherstripping			
Recommendation	1.65 *	1.12 *	0.81 *
Implementation	-0.76 *	-0.38	-0.56 *
Duct Insulation			
Recommendation	-0.05	0.39	-0.94 *
Implementation	N/A	N/A	N/A
Pipe Insulation			
Recommendation	1.44 *	0.75 *	0.55 *
Implementation	-0.94	-0.64	-0.11
Water Tank Insulation			
Recommendation	1.02 *	0.40	0.96 *
Implementation	-1.38 *	-1.09 *	-0.50
Clock Thermostat			
Recommendation	0.59 *	0.01	0.10
Implementation	-0.76	-0.25	-0.69
Replace A/C System			
Recommendation	0.60	0.73 *	-0.06
Implementation	1.23	0.34	0.23
Awnings			
Recommendation	N/A	-0.29	0.33
Implementation	N/A	4.25 *	0.92

Table 4 Effect of Specific Audit Recommendations on Energy Use (Continued)

(Gas Heat Professional Participants Only)

SUMMER SEASON

	Total Energy	Electricity Use	Gas Use
Auto Pilot Light			
Recommendation	0.53	-0.60	-0.23
Implementation	-2.10 *	-1.60 *	-0.50
Window Door Film			
Recommendation	0.18	-0.50	-0.59 *
Implementation	1.68 *	1.55 *	0.34
Thermostat Setting			
Recommendation	2.14 *	1.29 *	1.01 *
Implementation	-0.11	0.54 *	-0.85 *
Wall Insulation			
Recommendation	0.23	0.08	0.17
Implementation	0.47	-0.02	0.31 *
Ceiling Insulation			
Recommendation	3.11 *	-0.66 *	-0.38
Implementation	0.69 *	2.35 *	1.30 *
Floor Insulation			
Recommendation	0.69 *	0.32	0.21
Implementation	-0.23	-0.03	0.20

Notes: The estimated coefficients measure the changes in million BTUs. A positive sign for a recommendation coefficient indicates the extra energy used by a customer for whom the measure was recommended as compared to a customer for whom the recommendation was not made. A negative sign for an implementation coefficient shows the fall in energy use resulting from the implementation of the recommendation. An asterisk * denotes statistical significance at the 95 % confidence level, using a one-tailed test. For details of the estimating equation, see the text.

AN EVALUATION OF RESIDENTIAL CONSERVATION SERVICE PROGRAMS IN THE DISTRICT OF COLUMBIA

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AN EVALUATION OF RESIDENTIAL CONSERVATION SERVICE PROGRAMS IN THE DISTRICT OF COLUMBIA

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INTRODUCTION

The purpose of the paper is to illustrate how profiles of participants and nonparticipants can provide information useful for determining the effectiveness of Residential Conservation Service (RCS) programs. To this end, the author seeks to illustrate:

1. How (RCS) program evaluations, whose scope is determined by research design methods, can be useful in (a) identifying issues, success, and problems in the RCS programs, and (b) formulating economic energy demand models based on information gathered through the program evaluation.

2. As an example, the analysis of the demographic, attitudinal, and housing and energy system characteristics of RCS participants and nonparticipants is shown to be useful in understanding some of the factors that contribute to residential energy conservation behavior (e.g. (a) requesting an RCS audit and (b) implementing or not implementing conservation measures are recommended).

3. How the RCS participant and nonparticipant profiles can be useful in identifying problems and issues in the design of RCS programs and in the way the programs are being implemented. In keeping with the guidelines set by the sponsors of this conference, the emphasis in this paper will be on the conceptual framework, methodology, and empirical results rather than on the policy implications.

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* The opinions expressed by the author are hers and do not reflect the policies or views of the Public Service Commission of the District of Columbia.

An evaluation of RCS programs can be conducted on three levels: 1) outreach effectiveness; (2) educational effectiveness; and (3) energy consumption impacts. This paper is devoted to an analysis of both the outreach and educational effectiveness of the RCS programs undertaken by the Potomac Electric Power Company (PEPCO) and the Washington Gas Light Company (WGL) in the District of Columbia. Dr. Subodh Mathur's paper examines the energy consumption impacts of these programs. Therefore, the two papers are complementary because the extent to which the audits affect energy consumption depends, among other things, on the extent to which participants implement any of the conservation measures that are recommended.

Pertinent questions under outreach effectiveness are:

1. Who is being reached by the programs and why?

2. Who is not being reached and why?

These two questions can be examined by exploring the determinants or factors which lead residential households to request an RCS audit.

The effectiveness of RCS audits in convincing participants to implement conservation measures is the subject of the educational effectiveness. My analysis shows that factors and criteria additional to those involved in requesting an audit are important.

Before presenting the results of the analyses, let me provide some background information on the RCS programs and the underlying evaluation conceptual framework.

BACKGROUND

RCS audits have been provided in the District of Columbia by PEPCO since 1978 and by WGL since October, 1984. Together they have performed approximately 14,000 audits over this period. In the last two years, 1985 and 1986, they performed nearly 6,300 audits with PEPCO accounting for 70 percent of the total and WGL performing the remainder. (See Table 1 for more detailed information.) Depending on how the eligible population is defined, in the two years, the two programs reached approximately three percent of the D.C. residential population or approximately four percent of PEPCO's and WGL's residential customers. Most of the penetration is among owners - the program reached approximately five percent of potential owner occupied units and approximately six percent of PEPCO's and WGL's residential customers who own their homes. In contrast, outreach to renters has been negligible, less than one percent.

In Formal Case No. 743, Order No. 7617 (dated July 16, 1982) and as amended in Order No. 7738 (dated February 15, 1983), the District of Columbia Public Service Commission

established a set of goals, evaluation criteria, and reporting requirements for the RCS programs in its jurisdiction. The evaluation goals were as follows:

1. A reduction in the costs of energy to all classes of customers through installation of energy conservation measures by residential customers;

2. Reduction in the growth in demand for energy by the residential class; and

3. Maximum participation practicable by low income residential customers.

These three goals can be regrouped as follows:

1. Outreach effectiveness of the RCS programs (item 3)

2. Energy consumption impacts, present and future (item 2)

3. Utility company impacts (item 1).

The evaluation criteria set by the Commission are as follows (sequence changed):

1. Proportion of potential participation in the program, measured in terms of the number of customers of varying income levels who actually took part in the program

2. Extent of actual energy savings to customers due to implementation of audits' recommendations

3. Proportion of the potential penetration by the program, measured in kilowatt hours and therm sales

4. Cost effectiveness (i.e., whether there are net savings due to avoided costs to the utilities)

These four criteria are directly related to the three goals. Criterion number 1 is related to the outreach effectiveness of the RCS programs. Criterion number 2 pertains to the energy consumption impacts. Criteria numbers 3 and 4 relate to the impacts of the programs on PEPCO and WGL, and, hence, other ratepayers.

Finally, PEPCO and WGL were required to file four types of reports as indicated below:

1. Annual reports profiling RCS participants (or a statistically valid *sample) and a statistically valid sample of nonparticipants

2. Energy avoidance studies which compare the energy consumption (pre and one year post audit) of RCS participants to nonparticipants over the same period

3. Quantification of the evaluation criteria stated above after two years of operations

4. Annual statements on program costs.

Information for the above stated reports was collected by PEPCO and WGL at two different times. First, at the time of the audit, information was obtained from many participants on demographic characteristics, housing and energy characteristics, how they learned of the program and existing conservation measures. Postaudit telephone surveys of RCS participants were conducted between 2 months and about one year after audits were completed. (It appears that RCS participants should be given at least one year for implementation before reliable implementation rates can be ascertained). The focus during the postaudit surveys was on demographic information and implementation rates for each conservation measure that had been recommended. RCS participants were also asked why they did and did not implement conservation measures.

At the same time the postaudit telephone survey of RCS participants occurred, telephone surveys were conducted of samples of nonparticipants. Nonparticipants were asked questions regarding their demographic profile, the extent to which they were familiar with the RCS programs and, if so, why they had never asked for an audit, and implementation rates for the same set of conservation measures over the same period of time as were asked of the RCS participants. Some RCS nonparticipants were also asked why they did or did not implement conservation measures. However, an inadequate amount of information was collected on both the housing and energy system characteristics of nonparticipants. Also inadequate information was collected on the extent to which nonparticipants had already implemented conservation options.

Table 2 summarizes the data sets that were compiled by both PEPCO and WGL in response to the Commission's Orders. The data bases that are starred (*) are also the ones which were utilized by Commission Staff in the evaluation of the RCS programs. The figures contained in this paper are based on an analysis of PEPCO's 1986 data set and WGL's 1985 and 1986 data sets. The three data sets are of comparable size.

The Office of Economics of the District of Columbia Public Service Commission, through contracts with the Center for Applied Research on Urban Policy (CARUP) at the University of the District of Columbia (UDC) and both utilities, was able to obtain the audit input and

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*The Commission required the sample sizes to be statistically significant at the 95% confidence interval.

postaudit survey data tapes from PEPCO and WGL, have them installed on a mainframe computer at UDC, and then access them either on the premises of UDC, from the Commission Office, or from our computers at home. Dr. Subodh Mathur, econometrician and consultant to Commission Staff, performed all of the SAS programming. He also conducted the difficult task of merging the information obtained at the time of the audits with the information obtained subsequently during postaudit telephone surveys in order to compare preaudit and postaudit behavior. Together we renamed and recoded most of the more than 800 variables in the data sets in order to evaluate PEPCO's and WGL's programs on a consistent basis.

UDC's Computer Center had two features which were especially useful. First, the computer system is set up for modem connection at the 2400 baud rate. (Use of 1200 baud modems proved to be entirely too slow, and thus was not practicable.) Second, the university's computer system is set up for full rather than half duplex usage.

EVALUATION CONCEPTUAL FRAMEWORK

The evaluation of the RCS programs was aimed at addressing four basic questions as follows:

1. Who is being reached by the RCS programs and how do they compare to nonparticipants?

2. Why are the programs reaching some households and not others?

3. To what extent have the programs been effective in getting households to implement conservation measures and why?

4. What has been the impact of the programs on the energy consumption of participants as compared to nonparticipants?

This paper addresses questions 1 through 3 and Dr. Mathur's paper addresses question 4. Questions 1 and 2 are indicators of the outreach effectiveness of the RCS programs and questions 3 and 4 are indicators of the effectiveness of the programs in educating participants and on their energy consumption.

For evaluation purposes, RCS programs should be viewed within the broader context of the determinants of residential energy consumption. Chart 1 provides an illustration. It identifies eight factors, internal to the residential household unit, which influence the household's energy consumption. These factors are:

1. Homeownership status (owners versus renters)

2. Demographic characteristics

3. Housing characteristics

4. Energy system characteristics

5. Attitudes, priority given to conservation and awareness of energy prices

6. Existing conservation measures or lack thereof

7. Evaluation of the RCS audit by the household

8. Implementation rates for additional measures based on the audit.

As the chart also shows, there are additional factors, external to the household unit, which may influence its energy consumption. They are:

1. Building codes and their enforcement

2. Level payment plans

3. Submetering laws.

Moreover, there are external factors which influence a residential customer's decision whether or not to implement additional conservation measures. They include:

1. Availability and cost of conservation options

2. Availability and cost of contractors and persons to install the options

3. Availability of external sources of funds and incentive programs.

METHODOLOGY

The eight factors internal to the residential household unit are measured by the following variables:

1. Homeownership Status

a. percent of households who own

b. percent of households who rent

2. Demographic Characteristics

a. median household annual income or income class

b. median mortgage or rental costs (annual or monthly)

c. median educational levels

d. median family size

e. percent of households with children

f. percent of households with persons aged 65 and over

g. median age

h. percent employed full-time

i. percent retired

j. percent unemployed

3. Housing Characteristics

a. most prevalent type of house - detached, townhouse, or apartment

b. median size measured by area square foot or number of heated rooms

c. median age of house or year built

4. Energy Systems Characteristics

a. heating systems

i. percentage of households using gas, electricity or oil for heating

ii. median annual heating costs

iii. median age or year purchased

b. water heating systems

i. percent gas or electric

ii. median size measured by capacity

c. cooling systems

i. percent of households which have air conditioning

ii. percent of households which have central air conditioning

iii. median size

iv. median annual cooling costs

v. median age or year built

5. Attitudes and Awareness

   a. why requested an audit

   b. percent who know prices of electricity or gas

   c. purpose of audits and priority given to conservation in comparison to time constraints and comfort goals

   d. how learned of audit

6. The information required for item 6 is the lack of existing conservation measures and recommendation rates for each conservation measure recommended during audits. The recommendations are sorted into four cost categories (no expenditure, low cost of less than $100, medium cost of $100-$1000, and high cost of greater than $1000) based on the actual reported costs of implementation by RCS participants.

7. Implementation rates

   a. Number of times each option is implemented divided by the number of times it was recommended (first definition)

   b. Number of times each option was implemented divided by the number of households in the sample (second definition)

8. Evaluation of the RCS programs by the customers

   a. Reasons why they implemented options

   b. Reasons why they did not implement options

   c. Usefulness of audits

The second definition of implementation rates is necessary when comparisons are made between participants and nonparticipants because there is no measure of recommendation rates for nonparticipants in the PEPCO samples. PEPCO did not ask nonparticipants whether or not they had implemented each measure prior to the 12 month period queried in the survey. To understand why conservation measures are or are not implemented, it is necessary to trace the connection between the basis or criteria used to recommend conservation measures and the implementation rates. To this end, the following comparisons were made:

1. The lack of existing conservation measures with the recommendation rates

2. Recommendation rates with the implementation rates for each conservation measure. For this analysis, implementation rates are measured based on the first definition.

The above information was calculated by Commission Staff at three levels: 1. for participants and for nonparticipants separately in the samples; 2. for owners and renters, separately; and 3. for owners for each of four income classes and for renters for each of four income classes.

Unfortunately, PEPCO and WGL did not use the same income class definitions, therefore the analysis by income class had to be undertaken separately for each utility. The four income classes for PEPCO are as follows:

1. under $15,000

2. $15,000 -$24,999

3. $25,000-$49,999

4. $50,000 and over

The four income classes for WGL are:

1. under $15,000

2. $15,000-$24,999

3. $25,000-$39,999

4. $40,000 and over.

SUMMARY PROFILES

1. Participants Versus Nonparticipants

A higher proportion of RCS participants (1) are homeowners, (2) have higher incomes, (3) are more educated, (4) have children and (5) are younger than nonparticipants. Overall,

almost all of RCS participants are homeowners (94 percent), they have a median income of $35,000-$40,000, they are college graduates, they have no children, they are between 35 and 49 years old, and they are employed full-time.

In comparison, a substantially lower share of nonparticipants are homeowners (62 percent). Their median income is $25,000, they have some college education but have not graduated, they also have no children, and they are older (the majority are 50-64 years of age).

As shown in Table 3, there is not much variation in the demographic profiles of RCS participants and nonparticipants among the three data sets. The WGL data sets for participants have somewhat higher proportions of owners and lower percentages of households with children than does PEPCO's 1986 participant data set. PEPCO's nonparticipant data set has a somewhat lower median income than the WGL data sets; otherwise the demographic profiles of the data sets are nearly identical.

The demographic profiles provide some insight into why relatively high income and well-educated homeowners with no children and between 35-49 years of age requested audits. The relatively high income provides the financial basis for implementing measures the household deems worthwhile. The homeownership status is an added incentive to invest in conservation measures. Finally, the 35-49 age group was the principal home purchase group during the inflationary periods of the 1970s and high housing prices during the 1980s. Thus, this age group, with possibly high mortgages, has an incentive to minimize its energy costs.

Although low income households comprise a small percentage of the RCS participants (approximately twelve percent), nearly half of the low income households includes persons aged 65 and over. Senior citizens, facing a possible diminution of income and longer hours at home, are also likely candidates for home energy audits.

The housing characteristics of RCS participants also enhance the likelihood they would request an audit. The majority of RCS participants live in single family, detached houses which are at least 2,000 square feet and were built before 1940. Detached houses have more exposed walls; large houses may be more vulnerable to heat loss if conservation measures do not exist, and older houses are more likely to lack insulation and other conservation measures which were not installed when they were built.

Finally, the characteristics of the heating and cooling systems of RCS participants provide some insight into why RCS participants requested audits. In the District of Columbia, over 80 percent of the residential households use gas for heating and hot water heating. Most RCS participants and nonparticipants use gas for heating hot water heating. The majority of RCS participants have furnaces which are over ten years old, annual heating costs are approximately $1,001-$1,500 and annual cooling costs are $301-$400. The majority of participants also have air conditioning and almost half of these have central air conditioning. Half of the air conditioned units of participants are 7-8 years old. Although we do not have comparable information on nonparticipants, existing information suggests more RCS participants have air conditioning and particularly central air conditioning than nonparticipants.

3. Both participant and nonparticipant owners tend to be older than participant and nonparticipant renters. However, participant owners are younger than the nonparticipant owners and participant renters are younger than nonparticipant renters.

4. In most cases, a larger proportion of owners than renters have children or retired members of the household.

Although the information on housing characteristics is more limited than on demographic characteristics (see Table 11), there is evidence that the housing characteristics of owners favor their interest in RCS audits. Owners appear to have larger and older houses than renters. Most owners have single family, detached houses while most renters live in apartments or townhouses.

Heating and air conditioning systems of owners make them likely candidates for audits as compared to renters. Although the vast majority of both use gas for heating and hot water heating and have air conditioning, owners' heating and cooling costs are higher than renters' heating and cooling units (possibly related to the differences in housing characteristics). Both owners and renters have relatively old heating and air conditioning units; the heating units are even older than the air conditioning units. Owners are also more likely to have air conditioning, including central air conditioning, than renters.

The key difference in attitudes about audits appears to be between participants and nonparticipants as well as owners and renters. (See Table 12) "Saving energy" was the most prevalent response of both participant owners and renters. In contrast, nonparticipant owners cited resale value most often. Nonparticipant renters cited "comfort."

It appears from Table 13 that owners and renters have similar needs for energy audits and the implementation of conservation measures based on the proportion of households which lack each conservation measure as per the PEPCO 1986 RCS data set. (Comparable information is not available from WGL's data sets.) However, it should also be pointed out that the sample size of renters is relatively small (ranging from 19-31) compared to the sample size of owners (ranging between 171-241). Thus, the figures for the renters are not as reliable.

The PEPCO data on recommendation rates (see Table 14) show participant owners, in most cases, have higher recommendation rates than participant renters, but the reverse is true in the WGL data sets. However, the WGL renter data sets are too small (only six in the 1985 data set and 15 in the 1986 data set) to yield reliable results. Therefore, participant owner versus renter comparisons of recommendation rates are highly dubious.

Although the same sample size problem exists for the implementation rates of participant renters, by both definitions, nonparticipant owners have higher implementation rates than nonparticipant renters. (See Tables 15 and 16.) In this latter case, the sample sizes of

participants and nonparticipants in the PEPCO and WGL data sets (the WGL data sets are merged into one).

The three top reasons for implementing measures provided by participants and nonparticipants are similar; to save money, for comfort, and to save energy (or insulate). Saving money is clearly a necessary motivation for implementing conservation measures although it was the lowest ranked purpose of an audit (a possible proxy determinant for requesting an audit).

The three leading reasons for not implementing conservation measures are also similar in the PEPCO and WGL data sets but their relative ranking is different. The most frequently cited answer by WGL participants and nonparticipants was "no need for the measures" and the proportion of respondents giving this answer was slightly higher for participants than for nonparticipants. "Lack of cost-effectiveness" was the second leading answer by WGL participants. These responses suggest WGL has not been effective in convincing participants of the cost-effectiveness of its recommendations or conservation measures in general.

The three top responses in the PEPCO survey of participants only on this issue were: no money (46 percent); no need (10 percent); and no time (10 percent). (No money had ranked third among WGL participants and second among nonparticipants). It is unclear whether these responses mean there is a lack of availability of outside funds or that the respondents are not sufficiently convinced of the cost effectiveness of the measures to commit their own funds, much less borrow funds.

2. Owner Versus Renter Profiles

It has already been shown that the RCS programs of PEPCO and WGL have reached primarily owner-occupied households. The penetration rate for renter households is negligible. Thus, it is useful to analyze the owner versus renter profiles of RCS participants and nonparticipants for insights into why there is an owner bias in the programs. The owner/rental distinction is important because, in the District of Columbia, over 80 percent of the low income live in rental units.

Table 11 summarizes the demographic profiles, housing characteristics and energy systems of RCS participant and nonparticipant owners and renters. The basic patterns are similar for both PEPCO's and WGL's data sets. The following conclusions are evident:

1. The median income of owners is higher than renters for both participants and nonparticipants.

2. Both participant and nonparticipant owners have more education than their renter counterparts.

Responses by RCS participants (after the audit) and nonparticipants to questions on the purposes of audits provide some insight into the relative priority they give to energy audits. Both participants and nonparticipants were asked the extent to which they agreed that the purposes of audits were to (1) save energy, (2) increase comfort, (3) save money, and (4) increase the resale value of the home. Two conclusions are evident from the information contained in Table 4. The first is the fact that the percentage of participants which agrees that each item is a purpose of the audits is higher for participants than for nonparticipants. This result suggests the audits may have had some positive influence in participants' attitudes about the audit. Second, in both cases, saving money is ranked last by both participants and nonparticipants. In contrast, comfort ranks high; first among nonparticipants and second among participants. If nonparticipants expect audits to address comfort questions first, then this could be a barrier to their participation in the program. Dr. Mathur discusses this issue in more detail in his paper.

Information on the extent to which participants (preaudit) and nonparticipants lacked conservation measures is contained in Table 5. It is difficult to analyze PEPCO's and WGL's data on the lack of existing conservation measures because the information is not always comparable. PEPCO has obtained more information on participants than has WGL but the measurement criteria for the two sources appear to be different because the companies asked different questions. Moreover, PEPCO did not obtain similar information for nonparticipants. WGL collected information on nonparticipants which could be used as a proxy. For example, WGL asked nonparticipants if they had not implemented a measure in the last twelve months, was it because they had already done it or because it was not applicable. The figures for WGL are derived on the basis of these data.

With these caveats in mind, the data suggest a majority of D.C. households lack many conservation measures prior to having an audit. One might conclude from this information that there is a sizeable potential among D.C. residential customers for implementing conservation measures.

Table 6 summarizes recommendation-rates for RCS participants in the PEPCO 1986 and WGL 1985 and 1986 data sets for each conservation measure. In most cases, PEPCO's recommendation rates are higher than WGL's rates. This result is consistent with the relatively higher lack of existing measures for PEPCO's RCS participants than for WGL's, where data exist on both sources. But, more importantly, the question arises, given similar demographic profiles and housing and energy systems characteristic among the three samples, why is there such a disparity in recommendation rates? The answer could lie in different criteria used by the companies in recommending measures. It is an issue, therefore, that warrants further investigation.

Tables 7, 8, and 9 present implementation rates on each conservation measure for which there is an expenditure by RCS participants and nonparticipants. The implementation rates in Table 7 are in accordance with the first definition (the number of times a measure is implemented divided by the number of times it is recommended). The implementation rates in Table 8 are

based on the second definition (the number of times a measure is implemented divided by the number of households in the sample). The list of measures in Table 8 is the same as in Table 7. Table 9 presents the implementation rates for conservation measures that do not require an expenditure of funds for implementation. Data on these nonexpenditure measures are available only from the PEPCO data set.

Six points are noteworthy regarding these tables. First, in most cases, although demographic and housing characteristics are similar among all three data sets, implementation rates for PEPCO's RCS participants are higher than the implementation rates for WGL's participants, whether measured by the first or second definitions. Second, implementation rates for WGL's nonparticipants are higher than for PEPCO's nonparticipants. Third, in PEPCO's sample, participants have, in most cases, higher implementation rates than nonparticipants, but the reverse is true in both of WGL's samples.

Fourth, in all three data sets, implementation rates are highest for such low cost items as caulking and weatherstripping and the medium cost storm windows and doors measures. They are lowest for the high priced items (replacing heating systems and air conditioners) but also many low cost items (such as automatic pilots, clock thermostats and duct or pipe insulation).

Fifth, on the basis of the PEPCO data on "no expenditure" measures, the audits were somewhat successful in getting people to take action. It appears that only professionally audited participants (as opposed to households with do-it-yourself audits) set their thermostats back during the winter more so after the audits than before. However, a higher proportion of both professionally audited and do it yourself audited households set back their thermostats at night than did nonparticipants. The practice of setting up thermostats at night during the summer also increased among households who had professional audits. Finally, a majority of RCS participants kept their water heater thermostats on medium or high before the audit. Although more RCS participants lowered their water heater temperature settings after the audit than before, a smaller proportion did so than nonparticipants. Sixth, overall, implementation rates for participants averaged 18 percent by the first definition and 12 percent by the second definition. The average implementation rate for nonparticipants was 16 percent by the second definition.

These results raise two questions: First, why are implementation rates for the WGL program higher for nonparticipants than for participants when the reverse is true for the PEPCO study, given the fact that both sample groups appear to be similar in their demographic and housing characteristics? Second, why are implementation rates so low among D.C. households when a sizeable potential for energy conservation appears to exist?

There are three possible sources of answers to these questions (1) RCS program design, (2) the way the programs are being implemented, and (3) consumer preferences.Further investigation is warranted in each of those areas.

Some insights may be gained by analyzing the reasons participants gave for implementing and not implementing conservation measures. Table 10 summarizes the results for

nonparticipant renters are substantially larger (ranging from between 118 and 200 households) than for participant renters.

The PEPCO audits appear to be successful in getting both participant owners and renters to set thermostats back at night in the winter and set thermostats up in the summer but owners do so more so than renters (see Table 17). The audits were less successful in convincing participant owners and renters to lower their water heater settings although some improvement occurred among owners.

Reasons for implicating conservation measures are similar for participant and nonparticipant owners and renters saving money, comfort, and saving energy (see Table 18). However, the reasons given for not implementing measures differ between the two groups. Owners cite lack of money, need and cost effectiveness. In contrast, renters cite their rental status as the overwhelming barrier.

3. Low Income Versus High Income Profiles

As is evident from the goals and evaluation criteria set by the District of Columbia Public Service Commission, reaching low income households is one of the three major goals of the RCS program. It is thus useful to analyze the profiles of low income versus high income RCS participants and nonparticipants and by owners and renters for insights into this issue. As a reminder, low income is defined as households having incomes under $15,000. High income is defined as $50,000+ in the PEPCO sample; in the WGL samples it is $40,000+.

The demographic profiles of low and high income households in the three data sets is contained in Table 19. The information is provided in four categories (1) participant owners, (2) participant renters, (3) nonparticipant owners and (4) nonparticipant renters. Despite these breakdowns, the patterns are the same in almost all categories. To summarize:

1. Low income households have less education than high income households.

2. Low income households have smaller family sizes (except for nonparticipant renters where the reverse is true).

3. The median age of low income respondents is higher than for high income respondents (data are available for the PEPCO data set only).

4. A lower percentage of low income households have children than do high income households (except nonparticipant renters where the reverse is true).

5. Low income households are more likely to have retired persons than high income households. In fact, nearly half of the low income participant households are comprised of senior citizens

The relatively small family sizes and the absence of children among low income participants reflects the large senior citizen composition of the low income participant group. Moreover, even greater potential to reach low income senior citizens appears to exist given the fact, according to the PEPCO sample, 82 percent of the low income nonparticipant owners had members of the household who were aged 65 or over.

The RCS programs do not appear, however, to be reaching low income renter households, and, particularly, those which are relatively large and with children. Reaching this group may well require resources beyond the scope of the existing RCS programs. Housing characteristics of RCS participants appear to vary with income. This is not the case for nonparticipants. All three data sets show similar patterns as follows (See Table 20):

1. A majority of low income participant owners live in townhouses; a majority of high income participant owners live in single family, detached housing.

2. A majority of low income participant renters live in apartments; a majority of high income participant renters live in townhouses.

3. A majority of both low and high income nonparticipant owners live in single family, detached houses.

4. In the PEPCO data set, both high and low income nonparticipant renters live in single family detached housing; in the two WGL data sets, both low and high income nonparticipant renters live in apartments.

Information on the age of houses or year they were built is available only for participant owners and renters in PEPCO's set. Both low and high income participant owners live in housing built before 1940. In comparison, both low and high income participant renters live in newer housing but built before 1960.

Two measures of the size of the houses were used - the square footage and the number of heated rooms. The square footage data were collected only by PEPCO. They show low income participant owners and renters live in smaller housing than high income owner and renter participants. The information on the number of heated rooms is available for nonparticipants only and was collected by both PEPCO and WGL. In every case, low income households live in smaller housing than high income households.

In summary, high income participant households live in larger, and detached housing and low income participant households live in smaller apartments or townhouses. Both high and low income participant owners live in relatively old housing compared with high and low income participant renters. Thus, high income participant households satisfy more criteria for the likelihood of requesting an audit than do low income participant households.

The only heating system characteristics appear to vary with income are the age of the units and heating costs. (See Table 21.) Data are available for RCS participants only in the PEPCO data set. Low income households have older furnaces than high income households although the majority of both have units which are more than ten years old (also possibly related to their housing characteristics). A majority of both high income participant owners and renters reported annual heating costs of $1,000 - $1,500. In contrast, low income participant owners had median annual heating costs of $501- $1,000 and low income participant renters had median annual heating costs of about $300.

Table 22 presents the cooling systems data for participant and nonparticipant owners and renters by income class. It provides some supporting evidence for why high income households account for the majority of RCS participants. First, high income households are more likely to have air conditioning than low income households. Moreover, a larger proportion of high income households who have air conditioning have central air conditioning. The majority of low income households who have air conditioning (both participants and nonparticipants) have window units. The majority of high income participants have central air conditioning. Second, high income households, in most cases, have older air conditioning units than low income households. Third, high income participants have larger annual cooling costs - the median was $401 a year - compared to $301 for low income participant owners and $201 for low income participant renters.

How households view the purposes of the audits may be a factor in whether or not they request an audit. Table 23 provides the data by income class. It shows low income participants appear to expect audits to address comfort as the principal issue; higher income households appear to put more emphasis on saving energy first. In both cases, saving money was mentioned the least often. Thus, failure of the public to recognize the financial savings which could be associated with conservation may be a barrier to the expansion of the programs.

Nonparticipants' views on the purpose of audits are particularly important for they may provide clues to why this group has not requested an audit. Owners with incomes under $50,000 cite resale value most frequently as the purpose of an audit; owners with incomes of $50,000+ cite saving energy first. In comparison, however, low income renters cite comfort first; middle income renters cite resale value most frequently; and high income renters cite saving energy and comfort.

Table 24 enables one to compare the lack of conservation measures for RCS participant owners and renters by income class in PEPCO's 1986 data set. The table reveals that the lack of conservation measures is prevalent in all income classes. In many cases, the existence of conservation measures is no more prevalent for high income households than for low income households. This conclusion appears also to be applicable for both owners and renters. However, the small renter sample sizes yield unreliably high percentages.

Table 25 presents the recommendation rates for low income and high income participants in both the PEPCO and WGL data sets for each conservation measure. The sample sizes for

renter participants in each income class are too small to provide reliable results. Therefore, the analysis focuses on low income versus high income owners.

The most significant conclusion from this table is that recommendation rates for low income households are not always greater than for high income households and this is evident in all three data sets. It further corroborates the fact that the need for home energy audits is widespread among all income classes. However, it also confirms the need to reach the low income owner households.

Tables 26 and 27 present the implementation rates for low and high income participant and non participant households for each conservation measure and for the PEPCO and WGL data sets. The principal result is that, in some instances, low income households have higher implementation rates than high income households and this occurs even for some of the more expensive items. The same pattern is evident among nonparticipants but to a lesser extent, particularly in the WGL data sets. (See Table 28.)

How then do the reasons for implementing conservation measures vary by income class? Table 29 presents the supporting data. At least three observations can be made. First, comfort is clearly more important to low income than high income households and especially in the PEPCO data set. Second, also in the PEPCO data set, saving money, ironically, is cited more frequently by high income than low income households. Third, in the WGL 1986 data set, both low income and high income renters cited tax credits most frequently as the reason they implemented conservation measures. This response must reflect the lack of the mortgage interest tax deduction for this group.

There are striking similarities in the responses of low income and high income households to why they did not implement conservation measures. Among owners, the leading answers were, in each sample, "too costly," "no time," "don't need," and "not cost effective." Among renters, "renting" was the response of the majority of both high and low income households.

SUMMARY AND CONCLUSION

The empirical analysis of the profiles of RCS participants and nonparticipants provides a foundation for addressing the outreach and educational effectiveness of PEPCO's and WGL's RCS programs. Both programs appear to be reaching similar types of residential households based on demographic, housing and energy characteristics. That is, participants tend to be high income, well educated, young homeowners with relatively old housing and energy systems, high heating and cooling costs, and large and detached housing. Almost half of low income participants are senior citizens. On the basis of all of these characteristics, the program appears to be reaching suitable residential households. However, the issues of how to reach more of these persons and how to reach many of the more difficult to reach households such as the renters and the low income requires further investigation.

Both PEPCO's and WGL's RCS programs have not been as effective in convincing participants to implement measures that have been recommended, despite an apparent interest in saving energy and lowering utility bills by participants who voluntarily requested audits. This is evidenced by the relatively low implementation rates given the high recommendation rates. Moreover, implementation rates the for WGL's program participants are even lower than for nonparticipants.

As a consequence of the weak implementation performance of RCS participants, the RCS programs of both PEPCO and WGL have clearly not met the objectives set by the Commission. The next step, therefore, is to examine the more detailed aspects of the program designs and the way the programs are being operated in an effort to improve their chances of meeting these goals. Additional research on residential conservation behavior is also warranted.

FUTURE RESEARCH

An analysis of the profiles of participants and nonparticipants is a necessary first step in evaluating RCS programs. As such, the conclusions from the empirical analysis can serve as hypotheses which are then subjected to more stringent econometric and other in depth analyses. Additionally, the profiles are useful in identifying issues of program design and operation which warrant further investigation.

Dr. Mathur and I are considering several follow-up studies. First, an investigation is already underway with respect to the issue of why the WGL implementation results are different from the PEPCO results, given the similarities in the demographic and housing characteristics. Second, we are considering the formulation of logit or probit econometric models which will better explain implementation behavior and how it is related to income and other factors. Third, as Dr. Mathur describes in more detail in his paper, we are planning to examine the role of comfort and time as well as conservation preferences in the utility functions of residential consumers and reformulate demand models taking these factors into consideration. Finally, I am investigating an auxiliary proposal to improve the outreach to low income households (80 percent of whom live in rental housing) which will be beneficial both to the utility companies and the rentpayers. In any event, all of these proposed research projects first required an understanding of the profiles of RCS participants and nonparticipants in the District of Columbia.

CHART 1

EVALUATION CONCEPTUAL FRAMEWORK

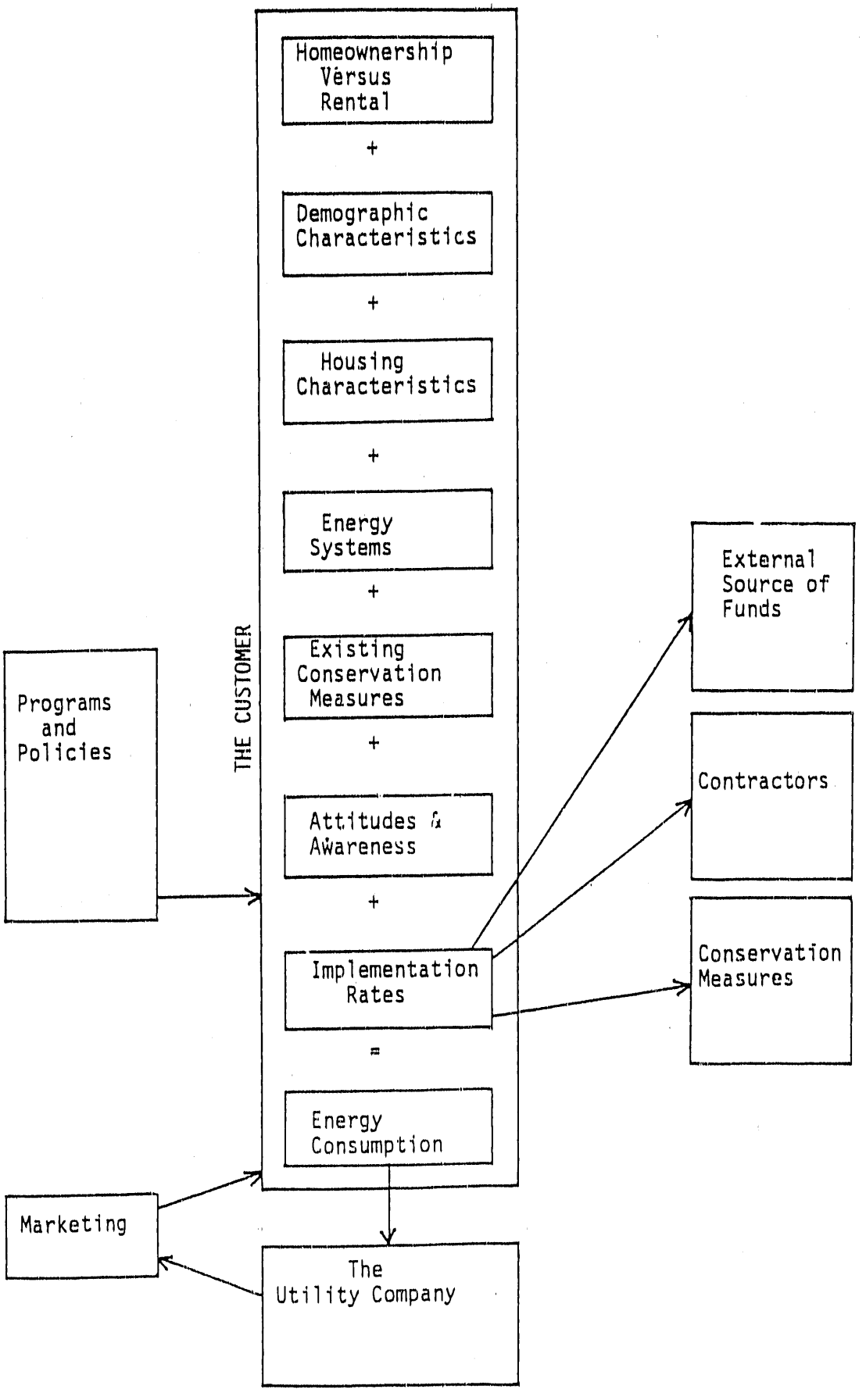


TABLE 1

NUMBER OF RCS AUDITS, 1985-1986

CATEGORY	PEPCO	WGL	TOTAL
No. Requested			
1985	2,073	840	2,877
1986	2,681	1,149	3,830
	4,718	1,980	6,797
No. Completed			
1985	1,813	721	2,534
1986	2,612	1,143	3,755
	4,425	1,864	6,269
% Completed			
1985	89	86	88
1986	97	99	98
	94	94	94

Sources: Pepco's Response to Staff Data Request No. 13.1 and
WGL's Response to Staff Data Request No. 9.1

TABLE 2

A. DATA BASES FOR RCS PARTICIPANTS, PEPCO, & WGL

Audit Type	RCS Population	Sample Size		Energy Avoidance	
	No	No	%	No	%
I	1985 Reports - Pepco				
	A. 1/84-9/30/84 - Period of Audit			B. Date of Survey Jan/Feb 1985 (4 mos)	
Prof	947	270	29	26	3
DIY	186	92	49	17	9
Total	1133	362	32	43	4
II	1986 Report - Pepco				
	A. 10/1/84-9/30/85 - Period of Audit			B. Date of Survey March-May 1986 (6 mos)	
Prof	1258	300	24	110	9
DIY	209	40	19	9	4
Total	1467	*340	23	119	8
III	1985 - WGL				
	A. 10/1/84 - 9/30/85			B. None	
Total	663	*249	38	NA	NA
IV	1986 - WGL				
	A. 9/1/85 - 8/31/86			B. Date of Survey November 1986(3mos)	
Total	1175	*229	35	188	28

* Utilized by District of Columbia Public Service Commission Staff in this paper

TABLE 2

8. DATA BASES FOR NONPARTICIPANTS, PEPCO & WGL

	Eligible	Annual Report		Energy Avoidance Study	
	No.	No.	%	No.	%
I	1985 Reports-Pepco				
	179,000	385	0.2	14	0
II	1986 Reports-Pepco				
	181,710	*380	0.2	104	0
III	1985 Annual Reports-WGL				
	130,000	*387	0.3	0	0
IV	1986 Annual Reports-WGL				
	130,000	*390	0.3	328	0.3

* Utilized by District of Columbia Public Service Commission Staff for this paper

TABLE 3
DEMOGRAPHIC, HOUSING & ENERGY SYSTEMS CHARACTERISTICS,
RCS PARTICIPANTS AND NONPARTICIPANTS

	PARTICIPANTS			NONPARTICIPANTS		
CATEGORY	PEPCO '86	WGL '85	WGL '86	PEPCO '86	WGL '85	WGL '86
			DEMOGRAPHIC PROFILES			
MEDIAN INCOME	$35,000-$49,999	$40,000 +	$40,000 +	$15,000-$24,999	$25,000-$39,999	$25,000-$39,999
MEDIAN AGE	35-49	NA	NA	50-64	NA	NA
MEDIAN FAMILY SIZE	2-3	2	2	2	2	2
MEDIAN EDUCATION	College Grad	College Grad	College Grad	Some College	Some College	Some College
% OF HH WITH PERSONS AGED 65+	25	24	22	31	20	22
% OF HH WITH CHILDREN	44	36	37	31	35	33
% OWNERS	89	94	97	57	67	60
% RENTERS	11	6	3	43	33	40
% LOW INCOME	18	12	11	34	24	21
% HIGH INCOME	37 ($50,000 +)	61 ($40,000 +)	63 ($40,000 +)	17 ($50,000)	33 ($40,000 +)	37 ($40,000 +)
			HOUSING CHARACTERISTICS			
PRINCIPAL HOME TYPE	Two story	Single, Detached	One story	One story	Single, Detached	Single, Detached
MEDIAN NUMBER OF ROOMS	7	NA	-	7	NA	NA
MEDIAN YEAR BUILT	Pre 1940	NA	NA	NA	NA	NA
			ENERGY SYSTEMS			
MEDIAN HEATING FUEL**	Gas 87%	GAS 94%	GAS 94%	Gas 81%	GAS 72%	NA
MEDIAN WATER HEATING FUEL	GAS	GAS	GAS	GAS	GAS	GAS
MEDIAN TYPE OF HEATING SYSTEM	Hot Water (50%)	NA	NA	NA	NA	NA
MEDIAN AGE	10 years	12 years	10 years	NA	NA	NA
MEDIAN HEATING COST ($)*	1,001-1,500	NA	NA	NA	NA	NA
% WITH AIR CONDITIONING	78	42	59	75	NA	NA
% WITH CENTRAL AIR CONDITIONING	47	41	45	29	NA	NA
MEDIAN AGE*	Pre 1979	7 years	7 years	NA	NA	NA
MEDIAN SIZE	2.5 Tons	NA	NA	NA	NA	NA
MEDIAN COOLING COST ($)*	301-400	NA	NA	NA	NA	NA

*Professional audits only
** Gas refers to central gas.

TABLE 4

PURPOSE OF AUDITS - PARTICIPANTS AND NONPARTICIPANTS - PEPCO 1986
DATA SET ONLY

CATEGORY	PERCENT THAT AGREES
Participants*	
Save Energy	77
Comfort	73
Resale Value	62
Save ($)	59
Nonparticipants	
Save Energy	62
Comfort	62
Resale Value	60
Save ($)	51

* Post Audit

TABLE 5

LACK OF EXISTING CONSERVATION MEASURES - RCS PARTICIPANTS AND NONPARTICIPANTS

MEASURES	PARTICIPANTS			NONPARTICIPANTS		
	PEPCO '86	WGL '85	WGL '86	PEPCO '86	WGL '85	WGL '86
HIGH COST (> $1,000)						
REPLACE AIR CONDITIONER	46	13	14	NA	58	69
REPLACE HEATING SYSTEM	59	60	53	NA	55	74/68 *
MEDIUM COST ($100 - $1,000)						
STORM WINDOWS	42	NA*	NA	NA	71	81
STORM DOORS	58	NA	NA	NA	67	80
WALL INSULATION	80	NA	NA	NA	66	75
CEILING INSULATION	69	NA	NA	NA	67	77
SHADING	-	NA	NA	NA	72	77
LOW COST (< $100)						
CAULKING	88	NA	NA	NA	76	84
WEATHERSTRIPPING	91	NA	NA	NA	77	84
WATER TANK INSULATION	79	87	76	NA	73	82
DUCT INSULATION	53	NA	NA	NA	62	80
PIPE INSULATION	-	NA	NA	NA	70	78
AUTOMATIC PILOT	70	0.4	4	NA	71	80
CLOCK THERMOSTAT	90	59	72	NA	68	82
FLOOR INSULATION	83	NA	NA	NA	64	79
FLUE	-	2	5	NA	65	81

* The first number refers to furnaces and the second number refers to oil burners.
NA means not available.

TABLE 6

RECOMMENDATION RATES OF RCS PARTICIPANTS FOR EACH CONSERVATION MEASURE

MEASURES	PARTICIPANTS PEPCO '86 %	WGL '85 %	WGL '86 %
HIGH COST (> $1,000)			
REPLACE AIR CONDITIONER	16	11	14
REPLACE HEATING SYSTEM	61	57	52
MEDIUM COST ($100 - $1,000)			
STORM WINDOWS	68	70	74
STORM DOORS	62	10	40
WALL INSULATION	44	24	31
CEILING INSULATION	67	66	77
SHADING	0	1	19
LOW COST (< $100)			
CAULKING	86	75	83
WEATHERSTRIPPING	88	70	62
WATER TANK INSULATION	73	86	77
DUCT INSULATION	12	5	11
PIPE INSULATION	19	1	16
AUTOMATIC PILOT	70	1	1
CLOCK THERMOSTAT	69	58	72
FLOOR INSULATION	59	36	54
FLUE	42	2	5

TABLE 7

IMPLEMENTATION RATES (FIRST DEFINITION) FOR EACH CONSERVATION MEASURE FOR RCS PARTICIPANTS

MEASURES	PARTICIPANTS		
	PEPCO '86	WGL '85	WGL '86
HIGH COST (> $1,000)			
REPLACE AIR CONDITIONER	6	4	7
REPLACE HEATING SYSTEM	11	9	6
MEDIUM COST ($100 - $1,000)			
STORM WINDOWS	24	12	28
STORM DOORS	24	37	19
WALL INSULATION	13	12	8
CEILING INSULATION	19	24	20
SHADING	-	0	9
LOW COST (< $100)			
CAULKING	65	57	49
WEATHERSTRIPPING	57	36	40
WATER TANK INSULATION	28	21	16
DUCT INSULATION	17	17	6
PIPE INSULATION	27	0	23
AUTOMATIC PILOT	11	0	0
CLOCK THERMOSTAT	15	13	14
FLOOR INSULATION	11	12	8
FLUE	14	0	7
AVERAGE	22	16	16

TABLE 8

IMPLEMENTATION RATES (SECOND DEFINITION) FOR EACH CONSERVATION MEASURE FOR RCS

MEASURES	PEPCO '86		WGL '85		WGL '86	
	PARTICIPANTS %	NONPARTICIPANTS %	PARTICIPANTS %	NONPARTICIPANTS %	PARTICIPANTS %	NONPARTICIPANTS %
HIGH COST () $1,000)						
REPLACE AIR CONDITIONER	1	6	0.4	11	1	14
REPLACE HEATING SYSTEM	9	2	5	14	3	16/12*
MEDIUM COST ($100 - $1,000)						
STORM WINDOWS	16	15	26	37	21	40
STORM DOORS	15	9	1	28	8	37
WALL INSULATION	6	3	3	14	2	14
CEILING INSULATION	12	5	16	20	15	21
SHADING	-	-	0	24	2	24
LOW COST (($100)						
CAULKING	56	39	42	41	40	45
WEATHERSTRIPPING	50	39	25	44	25	42
WATER TANK INSULATION	20	6	18	17	12	18
DUCT INSULATION	2	3	1	12	1	13
PIPE INSULATION	5	3	0	17	4	14
AUTOMATIC PILOT	8	-	0	16	0	11
CLOCK THERMOSTAT	10	5	8	19	10	21
FLOOR INSULATION	6	2	4	13	4	12
FLUE	6	-	0	11	0	15

*The first number refers to furnaces and the second number refers to oil burners.

TABLE 9

IMPLEMENTATION RATES OF "NO EXPENDITURE" MEASURES
FOR PARTICIPANTS AND NONPARTICIPANTS IN
PEPCO'S 1986 DATA SET ONLY

CATEGORY	PERCENTS
1. WINTER SETBACK	
Participants	
Preaudit	
Professional	28
Do it Yourself	75
Postaudit	
Professional	58
Do it Yourself	53
Nonparticipants	37
2. SUMMER SETUP	
Participants	
Preaudit	
Professional	2
Do it Yourself	24
Postaudit	
Professional	25
Do it Yourself	22
Nonparticipants	12
3. PILOT OFF - PREAUDIT*	
Participants	21
Nonparticipants	NA
4. % WITH WATER HEATER SETTING ON LOW*	
1985	27
1986	19
5. LOWERED WATER HEATER SETTINGS	
Participants	
Preaudit	31
Postaudit	39
Nonparticipants	46

* Professional Audits Only

TABLE 10

REASONS WHY RCS PARTICIPANTS AND NONPARTICIPANTS DID AND DID NOT IMPLEMENT CONSERVATION MEASURES

LEADING REASONS	PEPCO PARTICIPANTS		WGL PARTICIPANTS		WGL NONPARTICIPANTS	
		Why Implemented				
#1	Save $	35%	Save $	45%	Save $	38%
2	Comfort	22%	Comfort	24%	Comfort	19%
3	Save energy	21%	Insulate	17%	Insulate	18%
		Why Not Implemented				
#1	No	46%	Not Needed	27%	Not Needed	25%
2	Not Needed	10%	Not Cost Effective	24%	No Money	23%
3	No Time	10%	No Money	20%	Renting	20%

TABLE 11

DEMOGRAPHIC, HOUSING & ENERGY SYSTEMS CHARACTERISTICS
OF BCS PARTICIPANT AND NONPARTICIPANT OWNERS AND RENTERS

	PARTICIPANTS				NONPARTICIPANTS			
	OWNERS		RENTERS		OWNERS		RENTERS	
CATEGORY	PEPCO	WGL	PEPCO	WGL	PEPCO	WGL	PEPCO	WGL
DEMOGRAPHIC CHARACTERISTICS								
MEDIAN INCOME ($,000)	35.0-49.9	40.0+	15.0-24.9	15.0-24.9	25.0-34.9	25.0-35.9	10.0-14.9	15.0-24.9
MEDIAN FAMILY SIZE	2-3	2-3	2	3	2	3	2	2
MEDIAN EDUCATION	COLL GRAD	COLL GRAD	HS GRAD	SOME COLL	SOME COLL	SOME COLL	HS GRAD	SOME COLL
% OF HH WITH PERSONS AGED 65+	24	23	23	29	36	26	24	7
% OF HH WITH CHILDREN	41	37	43	33	31	35	32	31
MEDIAN AGE	35-49	NA	18-24	NA	50-64	NA	35-49	NA
HOUSING CHARACTERISTICS								
PRINCIPAL HOME TYPE	SINGLE, DETACHED	SINGLE, DETACHED	APT	APT/TH	SINGLE, DETACHED	SINGLE, DETACHED	SINGLE, DETACHED	APT
MEDIAN SIZE ('000 SQ. FT.)	2	NA	1.2	NA	NA	NA	NA	NA
MEDIAN YEAR BUILT	PRE 1940	NA	1940-60	NA	NA	NA	NA	NA
ENERGY SYSTEMS CHARACTERISTICS								
MEDIAN HEATING FUEL	GAS	GAS	GAS	GAS	GAS	GAS	GAS	GAS
MEDIAN WATER HEATING FUEL	GAS	GAS	GAS	GAS	GAS	GAS	GAS	GAS
MEDIAN TYPE OF HEATING SYSTEM	HOT WATER	NA	FORCED AIR	NA	NA	NA	NA	NA
MEDIAN AGE	>10 YEARS	NA	>10 YEARS	NA	NA	NA	NA	NA
MEDIAN TOTY HEATING COST ($)*	1,001-1,500	NA	501-1,000	NA	NA	NA	NA	NA
% WITH AIR CONDITIONING	79	NA	74	NA	79	NA	68	NA
MEDIAN AGE OF A/C	@ 10 YEARS	NA	10 YEARS	NA	NA	NA	NA	NA
MEDIAN SIZE OF A/C	2.5 TONS	NA	2.0 TONS	NA	NA	NA	NA	NA
MEDIAN TOTY COOLING COST ($)*	301-400	NA	201-300	NA	NA	NA	NA	NA

NA means not available
* Professional audits only

TABLE 12

PURPOSES OF AUDITS - RCS PARTICIPANT AND NONPARTICIPANT OWNERS AND RENTERS (Pepco's 1986 Data Set Only)

	PARTICIPANTS		NONPARTICIPANTS	
CATEGORY	OWNERS %	RENTERS %	OWNERS %	RENTERS %
	PERCENT THAT AGREES			
Save Energy	77	86	57	64
Comfort	72	86	58	69
Resale Value	66	43	62	63
Save ($)	60	60	47	55

TABLE 13

LACK OF EXISTING CONSERVATION MEASURES - RCS PARTICIPANT OWNERS AND RENTERS

	PEPCO 1986	
MEASURES	OWNERS %	RENTERS %
HIGH COST () $1,000)		
REPLACE AIR CONDITIONER	44	25
REPLACE HEATING SYSTEM	61	46
MEDIUM COST ($100 - $1,000)		
STORM WINDOWS	42	45
STORM DOORS	58	57
WALL INSULATION	80	72
CEILING INSULATION	76	100
SHADING	--	--
LOW COST (($100)		
CAULKING	88	85
WEATHERSTRIPPING	91	89
WATER TANK INSULATION	78	55
DUCT & PIPE INSULATION	47	57
FLUE	NA	NA
AUTOMATIC PILOT	85	100
CLOCK THERMOSTAT	89	100
FLOOR INSULATION	89	100

TABLE 14

RECOMMENDATION RATES FOR EACH CONSERVATION MEASURE BY RCS PARTICIPANT
OWNERS AND RENTERS

	PEPCO 1986		WGL 1985		WGL 1986	
MEASURES	OWNERS %	RENTERS %	OWNERS %	RENTERS %	OWNERS %	RENTERS %
HIGH COST (> $1,000)						
REPLACE AIR CONDITIONER	[illegible]	10	[illegible]	--	[illegible]	--
REPLACE HEATING SYSTEM	[illegible]	48	55	[illegible]	[illegible]	40
MEDIUM COST ($100 - $1,000)						
STORM WINDOWS	[illegible]	65	67	100	76	87
STORM DOORS	62	55	9	33	39	33
WALL INSULATION	[illegible]	32	17	[illegible]	31	20
CEILING INSULATION	70	39	70	[illegible]	77	60
SHADING	--	--	0.5	--	20	7
LOW COST (< $100)						
CAULKING	[illegible]	[illegible]	74	100	[illegible]	[illegible]
WEATHERSTRIPPING	[illegible]	[illegible]	65	100	[illegible]	[illegible]
WATER TANK INSULATION	[illegible]	[illegible]	64	100	[illegible]	[illegible]
DUCT INSULATION	[illegible]	10	4	--	11	[illegible]
PIPE INSULATION	24	0	--	--	15	40
FLUE	[illegible]	[illegible]	0.5	--	[illegible]	--
AUTOMATIC PILOT	[illegible]	[illegible]	[illegible]	--	[illegible]	--
CLOCK THERMOSTAT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FLOOR INSULATION	[illegible]	[illegible]	[illegible]	--	[illegible]	[illegible]

TABLE 15

INSTALLATION RATES (FIRST DEFINITION) FOR EACH CONSERVATION MEASURE BY RCS PARTICIPANT
OWNERS AND RENTERS

MEASURES	PRIOR 1984 OWNERS %	PRIOR 1984 RENTERS %	1985 OWNERS %	1985 RENTERS %	1986 OWNERS %	1986 RENTERS %
HIGH COST (> $1,000)						
REPLACE AIR CONDITIONER	3	0	5	--	0	--
REPLACE HEATING SYSTEM	9	7	10	20	7	0
MEDIUM COST ($100 - $1,000)						
STORM WINDOWS	23	20	35	17	22	23
STORM DOORS	20	6	12	0	17	0
WALL INSULATION	13	0	16	0	5	0
CEILING INSULATION	17	0	24	0	19	11
SHADING			0	0	11	0
LOW COST (< $100)						
CAULKING	69	52	54	33	51	23
WEATHERSTRIPPING	60	50	33	17	36	17
WATER TANK INSULATION	20	19	21	17	18	9
DUCT INSULATION	15	33	25	--	7	0
PIPE INSULATION	22	--	--	--	20	0
FLUE	16	0	0	--	10	--
AUTOMATIC PILOT	10	10	0	--	25	--
CHECK THERMOSTAT	10	0	12	0	15	0
FLUE INSULATION	11	0	13	--	7	11

TABLE 16

IMPLEMENTATION RATES (SECOND DEFINITION) FOR EACH CONSERVATION MEASURE FOR RCS PARTICIPANT AND NONPARTICIPANT OWNERS AND RENTERS

MEASURES	PEPCO '86				VGL '85				VGL '86			
	PARTICIPANTS		NONPARTICIPANTS		PARTICIPANTS		NONPARTICIPANTS		PARTICIPANTS		NONPARTICIPANTS	
	OWNERS	RENTERS	OWNERS	RENTERS	OWNERS	RENTERS	OWNERS	RENTERS	OWNERS	RENTERS	OWNERS	RENTERS
HIGH COST (> $1,000)												
REPLACE AIR CONDITIONER	0.4	0	11	3	0.5	--	14	8	1	--	13	15
REPLACE HEATING SYSTEM	6	3	1	0.7	5	17	10	6	4	0	21/14*	12/10*
MEDIUM COST ($100 - $1,000)												
STORM WINDOWS	15	13	22	9	24	17	51	19	17	20	47	32
STORM DOORS	17	3	21	1	11	0	39	11	7	0	46	22
WALL INSULATION	5	0	7	0	3	0	10	0	2	0	21	3
CEILING INSULATION	12	3	8	1	17	0	28	9	15	7	20	0
SHADING	--	--	--	--	0	0	29	19	2	0	25	19
LOW COST (< $100)												
CAULKING	61	45	51	30	40	33	54	25	42	20	48	37
WEATHERSTRIPPING	54	42	51	30	22	17	58	25	22	13	51	31
WATER TANK INSULATION	21	13	8	4	10	17	22	3	14	7	22	12
DUCT & PIPE INSULATION	2 5	3 0	6 6	-- --	1 --	-- --	17 24	3 5	1 4	0 0	16 19	7 0
FLUE	6	0	--	--	0	--	16	6	0.4	--	10	10
AUTOMATIC PILOT	7	6	--	--	0	--	23	0	1	--	16	4
CLOCK THERMOSTAT	13	6	7	4	7	0	25	0	11	7	26	12
FLOOR INSULATION	7	3	4	0.7	5	--	16	8	3	7	16	7

* The first number refers to furnaces and the second number refers to oil burners

TABLE 17

IMPLEMENTATION OF "NO EXPENDITURE" MEASURES BY PARTICIPANT AND NONPARTICIPANT OWNERS AND RENTERS
PEPCO'S 1986 DATA SET ONLY

CATEGORY	OWNERS	RENTERS
1. WINTER SETBACK		
Participants		
Preaudit		
Professional	29	25
Do it Yourself	76	67
Postaudit		
Professional	61	38
Do it Yourself	52	67
Nonparticipants	45	27
2. SUMMER SETUP		
Participants		
Preaudit		
Professional	2	6
Do it Yourself	25	0
Postaudit		
Professional	25	21
Do it Yourself	25	0
Nonparticipants	14	9
3. PILOT OFF		
Professional	21	18
4. WATER HEATER SETTINGS GREATER THAN LOW*		
1985	73	--
1986	91	85
5. LOWERED WATER HEATER SETTINGS		
Participants		
Preaudit	31	33
Postaudit	40	17
Nonparticipants	52	36

* Professional Audits Only

TABLE 18

REASONS WHY RCS PARTICIPANT AND NONPARTICIPANT OWNERS AND RENTERS DID AND DID NOT IMPLEMENT CONSERVATION MEASURES

LEADING REASONS	PEPCO				MGI							
	PARTICIPANTS				PARTICIPANTS				NONPARTICIPANTS			
	OWNERS		RENTERS		OWNERS		RENTERS		OWNERS		RENTERS	
Why Implemented												
#1	Save $	35%	Comfort	33%	Lower Bills	45%	Lower Bills	41%	Lower Bills	40%	Lower Bills	34%
2	Comfort	21%	Save $	22%	Comfort	25%	Save Energy	29%	Comfort	19%	Comfort	22%
3	Save Energy	8%	Save Energy	15%	Insulate	17%	Insulate	29%	Insulate	19%	Insulate	18%
Why Not Implemented												
#1	No $	50%	Renting	49%	Not Need	28%	Renting	63%	Renting	32%	Renting	55%
2	Not Need	11%	No $	20%	Not C/E	25%	No Money	27%	Not Need	17%	No $	11%
3	Not C/E	10%	Not Need	6%	No $	20%	Not C/E	5%	Not C/E	17%	Not Need	8%

C/E - Cost Effective

TABLE 19

DEMOGRAPHIC PROFILES OF RCS PARTICIPANT AND NONPARTICIPANT OWNERS AND RENTERS BY INCOME CLASS

	PEPCO 1986		WGL 1985		WGL 1986	
CATEGORY	Low Income	High Income	Low Income	High Income	Low Income	High Income
PARTICIPANT OWNERS						
MEDIAN EDUCATION	Some HS	Post Grad	HS Grad	Post Grad	Some HS	Post Grad
MEDIAN FAMILY SIZE	2	3	2	3	2	3
MEDIAN AGE	50-64	35-49	NA	NA	NA	NA
% OF HH WITH PERSONS AGED 65+	49	10	37	15	78	12
% OF HH WITH CHILDREN	40	48	26	45	17	91
PARTICIPANT RENTERS						
MEDIAN EDUCATION	Some HS	Post Grad	HS Grad	Post Grad	Some HS	Col Grad
MEDIAN FAMILY SIZE	1	4	1	3	2	5
MEDIAN AGE	50-64	35-49	NA	NA	NA	NA
% OF HH WITH PERSONS AGED 65+	40	0	50	0	67	0
% OF HH WITH CHILDREN	NA	NA	0	100	50	50
NONPARTICIPANT OWNERS						
MEDIAN EDUCATION	HS Grad	Post Grad	HS Grad	Col Grad	HS Grad	Post Grad
MEDIAN FAMILY SIZE	2	3	2	3	2	3
MEDIAN AGE	65+	35-49	NA	NA	NA	NA
% OF HH WITH PERSONS AGED 65+	82	11	61	9	55	12
% OF HH WITH CHILDREN	8	46	29	40	21	44
NONPARTICIPANT RENTERS						
MEDIAN EDUCATION	HS Grad	Post Grad	HS Grad	Post Grad	HS Grad	Col Grad
MEDIAN FAMILY SIZE	1	2	2	2	3	2
MEDIAN AGE	35-49	25-34	NA	NA	NA	NA
% OF HH WITH PERSONS AGED 65+	29	0	26	5	9	5
% OF HH WITH CHILDREN	NA	NA	33	21	59	22

NA Means not available
Low Income is defined as <$15,000 a year
High Income is defined as $50,000+ in Pepco sample; $40,000+ in WGL sample

TABLE 20

HOUSING CHARACTERISTICS OF RCS PARTICIPANT AND NONPARTICIPANT OWNERS AND RENTERS BY INCOME CLASS

	PEPCO 1986		WGL 1985		WGL 1986	
CATEGORY	Low Income	High Income	Low Income	High Income	Low Income	High Incom
PARTICIPANT OWNERS						
PRINCIPAL HOME TYPE	TH	SD	SD	SD	TH	SD
MEDIAN YEAR BUILT	PRE 1940	PRE 1940	NA	NA	NA	NA
MEDIAN SIZE ('000 SF)	1.4-1.6	2.0-2.2	NA	NA	NA	NA
PARTICIPANT RENTERS						
PRINCIPAL HOME TYPE	Apt	TH	Apt	TH	Apt	TH
MEDIAN YEAR BUILT	Pre 1960	Pre 1960	NA	NA	NA	NA
MEDIAN SIZE ('000 SF)	(1	2.0-2.2	NA	NA	NA	NA
NONPARTICIPANT OWNERS						
PRINCIPAL HOME TYPE	SD	SD	SD	SD	SD	SD
MEDIAN YEAR BUILT	NA	NA	NA	NA	NA	NA
MEDIAN SIZE (No. of Rooms)	6	7	7	9	8	10
NONPARTICIPANT RENTERS						
PRINCIPAL HOME TYPE	SD	SD	Apt	Apt	Apt	Apt
MEDIAN YEAR BUILT	NA	NA	NA	NA	NA	NA
MEDIAN SIZE (No. of Rooms)	3	7	5	6	6	7

TH - TOWN HOUSE
SD - SINGLE FAMILY, DETACHED
NA - NOT AVAILABLE
Low Income is defined as ($15,000 a year
High Income is defined as $50,000+ in Pepco sample; $40,000+ in WGL sample

TABLE 21

HEATING SYSTEM CHARACTERISTICS OF RCS PARTICIPANT
AND NONPARTICIPANT OWNERS AND RENTERS BY INCOME CLASS

CATEGORY	PEPCO 1986		WGL 1985		WGL 1986	
	Low Income	High Income	Low Income	High Income	Low Income	High Income
PARTICIPANT OWNERS						
MEDIAN HEATING FUEL	G (77%)	G (87%)	G (95%)	G (97%)	G (96%)	G (94%)
MEDIAN WATER HEATING FUEL	G (95%)	G (87%)	G (100%)	G (97%)	G (96%)	G (98%)
MEDIAN TYPE OF HEATING SYSTEM	HW (54%)	HW (55%)	NA	NA	NA	NA
MEDIAN AGE (YRS)	15-20	12-15	15	10	11	10
MEDIAN HEATING COST (PROF. ONLY) ($)	501-1000	1000-1500	NA	NA	NA	NA
PARTICIPANT RENTERS						
MEDIAN HEATING FUEL	G (60%)	G (80%)	G (100%)	G (100%)	G (100%)	G (100%)
MEDIAN WATER HEATING FUEL	G (40%)	G (80%)	G (100%)	G (100%)	G (100%)	G (100%)
MEDIAN TYPE OF HEATING SYSTEM	HW (60%)	HW (80%)	NA	NA	NA	NA
MEDIAN AGE (YRS)	20	15	15*	12*	18	10
MEDIAN HEATING COST (PROF. ONLY) ($)	301	1001-1500	NA	NA	NA	NA
NONPARTICIPANT OWNERS						
MEDIAN HEATING FUEL	G (92%)	G (80%)	NA	NA	G (76%)	G (80%)
MEDIAN WATER HEATING FUEL	G (86%)	G (76%)	NA	NA	NA	NA
MEDIAN TYPE OF HEATING SYSTEM	NA	NA	NA	NA	NA	NA
MEDIAN AGE (YRS)	NA	NA	NA	NA	NA	NA
MEDIAN HEATING COST (PROF. ONLY) ($)	NA	NA	NA	NA	NA	NA
NONPARTICIPANT RENTERS						
MEDIAN HEATING FUEL	G (52%)	G (50%)	NA	NA	G (79%)	G (71%)
MEDIAN WATER HEATING FUEL	G (75%)	G (75%)	NA	NA	NA	NA
MEDIAN TYPE OF HEATING SYSTEM	NA	NA	NA	NA	NA	NA
MEDIAN AGE (YRS)	NA	NA	NA	NA	NA	NA
MEDIAN HEATING COST (PROF. ONLY) ($)	NA	NA	NA	NA	NA	NA

TABLE 22

COOLING SYSTEM CHARACTERISTICS OF RCS PARTICIPANT AND NONPARTICIPANT OWNERS AND RENTERS BY INCOME CLASS

	PEPCO 1986		WGL 1985		WGL 1986	
CATEGORY	Low Income	High Income	Low Income	High Income	Low Income	High Income
PARTICIPANT OWNERS						
% WITH AIR CONDITIONING	62	33	21	49	43	65
MEDIAN AGE	PRE '79	PRE '79	NA	NA	NA	NA
MEDIAN SIZE	2.5	2.5	NA	NA	NA	NA
MEDIAN COOLING COST ($)*	$301	$401	NA	NA	NA	NA
TYPE OF A/C-WU %	65	41	33	41	53	43
TYPE OF A/C-CE %	35	51	16	47	40	56
PARTICIPANT RENTERS						
% WITH AIR CONDITIONING	67	80	0	0	50	33
MEDIAN AGE	1979+	PRE '71	NA	NA	7	10
MEDIAN SIZE	NA	NA	NA	NA	NA	NA
MEDIAN COOLING COST ($)*	$201	$401	NA	NA	NA	NA
TYPE OF A/C-WU %	65	0	100	100	80	75
TYPE OF A/C-CE %	53	75	NA	NA	20	25
NONPARTICIPANT OWNERS						
% WITH AIR CONDITIONING	65	70	NA	NA	NA	NA
TYPE OF A/C-WU %	67	38	NA	NA	NA	NA
TYPE OF A/C-CE %	37	75	NA	NA	NA	NA
NONPARTICIPANT RENTERS						
% WITH AIR CONDITIONING	64	100	NA	NA	NA	NA
TYPE OF A/C-WU %	70	50	NA	NA	NA	NA
TYPE OF A/C-CE %	30	50	NA	NA	NA	NA

WU - Window units
CE - Central electric
*Professional audits only
Low income is defined as $15,000 per year.
High income is defined as $50,000 + per year in the Pepco data set;
$40,000 + per year in the WGL data sets.

TABLE 23

PURPOSES OF AUDITS - RCS PARTICIPANT AND NONPARTICIPANT
OWNERS AND RENTERS (Pepco's 1986 Data Set Only)

	PERCENT THAT AGREES							
	OWNERS ('000)				RENTERS ('000)			
CATEGORY	($15	$15-$24.9	$25-$49.9	($50+	($15	$15-$24.9	$25-$49.9	($50+
PARTICIPANTS								
Save Energy	87	77	81	81	79	100	100	100
Comfort	92	90	68	66	93	100	100	60
Resale Value	88	87	59	52	20	100	63	60
Save ($)	69	73	66	52	60	100	67	40
NONPARTICIPANTS								
Save Energy	51	66	58	67	55	79	82	86
Comfort	68	62	51	63	67	68	79	86
Resale Value	76	66	65	65	50	100	100	75
Save ($)	57	59	47	39	55	61	69	57

TABLE 24

LACK OF EXISTING CONSERVATION MEASURES (PREAUDIT); PEPCO'S 1986 DATA SET
OWNERS VS RENTERS

MEASURES	OWNERS ($)												RENTERS ($)											
	<15,000			15,000-24,999			25,000-49,999			50,000+			<15,000			15,000-24,999			25,000-49,999			50,000+		
	%	No	SS	%	No	SS	%	No	SS	%	No	SS	%	No	SS	%	No	SS	%	No	SS	%	No	SS
HIGH COST (> $1000)																								
REPLACE AIR CONDITIONER	44	4	9	40	2	5	38	11	29	45	19	42	20	1	5	0	0	0	25	1	4	33	1	3
REPLACE HEATING SYSTEM	71	27	38	63	15	24	54	38	71	61	51	83	57	8	14	50	1	2	25	2	8	50	2	4
MEDIUM COST ($100-$1000)																								
STORM WINDOWS	54	21	39	40	12	30	37	29	79	42	39	93	27	4	15	100	2	2	56	5	9	60	3	5
STORM DOORS	64	25	39	50	15	30	53	42	79	61	57	93	40	6	15	50	1	2	63	5	8	100	5	5
WALL INSULATION	83	29	35	86	24	28	72	54	75	83	74	89	57	8	14	100	2	2	89	8	9	75	3	4
CEILING INSULATION	74	28	38	93	25	27	75	56	75	73	66	91	100	9	9	100	2	2	100	5	5	100	5	5
LOW COST (< $100)																								
CAULKING	97	38	39	93	28	30	84	66	79	85	79	93	100	15	15	100	2	2	78	7	9	100	5	5
WEATHERSTRIPPING	95	36	38	100	24	24	89	63	71	88	73	83	86	12	14	100	2	2	100	8	8	75	3	4
DOOR	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WATER TANK INSULATION	66	25	38	97	28	29	84	63	75	72	65	90	60	9	15	100	2	2	78	7	9	80	7	5
DUCT INSULATION	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PIPE INSULATION	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-
DOOR	55	20	38	54	13	24	38	27	71	49	41	83	50	7	14	50			75	6	8	50	2	4
FLUE	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-
AUTOMATIC IGNITION	95	28	30	85	17	20	83	40	48	84	61	73	100	8	8	100	2	2	100	6	6	100	3	3
CHECK INCANDESCENT	100	38	38	100	24	24	85	63	71	81	67	83	100	14	14	100	2	2	100	8	8	100	4	4
FLOOR INSULATION	100	37	37	80	24	30	84	63	75	92	81	88	90	9	10	100	2	2	100	6	6	100	5	5

No - Number
SS - Sample Size

TABLE 25

RECOMMENDATION RATES FOR EACH CONSERVATION MEASURE OF BCS PARTICIPANT OWNERS AND RENTERS BY INCOME CLASS

	PEPCO 1986				MGL 1985				MGL 1986			
	OWNERS %		RENTERS %		OWNERS %		RENTERS* %		OWNERS %		RENTERS %	
MEASURES	Low Income	High Income	Low Income	High Income	Low Income	High Income	Low Income	High Income	Low Income	High Income	Low Income	High Income
HIGH COST (> $1,000)												
REPLACE AIR CONDITIONER	6	16	7	20	--	--			4	20	3	8
REPLACE HEATING SYSTEM	64	65	60	60	68	12			57	52	83	33
MEDIUM COST ($100 - $1,000)												
STORM WINDOWS	69	73	40	100	47	74			74	77	100	67
STORM DOORS	67	68	40	100	11	9			39	42	50	50
WALL INSULATION	36	46	33	20	37	24			48	29	17	17
CEILING INSULATION	69	69	40	0	74	69			74	77	33	83
SHADING	--	--	--	--	--	1			13	22	--	--
LOW COST (< $100)												
CAULKING	97	85	87	100	84	73			91	79	100	83
WEATHERSTRIPPING	74	87	88	80	63	67			78	56	83	100
WATER TANK INSULATION	64	69	60	60	74	82			61	81	100	50
DUCT INSULATION	8	16	13	0	--	--			22	11	--	--
PIPE INSULATION	31	24	0	0	--	--			13	13	50	50
FLUE	46	44	20	40	--	1			4	5	--	--
AUTOMATIC PILOT	69	75	60	80	--	2			--	5	--	--
CLOCK THERMOSTAT	82	68	67	60	42	58			83	69	67	83
FLOOR INSULATION	54	67	33	60	53	34			57	48	67	50

* Sample sizes are too small to provide meaningful information

TABLE 25

IMPLEMENTATION RATES (FIRST DEFINITION) FOR EACH CONSERVATION MEASURE BY BCS PARTICIPANT OWNERS AND RENTERS BY INCOME CLASS

	PEPCO 1986				MGL 1985				MGL 1986			
	OWNERS %		RENTERS %		OWNERS %		RENTERS* %		OWNERS %		RENTERS %	
MEASURES	Low Income	High Income	Low Income	High Income	Low Income	High Income	Low Income	High Income	Low Income	High Income	Low Income	High Income
HIGH COST (> $1,000)												
REPLACE AIR CONDITIONER	33	0	0	0	--	7			0	10	--	--
REPLACE HEATING SYSTEM	12	2	11	0	23	5			0	0	0	0
MEDIUM COST ($100 - $1,000)												
STORM WINDOWS	37	21	17	20	33	34			53	25	17	25
STORM DOORS	30	22	17	0	50	9			14	17	0	--
WALL INSULATION	13	7	0	0	0	11			0	7	0	0
CEILING INSULATION	19	11	17	0	21	24			24	22	0	20
SHADING	-		--	--	--	0			0	9	0	--
LOW COST (< $100)												
CAULKING	74	70	54	60	56	52			52	50	17	20
WEATHERSTRIPPING	65	58	50	75	42	26			33	28	0	33
WATER TANK INSULATION	48	20	11	50	0	23			29	17	0	33
DUCT INSULATION	0	33	0	0	--	--			20	0	--	--
PIPE INSULATION	50	10	0	0	--	--			67	29	0	0
FLUE	17	20	0	0	--	0			0	13	--	--
AUTOMATIC PILOT	26	3	11	25	--	0			--	29	--	--
CLOCK THERMOSTAT	31	14	10	25	25	10			11	17	0	20
FLUE INSULATION	24	0	0	33	30	12			0	9	0	33

* Sample sizes are too small to be meaningful (4 in ($15,000 and 1 in $40,000+)

TABLE 27

IMPLEMENTATION RATES (SECOND DEFINITION) FOR EACH CONSERVATION MEASURE BY BGS PARTICIPANT
OWNERS AND RENTERS BY INCOME CLASS

	PEPCO 1986				MGL 1985				MGL 1986			
	OWNERS %		RENTERS %		OWNERS %		RENTERS* %		OWNERS %		RENTERS %	
MEASURES	Low Income	High Income	Low Income	High Income	Low Income	High Income	Low Income	High Income	Low Income	High Income	Low Income	High Income
HIGH COST (> $1,000)												
REPLACE AIR CONDITIONER	3	1	0	0	--	1			0	2	0	0
REPLACE HEATING SYSTEM	8	1	7	0	16	3			0	4	0	0
MEDIUM COST ($100 - $1,000)												
STORM WINDOWS	26	15	7	20	16	25			39	19	17	17
STORM DOORS	21	15	7	0	5	1			4	7	0	0
WALL INSULATION	5	3	0	0	0	3			0	2	0	0
CEILING INSULATION	13	8	7	0	16	17			17	17	0	17
SHADING	-	--	--	--	--	--			0	2	0	0
LOW COST (< $100)												
CAULKING	72	59	47	60	47	38			48	61	17	17
WEATHERSTRIPPING	62	51	40	60	26	16			26	16	0	33
WATER TANK INSULATION	31	11	7	40	0	19			17	14	0	17
DUCT INSULATION	0	5	0	0	--	2			4	0	—	—
PIPE INSULATION	15	4	0	0	--	--			9	3	0	0
FLUE	8	9	0	0	--	0			0	6	—	—
AUTOMATIC PILOT	18	2	7	20	--	0			—	1	—	—
CLOCK THERMOSTAT	26	10	0	20	11	6			9	12	0	17
FLOOR INSULATION	13	5	0	20	16	5			0	5	0	17

* Sample sizes are too small, 14 for low income and 1 for $40,000+.

TABLE 28

IMPLEMENTATION RATES (SECOND DEFINITION) FOR EACH CONSERVATION MEASURE BY DCS
NONPARTICIPANT OWNERS AND RENTERS BY INCOME

	PEPCO 1986				BGE 1985				BGE 1986			
	OWNERS %		RENTERS %		OWNERS %		RENTERS %		OWNERS %		RENTERS %	
MEASURES	Low Income	High Income	Low Income	High Income	Low Income	High Income	Low Income	High Income	Low Income	High Income	Low Income	High Income
HIGH COST (> $1,000)												
REPLACE AIR CONDITIONER	8	15	3	0	3	12	2	14	30	9	15	23
REPLACE HEATING SYSTEM	0	2	0	0	19	19	2	10	24/30[a]	17/12[a]	9	23
MEDIUM COST ($100 - $1,000)												
STORM WINDOWS	19	17	11	0	45	47	12	33	45	42	24	68
STORM DOORS	14	9	3	0	35	39	7	19	41	40	24	32
WALL INSULATION	5	7	0	0	19	16	0	19	21	23	6	5
CEILING INSULATION	11	2	1	14	35	27	0	19	24	28	15	9
SHADING	-	-	--	--	13	36	7	28	17	23	18	18
LOW COST (< $100)												
CAULKING	38	57	26	43	35	55	17	33	41	47	24	50
WEATHERSTRIPPING	38	57	26	43	42	64	14	43	38	47	21	41
WATER TANK INSULATION	11	9	4	14	19	17	0	10	21	24	9	23
DUCT INSULATION	8	0	0	0	3	20	0	10	14	18	12	9
PIPE INSULATION	8	0	0	0	3	29	2	10	17	20	9	14
FLUE	-	-	--	--	23	12	0	19	14	18	15	9
AUTOMATIC PILOT	-		--	--	13	27	5	19	10	17	6	5
CLOCK THERMOSTAT	3	7	7	0	23	31	5	10	28	26	15	14
FLOOR INSULATION	3	2	0	14	16	19	5	14	10	18	9	5

[a] First number refers to furnaces and second number refers to oil burners.

TABLE 29

REASONS WHY RCS PARTICIPANT AND NONPARTICIPANT OWNERS AND RENTERS BY INCOME DID AND DID NOT IMPLEMENT CONSERVATION MEASURES

PEPCO 1986 DATA SET

	PARTICIPANTS							
	OWNERS				RENTERS			
LEADING REASONS	Low Income	%	High Income	%	Low Income	%	High Income	%
#1	Comfort	31	Comfort	17	Comfort	56	Save $	33
2	Save $	26	Save $	39	Save $	22	Cheap to do	11
3	Save energy	11	Save energy	21	Save energy/ Cheap to do	11	Save energy	33
	Broken equipment	11						
#1	Too costly	51	Too costly	42	Renting	53	Too costly	40
2	No time	8	Not cost Efficient	16	Don't need	13	Renting	20
3	Don't need	3	Don't need	12	Too costly/ No time	7	No time	20

TABLE 29

REASONS WHY RCS PARTICIPANT AND NONPARTICIPANT OWNERS AND RENTERS BY INCOME DID AND DID NOT IMPLEMENT CONSERVATION MEASURES

WGL 1985 & 1986 DATA SETS

	PARTICIPANTS								NONPARTICIPANTS							
	OWNERS				RENTERS				OWNERS				RENTERS			
LEADING REASONS	Low Income	%	High Income	%	Low Income	%	High Income	%	Low Income	%	High Income	%	Low Income	%	High Income	%
			Why Implemented								Why Implemented					
#1	Lower bills	35	Lower bills	47	Save energy	100	Lower bills	50	Lower bills	28	Lower bills	41	Tax credit	27	Tax credit	24
2	Comfort	29	Insulate	26	-		Insulate	26	Comfort	22	Insulate	19	Lower bills	25	Lower bills	24
3	Insulate	21	Comfort	23	-		Comfort	23	Insulate	18	Comfort	16	Comfort	18	Insulate	16
			Why Not Implemented								Why Not Implemented					
#1	Too costly	41	Don't need	30	Renting	71	Renting	40	Too costly	44	Don't need	35	Renting	51	Renting	51
2	Don't need	23	Not cost efficient	29	Too costly	14	Too costly	20	Don't need	23	Not cost efficient	16	Too costly	13	Too costly	15
3	Not cost efficient	15	Too costly	14	-		Not cost efficient	20	Not cost efficient	20	Too costly	16	Don't need	12	Don't need	13

ALTERNATIVES TO THE CALIFORNIA ENERGY BASELINE PROGRAM

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ABSTRACT

The California Energy Baseline program is a Legislatively-mandated Lifeline program implemented by the California Public Utilities Commission. The program has the dual goals of conservation promotion and ensurance of a basic level of service to all. This paper is a policy analysis of the Baseline program. After identifying policy objectives, four alternative programs are designed to meet these objectives. Using data from California utilities, the analysis shows that there are programs more responsive to policy objectives than the status quo. The recommended alternative benefits low-income households directly, with little or no decrease in total allocative efficiency.

SECTION 1 -- INTRODUCTION

1.1 Intent and Scope of this Paper

This paper is a policy analysis of alternatives to the Baseline program in the regulated electric industry in California. Much of the discussion is directly applicable to the California Baseline program for natural gas. Further, there is some overlap between Baseline and objectives of the California Universal Telephone Lifeline Service (UTLS) program in the regulated telecommunications industry.

I will consider residential rate design alternatives to the present Baseline program in the context of the program's objectives. Alternative rate designs can cause significant differences in resource allocation, distribution of program benefits, and conservation efffects. I will attempt to measure the distributional effects of alternate rate designs across different income groups, and across households with different levels of energy consumption.

There are also broader programs and implementation alternatives to Baseline. These would take into account other (non-rate design) methods of achieving the program's objectives. For example, the CPUC and the utilities have implemented conservation programs, including the Zero Interest Loan Program (ZIP). Low-income households might be assisted through energy vouchers, direct income subsidies, or utility-sponsored assistance programs. In order to

ALTERNATIVES TO THE CALIFORNIA ENERGY BASELINE PROGRAM

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isolate rate design effects, this analysis will hold these programs constant, assuming any now in existence will continue as at present. Section 6.4.5 contains a discussion of some administrative adjuncts and alternatives to the Baseline program.

1.2 The Lifeline Program -- Precurser to Baseline

In the face of rising energy prices in the early 1970s, the California Legislature established the Lifeline program, officially the Miller-Warren Energy Lifeline Act of 1975. Lifeline was designed to simultaneously hold down the rates for the minimum energy needs of the average residential users' and to encourage energy conservation. The program was to have no effect on the rate of return of the regulated utilities, nor was it designed to affect the rates to the non-residential sector.

Lifeline changed the structure of rates to the residential sector in California from a declining block structure to a so-called "inverted rate structure" over a three year period Supply costs for the industry increased dramatically in the early 1970s, so that marginal energy costs moved above average (or "embedded") total costs. Thus, this rate structure change effectively tracked the changes in the economics of the time by moving marginal prices in the direction of marginal costs.

The fact that the economics were generally correct was not the driving force behind this Legislative initiative. The Legislature felt a need to "do something" about the rising utility bills at the time. Further, a growing awareness of the need for conservation initiatives influenced Legislative thinking. By setting a high second tier rate, the average cost per unit of energy increased as energy use increased. This encouraged consumers to take measures to conserve energy.

Another rationale for Lifeline was that lowering the first-tier rate helped out low-volume energy consumers. This allowed the Legislature and the backers of Lifeline to claim they were helping both the needy--who were assumed to consume less energy -- and those who used less energy through conservation. The legislation called for the first-tier to include a sufficient quantity of electricity and natural gas to meet a "significant portion of reasonable (household) energy needs."

During this period, residential rate increases were also kept down by passing more of the increase to the commercial and industrial classes. This interclass subsidy continues to this day. However, the CPUC has moved in recent years toward equal-percentage-of-marginal-cost EPMC) revenue allocations between classes, a move which may eliminate the interclass subsidies. While not directly related to Baseline, a reduction in this subsidy will increase residential rates and may increase the need for an intraclass subsidy program.

1.3 Lifeline Becomes Baseline

The Miller-Warren Energy Lifeline Act allowed the California Public Utilities Commission (CPUC) to "designate a lifeline volume off... electricity which is necessary to supply the minimum energy needs of the average residential user." The CPUC was required to take into account such end-uses of energy as a household's space and water heating, lighting, cooking, and refrigeration needs in determining the appropriate Lifeline quantity. This led to at least 130 different Lifeline classifications into which a household might fall. The classifications were complicated by the requirements to take climatic and seasonal variations into account when determining Lifeline quantities.

In 1982 the California Legislature passed the "Sher Bill" (AB 2443) to amend and simplify Lifeline. The new program--Baseline --encompassed the same general concepts as Lifeline, with the methods for calculation of the first-tier quantities now spelled out. The first-tier would include from 50% to 60% of the average aggregate residential consumption in each climate zone, priced at a rate from 15% to 25% below the system average rate. All end-use criteria for determination of quantities were eliminated, save for a higher winter allowance for so-called all-electric homes--those homes in which the primary source of heat and cooking is electricity instead of the more common natural gas. Other end use criteria were "grandfathered" in with phase-out provisions.

Section 2 -- OBJECTIVES OF THE BASELINE PROGRAM

The Lifeline program and the residential rate design system established in 1975 had four explicit objectives. These objectives were encompassed in the Sher bill of 1982 which established the Baseline program. In terms of Legislation, the objectives of the program remain the same today. However, many now question the propriety of the assumptions under which Baseline has operated. The ongoing objectives have been:

1. Protect the Residential Sector from the Full Effects of Energy Price Increases -- Throughout the 1970s and early 1980s, energy prices steadily increased by designating a quantity of energy to be priced at an arbitrarily low rate, every customer would have the opportunity to meet their basic energy needs at a low price

Over the last few years energy prices have dropped, at times significantly. However, energy prices remain high relative to the past, and the CPUC has lowered residential rates more slowly than rates to other customer classes. While this objective may be less immediate than in the past, the overall need to ensure basic needs are met has not changed. The operative queston is whether Baseline is the best method to meet these needs.

2. Conservation -- A high second tier price increases average cost per unit as energy use increases. This encourages energy conservation in order to limit exposure to the high second tier price. In times of high marginal energy prices, it may be less expensive to save a unit of energy than to generate another unit through a utility plant.

As energy supplies have stabilized and prices have fallen, some argue that conservation through the rate structure is no longer good public policy. Conservation incentives in the rate structure, it is argued, are not "cost-effective" because consumers react to high prices, even while marginal costs are low. Using more energy would lower overall average prices, so this is the policy that should be encouraged in the rate structure.

However, encouragement of conservation today may be good public policy for the future. Limiting future demand may delay or make unnecessary future construction of generating plants, thus holding down future costs. Further, we do not know if or when energy prices will increase in the future. Eliminating conservation signals now may halt efforts that will be needed in the near future Conservation is also an effective method of reducing energy bills.

A distinction should be made between three definitions of conservation. "Cost-effective conservation" should encourage reductions in consumption only to the point at which marginal conservation investments equal long-run marginal costs of the utility. "Energy-efficient conservation" encourages appliances, housing design and other contributers to energy use to minimize the energy necessary to reach a certain condition. "Less-use conservation" encourages consumers to use less energy regardless of cost circumstances. The conservation objective of the Baseline program does not clearly specify which type of conservation it is intended to promote, and interpretations have varied.

3. Help the Needy -- Many low-income and elderly people have trouble paying for their basic energy needs. They may cut consumption below the level of basic needs to save money, substitute energy consumption for other consumption, or simply not pay their bills. It is important to note that aid to low income households is not specifically mentioned in either the 1975 or 1982 bills. However, that this has been an implicit objective for residential rate design all along is not in dispute.

The public policy objective of helping the needy is not in question. But should this objective be met through the rate structure? Other agencies exist to meet the needs of low-income and elderly people, and energy assistance programs already exist, including utility-sponsored energy assistance programs. However, as a State agency, the Public Utilities Commission may have a responsibility to participate in alleviating the needs of those who cannot afford enough enegy.

The CPUC may not be able to do a better job in meeting this objective than, say, the State Social Services Department. On the other hand, it is not clear that there is anything wrong with such a program having a CPUC locus; there are administrative benefits from integrating redistribution and regulation. Since rate design inherently involves distribution of charges, it already includes some income redistribution through energy prices. No intermediary is needed to collect taxes or contributions and then redistribute the funds.

4. Market Forces -- The explicit purpose of CPUC regulation of the energy industry is to ensure that the natural monopolies in this industry operate under simulated competitive market

forces conditions. This is not only so that their operation will be efficient, but so that the consumers are protected from the potential abuses of monopoly power.

The efficient use of energy resourues has never been an explicit goal of thc Baseline program. In fact, the other goals have tended to move in a direction away from economic efficiency. However, the California Legislature in 1986 passed AB 2764, a bill directing the CPUC to study the Baseline program. This bill for the first time from the Legislature mentioned "efficient utilitization of energy resources" as one of the considerations to be studied.

SECTION 3 -- PROBLEM DEFINITION

3.1 Rate Design and Lifeline Programs

Electric utilities are regulated because they are natural monopolies. The amount of revenue a utility can receive is limited by regulators to the amount necessary to allow the utility to gain a fair rate of return. This entails total revenues which are not based on marginal costs of production. Economic theory says marginal cost pricing is the most efficient pricing system in perfectly competitive markets. Utilities are monopolies, so the State steps in to attempt to simulate competitive conditions, within the constraint that across-the-board marginal cost pricing is not possible.

From a regulator's perspective, the dual purposes of rate design are to institute a fair distribution of charges between customer classes, and to promote an efficient allocation of resources. A fair distribution of charges is a regulatory concern by the following reasoning:

a) The constraint of the revenue requirement ensures that the utility will receive the same total revenue no matter how the rates are designed;

b) If the State was indifferent about how much each customer class paid, the rate design could be left to the utility;

c) Since the State does have an interest in "fair" distribution of charges, the regulatory agency must ensure that the rate design is "fair" to the various customer classes.

Lifeline programs exist to ensure that some consumers can purchase electricity at an "affordable" price, and/or so a designated quantity of electricity is available to all consumers at below average cost. Thus some electricity must be priced below average costs and the lost revenue must be made up by above average cost rates to other customers (or through external funding). Lifeline programs exist because society places some value on ensuring that all households can meet their electricity needs -- it is a response to "positive externalities." Although a less economically efficient allocation of resourses may result, this is acceptable if the distributional benefits -- the value of the externalities -- are high enough from the program.

Efficiency can enter the calculus either before or after the fairness question is resolved. Either an efficient rate design can be adjusted for fairness, or a fair rate design can be adjusted for efficiency. The result will not necessarily be the same; the constraints are different. The problem faced with the Baseline program is how to take a lifeline program which was larqely developed on fairness grounds, keep it fair, and then make it as efficient as possible.

3.2 Benefits for Whom?

One group of residential ratepayers has been singled out to receive greater benefits from Baseline. These are low-volume households. Because the higher second-tier rate is used to subsidize the lower first-tier, households that consume below a breakeven point benefit from the program. The Legislature assumed that low-income people tend to use less energy than others. The Legislature also intended that all households could receive some benefits if they reduced their consumption to the Baseline level. However, the current program contains a confusing and contradictory design which does not clearly accomplish these objectives.

The program does give a cross-subsidy to small energy users from large energy users. However, low-income households who consume large volumes of energy are not helped by Baseline. In fact, low-income families who consume large volumes of energy subsidize non-low income families who consume small volumes of energy. This does not seem to have been the intent of the program.

Some aspects of the program benefit households more as their energy consumption increases. Baseline quantities are based on the average consumption in one's climate zone; zones with higher-usage households receive higher Baseline quantities. Granting additional benefits for extra energy needs seems at odds with the concept of cross-subsidies from large to small volume consumers. Further, energy consumers in similar settings may have different reasons for similar energy consumption; a large, poor family may consume as much as a small, financially secure family. Is the program intended to grant the same benefits to both families?

3.2 Customer Charges

Customer costs are the specific costs incurred in order to serve individual ratepayers. Even if a ratepayer does not use any energy, there are still billing, meter-reading, and collections costs incurred by the utility to keep the customer on line. These costs have often been included in the rates. However, it is possible to 'unbundle' customer costs so that the customer pays the specific costs they impose on the system separately from tha charge per kilowatt-hour. One way to do this is through minimum bills, such as the current $3.00 a month minimmn bill for Southern California Edison residential customers. The problem with minimum bills is that the first few kilowatt-hours of electricity are effectively free, since the minimum bill must be paid regardless of consumption.

A policy question involves whether the customer charge should be included in with the energy charges. The question arises hecause the Baseline legislation does not mention a customer

charge (or a minimum bill). If the customer charge is separated, and the Baseline rate is set according to the assigned methodology, the effective bill (energy charges plus customer charges) can be the same as if the customer charge was included in the Baseline rate.

However, the distributional effects of the different methods deserve examination. Fixed customer charges are regressive in nature, increasing in relative importance as less and less energy is consumed. If a fixed customer charge is included in the bill, the effective rate (customer charge plus energy dharges) can become greater than 85% of the system average rate. Adding the customer charge to the first tier causes the rate to come down, as the revenue requirement is held constant. This effectively decreases the cross-subsidy from the higher second-tier rate. This seems to conflict with the intent of the Sher bill, if not the letter.

This analysis will compare the alternatives without separated customer charges.

3.3 Elasticities

The consumption of energy is affected by the price of energy. The higher the price, the lower the consumption. The magnitude of this adjustment is expressed in the demand price elasticity. When a price change is contemplated, it is prudent to consider the consumption effects when attempting to calculate the resultant revenue.

Unfortunately, this is not how the CPUC performs its calculations for the residential sector. A revenue requirement for the residential sector is established by subtracting the revenues from all other sectors from the total revenue requirement. The Baseline quantities and prices are calculated from the formulas mandated by Legislation. Given the predicted level of energy consumption, the second-tier price is calculated by subtracting the Baseline consumption from the overall (predicted) residential consumption, and then setting the price to recover the necessary residual revenue.

This method does not encompass price elaaticity. Clearly, the price of the second tier cannot be set at different levels (depending upon the formulaic needs) and still result in the same level of consumption (unless elasticity is 0, which is unlikely). While no definitive studies have been done and accepted industry wide, there are some indications of the actual figures for short-term elasticity. A study of the Los Angeles Department of Water and Power Lifeline program determined elasticities between -.09 and -.23. A study of San Diego Gas and Electric found elasticity of between -.20 and -.40. Southern California Edison has estimated price elasticity of -.20 for specific appliance use. Price elasticity of -.20 thus seems to be a reasonable approximation that can be used to estimate the effects of price changes.

The inevitable disparities from the current system are accounted for through adjustment processes between the general rate cases. While these tend to compensate for the errors, less compensation would be necessary if elasticities were explicitly included in the original calculations. However, this is not likely to occur soon, for several reasons. First, the elasticities are not well known and studies to determine them would take much time before they could be used. Second, there are more different groups which may have different

elasticities. While an overall figure is a good start, it is incomplete. Third, this would be a major process change, requiring considerable computational adjustment at the CPUC, the utilities, and other interest groups.

This study will analyze alternatives without reference to elasticities in the price levels. However, when evaluating alternatives I will include a measure of efficiency--change in consumer surplus--which includes elasticity.

SECTION 4 -- THE FOUR ALTERNATIVES

4.1 Alternative 1 -- The Present System

The present Baseline system is substantially governed by the 1982 Sher Bill, AB 2443. Under the Sher Bill, the first-tier rate for electricity (and natural gas) for the residential sector is set at between 75% and 85% of the system average rate (SAR). The SAR is the total revenue requirement divided by total sales of all classes. This rate applies to between 50% and 60% of the consumption level of the average household (the "average aggregate consumption") for each climate zone. Climate zones are approved by the CPUC Commissioners for each regulated utility. In addition, all-electric households receive 60% to 70% o the "average aggregate consumption" of electricity in their climate zone during the period from November 1 to April 30.

For comparison purposes, I will use figures from the 1985 Test Year for Southern California Edison (SCE) as the example of the present system. Table 1a shows the relevant figures. The Baseline rate as of January 1, 1986 is 6.653 c/kwh and the second tier rate is 9.781 c/kwh. The Baseline tier includes 58.4% of average aggregate consumption, with the other 41.6% at the second-tier rate. There are 3,006,518 households in the SCE service territories in seven climate zones in 1985. There are approximately 350,000 all-electric homes. There are no explicit customer charges at present, but there is a $0.10 per day minimum bill (about $3.00 per month).

Table 1b shows the relevant figures for the average SCE household. Average household consumption is 507 kwh/month, with 58.4%, or about 280 kwh/month priced at the Baseline rate.

4.2 Alternative 2 -- Expansion of Baseline

This alternative explores two methods of expanding the amount of usage covered by Baseline. Alternative 2a includes 75% of average aggregate consumption under the Baseline rate. The all-electric special allowance would be eliminated in favor of this allowance. The second-tier rate needs to increase to 11.88q/kwh in order to raise the required revenue.

Alternative 2b is a system where the first-tier rate is set at marginal cost. I will use 5.5 c/kwh as an estimate of marginal cost (based on CPUC estimates of total marginal cost for the residential class). The Baseline quantity would remain at 55% of average aggregate

TABLE 3

TWO SYSTEMS FOR ESTIMATION OF THE NUMBER OF HOUSEHOLDS IN EACH INCOME AND DEMAND LEVEL

WEIGHTING SYSTEM 1: Even Distribution

This system assumes households are distributed evenly throughout different demand levels.

Demand Level	Income Level: Low (20% of Total)	Income Level: Other (80% of Total)	All Incomes
Low	33.3%	33.3%	33.3%
Medium	33.3%	33.3%	33.3%
High	33.3%	33.3%	33.3%
Total	100%	100%	100%

WEIGHTING SYSTEM 2: Usage Correlated With Income

This system assumes there are more low-income households in low-demand categories, and more non-low-income households in higher demand categories.

Demand Level	Income Level: Low (20% of Total)	Income Level: Other (80% of Total)	All Incomes
Low	50%	20%	26%
Medium	30%	30%	30%
High	20%	50%	44%
Total	100%	100%	100%

consumption, and 70% for all electric households. The second tier rate would need to increase 11.41 c/kwh in order to raise the required revenue.

4.3 Alternative 3 -- Baseline Only for Specific Households

The purpose of this alternative is to target the benefits of the Baseline program more directly than at present. In order to benefit low-income households directly, all of their consumption is priced below the average rate, instead of only a fixed quantity. Low-income households are defined as those households with annual incomes below 150% of the proverty level for their household size. This figure includes approximately 20% of the households in California. The current Universal Lifeline Telephone Service program for the regulated telecommunications industry in California uses this eligibility criteria.

Alternative 3A introduces a flat rate structure for non-low income households. For low-income households, the Baseline rate will stay at 6.653 cents and the non-Baseline rate will be a flat 8.29 cents. This assumes the 20% of households in the Baseline category consume 20% of the total energy (e.g., consumption patterns of low income households and non-low income households do not vary significantly).

In Alternative 3b the non-Baseline households will face a two-tier system. The first-tier will be at the current Baseline of 6.653 cents and apply to 55% of average aggregate consumption, or 280 kwh/month. This is similar to the rate structure at present for this portion of consumption. The second-tier then must be priced at 10.28 cents in order to recover the residual revenue requirement. This again assumes consumption by the Baseline class in 20% of total residential energy consumption). The all-electric provision would be eliminated for low-income households, but retained for the rest.

Why allow all 100% of electricity use at the Lifeline rate for low income households? There are three reasons:

1) There are many low-income households who consume more than the average amount; these households would not be helped if there was a higher second tier rate.

2) If less than 100% of usage was included, the non-Lifeline class would have lower rates than under this system. However, the societal value of the extra energy used by low-income households is greater than the societal value of extra usage by the non-Lifeline class. This is because the extra consumption represent a higher percentage of household income for low-income people.

4) Lowering the average rate brings this class 16.5% closer to marginal cost. The non-Baseline class have their average rates increased by only 5% under either system.

There is one other design which might be considered in this alternative. This would include the same provisions for low-income households as above, but financed by a tax on the other households. This is similar to the Universal Lifeline Telephone Service financing method,

which taxes long-distance phone calls. However, this tax also would effectively give a higher rate to the non-Lifeline class. The consumption effects would be the same if financed by a tax or by a higher rate, if the ratepayers are price-sensitive to the total bill. Collection and distribution of a tax would involve extra costs as well. A tax might be advantageous in an efficiency sense if the tax was not levied on consumption. If revenues from a tax were used to finance the lifeline tier, the non-lifeline bills would not increase. No extra allocative inefficiency would result from moving further from cost-based pricing.

4.4 Alternative 4 -- No Baseline Program Through the Public Utilities Commission

This final alternative eliminates Baseline and considers a change in the CPUC's role as a redistributive agency. This rate design does not take into account any considerations of need or variability of consumption. Any redistributive policies could be handled outside of the rate-setting process.

There are two possible rate designs I will consider here Alternative 4a is a flat rate. All households pay the same rate for every kilowatt-hour. The flat rate necessary to recover the SCE residential revenue requirement is 7.96 cents. However, the residential class currently underpays in relation to other classes. In order to make efficiently design all rates, the residential class should raise enough revenue to pay an equal percentage of marginal costs (EPMC) as all other classes. This would entail an average rate at approximately the system average rate, which is 8.32 q/kwh. This would be the flat rate as well. The rate based on EPMC revenue allocation will be used in this analysis.

In Alternative 4b, the second-tier is priced at marginal cost and the first-tier at the residual necessary to recover the residential revenue requirement. As with Alternatlve 4a, I will lncrease the total residential revenue generated in order to promote interclass equity and economic efficiency. The first-tier would include 50% of average aggregate consumption, or 255 kwh per month. The second-tier rate would equal 5.5 cents and the first-tier rate would be 11.13 cents. This sub-design is a declining block rate design similar to that used pre-1975.

Table 2 summarizes the four Alternatives.

SECTION 5 -- CRITERIA AND METHODOLOGY

In order to evaluate the current Baseline program and alternatives, we need a set of criteria by which we can measure each alternative. While some of the criteria can be quantified, others are not amenable to this type of methodology. The next section will analyze the alternatives according to both types of measure.

5.1 Economic Efficiency -- How close does the alternative come to simulated competitive market conditons?

An efficient change occurs when the gains to the gainers outweigh the losses to the losers. Optimally, we would hope to find a program in which there were only gainers and no losers.

TABLE 2

RATES FOR EACH ALTERNATIVE

	1ST TIER RATE	2ND TIER RATE	1ST TIER QUANTITY (KWH/YEAR)	2ND TIER QUANTITY (KWH/YEAR)
ALTERNATIVE 1				
PRESENT	$0.0665	$0.0978	10,68[illegible],691,000	7,613,609,200
ALTERNATIVE 2				
ALLOW 75% OF AGGREGATE CONSUMPTION IN BASELINE	$0.0665	$0.1188	13,72[illegible],725,000	4,573,575,000
BASELINE RATE AT MARGINAL COST	$0.0550	$0.1141	10,68[illegible],691,000	7,613,609,200

ALTERNATIVE 3	LOW INCOME RATE	% USED BY LOW-INCOM HOUSEHOLD	FLAT NON-LOW-INCOME RATE	LOW-INCOME QUANTITY (KW- YEAR)	NON-LOW-INCOME QUANTITY (KWH/YEAR)
LOW-INCOME FLAT RATE, NON-LOW-INCOME FLAT RATE (20% IN LOW-INCOME CLASS)	$0.0665	0.15	$0.0819	2,74[illegible],145,000	15,550,155,000
	$0.0665	0.2	$0.0829	3,65[illegible],860,000	14,635,440,000
	$0.0665	0.25	$0.0839	4,573,575,000	13,720,725,000

	LOW-INCOME RATE	1ST TIER (NON-LOW-INCOME)	2ND TIER (NON-LOW-INCOME)
LOW-INCOME FLAT RATE TWO TIER NON-LOW-INCOME RATES (20% IN BASELINE CLASS) 280 KWH IN 1ST TIER	0.06653	0.06653	0.1028

ALTERNATIVE 4	1ST TIER RATE	2ND TIER RATE	1ST TIER QUANTITY (KW-/YEAR)	2ND TIER QUANTITY (KWH/YEAR)
FLAT RATE	$0.0832	N.A.	18,29[illegible],300,000	N.A.
2ND TIER AT MARGINAL COST	$0.1113	$0.0550	9,147,150,000	9,147,150,000

BILL LEVELS FOR EACH ALTERNATIVE

		ALTERNATIVE 2			ALTERNATIVE 3		ALTERNATIVE 4	
KWH/MONTH	PRESENT BASIC	75% IN BASELINE	1ST TIER AT MC	LOW-INCOM	FLAT RATE NON-LOW-INC	TWO TIER NON-LOW-INCOME	FLAT RATE	2ND TIER AT MC
200	$13.31	$13.31	$11.00	$13.31	$16.57	$13.31	$16.63	$22.27
275	$18.30	$18.30	$15.13	$18.30	$22.79	$18.30	$22.87	$29.49
300	$20.58	$19.96	$17.68	$19.96	$24.86	$20.68	$24.95	$30.86
400	$30.37	$27.66	$29.09	$26.61	$33.14	$30.97	$33.27	$36.36
507	$40.83	$40.37	$41.30	$33.73	$42.01	$41.97	$42.16	$42.25
600	$49.93	$51.41	$51.91	$39.92	$49.72	$51.53	$49.90	$47.36
670	$56.77	$59.73	$59.90	$44.58	$55.52	$58.73	$55.72	$51.21
800	$69.49	$75.17	$74.73	$53.22	$66.29	$72.09	$66.53	$58.36
1000	$89.05	$98.93	$97.55	$66.53	$82.86	$92.66	$83.16	$69.36
1500	$137.96	$158.32	$154.60	$99.80	$124.29	$144.07	$124.74	$96.86

However, few programs are designed so badly that every participant can be much better off through a redesign Thus, we seek a program that will make the participants in general better off, even if some groups are not helped.

Efficiency for this and the other alternatives can be measured through a calculation of consumer surplus. Consumer surplus is the difference between what consumers (ratepayers) are willing to pay for a good and the price of the good, aggregated over all consumers. For example, a person who is willing to pay $5.00 for a product that cost $3.00 receives $2.00 of consumer surplus. If this were true for all 3 million consumers, there would be a total consumer surplus of $6 million.

Consumer surplus plus producer surplus (profit) will be maximized at the point of efficient allocation of resources. Since the revenue requirement is not affected throughout this analysis, producer surplus does not change. Thus increases in consumer surplus are increases in efficiency here. This is a measure of benefits to all households, on average.

We can calculate consumer surplus for particular groups of consumers. Separation of groups is useful in order to isolate the effects of the policies. However, in order to simplify calculations, only three groups will be used: High demanders, medium demanders, and low demanders. High demanders are defined as those who consume 670 kwh per month. This figure represents the consumption level under which 75% of households consume. Medium damanders are defined as those who consume 507 kwh per month, the mean consumption level. Low demanders are those who consune 275 kwh per month. This represents the consumption level under which 25% of households consume.

The number of households in each group is not known. Two "weighting systems" will be used to evaluate the effects of policy changes. Under the first system, we assume a distribution in which 33% of households are low demanders, 33% are medium demanders, and 33% are high demanders. Under the second system, there are 26% low demanders, 30% medium demanders, and 44% high demanders. The first system has the same distribution for both low-income and non-low-income groups. The second system assumes more low-income households are low demanders, and more non-low-income groups are high demanders. Consumption is probably somewhat correlated with income, but perhaps not as much as in System 2. Thus, these two systems give reasonable bounds to the actual distributions. Table 3 shows the distributions in each system.

We cannot calculate total consumer surplus directly, because the overall demand curves for the different groups are not well known. However, changes in consumer surplus can be calculated by using the present system as a base.

In order to calculate changes in consumer surplus, we need the demand curve in the relevant range. There is enough information to approximate this section of the demand curve if we made a few simplifying assumptions. I will assume an overall price elasticity of -0.20. However, elasticity is probably not constant over all consumers. Studies show that low-income groups and low-consumption households have more in elastic demand than other

TABLE 1 A

SOUTHERN CALIFORNIA EDISON 1985 TEST YEAR FIGURES

CURRENT RATES (1/1/86) :	
BASELINE	$0.06653
2ND TIER	$0.09781
AVERAGE	$0.07860
YEARLY QUANTITIES CONSUMED (IN KWH):	
TOTAL	18,294,300,000
BASELINE	10,680,691,000
2ND TIER	7,613,609,200
REVENUE REQUIREMENT (RESIDENTIAL) =	$1,456,119,615
RESIDENTIAL CUSTOMERS =	3,006,518
PRESENT CUSTOMER CHARGES =	NONE
MINIMUM BILL =	$0.10/DA
MARGINAL COST, RESIDENTIAL CLASS	$0.0550
SYSTEM AVERAGE RATE =	$0.0832

TABLE 1 B

PRESENT STATISTICS FOR BASIC CUSTOMERS

AVERAGE BASELINE USE =	280 KWH/MONTH
AVERAGE 2ND TIER USE =	227 KWH/MONTH
AVERAGE TOTAL USE =	507 KWH/MONTH
AVERAGE MONTHLY BILL =	40.83 DOLLARS/MONTH

groups. Therefore, I will assume elasticity of -0.15 to low-income and low-consumption households, and -0.25 to the rest.

The calculation of change in consumer surplus involves measuring the deadweight loss triangle associated with each alternative. This is calculated by determining the change in consumption for each of the six customer groups. The change in consumption results from the elasticity response to the change in the prices for both the first and second tier rates (where applicable.)

A note on the magnitudes involved here: There are approximately 9 million households in California. An increase in consumer surplus of $1.00 per household per month would equal a total efficiency gain of 9 million x 12 months x $1.00, or $108 million.

5.2 Equity -- What is the distribution of costs and benefits of this program and its alternatives? Who are the gainers and who are the losers?

An efficient change gives more benefits than losses in general, but this says nothing about the distribution of the benefits and losses. In the extreme, one person might gain all the benefits, and everyone else might share all the losses. While this could be more efficient, it is not equitable by most standards. One way to define an equitable change is: The gains to the gainers outweigh the losses to the losers, within the constraint that the targeted groups are not made worse off.

However, there is often a tradeoff between increased efficiency and increased benefits to targeted groups. This occurs because the inefficiency in a program often results from the targeting of these groups in the first place. Therefore, a second definition of an equitable change is: The gains to the gainers outweigh the losses to the losers, given more emphasis on the effects on the targeted group.

Changes in consumer surplus can measure the relative distributional effects according to the second definition. This can be done by assigning weights to the different groups based upon distributional preferences. To the categories of high, medium and low demanders above, we can add the dimension of low-income and non-low income households. Thus, there are six groups; the distributions are shown in Table 3.

The calculation of this equity-consumer surplus depends upon the assigned weights for each group. I will calculate equity-consumer surplus assigning double weight to the low-income groups and single weight to the others. I will also separate the effects on low-income households from the effect on other households.

5.3 Simplicity and Administrative Ease -- How difficult is it for ratepayers to understand the alternative compared to the present system? How much extra or less work and complication for the implementors of the program is caused by the alternative?

5.4 Conservation -- How well does the alternative promote conservation of energy resourues?

Conservation is included as a goal in the Sher Bill mandating Baseline. As such, it is reasonable to judge the Alternatives by how well they encourage conservation. However, "use-less conservation" is less important today because increased consumption will cause production costs to decline, which benefits all ratepayers. Conservation has the opposite effect.

"Cost-effective conservation" should still be encouraged. This occurs when the value of decreasing usage is greater than the social loss of not having lower average costs; there needs to be long-term or other gains for conservation to be useful. These gains can occur if long-term demand reductions occur, allowing the delay or cancellation of new plants, or if high-cost peak power did not need to be purchased. Any conservation also has social benefits if it helps needy people meet their energy needs. However, these conservation incentives can be addressed through non-rate-design efforts, such as weatherization programs.

Within this context, I will consider the conservation effects of each design as the change in total consumption for each alternative, relative to the status quo.

SECTION 6 -- EVALUATION OF ALTERNATIVES

6.1 Alternative I -- The Present System

6.1.1 Efficiency -- The total consumer surplus cannot easily be calculated for this alternative because we do not know the equation of the overall demand curves. However, changes in consumer surplus from this alternative to the others can be calculated with more confidence. Therefore, this alternative will be considered a base of zero consumer surplus; the other alternatives will be judged more or less efficient by the standards of this system.

The present system is not a very efficient design; it was not meant to be so. The residential class is subsidized by other classes, causing inefficiency for all classes. Further, the intents of the Baseline subsidies have always taken precedent over designs for efficiency since 1975.

6.1.2 Equity -- As with efficiency, the present system will be the yardstick by which other systems are measured. Therefore, the equity-consumer surplus of this alternative is zero.

In this alternative, larger consumers tend to subsidize smaller consumers. However, adding the income dimension, we see that low-income large consumers subsidize non-low-income small consumers.

Table 4 shows the general distribution of usage by income from Pacific Gas and Electric Company Residential Appliance Saturation Survey data. The data shows that 28% of low income households receive no benefits from the Baseline program. Only 39% of low-income households receive all of their consumption at fully subsidized rates. Looking at the high-income households, we see that 15% receive fully subsidized rates, and 43% receive

some subsidies from the program. (These figures are consistent with data from Southern California Gas company.)

Many low-income households receive assistance in paying energy bills from government and private social welfare agencies, including programs originating at the utilities. These households may pay less than the full cost of their bill. These people have less incentive to consume less energy than those who pay the full bill. Thus, the Baseline subsidy is more meaningful for those households which consume small energy quantities and are not recipients of energy assistance programs. These households--mostly non-low-income--enjoy most of the benefits of the program. Most of the costs are thus borne by non-low-income large energy consumers, and by the agencies which subsidize large energy consumption for needy households.

6.1.3 Administration and Simplicity-- In general, the Baseline program is not difficult to administer and understand. The greatest difficulty is in the work needed to establish climate zone boundaries, determine how to calculate quantities given the existence of all-electric homes, master-meter buildings and the like, and determine which dwellings meet which criteria. As of 1986, Baseline was not completely phased-in for any utility, and some changes can be expected in the future over methods of rate and quantity calculation.

The Baseline program is fairly simple for the ratepayers to understand. The rates are listed on the bills and do not change frequently (except due to adjustments apart from the Baseline program). Ratepayers can calculate the impact of changes in consumption. Complications set in when people move to another climate zone or utility territory, because their Baseline quantities change.

6.1.4 Conservation -- The existence of a second-tier rate which is 47% higher than the first tier should be an incentive for conservation. Both average costs and marginal costs are higher when consumption is higher. The greatest incentive for conservation comes near the point where the second tier starts. After that point, the rate increases. so there is a great incentive to stay below the second-tier level.

Some elements of Baseline have other effects relevent to conservation. The all-electric pricing system may encourage conservation to a lesser degree than the basic system because the Baseline rate seems to cover a greater percentage of consumption. However, this is not necessarily true. Baseline covers 70% of average aggregate all-electric consumption. If all-electric homes use a much higher average quantity (more than 70/55 = 1.27 times as much), the allowance for them is actually lower than for basic consumers. The existence of climate zones discourages conservation in the zones with high consumption, relative to a system in which the Baseline quantity is the same for all the zones. As with the efficiency and equity criteria, changes in conservation will be measured relative to the present system.

TABLE 4

WHO BENEFITS AND WHO PAYS ACCORDING TO HOUSEHOLD INCOME

	LOW HOUSEHOLD INCOME (0-$15 K)	MIDDLE HOUSEHOLD INCOME ($15K-$40K)	HIGH HOUSEHOLD INCOME ($40K +)	
RECEIVE LARGE BENEFITS[1]	13.7%	10.3%	2.7%	26.8%
RECEIVE LITTLE OR NO BENEFITS [2]	11.8%	14.5%	5.1%	31.3%
PAY FOR THE BENEFITS[3]	10.1%	21.6%	10.3%	42.0%
	35.5%	46.4%	18.1%	100.0%

WITHIN EACH INCOME GROUP:

	RECEIVE LARGE BENEFITS	RECEIVE SMALL OR NO BENEFIT	PAY FOR BENEFITS	
AMONG LOW INCOME:	39%	33%	28%	100%
AMONG MIDDLE INCOME	22%	31%	47%	100%
AMONG HIGH INCOME:	15%	28%	57%	100%

Explanatory Notes:

1) Large Benefits go to those who use under Baseline quantity

2) Little or No Benefits go to those who use between Baseline quantity and average quantity during the year.

3) Benefits paid for by those who use more than average quantity

6.2 Alternative II -- Expansion of Baseline

6.2.1 Efficiency -- Both sub-designs of this alternative are less efficient than the present system.

Alternative 2a -- 75% in Baseline -- confers no gains or losses for the low demand group, since the price stays the same for all of their consumption. For the medium demand group, the average price decreases, while the average price per kilowatt-hour increases for the high demand group. This results in a weighted loss of between $0.83 and $1.17 per household.

For Alternative 2b -- the Baseline rate lowered to marginal cost -- there is a price decrease for the low demand group and a price increase for the medium and high demand groups. The low demand group faces a large price decrease of 1.15 cents per kilowatt-hour. The medium demand group sees a small increase while the high demand group faces a price increase of .47 cents per kilowatt-hour. Overall, there is a net weighted loss of between $0.13 and $0.69 per household.

6.2.2 Equity -- Low income households as a group are not made better off in Alternative 2a. The average low-income household is worse off by between $0.44 and $0.83. In fact, non-low income households are not made better off either. They lose between $0.83 and $1.33 per household in consumer surplus each month. In general, neither group benefits at the other's expense, because neither group as a whole benefits from this alternative (there is increased deadweight loss).

The winners -- those whose overall bill decreases -- in Alternative 2a are those who consume between the 55% and the 75% level of average aggregrate consumption. These are the medium-demanders in this format. The losers are those who consume above the level of 75% level.

The winners in Alternative 2b are the low consumption households. The breakeven point --the point where the bills are equal -- is at about 500 kwh/month. (This amount would be higher or lower depending upon which climate zone a family lived in.) The losers are those who consume above the breakeven point. Low-income families gain more than non-low-income families to the extent that low-income families average less consumption. The average low-income households gains up to $0.82 per month.

6.2.3 Administration and Simplicity -- There is little reason to suspect that either of the designs in this alternative would be any more or less difficult to administer or understand than the present system.

In terms of simplicity, the ratepayers would require a time of adjustment before they understood the implications of any new rate designs. For example, since the point at which the rate changes from first to second-tier is different in one sub-design, ratepayers who are sensitive to marginal costs would need to adjust to this change. However, the alterations are relatively simple, unlike adding a tier or going to a declining structure.

6.2.4 Conservation -- Increasing the first-tier quantity and simultaneously increasing the second-tier price --Alternative 2a -- sends a stronger conservation signal to the ratepayer with marginal consumption in this tier. The larger allotment discourages conservation in the first tier. Most households consume into the second tier (70% by CPUC staff estimmates) at present, and this would still be true even with the increased Baseline quantities. Therefore, this alternative increases the conservation signal relative to the present system.

Alternative 2b -- a lower Baseline rate --brings on a similar situation. The lower first-tier rate discourages conservation for households which stay within that tier. For households in the second-tier, the increased price increases the conservation signal. On balance, this alternative increases conservation signals relative to the present system.

6.3 Alternative III -- Baseline Only for Specific Households

6.3.1 Efficiency -- Both designs in this alternative may increase allocative efficiency.

Alternative 3a is a one-tier rate for both low-income and other households, with a higher flat rate for non-low-lnoome households. The low-income low-demand households again face no price change. Other low-income medium and high-demand households face a price decrease. Non-low-income, low and medium-demand households face a price increase, but high demand households face a price decrease. The weighted change in consumer surplus for this alternative is an increase of from $0.11 to $0.42 per household per month.

Alternative 3b -- a one-tier flat rate for low-income households and a two tier rate for all other households -- shows no change for any low demand households. This is because the rate for their level of consumption does not change. For medium and high-demand, low-income households, the average rate decreases. For medium and high-demand, non-low-income households, the average price increases. Overall, the total weighted change is an increase of between $0.13 and a $0.48 per household per month.

6.3.2 Equity -- This alternative is specifically designed to target the benefits (from cross-subsidies) of the program toward low-income households. No low-income households receive an increase in their average bill under either sub-design, and low-income households who consume above the current Baseline level all receive a decrease in average total bills. Those low-income households who presently consume below the Baseline level would continue to receive a subsidy as under the present system. Alternative 3b also continues to target low-consumption households. The current subsidy is retained, by keeping the current rate for at least 55% of average aggregate consumption.

Both variations in this alternative highly benefit low-income households. The average low-income household gains between $4.84 and $6.73 per month. This is up to $80.00 a year assistance per low-income family. On the other hand, the average non-low-income household pays not more than $1.32 per month extra, and as little as $0.61. This translates to no more than $15.00 per year subsidy. Aggregating over the 3 million SCE customers, this is a redistribution of about $50 million a year to low-income households.

In this alternative, there are large gains to a few gainers and small losses to many losers. The gainers are those whom lifeline programs are meant to benefit low-income households. Under both systems, only those households with income above 150% of the poverty line would pay more than at present. Under the two-tier non-Baseline system, only those households who consume more than the Baseline level would pay more than at present.

This alternative directly addresses one of the major problems of Baseline -subsidies from low-income households and to higher income households. This would not occur under either version of this alternative. The program would also directly benefit low-income households. Further, there would only need to be a 5% second-tier rate increase -- this would result in only a 3.4% increase to the average high-demander.

6.3.3 Administration and Simplicity -- Both sub-designs of this alternative bring up major questions of administrative costs. How are the low-income households to be identified? Who will make the decision about whether a household is eligible for the Baseline category?

Eligibility for the Baseline category could be limited to those households with income levels below 150% of the poverty level for households of that size, the definition used by the CPUC for the Universal Lifeline Telephone Service (ULTS). This would equal $11,900 per year for a two-person family. CPUC demographic analysis shows this to be approximately 20% of California households. Note that 20% of households may include much more than 20% of residents, if low-income households are larger than average.

One way to identify eligible households is self-identification. ULTS in California uses self-identification to identify its eligible participants. The problem is that ineligible households may sign up for the program -registration is done by sending in forms found in monthly telephone bills. Thus far, there is little information showing how many ineligible households have signed up for ULTS. The ULTS program is not advantageous for all households, so many do not have an incentive to cheat. However, the Baseline alternatives here would be advantageous for large energy users. Any small energy consumers who are not eligible and still sign up do not cause any inefficiency under the two-tier design, since their rates would remain the same whether in the prugram or not.

Self-identification has costs of transforming records and handling sign ups. Other identification methods would surely have higher administrative costs. The same record handling costs would apply, but the costs of identification would be higher. For example, if social service records were relied upon, there are costs of obtaining and processing these records. Further, not all low-income households would appear on social service records, and not all social service recipients are from low-income households. Thus, extra administrative time and costs would be necessary to target the correct recipients of Baseline.

Methods of identification which include compliance checks would also consume much effort. Any method of compliance checking would only be worthwhile if the value of the efficiency gained from the increased compliance outweighed the cost of the compliance checks. While this is possible, it is likely that the larqer problem would be underutilization by eligible groups,

such as has been the case with ULTS. However, some enforcement mechanism would be worthwhile in order to dissuade cheating. Therefore, periodic checks of a random sample of applicants might be in order to ensure the program goes to the targeted households. The cost of this limited number of checks would be much lower than checking all applicants; the benefits from accurate targeting could be considerable.

6.3.4 Conservation -- Alternative 3a has a flat non-Baseline rate which contains no conservation incentives. As consumption increases, the average and the marginal rate stay at the same level. In comparison to an increasing block design, there will clearly be less conservation in this alternative.

For Alternative 3b, the two-tier non-baseline system, there is an increased conservation incentive for large energy users. As the rate increases from 6.65 cents to 10.28 cents, incentive to limit consumption increases. Further, the incentive in this portion of the rate design is greater than at present, where the second tier is 9.78 c/kwh. These elements should tend to at least balance out the decreased incentive from the lower rate to low-income households. Note further that increased consumption from low-income households may be desireable even for conservation advocates, and that low-income households still face an income constrain against wasteful usage.

6.4 Alternative IV -- No Baseline Program

6.4.1 Efficiency -- This Alternative is meant to design a rate structure that is responsive to efficiency. If the distributive consequences generated are not acceptable, mitigating measures would be necessary outside of rate design.

Both Alternative 4a and 4b increase efficiency considerably in the non-residential sectors. The gains result from lowering non-residential rates closer to production costs. The actual amount of the increase will not be calculated within this analysis; suffice to say, the gains would be significant because every ratepayers in these classes could benefit (depending on the rate design).

Alternative 4a, a flat rate for everyone, is based on the concept of average cost pricing -- in general, all residential rates must net out at the average cost per unit necessary to meet the residential revenue requirement. All rate designs are a variation on average cost pricing; Alternative 4a is the simplest version.

Under the flat rate system, we find that high demand households are the winners, as their average rates are considerably lower. Medium and low volume users face increases in their average prices. Overall, there is a weighted loss in efficiency of between $1.16 and $1.64 per household per month in the residential sector.

Alternative 4b, a declining block structure, is theoretically an efficient pricing system in times of declining marginal costs. The second tier is priced at marginal cost, so that decisions about consumption in this tier are tied to the true cost of supply. However, if customers are actually sensitive to average costs (total bill), these efficiencies may not appear.

Alternative 4b increases average prices for low-demand households and decreases average prices for all other households. As with Alternative 4a, the winners are high-demand households. The weighted change in consumer surplus, however, is a loss of between $1.04 and $2.53 under the different weighting systems.

6.4.2 Equity -- Alternative 4 is not designed to assist low-income households. The actual effects of the two Alternative 4 designs are much as expected. When low-income households are weighted double, the flat rate design results in a loss of between $1.74 and $1.96 per household per month. When the effects on low-income households are considered separately, we see the expected losses again. Alternative 4a does not clearly benefit non-low-income households either. This is because the residential sector takes on the burden of extra revenue generation in this alternative, in order to decrease the current interclass subsidy.

In Alternative 4b, as expected, low-income families lose from $2.53 to $5.10 per month. Aggregating over the 3 million SCE customers, this would be a transfer of up to $183 million a year from low-income households to others (mostly in the non-residential class). Thus, a compensating program worth up to $183 million would need to be established just to keep the status quo distribution.

6.4.3 Administration and Simplicity -- A flat rate design would be very simple to understand. Ratepayers would not have to concern themselves with changes in price at different consumption levels. Some administrative adjustment would be necessary at first, but soon this system would be as simple or simpler to administrate as at present.

The two-tier declining block rate design would be about as simple to administer as at present, but would not be as simple to understand. It takes time for people to adjust to a different type of rate design, such as moving from an increasing block to a declining block. Those ratepayers sensitive to marginal prices would especially notice large changes in their bill structures.

6.4.4 Conservation -- A flat rate design gives no built-in incentive for conservation. Average and marginal rates are the same regardless of consumption, and are equal to each other. Thus, costs per unit do not increase as consumption increases. There is, however, an incentive for conservation for low consumption households relative to the present system. This is because the average rate increases for low consumption households. However, the average price decreases from the present for higher consumption households, so incentives for conservation decrease. Overall, this design would have less incentive for conservation than the present design.

The declining block design definitely has negative conservation incentives compared to the present. The very nature of a rate design with a lower second tier is to encourage consumption in the second tier. This is the system that was in effect before 1975, when the marginal cost of energy was declining. This is also true today, but conservation is a separable issue from efficiency. Conservation advocates are interested in such matters as detering new construction by limiting future demand.

6.4.5 Programmmatic Options

The feasibility of this alternative is partially dependent upon other non-rate design programs which might be used to assist low-income households. Although this paper cannot fully consider and analyze these measures, a brief mention of some of the major non-rate design possibilities is warranted. Note that rate design administrative costs would remain at about the same level, since this CPUC function would still need to continue.

One such program is an energy voucher plan. This would work similarly to food stamps: targeted people would receive stamps entitling them to purchase a quantity of electricity at a discount; the government then buys the coupons from the utility at full prevailing rates. The subsidy to the targeted population depends upon the amount of discount offered by each coupon and number of coupons purchased. Coupons would not be transferable if the program is run similarly to the food stamp program. The administrative costs of printing coupons, identifying and keeping track of recipients, and redeeming the coupons could well outweigh the efficiency gains from the rate design.

A second alternative program might be direct cash transfers to certain households. As with energy stamps, the specific recipients of the transfer would have to be identified and located, and differential transfer levels could exist. The cash would not have to be used for purchase of energy. There would be efficiency gains from the ability of program recipients to choose how to spend their funds. On the other hand, administrative costs - including identification of recipients, distribution of cash, and follow-up--might be high. Any efficiency gains from rate design might be offset inefficiency from new taxation. Further, if the recipients do not use their cash transfers to pay for energy consumption, and still require assistance to pay their bills, it is highly likely that the government would still need to step in and assist some people.

A third possible program would be private or utility-sponsored assistance. Although there would be high administrative costs in such a program, this would be counter-balanced by the public relations benefits. However, it might be difficult for the government or regulators to influence which ratepayers would benefit from such programs, or how much they would benefit. On the other hand, a program designed cooperatively between a utility and the CPUC staff might alleviate this concern.

Table 5 shows the consumer surplus and equity-consumer surplus results for each alternative under the two weighting systems and for each level of consumption.

SECTION 7 -- TRADEOFFS BETWEEN ALTERNATIVES

In order to reach a conclusion as to which alternative to recommend, we must consider the relative value of each evaluation measure. Table 6, Assessment of Alternatives, shows the various possibilities in relation to the present system. A plus signifies that the alternative is considered better than the present system on that measure, and a minus means that it is not as good. A plus and a minus means that in some ways it is better, and some ways not as good as the present alternative.

TABLE 5

QUANTITATIVE ANALYSIS OF ALTERNATIVES

Equity = weight low income households double

AVERAGE PRICES

kwh/mo	PRESENT BASIC	75% IN BASELINE	1ST TIER AT MC	FLAT RATE LOW-INCOM	FLAT RATE NON-LOW-INCOME	2 TIER NON-LOW-INCOME	FLAT RATE	2ND TIER AT MC
275	0.0665	0.0665	0.0550	0.0665	0.0829	0.0665	0.0832	0.1072
507	0.0805	0.0796	0.0815	0.0665	0.0829	0.0828	0.0832	0.0833
670	0.0847	0.0891	0.0894	0.0665	0.0829	0.0877	0.0832	0.0764

CHANGES IN CONSUMER SURPLUS

WEIGHTING SYST (even distributio (26.4% non low inc/low demand, 26.4% non low inc/med demand, 26.4% non low inc/high demand, 6.3% low inc/low demand, 6.3% low inc/med demand, 6.3% low inc/high demand)

kwh/mo	PRESENT BASIC	75% IN BASELINE	1ST TIER AT MC	FLAT RATE LOW-INCOM	FLAT RATE NON-LOW-INCOME	2 TIER NON-LOW-INCOME	FLAT RATE	2ND TIER AT MC
275	$0.000	$0.000	$3.226	$0.000	($4.601)	$0.000	($4.685)	($11.877)
507	$0.000	$0.464	($0.468)	$7.224	($1.182)	($1.140)	($1.328)	($1.422)
670	$0.000	($2.971)	($3.140)	$12.461	$1.261	($1.947)	$1.057	$5.616
EFFICIENCY	$0.000	($0.827)	($0.126)	N.A.	$0.105	$0.484	($1.636)	($2.535)
EQUITY 1	$0.000	($0.992)	($0.151)		$1.170	$1.486	($1.964)	($3.042)
LOW INCOME	$0.000	($0.827)	($0.126)	$6.496	N.A.	N.A.	($1.636)	($2.535)
NON LOW INCOME	$0.000	($0.827)	($0.126)	N.A.	$0.105	$0.484	($1.636)	($2.535)

WEIGHTING SYST (usage correlated with income) 16% non low inc/low demand, 24% non low inc/med demand 40% non low inc/high demand, 10% low inc/low demand, 6% low inc/med demand, 4% low inc/high demand)

kwh/mo	PRESENT BASIC	75% IN BASELINE	1ST TIER AT MC	FLAT RATE LOW-INCOM	FLAT RATE NON-LOW-INCOME	2 TIER NON-LOW-INCOME	FLAT RATE	2ND TIER AT MC
275	$0.000	$0.000	$3.212	$0.000	($4.573)	$0.000	($4.660)	($11.706)
507	$0.000	$0.522	($0.527)	$7.633	($1.032)	($1.141)	($1.499)	($1.240)
670	$0.000	($2.974)	($3.145)	$12.396	$1.261	($1.962)	$1.058	$5.630
EFFICIENCY	$0.000	($1.168)	($0.683)	N.A.	$0.416	($0.126)	($1.152)	($1.043)
EQUITY	$0.000	($1.049)	($0.429)		$1.123	$0.672	($1.743)	($1.743)
LOW INCOME	$0.000	($0.438)	$0.819	$4.769	N.A.	N.A.	($2.568)	($5.099)
NON LOW INCOME	$0.000	($1.331)	($1.088)	N.A.	($0.593)	($1.323)	($0.853)	$0.102

TABLE 6

A COMPARISON OF THE EFFECTS OF EACH ALTERNATIVE

	1 PRESENT	2a 75% IN BASELINE	2b LOWER 1ST TIER	3a 2 FLAT RATES	3b TWO-TIER NON-BASELINE	4a FLAT RATE	4b 2ND TIER AT MC
EFFICIENCY	0	-	-	+	+/-	+*	+*
		-0.83	-0.13	0.11	0.48	-1.64	-2.54
		-1.17	-0.68	0.42	-0.13	-1.15	-1.04
EQUITY 2 X LOW-INCOME	0	-	-	+	+	-	-
		-0.99	-0.15	1.17	1.49	-1.96	-3.04
		-1.05	-0.43	1.12	0.67	-1.74	-1.74
LOW INCOME	0	-	+/-	↔	↔	-	-
		-0.83	-0.13	6.50	6.50	-1.64	-2.54
		-0.44	0.82	4.77	4.77	-2.57	-5.10
NON LOW INCOME	0	-	-	+/-	+/-	-	+/-
		-0.83	-0.13	0.11	0.48	-1.64	-2.54
		-1.33	-1.09	-0.59	-1.32	-0.85	0.10
ADMINISTRATION & SIMPLICITY	0	0	0	-	-	+	0
RATE STABILITY	0	0/-	0/-	-	0	-	-
CONSERVATION	0	+/-	+/-	-	0	-	-

* -- Alternative 4a and 4b increase efficiency over the present because there are large efficiency gains in the non-residential sectors.

Table 6 also provides the results of the consumer surplus analysis, in terms of change per household per month. Recall that the equity-consumer surplus calculation assign a double-weight to low-income households. The row labeled "equity" shows these results. The rows marked "low-income" and "non-low-income" show the changes in consumer-surplus for these specific households, and are another measurement of equity effects.

Decision-makers must decide which criteria are more important than others, and by how much, in order to make their policy judgments. The criteria, again, are efficiency, equity, conservation, and simplicity. The results of this analysis can provide assistance in making these judgments.

There is often a tradeoff between equity and efficiency. A design which lacks in one measure should make up for this in the other. On this basis, we see that Alternative 2a -- 75% in Baseline -- fails to increase either efficiency or equity. As there are no other clear advantages of this alternative, it would be difficult to defend.

Among the other alternatives, there are tradeoffs between the various criteria, and no clear dominant alternative Three designs -- the Flat Rate (4a), and Alternatives 3a and 3b -- improve both efficiency and at least one measure of equity.

The advantages of Alternative 2b are that it is somewhat beneficial to low-income households and it is as simple as the present system. However, it is not strong on the other criteria.

Alternative 4a and 4b are very good on efficiency grounds, after considering the effects on the non-residential classes. While low-income households fall short, these Alternatives perhaps should not be marked down on this measure, as they are meant to be combined with other measures to mitigate this effect. Whether these measures would be implemented is questionable.

Alternative 3b -- a two-tier structure for the non-Baseline class -- is the only alternative in which low-income households benefit and in which there may be a more efficient design.

If a policy-maker wants to concentrate on gains in efficiency, Alternatives 4a and 4b are the best choices. If rate-design assistance to low-income households is most important, choose Alternative 3a or 3b. If a more efficient allocation and assistance to low-income households is desired, Alternative 3a and 3b are again the best; Alternatives 4a and 4b may also pass if some mitigation measures follow.

Conservation advocates might not prefer any design more than the present system. Certainly, any design without an inverted rate structure (3a, 4a and 4b would fall short on the "use-less" conservation standard Alternative 2b would entail a declining block rate structure if marginal costs rose considerably, and thus be less acceptable on conservation grounds as well.

Finally, if limiting administrative complexity in the rate structure is important, Alternatives 3a and 3b might not be considered. In terms of overall administrative complexity, Alternatives

4a and 4b might also lead to increased costs, due to the potential for new or expanded programmatic initiatives.

SECTION 8 -- RECOMMENDATIONS

This paper has attempted to analyze examples of all the major categories of alternatives to the present Baseline program, including the status quo. While other alternatives are conceivable, they are likely to be variations on the sane four themes. Given the analysis of these themes, we can see that several of the alternatives presented here could be acceptable under differing scenarios.

I recommend Alternative 3b -- a single rate for low-income households at the current Baseline rate, and a two-tier design for other households; their first-tier would encompass the same amount of energy as at present priced at the current Baseline rate, and their second-tier would be 5% higher.

This alternative has many advantages over the present system and other positive features:

o Efficiency -- Because there are more households which receive a rate closer to marginal cost, and fewer households which have to provide subsidies, a more efficient allocation of energy resources results. This increase in allocative efficiency brings about overall assistance to all ratepayers, one of the objectives of the Baseline program.

o Assistance for low-income households -- All low-income households receive a subsidized rate under this design; none of these ratepayers must subsidize anyone else. In particular, no low-income households subsidize non-low-income households. This alternative shows the greatest increase in benefits when low-income households are given more weight, and the greatest benefits to low-income households in particular. The average low-income household would receive over $60.00 a year in assistance; other households would pay about $15.00 a year more to finance this. This totals a transfer of over $30 million a year to low-income households in the SCE service territory.

o Rate Stability -- Most households would find decreases in their overall bills. Of the households that receive bill increases, these increases are kept below 5% -- the amount allowed under the phase-in of the present Baseline system.

o Administration and Simplicity --While some adjustment for the CPUC, the utilities and the ratepayers would be necessary, the self-certification method would minimize the complexity of implementing this system. Evidence from the Universal Lifeline Telephone Service program indicates that this is a reasonable and viable method of implementation. Periodic random checks of recipients would be a cheap and effective method to prevent abuse. The single tier rate for low-income households is easier to understand than the present structure.

The most obvious disadvantage of this system lies in the implementation stage. It is possible that many eligible households would not sign up for the program. However, if these are Baseline-level consumers of electricity, they would still receive the same rate even without the Lifeline structure. Similarly, those who sign up for the lower rate and do not qualify on income criteria would receive no extra benefits if they were not large energy consumers. The problem is if larger consumers who are eligible do not sign up, or if ineligible larger consumers do sign up. The best hope is that there will not be too many in either of these categories. Further study of the ULTS program may indicate whether this is a problem, and possible mitigation measures.

Finally, the time is right for a change. The Lifeline and Baseline programs in California and in other states have been criticized for years on grounds of inefficiency and unfairness. The original Lifeline program developed in 1975 was responsive to a different era of energy supply and demand than exists today. Further, there is a recognition that unforeseen complications have occurred since 1975 that have not been addressed as of yet. The alternative recommended in this analysis is an attempt to work around these difficulties and present a program which is in the long term interests -- both economic and distributional -- of the residential class of ratepayers.

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DESIGNING AND DEVELOPING AN ENERGY-RELATED PROGRAM FOR PUBLIC HOUSING RESIDENTS AND RENTERS

ALLISON BRYANT

DESIGNING AND DEVELOPING AN ENERGY-RELATED PROGRAM FOR PUBLIC HOUSING RESIDENTS AND RENTERS

Allison Bryant

The Assignment Group

The term "public housing" is a double-entendre when introduced within the context of energy conservation. What immediately comes to mind is the massive consumption generated by millions of tenants living in subsidized quarters. However, a divergent view identifies opportunities for significant savings to the nation. This project undertook the challenge of the divergent view by trying, as a practitioner, to design and develop an energy-related program for public housing residents with application to renters. This paper reports primarily on the methodology and references the formal reports that document the entire demonstration project.

The U.S. Department of Housing and Urban Development (HUD) oversees public (and other federally-assisted) housing for which it spends more than $1 billion on energy for approximately 1.2 million units housing 3.4 million people. This represents about 9,900 projects managed by 2,700 local housing authorities. Of the 3.4 million occupants, more than 60 percent are minority populations who reside in 76% of the dwellings designated as family units. (The remaining 24% are occupied by the elderly.)[1]

Public housing, in most instances was completed prior to the 1973 oil crisis and, as such, energy conservation was not considered in its design, materials, nor construchion.[2] Although it is difficult to accurately compare energy use in public housing to private residential units since those figures also include consumption from common areas, administrative space, etc.--and the process to disaggregate tenant versus PHA costs has not been perfected--it has been estimated that 65% of energy end use in public housing is for space heating.[3] Hot water heating is the second largest end use at 22 percent.[4] It can be safely assumed that those figures vary from private residential units since in public housing the families tend to be larger and more people are at home during the day.

Comparing public housing site energy consumption and its costs to private residential use is virtually unfathomable since consumption and costs are recorded by project. In those limited cases where tenants have individual meters, true costs are not reflected since HUD guidelines require that energy allowances be made. Tenants would pay the difference between allowance and use. The process of collection is not universally enforced. Generally though, site energy consumption is 11% for electricity, 25% for oil, and 64% for natural gas. However,

percentage of energy costs reflect costly electricity at 29.8%, while oil is even at 25.9% and gas cheapest at 44.3% of total dollars spent.[5]

Further complicating the public housing energy use picture are the variables of age and type of building, unit size and condition, central versus individual heating systems, fuel used, and type of occupants. All these influence energy use patterns, and they all contribute to the significant potential for energy savings.

To meet the potential for energy savings that public housing presents, fifty-eight energy conservation opportunities (ECOs) were identified by the Ehrenkrantz Group in a 1980 report to HUD. Of the fifty-eight ECOs, none was specific to the behavior of public housing tenants. In order words, the ECOs identified were dependent upon the local housing authority taking the initiative for implementation or application. It was this writer's opinion that sound, long-term energy conservation had to also consider the end users, for if they did not modify their behavior in the form of their practices, ECOs would be limited in their value. This project, to design and develop an energy-related program for public housing residents, focused on the tenants and their assumption of responsibility for energy conservation conscious behavior.

Although there is no readily-available documented previous work in this area, the writer believed that adult learning principles that the firm applies in its management development, training, and organization development activities would also apply with tenants in public housing. Namely, adults learn best and take responsibility for those actions where they: (1) understand the overall purpose, (2) take part in the planning, (3) experience success, and (4) the learning occurs in the context of their own experiences. To this end, the project approach and methodology attempted to address the issue of energy conservation practices, i.e., things the tenants controlled, within the context of an experientially-based framework. Because of the disparate costs for electricity, it was decided to involve public housing authorities whose space heating was electrically provided.

PROJECT METHODOLOGY

The final design methodology was preceded by a year-long effort to document tenant behavior and modification after a training intervention. A rather optimistic goal was established: the design and development of an energy-related demonstration program that educates public housing residents, facilitates indigenous business development where appropriate, and trains residents to provide needed services.

To meet the goal, it was necessary to focus on activities that lend themselves to typical public housing and PHA resident councils. This meant objectives that distinguished the specific strategies or major undertaking while also allowing the host organization(s) to witness concrete actions and benefits during the project phases. For that reason, the following objectives served as the basis for planning and action for the initial phase of the project:

1. To ascertain current annual costs for energy use in designated PHA units and compare to energy use costs in similar private units.

2. To determine over a 30-day period the extent to which energy-related decisions get exercised in daily routine and note the extent of the information base.

3. To design and develop, with respective resident populations, energy-related programs that employ energy decision data to reduce consumption, initiate needed services, and train residents as providers of needed services.

4. To disseminate findings within 90 days to other public housing authorities interested in improved energy efficiency -- with special emphasis on those authorities undergoing homeownership conversions.

The overall strategy to meet the goal first required finalizing arrangements with the selected PHAs, the Cuyahoga Metropolitan Housing Authority, Cleveland, OH, and the New Haven Housing Authority (CT). Included in the final arrangements were delineation of specific roles, identification of involved units, informational meetings with tenant councils, and scheduling for the final work plan. Completion of this activity began implementation of the specific objectives through a three-phase approach.

Phase I - Ascertainment of Costs and Decision Style

During this phase efforts were undertaken to review PHA documents and data that identified energy use costs. Those costs were compared against similar costs for like-situated private housing units. Research of local utilities, private housing associations, and related energy-provider data also served as the base for comparison. As already mentioned, comparisons could only be made in an aggregate.

In order to ascertain costs for individual units within public housing projects, either individual billings have to be in effect and/or meters that record per household energy consumption were in use. The cost data made available reflected a disparate percentage going toward energy consumption, but those costs were for total buildings and/or blocks of units--data that was not very useful. However, when compared to private housing of similar size there existed a disproportionate expenditure of energy dollars by public housing authorities.

A decision matrix instrument was structured based upon the type of energy sources available, established conservation methods, and the unit size and structure. The results were analyzed to determine decision style. All data suggested wasteful patterns of energy consumption to which training needed to respond. These practices also provide the best occasion to avail the tenants of energy conservation opportunities that were directly under their control. There was an attempt made to correlate findings with demographic data for further tailoring of training. There were no significant correlations. The thirty-four respondents to the first part of the data form were evenly divided between highrise buildings and lowrise and townhouses. The

average household had 4.3 individuals with two New Haven families accounting for twenty-one individuals. Those households did not skew the data collection since energy practices were recorded by households and not individuals.

Phase II - Design and Development of Program

During the second phase, the results from Phase I were shared with the tenant councils and their input solicited regarding corrective measures, identified needs to improve conservation, and the actual design and development of programs that responded to those identified needs. Once developed, selected tenants were trained in the whole process of on-site ascertainment through determining their improvement needs and how to secure them.

The design and development focused on approaches that would provide the tenants experience to analyze their behavior regarding use of energy conservation opportunities and give them more information from which to make decisions about improved energy practices.

The evaluation instrument administered to the tenant participants was designed to measure their reaction to (1) the effectiveness of training in accomplishing the stated objectives, (2) the planning and administration aspects of the program, and (3) an overall assessment of the program content, the quality of instruction and the relevance of the program. One hundred percent of the respondents rated the training as excellent and emphasized the amount of time was just right.

Phase III - Dissemination of Results

The third phase required THE ASSIGNMENT GROUP to be responsible for disseminating the project's results to the two dominant PHA associations, the National Association of Housing Rehabilitation Officials and the Council of Large Public Housing Authorities. Although arrangements were made for dissemination, final distribution was delayed until completion and acceptance by DOE of the report on the total two-year effort.

The use of an energy conservation practices matrix proved too demanding for the tenants who were not generally required to be as disciplined in their routine as the instrument necessitated. It also became evident that effective execution of the project required involvement of the tenant associations. Although loosely structured, such associations provide a "friendly" entre to skeptical tenants. Additionally, the need for training in specific energy conservation uses and behaviors was identified.

A complete report on the activities of the first year can be found in the document, "Initial Phase Report On Project To Design and Develop An Energy-Related Program for Public Housing Residents," July, 1985, Office of Minority Economic Impact, DOE.

FOLLOW-ON TO INITIAL PROJECT ACTIVITY

The limited time span for the initial demonstration project necessitated concentrated front-end staff work and interaction with tenants. A benefit from that concentrated effort was the early identification of needed modification to the project scope and approach.

During the training, the residents voiced concerns about other tenants and the ability of all of them to effectively modify energy practices when they did not know how nor have access to information and guidance. In addition, the tenant participants in the training expressed a desire (and a willingness) to get more information and influence their neighbors regarding improved energy practices.

THE ASSIGNMENT GROUP determined that the tenants had identified a legitimate need that, if addressed, would probably expand the number of people directly benefitting from this demonstration and increase the number of options available to tenants for improving their energy practices. Modifications were made and the new objectives became:

1. To conduct an Energy Conservation Practices Institute for public housing tenants who will train others in the practices that are most energy-conscious.

2. To compile a tenant-oriented energy practices curriculum and guide to serve as a tool for enhanced use of energy conservation opportunities.

There were two distinct advantages to these objectives. A core of trained tenants, who were indigenous to the public housing environment, were better able to serve as models and replicate the use of energy conservation opportunities that exist in most of the tenants' energy practices. Once this core of tenants is trained, there will be less need for an outside consultant and long-term corrective action will be more feasible. The curriculum guide also bolsters the potential for tenants to become more self-sufficient. The guide is a practical, easy reference that can be used to assist in implementing energy conservation opportunities through measurement and cost determination methods for common appliances, heating, and air conditioning.

The modified approach required two distinct phases: ECPI Development and Implementation and Curriculum and Guide Compilation.

Phase I - ECPI Development and Implementation

The design, development, and implementation of the Energy Conservation Practices Institute was geared toward the identification of interested and capable residents who could serve as trainers of other residents. The identification process began with those who participated in the training by TAG and expanded from there. Among the criteria used was commitment to devote the time to getting trained and actually training other residents.

The residents selected to be trained as tenant trainers played a role in defining the content of their training based on the appliances and other energy consumers present in their units. They were also exposed to an approved industry standard for training of trainers. In addition to their input, TAG further researched what basic information was needed to have versatility in energy conservation matters. To facilitate replication, only existing utility publications publicly available were used.

After the determination of training needs, the design and development of a training system that supported those needs commenced.

Participant Manual and Instructor Training Guide*

THE ASSIGNMENT GROUP's approach to training is that it should be learner-centered and experiential. Since adults learn best by doing, in an environment that is comfortable and receptive to participant input, the training manuals and programs were structured to be largely participatory. The training packages were designed to guide and supplement the training and to serve as a resource for tenants at home.

The content of the "Participant Manual" and "Instructor Training Manual" was influenced by principles of adult learning theory, and by what TAG believed was important for participants to know about energy conservation.

The "Instructor Training Manual", which served as a "map" for the TAG-conducted training programs, provided all the information about content and process the tenant trainers needed to lead the program. A step-by-step description of the training day, specific in its detail about the use of time for each learning activity and an explanation, was included.

Information about adult learning theory and making presentations was included to assist the tenant trainers understand the rationale behind the entire program and to introduce them to information which would assist them in their own presentations.

To help them be successful with their training, a detailed description of the format they would follow as they worked with other tenants was developed. To supplement this information, TAG included facts which could be used to guide their discussions, supplied answers to the energy quiz, and provide a written tool they would use to plan for the training they would conduct. Also, the Participant Manual for the tenant training program was included to be used in preparation for the training they would conduct.

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* "Energy Conservation Practices Participant Manual for Public Housing Residents and Renters," DOE, December 1986, and "Instructor Training Manual," DOE, December 1986.

Decisions about the contents of the Participant Manual were guided by the same principles of adult learning. To provide an overview of the program, an agenda and introduction were included; the latter defined several key words related to energy conservation and stated the program objectives.

In order to involve participants quickly in the work and to assess their knowledge about energy matters, an energy quiz was included as a pre-test (and post-test) in the manual. To reinforce further what they knew at the start and to arouse their interest, a fact sheet with easy-to-grasp information about the use of energy in the home was provided.

A case study about a family's use of energy in their home was included for several reasons. It was a tool to provide participants an opportunity to demonstrate further what they knew about energy use. It was a vehicle to move the group into a discussion of a decision-making process. It was a tool to encourage them to begin to consider their family's use of energy.

The decision-making content flowed from the case study material. A step-by-step approach to making decisions was included, followed by a brief statement of obstacles which might inhibit the process. This information was important to the remainder of the program and to the tenants' application of what they learned in the session to their home environment.

It was necessary to include definitions of key words and concepts in energy conservation to assure that participants understood the vocabulary of energy matters and the material in the Energy Conservation Matrix, which was a capstone of the Participant Manual. The detailed matrix provided facts about energy conservation practices and measures that could be applied in the home. It was not only an integral component of the training program, but was a valuable resource for participants who could refer to it when they had energy related questions.

An Energy Questionnaire was included to provide TAG with demographic information about the participants' family composition, energy/utility components, and the physical structure of their home.

Finally, an evaluation form with open-ended and specific response questions was included. This provided an assessment of the participants' perceptions of the program and its value to them.

Both the "Participant Manual" and the "Instructor Training Manual" were organized to take participants through a developmental learning process. That is, the foundation for learning was established at the start and other elements were added to it systematically, one learning activity and informational piece built on the one which preceded.

Training of Tenant Trainers

Early into the design phase, a decision was made to use tenant teams for training. It was determined that a team approach would provide additional support on site and be a confidence booster. Also, the team approach allowed a more concentrated focus on training of trainers.

The training of the tenant trainers was designed to occur in one 6-1/2 hour-day. The program was comprehensive, in that it introduced the tenant trainers to the training process as well as to the content of energy conservation. A major component of the training design was the actual program they would conduct for other tenants.

The training day was to serve several purposes. It was to:

- Provide a model for their training program;
- Expand their knowledge of energy conservation;
- Get them involved in thinking about energy conservation;
- Provide opportunities for them to practice presentation skills;
- Prepare them to train other tenants in energy conservation.

The process of the day was designed to move from leader-focused to learner-centered activities. The structure allowed TAG trainers to set the tone and establish the framework, with a plan to move control of the day into the hands of the tenants. The plan was a reflection of the principles on which the program was based and intended to encourage independence and confidence on the part of the participants.

The training program combined theory and practical application. Some aspects of the program began with an activity, which was followed by a discussion of the theory important to it. With other parts of the day, the theoretical discussion or presentation of information was first, followed by a look at ways they could be applied to the training/learning process.

Learning occurs on three levels--knowledge, skills and attitudes--and involves change in any or all of these areas. The training program addressed all levels by (1) introducing information important to the learners about energy conservation and the training of others, (2) helping them understand why the information was important to them as trainers and as public housing residents, and (3) providing information about and opportunities to apply what they learned during the training program and at home.

While there were a variety of methods which could have been used to transmit information, the most important in the development of trainers was to involve them as much as possible in the learning process.

The day began with group and trainer introductions. The tenant-trainers' expectations for the day and the program in general were discussed. Program objectives were reviewed and an

overview of the day was presented. Beyond the task of introducing the material, this time was used to establish an informal and welcoming environment.

The proposed Training and Participant Manuals were reviewed as the group moved into the first learning activity. Each participant was given a blank sheet of paper and asked to construct an airplane with it. After a few minutes each person was asked to fly his/her plane. This created a stir in the group. The group selected the person whose plane flew the best. The trainer asked that person to instruct the group to make a plane like his/hers. The rules were that he/she could only use words and the participants had to wait until the explanation was completed before starting their plane. Participants were asked to construct and fly their planes. Finally, the same person explained again how to make a plane, this time showing the group at the same time as he/she described what to do. He/She offered assistance and answered questions. Most of the participants successfully accomplished the task on the last attempt.

The purpose of the activity was discussed. The idea was to introduce principles of adult learning and emphasize the importance of two-way communication. The manual pages "How Adults Learn" and "Key Principles of Training Adults" were reviewed. The information on the next pages ("Preparing for Your Presentation," "Assessing Your Presentation Style," "The Importance of Asking Questions," and "On the Day of Your Presentation") were also discussed and related specifically to the training they would conduct.

The "Participant Manual" and the "Instructor Manual" that accompanied it were reviewed page-by-page. This ensured the group understood each activity and the information in the document.

The next task moved the focus of the program from the trainer to the group. Participants were instructed to work as a group to plan their presentation of the tenant training program. They were told that each participant had to do some part of the training and they were to include all activities, though in an abbreviated form. They had two hours to plan for the presentation. They incorporated lunch in their planning time.

After lunch, participants conducted the tenant training program, using the "Instructor Manual" and "Parhicipant Manual" to guide them. The group and TAG trainers critiqued the presentations, offering suggestions for improvement and emphasizing aspects which were handled well.

At the conclusion of the tenant training program participants were asked to look at the form, "Your Plan for Conducting the Residents' Program." They worked in pairs or triads, designated by the TAG trainer, to make decisions about and specific plans for their training. Responsibilities for tasks and a timeline were decided by each team. THE ASSIGNMENT GROUP used the information generated through these discussions to check that all tasks were assigned in the team and in an appropriate time frame.

The training was summarized, the participants were thanked for their interest and involvement, and they were asked to complete and submit the evaluation form.

Tenant-trainers were responsible for following through with the plan they developed during their training. The training team had to: decide on a date and location for the training; recruit tenants to participate in the training; request training materials from TAG, and resolve how the team would divide the preparation and training responsibilities.

The design of the program was included in the tenant-trainer's manual. The "Instructor Manual" provided explanations of how to conduct each part of the program. They were to follow these directions.

On-site monitoring was to be provided by TAG for the tenant programs. The purposes were to provide support for the tenant trainers, observe the training process, and analyze the program content and design to decide if modifications were necessary.

Phase II - Curriculum and Guide Compilation*

Compiling a curriculum and guide for tenant use was a primary step toward giving tenants a basis for continued energy conservation awareness and generating support from the public housing authorities for incentives for the residents. The curriculum and guide was to be a step-by-step process for the care and maintenance of standard appliances found in most units. The curriculum portion codifies important energy conservation measures and information; the guide portion explains the application of the relevant parts of that information.

Previous research data were segmented to specifically address the conditions found in public housing. The compilation commenced with the development of a subject outline, subject content outline, then a detailed outline. Once the detailed outline was complete, it was circulated to the tenants, PRAs, and local utilities for reaction and suggestions for modifications. These entities served as a "panel" of "experts" who played a direct role in its use. From this process emerged the final document.

As part of this overall approach, TAG suggested the inclusion of another public housing authority within the demonstration project. If another PHA, preferably from the West Coast, were included, then the training developed and curriculum and guide compiled would be more inclusive of the nation and thereby make any products more replicable nationwide.

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* "Conservation Currlculum Guide for Publlc Houslng Residents," DOE, December 1986.

United Illuminating's Involvement

The local utility for the New Haven (CT) site, United Illuminating, was approached about participating in the project. One of the two housing developments included in the training effort had a history of the highest energy consumption among UI's customers of similar size, density, etc.

The United Illuminating utility agreed to participate and assigned a staff person to serve as liaison with TAG. Among the services provided were:

1. Training space and refreshments for the tenant training program;

2. Cash incentives ($50.00) for tenants who participated in tenant-led training;

3. Staff and resources for research and data collection in the compilation of the energy pamphlet, "Conservation Curriculum."

The involvement of UI was unique to the New Haven location. The company's involvement facilitated communication between the Housing Authority of the City of New Haven and UI officials who had been trying for some time to reach an accord regarding the high energy usage. From that developing relationship came a development-wide energy audit and individualized needs analysis for each unit in the effected housing projects. This represented a substantial undertaking since fifty-one units were involved. In addition, UI agreed to provide resources toward ameliorating problems that were found to be common among the units, e.g., weatherization materials.

Another unique initiative resulting from the relationship with UI was contact with the executive level within the Department of Housing and Urban Development regarding the disincentive of HUD's current energy policy that penalizes PRAs after the first year's savings. During year one savings, HUD shares with the PHA any recognized savings on a 50-50 basis. After the first year, the PHA allocation is reduced by the amount saved.

West Coast PHA Program Implementation

The West Coast City of San Francisco, CA, was added to the span of the tenant training program. Among the reasons for selecting San Francisco were: (1) its distinctive difference from the New Haven and Cleveland sites, i.e., size, density, numbers; (2) recently hired executive director at the PHA who was familiar with the program's aims; (3) geographic relationship to the Lawrence Berkeley Laboratory which was engaged in similar efforts that could possibly serve as a building block for further energy conservation activities.

Once the San Francisco Housing Authority agreed to become involved in the training project, the same implementation activities were employed that were used for the original locations.

An analysis of the activities of the project demonstrate that the objectives were essentially met i.e, the Institute was conducted, training manuals and curriculum exist. Those were aspects of the project that were under the direct control of THE ASSIGNMENT GROUP. On the other hand, facilitating the training of tenants by other tenants did not occur as TAG desired. There were several variables that precluded that dimension from being as effective. Most of the variables could be linked to limited public housing authority support and the need for an onsite coordinator. The document to consult on the entire project is "Final Report on the Project to Design and Develop an Energy-Related Program for Public Housing Residents," December 1986, DOE-FG01-85MI10072.

CONCLUSIONS FOR REPLICATION

The purpose of this paper was to report on the methodology for implementation of the project to design and develop an energy-related program for public housing residents. By detailing the steps, the writer hoped to provide enough guidance for replication. There are, however, some conclusions specific to such replication that need to be highlighted. Each conclusion also offers a benefit.

- Public housing authorities might not be willing or eager to engage in such a project because of the disincentive of HUD's "50/50 formula." Under the current funding system, HUD and the local PHA split excess consumption costs 50/50. If consumption decreases below the predetermined formula, the savings is also split 50/50. In addition, the PHA subsidy for the following years is reduced by the amount saved.

  In spite of what seems to be a disincentive to the PHA, they might still enjoy benefits that result from HUD's demonstration projects on the 50/50 issue. Even more important is the increased discipline and sense of ownership for their units tenants gain through involvement in an energy conservation practices project. That can translate into a more "decent, safe, and sanitary environment," which is the PHAs' mission.

- The term "minorities" has broader implications as refugees and immigrant populations grow and find available private housing beyond their means. As public housing is made available, the face of the traditional minority population changes, and with the changes come new values, customs, and ways of behaving. Applying the same treatment across the board may not prove effective. Therefore, any replication must consider which minority population is being treated and commence accordingly.

  A benefit to follow up with this project is the further delineation of the various minority populations and the ability to target each according to its customs, values, mores, and experience in public housing. In addition, public housing authorities gain useful information to assist their staffing patterns and program development.

- Energy conservation cannot effectively occur universally without joint participation of the local utility. The utility has control of all necessary records, possess extraordinary analytical capability, and has a vested interest since lower electrical utilization accommodates reduced plant construction. Additionally, the local utility has resources that far exceed the PRA and, therefore, can offer incentives for savings to tenants.

  By forming a partnership with the local utility, a team approach can be undertaken. Such an approach has benefits in the support that can be made available, generate more accountability for utility clients' end use, and hold the practitioner to a higher standard of performance.

- Another relationship that requires nurturing is that between the practitioner and the PHA. It is essential to have a liaison with which to work if any activity is going to be effected with tenants. The public housing environment is replete with rules, regulations, policies, and procedures. To work within the context of the PHA structure requires an understanding of and appreciation for that framework.

  Developing a liaison with the PHA benefits the total design, development, and delivery processes. It is this linkage that can augment an effective implementation and protect the practitioner from unrealized taboos. Once the culture of the PHA has been violated by an outsider, their re-entry is made compoundingly difficult.

- There is a dirth of research in this area of energy conservation practices generally and its application to minorities specifically. That fact requires an approach that provides flexibility and changeability as additionally assumptions are made and principles applied. The almost total lack of predictability makes research and/or demonstration projects openly susceptible to scrutiny and critical analysis of those whose approach is more firmly grounded in a scientific motif. This is not an area for the unadventurous.

  The benefits, however, to delving in this unchartered area include furthering the investigation of researchers whose work has laid a partial foundation, e.g., the energy conservation opportunities of the Ehrenkrantz Group, and opening new perspectives on a problem as ancient as the cave man, what can be done to harness resources to keep comfortable yet some still remain for later use.

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4 Id.

5 Id.

UTILITY SURVEY RESULTS: BEYOND THE ENERGY FORECAST

KAREN N. BUGLASS

UTILITY SURVEY RESULTS: BEYOND THE ENERGY FORECAST

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INTRODUCTION

Boston Edison is a publically held electric utility serving customers in the City of Boston and 39 adjacent communities within the Boston metropolitan area. Residential customers account for 87 percent of the Company's retail electric customers and consume about one quarter of all Kilowatthours sold. As of year end 1986, residential customers were purchasing over 3 billion kilowatthours annually. Each household was using an average of 5,735 kilowatthours a year.

Serving the energy needs of these customers requires an understanding of how households are using electricity, and what factors are influencing their consumption decisions. Once the relationship between energy consumption and influential factors is understood, the utility is In a strong position to forecast and plan for future energy needs. In the short term, this is accomplished by utilization of least cost capacity options. In the long term It means assuring sufficient distribution, transmission and generation facilities to meet these energy requirements.

One of the best ways to get a clear picture of the electricity consumption patterns among residential customers is to undertake surveys on a regular basis. At Boston Edison, a territory-wide mail survey is developed and conducted every three years. The survey's main purpose is to understand appliance ownership and usage patterns in conjunction with household socio-economic characteristics, so that mathematical models can be developed which capture the relationships among those variables. Using these models, along with a forecast of what the typical customer might look like and how many customers we expect to have, the company is able to predict its residential energy requirements for a given forecast horizon. But applications for utility survey results need not stop at forecast modelling. These surveys are rich in information about household economics and household size. They provide insight into appliance ownership and usage patterns that can be examined in the context of income class, with application for policy or program development.

The remainder of this paper will describe the way in which Boston Edison uses its survey results to estimate and forecast energy consumption. It will take a look at survey results over time to see how appliance ownership patterns vary by income class. Finally it will review how these patterns may or may not be affected by national appliance efficiency standards in the years ahead.

FORECASTING RESIDENTIAL ELECTRICITY CONSUMPTION

The demand for electricity among residential customers is really a function of two separate factors. First and foremost, it is dependent upon household ownership of electric appliances. Secondly, it responds to the ways in which each of the appliances is operated by the household -- more specifically how many kilowatthours each consumes.

Because appliance ownership is key to the analysis of residential electricity consumption, the company's survey solicits ownership information about more than 20 household appliances, including cooking, laundry and entertainment appliances. For each major appliance, a percentage of total households owning that appliance is calculated. This percentage is referred to as appliance saturation. Appliance saturations also are calculated for various population subgroups defined according to factors such as household size, tenure and age of household head. These characteristics are then reviewed for statistically significant relationships with appliance saturations. The strongest consistent factor related to appliance ownership is and has been household income. In general, both across appliance type and longitudinally across surveys, the higher the level of household income, the greater the likelihood of appliance ownership. This is true for normal goods, such as frost free refrigerators and luxury goods such as central air conditioning. Inferior goods, however, display exactly the opposite relationship, i.e., the likelihood of appliance ownership decreases as income rises. Inferior goods are typically those where a superior alternative exists, but is available at a higher price. The standard refrigerator is example of an inferior good. Its substitute is the frost free model.

Because of the strength of the relationship between ownership and income, individual appliance saturations are modelled as a function of household income. These models are referred to as saturation-income functions. While statistical strength is a necessary precursor to model development, the practical consideration of the availability of forecasted values for the independent variable also makes income a good model choice.

In order to specify each model, saturations are first calculated for individual income groups. These saturations are then plotted against income values to view the relationships, with alternative regression specifications tested. Those relationships which are both statistically reliable and produce reasonable results are included for use in the company's forecasting model.

The second component to understanding residential energy is average kilowatthour consumption by appliance. While the survey data can be used to support relationships between household characteristics and usage behavior, average annual consumption figures

are more easily derived from industry data. The Edison Electric Institute and the Association of Home Appliance Manufacturers regularly report average annual consumption figures for individual appliances. For future use, Boston Edison is currently metering appliances in two separate studies to develop up-to-date territory specific usage estimates. Eventually these values will replace the national numbers in the Boston Edison forecast.

The saturation figures and usage estimates are combined, along with a forecast of total residential customers, to get to total kilowatthour consumption. The Calculations include the effects of price elasticity and mandated appliance efficiency standards, along with the impacts of company sponsored conservation programs.

APPLIANCE OWNERSHIP AND INCOME CLASS: OVERVIEW

In 1980 and 1983, Boston Edison surveyed a sample of 8,000 residential customers, getting identical information about appliance ownership and income class. (As this paper is submitted, the 1986 results are being tabulated and are not yet available for inclusion in this study.) For the majority of appliances where there exists a positive relationship between household income and ownership levels, the 1980 and 1983 data examined together (with income expressed in comparable real dollar terms) show that appliance ownership at nearly every income level has increased over time. This is true for luxury appliances like microwave ovens and normal goods like frost-free refrigerator freezers. For a small segment of the normal goods class, there was virtually no shift in saturation between the two surveys. This held true regardless of income levels. A good example of an appliance for which this was true is color televisions. Finally, for inferior goods like Standard refrigerator freezers, appliance ownership at every income level decreased over time. What is most interesting about the results overall is not so much the individual saturation levels, but the change in saturation levels between the two surveys for comparable income classes. While the three year period did not bring parity among income groups with respect to appliance saturations, the incremental changes in appliance ownership patterns between 1980 and 1983 showed that all households were modifying their appliance holdings in a similar fashion -- regardless of income level. In other words, although ownership levels were not converging, appliance acquisition behavior appeared to be neither influenced nor constrained by household income.

By example, the following sections will examine survey results for each of the three types of appliances. Representing luxury goods will be microwave ovens; representing normal goods will be color televisions. Finally, representing inferior goods will be the standard refrigerator freezer.

MICROWAVE OVEN

The microwave oven showed increased saturation for every income category between 1980 and 1983 (Exhibit 1). With income expressed from both surveys in constant 1982 dollars, saturation more than doubled for households with incomes below $5,500, and nearly doubled for households with incomes between $5,500 and $12,000. In each case, saturation levels rose approximately 3 percentage points. While clearly a smaller absolute gain than what was

experienced by other income groups, only those households with incomes above the $45,000 point could claim saturation levels nearly doubling. The two groups experiencing comparable percentage point gains were households with incomes between $12,000 and $21,000, and those with incomes between $36,000 and $45,000. Their saturation gains averaged 8 percentage points. In other words, strong saturation increases in both relative and absolute terms were not limited to households at upper income levels.

COLOR TELEVISIONS

Color television saturations did not change much between 1980 and 1983 for any of the income categories (Exhibit 2). For example, households in the lowest income category saw saturations stay virtually the same, shifting from 58.2 to 58.4 percent. Households earning between $36,000 and $45,000 saw a small decline from 82.9 to 80.0 percent during the three year period. The same consistency was demonstrated by upper income households in the $45,000 to $60,000 range, with saturations experiencing a barely perceptible increase from 87.3 to 88.6 percent.

STANDARD REFRIGERATOR FREEZERS

Being an inferior good, standard refrigerator freezer saturations declined overall between 1980 and 1983, and did so consistently for all income levels (Exhibit 3). The greatest saturation declines were experienced by households in the very lowest (under $5,500) and very highest (over $54,000) income categories. In each case the decline was more than 20 percentage points, with most of the remaining income groups showing saturation declines ranging from 6 to 15 percentage points.

APPLIANCE OWNERSHIP AND INCOME CLASS: OBSERVATIONS AND INFERENCES

Boston Edison's residential survey data clearly show that modifications in appliance ownership patterns between 1980 and 1983 were directionally consistent for all income groups. This consistency held true for all types of appliances, whether luxury, normal or inferior goods. In addition, these consistent modifications took place during a period of weak economic times, when unemployment was high, affordable housing opportunities were shrinking and presumably those at the lower end of the economic scale were at a disadvantage with respect to all durable goods acquisitions.

At the same time, however, these economic constraints may have produced pressures which forced low income households to restructure priorities and in turn encouraged appliance acquisition behavior which favored convenience and comfort -- two drivers typically behind the appliance purchase decisions of middle and upper income households. Convenience became a highly desired commodity as lower income households saw householders away from home in employment or employment seeking activities, leaving less time to be spent on home based pursuits. For lower income elderly, the constraints of old age forced convenience to become a higher priority, out of operational necessity.

Comfort also became a driving factor behind appliance acquisition behavior. As the price of all goods and services were rising, many appliances became relatively rea onable purchases. These purchases were able to provide a dimension of household satisfaction and comfort otherwise unattainable under economically constrained conditions.

What the company's 1986 survey should show is a continuation of the pattern discovered between 1980 and 1983 -- that appliance saturation changes will occur consistently across income classes. Bolstered by improving economic conditions and the drop in real price of many electronic-based appliances, lower income households should continue to increase their saturations of normal and luxury appliances and decrease their holdings of inferior goods in much the same way as middle and upper income households would be expected to do.

APPLIANCE EFFICIENCY STANDARDS: WHAT EFFECT?

Having been signed into law this past April, national appliance efficiency standards w1ll take effect on January 1, 1990, and will cover 12 major appliances, along with any others that may be specified by the Secretary of Energy at a later date. There is some concern as to whether these legislated efficiencies will hamper the acquisition of major appliances by low and moderate income households and whether the legislation will slow or reverse the pattern of consistent changes in saturation levels across income class. While no one can be sure of the future, it appears the standards should have little effect, if any, on the ability of lower income households to afford or acqu1re the covered products. The lack of effect has more to do with the nature of the standards themselves than with the much analyzed incremental first cost issues associated with standards implementation.

A review of the legislation shows specific maximum kilowatthour consumption levels or minimum efficiency requirements for only six of the twelve specified appliances. The other six require pilotless ignitions or unheated cycles which typically are included on today's major appliances. In some cases, these options have lowered the cost of the unit involved (e.g. dishwashers with unheated drying cycles are typically less costly because they do not involve the installation or operation of a supplementary heating element). In other words, for half the appliances covered, the market already meets the energy efficient requirements, and typically does so at the lower end of the model line.

For the six where maximum consumption levels or minimum efficiencies are detailed specifically, the market is probably less well prepared with current product lines. However, these appliances (e.g. refrigerators, air conditioners) often require alternative engineering applications to meet efficiency levels, and up until recently these alternatives were viewed as luxury options, available only on top-of-the line models. The obstacles to ownership of these units rest more with the basic purchase price than with the incremental costs associated with increased efficiencies. A new refrigerator freezer typically costs between $600 and $700; it is estimated efficiency standards will initially add between $50 and $75 to the price -- somewhere in the vicinity of ten percent. For room air conditioners, comparable 6,000 BTU

units varying only in efficiency level can be found in major retail catalogues with virtually identical price tags.

In general, the purchase of an appliance covered by the detailed standards is an undertaking embarked upon by the household every 10 to 20 years, and typically under circumstances of malfunctioning units -- the purchase is not usually a discretionary one. A $700 price tag, more than a $50 "efficiency charge" is what lower income households are up against. This argument is not meant to belittle the incremental additional cost imposed by efficiency standards, but to show that a purchase made, on average, once every fifteen years, is not unduly burdened by an efficiency "surcharge". In the case of renter households, the landlord pass-through of an energy efficient replacement unit should be virtually offset by reduced electricity bills.

SUMMARY AND CONCLUSIONS

What lies ahead for those of us involved with residential energy consumption issues is an era of policy application, where the prospects for and impacts of policy decisions must be evaluated and examined so the public may be best served. In serving its customers, the electric utility typically gathers valuable socio-economic data and appliance ownership information vital to successful energy forecasts. These data have shown their importance here for examining changes in appliance ownership patterns and may also be a vital resource for other policy analysts and program planners concerned with the energy future.

Exhibit 1

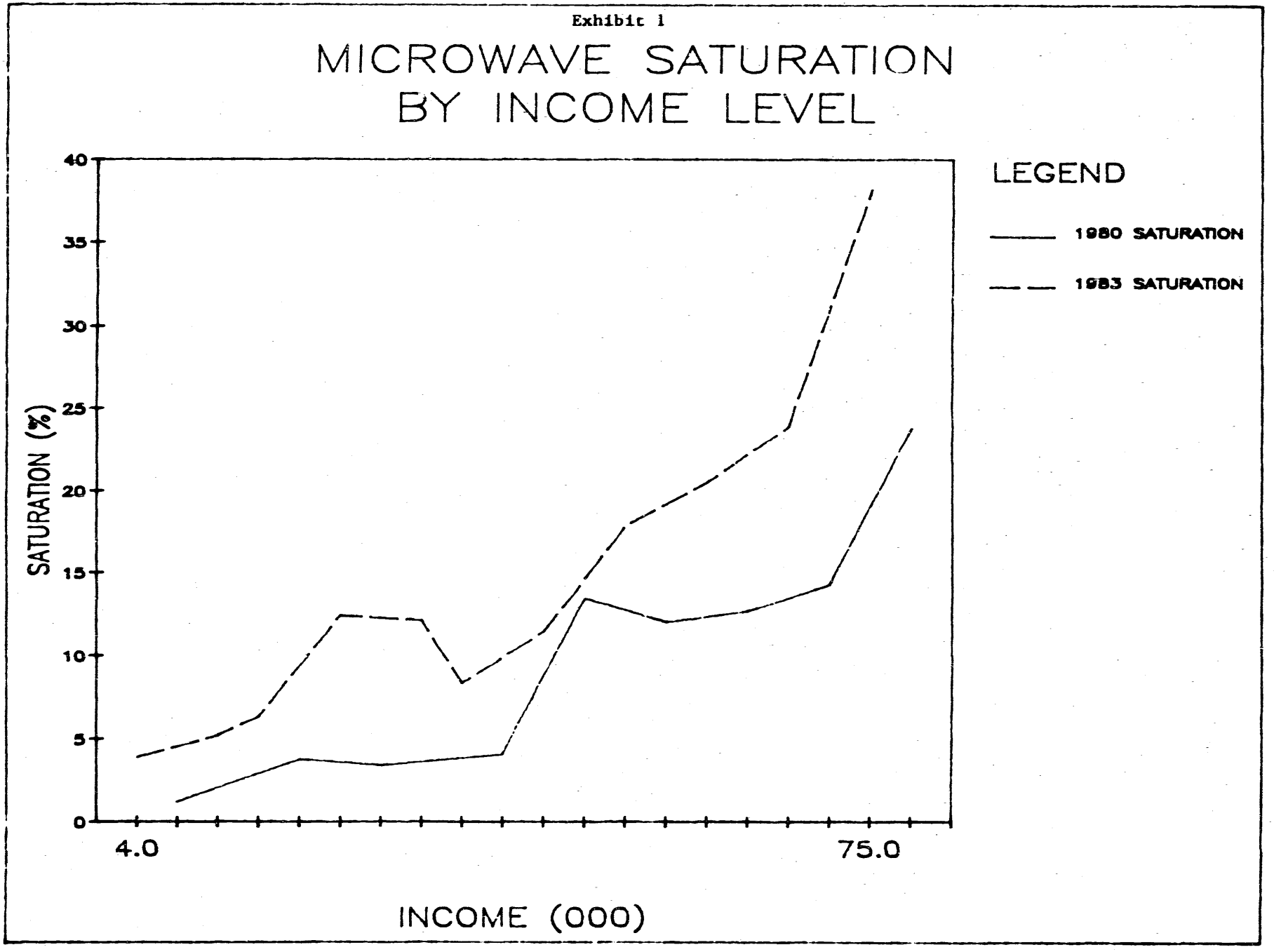

MICROWAVE SATURATION
BY INCOME LEVEL
LEGEND
1980 SATURATION
1983 SATURATION
SATURATION (%)
40
35
30
25
20
15
10
5
0
4.0
75.0
INCOME (000)

Exhibit 2

COLOR TELEVISION SATURATION BY INCOME LEVEL

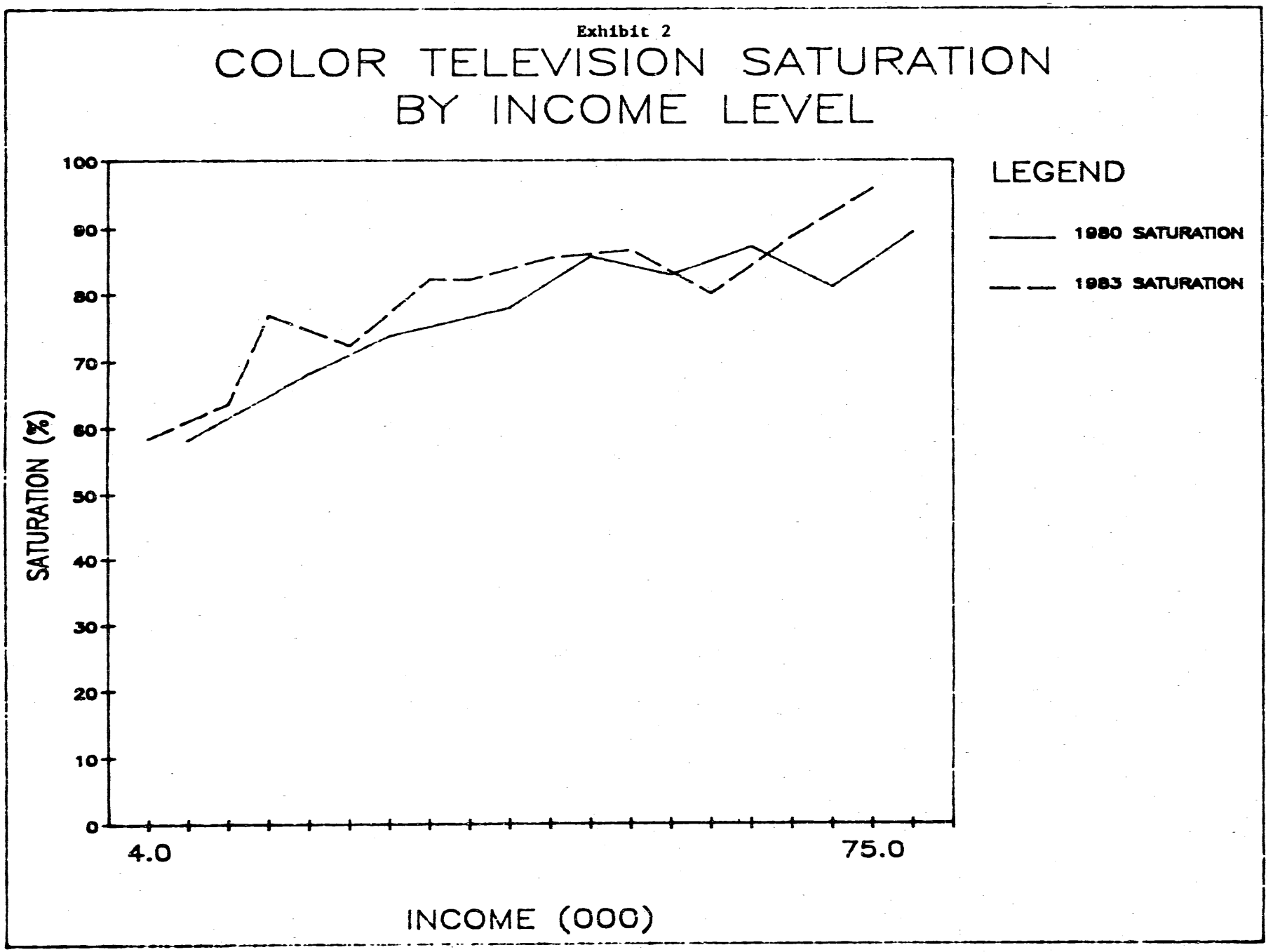
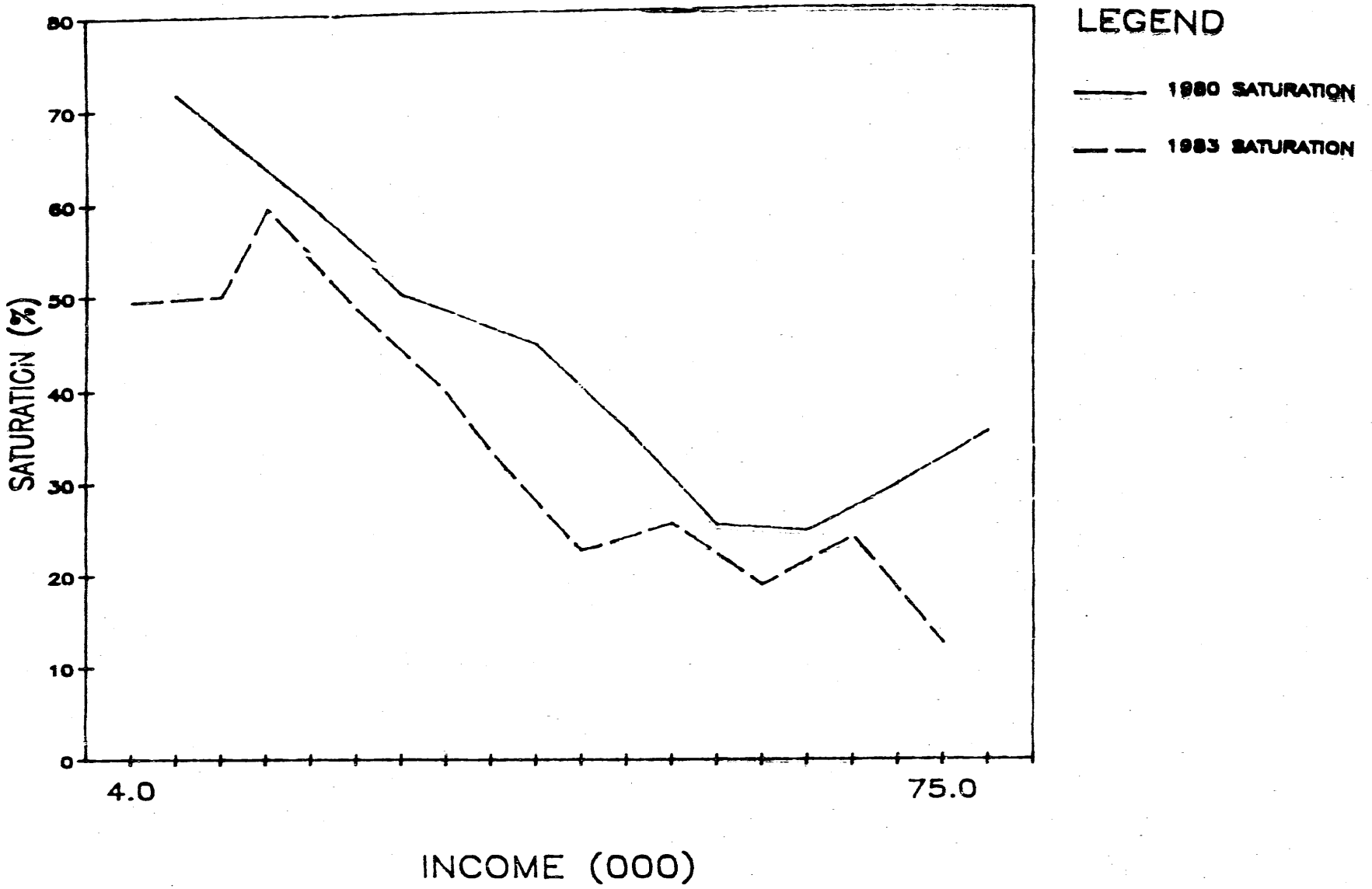


Exhibit 3

STANDARD REFRIGERATOR SATURATION BY INCOME LEVEL



ENERGY CONSUMPTION, APPLIANCE HOLDING, HOUSING, AND DEMOGRAPHIC CHARACTERISTICS OF TARGET GROUPS IN THE PG&E SERVICE TERRITORY

LISA A. SKUMATZ, PH.D.

ENERGY CONSUMPTION, APPLIANCE HOLDING, HOUSING, AND DEMOGRAPHIC CHARACTERISTICS OF TARGET GROUPS IN THE PG&E SERVICE TERRITORY

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I. INTRODUCTION

Pacific Gas and Electric Company (PGandE) is responsible for serving over 3.8 million residential customers in Northern and Central California. PGandE conducts periodic surveys designed to collect detailed and representative data about the appliance holdings and demographic characteristics of residential customers. These data support applications in demand forecasting, load analysis, conservation and load management program design and marketing, and a variety of other uses, and also meet regulatory requirements.

Using the latest in this series of surveys, the 1986 Residential Appliance Saturation Survey (RASS), we conducted a detailed analysis of the energy-related characteristics of a series of residential customer target groups, including:

- five ethnic groups (white, hispanic, black, asian, and other)
- senior households (all occupants over 60 years of age),
- the poor, defined as 100% of the 1986 poverty level, and an alternate definition, based on 200% of poverty for senior households, and 150% for non-senior households.

The study has two objectives:

1) to identify differences in energy-related characteristics for these groups, including:

- housing characteristics

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*Kellogg L. Warner, Richard S. Barnes and Sylvie Nordson provided valuable assistance in the preparation of this paper.

- appliance holdings
- end-use appliances and fuels
- conservation devices
- demographic characteristics.

2) to analyze differences in energy use for the target groups.

The research required a four-part analysis. Section II of this paper gives a detailed assessment of how these customer groups differ in their housing, appliance, and demographic characteristics. This section of the paper is lengthy, but specifically details the significance of differences between the combinations of target group categories for a large set of descriptive variables.

Recognizing that analyzing saturation differences between groups ignores important factors influencing differences in the means, we conducted a multivariate logit analysis of characteristics of interest. The results are reported in Section III. The logit analysis allows us to separate the effects of ethnicity, poverty, and age from other explanatory factors, such as income, residence types, etc. This technique allows us to control for a wide variety of factors and test for remaining differences by target group.

In Section IV, we analyze differences in average energy consumption by target groups. First we calculated mean consumption for gas and electricity for each of the groups and tested for significant differences.

Then, in order to determine the source of apparent differences in average energy consumption, we conducted a conditional demand analysis. This technique allows us to determine whether energy use by these target households differs after controlling for important contributing factors like appliance holdings, weather, house size, number of residents and other factors. This work is contained in Section V.

The summary and conclusions are contained in Section VI.

The Database: PGandE's 1986 Residential Appliance Saturation Survey (RASS) was conducted using a two-stage technique. A series of two mailings was followed by a follow-up of 20% of the non-respondents via phone or in-person interview techniques. The response rate to the two mailings was over 48%, and a 58% response rate to the follow-up was achieved. The final database consists of 22749 observations, representing a residential household customer population of 3.8 million. The mail survey started in late February of 1986 and the follow-up portion was completed in August. The survey data were verified, validated, weighted, and merged with Company information on billing and energy consumption, and information from the U.S. Census database. Extensive validation of the data was performed, with cross-checking within the survey responses and against company records and billed energy use patterns. As a final stage, statistical imputation procedures were used to fill in

missing data. This was done to reduce truncation bias in saturations due to systematic item non-response. This database is considered proprietary and is not available for use by researchers other than PGandE staff.

II. ANALYSIS OF SATURATIONS

Tables 1-3, included at the end of this paper, present the mean percentages of residential households reporting a series of characteristics of interest. The saturations are weighted to represent the entire residential customer population. Table 1 gives the saturations by ethnic group, Table 2 shows the saturations for the poor, and Table 3 shows the saturations for senior vs. non-senior households.

Variances were calculated and significance tests of the differences between the means for each of the target groups were performed. Discussion of categories of variables with significant differences follows. All differences pointed out in the text represent differences significant at the 95% level. Unfortunately, the number of target groups involves a large number of two-way comparisons and there is no compact way of presenting the information accurately. For the convenience of the reader, Table 7, included in Section VI, summarizes the general direction of differences by target group that are detailed in this section.

Housing characteristics

Ethnic: There are clear differences in the characteristics of houses inhabited by different minority groups. Whites, Hispanics, and other ethnic groups (64-71%) live in single family dwellings significantly more than black households (50.4%). Blacks live in apartments in significantly greater percentages than other minorities. Whites are far more likely to live in mobile homes. Asians are significantly more likely to live in 2-4 unit buildings than whites or the other ethnic group. Black households are disproportionately in the oldest homes, despite the fact that they tend to live in apartments. Finally, blacks and hispanics are most often in the smallest homes, with significantly larger percentages in homes under 1000 square feet than any other ethnic group, and significantly fewer in homes over 2000 square feet.

Poor: As expected, the poor are significantly less likely to live in single family homes, and are significantly more likely to live in 2-4 unit dwellings. The percentage of ownership is dramatically lower (62.1% vs. 37.3%), and the poor are significantly more likely to have lived in their home for shorter periods of time. The poor are significantly less likely to live in homes built relatively recently (1975-1981), but are much more likely to live in the oldest categories of homes (before 1950). The poor tend to live in homes with four or fewer rooms, and are much less likely to live in homes with 6-7 or 11 or more rooms. Correspondingly, they are more likely to live in houses with two or fewer bedrooms and the non-poor are more likely to live in houses with three or more bedrooms. The poor inhabit smaller homes. They are significantly more likely to live in homes under 1000 square feet and significantly less likely to live in homes 1500-3500 square feet.

Seniors: Households composed solely of residents age 60 or more are significantly less likely to live in single family homes or 2-4 unit multi-unit dwellings, but significantly more likely to live in mobile homes (12.4% vs. 4.3%). They are far more likely to own their homes than younger households (70.9% vs. 57.5%). Seniors are underrepresented among those people reporting having lived in their homes less than 4 years and far more likely to be among the households having occupied the home more than 16 years. The saturation for seniors in homes built since 1979 is significantly lower and significantly higher for those homes built between 1940 and 1960. The non-senior households are more likely to live in homes with seven or more rooms. Seniors tend to live in homes with fewer bedrooms (1-2), and less commonly have three or more. Non-senior homes are more likely to be over 1500 square feet.

Appliance holdings

Ethnic: Hispanic customers in the PGandE service territory are more likely to have zero or one refrigerator, and whites are the most likely customer segment to have more than two refrigerators. Asian and hispanic customers tend not to own freezers. Waterbeds are most common among whites, and least common among asians and hispanics. Black and hispanic customers have lower saturations of dishwashers than any other ethnic group. The distribution of holdings of television sets also showed significant differences. Asians were more likely than any other ethnic group to have more than one color television and zero black and white sets. PC/videos and VCRs were more common among asian households than in black, hispanic, and white households. Blacks showed significantly lower saturation of VCRs than the other major ethnic groups, and hispanics showed significantly lower saturations of PCs than any ethnic group except blacks.

Poor: The poor are less likely to own a whole array of discretionary appliances, including: microwave ovens, more than one refrigerator (but are more likely to own none), any frost free refrigerators, any freezers, dishwashers (58.3% vs. 24.7%), clothes washers and dryers, color television sets, computers, and VCRs.

Senior: Senior households are more likely to have two refrigerators and some type of separate freezer than younger households. They are less likely to have waterbeds, dishwashers, VCRs, computers, or more than one color television set. They are more likely to have access to a clothes washer.

End-use appliances and fuels

Ethnic: There are significant differences in the types of heating equipment found in households of different ethnicities. Central heating is less common, and multi-residential systems more common in blacks and hispanics, obviously related to their greater tendency to be in multifamily housing. Smaller, wall-type units (gas or electric) are also more common for these households than for white households. Heat pumps are most common among white households. This phenomenon can be related to the fact that heat pumps are most common

in one area of our service territory, and that area has a significantly higher percentage of whites in its population than other areas of the territory.

Fireplaces and wood stoves are significantly more common in white, asian, and hispanic homes than in black residences, and as a secondary heating source, they are also similarly more common in white homes than in hispanic or asian dwellings. Portable heaters are more common in 'other' households than in any other ethnic group. Black households have a higher saturation of natural gas heating than any other ethnic group, and white households also have a lower saturation of natural gas heat than either hispanics or asians. In a related vein, whites show higher saturations of electricity as a heating fuel than blacks or hispanics. This is very likely related to the fact that whites tend to live in newer dwellings, and newer homes have a greater likelihood of electricity as a heating fuel. As a heating fuel, solar is significantly more common in hispanic and white households than in black homes. Among the other alternative heating fuels, the only significant differences are that blacks heat with bottled gas less than white households, and whites also heat with kerosene more often than asian households.

Blacks are less likely than whites or hispanics to have air conditioning systems, and asians and hispanics are less likely than whites to have air conditioning (asians are also less likely than hispanics to have air conditioning). Central air conditioning systems are reported significantly more often in white homes than in black, hispanic, or asian homes, and the other ethnic group also reports central air more often than blacks. Blacks are also significantly less likely to have window air conditioners or evaporative units than whites. Asian and black residents report evaporative units significantly less often than white and hispanic residents.

Blacks, hispanics, and asians are all less likely to have washing machines than whites, and all ethnic groups are less likely to have dryers than white households. There are no significant differences in the fuel splits among ethnic groups. Differences are also apparent in the cooking fuels represented by ethnic group. Hispanics and blacks are more likely to have gas as their cooking fuel, probably related to the fact that they reside in older homes which have a higher probability of having gas. Bottled gas as a cooking fuel is significantly more common among whites, although still a low percentage (3.6%).

Access to swimming pools is less common for blacks than for white or asian residents, and hispanics are less likely than whites to have pools. Hot tubs show similar differences in ownership, with the addition that 'other' households are also more likely than blacks to have hot tubs or spas.

Poor: The poor are more likely to reside in homes with room-type or portable heaters rather than central heat (most likely a single family residence effect). They are also more likely to have no main or secondary heating system. No significant differences in heating fuels were found (except the "none" category). Heat pumps are significantly less common among the poor, and electric fans are more common.

Surprisingly, the poor were not significantly less likely to have some type of air conditioning system. However, they had lower saturations of central systems and higher saturations of window-wall or evaporative units.

Electricity as a cooking fuel is significantly more common among the poor. A lack of any kind of water heating was also more common for the poor, as is bottled gas as a water heating fuel. Solar water heating is much less common. Significantly fewer of the poor have access to either pools or spas.

Senior: No significant differences in heating systems or fuel types were noted for senior households. For air conditioning systems, senior households are more likely to have some system, more commonly a window wall or evaporative unit. No differences in cooking fuel was found, but microwave ovens are less common among seniors.

Solar water heating was less common among the older households. Pools are less common, as are hot tubs (which are more commonly heated with gas than electricity).

Conservation devices

Ethnic: There were very clear patterns in the results for the presence and vintage of conservation devices in homes. In general, blacks and hispanics showed lowest saturation of conservation devices, but hispanics were the most likely to have installed conservation equipment in the last year. Whites and asians were more likely to have installed the equipment prior to 1985. Similar patterns were evident for low-flow shower heads, caulking, weatherstripping, and duct wrap.

For ceiling insulation, we found that every ethnic group had a higher saturation of wall insulation than blacks, and hispanics were also less likely to have wall insulation than white households. White and asian households had the highest saturations of ceiling insulation, and it was significantly more common than for either black or hispanic households. This may be related to the fact that blacks are less likely to reside in single family dwellings, that does not explain the higher saturation among asians. No significant differences were noted in whether a water heater blanket was present, although hispanics were more likely to have installed the devices in the last year, and blacks and hispanics least likely to have installed blankets prior to 1985.

Poor: Saturations of conservation devices were significantly lower for the poor vs. the nonpoor. This includes ceiling insulation, water heater blankets, caulking, and duct wrapping. However, in most cases, the poor were more likely to have installed the device in the last year than the nonpoor.

Senior: Conservation devices are more common in older households. This includes clock thermostats, weatherstripping, ceiling insulation, water heater blankets, low flow shower heads, and caulking. This equipment was less likely to have been installed in the last year than in non-senior households.

Demographic characteristics.

Ethnic: Significant patterns in income levels for the various ethnic groups were evident. We found that blacks and hispanics tended to be overrepresented in the lowest income categories, especially when compared with asians and whites. Comparably, the highest income categories showed significantly more white households than either black or hispanics. Medium high income levels showed significantly more white and asian households than blacks, and the middle bracket showed more whites and asians than blacks.

Among households with less than high school education, hispanic households were significantly overrepresented, while whites and asians showed the lowest tendency for lower education levels. No significant differences by ethnic group were found for households reporting a high school level education. At the tech or business school level, whites are significantly more common than hispanics. Households with college graduates are significantly more likely to be whites or asians than hispanics, and this is more pronounced at the graduate school level, where all ethnic groups are more common than blacks or hispanics. Asian households were more likely than any other ethnic group (except the "others") to have a graduate degree.

Hispanic and asian households were more likely to have larger households than white customers. Blacks were the most likely to have a one-person household, and hispanics and asians were the least likely to live alone. Hispanic households were far more likely than any other ethnic group to have children under 5 (35.7% of the households). For comparison, the percentage for white households was the lowest (15.1%). This is very consistent with the family trends found elsewhere and the predictions for the expected future make-up of our service territory. Asian households were also more likely than whites to have small children (25.9%). Hispanic households were also the most likely to have household members between ages 6 and 19 (46.1% of hispanic households). Black and asian households also were significantly more likely to have family members in this age category than whites (33.8% and 32.3% compared with 22.9%). Blacks were less likely than hispanics or whites to have family members between 60 and 64. Whites were more likely than hispanic or asians to have residents over 65.

Poor: The poor were significantly more likely to have achieved only a high school education or below. Family sizes of five or more are significantly more common among the poor, as are family members less than age 19 or over 65. Significantly fewer whites are represented among the poor, and significantly more asians, blacks, hispanics, and other ethnic groups. Especially telling is the fact that the poor are significantly less likely to speak English, and are significantly more likely to speak spanish, chinese, or south east asian languages. The poor are also significantly more likely to be home during the day (80.7% vs. 63.6%).

Senior: Seniors were much more likely to have incomes less than $15,000, and less likely to have incomes over $30,000 than younger households. They are significantly more likely to have completed high school or less, and are underrepresented among the households with college or more. Family sizes of one and two represent practically all seniors. The senior

households are far more likely to be white and less likely to be asian, black, or other ethnicities. The elderly households are far more likely to speak only english, and chinese and spanish speakers are underrepresented among households consisting entirely of elderly residents. The elderly are also more likely to be home during the day.

Energy Use

Ethnic: Black and hispanic households were more likely to be in the lower energy consumption categories (100-200 kwh per month) than whites or 'other' households. These two ethnic groups were also less likely to be in the highest categories, while whites were significantly more common in the highest categories than blacks, hispanics, and asians. In consumption of gas and overall Btu use, there are individual differences, but patterns are less apparent. More detailed analysis of energy use patterns appears in the Conditional Demand section of this paper.

Poor: The poor are more highly represented among the electricity consumption levels below 300 kilowatt hours per month, and are less likely to consume between 500 and 1200 kilowatt hours monthly. In gas consumption, the poor are significantly more likely to consume less than 20 therms per month, and the non-poor are more likely above that to about 120 therms. Btu consumption is likewise lower for the poor.

Senior: Few significant differences in energy use patterns were found.

III. LOGIT ANALYSIS

As we found in the previous section, there are many apparent differences between these target groups and the general customer population. However, the analysis of differences in saturations is a limited analysis technique. Only one factor can be examined at a time; contributing factors remain buried.

To examine differences among customer classes in a way that would allow us to control on series of other factors, we used a logit analysis technique. This method explains the likelihood of a household having a certain characteristic (owning a certain appliance) as a function of a series of variables, and allows the researcher to assess the significance of those factors in explaining ownership of the appliance.

We constructed logit models of the following variables: ownership of microwave ovens, televisions, air conditioning systems, waterbeds, dishwashers, clothes washers, portable heaters, wall insulation, freezers, ceiling insulation, hot tub/spas, pools, central heating, wood heating systems, heat pumps, room heaters. The models were constructed to control for important contributing factors to differences in appliance and household characteristics, especially:

income level and a measure of housing value

- residence type (single family vs. multifamily vs. mobile home)
- age of the building
- number of residents in the homes
- ownership vs. rental of the home

Each model also contained variables of special explanatory power for the specific appliances being examined. The models were then estimated including the three factors we wished to assess beyond these underlying factors:

- ethnicity
- poverty level
- elderly households.

We were interested to see if households of these types differed significantly in their likelihood to own certain appliances after controlling for the factors listed above.

Table 4 presents the results of the analyses. A positive sign implies that the target group in question had a significantly higher likelihood of possessing the appliance. A negative sign indicates that they were significantly less likely to have the appliance. A zero indicates there was no significant difference. Notice that whites as an ethnic group do not appear. To avoid singularity, that ethnic group was omitted, and the results for all other ethnic groups are differences from the behavior of the white group. A positive sign on the Mobile Home coefficient implies that residents of mobile homes are significantly more likely to have the appliance than residents of single family detached homes (the omitted housing type). Values of income increase as income rises, and the categories of building age are set up-so that higher values represent older homes. Thus, a positive sign on building age implies that older homes are more likely to have the appliance. The variable "yuppie" is a counter that indicates households with a predisposition to having optional or luxury-type appliances.

The table is presented in two parts, although they represent the results of single equations for each row variable. The first half of the table includes the significance for those variables we are "controlling" on. The second part of the table focuses on the remaining significance attributable to the target group beyond the control factors.

Table 4. Results of the Logit Analysis

	Income	Yuppie	House Value	Own/Rent	2-4 Units	Over 4 Units	Mob. Home	# of Resids.	Bldg Age
Appliances									
Freezer	-	+	-	+	-	-	-	+	0
Dishwasher	+	+	+	+	-	-	-	+	-
Clothes Washer	+	+	-	+	-	-	-	+	-
Water Bed	0	+	-	-	-	-	-	+	-
Microwave Oven	+	+	-	+	-	-	+		
No color TV	0	-	0	-	+	0	+	-	+
2 or more color TVs	+	+	0	+	-	-	-	+	-
Hot Tub/Spa	+	+	0	+	-	-	-	0	-
Pool	+	+	-	+	-	0	-	+	0
Heating/Cooling									
Heat Pumps	+	+	0	-	-	-	-	-	-
Room Heaters	-	-	-	+	+	+	+	-	+
Central Heating	+	+	0	+	-	-	+	+	-
Portable Heaters	-	+	+	0	-	-	-	0	+
Wood Heating	-	+	+	-	-	-	-	+	-
Central A/C	+	+	0	+	+	+	-	0	-
Wall Air Cond	-	0	0	-	+	+	-	-	+
Conservation									
Ceiling Insul	+	+	-	+	-	-	-	+	-
Wall Insulation	+	+	-	+	0	0	+	+	-
Weatherstripping	+	+	0	-	-	-	-	0	-
Caulking	+	+	0	-	-	-	-	0	-
Water Heater Blnkt	+	+	0	-	-	-	-	+	-
Low Flow shower	0	+	0	-	-	-	-	+	-
Duct Wrap	+	+	+	-	-	-	-	+	-
Clock Thermostat	+	+	0	-	-	-	-	0	-

	Hispanic	Black	Asian	Other	Poor	Senior
Appliances						
Freezer	-	+	-	0	-	+
Dishwasher	-	-	-	-	-	+
Clothes Washer	-	-	-	-	-	+
Water Bed	-	-	-	-	-	-
Microwave Oven	-	-	0	-	-	
No color TV	0	0	0	0	+	-
2 or more color TVs	0	+	0	0	-	+
Hot Tub/Spa	-	-	-	-	0	-
Pool	-	-	-	-	0	-

Table 4, Cont'd. Results of the Logit analysis

Heating/Cooling						
Heat Pumps	-	0	0	0	0	+
Room Heaters	+	0	0	+	+	-
Central Heating	-	+	+	0	0	+
Portable Heaters	-	0	+	0	0	+
Wood Heating Fuel	-	-	-	-	-	-
Central A/C	-	0	+	0	0	+
Wall Air Conditioner	0	0	0	0	0	0
Conservation						
Ceiling Insulation	-	-	-	-	0	+
Wall Insulation	-	-	-	0	0	+
Weatherstripping	-	0	-	0	0	+
Caulking	-	0	-	-	0	0
Water Heater Blanket	-	-	-	-	0	0
Low Flow shower	-	0	-	-	0	0
Duct Wrap	-	-	-	0	-	+
Clock Thermostat	+	+	0	0	+	+

Discussion of the Logit Results

As expected, income, home ownership, and building age and type were significant factors in explaining ownership of appliances, heating and cooling equipment, and the presence of conservation equipment. The following paragraphs describe the results in more detail, and discuss the remaining significance of target group effects after controlling for these related factors.

Appliance Holdings:

Most of the appliance holdings were significantly positively affected by income level and home ownership (owners more likely than renters to have appliances). Residents of multifamily dwellings were much less likely to have optional appliances, as were residents of mobile homes (except for their increased likelihood of having microwave ovens). Presence of freezers, dishwashers, clothes washers, and extra televisions increased with increasing number of residents in the household. Older houses were significantly less likely to have dishwashers, clothes washers, water beds, and hot tubs.

After controlling for these effects, we still find patterns of ownership associated with ethnicity, and the other target groups. Excluding television sets, all groups except seniors (including hispanics, asians, blacks, other, and the poor) were less likely to have virtually all the appliances in the table than were white households. Black households were more likely to have freezers and more than one television set, and the poor were more likely to have no color

television sets. Generally, all groups were about equally likely to have the same distribution of television sets once the effects of factors such as income, number of residents, etc. were controlled.

Seniors showed a different pattern. They were significantly more likely to have freezers, dishwashers, clothes washers, and more than one television set. This is most likely related to the fact that these households tend to be more established and have had a longer period over which to acquire these appliances than the average household.

Heating and Cooling Equipment:

Heating and cooling equipment is very related to income, housing type, and building age. We found that heat pumps are less common in older buildings, multifamily dwellings, and mobile homes, and more likely with higher incomes and with households whose residents have more optional appliances (such as VCRs, computers, etc., here termed "yuppies" for short). As expected, room heaters are more common in multifamily dwellings, and central heating is more common in single family dwellings and mobile homes. The number of residents is also positively associated with central heating. Wood heating and use of portable heaters is more common among yuppies and houses with more residents, and less likely in multifamily structures and mobile homes.

The likelihood of central air conditioning increases with increased income, and is more common in multifamily buildings (than in single family dwellings) in the service territory. Mobile homes and older dwellings are significantly less likely to have central air conditioning. Multifamily dwellings are also more likely to have room air conditioners, as are older buildings. Mobile homes are less likely than single family residences (the omitted residence type) to have room air conditioners.

After controlling for factors related to income, building type and age, and family size, some significant patterns remain based on ethnic type. Hispanic households are more likely to have only room heaters and less likely to have any other heating system or air conditioning. Senior households are more likely to have heat pumps, central heating and central air conditioning, and portable heaters, and less likely to use room heaters or wood. Central heating is more likely for black and asian residents, and the poor and the 'other' ethnic group are more likely to use room heaters. Every group is less likely to burn wood for heat than white households (the omitted ethnic group).

Conservation Equipment:

The presence of conservation equipment is very clearly related to income, residence type and age factors. Virtually all conservation equipment is more common as income rises and less common in older homes. Mobile homes and multi-unit dwellings are less likely to have conservation equipment. The number of residents is positively related to many conservation items.

After controlling for these factors, there are still interesting and very significant patterns in the types of households that have conservation equipment. All the ethnic groups are significantly less likely to have conservation equipment in their homes than white households. Very few significant differences were found for poor households, but the seniors were significantly more likely to have insulation, duct wrap, weatherstripping, and thermostats.

IV. DIFFERENCES IN AVERAGE GAS AND ELECTRICITY USAGE

In this section of the paper we examine whether there are significant differences between the average energy consumption (gas and electricity) associated with the different target groups. Table 5 presents the average annual kilowatt hour and therms consumption for all households with nonzero consumption in the PGandE territory, and then for each subgroup in turn.

Most of the ethnic categories show consumption differences that are significant. For electricity, consumption for each ethnic category is significantly lower than the white consumption level. All other comparisons of electricity levels are also significantly different except asians compared to blacks or hispanics, and hispanics compared to blacks. Blacks and Asians show the lowest mean electricity consumption levels, followed closely by Hispanic consumers. White customers have the highest electricity consumption levels.

Significant differences in average gas consumption are also evident. Consumption for every ethnic category is significantly different from each other except when comparing consumption for hispanics vs. "other". In this case, hispanics, asians and "other" ethnic groups show the lowest consumption. Surprisingly, blacks show the highest average gas consumption levels.

The analysis of differences by poor and elderly target groups also showed significant differences. Significant differences between the poor and non-poor, and for the seniors vs.

Table 5: Average annual kwh and therms consumption

	Electricity	Gas
All households	6268.8	603.7
Black	4961.2	686.4
White	6626.5	617.5
Other	5965.1	544.9
Asian	4970.6	492.5
Hispanic	5293.8	540.8
Poor (100%)	5315.9	529.1
Non-Poor (100%)	6361.5	611.0
Poor (150/200%)	5163.7	536.2
Non-Poor (150/200%)	6573.6	621.5
Senior	5531.3	614.1
Non-Senior	6410.9	601.8

non-seniors are found for electricity. In each case, electricity consumption was significantly lower for the members of target group than for non-members. Average gas consumption levels were also lower for the poor than for the non-poor. However, the differences were not significant for the group defined as 100% of poverty. Average gas consumption for seniors was slightly higher than for non-seniors, however the difference is not significant.

These differences are certainly related to a variety of factors that are not controlled for in simple calculations of mean consumption, including differences in housing type, size, and age; appliance holdings; family size and characteristics; income; presence of conservation devices; weather; and usage and efficiency of appliances. The differences can also related to factors such as all-electric houses, weather zones, and other unincluded factors. In the next section we use conditional demand techniques to try to determine if differences in consumption remain after controlling for a variety of these omitted factors.

V. CONDITIONAL DEMAND ANALYSIS

This section of the paper describes our efforts to examine differences in energy consumption by target groups vs. the general customer population. Conditional demand analysis is a statistical technique that attributes the energy used by a household to the end-uses. The technique can separately control for a variety of factors through a series of interaction terms. The specification of the conditional demand model estimated here controls for

- weather,
- appliance holdings,
- house size,
- number of residents,
- income,
- presence of conservation devices, and
- whether the residents are home during the day.

We divided the household's electricity consumption into six component end-uses:

- miscellaneous factors, including those related to daylight hours, whether someone is home during the day, number of residents, and number of rooms in the house,
- basic end-uses, including refrigerators, freezers, cooking, well use, televisions, and dishwashers,
- airconditioning use, including the various types of air conditioning and factors related to weather,
- space heating, including main and auxiliary heating systems and factors related to weather,

- water heating, including factors related to solar fuel, and
- pool, including pools, hot tubs, their fuel types, and whether auxiliary equipment is present.

Conditional demand coefficients were estimated for the general population. These coefficients were then multiplied by the relevant saturations to derive Unit Energy Consumption figures (UECs) for each observation. These UECs are a measure of the amount of energy (in kilowatt hours per day) used for a particular end-use. To determine if significant differences exist between segments of the population, the following equation was estimated using OLS:

$$\text{kilowatt hours} = f(\text{const}+\text{misc}+\text{basic}+\text{ac}+\text{heat}+\text{water}+\text{pool}+ \text{const}'+\text{misc}'+\text{basic}'+\text{ac}'+\text{heat}'+\text{water}'+\text{pool}')$$

where the prime terms are for each special subgroup being tested. If the model were estimated over the entire customer population, with no primed terms, we would expect all coefficients to equal one, and an insignificant constant term. If any of the primed coefficients are significant, then the UEC for that end use for that ethnic group is significantly different than the control group (in this case, whites were selected as the control).

Discussion of Conditional Demand Results

Table 6 presents results of the conditional demand analysis. The UECs for each group and end-use are presented, and if the UEC was found to be significantly different from the UEC estimated for the control group, whites, it is noted by an asterisk. Significant differences between the poor and seniors as compared with their control groups are denoted by a pound sign (#). The results in Table 6 demonstrate that electricity use by target groups differs even after controlling for ownership of appliances, number of residents, income, size of house, and weather and other factors. The coefficient can be interpreted as the energy that the appliance would use assuming that the household had the appliance.

The results show that black households tend to use more energy for "basic" end-uses than any ethnic group. This result is especially significant because that energy use attributable to the "basic" end-use is the largest share of household electricity consumption. The "Other" ethnic group shows the lowest energy use for "basic" end uses. However, for both these subgroups, significant differences of the opposite sign are found on the miscellaneous category, which is fairly collinear with "basic". Examining the sum of these two end-uses, we find that in fact, the 'basic plus miscellaneous' usage for the other ethnic group is very close to that for whites, and is only larger by 1 UEC/day for the black group. Basic and miscellaneous usage by asians is also lower than for white households.

Table 6. Mean UECs (in kilowatt-hours per day)
(Coefficients significantly different from White denoted by an asterisk. Coefficients significantly different from relevant non-poor, non-senior group denoted by #)

	Misc	Basic	A/C	Heat	Water	Pool	Const	Calc. Total	Meas. Kwh[b]
All Customers	3.81	10.36	.735	.476	.952	.704		17.04	17.29
Black	2.87*	12.35*	.665	.537	1.191	2.189[a]*		19.82*	14.7?
White	3.95	10.34	.748	.486	.933	.680		17.14	18.0?
Other	4.65*	9.47*	.773	.252*	1.314*	.613		17.07	16.31
Asian	2.40*	10.37	.440*	.355*	.760*	.975*		15.31*	14.74
Hispanic	3.12*	10.40	.565*	.423*	1.043*	.853*		16.41*	14.58
Poor(100%)	3.51	11.04#	.747#	.557#	.905	.761	.070	17.59	15.43
NonPoor	3.85	10.34	.731	.473	.952	.704	-.050	17.00	17.40
Poor(150/200%)	3.37#	10.11	.766	.510#	.918#	.429#	.748#	16.85	14.62
NonPoor	3.90	10.44	.731	.476	.957	.706	-.227	16.98	17.85
Senior	3.60#	9.90#	.762#	.508#	.858#	.607#	.558#	16.80	15.20
NonSenior	3.81	10.43	.728	.470	.967	.710	-.051	17.06	17.65

[a] Because of small sample sizes for this variable for black households in our sample, results for this column should be used with care.

[b] Observed daily kwh for ethnic subgroup is significantly different from each other ethnic group except: asians vs. blacks; hispanics vs. blacks; and hispanics vs. asians.

White and 'other' households tend to use more electricity for air conditioning than the other ethnic groups (significantly more than the hispanics and asians). White and black households use significantly more energy for heating than the other ethnic groups. 'Other' households tend to use significantly less energy for space heating and more than average for water heating. Asian households tend to use less energy than average for all end-uses except pools. Hispanic customers tend to consume less energy for air conditioning and space heating than the average, but more for water heating and pools.

Comparing total UEC energy use (second to last column), we find significantly lower use by asians and hispanics (as compared to whites), and significantly higher usage by blacks. No significant difference for the 'other' category is evident. The result for blacks bears discussion because the coefficient for pools is highly suspect due to sample size problems. For comparison purposes, if we assume an average usage for pools for blacks, we derive a total UEC of about 18.3. This level is still higher than the total for whites, but more within the range for other ethnic groups. Contributing factors for this higher usage level by blacks are higher use for basic-plus-miscellaneous, and for water heating, and a slightly higher level for heating.

Notice that for the first of the poor categories, significantly more energy than average is assigned for "basic" end-uses (but the opposite is true for the other poor category). However, when considering the level in combination with miscellaneous usage (and in this model we also need to add the constant term), we find that the usage for the poor is higher than for the non-poor for these general end-uses. The poor also show significantly higher electricity use for air conditioning and heating, but generally lower consumption for water heating. Total UEC energy use shows little difference comparing the poor to their control categories.

Senior households show lower basic and water heating usage, and (as might be expected) higher than average space conditioning usage. Total UECs for seniors are lower than for non-senior households.

The specification of the conditional demand model assures that these differences remain after controlling for a wide range of factors related to owning the appliance, climate, size of family, etc. Unfortunately, differences in the UECs reflect two effects that cannot be disentangled. Higher UECs may be related to higher use of the appliance by the household, or may reflect a lower average efficiency of the appliance. In other words, a higher UEC means that, given ownership of the appliance and controlling for other factors, (including whether the customer is home during the day, number of daylight hours, and the rest of the list) either the subgroup uses the appliance more often, or the appliance is less efficient on average.

Differences in Observed Total Electricity Consumption by Subgroup

The last column of Table 6 presents the average measured electricity consumption (converted to daily consumption) for each of the customer strata. As the footnote mentions, the consumption values for each ethnic group are significantly different from each other ethnic group except asian from blacks, hispanics from blacks, and hispanics from asians. Measured consumption is highest for the whites, and significantly lower for hispanics, asians, and blacks. The table also shows that observed total electricity consumption by the poor and senior citizens is lower than that for the non-poor or non-seniors. The second to last column of Table 6 shows the total calculated UECs by ethnic group.

Comparing the mean measured electricity consumption (the last column) with the total of the calculated UECs (the second-to-last column) points out some interesting differences. Because the calculated UEC column assumes ownership of a set of appliances and the measured kwh does not (rather, it is related to actual appliance holdings), some of the differences we see are related to differences in appliance ownership. We can tell from the columns that, although measured electricity usage is low for blacks, the UEC column tells us that if appliance holdings were the same, black households would consume considerably more energy. Similar effects are found for each of the poor households and also for the seniors. Apparently at least some of the differences in observed energy consumption for these groups is driven by appliance holdings differences. Were these groups to have a more 'typical' appliance mix, indications are that their energy consumption would be similar to or exceed other groups. Similar conclusions, but to a smaller degree, are demonstrated for the other non-white customer

segments. The asian and hispanic households would consume more energy than currently, but would still consume less than whites.

One relevant footnote to this discussion is that although the conditional demand model controls for the presence of ceiling and wall insulation, we are not able to control for the level or age or effectiveness of that insulation. Some differences may be attributable to effects like these.

VI. SUMMARY AND IMPLICATIONS

The results of the analyses undertaken in this study show clearly that there are significant differences in the energy-related characteristics of target group customers within the PGandE service territory. Customer subgroups differ in many significant ways:

- appliance holdings differences
- demographic characteristics
- energy use for basic and discretionary end-uses o total energy use.
- presence of conservation equipment.

Table 7 presents a general summary of the results of the analyses discussed in Sections II-V. The table does not track the results of all two way comparisons, but gives the general characteristic differences for the target groups. It also summarizes the results of the logit and conditional demand analyses.

A simple comparison of the appliance holdings of target groups showed that for a wide variety of appliances, these target groups exhibited lower saturations than average. In general, the minorities and the poor had fewer appliances, smaller houses, lower education, and lower incomes than the average customer. They also were less likely to have installed conservation equipment. Senior citizen households had acquired more appliances, and used more energy for space conditioning and had more conservation equipment. However, they were also more likely to have lower incomes and lower education levels.

Recognizing that simple difference in means were ignoring the effects of important explanatory factors, we used a logit modeling technique to examine differences in appliance holdings controlling for differences in income, housing type, and a variety of other factors. We found that many ethnic groups were still less likely to have many appliances and lower incidence of conservation equipment. Senior households, however, were more likely to have some appliances and conservation equipment than would be expected holding income and these other factors constant.

An examination of energy usage by ethnic groups showed that minorities tended to consume significantly less electricity than whites, as did the poor and senior households. The minority groups and the poor also tended to consume less natural gas than white households, except for black households.

However, after using conditional demand analysis to control for contributing factors such as appliance holdings, income, housing type, weather, and a variety of other factors, we found some interesting results. Although blacks use less electricity than average, if these factors were held constant, their electricity consumption would be significantly higher than the energy used by white households. Under similar conditions, asian and hispanic households would use significantly less energy than whites. Clearly appliance holdings, income, number of residents, and the other differences are important factors in explaining differences in energy use by minority groups. A similar conditional demand analysis for natural gas consumption will be completed in the near future.

Projections of California population growth by ethnic category show significant differences in growth rates by ethnicity. Hispanic and Asian households are expected to increase rapidly, and blacks and whites will have much slower growth rates. As a consequence of these variant growth rates, PGandE's customer mix will change fairly dramatically. Although currently hispanic households make up only 9.6% of customers, they are expected to be over 13% of the customer base by the year 2000. Asian and 'other' households will grow from 6.2% to 7.8%. and 2.5% to 3.1% respectively by the year 2000. Black households will maintain as a relatively constant share of PGandE's customers. However, most significant for energy use and appliance holdings impacts is the fact that white customers as a share will decline from the current 76.1% to 70% by the year 2000. Based on the results of this paper, these changes may have implications on the energy-related characteristics of PGandE's future residential customer base.

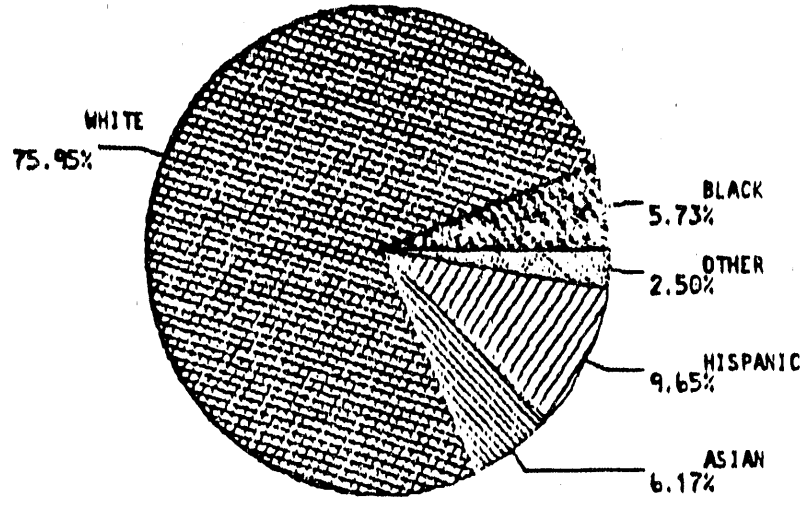
Table 7: SUMMARY TABLE

Blacks	Whites	Hispanic	Asians	Other
Saturation Results			**Saturation Results**	
o more apartments	o more single family	o more single fam	o more small multifamily	o more single family
o older homes	o more mobile homes	o smaller homes	o fewer freezers	
o smaller homes	o more refrigs	o fewer refrigs	o fewer waterbeds	
o more freezers	o more waterbeds	o fewer freezers	o more color tv's	
o fewer dishwashers	o more dishwashers	o fewer dishwashers	o more pc, vcr	
o fewer computers/vcrs	o more heat pumps	o fewer waterbeds	o more gas heat	
o less central heat	o more wood heat	o fewer computer, vcr	o less air condit.	
o more gas heat	o more solar heat	o less central heat	o more pools and spas	
o less air condit.	o more alternate heat fuels	o more gas heat	o installed conserv. equip. before 1985	
o fewer washer/dryers	o more electric heat	o more air condit.	o higher income	
o more gas cooking	o more air cond, incl. central		o higher education	
o fewer pools	o more washer/dryers	o fewer washer/dryer	o larger families	
o fewer hot tubs/spas	o more electric cooking	o more gas cooking	o more children	
o less conserv. eqpt.	o more bottled gas cooking	o fewer pools	o fewer b/w televisions	
o lower income	o more pools and spas	o fewer hot tubs/spa	o fewer washers/dryers	
o lower energy use	o more conserv. eqpt.	o less conserv. eqpt.		
	o installed conserv. equip. before 1985	o installed conserv. equip. in 1985		
	o higher income	o lower income		
	o higher education	o lower education		
	o lower number of youngsters	o larger families		
		o more children		
		o lower energy use		
Logit Results			**Logit Results**	
o fewer discretionary appliances	o more optional appliances	o fewer discretionary appliances	o some discretionary appliances	o some discretionary appliances
o more freezers	o more conserv. equip.	o less space heating	o lower conservation equipment	o little differences in heating equip.
o lower conservation		o less conserv. eqpt.	o more central heating	o somewhat less conserv. equipment.
			o more air conditioning	
Conditional Demand Results			**Conditional Demand Results**	
o more basic usage	o more air cond. usage	o less misc. usage	o less misc. usage	o higher water heat usage
o higher pool usage	o higher actual kwh usage	o high a/c usage	o lower air cond. usage	o low total UEC usage
o high heating use	o high total UEC use	o lower heating usage	o lower heating usage	o low actual kwh usage
o high water heat use		o higher water heat	o lower water heat usage	
o high total UEC use			o low total UEC usage	
o low actual kwh usage			o low actual kwh usage	

Table 7, Cont'd: SUMMARY TABLE

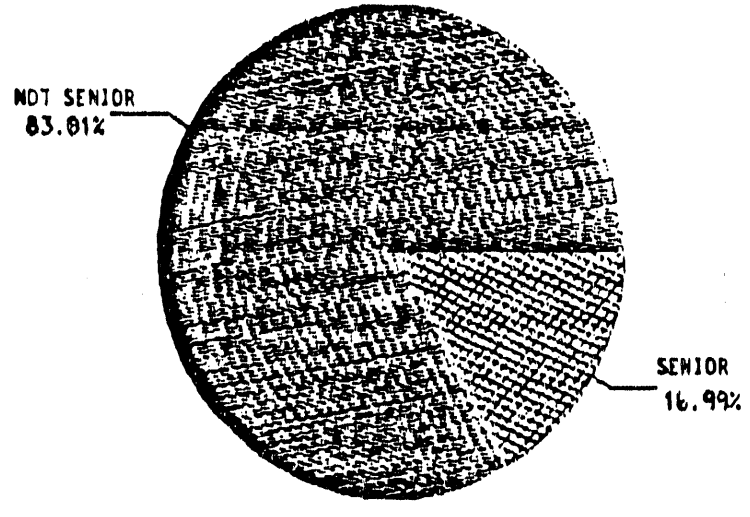
Poor	Senior
Saturation Results	
o less single family	o fewer single family
o more renters	o more mobile home
o shorter length of residence	o more owners
o older homes	o longer length of residency
o smaller homes	o older homes
o fewer discretionary appliances	o smaller homes
o no freezers	o more refrigerators
o more room and portable heaters	o more freezers
o less central heating	o more washers
o more 'no heat'	o some discretionary appliances
o no heat pumps	o no heating system differences
o have air conditioners	o more air conditioners
o more electric cooking	o fewer microwave ovens
o no pools or spas	o no pools or spas
o fewer conservation devices	o more conservation equipment
o more likely to have added conserv. equip. in 1985	o more likely to have installed conserv. equip. before 1985
o lower education	o lower education
o larger families	o smaller number of residents
o fewer white households	o lower income
o home during day	o more white residents
o lower energy use	
Logit Results	
o fewer discretionary appls.	o more discretionary appliances
o lower wood heat	o lower wood heat
o more room heaters	o more central heating
o average conservation equip.	o more air conditioning
	o more conservation equipment
Conditional Demand Analysis	
o higher basic usage	o lower basic usage
o higher air conditioning usage	o lower water heating usage
o higher heating usage	o higher air conditioning usage
o lower water heating usage	o higher space heating usage

Ethnic Groups In PGandE Service Territory



SOURCE: 1990 RASS
MARKET RESEARCH & INFORMATION SECTION

Senior Groups In PGandE Service Territory



SOURCE: 1990 RASS
MARKET RESEARCH & INFORMATION SECTION

TABLE 1

PACIFIC GAS AND ELECTRIC COMPANY
1986 RESIDENTIAL APPLIANCE SATURATION SURVEY
SATURATIONS BY ETHNIC GROUP
(PERCENT)

	BLACK	WHITE	ALL OTHER	ASIAN	HISPANIC
DWELLING TYPE					
SINGLE FAMILY	90.6	86.1	71.2	52.2	63.9
2 - 4 UNITS	14.5	10.6	7.1	19.4	17.6
5 UNITS OR MORE	33.9	17.0	10.0	22.4	16.7
MOBILE HOME	1.0	7.0	2.5	0.0	1.0
OTHER	1.1	0.3	0.5	0.2	0.0
OWN OR RENT DWELLING					
OWN	30.1	63.0	62.3	56.6	48.4
RENT	69.7	34.5	35.5	43.2	51.3
OTHER	1.2	2.5	2.3	0.2	0.3
TYPE OF OCCUPANCY					
FULLTIME	99.0	97.6	98.4	96.0	98.6
PARTTIME	1.0	1.7	1.2	2.8	1.2
OTHER	0.0	0.1	0.4	0.2	0.1
NOT SURE/BLANK	0.2	0.6	0.0	0.9	0.4
LENGTH OF OCCUPANCY (YEARS)					
LESS THAN ONE	9.4	10.4	14.6	12.9	10.1
ONE	10.0	11.3	5.3	8.2	11.2
TWO	13.4	10.1	16.6	10.2	12.9
THREE	7.2	7.9	6.1	7.4	11.6
FOUR	3.9	4.8	6.7	5.0	5.9
FIVE	5.1	4.3	5.2	5.3	3.2
6-10	14.3	20.0	24.2	17.5	23.2
11-15	10.8	11.1	7.9	12.2	10.9
16-20	9.5	7.3	5.2	4.1	4.2
21 OR MORE	16.3	13.3	11.2	9.2	7.8
AGE OF RESIDENCE					
1986 OR LATER	1.8	3.0	3.5	4.9	3.6
1982-85	0.8	3.2	0.1	0.2	3.4
1979-81	3.7	7.3	10.4	7.7	5.9
1975-78	4.8	10.7	8.8	12.9	10.8
1970-74	7.0	13.4	12.8	13.1	12.8
1960-69	17.5	21.3	13.6	13.1	10.5
1950-59	14.9	17.2	12.8	13.8	17.7
1940-49	11.5	9.1	10.9	5.5	9.4
BEFORE 1940	37.2	14.8	20.9	22.9	17.3

	BLACK	WHITE	ALL OTHER	ASIAN	HISPANIC
YEAR OF REMODELING					
1986 OR LATER	6.5	5.4	6.2	3.2	10.9
1982-85	4.3	3.8	2.2	1.4	2.5
1979-81	1.9	2.9	4.1	1.4	2.8
1975-78	1.2	2.8	1.8	1.9	1.5
1970-74	0.3	1.7	4.5	1.4	2.5
1960-69	2.2	2.1	1.2	1.1	1.4
1950-59	0.3	1.5	0.9	0.1	0.3
1940-49	0.0	0.2	0.4	0.0	0.0
BEFORE 1940	0.0	0.5	0.1	0.1	0.5
NOT REMODELLED	80.5	67.7	52.5	68.6	58.6
NOT SURE/BLANK	23.8	12.2	27.8	20.7	18.9
NUMBER OF ROOMS					
ONE	2.3	0.9	0.7	1.6	0.8
TWO	8.4	2.9	4.6	6.2	3.4
THREE	12.5	9.9	9.2	16.8	15.3
FOUR	25.4	17.0	15.5	15.6	23.1
FIVE	21.2	23.7	30.8	20.6	26.1
SIX	11.9	21.7	19.6	16.4	17.6
SEVEN	6.5	12.2	10.0	11.3	8.9
EIGHT	6.5	6.6	10.5	7.2	2.8
NINE	0.5	2.6	1.6	2.7	2.8
TEN	2.4	1.2	0.3	0.5	0.3
ELEVEN OR MORE	0.0	1.2	1.8	1.1	0.3
NUMBER OF BEDROOMS					
NONE	2.4	1.4	0.5	1.4	1.2
ONE	21.5	13.5	9.0	14.5	17.5
TWO	37.6	32.4	35.4	33.8	34.3
THREE	24.1	38.3	37.1	28.2	33.0
FOUR	11.3	11.6	13.8	19.3	12.2
FIVE OR MORE	3.1	2.9	3.9	2.8	1.7

	BLACK	WHITE	ALL OTHER	ASIAN	HISPANIC
SQFT OF RESIDENCE					
< 600 SQFT	9.7	3.2	1.8	5.9	9.6
600-999 SQFT	9.7	6.4	6.2	6.8	11.3
600-999 SQFT	20.2	19.6	15.2	22.1	30.2
1000-1499 SQFT	21.6	32.0	32.8	28.9	25.5
1500-1999 SQFT	17.2	23.2	22.9	24.2	17.8
2000-2699 SQFT	6.8	11.2	13.4	9.2	6.4
2700-3499 SQFT	4.1	3.2	5.1	1.5	0.7
> 3500 SQFT	2.7	1.2	0.7	0.5	0.7
MAIN SPACE HEATING SYSTEM					
MULTI-RES SYSTEM	6.1	2.2	1.8	4.6	7.4
CENTRAL HEAT	37.5	56.3	52.7	57.3	39.9
GAS WALL/FLOOR	52.7	25.0	31.3	27.7	41.1
ELEC WALL/BB/CEI	2.4	4.9	6.4	2.6	2.1
ELEC HEAT PUMP	0.3	1.3	1.2	1.6	0.1
PORTABLE HEATER	0.1	0.6	0.4	2.2	0.4
WOOD STOVE	0.2	6.0	4.1	0.0	3.4
FIREPLACE	0.3	1.8	3.2	0.3	0.5
SOLAR	0.0	0.2	0.4	0.1	0.9
OTHER	1.1	0.3	0.4	0.2	0.5
NONE	0.1	0.1	0.0	1.0	1.0
DON'T	0.3	1.4	0.1	1.5	0.1
SECONDARY SPACE HEATING SYSTEM					
NONE	75.4	86.8	80.9	84.4	72.7
CENTRAL	0.7	2.5	2.0	0.7	1.1
GAS WALL/FLOOR	0.2	1.9	0.5	2.5	0.8
ELEC WALL/BSBRD	0.7	2.7	5.0	3.0	1.0
ELEC HEAT PUMP	0.0	0.3	0.4	0.2	0.1
PORTABLE HEATER	15.6	36.1	17.7	29.4	12.8
WOOD STOVE	0.3	0.4	4.2	1.6	2.9
FIREPLACE	0.4	23.1	17.0	25.5	10.5
PASSIVE SOLAR	0.0	0.6	0.0	0.2	0.0
SOLAR PANELS	0.1	0.3	0.7	0.2	0.5
OTHER	3.0	0.5	0.0	1.1	0.3

TABLE 1

PACIFIC GAS AND ELECTRIC COMPANY
1986 RESIDENTIAL APPLIANCE SATURATION SURVEY
SATURATIONS BY ETHNIC GROUP
(PERCENT)

	BLACK	WHITE	ALL OTHER	ASIAN	HISPANIC
[illegible]					
MULTI-RES SYSTEM	6.1	2.2	1.0	4.6	7.4
CENTRAL	38.2	58.8	38.5	58.0	39.9
GAS WALL/FLOOR	52.9	25.8	31.8	31.1	43.5
ELEC WALL/FLOOR	3.1	7.5	11.3	5.6	3.5
ELEC HEAT PUMP	0.3	1.8	1.6	1.2	0.4
PORTABLE HEATER	15.7	16.7	18.1	31.5	13.4
WOOD STOVE	0.5	12.3	8.3	2.5	6.5
FIREPLACE	8.7	24.9	16.2	15.0	11.8
PASSIVE SOLAR	0.0	0.6	0.0	0.2	0.0
SOLAR PANELS	0.1	0.5	1.0	0.2	1.4
OTHER	2.1	0.8	0.4	1.3	0.8
NONE	0.1	0.1	0.0	1.0	1.7
DON'T KNOW	0.0	0.0	0.0	0.0	0.0
[illegible]					
NATURAL GAS	90.0	77.1	89.2	86.0	84.5
ELECTRICITY	4.7	19.0	8.9	9.7	5.7
BOTTLED GAS	0.6	3.0	4.2	1.7	2.6
KEROSENE	0.2	0.5	0.0	0.0	0.2
WOOD	0.5	0.2	1.4	1.0	4.2
SOLAR	0.0	0.2	0.4	0.1	1.0
OTHER	0.1	0.1	0.1	0.0	0.0
NONE	0.1	0.1	0.0	1.0	1.0
[illegible]					
YES	84.9	82.9	86.5	82.9	76.0
NO	13.8	16.8	13.4	12.1	21.4
DON'T KNOW	1.3	0.3	0.2	5.0	1.7
[illegible]					
ONE	86.3	38.2	61.6	77.5	75.1
TWO	0.0	26.0	42.6	11.7	13.5
THREE OR MORE	13.4	29.3	30.3	10.8	3.9
DON'T KNOW/BLANK	0.0	15.5	5.7	0.0	7.5

[illegible] REFER TO RELEVANT SUBSET OF POPULATION

	BLACK	WHITE	ALL OTHER	ASIAN	HISPANIC
SPACE COOLING SYSTEM					
NONE	67.2	43.7	51.7	61.6	54.9
MULTI-RES SYSTEM	0.5	0.2	1.4	0.2	0.5
CENTRAL ELECTRIC	8.9	23.0	21.0	14.4	14.0
CENTRAL HAT GAS	2.5	2.6	1.7	0.8	1.1
WINDOW-WALL UNIT	5.1	9.9	8.8	7.2	7.8
ELEC HEAT PUMP	0.0	1.5	0.8	1.7	0.5
EVAPORATIVE	3.4	9.1	5.9	2.9	0.6
ELECTRIC FAN	12.3	9.8	8.8	9.2	15.9
OTHER	0.0	0.1	0.0	0.0	0.6
*AIR CONDITIONING THERMOSTAT					
YES	50.4	69.6	66.9	66.0	44.6
NO	40.1	33.0	27.2	25.9	44.8
DON'T KNOW	9.5	0.4	6.0	0.1	10.8
*ELECTRIC HEAT PUMP					
HEAT ONLY	81.4	29.8	52.1	30.9	12.5
A/C ONLY	0.0	17.5	2.7	30.2	34.3
HEAT & A/C	18.6	52.7	45.2	40.9	53.2
*NUMBER OF AC WINDOW/WALL UNITS					
ONE	80.5	72.1	65.9	70.8	71.6
TWO	0.0	10.3	17.1	1.6	0.6
THREE OR MORE	2.1	1.2	0.0	2.2	1.3
DON'T KNOW/BLANK	17.4	16.5	17.0	17.5	16.5
*TYPES OF ELECTRIC FANS					
WHOLE HOUSE FANS	2.3	3.3	0.0	1.4	1.9
ATTIC FANS	0.0	4.7	3.9	3.6	0.4
CEILING FANS	5.8	24.4	33.9	6.0	20.7
PORTABLE FAN	93.0	81.4	74.0	98.9	92.4
OTHER FANS	0.5	1.9	0.0	0.0	0.0

*PERCENTAGES REFER TO RELEVANT SUBSET OF POPULATION

	BLACK	WHITE	ALL OTHER	ASIAN	HISPANIC
TYPE OF RANGE OR STOVE					
ELECTRIC	37.0	68.1	66.9	63.1	65.1
NATURAL GAS	62.5	33.5	30.0	36.5	32.6
BOTTLED GAS	0.5	3.6	2.6	1.2	2.3
OTHER	0.0	0.2	0.5	0.0	0.0
MORE THAN ONE	0.1	0.4	0.0	0.1	0.0
MICROWAVE-FEED	0.6	0.2	0.0	0.0	0.7
MICROWAVE OVEN					
YES	38.9	58.1	48.2	54.3	39.4
NO	73.1	41.9	51.8	45.7	60.6
[illegible]					
NONE	0.2	0.0	0.0	0.0	2.1
ONE	88.6	89.0	87.0	88.1	87.4
TWO	9.8	14.1	14.4	10.2	9.4
THREE OR MORE	1.4	1.3	1.9	2.0	0.6
*NUMBER OF FROST FREE REFRIGERATORS					
NONE	29.6	21.6	23.3	27.0	33.1
ONE	66.0	71.6	68.5	66.3	63.1
TWO	5.3	6.2	9.3	6.8	3.7
THREE OR MORE	0.1	0.6	0.0	2.1	0.1
TYPE OF FREEZER IN MAIN REFRIG.					
TOP FREEZER	62.1	63.3	63.1	59.4	68.7
BOTTOM FREEZER	2.0	5.7	2.6	2.8	3.1
SIDE BY SIDE	17.5	18.9	17.5	19.0	14.0
NO FREEZER	18.7	9.7	12.8	14.2	13.0
DON'T KNOW/BLANK	2.6	2.5	4.0	4.6	3.2
TYPE OF FREEZER					
UPRIGHT FROSTFREE	5.0	7.7	13.4	6.4	5.7
UPRIGHT FREEZER	13.4	14.4	11.2	9.4	8.6
CHEST FREEZER	6.4	7.7	7.5	6.6	6.2
UPRIGHT & CHEST	2.0	0.7	0.9	0.0	0.1
NO FREEZER	71.2	69.7	67.1	79.6	79.1
LEFT BLANK	0.0	0.0	0.0	0.0	0.0

*PERCENTAGES REFER TO RELEVANT SUBSET OF POPULATION

TABLE 1

PACIFIC GAS AND ELECTRIC COMPANY
1986 RESIDENTIAL APPLIANCE SATURATION SURVEY
SATURATIONS BY ETHNIC GROUP
(PERCENT)

	BLACK	WHITE	ALL OTHER	ASIAN	HISPANIC
NUMBER OF REFRIGERATORS					
NONE	07.3	02.5	00.0	00.6	00.6
ONE	12.3	13.7	0.5	5.9	7.5
TWO	0.3	3.1	2.1	2.7	1.7
THREE OR MORE	0.1	0.7	0.4	0.7	0.2
REFRIGERATOR					
YES	30.1	09.2	97.5	92.7	31.5
NO	09.9	30.0	02.5	07.3	00.5
CLOTHES WASHER					
PRIVATE USE	53.5	74.4	72.9	60.6	64.0
SHARED USE	21.4	14.0	10.3	29.0	13.5
NONE	25.0	10.9	16.7	10.6	22.4
CLOTHES DRYER					
PRIVATE USE	40.6	00.4	00.5	51.9	44.0
SHARED USE	10.3	14.7	13.9	21.4	14.3
NONE	40.1	15.9	25.7	26.7	40.9
*CLOTHES DRYER FUEL					
ELECTRICITY	72.7	77.2	70.1	01.1	74.4
NATURAL GAS	27.3	22.0	21.5	30.6	25.3
BOTTLED GAS	0.0	0.0	0.3	0.3	0.3
NUMBER OF COLOR TELEVISIONS					
NONE	6.7	5.2	7.1	3.0	6.0
ONE	37.2	50.3	05.9	49.0	01.0
TWO	25.2	20.3	27.9	29.7	23.0
THREE	6.4	0.0	0.6	15.2	7.5
FOUR OR MORE	4.5	2.1	2.5	2.3	1.7
NUMBER OF BLACK/WHITE TV'S					
NONE	45.0	37.4	54.0	02.0	53.7
ONE	46.0	35.2	40.7	30.6	40.0
TWO	7.3	6.0	3.6	5.6	5.0
THREE	0.6	1.3	0.9	0.6	0.4
FOUR OR MORE	0.3	0.2	0.0	0.3	0.0

*PERCENTAGES REFER TO RELEVANT SUBSET OF POPULATION

	BLACK	WHITE	ALL OTHER	ASIAN	HISPANIC
OWNERSHIP OF OTHER APPLIANCES					
PC/VIDEO GAMES	14.2	19.2	20.6	20.6	10.0
HOME STEREO	61.4	67.7	54.2	62.3	50.6
VIDEOCASSETTE RE	20.1	46.7	41.5	60.6	40.1
HUMIDIFIER/FILTE	5.0	4.5	5.9	7.0	7.0
NO OTHER APPL.	33.0	21.7	23.5	19.7	22.6
WELL WITH ELECTRIC PUMP					
NO	97.5	00.1	92.2	06.5	00.0
HOUSE/GARDEN USE	2.4	0.7	6.0	2.0	0.0
GARDEN USE ONLY	0.1	1.2	1.0	0.7	0.3
HOT WATER HEATER					
SOLE USE	74.0	55.3	06.3	71.4	03.3
SHARED USE	25.1	14.6	14.5	20.5	16.6
NONE	0.2	0.1	0.2	0.1	0.1
*WATER HEATER FUEL					
NATURAL GAS	00.2	01.6	01.3	01.1	00.7
ELECTRIC	5.0	12.2	14.2	6.9	4.1
BOTTLED GAS	0.5	4.6	4.4	1.0	4.1
SOLAR	4.1	3.0	1.2	3.9	2.2
OTHER	2.2	0.7	0.1	0.2	0.2
NOT SURE	0.6	0.0	0.0	0.0	0.0
*SOLAR WATER HEATER FUEL					
SOLAR ONLY	64.4	23.2	0.2	52.2	46.5
SOLAR/NAT GAS	6.4	30.3	51.6	41.7	43.1
SOLAR/ELEC	29.2	16.1	42.2	4.7	1.6
SOLAR/BOT GAS	0.0	5.1	0.0	1.4	0.3
SOLAR/OTHER	0.0	0.0	0.0	0.2	0.0

*PERCENTAGES REFER TO RELEVANT SUBSET OF POPULATION

	BLACK	WHITE	ALL OTHER	ASIAN	HISPANIC
SWIMMING POOL					
NONE	90.9	00.1	05.9	02.0	00.1
PRIVATE	1.5	0.0	3.6	6.7	7.1
SHARED	7.6	11.0	10.4	13.3	
*SWIMMING POOL LOCATION					
IN GROUND	07.5	00.9	00.1	07.6	07.0
ABOVE GROUND	12.5	0.1	0.9	2.4	10.1
*POOL FUEL					
NONE	00.7	00.0	00.0	02.7	01.1
NATURAL GAS ONLY	3.7	17.7	25.3	9.2	11.1
ELECTRIC ONLY	16.5	7.4	12.0	11.5	7.4
SOLAR	22.2	17.4	3.0	20.6	10.7
SOLAR COVER	1.6	0.5	1.7	2.6	0.9
NAT GAS/SOL SYS	0.0	4.4	4.3	11.3	1.0
ELEC/SOL SYS	0.6	0.0	0.4	0.0	0.4
NG/SOL SYS/COV	0.0	0.7	0.0	0.0	0.0
ELEC/SOL SYS/COV	0.0	0.1	0.0	0.0	0.0
SOL SYS/COVER	0.0	1.0	0.0	0.0	0.4
NAT GAS/COVER	0.0	1.7	0.5	0.0	1.0
ELEC/COVER	0.0	0.1	0.0	0.0	0.0
OTHER	0.1	1.2	0.0	0.0	0.6
NOT SURE	0.0	0.0	0.0	0.0	0.0
*TIME CLOCK OR POOL PUMP					
YES	00.0	02.0	00.0	00.4	77.0
NO	13.0	17.5	00.0	11.6	27.2
*AUTOMATIC POOL SWEEP					
YES	30.4	20.5	29.0	53.0	31.0
NO	00.6	04.5	71.0	00.1	00.7
HOT TUB OR SPA					
NONE	00.1	00.7	01.7	00.4	00.0
PRIVATE	0.6	5.9	3.7	3.0	2.2
SHARED	1.3	4.4	4.6	3.0	1.0

*PERCENTAGES REFER TO RELEVANT SUBSET OF POPULATION

TABLE 1

PACIFIC GAS AND ELECTRIC COMPANY
1986 RESIDENTIAL APPLIANCE SATURATION SURVEY
SATURATIONS BY ETHNIC GROUP
(PERCENT)

	BLACK	WHITE	ALL OTHER	ASIAN	HISPANIC
TUB OR SPA HEATER FUEL					
NATURAL GAS ONLY	32.6	49.0	25.4	62.8	43.2
NT GAS/ELEC SYS	23.8	7.6	8.5	8.8	1.4
ELEC SYS/GAS	9.8	1.5	8.8	3.1	8.8
NT GAS/OTHER	8.8	8.6	8.8	1.7	8.4
ELECTRIC ONLY	15.2	21.8	36.7	9.5	36.3
ELEC/SOL SYS	28.2	1.1	6.9	8.1	1.3
ELEC/SOL SYS/GAS	1.8	8.3	8.8	8.7	8.2
ELEC/OTHER	8.8	38.3	11.4	1.8	2.2
OTHER	4.7	8.1	8.8	13.8	11.3
OTHER OTHER	8.8	3.2	8.8	1.3	8.2
NO SYS/OTHER	8.6	8.5	8.8	8.8	8.8
OTHER	2.8	4.3	8.8	2.8	3.6
NONE	8.8	8.8	8.8	4.1	3.6
NOT SURE	8.8	8.8	8.8	8.8	8.8
% NOT TUB OR SPA					
1-TUB/SPA ONLY	5.6	17.8	13.7	38.2	31.5
>1 ONLY	88.3	56.9	48.9	67.1	68.1
>1 & 1+ TUB/SPA	34.1	25.1	37.4	22.7	19.4
XXX THERMOSTAT					
INSTALLED 1985	8.4	2.3	1.2	1.2	2.3
BEFORE 1985	5.1	9.3	6.1	18.9	18.4
NEVER INSTALLED	88.8	71.8	66.5	71.1	74.8
NOT SURE/BLANK	34.5	17.4	24.2	16.8	13.4
XXX THERMOSTAT					
INSTALLED 1985	9.1	16.1	9.9	6.2	13.8
BEFORE 1985	32.8	44.7	44.9	33.7	28.9
NEVER INSTALLED	43.8	29.8	23.5	43.4	42.3
NOT SURE/BLANK	15.8	18.3	21.7	16.7	15.8
% INSULATION					
YES	36.2	38.4	35.6	52.9	58.2
NO	63.8	61.6	64.6	47.1	48.8

	BLACK	WHITE	ALL OTHER	ASIAN	HISPANIC
CEILING INSULATION					
YES	52.1	68.9	57.3	62.8	56.3
ADDED LAST YEAR	11.4	6.8	9.7	5.5	18.4
NONE	36.4	24.3	33.8	31.8	33.4
POSSIBLE TO INSTALL CEILING INSULATION					
YES	31.1	32.8	25.6	23.8	33.8
NO/NO SPACE	7.7	28.6	28.8	35.6	11.6
NO/YES, ADDED	7.8	9.1	5.8	8.6	3.7
PARTIALLY	3.9	5.6	4.4	5.1	13.4
NOT SURE	88.3	31.8	44.8	47.8	38.3
WATER HEATER BLANKET					
INSTALLED 1985	5.2	7.8	8.8	5.5	12.1
BEFORE 1985	18.9	26.5	27.1	23.3	14.3
NEVER INSTALLED	51.9	46.6	42.7	47.9	51.3
NOT SURE/BLANK	32.1	19.8	21.3	23.3	22.2
LOW FLOW SHOWER HEAD					
INSTALLED 1985	7.1	9.6	18.4	8.8	12.8
BEFORE 1985	16.7	28.6	25.4	25.3	17.7
NEVER INSTALLED	32.8	48.4	36.8	45.5	48.8
NOT SURE/BLANK	23.4	19.3	27.3	21.2	28.7
CAULKING					
INSTALLED 1985	5.8	8.2	9.1	4.8	8.6
BEFORE 1985	15.2	28.9	24.2	22.3	17.4
NEVER INSTALLED	48.3	33.6	32.3	41.6	47.5
NOT SURE/BLANK	29.6	29.3	34.4	32.1	26.5
HEATING/COOLING DUCTS WRAPPED					
INSTALLED 1985	1.6	3.1	5.5	1.5	3.5
BEFORE 1985	18.6	25.6	23.1	14.3	14.7
NEVER INSTALLED	52.7	34.8	29.9	48.1	45.2
NOT SURE/BLANK	36.1	37.2	41.6	44.8	36.6

	BLACK	WHITE	ALL OTHER	ASIAN	HISPANIC
1986 NEW PURCHASES (ADDED & REPLACED)					
REFRIGERATOR	13.9	18.8	11.1	17.2	16.4
FREEZER	2.9	2.8	3.1	2.8	1.8
STOVE OR RANGE	8.8	5.5	7.5	8.8	9.5
MICROWAVE	4.3	13.2	12.9	18.5	11.7
DISHWASHER	2.2	4.7	3.8	2.8	2.8
CLOTHES WASHER	4.9	18.4	8.8	9.8	11.1
CLOTHES DRYER	6.8	8.8	8.6	8.1	11.4
WATER HEATER	5.2	5.8	9.5	4.2	7.1
HEATING SYSTEM	1.7	1.6	2.8	2.8	1.4
PORTABLE HEATER	1.8	3.6	2.8	7.7	2.5
WINDOW/WALL A/C	8.5	1.1	2.9	8.9	1.8
CENTRAL A/C	8.3	8.7	8.4	8.7	8.4
HUMIDIFIER	8.3	8.7	1.1	2.8	8.5
WATERBED	1.6	2.4	3.1	1.2	1.3
POOL HEATER	8.8	8.3	8.2	8.8	8.2
HOT TUB/SPA	8.8	1.2	8.4	8.9	8.2
COLOR TELEVISION	18.9	17.9	28.8	21.8	28.8
BLACK & WHITE TV	4.8	3.2	2.8	8.1	4.8
STEREO	18.8	8.2	13.8	16.9	12.8
VIDEOCASSETTE RE	8.5	16.8	18.4	23.8	17.5
COMPUTER / VIDEO	3.8	4.8	7.3	18.8	3.8
ANNUAL HOUSEHOLD INCOME					
UNDER $5000	12.4	3.8	4.8	7.8	7.7
$5000 - $9999	17.3	8.5	13.5	18.1	17.2
$10000 - $14999	18.3	9.8	18.9	8.1	16.8
$15000 - $19999	11.2	8.3	18.5	5.1	12.4
$20000 - $24999	8.1	11.3	8.6	8.8	18.5
$25000 - $29999	7.8	18.5	7.1	13.1	18.1
$30000 - $34999	4.6	8.7	8.7	12.8	8.5
$35000 - $39999	8.6	7.4	8.2	7.8	3.2
$40000 - $44999	8.3	8.9	18.9	8.4	2.8
$45000 - $49999	8.7	8.3	3.4	8.8	3.2
$50000 - $74999	8.8	12.3	12.5	13.8	8.1
$75000 OR MORE	1.8	6.2	4.6	3.4	2.3

RESPONSES GIVEN TO RELEVANT SUBSET OF POPULATION

TABLE 1

PACIFIC GAS AND ELECTRIC COMPANY
1986 RESIDENTIAL APPLIANCE SATURATION SURVEY
SATURATIONS BY ETHNIC GROUP
(PERCENT)

	BLACK	WHITE	ALL OTHER	ASIAN	HISPANIC
EDUCATION LEVEL: HEAD OF HOUSEHOLD					
GRADE SCHOOL	11.7	3.1	10.2	7.5	19.3
SOME HIGH SCHOOL	11.1	7.1	6.4	5.2	19.8
HIGH SCHOOL GRAD	22.1	21.5	24.5	23.7	22.7
SOME COLLEGE	25.5	25.2	17.4	16.3	10.4
BUSI/TECH SCHOOL	6.6	7.8	5.4	6.3	3.6
COLLEGE GRADUATE	17.1	18.2	13.6	10.7	10.3
SOME GRAD SCHOOL	0.7	5.0	0.7	2.4	1.9
GRADUATE DEGREE	5.3	12.9	17.9	19.9	6.1
NUMBER OF RESIDENTS					
ONE	24.6	22.4	18.3	15.4	11.4
TWO	25.9	38.3	31.7	23.3	18.4
THREE	17.1	16.5	21.8	18.3	20.6
FOUR	12.0	15.5	14.1	19.5	17.3
FIVE	12.8	4.8	7.4	8.0	14.5
SIX	1.5	1.5	2.6	7.6	8.6
SEVEN	3.1	0.5	1.9	1.8	3.7
EIGHT	1.6	0.2	1.2	3.3	3.9
MORE OR MORE	1.4	0.3	1.1	2.6	1.7
# OF RESIDENTS					
AGE 5 OR OR LESS	30.2	15.1	16.7	25.9	35.7
AGE 6-19 YRS	33.6	22.9	28.1	32.3	46.1
AGE 20-24 YRS	16.9	14.4	13.1	25.0	23.6
AGE 25-34 YRS	41.2	38.6	27.7	40.2	44.2
AGE 35-44 YRS	31.1	28.9	29.5	33.3	32.9
AGE 45-54 YRS	17.2	16.5	13.4	26.2	29.9
AGE 55-59 YRS	15.4	16.3	8.4	13.9	11.9
AGE 60-64 YRS	4.4	9.5	5.1	7.7	9.8
AGE 65 YRS +	28.8	21.1	17.3	15.9	7.3

	BLACK	WHITE	ALL OTHER	ASIAN	HISPANIC
RACE OR ETHNIC GROUP					
WHITE RESIDENTS	0.0	100.0	41.6	7.8	8.3
HISPANIC RESID.	0.0	0.0	0.0	0.7	97.2
ASIAN RESIDENTS	0.0	0.0	30.0	90.2	0.0
BLACK RESIDENTS	100.0	0.2	0.0	0.4	0.4
AMERICAN INDIAN	0.0	0.0	11.4	0.0	0.0
EASTERN INDIAN	0.0	0.0	14.0	0.1	0.0
OTHER ETHNIC	0.0	0.0	14.9	0.1	0.3
LEFT BLANK	0.0	0.0	7.8	0.7	0.2
PRIMARY LANGUAGE					
ENGLISH ONLY	99.6	100.0	46.1	51.4	47.8
SPANISH	0.1	0.0	0.0	1.3	52.0
CHINESE	0.2	0.0	0.0	22.5	0.0
JAPANESE	0.0	0.0	10.1	0.0	0.0
TAGALOG	0.0	0.0	0.9	12.4	0.0
OTHER	0.1	0.0	43.9	4.4	0.2
S.E. ASIAN	0.0	0.0	0.0	0.0	0.0
SOMEONE REGULARLY HOME DURING DAY					
YES	71.5	63.5	75.3	65.6	72.3
NO	28.5	36.5	24.7	34.4	27.7

	BLACK	WHITE	ALL OTHER	ASIAN	HISPANIC
MONTHLY ELEC USAGE (KWH)					
0-100	7.7	4.1	2.8	4.7	5.0
101-200	19.7	11.3	9.6	12.6	17.1
201-300	19.7	13.6	10.9	25.6	16.2
301-400	13.2	14.2	13.8	19.5	15.9
401-500	10.0	12.8	19.1	12.6	12.0
501-600	8.0	10.9	9.1	7.1	9.7
601-800	11.4	16.3	12.8	9.7	12.6
801-1200	9.7	12.1	9.7	6.0	9.5
1201-1600	0.2	3.0	2.9	2.0	1.4
1601-2000	0.4	1.1	0.9	0.3	0.1
OVER 2000	0.0	0.0	0.3	0.0	0.0
MONTHLY GAS USAGE (THMS)					
0-10	4.1	8.2	6.0	12.3	7.2
11-20	14.0	7.8	8.4	11.3	11.0
21-30	9.4	11.2	15.1	13.0	12.5
31-40	4.6	14.5	21.4	11.9	17.2
41-60	24.7	28.4	28.6	26.9	28.3
61-80	30.5	19.3	10.2	9.6	15.2
81-120	21.8	10.2	5.0	5.2	8.3
121-160	1.7	1.9	0.4	0.5	0.2
161-200	0.2	0.2	0.0	0.3	0.0
201-240	0.2	0.1	0.0	0.0	0.0
OVER 240	0.0	0.0	0.0	0.0	0.1
MONTHLY ENERGY USAGE (100,000 BTUS)					
0-20	4.3	6.6	7.0	11.9	8.2
21-40	26.0	14.5	14.9	23.0	22.7
41-60	28.2	23.3	26.5	27.1	25.9
61-80	12.4	25.0	17.9	22.0	23.5
81-100	16.2	15.9	17.3	11.5	10.7
101-120	8.5	7.7	3.6	1.8	5.7
121-140	11.9	5.2	2.7	2.3	3.1
141-200	0.1	0.7	0.0	0.7	0.1
201-240	0.5	0.2	0.0	0.0	0.0
241-280	0.0	0.1	0.0	0.0	0.0
OVER 280	0.0	0.1	0.0	0.0	0.1

TABLE 2

PACIFIC GAS AND ELECTRIC COMPANY
1986 RESIDENTIAL APPLIANCE SATURATION SURVEY
SATURATIONS BY 100% POVERTY LEVEL GROUP
(PERCENT)

	NON POOR	POOR
DWELLING TYPE		
SINGLE FAMILY	84.6	86.3
2 - 4 UNITS	11.5	10.1
5 UNITS OR MORE	17.9	21.3
MOBILE HOME	5.0	6.2
OTHER	0.4	0.1
OWN OR RENT DWELLING		
OWN	62.1	37.3
RENT	36.9	61.2
OTHER	1.1	1.5
TYPE OF OCCUPANCY		
FULLTIME	97.7	96.9
PARTTIME	1.7	1.8
OTHER	0.5	0.2
NOT SURE/BLANK	0.5	1.1
NUMBER OF OCCUPANTS (HOUSEHOLD)		
LESS THAN ONE	13.2	14.2
ONE	10.9	9.8
TWO	30.8	15.4
THREE	8.3	6.4
FOUR	4.7	5.4
FIVE	4.4	3.7
6-10	29.4	15.6
11-15	11.1	10.1
16-20	6.6	7.1
21 OR MORE	12.7	12.3
AGE OF RESIDENCE		
1984 OR LATER	3.0	3.9
1982-83	3.6	2.4
1979-81	7.4	4.8
1975-78	10.9	9.8
1970-74	13.8	12.8
1960-69	28.3	18.8
1950-59	16.8	17.0
1940-49	8.8	11.7
BEFORE 1940	16.3	23.7

	NON POOR	POOR
YEAR OF REMODELING		
1984 OR LATER	5.7	7.4
1982-83	2.9	2.7
1979-81	2.7	2.3
1975-78	2.6	2.1
1970-74	1.9	0.5
1960-69	2.1	1.1
1950-59	1.3	0.8
1940-49	0.2	0.3
BEFORE 1940	0.4	0.3
NOT REMODELLED	66.8	58.2
NOT SURE/BLANK	13.5	23.2
NUMBER OF ROOMS		
ONE	0.9	2.9
TWO	3.3	5.5
THREE	16.5	14.8
FOUR	16.9	28.0
FIVE	23.6	25.6
SIX	21.1	13.5
SEVEN	12.4	3.6
EIGHT	6.4	5.0
NINE	2.5	1.6
TEN	1.2	0.3
ELEVEN OR MORE	1.2	0.2
NUMBER OF BEDROOMS		
NONE	1.3	2.1
ONE	13.9	10.6
TWO	32.1	42.3
THREE	37.3	27.1
FOUR	12.6	7.7
FIVE OR MORE	2.8	2.2

	NON POOR	POOR
SQFT OF RESIDENCE		
< 600 SQFT	3.6	11.3
600-999 SQFT	6.5	13.1
1000-1499 SQFT	19.5	25.0
1500-1999 SQFT	31.7	30.9
2000-2499 SQFT	23.4	12.3
2500-2999 SQFT	11.0	5.3
3000-3499 SQFT	3.1	0.8
> 3500 SQFT	1.2	1.3
MAIN SPACE HEATING SYSTEM		
MULTI-RES SYSTEM	2.1	2.3
CENTRAL HEAT	55.3	36.7
GAS WALL/FLOOR	26.6	48.0
ELEC WALL/BB/CEI	4.6	2.3
ELEC HEAT PUMP	1.2	0.4
PORTABLE HEATER	0.6	1.7
WOOD STOVE	5.0	5.7
FIREPLACE	1.5	1.4
SOLAR	0.3	0.1
OTHER	0.2	0.6
NONE	0.2	1.6
DON'KNOW	1.0	0.4
SECONDARY SPACE HEATING SYSTEM		
NONE	84.5	73.0
CENTRAL	2.2	1.9
GAS WALL/FLOOR	1.6	2.8
ELEC WALL/BSBRD	2.6	1.2
ELEC HEAT PUMP	0.4	0.0
PORTABLE HEATER	10.7	15.6
WOOD STOVE	0.3	2.4
FIREPLACE	21.9	0.0
PASSIVE SOLAR	0.5	0.0
SOLAR PANELS	0.3	0.1
OTHER	0.6	1.2

TABLE 2

PACIFIC GAS AND ELECTRIC COMPANY
1986 RESIDENTIAL APPLIANCE SATURATION SURVEY
SATURATIONS BY 100% POVERTY LEVEL GROUP
(PERCENT)

	100 POOR	POOR
MAIN + SECONDARY SPACE HEATING		
MULTI-RES SYSTEM	3.1	3.3
CENTRAL	37.5	37.4
GAS WALL/FLOOR	28.2	29.0
ELEC WALL/BASEBD	7.2	3.5
ELEC HEAT PUMP	1.6	0.4
PORTABLE HEATER	17.3	17.3
WOOD STOVE	10.6	0.1
FIREPLACE	23.4	7.4
PASSIVE SOLAR	0.5	0.0
SOLAR PANELS	0.6	0.2
OTHER	0.8	1.9
NONE	0.2	1.5
NOT SURE	0.0	0.0
MAIN SPACE HEATING FUEL		
NATURAL GAS	79.2	80.1
ELECTRICITY	9.4	7.3
BOTTLED GAS	3.5	3.4
KEROSENE	0.5	0.2
WOOD	6.9	7.2
SOLAR	0.3	0.1
OTHER	0.1	0.0
NONE	0.2	1.6
*MAIN SPACE HEATING THERMOSTAT		
YES	69.3	73.0
NO	26.1	23.4
NOT SURE	0.6	2.7
*NUMBER OF PERMANENT PORTABLE HEATERS		
ONE	47.0	61.5
TWO	25.4	12.8
THREE OR MORE	26.5	13.0
NOT SURE/BLANK	11.2	11.9

*PERCENTAGES REFER TO RELEVANT SUBSET OF POPULATION

	100 POOR	POOR
SPACE COOLING SYSTEM		
NONE	47.4	46.8
MULTI-RES SYSTEM	0.2	1.0
CENTRAL ELECTRIC	21.6	13.7
CENTRAL NAT GAS	2.4	1.4
WINDOW-WALL UNIT	8.9	12.6
ELEC HEAT PUMP	1.4	0.7
EVAPORATIVE	7.6	14.2
ELECTRIC FAN	10.3	11.7
OTHER	0.2	0.0
*AIR CONDITIONING THERMOSTAT		
YES	60.0	44.1
NO	32.4	47.3
NOT SURE	6.8	8.5
*ELECTRIC HEAT PUMP		
HEAT ONLY	29.6	13.7
A/C ONLY	17.8	44.5
HEAT & A/C	52.5	41.7
*NUMBER OF AC WINDOW/WALL UNITS		
ONE	71.8	77.3
TWO	20.0	6.4
THREE OR MORE	1.4	0.2
NOT SURE/BLANK	16.8	16.1
*TYPES OF ELECTRIC FANS		
WHOLE HOUSE FANS	3.0	2.2
ATTIC FANS	3.9	0.9
CEILING FANS	22.9	9.6
PORTABLE FAN	83.9	90.4
OTHER FANS	0.0	0.0

*PERCENTAGES REFER TO RELEVANT SUBSET OF POPULATION

	100 POOR	POOR
TYPE OF RANGE OR STOVE		
ELECTRIC	61.2	48.3
NATURAL GAS	36.2	50.0
BOTTLED GAS	2.0	4.5
OTHER	0.1	0.3
NONE USED	0.3	0.1
MICROWAVE-FILER	0.2	0.1
MICROWAVE OVEN		
YES	56.2	31.2
NO	43.8	68.8
NUMBER OF REFRIGERATORS		
NONE	0.7	3.1
ONE	84.3	85.7
TWO	13.7	8.2
THREE OR MORE	1.3	2.8
*NUMBER OF FROST FREE REFRIGERATORS		
NONE	22.4	36.4
ONE	70.9	59.4
TWO	6.2	3.4
THREE OR MORE	0.5	1.8
TYPE OF FREEZER IN MAIN REFRIG.		
TOP FREEZER	63.5	61.2
BOTTOM FREEZER	3.0	4.6
SIDE BY SIDE	30.9	32.5
NO FREEZER	10.1	16.8
NOT SURE/BLANK	2.5	4.9
TYPE OF FREEZER		
UPRIGHT FROSTFRE	7.6	9.8
UPRIGHT FREEZER	14.9	7.6
CHEST FREEZER	7.5	7.8
UPRIGHT & CHEST	0.7	0.5
NO FREEZER	70.5	75.6
LEFT BLANK	0.0	0.0

*PERCENTAGES REFER TO RELEVANT SUBSET OF POPULATION

TABLE 2

PACIFIC GAS AND ELECTRIC COMPANY
1986 RESIDENTIAL APPLIANCE SATURATION SURVEY
SATURATIONS BY 100% POVERTY LEVEL GROUP
(PERCENT)

	NON POOR	POOR
NUMBER OF REFRIGERATORS		
NONE	0.9	0.2
ONE	12.6	30.1
TWO	2.8	2.6
THREE OR MORE	0.6	0.1
FREEZER		
YES	85.3	36.7
NO	41.7	76.3
CLOTHES WASHER		
PRIVATE USE	72.7	57.3
SHARED USE	15.3	15.7
NONE	12.0	27.1
CLOTHES DRYER		
PRIVATE USE	66.6	39.7
SHARED USE	15.2	16.0
NONE	18.2	44.3
*CLOTHES DRYER FUEL		
ELECTRICITY	77.0	78.1
NATURAL GAS	22.3	21.2
BOTTLED GAS	0.7	0.7
NUMBER OF COLOR TELEVISIONS		
NONE	4.9	10.7
ONE	56.4	66.3
TWO	28.9	16.0
THREE	8.4	6.9
FOUR OR MORE	2.4	1.9
NUMBER OF BLACK/WHITE TV'S		
NONE	56.6	57.8
ONE	36.1	36.9
TWO	6.1	4.6
THREE	1.2	0.3
FOUR OR MORE	0.1	0.3

*PERCENTAGES REFER TO RELEVANT SUBSET OF POPULATION

	NON POOR	POOR
OWNERSHIP OF OTHER APPLIANCES		
PC/VIDEO GAMES	20.1	7.2
HOME STEREO	60.3	31.5
VIDEOCASSETTE RE	46.8	23.0
HUMIDIFIER/FILTE	5.3	3.3
NO OTHER APPL.	20.1	46.3
WELL WITH ELECTRIC PUMP		
NO	98.3	99.1
HOUSE/GARDEN USE	0.6	0.3
GARDEN USE ONLY	1.1	0.6
HOT WATER HEATER		
SOLE USE	83.9	81.7
SHARED USE	16.1	17.7
NONE	0.1	0.6
*WATER HEATER FUEL		
NATURAL GAS	83.4	84.6
ELECTRIC	14.6	8.9
BOTTLED GAS	1.9	5.9
SOLAR	1.0	2.2
OTHER	0.0	0.2
NOT SURE	0.0	0.0
*SOLAR WATER HEATER FUEL		
SOLAR ONLY	35.0	57.7
SOLAR/NAT GAS	38.0	18.0
SOLAR/ELEC	15.9	9.0
SOLAR/BOT GAS	4.4	11.6
SOLAR/OTHER	6.6	4.0

*PERCENTAGES REFER TO RELEVANT SUBSET OF POPULATION

	NON POOR	POOR
SWIMMING POOL		
NONE	81.0	89.4
PRIVATE	8.2	3.2
SHARED	10.8	7.4
*SWIMMING POOL LOCATION		
IN GROUND	91.0	98.0
ABOVE GROUND	9.0	0.2
*POOL FUEL		
NONE	61.0	73.6
NATURAL GAS ONLY	17.2	6.2
ELECTRIC ONLY	8.2	4.9
SOLAR	17.3	11.4
SOLAR COVER	6.1	1.4
NAT GAS/SOL SYS	4.9	0.2
ELEC/SOL SYS	0.6	0.0
NG/SOL SYS/COV	0.6	0.0
ELEC/SOL SYS/COV	0.1	0.0
SOL SYS/COVER	1.7	0.2
NAT GAS/COVER	1.6	2.1
ELEC/COVER	0.1	0.2
OTHER	1.6	0.2
NOT SURE	0.0	0.0
*TIME CLOCK ON POOL FILTER		
YES	80.2	72.3
NO	19.8	27.7
*AUTOMATIC POOL SWEEP		
YES	36.7	30.8
NO	63.3	69.5
HOT TUB OR SPA		
NONE	93.4	97.4
PRIVATE	5.5	1.3
SHARED	4.1	1.3

*PERCENTAGES REFER TO RELEVANT SUBSET OF POPULATION

TABLE 2

PACIFIC GAS AND ELECTRIC COMPANY
1986 RESIDENTIAL APPLIANCE SATURATION SURVEY
SATURATIONS BY 100% POVERTY LEVEL GROUP
(PERCENT)

	NON POOR	POOR
*HOT TUB OR SPA HEATER FUEL		
NATURAL GAS ONLY	40.2	30.0
HOT GAS/OIL SYS	6.6	3.5
NG/OIL SYS/COM	1.5	0.0
HOT GAS/OTHER	5.1	1.8
ELECTRIC ONLY	22.4	25.0
ELEC/OIL SYS	1.5	0.0
ELEC/OIL SYS/COM	0.3	0.0
ELEC/OTHER	9.7	0.0
SOLAR	5.8	0.0
SOLAR OTHER	2.8	7.0
SOL SYS/OTHER	0.5	0.0
OTHER	4.1	1.5
NONE	1.0	2.1
NOT SURE	0.0	0.0
*POOL, NOT TUB OR SPA		
H-TUB/SPA ONLY	16.6	2.4
POOL ONLY	57.8	76.2
POOL & H-TUB/SPA	25.6	21.4
CLOCK THERMOSTAT		
INSTALLED 1986	2.2	1.6
BEFORE 1985	9.6	5.5
NEVER INSTALLED	71.3	75.7
NOT SURE/BLANK	16.9	17.2
WEATHERSTRIPPING		
INSTALLED 1986	9.7	14.2
BEFORE 1985	43.7	23.2
NEVER INSTALLED	31.3	44.0
NOT SURE/BLANK	15.3	18.6
WALL INSULATION		
YES	57.0	45.1
NO	43.0	54.9

*PERCENTAGES REFER TO RELEVANT SUBSET OF POPULATION

	NON POOR	POOR
CEILING INSULATION		
YES	66.9	50.1
ADDED LAST YEAR	7.3	8.8
NONE	25.8	33.9
POSSIBLE TO INSTALL CEILING INSULATION		
YES	30.8	40.2
NO/NO SPACE	14.5	15.7
NO/RES. ABOVE	8.4	6.1
PARTIALLY	6.7	3.5
NOT SURE	36.7	34.5
WATER HEATER BLANKET		
INSTALLED 1986	7.7	10.2
BEFORE 1985	25.4	13.8
NEVER INSTALLED	46.9	52.3
NOT SURE/BLANK	20.0	23.7
LOW FLOW SHOWER HEAD		
INSTALLED 1986	9.4	13.2
BEFORE 1985	29.4	15.5
NEVER INSTALLED	41.7	46.2
NOT SURE/BLANK	19.5	25.0
CAULKING		
INSTALLED 1986	7.8	8.5
BEFORE 1985	27.8	13.2
NEVER INSTALLED	35.3	46.8
NOT SURE/BLANK	29.0	32.2
HEATING/COOLING DUCTS WRAPPED		
INSTALLED 1986	3.0	2.9
BEFORE 1985	24.4	6.8
NEVER INSTALLED	35.1	49.7
NOT SURE/BLANK	37.5	38.6

	NON POOR	POOR
1986 NEW PURCHASES (ADDED & REPLACED)		
REFRIGERATOR	11.7	14.4
FREEZER	2.6	3.4
STOVE OR RANGE	6.1	[illegible]
MICROWAVE	13.1	9.3
DISHWASHER	4.4	2.1
CLOTHES WASHER	10.5	7.3
CLOTHES DRYER	9.0	6.3
WATER HEATER	6.0	9.3
HEATING SYSTEM	1.7	1.0
PORTABLE HEATER	3.7	2.9
WINDOW/WALL A/C	1.1	1.6
CENTRAL A/C	0.7	0.4
HUMIDIFIER	0.9	0.5
WATERBED	2.3	1.3
POOL HEATER	0.3	0.0
HOT TUB/SPA	1.1	0.0
COLOR TELEVISION	19.9	26.6
BLACK & WHITE TV	3.6	5.1
STEREO	16.5	3.7
VIDEOCASSETTE RE	17.2	7.4
COMPUTER / VIDEO	5.6	[illegible]
ANNUAL HOUSEHOLD INCOME		
UNDER $5000	0.0	[illegible]
$5000 - $9999	0.3	24.6
$10000 - $14999	10.3	30.5
$15000 - $19999	9.5	0.9
$20000 - $24999	11.0	0.4
$25000 - $29999	11.5	0.0
$30000 - $34999	10.3	0.0
$35000 - $39999	7.7	0.0
$40000 - $44999	6.2	0.0
$45000 - $49999	5.7	0.0
$50000 - $74999	12.8	0.0
$75000 OR MORE	5.9	0.0

TABLE 2

PACIFIC GAS AND ELECTRIC COMPANY
1986 RESIDENTIAL APPLIANCE SATURATION SURVEY
SATURATIONS BY 100% POVERTY LEVEL GROUP
(PERCENT)

	[illegible]	[illegible]
[illegible]		
[illegible]	3.7	23.6
[illegible]	[illegible]	22.0
[illegible]	23.5	[illegible]
[illegible]	20.5	[illegible]
[illegible]	6.0	6.4
[illegible]	10.7	3.4
[illegible]	4.7	1.1
[illegible]	13.2	2.3
[illegible]		
[illegible]	30.6	22.4
[illegible]	30.5	16.2
[illegible]	17.9	10.2
[illegible]	15.9	13.2
[illegible]	5.9	[illegible]
[illegible]	2.1	7.0
[illegible]	0.5	3.6
[illegible]	0.6	2.7
[illegible]	0.4	3.9
[illegible]		
[illegible]	16.4	33.1
[illegible]	25.1	[illegible]
[illegible]	16.1	25.3
[illegible]	22.9	24.4
[illegible]	20.1	24.7
[illegible]	10.7	12.2
[illegible]	11.2	0.1
[illegible]	0.2	7.0
[illegible]	10.4	26.9

	[illegible]	[illegible]
[illegible]		
[illegible]	81.1	61.7
[illegible]	7.7	25.2
[illegible]	5.9	10.5
[illegible]	5.4	11.6
[illegible]	0.3	0.4
[illegible]	0.4	0.2
[illegible]	0.4	1.4
[illegible]	0.3	0.1
[illegible]		
[illegible]	[illegible]	72.2
[illegible]	3.8	[illegible]
[illegible]	1.1	4.0
[illegible]	0.3	0.1
[illegible]	0.7	1.3
[illegible]	1.3	2.3
[illegible]	0.4	1.7
[illegible]		
[illegible]	63.6	80.7
[illegible]	36.4	19.3

	[illegible]	[illegible]
[illegible]		
0-100	0.1	7.1
101-200	12.0	16.3
201-300	14.4	22.1
301-400	14.4	17.0
401-500	12.9	10.5
501-600	10.6	7.4
601-800	14.8	10.0
801-1200	11.8	6.4
1201-1600	3.4	2.0
1601-2000	0.9	0.7
OVER 2000	0.6	0.3
[illegible]		
0-10	5.3	10.8
11-20	8.4	12.6
21-30	11.7	0.1
31-40	13.7	10.3
41-60	30.1	29.4
61-80	18.7	13.0
81-120	10.7	6.4
121-160	0.5	1.3
161-200	0.2	0.5
201-240	0.1	0.0
OVER 240	0.0	0.0
[illegible]		
0-20	6.0	9.1
21-40	16.0	25.4
41-60	23.5	28.7
61-80	24.5	20.1
81-100	15.0	7.1
101-120	7.3	3.2
121-140	5.0	6.3
141-200	0.5	0.0
201-240	0.2	0.0
241-280	0.1	0.0
OVER 280	0.1	0.0

TABLE 3

PACIFIC GAS AND ELECTRIC COMPANY
1986 RESIDENTIAL APPLIANCE SATURATION SURVEY
SATURATIONS BY SENIOR GROUP
(PERCENT)

	NOT SENIOR	SENIOR
DWELLING TYPE		
SINGLE FAMILY	64.5	80.6
2 - 4 UNITS	12.5	9.0
5 UNITS OR MORE	20.3	7.8
MOBILE HOME	4.3	12.5
OTHER	0.4	0.1
OWN OR RENT DWELLING		
OWN	57.5	78.9
RENT	40.4	27.4
OTHER	2.1	1.7
TYPE OF OCCUPANCY		
FULLTIME	97.7	97.1
PARTTIME	1.6	2.2
OTHER	0.2	0.8
DON'T KNOW/BLANK	0.5	0.8
LENGTH OF OCCUPANCY (YEARS)		
LESS THAN ONE	11.8	4.4
ONE	12.4	3.9
TWO	12.7	3.9
THREE	9.8	3.7
FOUR	8.1	5.3
FIVE	6.5	3.3
6-10	19.8	20.4
11-15	10.7	12.5
16-20	5.8	10.7
21 OR MORE	8.3	34.8
AGE OF RESIDENCE		
1984 OR LATER	3.5	1.2
1982-83	3.7	1.6
1979-81	7.4	5.3
1975-78	10.8	8.4
1970-74	13.1	12.8
1960-69	20.9	21.3
1950-59	15.9	21.3
1940-49	8.6	11.6
BEFORE 1940	17.1	15.5

	NOT SENIOR	SENIOR
YEAR OF REMODELING		
1984 OR LATER	6.5	3.0
1982-83	2.9	2.0
1979-81	2.7	2.6
1975-78	2.6	2.4
1970-74	1.9	1.6
1960-69	1.7	3.7
1950-59	0.8	3.1
1940-49	0.2	0.3
BEFORE 1940	0.2	1.2
NOT REMODELLED	68.6	68.9
DON'T KNOW/BLANK	15.1	10.7
NUMBER OF ROOMS		
ONE	0.9	1.8
TWO	2.4	3.8
THREE	10.4	13.4
FOUR	17.6	19.5
FIVE	23.2	26.0
SIX	20.1	21.7
SEVEN	12.3	8.2
EIGHT	7.8	3.8
NINE	2.6	1.8
TEN	1.2	0.9
ELEVEN OR MORE	1.2	0.3
NUMBER OF BEDROOMS		
NONE	1.8	0.8
ONE	23.6	28.9
TWO	31.1	42.7
THREE	37.6	20.3
FOUR	13.8	6.8
FIVE OR MORE	2.1	1.3

	NOT SENIOR	SENIOR
SQFT OF RESIDENCE		
< 600 SQFT	4.1	5.1
600-999 SQFT	6.5	10.1
1000-1399 SQFT	20.1	19.8
1400-1999 SQFT	30.9	26.1
2000-2599 SQFT	23.0	19.6
2600-2999 SQFT	11.0	7.6
2700-3000 SQFT	3.2	1.5
> 3000 SQFT	1.2	1.2
MAIN SPACE HEATING SYSTEM		
MULTI-DES SYSTEM	2.0	1.8
CENTRAL HEAT	53.6	63.0
GAS WALL/FLOOR	28.2	30.3
ELEC WALL/BB/CEI	4.5	3.6
ELEC HEAT PUMP	1.2	1.2
PORTABLE HEATER	9.6	0.9
WOOD STOVE	5.2	6.3
FIREPLACE	1.4	1.6
SOLAR	0.2	0.2
OTHER	0.3	0.2
NONE	0.4	0.1
DON'T KNOW	1.3	0.8
SECONDARY SPACE HEATING SYSTEM		
NONE	57.9	61.7
CENTRAL	2.2	2.1
GAS WALL/FLOOR	1.8	2.3
ELEC WALL/BASEBD	2.4	2.2
ELEC HEAT PUMP	0.4	0.5
PORTABLE HEATER	16.9	15.5
WOOD STOVE	5.6	4.8
FIREPLACE	20.7	19.2
PASSIVE SOLAR	0.5	0.3
SOLAR PANELS	0.3	0.4
OTHER	0.7	0.2

TABLE 3

PACIFIC GAS AND ELECTRIC COMPANY
1986 RESIDENTIAL APPLIANCE SATURATION SURVEY
SATURATIONS BY SENIOR GROUP
(PERCENT)

	NOT SENIOR	SENIOR
MAIN + SECONDARY SPACE HEATING		
MULTI-RES SYSTEMS	64.5	3.8
CENTRAL	53.6	53.0
GAS WALL/FLOOR	29.8	32.4
ELEC WALL/BASEBD	6.9	6.8
ELEC HEAT PUMP	1.5	1.6
PORTABLE HEATER/	17.8	16.3
WOOD STOVE	10.6	9.1
FIREPLACE	22.1	20.9
PASSIVE SOLAR	0.5	0.3
SOLAR PANELS	0.8	0.6
OTHER	1.8	0.4
NONE	0.4	0.1
NOT SURE	0.0	0.0
MAIN SPACE HEATING FUEL		
NATURAL GAS	79.0	80.8
ELECTRICITY	9.5	7.6
BOTTLED GAS	3.2	4.5
KEROSENE	0.4	0.7
WOOD	7.1	6.1
SOLAR	0.3	0.2
OTHER	0.1	0.1
NONE	0.4	0.1
*MAIN SPACE HEATING THERMOSTAT		
YES	81.9	86.4
NO	17.3	13.7
NOT SURE	0.8	0.9
*NUMBER OF PORTABLE HEATERS		
ONE	54.6	41.0
TWO	21.4	22.5
THREE OR MORE	13.9	21.1
NOT SURE/BLANK	10.1	15.4

*PERCENTAGES REFER TO RELEVANT SUBSET OF POPULATION

	NOT SENIOR	SENIOR
SPACE COOLING SYSTEM		
NONE	49.2	37.1
MULTI-RES SYSTEM	0.3	0.6
CENTRAL ELECTRIC	20.6	22.1
CENTRAL NAT GAS	2.0	3.7
WINDOW-WALL UNIT	8.8	11.6
ELEC HEAT PUMP	1.3	1.3
EVAPORATIVE	7.8	10.4
ELECTRIC FAN	9.8	13.4
OTHER	0.2	0.0
*AIR CONDITIONING THERMOSTAT		
YES	59.4	58.6
NO	34.8	33.1
NOT SURE	6.6	8.3
*ELECTRIC HEAT PUMP		
HEAT ONLY	28.5	31.4
A/C ONLY	19.8	14.3
HEAT & A/C	51.7	54.2
*NUMBER OF AC WINDOW/WALL UNITS		
ONE	72.7	71.6
TWO	8.7	12.5
THREE OR MORE	6.9	2.7
NOT SURE/BLANK	17.7	12.8
*TYPES OF ELECTRIC FANS		
WHOLE HOUSE FANS	2.2	5.6
CEILING FANS	23.8	16.2
PORTABLE FAN	84.6	83.6
OTHER FANS	0.8	0.0

*PERCENTAGES REFER TO RELEVANT SUBSET OF POPULATION

	NOT SENIOR	SENIOR
TYPE OF RANGE OR STOVE		
ELECTRIC	58.7	56.7
NATURAL GAS	36.7	38.6
BOTTLED GAS	3.8	3.8
OTHER	0.1	0.4
NONE USED	0.3	0.4
MICROWAVE-PROH	0.2	0.0
MICROWAVE OVEN		
YES	55.9	44.1
NO	44.1	55.9
NUMBER OF REFRIGERATORS		
NONE	0.9	1.4
ONE	85.2	81.2
TWO	12.7	15.7
THREE OR MORE	1.3	1.7
*NUMBER OF FROST FREE REFRIGERATORS		
NONE	23.1	28.2
ONE	70.4	67.5
TWO	5.9	6.8
THREE OR MORE	0.7	0.3
TYPE OF FREEZER IN MAIN REFRIG.		
TOP FREEZER	61.9	60.6
BOTTOM FREEZER	4.4	6.1
SIDE BY SIDE	18.2	18.7
NO FREEZER	30.8	30.1
NOT SURE/BLANK	2.8	2.5
TYPE OF FREEZER		
UPRIGHT FROSTFREE	7.2	7.8
UPRIGHT FREEZER	12.3	10.8
CHEST FREEZER	7.1	9.9
UPRIGHT & CHEST	0.7	0.9
NO FREEZER	73.0	52.6
LEFT BLANK	0.6	0.9

*PERCENTAGES REFER TO RELEVANT SUBSET OF POPULATION

TABLE 3

PACIFIC GAS AND ELECTRIC COMPANY
1986 RESIDENTIAL APPLIANCE SATURATION SURVEY
SATURATIONS BY SENIOR GROUP
(PERCENT)

	NOT SENIOR	SENIOR
NUMBER OF REFRIGERATORS		
NONE	01.6	97.4
ONE	14.5	2.2
TWO	3.2	0.3
THREE OR MORE	0.7	0.0
DISHWASHER		
YES	56.5	48.6
NO	43.5	51.4
CLOTHES WASHER		
PRIVATE USE	71.3	71.5
SHARED USE	14.7	10.4
NONE	14.1	18.1
CLOTHES DRYER		
PRIVATE USE	66.3	63.0
SHARED USE	14.7	10.3
NONE	21.0	10.7
*CLOTHES DRYER FUEL		
ELECTRICITY	76.6	79.4
NATURAL GAS	22.7	26.0
BOTTLED GAS	0.7	0.6
NUMBER OF COLOR TELEVISIONS		
NONE	5.2	6.2
ONE	55.0	62.9
TWO	20.4	24.2
THREE	0.0	5.7
FOUR OR MORE	2.5	1.0
NUMBER OF BLACK/WHITE TV'S		
NONE	30.0	33.6
ONE	36.6	34.3
TWO	6.0	5.9
THREE	1.3	0.2
FOUR OR MORE	0.2	0.1

*PERCENTAGES REFER TO RELEVANT SUBSET OF POPULATION

	NOT SENIOR	SENIOR
OWNERSHIP OF OTHER APPLIANCES		
PC/VIDEO GAMES	21.9	4.0
HOME STEREO	71.6	37.0
VIDEOCASSETTE RE	61.9	19.1
HUMIDIFIER/FILTE	5.4	3.6
NO OTHER APPL.	17.0	50.0
WELL WITH ELECTRIC PUMP		
NO	90.7	87.9
HOUSE/GARDEN USE	6.3	10.7
GARDEN USE ONLY	2.0	1.4
HOT WATER HEATER		
SOLE USE	33.3	05.6
SHARED USE	16.6	14.1
NONE	0.1	0.2
*WATER HEATER FUEL		
NATURAL GAS	03.9	01.5
ELECTRIC	10.3	12.5
BOTTLED GAS	3.9	4.0
SOLAR	2.0	2.5
OTHER	0.6	1.2
NOT SURE	0.0	0.0
*SOLAR WATER HEATER FUEL		
SOLAR ONLY	37.5	33.9
SOLAR/NAT GAS	35.0	43.0
SOLAR/ELEC	15.0	19.0
SOLAR/BOT GAS	5.0	2.5
SOLAR/OTHER	7.1	1.5

*PERCENTAGES REFER TO RELEVANT SUBSET OF POPULATION

	NOT SENIOR	SENIOR
SWIMMING POOL		
NONE	01.2	04.7
PRIVATE	0.3	4.0
SHARED	10.5	10.4
*SWIMMING POOL LOCATION		
IN GROUND	00.6	04.4
ABOVE GROUND	0.4	5.6
*POOL FUEL		
NONE	43.4	30.7
NATURAL GAS ONLY	15.6	15.4
ELECTRIC ONLY	0.7	3.0
SOLAR	30.2	21.0
SOLAR COVER	5.0	5.7
NAT GAS/SOL SYS	3.0	0.4
ELEC/SOL SYS	0.6	0.1
GS/SOL SYS/COV	0.7	0.4
ELEC/SOL SYS/COV	0.1	0.0
SOL SYS/COVER	1.7	1.6
NAT GAS/COVER	1.5	1.4
ELEC/COVER	0.1	0.1
OTHER	1.7	0.6
NOT SURE	0.0	0.0
*TIME CLOCK ON POOL FILTER		
YES	02.2	05.1
NO	17.0	14.0
*AUTOMATIC POOL SWEEP		
YES	37.0	32.4
NO	03.0	07.6
HOT TUB OR SPA		
NONE	00.1	04.5
PRIVATE	5.0	1.0
SHARED	3.0	3.7

*PERCENTAGES REFER TO RELEVANT SUBSET OF POPULATION

TABLE 3

PACIFIC GAS AND ELECTRIC COMPANY
1986 RESIDENTIAL APPLIANCE SATURATION SURVEY
SATURATIONS BY SENIOR GROUP
(PERCENT)

	[illegible]	[illegible]
*[illegible]		
[illegible]	30.5	30.5
[illegible]	8.4	7.9
[illegible]	1.5	1.8
[illegible]	6.5	6.9
[illegible]	23.5	23.8
[illegible]	1.5	1.8
[illegible]	6.3	6.1
[illegible]	10.8	6.8
[illegible]	3.5	3.8
[illegible]	2.3	3.8
[illegible]	0.4	0.7
[illegible]	4.2	3.1
[illegible]	1.1	0.4
[illegible]	0.8	0.8
*[illegible]		
[illegible]	17.1	8.4
[illegible]	57.4	67.8
[illegible]	25.5	24.8
[illegible]		
[illegible]	2.3	1.2
[illegible]	9.4	8.4
[illegible]	23.7	62.8
[illegible]	34.6	28.4
[illegible]		
[illegible]	30.8	3.8
[illegible]	41.8	42.8
[illegible]	23.3	28.8
[illegible]	34.4	23.8
[illegible]		
[illegible]	55.3	34.1
[illegible]	42.7	45.5

* [illegible]

	[illegible]	[illegible]
CEILING INSULATION		
YES	64.9	72.1
ADDED LAST YEAR	7.8	5.1
[illegible]	27.3	22.8
FEASIBLE TO INSTALL CEILING INSULATION		
YES	32.5	26.9
NO/NO SPACE	58.5	54.8
NO/YES, ABOVE	7.9	9.6
PARTIALLY	6.6	4.8
NOT SURE	34.5	41.6
WATER HEATER BLANKET		
INSTALLED 1986	8.5	5.5
BEFORE 1986	24.2	24.7
NEVER INSTALLED	48.1	43.7
NOT SURE/BLANK	19.2	26.0
LOW FLOW SHOWER HEAD		
INSTALLED 1986	10.4	6.1
BEFORE 1986	28.2	27.5
NEVER INSTALLED	42.8	38.1
NOT SURE/BLANK	18.5	27.3
COOLING		
INSTALLED 1985	8.3	6.8
BEFORE 1986	26.2	27.9
NEVER INSTALLED	37.5	38.3
NOT SURE/BLANK	28.9	26.9
HEATING/COOLING DUCTS WRAPPED		
INSTALLED 1986	3.1	2.3
BEFORE 1986	22.8	23.9
NEVER INSTALLED	37.1	33.3
DON'T SURE/BLANK	37.8	40.6

	[illegible]	[illegible]
1986 NEW PURCHASES (ADDED & REPLACED)		
REFRIGERATOR	12.5	9.8
FREEZER	2.5	2.4
STOVE OR RANGE	6.1	5.8
MICROWAVE	13.6	8.7
DISHWASHER	4.3	2.4
CLOTHES WASHER	10.5	8.8
CLOTHES DRYER	8.2	6.1
WATER HEATER	6.8	5.3
HEATING SYSTEM	1.7	1.8
PORTABLE HEATER	2.8	2.7
WINDOW/WALL A/C	1.1	1.2
CENTRAL A/C	0.6	1.2
HUMIDIFIER	0.9	0.4
WATERBED	2.8	0.2
POOL HEATER	0.3	0.1
HOT TUB/SPA	1.1	0.2
COLOR TELEVISION	10.8	14.2
BLACK & WHITE TV	4.8	2.6
STEREO	11.1	8.4
VIDEOCASSETTE RE	10.2	7.4
COMPUTER / VIDEO	5.8	1.4
ANNUAL HOUSEHOLD INCOME		
UNDER $5000	2.9	10.2
$5000 - $9999	8.8	24.6
$10000 - $14999	8.7	16.2
$15000 - $19999	8.5	9.6
$20000 - $24999	11.1	8.8
$25000 - $29999	10.8	8.5
$30000 - $34999	10.1	7.5
$35000 - $39999	7.7	3.1
$40000 - $44999	6.2	2.9
$45000 - $49999	5.8	1.9
$50000 - $74999	13.1	4.8
$75000 OR MORE	5.9	2.7

TABLE 3

PACIFIC GAS AND ELECTRIC COMPANY
1986 RESIDENTIAL APPLIANCE SATURATION SURVEY
SATURATIONS BY SENIOR GROUP
(PERCENT)

	[illegible] SENIOR	[illegible]
EDUCATION LEVEL: HEAD OF HOUSEHOLD		
GRADE SCHOOL	4.5	10.7
SOME HIGH SCHOOL	6.9	15.8
HIGH SCHOOL GRAD	21.1	25.8
SOME COLLEGE	24.7	19.5
BUS1/TECH SCHOOL	6.3	7.9
COLLEGE GRADUATE	30.7	30.4
SOME GRAD SCHOOL	4.6	2.9
GRADUATE DEGREE	13.2	7.0
NUMBER OF RESIDENTS		
ONE	14.0	45.0
TWO	39.8	53.0
THREE	20.3	1.9
FOUR	18.9	0.1
FIVE	7.8	0.0
SIX	3.1	0.0
SEVEN	1.3	0.0
EIGHT	1.0	0.0
NINE OR MORE	0.8	0.0
AGE OF RESIDENTS		
ANY 5 YR OR LESS	21.8	0.0
ANY 10-24 YRS	20.5	0.0
ANY 25-34 YRS	30.0	0.0
ANY 35-44 YRS	26.6	0.0
ANY 45-54 YRS	22.9	0.0
ANY 55-59 YRS	13.1	0.0
ANY 60-64 YRS	8.2	27.4
ANY 65 YRS +	6.2	82.7

	[illegible] SENIOR	[illegible]
RACE OR ETHNIC GROUP		
WHITE RESIDENTS	75.7	91.3
HISPANIC RESID.	10.7	2.7
ASIAN RESIDENTS	7.1	2.6
BLACK RESIDENTS	6.5	3.4
AMERICAN INDIAN	0.3	0.2
EASTERN INDIAN	0.4	0.1
OTHER ETHNIC	0.6	0.0
LEFT BLANK	0.3	0.0
PRIMARY LANGUAGE		
ENGLISH ONLY	89.8	95.4
SPANISH	5.7	1.8
CHINESE	1.6	0.5
JAPANESE	0.2	0.3
TAGALOG	0.9	0.3
OTHER	1.4	1.5
S.E. ASIAN	0.6	0.1
SOMEONE REGULARLY HOME EARLY DAY		
YES	60.7	87.4
NO	39.3	12.6

	[illegible] SENIOR	[illegible]
MONTHLY ELEC USAGE (KWH)		
0-100	4.1	6.1
101-200	12.3	12.9
201-300	14.4	18.9
301-400	14.2	16.6
401-500	12.6	13.3
501-600	10.2	11.0
601-800	15.1	11.1
801-1200	12.1	7.3
1201-1600	3.6	2.2
1601-2000	1.0	0.3
OVER 2000	0.6	0.3
MONTHLY GAS USAGE (THMS)		
0-10	6.1	4.6
11-20	9.2	6.9
21-30	11.9	8.7
31-40	13.6	16.6
41-60	29.8	35.6
61-80	18.3	17.4
81-120	20.6	8.8
121-160	0.9	1.0
161-200	0.2	0.3
201-240	0.1	0.0
OVER 240	0.0	0.0
MONTHLY ENERGY USAGE (100,000 BTUS)		
0-20	7.2	6.0
21-40	17.1	15.2
41-60	23.2	20.3
61-80	23.6	27.1
81-100	15.4	13.2
101-120	7.0	6.7
121-140	5.6	2.7
141-200	0.6	0.7
201-240	0.2	0.1
241-280	0.1	0.0
OVER 280	0.1	0.0

LEAST COST ELECTRIC UTILITY PLANNING: A PRELIMINARY ASSESSMENT OF ITS IMPLICATIONS FOR BLACKS AND HISPANICS

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INTRODUCTION

Electric power is a large and important part of American life. In 1984, electric utility customers purchased 2,278 billion kilowatt-hours (kWh) of electricity (thus accounting for one-third of the primary energy consumed nationwide) at a cost of $143.1 billion (U.S. Department of Energy [DOE], 1986a). The 3,130 electric utilities that supply this energy are heavily capital intensive. Collectively they accounted for roughly $42 billion (1982$) per year in investment for new equipment during the 1970s, or an estimated one-half of all new common stock issues and one-tenth of gross private domestic investment (DOE, 1983).

This large and important industry is undergoing significant change. Whereas growth in the industry used to be quite stable, it is now quite uncertain. The price of electricity once was in steady decline, but from 1973 to 1983 it grew by 50% in constant dollars (DOE, 1983). Investment in the industry used to be secure and rewarding; since 1972 utilities have cancelled 115 proposed or partially constructed nuclear power plants at a cost of over $20 billion (Cavanagh, 1986).

This dramatic shift in conditions has led to several calls for a change in electric power planning. At first the focus was on planning at the national level. Such planning failed to emerge, however, largely due to a lack of consensus about the path of change that should be pursued (Katz, 1984). The arena for debate shifted in the early 1980s to regions and the states, and now the call is for "least cost utility planning" at the state or utility scale.

Some black interest group leaders and elected officials asserted that blacks had little or no opportunity to influenoe national energy policy during the Carter administration (Perry, 1984). In particular, they feared that President Carter's proposals would increaae energy prices, and thereby reduce economic growth, new job creation, and income growth for low income and minority households. Responding to these concerns the Congressional Black Caucus successfully strived to create the Office of Minority Economic Impact within DOE. Under the guidance of that office, other researchers began to investigate the energy consumption and expenditure patterns of minority households and, to a lesser extent, minority-owned small energy business development.

LEAST COST ELECTRIC UTILITY PLANNING: A PRELIMINARY ASSESSMENT OF ITS IMPLICATIONS FOR BLACKS AND HISPANICS

J. A. THROGMORTON

What is somewhat surprising is that the least cost and minority energy research projects have not overlapped. The least cost literature does not assses the effects of its arguments on minorities, and the minority energy literature pays very little attention to electric power.

The present article seeks to join the two streams of research. It reviews the main arguments and findings of the least cost literature and relates them to minorities. It then reports what is known about minority electric power consumption and expenditure patterns and relates that knowledge to least cost planning. It then attempts to break some new ground by correlating state electric power and minority population data. At the end it suggests possible paths for new research concerning "minority least cost electric utility planning".

LEAST COST UTILITY PLANNING AND ITS CRITICS

The Least Cost Perspective

The origins of the least cost utility planning concept can be traced back to seminal work by Armory Lovins (1976), Roger Sant (1979), and the Solar Energy Research Institute (SERI, 1981). Although the details of the concept vary, most least cost analysts agree that its fundamental purpose is to deliver energy services to residential, commercial, and industrial consumers at the least total cost.

What are "energy services"? They are the end use activities and conditions that energy helps the consumer do or experienoe. Thus mobility, comfort, light, cleanliness, and food preservation and preparation are the kinds of end uses that householders are likely to demand. These end uses or energy services are provided by a combination of energy and end-use technologies (e.g., air conditioners and refrigerators). Householders do not consume electricity; rather they consume the services that electricity helps facilitate.

Concern for end use energy is particularly appropriate for the electric power industry since most of the primary energy used to provide electric services is lost in the form of waste. In 1983 24.94 quadrillion Btu of primary energy were used to generate, transmit, and distribute the 7.34 quads of electric energy actually used nationwide (DOE, 1985a and b). Surely a more efficient way to meet the consumers' energy service demands can be found, the least cost advocates concluded.

The residential, commercial, and industrial sectors of the economy account for 35%, 29%, and 36% respectively of the electricity used. The end uses of electricity within each of these sectors have been reasonably well defined. For example, Table 1 indicates that the residential sector used 8.71 quadrillion Btu of electric energy (as primary energy, 11,500 Btu/kwh) in 1983. Of that total, households used 32% to keep temperatures in their homes within desired comfort ranges, 12% to light their homes, 27% to preserve and cook food, 17% to heat water, and 13% to provide the other services they sought (DOE, 1985b).

Table 1. Residential Electricity Consumption by End Use, 1983

End use	Electricity Consumption (quadrillion Btu)	Percent of Total
Space heating	1.66	19.1
Air conditioning	1.13	13.0
Lighting	1.02	11.7
Refrigerators	1.32	15.2
Freezers	0.46	5.3
Ranges/ovens	0.56	6.4
Water heating	1.46	16.8
Other	1.10	12.6
Total residential	8.71	100.0

Source: U.S. Department of Energy, 1985b

Reconceptualization of the electric utility business in terms of energy services has deep implications for electric utility planning. In the past, utility planning was limited primarily to forecasting future demand, determing how much additional power generation capacity was required, and comparing alternative supply options. Doing this was relatively easy. Utility planners simply extrapolated past demand trends into tbe future. Shifts in the costs of energy and capacity in the 1970s complicated matters, however, and induced utilities to turn to econometric forecasting techniques. By observing how consumer demand varied with changes in income and electricity prices, planners could calculate price and income elasticities of demand. The resulting elasticities could then be used to forecast short- and long-run changes in demand. In the short run, consumers might change their behavior by, for example, turning air conditioner thermostats up. In the long run, though, they might invest in new teohnologies that use electricity more efficiently; e.g., new air conditioners.*

Least cost analysts agree that demand-aide technological substitutions are stimulated by price shifts, but they argue that price elasticity estimates based on tbe declining cost conditions of the past are not a good guide to consumer behavior in the future. Consequently, they argue that econometric techniques need to be replaoed with end use engineering models that explicitly account for consumer adoption and use of end use technologies (SERI, 1981; Meirer, Wright, and Rosenfeld, 1987). Thus a residential end use model would include such variables as house size, housing mix, appliance saturation, and appliance efficiency, and it would assume that consumers adopt demand-side teohnologies in the optimum economic order; that is, adopt the measure with the lowest cost of conserved energy first.

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*Estimating the price elasticity of demand is neither a simple nor a purely technical matter. Bohi (1981) reports that the relevant literature shows "a startling lack of consensus on price elasticities." Using data published during the 1960s and 197Os, he found that estimates of the long run price elasticity of demand for electricity ranged from -0.51 to -1.82 in the industrial sector and from -O.45 to -1.89 in the residential sector.

This implies that "actual future elasticities" will depend on the extent to which market barriers to electricity-conserving technologies are removed.

To enable planners to rank conservation measures in order of increasing costs and to show the amount of energy saved by those measures, least cost analysts developed the supply curve of conserved energy (see fig. 1).

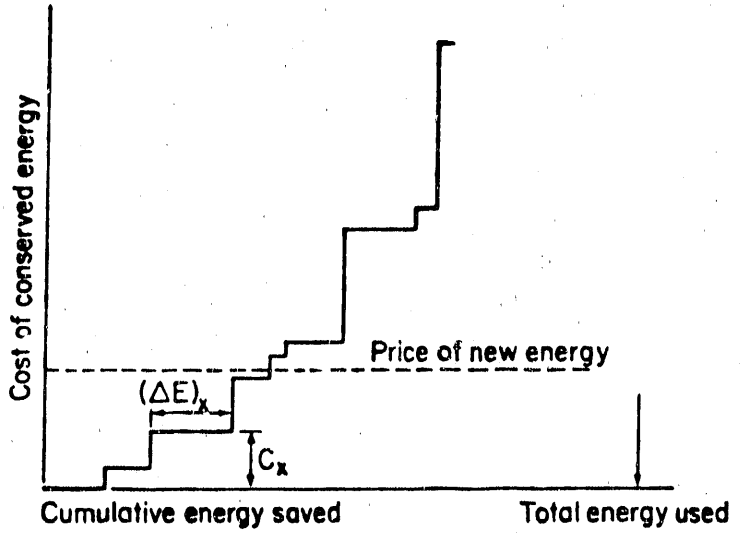


Figure 1. Schematic Supply Curve of Conserved Energy
Source: Meirer, Wright, and Rosenfeld, 1987

Four variables must be considered when preparing such supply surves: the measure's initial investment cost, the measure's expected annual energy savings, the investment's amortization period, and the investor's discount rate. Thus, the unit cost of conserved energy would be determined by the following formula:

$$C_x = \frac{\left(\frac{d}{1-(1+d)^{-n}}\right) I_x}{E_x}$$

where C_x = Unit cost of energy conserved by measure x

I_x = Investment (or initial cost) of conservation measure x

d = Investor's discount rate

n = Amortization period of the investment.

Resource planning would also be affected by the least cost approach. Utilities have traditionally chosen power generation technologies on the basis of the extent to which they minimize present-valued utility revenue requirements. Thus utility planners have traditionally chosen between coal and nuclear facilities for base-load power generation in terms of their life-cycle (total energy and capital costs over the lifetime of the plant) costs discounted to present value. Demand-side and non-utility power generation (e.g., cogeneration, wind power) investments have never been part of this traditional planning framework. Least cost proponents argue that utilities should compare supply-and demand-side investments on an equal basis, choosing a resource mix that minimizes total costs. Thus least cost advocates propose comparing conservation supply curves with power generation supply curves, and then using conservation and generation alternatives in optimum economic order. Supply and demand planning would be integrated.

Criticisms of the Least Cost Approach

Critics believe that the "least cost" approach suffers from at least three major defects:

- It ignores implementation problems
- It ignores increases in electricity demand that would accompany economic growth
- It might not be equitable.

First, critics believe that Lovins, Sant, and others pay too much attention to what electricity consumption would be like if all consumers behaved in an economically rational way, and too little attention to how consumers really do behave. They claim, in other words, that least cost advocates downplay the complexities of conservation program implementation and tend not to generate reliable data regarding cost, performance, customer acceptance, and customer response (Gellings, Chamberlain and Clinton, 1987). Research recently con-ducted by Temple, Barker, and Sloane, Inc. (TBS, 1986) for DOE concluded that forecasting the market penetration of demand-side options is the greatest remaining challenge in tbe supply-demand integration process. Most importantly, utilities need to be able to predict with reasonable confidence the amount and speed of electricity conservation, hence to treat conservation as an energy resource. This same resource indicated that community groups might be good partners and marketers ("transfer vehicles") for utility programs due to their greater credibility in communities.* TBS also reported that utilities need informatlon about how conservation affects load shapes (particularly peak load), hence the extent to which conservation can avoid the need for new capacity additions. In retort, least cost advocates stress the importance of government intervention to remote market barriers to electricity-efficient investments (Lovins, 1985a).

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*For the purposes of this report, it is important to note that no black or Hispanic organizations were contacted as a part of TBS's research.

Most importantly, they stress the need for applicance and new building efficiency standards, and mandatory utility subsidizations of effective conservation programs.

Critics also claim that "least cost" advocates do not account for new technologies, economic activities and demographic patterns that might increase the demand for electricity. Whether growth in electric power supply and growth in GNP are tightly linked is a very controversial topic. Supply side anslysts such as Siegel and Sillin (1985) argue that electricity growth increases nonlinearly with increasing levels of GNP. To butress their argument, they point out that electricity's share of the energy market increases from 27% in 1973 to 35% in 1984, largely because oil and natural gas prices increased more rapidly than did electricity prices over that time period. Similarly DOE's Electricity Policy Project (EPP) (DOE, 1983) emphasizes that the growth in electricity demand has consistently outpaced GNP growth; it grew 1.2 times faster than the GNP from 1973 through 1980.

On the other hand, Lovins (1985b) and others argue that, perhaps with temporary and localized exceptions, stable or falling electric demand is consistent with rapid economic growth. To support this argument, he notes that the electricity/GNP ratio has been falling, and that statistical correlation is not evidence of causality. He emphasizes that beginning in 1976, when rising real prices of electricity "took hold", the ratio stabilized and then fell. He also notes that the ratio of annual increases in electrical sales to annual increases in real GNP has been trending downward since early 1949. Thus rather than assuming a unitary ratio between electric and GNP growth (as Siegel and Sillin and the EPP report do), Lovins points out that the ratio has been steadily declining over the past 10 years (see Fig. 2).

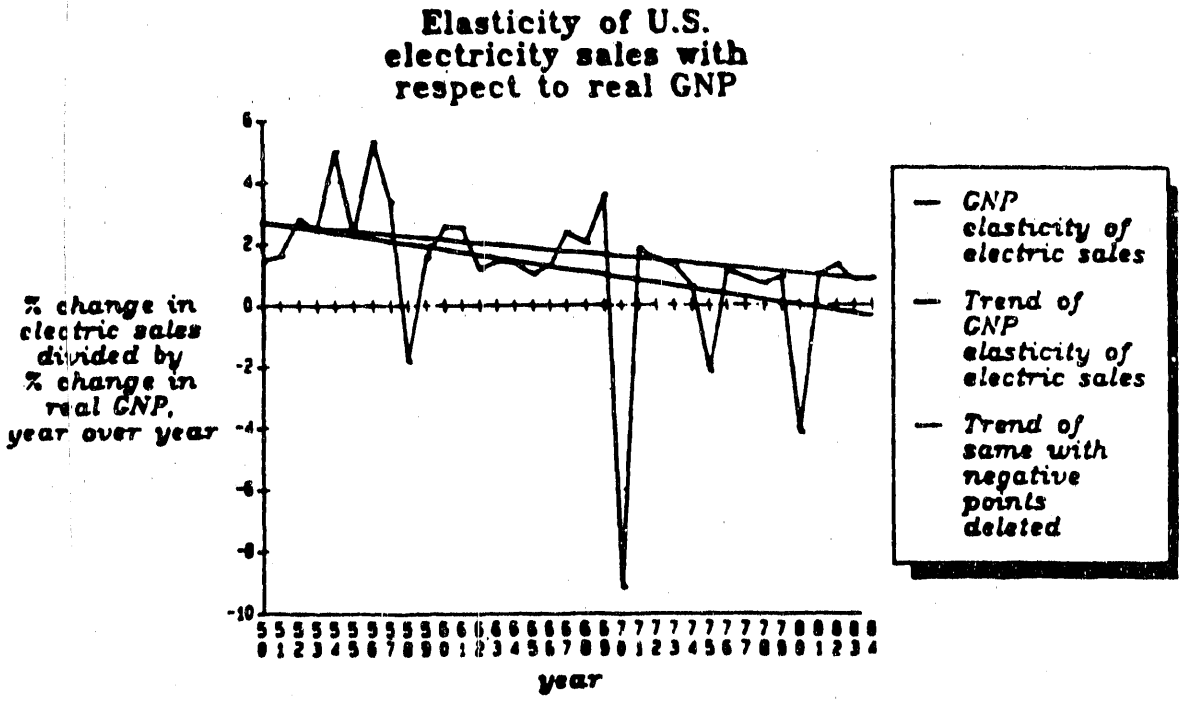


Figure 2. Changes in the Relationship Between Electricity and GNP
Source: Lovins (1985b)

Lovins also argues that electricity's real price relative to the real price of oil and natural gas is not very important when end-use efficiency improvements are far cheaper than any of the three fuels (or, in economic terms, that the own-price elasticity of electricity will swamp the cross-elasticities with other fuels). And even if electricity's share of the energy market continues to increase, that could be an increasing share of a dwindling energy market. A growing economy, in other words, would mean a growing market for energy services, not electricity. Lastly, Lovins argues that the near unitary relationship between electric and GNP growth will decline rapidly in the near future, primarily because the most important types of electricity-saving technologies have only come on the market since 1982, and because the nation is shifting to service-based economy. However, he also stresses that the speed and steepness of the decoupling depends on public and private policy.

Lastly critics have asked least cost to whom?* Here the debate is sharp. Three perspectives have emerged: societal, utility and consumer. Sant, Lovins, and other least cost advocates tend to assume the perspective of society as a whole, and pay little attention to the distribution of costs and benefits among groups in society. Here there is a certain degree of irony: even though least cost advocates vigorously criticize econometric analyses, they unhesitatingly accept the economic point of view and they seek to ensure that electric power investments are economically efficient. On the other hand, utilities tend to favor minimizing their present valued revenue requirements and to support only those conservation investments that have a favorable benefit-cost ratio from the utility point of view. Similarly, they oppose conservation programs that cannot pass a "no-losers" test; that is, programs that do not have a favorable benefit-cost ratio from the point of view of consumers who do not participate in utility

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*Least cost advocates and their critics both rely heavily on neoclassical economics. Most importantly, they view electric energy as a commodity and see tbe key decision-maker as being the rational self-interested individual. Regardless of the unarguable fact that the electric power industry is a regulated monopoly, they all build on a neoclasaical model which assumes that tbere are no institutions except the market and that economic change occurs as a result of changes in relative prices. Accordingly, they generally fail to recognize that some groups may define electric energy as more than a mere commodity and--acting on that belief--seek more fundamental structural change in the industry (North 1981; Throgmorton 1983). In this context it is important to recognize that electric power can be defined not only as a commodity bought and sold in markets, but also as an ecological resource, a social necessity, and a strategic material (Stern and Aronson 1984). Likewise to define electric power as a commodity and least cost utility planning as a tool of economic efficiency is to denigrate the importanoe of the political process and to deflect attention away from the politics of deciding whose version of least cost will be adopted in practice. Rather than limit themselves to helping utilities integrate demand-and supply-side planning, many groups may seek, for example, to create new public planning organizstions, or to secede from the private utility and create a new publicly-owned utility (Rudolph and Ridley, 1986).

subsidized conservation programs. Again this is ironic. Accused by many of bias and self-interest, utilities emphasize a need to make sure that conservation programs are equitable (or, in economic terms, Pareto optimal).

Where do blacks and Hispanics stand in all of this? How might they be affected by the least cost approach? Does anything about their circumstances warrant aggressive involvement in the least cost planning process? None of the key works in the least cost utility planning literature address those questions. In fact the least cost literature is silent with regard to blacks and Hispanics. Thus, the following section asks whether anything about those patterns warrants greater black and Hispanic participation in least cost planning or greater attention to blacks and Hispanics on the part of least cost researchers.

ELECTRIC POWER CONSUMPTION AND EXPENDITURE PATTERNS OF BLACK AND HISPANIC HOUSEHOLDS

Until recently blacks and Hispanics have had little reason to pay attention to energy issues. Concerned primarily about improving their access to jobs and economic livelihood, they have focused more on civil rights, education, immigration, family stability, and economic development issues. The energy price shocks of the mid- and late-1970s changed that, however. Observing that the adverse effects of those price shocks and resulting policy responses tended to fall more heavily on blacks and Hispanics, minority policy researchers began to pay attention to energy issues.

Most of the resulting research has focused on consumption and expenditure patterns of black and Hispanic households. In what follows, I will review what is currently known with regard to the electric power consumption patterns of those households. In doing so, I draw primarily from DOE's Residential Energy Consumption Surveys (RECS) and related work conducted at Argonne National Laboratory for DOE's Office of Minority Economic Impact.* Two separate questions will be asked: first, how important are black and Hispanic electricity consumption patterns to nationwide totals; and second, how important is the least cost enterprise to blacks and Hispanics?

When looked at nationally in the mid-1980s, electricity consumption by minority households appears to have modest significance for the least cost enterprise. According to DOE's Residential Energy Consumption Survey, 10.5 million black households consumed 0.24 quadrillion Btu (end use energy) at a cost of $5.3 billion in 1982 (DOE, 1984). Roughly 4.3 million Hispanic households consumed 0.10 quadrillion Btu at a cost of $2.2 billion. When combined, black and Hispanic households account for approximately 13% of residential

*For a capsule summary of much of this research, see Throgmorton and Bernard, 1986.

electric power consumption in 1982. If blacks and Hispanics have a significant effect on electricity patterns it is at a regional, state or local level or at some point in the future.

When looked at from the point of view of all black and Hispanic households, electricity and least cost utility planning again appear to be of modest significance. As do other households, blacks and Hispanics need electricity to light their homes, to run appliances, and for other purposes. The average black household consumed 23 MBtu at a cost of $503, and the average Hispanic household consumed 20 MBtu at a cost of $520 to help provide these energy services in 1982. One can only assume that electricity is important for these households. Least cost utility planning may not be very important for them, however, because they spend a relatively small fraction of their annual income of electricity. Arguably, however, electricity is far more important for those households that heat or cool their homes with electric power.

Space Heating

The magnitude of both consumption and expenditures depends heavily on whether the household uses electricity as its primary space heating fuel. As Table 2 indicates, 1.0 million black households (or 9.5% of all black households) used electricity as the primary space heating fuel in 1982. A much larger percent of white households, 17.9%, did so. Roughly 14% (or 0.6 million) of the 4.3 million Hispanic households used electricity for space heating. Those households that did rely on electric space heating consumed far more electricity than those that did not: black households that used electric heat consumed 48 MBtu at a cost of $866, whereas black households that used some other fuel consumed 21 MBtu at a cost of $467. Similarly Hispanic households that used electric heat consumed 51 MBtu at a cost of $882, whereas Hispanic households that used some other fuel consumed 20 MBtu at a cost of $465 (DOE, 1984).

Available data also indicate that blacks who rely on electricity for space heat use 13% less electricity than their white counterparts. Likewise Hispanics who rely on electricity use 7% less than their non-Hispanic counterparts (DOE, 1984). These data are somewhat surprising since we also know that blacks are far less likely to have energy conservation measures installed in their home than are whites. For example, only 54% of all blacks living in single-family units have roof or ceiling insulation, whereas 82% of single-family whites do (DOE, 1986b).

Air Conditioning

The amount of electricity used by black and Hispanic households, as well as the amount of money spent on that fuel, also depends heavily on whether the household uses air conditioning. Roughly 4.6 million black and 1.7 million Hispanic households use air conditioning. The resulting percentages of black and Hispanic households that have air conditioning, 44% and 40% respectively, are much smaller than the percent of white households (60%) that do. Blacks that have both electric space heat and air conditioning consume 53 MBtu at a cost of $952, whereas blacks that do not have air conditioning and use some other fuel for space

Table 2. Electricity Consumption and Expenditures by Population Category and by Use of Electricity as Main Heating Fuel, 1982 [a]

	Population Category			
	White	Black	Hispanic	Non-Hispanic
All Electric Space-heat Households				
Number of households (mil)	12.1 (59.2)	1.0 (9.5)	0.6 (3.7)	12.8 (66.7)
Electricity consumed per household (MBtu)	55 (25)	48 (21)	51 (20)	55 (24)
Electricity expenditures per household ($)	943 (520)	866 (467)	882 (465)	933 (514)
Air Conditioned Structures				
Number of households (mil)	9.4 (33.3)	0.6 (4.0)	0.3 (1.4)	9.9 (36.4)
Electricity consumed per household (MBtu)	57 (29)	53 (28)	60 (25)	56 (29)
Electricity expenditures per household ($)	1002 (607)	962 (596)	1118 (600)	993 (605)
Not Air Conditioned Structures				
Number of households (mil)	2.7 (25.9)	0.3 (5.6)	0.2 (2.3)	2.9 (30.3)
Electricity consumed per household (MBtu)	50 (20)	38 (15)	39 (16)	49 (19)
Electricity expenditures per household ($)	737 (408)	671 (375)	563 (383)	728 (403)

[a] Data for households that do not use electricity as the primary heating fuel are given in parentheses. Source: U.S. Department of Energy, 1984.

heating consume only 15 MBtu of electric energy at a cost of $375. The pattern is similar for Hispanics, except that electricity-intensive Hispanics consume more electricity than do blacks. Thus the 5.7% of black households that use electricity for both space heating and cooling consume over three and one-half times as much electricity as do blacks that do not. They spend more than two and one half times as much on electricity. In general, one would expect these electricity-intensive minority households to be much more interested in least cost planning than other minority households.

Far more blacks and Hispanics use air conditioning than electric space heating. Roughly 4.0 million black households have air conditioning but not electric heat. They consume an average of 28 MBtu at a cost of $596. Similarly 1.4 million Hispanics have air conditioning but not electric heat. They use an average of 25 MBtu at a cost of $600.

An important limitation of the space heating and air conditioning data just cited is that they do not control for the effects of income, climate, or regional electricity price variations. We know that blacks and Hispanics who use electric heat live in warmer climinates: such blacks experienced 3,011 heating degree-days (HDDs) in 1984, versus 3,580 for whites; and such Hispanics experienced 1,830 HDDs in 1980 versus 3,622 for non Hispanics (DOE, 1986). Analyzing 1981-82 DOE data, Klein, et al. (1984), attempted to control for the effects of climate on electricity consumption. They reported that blacks consumed substantially more electricity for space heat, controlling for climate, than did whites: 5,900 Btu/HDD versus 4,910 Btu/HDD. They also reported that Hispanics consumed even less: 2,750 Btu/HDD.

Likewise, we know that blacks and Hispanics, on average, pay higher prices for the electricity they consume: in 1982 blacks paid $21.72 per MBtu versus $19.76 for whites, and Hispanics paid $21.80 versus $19.90 for non Hispanics (DOE, 1984). We also know that blacks and Hispanics have, on average, much lower annual incomes than do whites and non-Hispanics. Using 1978-80 residential energy consumption survey data, Poyer (1983) estimated that electricity consumption by black households was slightly more responsive to electricity price changes than was the national population as a whole. He found little difference in income elasticities (see Table 3 below):

Table 3. Estimated Long-Run Price and Income Elasticities for Electricity, by Population Category

	Observed Elasticity of Demand	
Population Category	Price	Income
National	-0.71	0.24
Black	-0.82	0.22

Source: Poyer (1983)

Other Energy Services

Nothing has been reported in the published literature about how blacks and Hispanics use electricity for other energy services. All we know is that blacks are significantly less likely to use electricity for water heating than are whites (Poyer, 1983). However, unpublished analyses of RECS1 data by Argonne National Laboratory researchers indicate that blacks and Hispanics are much less likely to have electrical appliances than is the U.S. population as a whole (see Table 4). No data are available concerning the efficiencies of appliances used by minorities, but it is reasonable to assume that they are significantly lower than applicances used in the average U.S. household.

Table 4. Electrical Appliances in Households by Population Category, 1980

	Population Category (% of Category)		
Appliance	Black	Hispanic	U.S. Total
At least one refrigerator	99	100	100
Two or more refrigerators	9	6	14
One or more freezers	32	15	38
Electric stove	30	40	58
Dishwasher	12	19	33
Automatic clothes washer	56	60	72
Electric clothes dryer	24	32	47
Electric dehumidifier	2	3	9
Electric heat pump*	2	3	4

Source: Teotia, et al. (unpublished), based on RECS1
*Teotia, et al. (1985), based on 1980 Census of Housing

Conclusions

This brief review of tbe minority energy literature suggests several conclusions with regard to least cost energy planning. Most importantly, it reveals that the minority energy research literature is very quiet about electric power and least cost planning. Substantial amounts of data are available in DOE's RECS series; however, they have not yet been analyzed from an end use or least cost perspective. Consequently, very little end use electricity consumption data for blacks and Hispanics are available in the published literature, and we do not yet have an equivalent of Table 1 for minority households.

In addition, no one has developed an engineering end-use model or supply curves of conserved energy for minority households. Such models and curves would seem to be appropriate given the following facts. First, minority households are more likely to rent than are non-minority households, hence are less likely to remain at any one residence over the amortization period of many conservatlon measures. Second, minority households tend to have lower incomes,

hence to value tbe present more than the future and have much higher discount rates than wealthier households. And third, minorities tend to have fewer, yet older, and probably less efficient electric appliances than do non-minority households.

An end-use analysis of black and Hispanic electric power consumption might be of considerable interest to least cost researchers. Better knowledge of end-use consumption patterns might increase the predictability with which penetration of end use efficiency investments in the minority residential market can be forecasted.

We must also conclude that most minority energy researchers or activists do not yet see least cost electric utility planning as being important enough to deserve their attention. In part this is due to the facts that only a relatively small fraction of minority households use electricity to heat or cool their homes, and that minorities tend not to have many electrical applicances in their homes. Accordingly, the minority energy researcher's attention has been drawn more to policy-making for other fuels. This situation could change, however, if and when the average income of black and Hispanic households increases enough to induce greater reliance on electrical appliances and electricity for heating or cooling. In part the minority researcber's lack of interest in least cost planning may be attributable to a continuing perception that electricity growth and GNP growtb are tightly linked and that a growing GNP is necessary for economic improvement in minority communities. In the next section I will briefly present some evidence concerning electricity/GNP/black income links.

Electricity may also be much more important to blacks and Hispanics in a few states than it is nationwide, due primarily to current electricity price differentials or to "rate shocks" expected to accompany new power plants. Whether it is cannot be answered without comparative analysis of state data. Unfortunately, no such state-by-state comparative data can be found in tbe national literature. This is a major gap given that energy planning has largely shifted to the state and utility level. In the final section I will attempt to identify those states on which minority least cost researchers should focus their attention.

THE RELATIONSHIPS BETWEEN ELECTRIC GROWTH, ECONOMIC GROWTH AND INCOME GROWTH FOR BLACK HOUSEHOLDS

Virtually all proposals for improving the socioeconomic status of blacks call for full employment and continuous expansion of the GNP. If the EPP and Siegel and Sillin are right, then a failure to build needed new electric generating capacity would incresse the real price of electricity and reduce growth in the GNP, thus reducing new employment and business opportunities for minorities and reducing the amount of disposible income that minority households would have to spend on goods and services other than electricity. If Lovins and other least cost advocates are right, then a growing GNP depends far less on building new powerplants than it does on investments in end-use efficiency in homes and businesses. New employment and business opportunities for minorities would open up in the energy services sector of the economy. Investments in end use efficiency could create, they say, up to four times as many on-site jobs as large control station power plants (Cavanagh, 1986).

The general question this raises is whether blacks and Hispanics would be better off supporting rapid expansion of electric power supply or investments in end-use efficiency? Furtber research is needed to answer that question satisfactorily; only a few tentative comments can be made here.

Here I ask two questions: how has the median real income of black households changed annually over the period from 1970 through 1982; and how do those changes correlate with annual changes in GNP and primary energy input at electric utilities over the same period?

Table 5 lists the data used in this analysis. It indicates that the real median income of black households declined at a mean rate of 1.3% while the real GNP and energy input at electric utilities increased at mean annual rates of 3.1% and 4.4% respectively. Perhaps more importantly from a least cost planning point of view, it indicates that for every one percent increase in energy input at utilities, median black household income decreased by 1.3% Figure 3 illustrates the annual changes in this black income/electricity

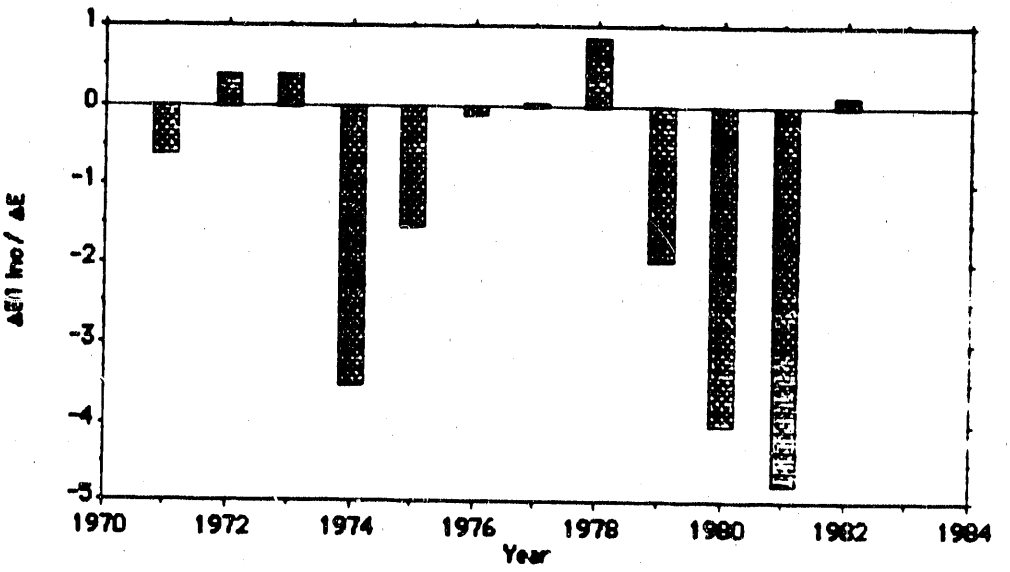


Figure 3. Changes in the Ratio of Median Black Household Income to Energy Input at Electricity Utilities, 1970-1982

EXPLORATORY ASSESSMENT OF THE RELATIONSHIP BETWEEN BLACKS/HISPANICS AND LEASTCOST ELECTRIC UTILITY PLANNING AT THE STATE LEVEL

States differ from one another with regard to their implications for minority least cost planning. They differ in their minority populations, in their prices for electricity, and in the extent to which they are the sites for new, expensive power plants.

Table 5. Annual Changes in GNP, Electric, and Black Household Income, 1970-82

	Percent Change in Real GNP (ΔGNP)	Percent Change in Energy Input at Electric Utilities (ΔE)	Percent Change in Real Median Black Household Income (ΔBI)	$\frac{\Delta E}{\Delta GNP}$	$\frac{\Delta BI}{\Delta GNP}$	$\frac{\Delta BI}{\Delta E}$
1971	4.0	5.4	-3.4	1.4	-0.8	-0.6
1972	10.8	8.0	3.1	0.7	0.3	0.4
1973	5.8	7.2	2.8	1.2	0.5	0.4
1974	-0.6	0.9	-3.2	-1.5	5.3	-3.6
1975	-1.2	1.6	-2.5	-1.3	2.1	-1.6
1976	5.4	6.0	-0.9	1.1	-0.2	-0.2
1977	5.5	5.2	0.1	0.9	0.0	0.0
1978	5.0	4.6	3.8	0.9	0.8	0.8
1979	2.8	1.6	-3.2	0.6	-1.1	-2.0
1980	-0.3	1.7	-6.9	-5.7	23.0	-4.1
1981	2.6	1.0	-4.8	0.4	-1.8	-4.8
1982	-1.9	-2.3	-0.3	1.2	0.2	0.1
Mean	3.1	4.4	-1.3	1.1	2.3	-1.3
St. Dev.	3.4	3.5	3.3	3.6	6.8	1.9

Sources: Bureau of the Census (1983); DOE (1985a)

Most importantly, states differ in their numbers of black and Hispanic residents. From the least cost researcher's point of view, blacks and Hispanics are important when they comprise a relatively large fraction of a state's population. The larger the minority fraction, the greater its potential influence over both least cost policy and electric utility consumption patterns. From the minority researcher's point of view, a more important consideration would be the absolute number of blacks and Hispanics in each state. The researcher would want to ensure that his research benefitted the largest number of minority households per unit of his resources.

Second, states differ in their average electricity rates. All else being equal, households that live in high rate states will spend more of their income on electricity, hence be more aware of electric power issues and more likely to participate in least cost planning activities. There are two major exceptions to this general statement, however. In some cases electricity rates may have been high for a long time; consumers would have no new incentive to undertake least cost initiatives. In other cases electricity rates may have been quite low historically, tben suddenly increased as a result of oil supply interruptions or costly shifts to new power generation technologies. Thus states also differ significantly in magnitude of recent increases in electric power rates. Those states that have experienced large increases over the past few years are more likely to have households that are interested in electric power issues that are states that have not.

To the extent that least cost utility planning concerns both supply and demand, a fourth factor would be whether the state contains at least one expensive and controversial power plant that either is under construction or, if completed, has not yet been defined as "used and useful" or included in the utility's rate base by the state's regulatory commission. For the purposes of this paper I will define a "controversial and expensive" plant as being a nuclear facility whose reported completion costs (expressed in $/kw) are above the average for all nuclear plants in construction or awaiting commercial operation as of December 31, 1985 (DOE, 1986c). The presence of one or more such plants in a state will be used as an indicator of the likelihood of substantial electric rate increases and consumer interest in least cost planning in the near future.

These differences between states (see Table 6) can be analyzed to identify which states deserve the greatest attention from minority least cost researchers.

Analysis of State Data

Analysis of the data was intentionally exploratory. I was initially curious to see wbether the data listed in Table 6 intercorrelated to any significant degree. The resulting correlation analysis indicated that they did not. The strongest correlation (O.463) was between the black/Hispanic population variable and the nuclear plant status variable. The remaining correlations (see Table 7) were not very strong. Upon reflection, this lack of strong intercorrelation is not surprising. The weak correlations between either the black/Hispanic population or black/Hispanic percent of population variables and the 1984 electricity price variable (0.205 and 0.107) provide good examples. Many of the states that have large minority

Table 6 - Data Used in Exploratory Assessment of the Relationship Between Blacks/Hispanics and Least Cost Electric Utility Planning

	Black/Hispanic Population[a]		Electricity Price[b]		Nuclear Construction[c]	
State	1000s	% of State	1984 ($/mBTu)	% Change (80 to 84)	Plant	$/KW
Alabama	1029	26.4	17.25	37.2	Bellefonte 1	3459
					Bellefonte 2	3459
Alaska	24	6.0	26.30	67.3		
Arizona	516	19.0	21.40	35.7	Palo Verde 1	2679
					Palo Verde 2	1630
					Palo Verde 3	1591
Arkansas	392	17.1	17.85	39.1		
California	6363	26.9	21.93	26.8	Diablo Canyon 2	2429
Colorado	442	15.3	18.51	42.3		
Connecticut	341	11.0	28.34	47.5	Millstone 3	3346
Delaware	106	17.8	21.76	13.6		
DC	467	73.2	20.79	39.2		
Florida	2201	22.6	23.02	41.0		
Georgia	1526	27.9	17.38	35.7	Vogtle 1	5051
					Vogtle 2	1916
Hawaii	89	9.1	32.76	48.5		
Idaho	40	4.2	9.93	33.7		
Illinois	2311	20.2	21.85	41.8	Braidwood 1	2627
					Braidwood 2	1897
					Byron 2	1857
					Clinton 1	4028
Indiana	502	9.1	17.06	37.8		
Iowa	68	2.3	19.85	41.4		
Kansas	189	8.0	20.41	47.7		
Kentucky	286	7.8	14.96	47.7		
Louisiana	1337	31.8	16.65	44.3	River Bend 1	3923
Maine	8	.7	19.99	22.0		
Maryland	1023	24.3	18.57	19.3		
Massachusetts	365	6.4	27.60	29.8		
Michigan	1361	14.7	19.56	26.4	Fermi 2	3487
Minnesota	85	2.1	16.30	22.4		
Mississippi	912	36.2	17.31	25.4		
Missouri	566	11.5	16.72	19.6		
Montana	12	1.5	10.54	80.5		
Nebraska	76	4.8	16.60	40.6		
Nevada	105	13.1	15.95	20.5		
New Hampshire	10	1.1	26.03	32.9	Seabrook 1	3846
New Jersey	1417	19.2	28.20	31.9	Hope Creek 1	3970
New Mexico	501	38.4	21.09	35.1		
New York	4061	23.1	28.18	42.5	Shoreham	5463
					Nine Mile Pt 2	5127
North Carolina	1446	24.6	17.16	45.8	Harris 1	4029
North Dakota	7	1.1	17.16	47.4		
Ohio	1297	12.0	17.71	35.8	Perry 1	3540
Oklahoma	262	8.7	17.11	44.3		
Oregon	103	3.9	12.68	68.4		
Pennsylvania	1201	10.1	21.04	38.0	Limerick 1	3635
					Beaver Valley 2	5172
					Limerick 2	3042
Rock Island	48	5.1	27.05	30.1		
South Carolina	982	31.5	16.00	43.4	Catawba 2	1587
South Dakota	6	.8	17.28	32.8		
Tennessee	760	16.6	15.11	41.0	Watts Bar 1	N.A.
					Watts Bar 2	N.A.
Texas	4696	33.0	19.29	51.3	South Texas 1	2218
					South Texas 2	2218
					Commanche Peak 1	2403
					Commanche Peak 2	2403
Utah	69	4.7	18.04	37.0		
Vermont	4	.7	20.08	39.4		
Virginia	1089	20.4	17.98	13.5		
Washington	226	5.5	9.46	12.9		
West Virginia	78	4.0	14.16	33.1		
Wisconsin	246	5.2	17.57	31.1		
Wyoming	27	5.7	13.15	75.8		
Mean	809	4.61	19.20	38.0		3174

[a] Source: Bureau of the Census, 1983
[b] Source: DOE, 1986d
[c] Source: DOE, 1986c

populations are located in the South where electricity prices are relatively low. Conversely, many of the high electricity price states are located in the Northeast where minorities are few.

I then tried to identify those states which had large black/Hispanic populations and high electricity prices, which had had large electricity price increases from 1980 to 1984, and which had expensive nuclear power plants under construction or awaiting commercial operation. Figure 4 summarizes the results of this effort.

Table 7. Correlation Matrix for State Least Cost Variables

	Electric Price (1984)	Electric Price Change (1980-84)	Nuclear Plant Status	Black and Hispanic Population (1000s)	Black & Hisp Population (% of State Total)
Elec. Price (1984)	1				
Elec. Price Change (1980-84)	-.059	1			
Nuclear Plant Status	.266	.026	1		
Black & Hisp. Pop. (1000s)	.205	-.055	.463	1	
Black & Hisp. Pop. (% of State Total)	.107	-.108	.256	.442	1

According to this analysis, two states (New York and Illinois) met all four criteria. Eight other states met three of the criteria. Two of them (Texas and Florida) had no expensive nuclear plants coming on line. Another three (New Jersey, Michigan, and Pennsylvania) had not experienced large price increases over the 1980-84 period. North Carolina and Louisiana still had low electricity prices even though recent price increases had been substantial, and Connecticut had a small minority population. Another 11 states and the District of Columbia met two of the criteria, whereas the remaining 29 states met only one of the criteria. The eight states that had large minority populations and high electricity prices accounted for 57.4% of the total U.S. population of blacks and Hispanics and for 41% of all electric energy consumed during 1984. Further, blacks and Hispanics comprised 22.5% of the total population of those eight states. These data suggest that researchers who are interested in both minorities and least cost utility planning should pay particular attention to the eight states listed in the upper right hand quadrant of Figure 4, plus North Carolina and Louisisna.

Black and Hispanic Population (1000s)	Electricity Price ($/mBtu), 1984			
	Low (< 19.2)		High (> 19.2)	
Large (>809)	Georgia*		California	
	North Carolina*		Texas	
	Louisiana*		New York*	
	Ohio*		Illinois*	
	Virginia		Florida	
	Alabama*		New Jersey*	
	Maryland		Michigan*	
	South Carolina		Pennsylvania*	
	Mississippi			
Small (<809)	Tennessee	Oregon	Arizona	Alaska
	Missouri	Minnesota	New Mexico	New Hampshire*
	Indiana	West Virginia	District of Columbia	Maine
	Colorado	Nebraska	Massachusetts	Vermont
	Arkansas	Utah	Connecticut*	
	Kentucky	Idaho	Kansas	
	Oklahoma	Wyoming	Delaware	
	Wisconsin	Montana	Hawaii	
	Washington	North Dakota	Iowa	
	Nevada	South Dakota	Rhode Island	

[a]States with a large electricity price change (>38.0% from 1980 through 1984) are underlined.

[b]States with expensive nuclear plants (>$3274/kw) in construction or awaiting commercial operation at the end of 1985 are marked with an asterisk (*).

Figure 4 - States Ordered in Terms of Black/Hispanic Population, Electricity Prices, Electricity Price Increases, and Nuclear Plant Construction

Many of these priority states have also been actively encouraging utilities to adopt least cost planning. In late 1985 Congresswoman Claudine Schneider conducted a survey of regulatory utility commissions' electrical resource planning and conservation activities. This survey concluded that few states had made significant progress toward least cost planning, and that least cost planning states lacked the resources needed to evaluate their utilities' planning activities effectively (Schneider, 1985). This and other work indicates that the states of California, Wisconsin, Florida, Nevada, Michigan, New Jersey, Illinois, Iowa, and New York, and the Pacific Northwest states are farthest along in promoting least cost utility planning. Note that six of those states are also priority states from a minority least cost planning perspective.

CONCLUSION

A large and important part of American life, the electric power industry, is currently undergoing significant change. To guide that change, many analysts have called for least cost utility planning at the state and utility level. Stating that the fundamental purpose of such planning would be to provide energy services - not electricity - to consumers at least total cost, those analysts advocate use of end use engineering models, supply curves of conserved energy, and other tools to determine the proper mix of conservation measures and new power generation facilities. Other analysts claim that the least cost approach overlooks important implementation problems, a tight linkage between electric and economic growth, and possible inequities for consumers who do not participate in utility conservation programs. This literature is silent with regard to blacks and Hispanics.

Prior to the energy price shocks of the 197Os, minority researchers had little reason to study energy issues. Following the price shocks, they paid more attention to energy, focusing primarily on the consumption and expenditure patterns of black households. They have paid little attention to electric power issues, perhaps because only a relatively small fraction of minority households use electricity to heat or cool their homes or use a wide variety of electric appliances. The minority energy research literature has been very quiet about electric power and least cost planning, and has not yet prepared an end use analysis of black and Hispanic electric power consumption.

This paper sought to unite the least cost and minority energy literatures. It also sought to make a unique contribution to that literature by (1) identifying the relationships between growth in electric power and growth in black household income; and (2) identifying key states that minority least cost researchers should focus on. This effort tentatively revealed that there was an inverse relationship between energy input at electric utilities and median black household income over the period 1970-82. It also revealed that 10 states, led by New York and Illinois, deserve priority attention from minority least cost researchers.

Least cost utility planning is perhaps the most important and controversial topic in the electric power arena todey. If pursued successfully, it would lead to fundamental change in the industry. If blacks and Hispanics are going to play a significant role in shaping that change,

then minority least cost researchers will have to pay more attention to the industry. In particular, this paper suggests that they would pursue any of the following research topics:

- How are blacks and Hispanics affected by macro changes in electric power supply and GNP? Are further investments in new generating capacity good for black and Hispanic household incomes, or would those households benefit more from investments in end use efficiency?
- How do the end use electricity consumption patterns of black and Hispanic households differ from that of non-minorities or the U.S. population as a whole?
- What would a minroity end use model look like? In particular, how does the discount rate of black and Hispanic households differ from non-minority households, controlling for income?
- What kinds of marketing programs are needed to ensure that black and Hispanic householders conserve electric energy on a predictable schedule?
- How would improvements in the annual incomes of black and Hispanic households affect - through increased market saturation of air conditioning and electrical appliances - national and regional residential electricity consumption forecasts?
- In those states that have already adopted the least cost strategy, what modifications are necessary to ensure that blacks and Hispanics receive their fair share of the resulting costs and benefits?

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A MODEL TO ASSESS THE RELATIVE IMPACT OF POLICY IN TRANSPORTATION ENERGY EXPENDITURES

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A MODEL TO ASSESS THE RELATIVE IMPACT OF POLICY IN TRANSPORTATION ENERGY EXPENDITURES*

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ABSTRACT

The paper describes recent results of the ongoing development of the Minority Transportation Allocation Model (MITRAM) now under development at Argonne National Laboratory for the U.S. Department of Energy's Office of Minority Impact. Results of application of standard methods of statistical analysis of the Nationwide Personal Transportation Study (NPTS) surveys of 1977 and 1983 are presented. Before presenting the NPTS-based statistics, non-NPTS national statistics are used to compile a description of 1977-83 changes in transportation costs and transportation-related consumer and household responses to those changes. T-tests for differences between 1983 NPTS means are then used to develop static comparative analyses of the relative economic, demographic and transportation consumption positions among whites, blacks, Hispanics, and "other" minorities. Dynamic 1977-83 percentage change comparisons by income and minority status are then compiled. Preliminary estimates of household-based vehicle holdings and vehicle-miles-traveled submodels which will be used as components of MITRAM are presented. In this paper ordinary least squares is used to estimate these submodels, and dummy variables are used to test for differences in minority and white behavior. Although time dummy variables are used to test for changes in coefficients from 1977 to 1983, the time coefficients are interpreted as representing the reaction of households to 1977-83 changes in transportation costs. The preliminary nature of the results causes us to be cautious about drawing conclusions. However, although statistically significant differences between transportation choices of minorities and whites appear to hold after controlling for socioeconomic attributes of the household such as household income, age and education of the household head, number in the household and access to transit, the statistics presented imply to us that the dominant forces

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that act on the minority household to determine transportation consumption are the same as those that act on whites. Overall, the most important differences between whites and minorities appear to be the differences in household income, education, employment, and demographic structure. Among low income households, however, minorities appear to have suffered relatively more as a result of the effects of the sharp 1977-83 rises in real used car and gasoline costs.

INTRODUCTION

This paper discusses ongoing developing of the household-based Minority Transportation Allocation Model (MITRAM) of vehicle and transportation energy consumption. The MITRAM will identify and account for differences in minority (black, Hispanic and "other" minorities) and majority (white) patterns of vehicle holdings and transportation energy consumption. The MITRAM is being formulated in such a fashion that its outputs will be compatible with Argonne's Minority Energy Assessment Model (MEAM) (see Poyer, 1983) and the Disaggregated Vehicle Stock Allocation Model (DVSAM) (see Saricks, 1985). The MEAM currently projects residential energy consumption by minority status, by fuel type, and by four census regions, but does not project transportation energy consumption. The DVSAM is a household based model adapted from a model developed by Lave and Train (1979). The model uses detailed household data and fuel price projections to build up the stock of vehicles held by all households and the vehicle miles of travel (VMT) generated by the vehicles held by all households and the vehicle miles of travel (VMT) generated by the vehicles used by those households. From estimates of the fuel economy of vehicles and the cost of fuel, national projections of transportation fuel consumption are generated. In its current form the DVSAM contains no information distinguishing minority households. The implicit assumption in the current version of DVSAM is that, for a given set of household characteristics, minorities and whites behave identically with regard to vehicle purchases and use. To the best of our knowledge, this implicit assumption has never been tested. In principle, if our tests of the assumption reveal it to be correct or nearly correct, the current version of DVSAM could be readily adapted to provide estimates of minority transportation energy consumption, so long as the income and demographic characteristics of minority households could be specified separately for minorities and others. Alternatively, if this research indicates that statistically significant and numerically substantial differences do exist, a new or revised model structure might be necessary.

Other research to be sponsored by DOE's Office of Minority Economic Impact will result in a model which predicts how the household income of minorities differs from that of whites during fluctuations in macroeconomic activity. That research, along with Census Bureau projections of the demographic characteristics of minorities, will provide the input projections to be used by the MITRAM for use in the MEAM. When combined, these research efforts will allow a complete description of the energy related responses of minorities to various energy, income and transportation policies, thereby providing a policy evaluation tool not previously available.

The research reported in this paper uses the 1977 and 1983 Nationwide Personal Transportation Study surveys (NPTS's) to estimate the cross-section and time responses of minority and majority households in terms of variations in vehicles held by the household, VMT per household vehicle, 1983 dollar income of the household, education and age of the household head, transit availability to the household, workers and non-workers per household, and urban vs. rural location.

Unfortunately, the NPTS's are conducted only once every few years and they do not include information on census region, on vehicle purchase cost or on gasoline cost. In principle, the absence of regional detail is a problem. However, according to research by Train (1986), in contrast to the power of regions to explain residential energy consumption in MEAM, the amount of variation in VMT explained by MEAM's census regions is statistically insignificant. MEAM also has the problem of not being able to account for many of the effects of costs and attributes of capital equipment such as furnaces and air conditioners, so the absence of detail on vehicle cost in the NPTS does not make this analysis any less revealing than that allowed by the five 1978-83 RECS surveys used to estimate MEAM.

In fact, the presence of vehicle attributes in the NPTS data bases makes the NPTS surveys more useful in terms of determining the capital stock (vehicle attribute) tradeoffs made by consumers in response to the sharp rise in gasoline prices from 1977 through 1983. The absence of gasoline price data and annual NPTS surveys, however, does create problems relative to the detail required by MEAM. Where MEAM estimates benefited from the high degree of both spatial and temporal variability of fuel prices, thus providing a rich source of information on the residential response to consumers to variations in energy price, the NPTS suffers severely by comparison. The greatest deficiency of the NPTS is the absence of annual surveys, because the variation of gasoline price over time has been far greater than the relatively small spatial variation of gasoline prices. If annual surveys had been taken it would be possible to impute gasoline prices by year and capture most of the variation over the 1977-83 period.

BACKGROUND

With these characteristics of the NPTS's in mind, it is helpful to examine other data sources concerning patterns of change of transportation costs, demographic structure, and consumer income from 1977 to 1983, relating changes in vehicle purchase patterns and VMT to the changes in these variables. This discussion will then be used as a point of reference to help assess the reasonableness of statistics developed from the two NPTS's. One potential problem with the 1977 to 83 comparisons is the far smaller sample size of the 1983 survey. There were 17949 observations in the 1977 NPTS, but only 6438 in the 1983 survey.

The microeconomic framework for assessing consumer responses to changes in fuel prices suggests that two effects exist - the substitution effect and the income effect. These effects are to be determined for a given level of consumer income. For the substitution effect, the degree to which other goods are substituted for fuel, holding consumer welfare (utility)

constant, would be determined. The income effect recognizes that, if fuel prices increase but all other prices and consumer income remain the same, consumers will be worse off, even after they substitute other goods for energy. The microeconomic income effect determines how much money consumers would have to be given to make them as well off as before the energy price increase. At this point in the MITRAM research there has been no effort to create specific estimates of the income and substitution effects. Nevertheless, this framework has been used conceptually in the selection and consideration of the statistics presented here.

The likelihood of the existence of a second, and perhaps even more important income effect resulting from energy price shocks has been studied recently by several economists, including Santini. This is a macroeconomic income effect in which energy price shocks have been shown statistically to precede decline in real national output and by inference, the real income of consumers with about a one year lag. See Santini (1986) for further discussion of this research. This latter area of research implies that real income of consumers is reduced through both microeconomic and macroeconomic effects of real energy price increases. The 1977 and 1983 NPTS's are especially useful in identifying whether minorities are effected differently than the majority by energy price shocks, because the largest two year percentage rise in gasoline prices in U.S. history occurred in the midst of this interval. It should be emphasized, however, that the statistical studies estimating losses of national income due to energy price shocks have similar results for periods other than the 1970s and 80s, so the 19770-83 interval may be unusual in the degree of energy price reaction, but not in the nature of that reaction.

The basic questions about reactions to energy price to be addressed in this paper fall into two broad categories, which are best described as income and substitution questions. First, did minority and white income appear to be reduced by the rise in energy prices that occurred from 1977-83, and further, was there evidence of a differential effect for minorities? Second, given the income effects suffered by minorities, is there any evidence that minorities substituted other goods for vehicles and vehicle travel any differently than whites?

Income Effects, 1977-83

There is little doubt that the real household income of white and minority households dropped sharply from 1977-83, and that the income of blacks and Hispanics dropped more sharply than that of whites. In 1984 constant dollars, the median household income of whites dropped by 6.7% from 1977 to 1983, while the median for blacks dropped by 10.1% and that for Hispanics dropped by 9.8% (Statistical Abstract, 1986, p. 445). Correspondingly, the proportion of households living in "poverty" (less than $10,000 in 1984 dollars) increased for all three of these groups, but more for minorities than whites. The proportion of whites in this category increased from .178 to .197 (a 10.7% increase in the proportion) from 1978 to 1983, while the analogous values for blacks increased from .358 to .406 (a 13.4% increase in the proportion), and for Hispanics from .241 to .311 (a sharp 29% increase in the proportion) (Statistical Abstract, 1986, p. 445).

Information on job growth per household implies that Hispanic households suffered real income losses even though they increased the number of jobs held per household and held more jobs per household in 1983 than whites. In 1977 the number of jobs held per household for whites was 1.22, for blacks 1.07, and for Hispanics 1.23 (Statistical Abstract, 1984, pp. 406, 459). By 1983, this figure had dropped to 1.20 for whites and 1.01 for blacks, but had increased to 1.27 for Hispanics (Statistical Abstract, 1986, pp. 391, 445). If these figures are divided into the corresponding median income figures, the number of dollars of median household income per household worker for Hispanics in 1983 is 12,950 in 1984 dollars, a figure only slightly higher than the 12,844 value for blacks. This represents a very sharp 13% 1977-83 drop of median real household income per worker for Hispanics, a value well in excess of the 5% drop for blacks and whites. The validity of these numbers is supported by the earlier figures on changes in the proportion of households in poverty for whites, blacks, and Hispanics. Although median incomes per household and per worker dropped from 1977 to 1983, the mean income per worker stayed almost the same. When the total national value of personal income for 1977 and 1983 is divided by the total number of workers employed and the 1977 value is inflated to 1983 dollars using the Consumer Price Index (CPI), mean personal income per worker was estimated to be $27515 in 1977 and $27213 in 1983, a drop of 1%.

In summary, these statistics show that, although real income per worker was about the same in 1983 as in 1977, real income per household declined because of a decline of number of workers per household in black and white households, and because of a sharp decline of income per worker in Hispanic households. There were relatively more households living in poverty (10,000 household income) in 1983 than in 1977, and the median income per household in all three categories dropped.

Substitution Effects

Among the most important of the energy price changes which precipitated many of the income changes discussed above was the 13% 1977-83 real increase in the cost of gasoline (EIA Annual Energy Review, 1985, p. 139). The worst of the gasoline price increases occurred from 1978-80, when a 60% real increase occurred. Thereafter, economic conditions deteriorated rapidly, and two recessions were experienced from 1980-82. The average "transactions cost" of these few new passenger cars that consumers chose to purchase increased in real terms by 7.7% from 1977-83 for new U.S. manufactured passenger cars (Motor Vehicle Manufacturers Association, 1986). These cars were more efficient in 1983 than those available in 1977. The average new car in the domestic fleet got 17.2 mpg in 1977 and 24.2 mpg in 1983 (MVMA, 1984, p. 73). With this efficiency gain and the pattern of annual use of cars purchased new as estimated in the 1983 NPTS (p. 4-23), and the 1983 car loan rate of about 12%, it would have taken a consumer approximately 6 years to recover through reduced fuel costs the added cost of a preferred 1983 car relative to a 1977 car. As a result of the combined effects of the 1978-80 fuel price increase and the Corporate Fuel Economy Standards, the automobile industry had, by 1983, provided a more fuel efficient car, although at an increase of 7.7% in real transactions cost.

Unfortunately, during the same time, real household income had dropped sharply and interest rates on car loans rose substantially. The result was a substantial reduction in the affordability of new cars. The response was to increase the length of finance periods in order to allow monthly payments to remain almost constant as a share of income. In 1977 the average annual loan payment per new car was 11.4% of median income and in 1983 it had been held to 11.8% by an extension of the average loan maturity from 40.7 to 45.9 months, a 13% increase (MVMA, 1986). For their part, consumers drove new cars 18% more miles in the first two years of use than they had in 1977 (U.S. Department of Transportation, 1986, p. 4-23), in order to get a quicker return on their investment in better fuel economy. In spite of these measures, preferred new cars were less affordable on the average. Consequently, new car sales dropped rapidly. In 1983 the number of cars and trucks in use from 0-4 years of age dropped by 15% from the 1977 value, while the number of cars and trucks greater than 4 years old increased by 30% (MVMA, 1978, 1984).

The demand for used cars apparently increased sharply, resulting in reduced scrappage rates (MVMA, 1986) and higher used car costs. Passenger car scrappage dropped from 8.23 million in 1977 to 6.24 million in 1983, a drop of 24%. Scrappage jumped by 18% from 1978 to 1979 to its all-time and 1977-1983 peak - probably as a result of the price shock making many low mpg cars obsolete. (Scrappage had also jumped to an all time peak during the 1973-74 oil price shock, and also dropped sharply during the ensuring recession). June prices of used cars sold at wholesale auctions increased in real terms by 16% from June of 1977 to June of 1983 (Crain Automative Group, April 24, 1985, p. 56), and the average real amount financed increased by 12.5% (MVMA, 1986). The real used car wholesale price increases did not occur until after the 1978-80 real gasoline price run-up. The real cost of a used car actually was lower in 1980 than in 1977, and the same was true for the average transactions cost of new cars. However, from 1980 to 1983, by these measures, the real cost of new cars increased by 15%, while the real cost of used cars increased by 27%. For used cars the average length of financing period increased from 31 months in 1977 to 38 months in 1983, a 22% increase.

Obviously, those households living below this paper's "poverty" line ($10,000 1983 dollars) do not purchase new cars. The fact that prices of used cars rose more rapidly than those of new cars means that poor households suffered relatively more than other households. Since black and Hispanic households are more often poor, they obviously suffered relatively greater losses than whites from reduced vehicle affordability. Further, unlike new car buyers at the top of the income scale, those used car buyers at the bottom of the scale were unlikely to get improved fuel economy in exchange for the higher price paid for a car. From 1977 to 1983, the number of cars over 16 years old increased by 188 percent (MVMA, 1978, 1984). Given their vintage, the 1983 16+ year old cars were not likely to be more fuel efficient than those kept in use in 1977.

At least some of the poverty level households should have been tempted by the used car and fuel price increases to switch to transit. This behavior was made even more likely by the declines in the real cost of transit that were achieved by a 65% real increase in state and local subsidies of transit operating expenses in 1983 as compared to 1977. This increased subsidy

more than offset the 6% real drop in the small share of operating expenses paid by the federal government, and resulted in about a 23% drop of average real costs to transit passengers (Statistical Abstract, various issues).

However, the only age group that used transit more frequently in 1983 was 16-19 year olds (U.S. Department of Transportation, 1986). The percentage of registered drivers in this group declined from 69.2 to 64.2 percent from 1977 to 1983 (U.S. Department of Transportation, 1986, p. 4-3). The increase in use of transit by this group was from 2.9 to 3.3 percent (U.S. Department of Transportation, 1986, p. 6-5). Geographically, the apparent price opportunities offered by transit were only used in center cities. There the average share of trips made by transit increased from 4.7% in 1977 to 5.4% in 1983. In suburbs and rural areas the rate of use of transit dropped (U.S. Department of Transportation, 1986, p. 6-13.)

Even though the number of 0-4 year old cars and trucks dropped sharply from 1977-83, the increased use of used vehicles caused the number of vehicles in use to rise more rapidly than the driving age (above 18) population and the number of registered drivers. However, on the average, national statistics imply that individual vehicles were not driven as many miles in 1983 as in 1977, with the net result that the car and truck VMT per driving age person or per registered driver was nearly the same in 1983 as in 1977. (This did, however, represent a probable sacrifice in terms of consumer expectations, since VMT per registered driver had been increasing at an average rate of 1% per year from 1970-77). Based on results presented later, the changes in this average contradict the behavior adjustments of the subset of individual households with non-retired heads as estimated with NPTS data. The latter statistics, combined with the statistics presented later in the paper, may indicate that retirees behaved very differently. Such differences are not addressed in this paper.

It is possible that a trade-off in reliability was involved in the pattern of behavior discussed above. Since used cars are less reliable than new cars, it was probably necessary to keep more cars in use to allow the same amount of VMT per driver. It is also likely that the sharp increase in used car prices resulted from the efforts of former new car buyers to economize on the fixed costs of cars and trucks so that the same amount of VMT could be enjoyed in spite of higher gasoline costs. This hypothesis is supported by the fact that the share of total personal consumption devoted to user-operated transportation declined from 14.7% in 1977 to 13.0% in 1983. During the same time the share of user-operated transportation spending devoted to gasoline increased from 25 to 31% (MVMA, 1986). Given the maintenance of VMT and the drop in new car purchases, it is obvious that consumers generally substituted older, cheaper cars for the cars they had previously purchased, and continued to drive about the same amount of miles. In economic terms, the demand for total vehicles and VMT was very inelastic, but the demand for new vehicles was very elastic.

HOUSEHOLD CHARACTERISTICS, 1983

Although it is undoubtedly presumed that typical minority households are different from typical white households, with Table 1 we begin our detailed study of household transportation consumption behavior by comparing white and minority mean household

characteristics in the 1983 NPTS data base and showing whether or not the groups are significantly different in the statistical sense.

TABLE 1 - Mean Household Attributes for Whites and Minorities, 1983 NPTS

Household Attribute	White	Black	Hispanic	Other
Size (Number)	2.61	2.89 (3.90*)	3.63 (8.71*) (5.60*)	3.12 (3.38*)
Age of Head (Yrs.)	48.0	46.3 (-2.31*)	41.3 (-7.30*) (-4.49*)	40.9 (-5.42*)
Education of Head (Yrs. of School)	12.8	11.0 (-11.64*)	10.2 (-9.44*) (-2.71*)	13.3 (1.34)
Number of Workers	1.20	0.93 (-7.41*)	1.30 (1.76) (5.54*)	1.36 (1.98*)
Vehicles Owned	1.79	0.99 (-18.99*)	1.46 (-4.67*) (6.05*)	1.64 (-1.40)
Vehicle Miles of Travel per Yr. x 10^3	17.02	8.38 (-16.04*)	13.13 (-3.87*) (4.56*)	15.83 (-0.85)
Access to Transit (1 if $\leq$2 mi., 0 else)	0.60	0.79 (11.19*)	0.83 (10.06*) (1.58)	0.86 (8.52*)
Distance to Transit if $\leq$2 mi. (Blocks)	4.40	3.02 (-9.33*)	3.66 (-2.66*) (2.20*)	3.83 (-1.58)

*Indicates that the means are different with 95% certainty (t-values) are given in parentheses - first t-value compares minorities to whites, while second under Hispanics compares blacks and Hispanics

The statistics in Table 1 show that average black households were, in the statistical sense, significantly differently from whites in each of the eight attributes listed, while Hispanics were significantly different in seven of the eight attributes. "Other" minority households, however, differed significantly from whites in only four cases. The second set of statistics listed in the Hispanic column indicate that the differences between black and Hispanic households were significant in every case. It can be said that the 1983 NPTS implies that, on the average, minority households are consistently larger than white households, that the heads of minority households are consistently younger than whites, that minority households drive fewer miles, and that they live where they have better access to transit. Blacks and Hispanic household heads have less education than white household heads, and, when they live within 2 miles of transit, black and Hispanic households live closer than white households. There is a very large difference in the number of workers in the households of Hispanics and blacks, with Hispanics having more workers per household. As a result of the greater number of workers in Hispanic households, Hispanic households presumably own more cars to get to work and they drive more. The statistics reflect these realities.

SAMPLE CHARACTERISTICS

The statistics presented in Table 1 are based on the full 1983 NPTS sample of 6438 households. The sample size for the first five of the eight attributes is 5332 for white households, 683 for blacks, 291 for Hispanics (non-black Hispanics), and 132 for other minorities. Sample sizes for the other three attributes are slightly smaller because of missing or non-applicable values. Discussions of the meaning and validity of various statistics is available in the 1983 NPTS's.

The remaining statistics compiled for this paper are for a condensed sample which was designed to get a more accurate picture of the impacts of the 1977-83 user provided transportation cost increases on minority households. Since minority households more often have a permanently low income and consequently a lower wealth level than white households, an effort was made to separate the permanently poor from the transitory poor. Similarly, an effort was made to examine effects on those households which needed employment to maintain the household. Households headed by a retired person were deleted from the sample. Those households which had income of less than $10000 but were able to afford and use relatively new cars were assumed to have a much higher permanent income than the $10000 value recorded in the sample year. Accordingly, we deleted those $10000 income households with a single car two or less years old and those $10000 income households with two vehicles each less than 6 years old and driven 12000 or more combined miles per year. Those $10000 income households headed by a person over 17 who was a student were considered to be college students who had reason to expect a far higher permanent income in the future and were deleted. In the 1983 sample it was also possible to isolate those $10000 households that lived in a rent-free dwelling or who lived in a household with $10000 of "non-family" income. Those were also deleted on the assumption that their real household income was understated by an unknown amount. If there is any bias introduced by these last two deletions, it would be to understate low income vehicle holdings and VMT in 1983 relative to 1977.

Even with this potential bias, the 1983 to 1977 comparisons indicate that, on the average, households with income $10000 were forced by circumstances or preverse preferences to increase vehicle holdings per worker and VMT per worker more than higher income groups. In fact, on the average, those in the sample with incomes above $10000 reduced their vehicle holdings per worker and the reduction was greatest for the highest income group.

These deletions resulted in about a 15% reduction in overall sample size for both the 1977 and 1983 NPTS. As we expected, the percentage reduction was greatest for whites, amounting to 15.8% in 1983. The 1983 percentage reductions for blacks, Hispanics and others were 13.3%, 8.9%, and 12.9%, respectively. Final sample sizes for statistics presented below were 5459 for 1983 and 15254 for 1977.

TRANSPORTATION ADAPTATION, 1977-83

An important question about the attempted adaptation of households to rising gasoline prices is the question of success or failure of the adaptation strategy. Economics does not assert that all members of society will adapt successfully (or even in similar ways) to changes in conditions. Basic models of competition, for example, simply say that those participants in the market who are not or cannot be competitive will fail. An argument was presented earlier which asserted that it would be reasonable (economically rational) to expect substitution of transit transportation services for vehicular transportation services, given the sharp rise in costs of vehicles and gasoline from 1977-83. Since it was argued that higher income consumers would shift their purchase pattern from newer to older, cheaper vehicles, thus driving up the cost of used cars, the "trickle down" effects should force households in the lowest income brackets to most frequently attempt to substitute transit services for vehicular transportation services. Given the geographic distribution of the best transit services - i.e. in urban areas and central cities of SMSAs, one might anticipate an increase in the tendency for the poorest households (who are more often renters) to move to urban areas and central cities in the event of a gasoline price increase. In fact, the only SMSAs for which the annual miles driven per driver were reduced were those of 3 million or more population, where transit systems are well developed (NPTS, 1983, p. 4-9). The potential flaw in the movement of low income households toward good transit service, however, is the well established trend of movement of jobs away from central cities and into the suburbs. If the poorest households were to move closer to transit because of its lower cost at the same time that the number of jobs accessible by transit was decreasing, the ability of the poor to reach low paying jobs might actually diminish as a result of the apparently logical decision by the household.

The 1977-83 NPTS statistics are consistent with the pattern of change described above. Use of transit increased in center cities at the same time it was decreasing in suburbs and rural areas (NPTS, 1983, p. 6-13). The proportion of households living within two miles of transit increased on the average for all households living within two miles of transit increased on the average for all household types, but it increased far more dramatically for those households earning less than $10,000 in 1983 dollars, and, among those households, it increased most dramatically for minorities. The same pattern of behavior was exhibited with respect to the distance to transit (Table 2). The NPTSs indicate that reductions in the distance to transit

were exhibited for all classes of household, but that these reductions resulted only from reductions within urban areas. In rural areas the distances increased for all but "other" minorities (Table 2), and in areas outside SMSAs the proportion of trips by transit decreased by 50% from 0.008 to 0.004 (NPTS, 1983, p. 6-13). The NPTS's sample distributions indicate that the proportion of minorities living in urban areas increased from 1977-83, while the proportion for whites decreased slightly. This continued and, based on changes in proportions of urban and rural households in our modified NPTS samples, accelerated a strong trend of movement from rural to urban areas by minorities that had been established from 1970 to 1980 (Statistical Abstract, 1984, p. 18)

The pattern of VMT per worker for those poor households that had work and owned cars indicates that they had to drive considerably farther in 1983 than they did in 1977 (Table 2). The increase in the amount of VMT per worker for those residing in urban areas was greater for white, black and Hispanic households earning less than $10000 than it was for the middle and upper income categories. For the urban and rural households combined, every household type with less than $10000 of income increased its VMT per worker more than households

TABLE 8 Percentage Changes in Household Attributes and Transportation-related Adaptations, by Income, 1977-83

Income Range Category	Workers per Household	Vehicles per Worker	Urban VMT per Worker	Aggregate VMT per Worker	VMT per Vehicle	Access to Transit[a]	Distance to Transit[b] Urban	Rural	Total
<10,000									
White	-0.9	9.0	18.0	24.2	14.3	5.7	-19.4	-2.0	-12.6
Black	-6.6	2.1	27.1	54.4	56.1	12.6	-52.6	-2.7	-40.6
Hispanic	18.6	-30.9	80.7	37.7	91.7	17.5	-39.2	12.5	-40.7
Other	57.6	-35.9	19.7	31.6	108.9	19.4	-78.3	-39.5	-62.6
TOTAL	-0.0	3.6	21.2	28.4	23.8	8.1	-30.5	-2.0	-20.1
10,000-25000									
White	0.6	-2.6	5.4	12.1	19.3	4.8	-19.8	2.7	-7.8
Black	-1.5	3.5	25.1	23.8	17.2	2.2	-21.9	5.1	-20.3
Hispanic	3[illegible].6	-11.8	-15.7	-10.7	-2.8	-0.6	14.1	-7.4	8.3
Other	13.3	1.1	19.8	18.9	12.8	8.5	22.4	-2[illegible].7	-16.8
TOTAL	8.7	-0.4	6.3	12.2	15.6	4.4	-17.5	2.5	-6.3
>25000									
White	15.6	-8.2	2.2	6.0	13.6	1.2	-18.7	5.2	-3.8
Black	19.1	-10.3	-9.9	-8.8	-1.6	0.1	43.3	28.1	25.1
Hispanic	23.9	1.6	-4.4	-0.8	0.8	5.8	-8.2	25.2	-2.8
Other	1.0	1.8	9.5	23.5	21.7	9.4	-16.3	11.9	-14.6
TOTAL	15.9	-8.2	0.8	5.1	14.3	1.8	-17.1	5.8	-3.9
GRAND TOTALS									
White	9.4	-3.2	3.5	9.8	13.6	3.4	-20.1	2.6	-6.9
Black	0.3	-0.8	8.4	19.7	19.7	6.5	-23.6	2.4	-24.3
Hispanic	24.7	-14.2	4.1	3.1	19.7	7.1	-9.8	4.0	-12.4
Other	18.3	-1.0	20.1	30.3	29.2	11.1	-10.4	-13.8	-24.7
TOTAL	9.4	-3.8	3.0	10.1	14.1	4.2	-20.7	2.6	-9.2

[a]See Table 1 for access variable definition
[b]Assumes that all households in excess of 24 blocks from transit are 30 blocks away

of greater income. In fact, black and Hispanic households with above $25000 of income were estimated to have reduced VMT per worker (Table 2). Many of these same households were probably also able to purchase a new, more fuel efficient car, thereby reducing gasoline spending even further. These NPTS statistics imply that low income black and Hispanic households may have suffered most severely from higher vehicle operating costs, while upper income blacks and Hispanics probably reduced these costs, while whites and other minorities may not have done so. It must be kept in mind, however, that the sample size for upper income minorities is relatively small in 1983, ranging from 114 for blacks down to 54 for "other" minorities.

The overall statistics developed in Table 2 often deviate from those developed from national statistics and presented in the introduction. They also appear to deviate from the some of the detailed statistics developed in the NPTS Vol. 1. These differences are occasionally major. Alternative explanations for them have not been examined at this time. Differences from national statistics should be expected due to NPTS sampling error. Differences between our statistics and published NPTS statistics are to be expected due to our sorting of the data to obtain better estimates of the behavior of those households headed by labor market participants (i.e. not retirees) which are likely to have permanently low income. At a later date we will examine the pattern of behavior of retirees and see how their inclusion would affect the inferences about low income households. We have also chosen to present per worker statistics, while per driver statistics are presented in the NPTS. Because of demographic patterns, the number of registered drivers among retired households is increasing far more rapidly than is the number of workers in the population, so the presence of absence of retired households should have a strong effect on per driver vs. per worker statistics.

Past discussion has focused on the 1977-83 adjustment to rising user-operated transportation costs. It has focused more on differences among households in poverty and higher income groups than on differences among minorities and others. As Table 1 shows, this emphasis does not imply that the average minority household will respond in the same way to transportation cost shifts as will the average white household. Since Table 2 clearly shows that there were pronounced differences by poor and non-poor households in response to the transportation cost shifts of 1977-83, it is obvious that the average minority household should have responded differently than whites. These differences show up in the "Grand Totals" rows of Table 2, where the income distributions of minority and white households come into play.

Hispanics reduced the amount of vehicles they owned per worker far more than whites or blacks, but increased the VMT per worker. Blacks and other minorities increased VMT per worker far more than whites and Hispanics, but did not change the vehicles held per worker by very much. The net effect of these patterns was to cause average VMT per vehicle to increase more sharply for all minorities than for whites. Non-retired minority households with current incomes less than $10000 and low expectations for lifetime income increased their VMT per vehicle by any where from 56 to 110%, a far greater amount than for any other household category in Table 2. It seems dubious that such behavior could be due to changed

preferences. Since these groups moved much closer to transit it seems logical that their intentions were to reduce travel expenses. This would be economically rational behavior. The sharp increases in low income minority VMT per vehicle are consistent with the theory that the superficially rational moves that low income minorities made toward transit were mistakes because jobs were moving away from those locations with transit access. The net result, under this theory, was to force low-skill, low income minorities to continue to depend on the automobile to get to work and to force them to travel further to find jobs.

These arguments and patterns have to do with adjustments over time. Unfortunately, the NPTS only covers, for purposes of the year-specific variables used in this study, two points in time. Consequently, there is only a limited ability to confirm the validity of the above arguments with NPTS data. Further, even if detailed information were available for every year from 1977-83, there would still be a description of minority impacts for only one oil price shock. Given these realities, confidence in the above interpretations will, even with further study, be based on the confidence in the logic presented and the degree of belief that this single case is generalizable as a description of a probable sequence of events that would follow from a future oil price shock, absent counteracting policies based on this analysis. It should be stressed that the findings presented at this time are of the nature of a report on work in progress. We intend to conduct further statistical tests to confirm the degree of statistical certainty that can be attached to the differences in minority and white 1977-83 adjustments to changing transportation costs.

PRELIMINARY TRANSPORTATION DEMAND SUBMODELS

Although these caveats are necessary with respect to the time adjustment findings, there is less uncertainty about the general validity of most variables in the preliminary regression models we have included in Tables 3 and 4. the NPTS's are perhaps the best cross-section data bases on travel behavior. Consequently, the ability to assess long-run household transportation consumption patterns with these data bases is excellent. Further, there is precedent in the literature which suggests that certain variables will be important predictors of travel behavior. the Lave-Train, Train, and DVSAM models all contain a set of recognized, accepted predictors of transportation demand behavior. In Table 3 we present an Ordinary Least Squares (OLS) regression model which can be used to predict the number of vehicles held per household. In the final version of the MITRAM a discrete choice model will probably be substituted for this OLS model. However, unlike Train's recent analysis (1986) which confined itself to one and two vehicle households, this analysis includes households with several vehicles. Consequently, vehicles per household is more nearly a continuous function than in Train's analysis, and the use of OLS probably provides a useful first approximation in this case.

At this point, we have run these preliminary regressions with those independent variables that have historically been used in DVSAM, and which the Center for Transportation Research has a history of using in its projections. Consequently, some variables that might provide improvement in the goodness-of-fit of the equation have not been included. For example, although the inclusion of registered drivers per household improves both regression models,

TABLE 3 - Household Vehicle Holding Model [a,b]

	Explanatory Variable	Estimated Coefficient	t-statistic
1.	Adjusted natural log of income (1983$) per worker[c]	.3324	37.46
2.	Education of household head in in terms of number of years of schooling	.0065	2.94
3.	Education of household head if he/she is Hispanic, zero otherwise	.0175	3.01
4.	Dummy variable for age of household head in the age group 34 or younger	-.1104	-4.26
5.	Dummy variable for combined age and time representing the age group in item 4 and the 1983 Survey[d]	-.0954	-3.10
6.	Dummy variable for age of household head in the age group 35-49	.0498	1.78
7.	Dummy variable for combined age and time representing the age group in item 6 and the 1983 Survey[d]	-.0920	-2.74
8.	Dummy variable for age of household head in the age group 50-64	.1242	5.00
9.	Dummy variable for transit accessibility	-.3131	-23.69
10.	Number of household members per worker	.1477	35.12
11.	Number of household members per worker if household head is black, zero otherwise	-.0963	-17.24
12.	Number of household members per worker if household head is Hispanic, zero otherwise	-.1015	-10.45

TABLE 3 - Household Vehicle Holding Model [a,b]

	Explanatory Variable	Estimated Coefficient	t-statistic
13.	Number of household members per worker if household head is of other (nonwhite) race/origin, zero otherwise	-.0845	-6.38
14.	Number of workers in household	.7833	72.40
15.	Number of workers in household if household head is black, zero otherwise	-.1761	-10.43
16.	Number of workers in household if household head is Hispanic, zero otherwise	-.1511	-4.28
17.	Number of workers in household if the sample is from the 1983 survey, zero otherwise	.0613	4.51
18.	Intercept	-.2023	-6.60

[a]Number of observations 20617

[b]The adjusted R-Square for the model was 0.406 while that for the basic model, excluding race/origin and age-time dummy variables -- items 3,5,7,11-13, and 15-17, was 0.384

[c]Log of the lowest income in the dataset ($1,588) was subtracted from the log of income per worker.

[d]This dummy variable represents the combined effect of time and age. Its value is one if both the conditions are met, zero otherwise

TABLE 4 - Vehicles-Miles-of-Travel per Vehicle Model[a,b]

	Explanatory Variable	Estimated Coefficient	t-statistic
1.	Number of workers per vehicle	2380	11.89
2.	Adjusted natural log of income (1983$) per worker[c]	2103	19.34
3.	Adjusted natural log of income (1983$) per worker if household head is Hispanic[c], zero otherwise	1031	2.27
4.	Fraction of newer vehicles (up to four years old) among household vehicles	1282	6.12
5.	Fraction of newer vehicles (up to four years old) among household vehicles if the sample is from the 1983 Survey, zero otherwise	1570	3.65
6.	Education of household head in terms of number of years of schooling	366	13.93
7.	Education of household head if he/she is Hispanic, zero otherwise	-235	-2.73
8.	Education of household head if the sample is from the 1983 Survey, zero otherwise	-141	-4.71
9.	Dummy variable for combined effect of single vehicle ownership and the 1983 Survey[d]	2519	6.73
10.	Dummy variable indicating ownership of two vehicles	672	4.03
11.	Dummy variable for combined effects of two vehicle ownership and the 1983 Survey[d]	1271	3.35
12.	Dummy variable for age of household head in the age group 34 or younger	3506	10.92
13.	Dummy variable for combined effects of age of head and time, representing the age group in item 12 and the 1983 Survey[e]	1531	3.92

TABLE 4 - Vehicle-Miles-of-Travel per Vehicle Model[a,b]

	Explanatory Variable	Estimated Coefficient	t-statistic
14.	Dummy variable for age of household head in the age group 35-49	3522	10.76
15.	Dummy variable for combined effects of age of head and time, representing the age group in item 14 and the 1983 Survey[e]	1036	2.69
16.	Dummy variable for age of household head in the age group 50-64	2959	9.72
17.	Distance to the nearest transit facility in number of blocks	28	4.50
18.	Distance to the nearest transit facility if the sample is from the 1983 Survey, zero otherwise	41	3.66
19.	Number of non-workers per worker if the head of household is black, zero otherwise	-779	-6.61
20.	Number of workers in the household	1003	7.94

[a]Natural log of VMT/Vehicle modeled with 16643 observations, zero vehicle households excluded

[b]The adjusted R-square for the model was .137 while that for the basic model, excluding race-origin and age-time dummy variable -- items 3,5,7-9,11,13,15,18, and 19 was .131

[c]Log of the lowest income in the dataset ($1,588) was subtracted from the log of income per worker

[d]This dummy variable represents the combined effect of time and vehicle ownership. Its value is one if both the conditions are met, zero otherwise

[e]This dummy variable represents the combined effect of time and age. Its value is one if both the conditions are met, zero otherwise

we have no experience with projections of registered drivers, so the variable has not been included at this time. Further, although female headedness might improve the explanatory power, we, Lave, and Train have not historically broken out households by this criterion, so it has not been included in the early experiments.

The regressions presented in Table 3 and 4 include "dummy" variables designed to test whether minority households differ significantly from whites in their vehicle ownership and use patterns. Dummy variables were also used to test whether or not 1983 aggregate household values differed significantly from those that existed in 1977. We also tested whether overall (but not attribute specific) minority behavior was significantly different in 1983 than in 1977, after accounting for all other effects. We used a criterion of 95% certainty that coefficients were different from zero as the basis for retaining any coefficient (or logically bunched group of coefficients - i.e. age dummies in Table 3) in the models. We used the same criterion to test whether significant differences of minority coefficient values were present compared to those of whites. By this criterion, overall minority vehicle ownership and use patterns were not significantly different from those of whites, either in general or in 1983 as compared to 1977. However, minority coefficients did occasionally differ significantly for certain household attributes.

Time alone did not matter. In other words, the intercepts for the vehicle per household model and the VMT per vehicle model and the VMT per vehicle model did not shift significantly in 1983. Like minority coefficients, time coefficients did occasionally differ for certain coefficients of household attributes.

Another test that we conducted was to compare the goodness-of-fit (R^2) of a base model without minority and time coefficients and compare the base and minority/time enriched models. This showed that the vast majority of household behavior is explained by standard formulations consistent with travel demand models already in the literature. The R^2 value for the base vehicle per household model was .384. Adding statistically significant minority and time dummy variables increased the R^2 to .406, indicating that adding minority variables improved the R^2 by only about 5%. For the base VMT per vehicle model the corresponding R^2 values were .131 and .136, indicating that adding minority variables gave about the same degree of improvement.

The low R^2 values obtained in our current VMT per vehicle model are disappointing but they are consistent in size with Train's latest model, which used the 1978 NTS compiled by Cambridge Systematics. Train separately estimated two OLS VMT equations for one and two vehicle households, obtaining R^2 values of .114 and .117. Train's VMT models included an instrumental variables estimate of operating cost and relative newness of the vehicle in addition to household and geographic area descriptions (Train, 1986). In our models an operating cost variable has not yet been constructed, but the 1983 time dummy variables are interpreted as indicators of response to changes in travel costs.

Train's two VMT models contained ten and eleven variables respectively. In the one vehicle version of these models only one of ten independent variables was statistically significant at the level used here, while in the two vehicle version four were significant.

The models presented in Tables 3 and 4 were formulated in parallel with the adjustments analysis presented in Table 2. At the time it was believed that formulation of income as a continuous variable would be the theoretically proper approach for the regression models. However, the apparently unique adjustment behavior of low income minority households suggests that retesting of these equations with discrete income classes is desirable. The log of income is used in the equations because it proved to give results superior to income. The log of a base income is subtracted from the log of income simply as a statistical manipulation to alter the size of the intercept term and assure that it did not appear to be unreasonable. The theoretical problem of an estimate of negative vehicle holdings exists with the OLS model but it would be unusual, though not impossible, with the current model. A household which would be estimated to have negative vehicle holdings would probably be a single person in a 1983 household in which the single individual was young, had very little education, very little income, and lived close to transit. Obviously, such households can be easily found in the places where this model implies that they would be found. The problem of eliminating the possibility of estimates of negative vehicle holdings will be addressed later in the study by using alternative forms of estimation and alternative demand theories.

Vehicle Holdings Results (Table 3)

The coefficients of the vehicle holdings model imply that almost one vehicle will be purchased for each member of the household that is working. As the aggregate income of the household rises, the number of vehicles held is likely to rise, but at a decreasing rate with each additional dollar of income. Education of the household head also increases the odds of owning a vehicle. It is thought that some of this effect arises because education may be a surrogate for permanent income and/or wealth. Compared to households which are headed by a working person 65 or over, households with heads younger than 35 own fewer vehicles. Vehicle holding then rises with the age of the household head to values greater than the 65 or older category. The accumulation of wealth over a lifetime of work may increase the odds of owning a vehicle up to the point where the effects of age reduce the ability to drive. The age group dummy variables are consistent with this interpretation. As has previously been discussed, the cost of new and used vehicles was higher in real terms in 1983 than in 1977. Consequently, ceteris paribus, it would have taken more years in 1983 to accumulate enough wealth to own vehicles. Thus, the fact that the younger age groups were less likely to hold vehicles in 1983 than in 1977 is economically logical. If the household lived within two miles of transit it owned about one-third less cars on the average. When whites added household members per worker they were likely to add vehicles to provide those members with mobility.

All three classes of minorities, however, were far less likely to add vehicles than were whites as the number of household members per worker increased. Minority status also reduced the likelihood of owning vehicles as workers were added to the household. Blacks and Hispanics

owned about a sixth fewer cars per worker than whites. In 1983 the number of cars required per worker apparently increased. This may have simply been a result of continuing suburbanization and movement to the auto dependent south and west.

Vehicle-Miles of Travel Per Vehicle (Table 4)

Each worker per vehicle causes about 1400 VMT per year. Use of the vehicle also increases with income, but at a declining rate. Hispanics, who are geographically concentrated in the auto-dependent cities of the south and west, travel more per dollar of income than whites. To the extent that they are seasonal or migrant workers shifting locations this may also contribute to their higher rates of use of the vehicle. Newer vehicles tend to be driven more miles per year than older vehicles. The positive time dummy for the vehicle newness measure supports the earlier argument that purchasers of the more costly but more fuel efficient post oil price shock models were driven more miles per year in their early life in order to get a quicker return on investment. An alternative way to looking at it is that only those persons with relatively high annual travel demand found the capital costs of new cars to be defrayed by operating cost savings. Consequently, these were the only consumers that chose to buy new cars.

As education (and presumed lifetime earnings/wealth) increases, the amount of travel per year increases. The effect, however, is much smaller for Hispanics, the least educated group. This may simply imply that a minimum education level must exist before lifetime wealth, as a statistical average, is significantly affected. Given the increase in 1983 costs of gasoline, the negative sign on education in 1983 may imply that well educated households were better able to group trips together in order to reduce overall VMT.

Both single and dual vehicle households increased the VMT per vehicle, probably allowing reduction of capital expenditures on vehicles. Dual vehicle households used their vehicles slightly more per year than single vehicle households and households owning three or more vehicles. Single vehicle households increased the intensity of use of their vehicles in 1983 by about twice as much as dual vehicle households, who also drove their cars further per year after the rise in real vehicle costs. These results imply, as does Table2, that households compensated for high vehicle costs by reducing vehicle holdings but increasing the intensity of use of the vehicles that were owned.

Households with heads younger than those headed by a working person 65 years or more older consistently used their vehicles for about 3500 more miles of travel per year. As we saw in the vehicle holdings model, those households with heads less than 50 years old were not able to own as many vehicles in 1983 as in 1977. To compensate, they drove the cars that they could afford more miles per year. Further, consistent with earlier arguments, access to transit was not as effective in 1983 as in 1977 in allowing reduction of VMT, so the time dummy indicates more use of vehicles at a given distance from transit in 1983. The hypothesis that the more nonworking members of a household there are the more money must be spent on nontransportation goods was supported in the VMT model with a negative sign on a nonworkers per worker variable. When minority status was separately estimated this effect

appeared to hold only for black households. Future tests will focus on the age of the nonworking household members, testing the assumption that younger household members reduce VMT, while driving age nonworking household members increase VMT. The greater the number of workers in the household, the greater the VMT per vehicle. Since workers per vehicle is in the equation, this coefficient may measure the inability to optimize multiple commuting distances in a single household.

CONCLUSIONS

This paper is a report of work in progress. Although eventual findings are implied by the discussion in the paper, no conclusions are drawn at this time. It remains to be seen whether regression model coefficient estimates are close to the final values that will be used in the eventual projection model. It also remains to be seen whether coefficients similar to these will reproduce the adjustment behavior illustrated in Table 2. Further, the adjustment behavior in Table 2 itself needs to be statistically evaluated to determine whether the differences between minority adjustments and white adjustments are significant.

Where they are significant, we will attempt to assure that the model reproduced that behavior in simulations. The preliminary result in this paper do imply that important differences exist in the sensitivity of the travel demand of minorities and whites to changes in energy price, and that the welfare of black and Hispanic households may be reduced far more dramatically than the welfare of whites in the event of any energy price shock.

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RACIAL AND DEMOGRAPHIC DIFFERENCES IN HOUSEHOLD TRAVEL AND FUEL PURCHASE BEHAVIOR

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RACIAL AND DEMOGRAPHIC DIFFERENCES IN HOUSEHOLD TRAVEL AND FUEL PURCHASE BEHAVIOR*

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ABSTRACT

Monthly fuel purchase logs from the Residential Energy Consumption Survey's Household Transportation Panel(TP) were analyzed to determine the relationship between various household characteristics and purchase frequency, tank inventories, vehicle-miles traveled, and fuel expenditures. Multiple classification analysis (MCA) was used to relate observed differences in dependent variables to such index-type household characteristics as income and residence location, and sex, race and age of household head. Because it isolates the net effect of each parameter, after accounting for the effects of all other parameters, MCA is particularly appropriate for this type of analysis. Results reveal clear differences in travel and fuel purchase behavior for four distinct groups of vehicle-owning households. Black households tend to own far fewer vehicles with lower fuel economy, to use them more intensively, to purchase fuel more frequently, and to maintan lower fuel inventories than white households. Similarly, poor households own fewer vehicles with lower fuel economy, but they drive them less intensively, purchase fuel more frequently, and maintain lower fuel inventories than nonpoor households. Elderly households also own fewer vehicles with lower fuel economy. But since they drive them much less intensively, their fuel purchases are much less frequent and their fuel inventories are higher than nonelderly households. Female-headed households also own fewer vehicles but with somewhat higher fuel economy. They drive them less intensively, maintain higher fuel inventories, and purchase fuel less frequently than male-headed households.

INTRODUCTION

This paper reports on differences in travel and fuel purchase patterns by demographically distinct groups of households. The analysis was conducted as part of an ongoing effort by

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staff of Argonne National Laboratory (ANL) to analyze the relationship between various household attributes (primarily race and income) and transportation fuel use and expenditures. Prior work found a number of racial differences in vehicle ownership and use, particularly among low-income households living in central cities of metropolitan areas,[1,2] and suggested that minority and poor households may respond differently to changes in fuel price and availability, either because of earlier investments in energy-intensive capital equipment or reduced flexibility to adjust household expenditure patterns.[1-3]

The paper focuses on fuel purchase behavior. It includes a brief overview of data and methodology, followed by a presentation of major findings and a discussion of their implications.

DATA

The Residential Energy Consumption Survey's (RECS) Household Transportation Panel (TP) was the principal data source used in the effort.[4,5] The TP data set contains detailed fuel purchase and demographic/socioeconomic information for a monthly sample of approximately 1000 households who used vehicles for personal transportation, along with weighting factors for expanding the estimates to national monthly total (i.e., gallons purchased, fuel expenditures, miles traveled, etc.). Each month's panel was a representative national sample selected from the 48 contiguous states and the District of Columbia. Obtained via monthly logs, purchase data include the total cost and quantity of each fuel purchased, the price per gallon, the vehicle's fuel gauge reading before and after purchase, the odometer reading, and the type of fuel. Demographic/socioeconomic data include income, size and residence location of the household, and race/Spanish origin,* age, and sex of the household head. The weights account for sampling, household nonresponse and, in some cases, partial purchase data (as determined by an edit check). The data was collected over a 28-month period, from June 1979 through September 1981.

DATA STRUCTURE

The TP Public Use Tape is structured into a four-level hierarchy: (1) all records for a given survey month, (2) household records (all records pertaining to a given household participating in the panel during that month), (3) vehicle records (all records pertaining to a vehicle used in that month), and (4) purchase records (all records pertaining to each fuel purchase). The household record is particularly rich. In addition to variables describing the household's demographic, social, and economic attributes, it includes responses to several qualitative questions on the 1979 fuel shortage.

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*Because Spanish origin is coded on only about one-third ofthe records, it could not be used in this analysis.

Because our SAS software does not support hierarchical data structures, data restructuring was necessary. Restructuring involved the following operations:

1. Creating classifying variables. Based on data in the household record, a set of binary classifying variables was created. The full list of classifying variables appears in the Appendix. They included shortage (identifying the most acute portion of the 1979 shortage, i.e., June and July), short (marking those households who claimed they had experienced some problem obtaining fuel), black/nonblack, poor/nonpoor, elderly/nonelderly, etc.

2. Data merging. The classifying variables were posted on the corresponding vehicle and purchase records.

3. Stage one aggregation. Vehicle and purchase records were aggregated one level upward, (i.e., vehicle record data were summarized to create one household record describing all household vehicles; purchase record data were aggregated to create one vehicle record describing all fuel purchased for that vehicle).

4. Stage two aggregation. All data describing one stratum (i.e., one month, or one group of households defined by the classifying variables) were aggregated into a single, representative record.

It should be noted that depending on which level of aggregation is used to summarize a particular variable, degrees of freedom (df) and R^2 can vary substantially. When the analysis is performed on stage one data (with much inherent sampling variability), it is not surprising that the model tends to yield a relatively low R^2, i.e., it explains only that part of the variability attributable to the independent variables. Since we are concerned primarily with identifying the effects of specific factors, the model's R^2 is far less relevant than the F statistics associated with each of the factors. These tend to be highly significant.

Much of the analysis was performed on the fully aggregated data. Because of its relatively small size, the aggregated data set is convenient to work with and can be downloaded onto a personal computer. At the same time, it contains all the information relevant for analysis and produces the same results as the disaggregated data set.

METHODOLOGY

Multiple classification analysis (MCA) was the major analytical tool used in this project. MCA quantifies the effect of class or index-type independent variables on a particular dependent variable by estimating the mean deviation of any particular class from a base or "standard" case. Mechanically, it can be implemented using either multiple linear regression (with binary or dummy independent variables) or analysis of variance (ANOVA) procedures (MCA is described in some detail in Ref. 6 under ANOVA).

In this application, MCA provided a mechanism for testing various hypotheses regarding the effect of such factors as race, sex and age of household head, povety status, residence location, and the fuel shortage on driving and fuel purchase behavior. Although "standard" behavior was defined somewhat differently for each dependent variable, it generally corresponded to the mean value observed for a vehicle in a household headed by a nonpoor, nonelderly white male who lived in the central city of a standard metropolitan statistical area (SMSA) and reported no fuel purchase problems. For variables strongly influenced by (a) weather, (b) time or (c) the availability of more than one household vehicle, the "standard" was further constrained. These constraints were (a) spring or autumn months, (b) the last quarter year in the data set (i.e. July-September 1981), or (c) multivehicle households, respectively.

MCA is especially powerful in finding the "pure" effect of individual factors, after discounting the effect of other factors in the model. For example, since the percentage of black households who are poor is greater than the comparable percentage of white households, one might ask whether poverty is responsible for many observed differences between black and white households. The magnitude of the F statistic for the variable black (after accounting for all other variables, including poverty) shows whether this is the case.

DATA ANALYSIS

FUEL PURCHASES

Table 1 summarizes the effect of significant independent variables on monthly fuel purchases per vehicle. It states that in the standard case, 4.97 purchases are made per month. Elderly households have about 1.5 fewer purchases per month, while black households have 0.58 more purchases per month. Other factors which significantly affect purchase frequecy are rural (non-SMSA) residence (-0.42), other race (-0.54), and female head of household (-0.29). Households reporting some fuel purchase difficulty (short) have an additional 0.68 purchases per month.

Table 2 describes variations in the percentage of fuel purchases in which the vehicle tank is filled to capacity. In the standard case the tank is filled to capacity (topped) in 66% of all purchases. Blacks tend to top the tank about 20% less often. Members of other races, as well as the elderly, the poor and rural residents tend to top the tank more often (by 11%, 14%, 9%, and 8%, respectively). During June and July 1979 (shortage), an additional 12% of purchases ended in full tanks.

Recall that MCA gives the net effect of each variable, after accounting for the effects of all other variables. Thus, differences between any two population groups could vary substantially from the coefficient obtained by MCA. For example, because blacks have a higher proportion of poor and single-vehicle households, and a lower proportion of elderly households, the total difference between whites and blacks is greater than the value shown in Table 2. In MCA the extremely high F statistic associated with the variable black indicates that race explains more of the variability in the data than such other variables as poverty,

residence loccation, vehicle ownership, etc. Assuming that most of the significant variables have been included,the data suggest that blacks, due to their special attributes and circumstances (e.g., social effects, access to wealth and capital, fixed investments, expediture patterns, etc.), behave differently from nonblacks.

The data also suggest interesting differences between actual vs. perceived effects of the shortage. In the model, "short" identifies households who reported some fuel supply problem, and "shortage" identifies purchases made during the most acute shortage period. The analysis shows that shortage is a much more powerful predictor of tank topping (i.e., it has a much higher F statistic), suggesting that fuel purchase behavior was affected more by news repor and rumors about the shortage than individual households actually experiencing purcha difficulties.

Stability of Fuel Type Purchases

It can be hypothesized that in a free market without supply problems, drivers purchase a single grade (i.e., premium or regular octane) and type (leaded or unleaded) of fuel, the selection of which is based primarily on the manufacturer's recommendation and price, possibly slightly modified by individual preferences. Hence, variability in the type or grade of fuel purchased could indicate supply interruptions that limited motorists' choices.

To test this hypothesis, we sorted purchase records into single vs. multiple types or grades purchased for the same vehicle during the survey month. We were not concerned with what types were bought, or the extent of type of grade switches. We simply examined the frequency with which more than one fuel type or grade was used during the same month. Results showed that a single grade was used in more than 99% of the vehicles surveyed; a single type was used in more than 99.5%. We conclude that fuel shortages have no effect on misfueling or any other variability in fuel type and grade purchases.

FUEL INVENTORY

Fuel inventories provide additional insight into fuel purchase behavior, as well as important indicators of the relative ability of particular population groups to deal with a sudden shortage. Four measures of fuel inventory were examined in this study -- average inventory (the weighted average volume of fuel in the vehicle tank at any moment, expressed as a percentage of tank capacity), minimum inventory (the average volume just before refueling, also expressed as a percentage of capacity), average range (the number of miles than can be driven on the average inventory), and minimum range (the number of miles than can be driven on the minimum inventory).

Average and Minimum Inventories

In the standard case, the vehicle tank is filled to 58.5% of capacity on average, declining to 30.3% of capacity at minimum. During the TP survey, the data show a slight trend for inventories to decline with time. This can be attributed to the end of the 1979 shortage, which

reduced public apprehension about fuel supplies and, hence, should have prompted a return to normal fuel purchase habits. We can also attribute at least a portion of the decline to the recession and rising fuel prices which reduced both ready cash for fuel purchases and the amount of fuel obtained for a given outlay.

Table 3 shows that the variable elderly -- followed by other race and the shortage period itself -- increases both average and minimum inventories. Black -- followed by poor, rural, and first vehicle -- significantly decreases inventories. Again, the variables black and elderly have the highest coefficients in the model.

Fuel Inventory Expressed as Available Range

Available range (i.e., percent tank filled x tank capacity x mpg) represents both a "safety factor" against sudden fuel supply interruptions and the extent of required changes in behavior (i.e., having to build up large inventories) which might accompany the expectation of a shortage. Figure 1 displays both the average range (calculated from average inventory) and minimum range (calculated from minimum inventory) of vehicles in black and white households. Several trends are clear. First, whites have much longer ranges than blacks -- about 125 miles on average with a minimum of about 45 miles, vs. 75 miles on average with a minimum of only about 20 miles. Because blacks and whites purchase about the same average quantity of fuel (11 gal) the difference is attributable to both the above-noted inventory variation as well as racial differences in the fuel economy and tank capacity of household vehicles (see Fig.2). Fuel economy is also responsible for the clear seasonality shown in Fig. 1. Average inventories exhibit virtually no monthly variability.

FUEL EFFICIENCY

As shown In Table 4, fuel efficiency for the standard case is 14.5 mpg. Winter (-0.91), black (-1.25) or elderly householder (-0.75) and poverty (-0.95) all negatively affect mpg. Only female head (+0.70) and those variables associated with relatively less traffic congestion (i.e., rural and suburban residence) increase fuel efficiency (by 0.49 and 0.65 mpg, respectively).

A likely explanation for the lower fuel economy of vehicles owned by black, poor and elderly households lies in average vehicle age. As was shown in Ref. 1, these groups tend to own vehicles that predate the fuel efficiency improvements achieved since the late 1970s.

Figure 2 compares the average fuel efficiency of vehicles in black vs. white households. Blacks' consistently lower fuel efficiency is the cumulative result of all variables contained in Table 4 (as well as other unmeasured variables).

VEHICLE OWNERSHIP AND USE

Tables 5-7 summarize MCA resuts relating rates of vehicle ownership and use to household characteristics. The standard vehicle-owning household owns 1.76 vehicles. The most significant variables that reduce this rate are: female (-0.45) or elderly (-0.30) householder,

and poverty (-0.23). Race has a lower (though significant) effect, decreasing vehicle ownership by 0.18 for black households. Rural and suburban residence increase ownership by 0.24 and 0.195, respectively. Table 5 also shows a slightly increasing temporal trend in vehicle ownership. Over the TP data collection period, average ownership increased by 0.06 vehicles per household (about 1.7% annual growth).

According to the MCA results, monthly mileage per vehicle (768 miles in the standard case) and per household (1400 miles in the standard case) is higher for households residing outside a central city, and sharply lower for poor, elderly, or female-headed households (Tables 6-7). Mileage also exhibits a regular seasonal pattern, as well as a clear sensitivity to fuel price changes. That sensitivity may be seen in the sign and magnitude of the coefficients for those months (variables in the form PXYZZ) in which prices increased most sharply.

Note that each of the variables has a somewhat different effect on vehicle ownership and travel. Elderly or female-headed households and poverty reduce both ownership and travel while noncentral-city residence increases both ownership and travel. The variable black has a smaller and mixed effect -- slightly fewer vehicles and miles per household but slightly more miles per vehicle.

FUEL EXPENDITURES

Table 8 describes monthly household fuel expenditures. In the standard case, a household spent $124.19/month on transportation fuel, discounting the effects of all other variables. Temporal effects, primarily inflation and price increases (see variables of the form PXYZZ), increased expenditures by $39.42 per month compared to summer 1979. In addition to price, the major factors associated with expenditure differences are elderly (-$44.65) or female (-$36.28) householder, and rural (+$21.78) or suburban (+$18.03) residence. For each of these household groups, expenditure differences represent the net result of differences in vehicle ownership, fuel economy, vehicle utilization, and fuel price.

DISCUSSION

VEHICLE FUEL ECONOMY

Lower fuel economy is the major factor responsible for observed differences in fuel consumption and tank-filling behavior beween the standard case and either black or poor households. Clearly, lower fuel economy raises fuel expenditures for a given volume of travel, reduces vehicle range on a given volume of fuel, and -- unless additional inventories are used to compensate for these effects -- increases vulnerability to price runups and supply shortages.

Presumably, poor households' tendency to own vehicles with lower fuel economy is a direct reflection of (a) the dynamics of the secondary market and (b) the lead time needed for more fuel-efficient vehicles to pass into the low-cost segment of that market:

a. Until fairly recently, fuel prices were either rising or expected to rise, and older -- generally less fuel efficient -- vehicles retained less of their value on the secondary market. In terms of first cost, these vehicles became increasingly affordable to households with limited means; in terms of variable cost, they became increasingly expensive to operate.

b. Between 1976 and 1984, as newer, more fuel efficient vehicles came to comprise a larger share of the automotive fleet, average efficiency rose by nearly 25%, [8,9] However, some buyers of new and late-model used cars tend to be concentrated in the more affluent population, most efficiency improvements were confined to those segments and little, if any, improvement occurred in the fleet operated by lower-income households. By September 1981, the last month of TP data collection, more fuel efficient vehicles had not yet "trickled down" to lower income households. Not until quite recently could the fuel economy gains achieved in late-model vehicles be discerned in the gasoline expenditure patterns of lower-income households.[10]

Elderly and black groups also tend to own vehicles with substantially lower fuel economy. Among the elderly, low fuel economy is probably a function of preference and usage patterns. Market research has repeatedly shown that elderly households prefer larger, more comfortable vehicles and are more likely to own domestic makes.[11-13] Further, given their shorter daily travel distances, substantial portions of their travel is likely to be under "cold start" conditions, with a consequent loss of fuel economy.

Low fuel economy among black households is less readily explained, but probably attributable to income. Because we have no income variable other than poor/nonpoor, "black" may be picking up an income effect. Further, because of racial differences in the yearly fluctuation of dynamics of income (see Refs. 1 and 2) among poor households, it may be explaining some of the variability within "poor."

RISK TAKING AND FUEL PURCHASE BEHAVIOR

It can be hypothesized that under normal (i.e., nonshortage) conditions, motorists' fillup rates, fuel inventories, and refueling frequency reflect their general attitude toward risk, perhaps modified by such external factors as available cash (or credit) and their amount and ype of driving. Thus, the combination of much higher fillup percentages and fuel inventories, and much less frequent fuel purchases, suggest that elderly households tend to be risk averse, perhaps because of physical limitations that increase the difficulty associated with running out of fuel. Conversely, the combination of much lower fillup percentages and fuel inventories, and more frequent fuel purchases, suggest that black households tend to be risk prone.

To test this hypothesis, we calculated the average volume of fuel per purchase for black and elderly households and compared it to the average volume for the standard case. If elderly

households are indeed risk averse and black households are risk prone, the elderly should purchase fuel in equal or larger quantities than the standard case while blacks should purchase it in equal or smaller quantities. The results showed virtually no difference in average purchase quantity for elderly and standard households (10.5 vs. 10.6 gals), and somewhat higher volumes (11.2 gals) for black households. Thus, the hypothesis that fuel inventories and purchase frequency reflect fundamental differences in risk taking is not supported for black households, and neither confirmed nor denied for elderly households.

Among black households, observed differences in fuel inventories, purchase frequencies, and fillup rates are more likely related to household expenditure patterns, tank capacity, and fuel economy. The above-noted purchase quantities translate into an average outlay of approximately $14-15 per purchase. Many of those transactions are 10-gal or $10 purchases, reflecting either long-standing habits or household budget constraints. At the same time, differences in average vehicle age and size (hence, tank capacity) reported in Refs. 1 and 2, suggest that black households would have to purchase larger quantities of fuel to maintain standard inventories measured as a percent of tank capacity. Conceivably, the combination of larger tanks and habit- or budget-constrained purchase quantities account for the lower inventories and fillup rates, as well as the more frequent purchases of black households. Along with lower fuel economy, these differences in turn produce lower available range and fewer inventory-days (i.e., 2.7 driving days on average inventory vs. approximately 5 for the standard case).

Among elderly households, differences in fuel inventories purchase frequencies, and fillup rates are complicated by vehicle utilization rates only two-thirds those of the standard case. Purchase frequencies 30% below the standard are consistent with these extremely low utilization rates. While purchase habits (e.g., weekly fixed dollar, or fixed quantity) probably account for some of the differences in fuel inventories and fillup rates, extremely high minimum inventories (the tank is nearly 40% full just prior to refueling) suggest that risk aversion is also a factor.

SUMMARY AND CONCLUSIONS

Results of the MCA models presented above may be synthesized into a general description of the vehicle ownership, travel, and fuel purchase tendencies of "population groups" defined by the independent variables (i.e., household attributes) that enter the models. Recall that MCA isolates the contribution of each attribute to explaining the difference between all households with that attribute and a standad case. The resulting, single-attribute-defined "population group" is more homogeneous than the actual population of such households and, because the influence of covariant attributes has been removed, it highlights attribute-linked tendencies. For example, low vehicle ownership in female-headed households is usually attributed to a combination of gender, proverty, and race (since 47% of the families below the poverty line in 1983 were headed by women, 43% of whom were black[7]). By breaking out the influence of each of those factors, MCA shows that female-head has a greater impact

on ownership rates among vehicle-owning households -- almost take that of poverty alone and approximately 2.5 times that of race along. Quite likely, female head is a surrogate for household composition among vehicle-owning households.

The MCA results displayed in Tables 1-8 may be summarized into the following general descriptions of vehicle ownership, travel, and fuel purchase tendencies by vehicle-owning households having the following attributes:

1. Black households tend to own fewer vehicles with much lower fuel economy, to use them somewhat more intensively, and to purchase fuel more frequently than standard households. Although they purchase fuel in approximately equal quantities, they maintain much lower fuel inventories than standard households.

2. Poor households also tend to own far fewer vehicles with much lower fuel economy, to purchase fuel more frequently, and to maintain lower fuel inventories than standard households. Unlike black households, however, poor households use their vehicles less intensively.

3. Elderly households are the most unique of the attribute-defined groups. While they, too, tend to own far fewer vehicles with much lower fuel economy, they drive them much less intensively. Thus, they refuel much less frequently and maintain much higher fuel inventories than standard household.

4. Female-headed households also own far fewer vehicles but with higher fuel economy. They drive them less intensively, maintain higher fuel inventories, and purchase fuel somewhat less frequently than standard households.

These attribute-linked tendencies may be plotted for various pairs of dependent variables for which an expected behavior pattern can be hypothesized. Figures 3-5 show three such scatter diagrams in which the origin represents the standard case. Single-attribute-defined groups are represented by their deviation from the standard along each of the two dimensions.

As shown in Fig. 3, fuel economy tends to be inversely associated with purchase frequency. While all of the groups shown diverge substantially from the standard, most are in the expected direction. The key exception, the elderly, drive their vehicles much less than the standard. If corrected for vehicle utilization, the elderly data point would shift to the vertical axis, close to the "poor" data point.

Figure 4 shows the positive relationship between average inventories and fillup rates. Again, all groups diverge substantially from the standard case, but in the expected direction. Black and elderly groups diverge most. Since we have no true income variable, "black" may be capturing part of the income effect.

Figure 5 shows no clear association between vehicle ownership and utilization, primarily because such other factors as household size (or number of drivers), lifestyle, and income

intervene. Black households are the only group whose position is as expected, but this may be the result of countervailing factors (e.g., income, household size, and lifestyle). Rural households drive more -- largely because of longer distances, larger household sizes, and more dispersed travel opportunities -- while elderly households drive less, primarily because of smaller household sizes and fewer travel needs. Poor and female-headed households also tend to drive less than the standard case, a finding that may be interpreted in terms of such factors as fewer drivers per household, less income, lifestyle, fewer travel needs (if there are fewer workers per household), etc.

Next Steps

Some of the unexplained divergence apparent in Figs. 3-5 may arise from limitations of the analysis, particularly from the omission of significant dependent variables. While predictive ability has not been a focus of this effort, improvements in that regard are a logical direction for further research. As shown above, overall rates of household vehicle ownership, travel, and fuel expenditures are fairly well predicted by household demographic characteristics that reflect underlying travel needs. More vehicle dependent variables, however, (e.g., fuel economy, vehicle utilization, fuel purchase rates, and fuel inventories) are not so well predicted by demographic factors. These variables are either dependent on vehicle attributes not considered in this effort, or have so much internal variance (even within the same household) that a host of additional household- and location-specific variables would be needed to improve the predictive ability of the models.

As a next step to the research, such vehicle characteristics as model year and some measure of engine size could be entered into the models. This should improve predictive ability, but vehicle condition -- the basic variable influencing utilization and refueling -- would remain unmeasured and, hence, continue to account for substantial variance. Likewise, such factors as local weather and road conditions, unanticipated vehicle breakdowns, the amount of travel in nonhousehold vehicles (e.g., vacation travel in rental cars), household illness, etc. are not readily modeled. Hence, future research will find it difficult to increase the amount of variance explained by the models.

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TABLE 1 Effect of Independent Variables on Monthly Fuel Purchases per Vehicle Compared with the Standard Case[a]

Variable	B (purchases per mo)	Std. Error	F	PROB>F
Intercept[b]	4.965			
Black	0.584	0.142	16.86	0.0001
Other race	-0.538	0.226	5.66	0.0175
Poor	0.199	0.130	2.36	0.1250
Elderly	-1.503	0.127	139.91	0.0001
Rural	-0.415	0.129	10.25	0.0014
Winter	-0.251	0.157	2.54	0.1108
Summer	0.235	0.139	2.84	0.0918
Female head	-0.290	0.126	5.27	0.0218
Short	0.678	0.340	3.97	0.0466

[a]Standard case = monthly purchases per vehicle in a household headed by a nonelderly, nonpoor white male who lives in a central city of an SMSA and not reporting any fuel purchase problems.

$R^2 = 0.10$ (df = 1916)
$F_{tot} = 23.29$ (<0.0001)

[b]Standard case, 4.965 purchases per month.

TABLE 2 Effect of Independent Variables on the Percentage of Purchases with Complete Fillup Compared with the Standard Case[a]

Variable	B (% of Fillups)	Std. Error	F	PROB>F
Intercept[b]	65.66			
Black	-19.63	1.70	132.17	0.0001
Other race	10.73	2.54	17.79	0.0001
Poor	-8.42	1.50	31.39	0.0001
Elderly	14.15	1.45	94.04	0.0001
Rural	-7.82	1.49	27.37	0.0001
Shortage	11.74	2.60	20.42	0.0001
Short	4.02	3.85	1.09	0.2966
First vehicle	-5.42	1.39	15.14	0.0001

[a]Standard case = percentage of purchases with complete fillup in a multivehicle household headed by a nonelderly, nonpoor white male who lives in a central city of an SMSA and not reporting any fuel purchase problems.

$R^2 = 0.10$ (df = 1916)
$F_{tot} = 23.29$ (<0.0001)

[b]Standard case, 65.66% of purchases.

TABLE 3 Effect of Independent Variables on Fuel Inventory, Expressed in Percent of Tank Capacity, Compared with the Standard Case[a]

	Average Inventory[b]				Minimum Inventory[c]			
Variable	B (% Tank Capacity)	Std. Error	F	PROB>F	B (% Tank Capacity)	Std. Error	F	PROB>F
Intercept[b]	58.53				30.26			
Black	-6.77	0.75	80.59	0.0001	-2.84	0.63	20.11	0.0001
Other race	5.35	1.12	22.70	0.0001	2.69	0.93	8.34	0.0039
Poor	-3.47	0.65	28.45	0.0001	-2.07	0.54	14.60	0.0001
Elderly	8.51	0.63	181.82	0.0001	8.89	0.52	285.10	0.0001
Rural	-3.15	0.64	23.81	0.0001	-1.07	0.60	3.10	0.0785
Winter	-0.60	0.77	0.61	0.4339	1.99	0.62	10.24	0.0014
Summer	-0.71	0.73	0.95	0.3295	0.69	0.58	1.43	0.2318
Shortage	4.37	1.23	12.64	0.0004	4.98	1.01	24.31	0.0001
Female head	1.89	0.62	9.18	0.0025	1.50	0.52	8.25	0.0041
Short	2.29	1.68	1.85	0.1740	---	---	---	--
First vehicle	-2.90	0.60	23.31	0.0001	-2.33	0.50	21.10	0.0001

[a]Standard case = percent of vehicle tank filled during spring and autumn months, by a multivehicle household headed by a nonelderly, nonpoor white male who lives in a central city of an SMSA and not reporting any fuel purchase problems.

R^2 = 0.20 (df = 1655) for average inventory.
F_{tot} = 38.63 (<0.0001)

R^2 = 0.20 (df = 1712) for minimum inventory.
F_{tot} = 42.8 (<0.0001)

[b]Standard case, 58.53% of tank capacity filled on average; 30.26% at minimum.

TABLE 4 Effect of Independent Variables on Average Fuel Efficiency Compared with the Standard Case[a]

Variable	B (miles/gal)	Std. Error	F	PROB>F
Intercept[b]	14.530			
Black	-1.250	0.144	75.25	0.0001
Other race	0.829	0.310	7.15	0.0075
Poor	-0.950	0.132	52.73	0.0001
Elderly	-0.750	0.090	68.82	0.0001
Suburbs	0.653	0.090	52.48	0.0001
Rural	0.489	0.092	27.89	0.0001
Winter	-0.914	0.088	107.28	0.0001
Summer	0.562	0.081	47.30	0.0001
Shortage	-0.457	0.139	10.71	0.0011
Female head	0.705	0.107	43.11	0.0001

[a]Standard case = average miles/gallon during spring and autumn for vehicles in households headed by a nonpoor, nonelderly white male who lives in a central city of an SMSA.

$R^2 = 0.032$ (df = 16841)
$F_{tot} = 62.25$ (<0.0001)

[b]Standard case, shown as 14.53 mpg.

TABLE 5 Effect of Independent Variables on Ownership Rates of Vehicle-Owning Households Compared with the Standard Case[a]

Variable	B (Vehicles/household)[b]	Std. Error	F	PROB>F
Intercept[c]	1.755			
Black	-0.180	0.024	56.28	0.0001
Other race	-0.039	0.053	0.55	0.4578
Poor	-0.227	0.020	130.52	0.0001
Elderly	-0.298	0.013	496.15	0.0001
Suburbs	0.195	0.015	174.45	0.0001
Rural	0.240	0.015	246.18	0.0001
Winter	-0.039	0.016	5.89	0.0154
Summer	-0.020	0.014	1.96	0.1615
Shortage	0.154	0.078	3.87	0.0495
Female head	-0.451	0.015	843.47	0.0001
P6979	-0.064	0.018	12.29	0.0005
P101279	-0.043	0.020	4.56	0.0330
P1380	-0.052	0.021	6.23	0.0127
P4680	-0.025	0.019	1.63	0.2027

[a]Standard case = vehicle ownership rate during summer 1981 for a household headed by a nonpoor, nonelderly white male who lives in a central city of an SMSA.

$R^2 = 0.685$ (df = 1144)
$F_{tot} = 177.4$ (<0.0001)

[b]The number of vehicles is computed using weights in the vehicle data file (after removing vehicles not used during the survey month), while the number of households is computed from the household file. If vehicles had been computed from the household file, average ownership would be higher by about 0.1, although relationships would remain the same.

[c]Standard case, shown as 1.755 vehicles per household.

TABLE 6 Effect of Independent Variables on Monthly Miles per Vehicle Compared with the Standard Case[a]

Variable	B (miles)	Std. Error	F	PROB>F
Intercept[b]	768.2			
Black	57.3	15.7	13.28	0.0003
Poor	-44.9	13.3	11.37	0.0007
Age	-261.7	8.4	953.18	0.0001
Suburbs	77.6	9.1	72.36	0.0001
Rural	86.6	9.4	84.66	0.0001
Winter	-47.0	9.0	26.98	0.0001
Summer	70.5	7.9	79.40	0.0001
Female head	-51.1	10.5	23.52	0.0001

[a]Standard case = average monthly miles during spring and autumn by a vehicle in a household headed by a nonpoor, nonelderly white male who lives in a central city of an SMSA.

$R^2 = 0.076$ (df = 16871)
$F_{tot} = 172.89$ (<0.0001)

[b]Standard case, shown as 768.2 miles per vehicle.

TABLE 7 Effect of Independent Variables on Monthly Vehicle-Miles per Household Compared with the Standard Case[a]

Variable	B (miles)	Std. Error	F	PROB>F
Intercept[b]	1399.9			
Black	-61.1	31.3	3.81	0.0513
Poor	-219.9	25.9	71.81	0.0001
Elderly	-627.1	17.4	1290.86	0.0001
Suburbs	276.6	19.3	205.83	0.0001
Rural	327.2	20.0	268.64	0.0001
Winter	-91.7	23.6	15.09	0.0001
Summer	107.6	19.3	31.05	0.0001
Short	309.1	102.3	9.14	0.0026
Female head	-414.4	20.3	417.13	0.0001
P6979	-98.2	26.5	13.73	0.0002
P1380	-104.9	28.8	13.28	0.0003
P4680	-106.9	27.1	15.54	0.0001
P7980	-56.7	28.1	4.05	0.0443
P1381	-113.4	28.6	15.75	0.0001
P4681	-54.9	26.9	4.16	0.0417

[a]Standard case = average monthly vehicle-miles during summer 1981 for a vehicle-owning household headed by a nonpoor, nonelderly white male who lives in a central city of an SMSA.

$R^2 = 0.708$ (df = 1650)
$F_{tot} = 184.92$ (<0.0001)

[b]Standard case, shown as 1399.9 vehicle-miles per household.

TABLE 8 Effect of Independent Variables on Monthly Household Fuel Expenditures Compared with the Standard Case[a]

Variable	B ($/month)	Std. Error	F	PROB>Fc
Intercept[b]	124.19			
Black	4.84	2.54	3.62	0.0572
Other race	-6.96	5.59	1.55	0.2137
Poor	-12.23	2.10	33.78	0.0001
Elderly	-44.64	1.41	993.54	0.0001
Suburbs	18.03	1.56	132.88	0.0001
Rural	21.78	1.62	180.56	0.0001
Winter	-4.24	1.97	4.61	0.0321
Summer	5.53	1.74	10.05	0.0016
Short	21.52	8.29	6.73	0.0096
Female head	-36.28	1.64	486.69	0.0001
P6979	-39.42	2.47	253.22	0.0001
P101279	-24.16	2.95	66.91	0.0001
P1380	-17.19	2.16	29.55	0.0001
P4680	-17.52	2.68	42.46	0.0001
P7980	-13.93	2.62	28.23	0.0001
P101280	-7.69	2.94	6.84	0.0090
P1381	-7.41	3.15	5.53	0.0188
P4681	-4.51	2.67	2.85	0.0918

[a]Standard case = average monthly expenditures during summer 1981 by a household headed by a nonpoor, nonelderly white male who lives in a central city of an SMSA.

$R^2 = 0.69$ (df = 1139)
$F_{tot} = 138.83$ (<0.0001)

[b]Standard case, shown as $124.19 per month.

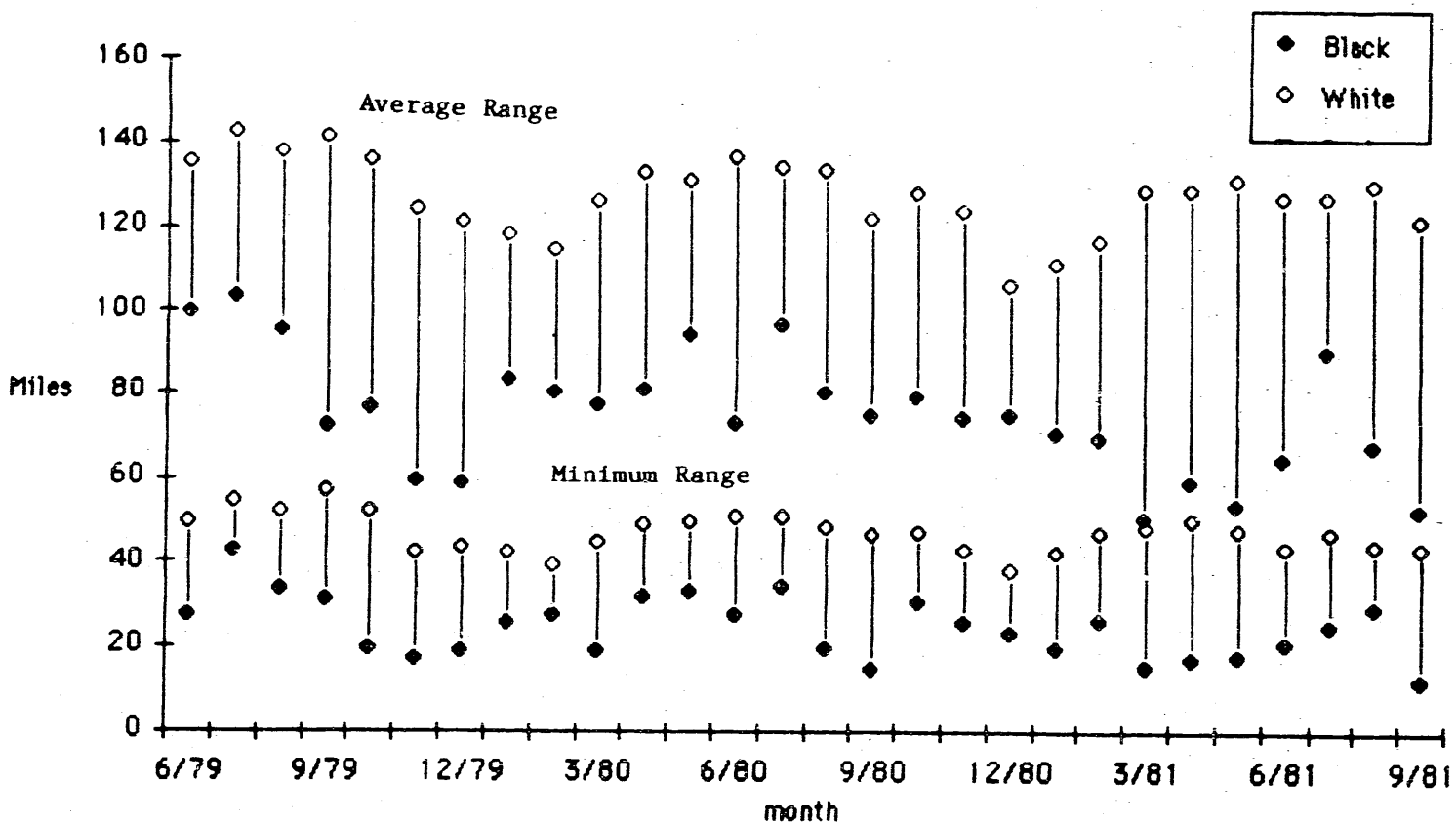


FIGURE 1 Available Range on Average and Minimum Volumes of Fuel in Vehicle Tank by Black vs. White Households

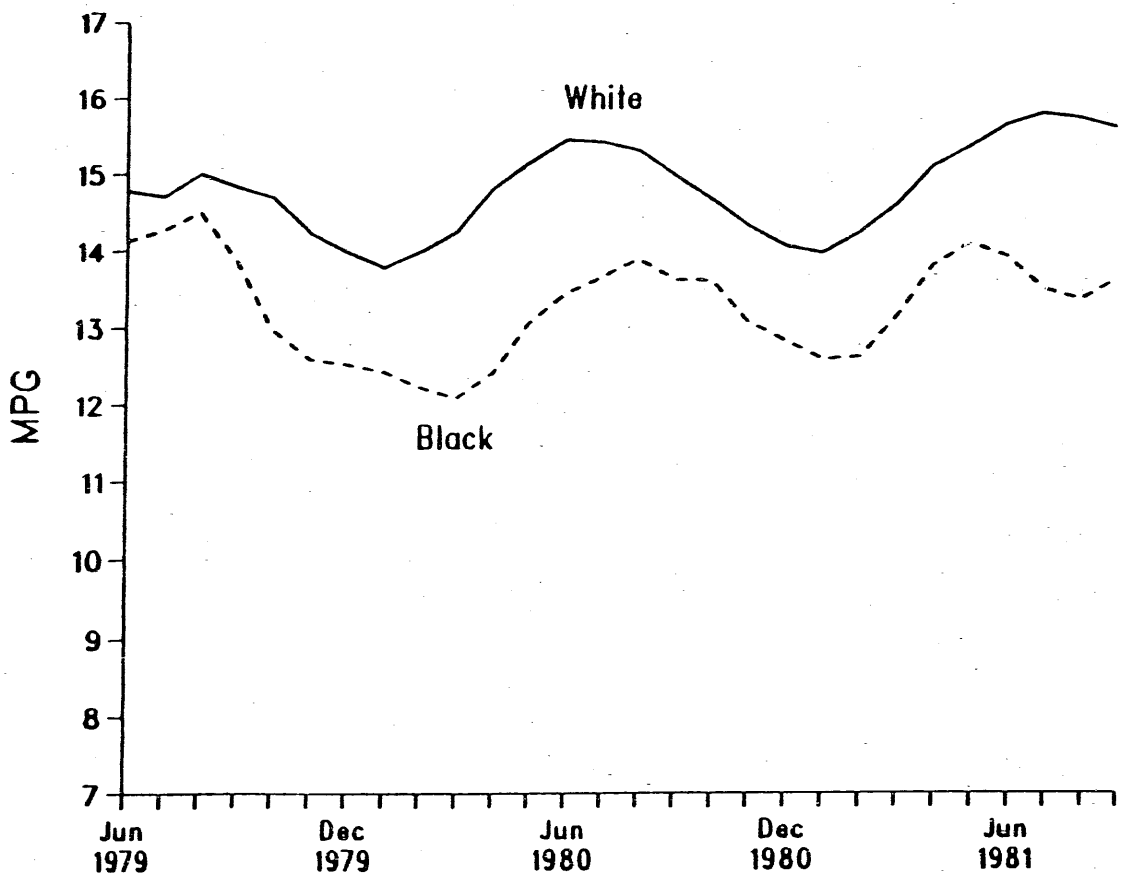


FIGURE 2 Fuel Efficiency of Vehicles in Black vs. White Households

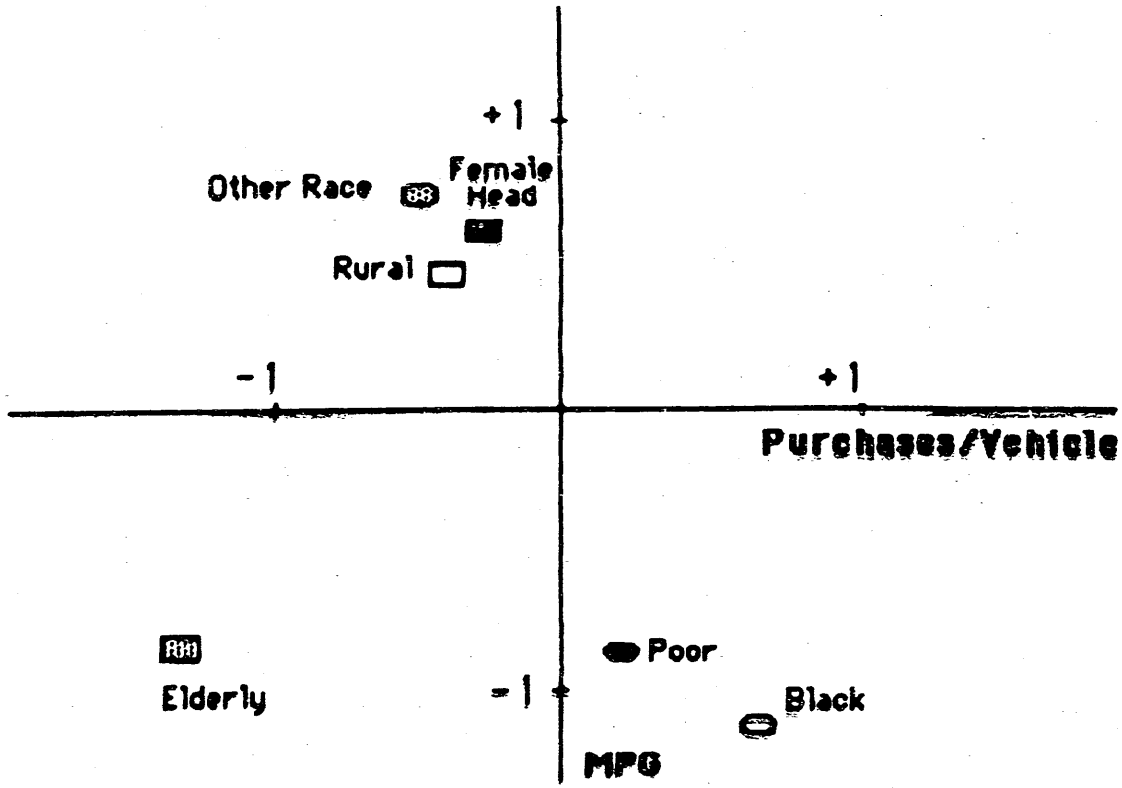


FIGURE 3 Relationship Between Variations in Fuel Purchase Frequency and Fuel Economy by Population Group

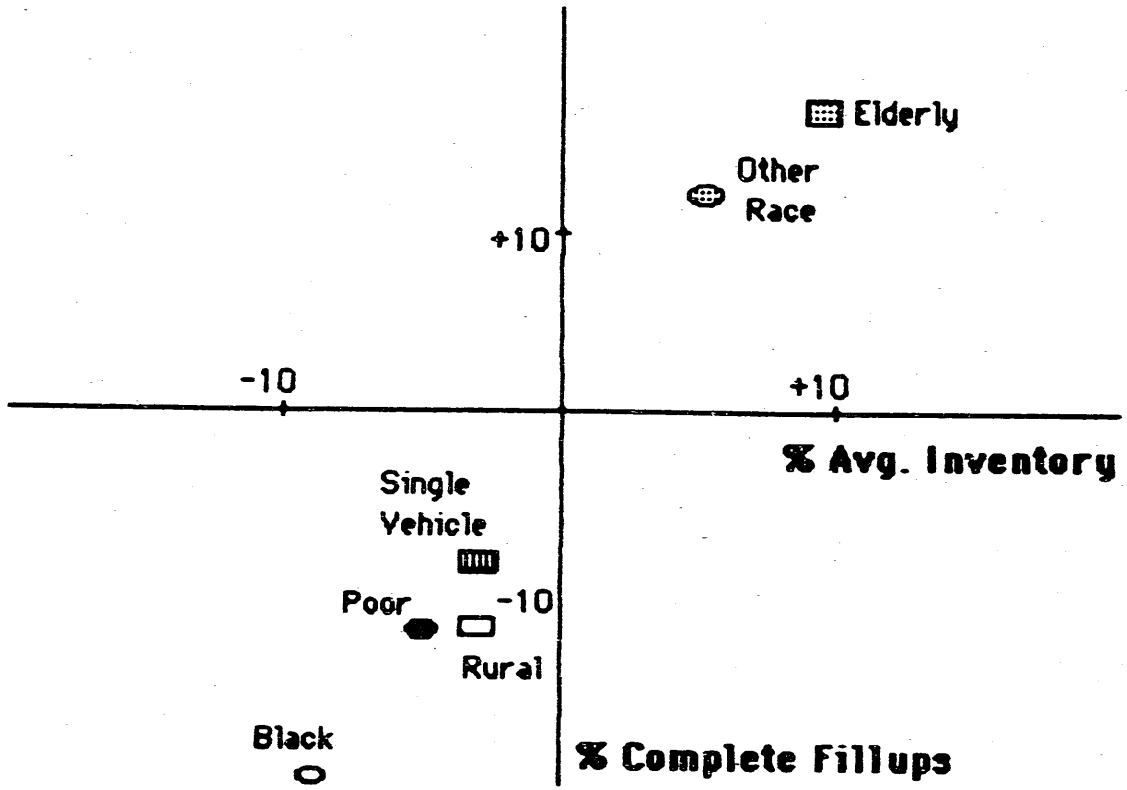


FIGURE 4 Relationship Between Variations in Inventory Level and Fillup Rate by Population Group

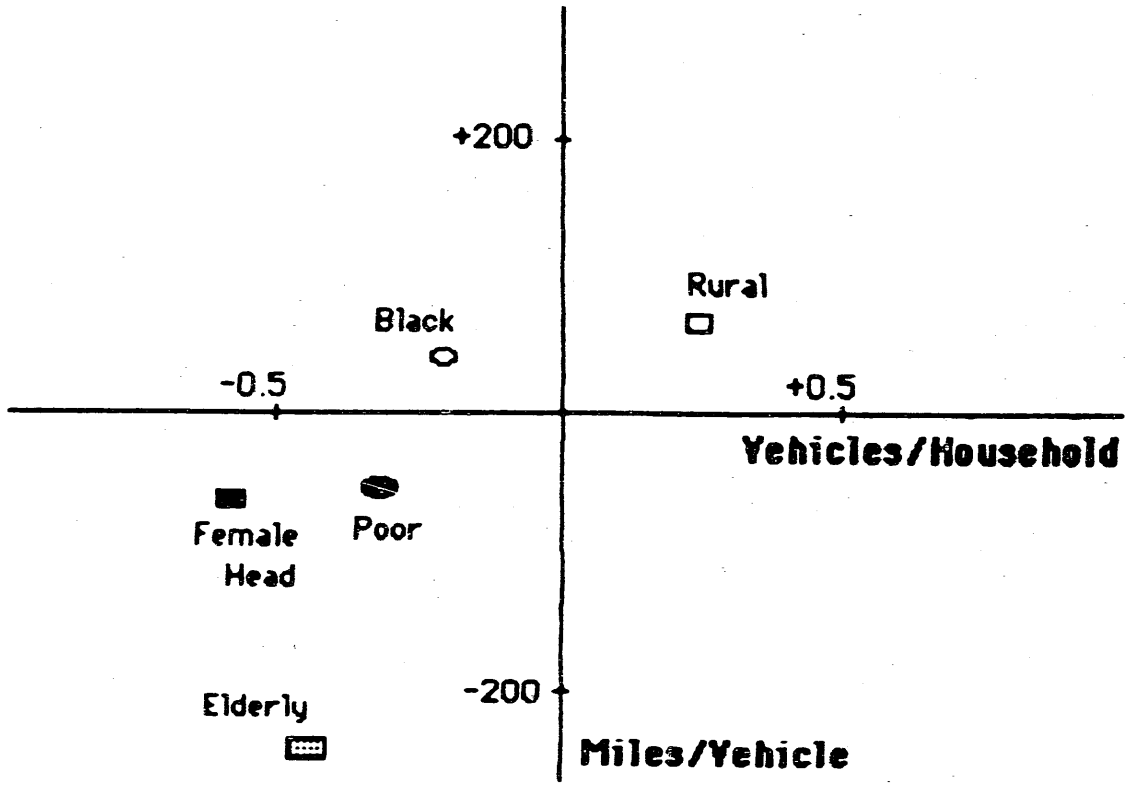


FIGURE 5 Relationship Between Variations in Ownership Rate and Vehicle Utilization by Population Group

APPENDIX

Black:	if household head is black
Other race:	if household head is neither white nor black
Poor:	if household income is less than 125% of the poverty level
Elderly:	if household head is more than 64 years of age
Female head:	if household is female-headed
Suburbs:	if household resides in an SMSA, but not in the central city
Rural:	if household resides outside an SMSA
Short:	if household reported the fuel supply situation was a problem
Shortage:	if the reporting month is June or July 1979, the time period when most purchase difficulties occurred
RegNE:	if household resides in the Northeast census region
RegS:	if household resides in the South census region
RegW:	if household resides in the West census region
PXYZZ:	if the reporting month is between x and y (inclusive) in the year zz. P101280 is 1 if the reporting month is October, November, or December 1980.
Winter:	if the reporting month is December, January, or February
Summer:	if the reporting month is June, July, or August
First:	if the vehicle is the first listed for the household

COMPARISON OF URBAN RESIDENTIAL ENERGY CONSUMPTION PATTERNS IN COSTA RICA AND INDIA

GERALD W. SAZAMA

COMPARISON OF URBAN RESIDENTIAL ENERGY CONSUMPTION PATTERNS IN COSTA RICA AND INDIA

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Study of urban residential energy and consumption patterns in the Third World should contribute to an understanding energy use by U.S. disadvantaged groups through cross cultural comparisons, and by offering information on supply conditions and policy options used in those contexts.

This paper will analyze the results of residential energy use surveys conducted in Costa Rica and India, with supplemental information available from surveys in Brazil and Chile, as well as some reference point information on the United States of America.

Both Costa Rica and India have had a growth with equity development strategy. Costa Rica is classified as a middle income country by the World Bank, while India is classified as a low income country. The results of this are reflected in energy consumption patterns. Indian urban households use predominantly traditional fuels (firewood and dung). In Costa Rica there is a significantly higher percentage of use of commercial fuels among the urban poor, with fuel expenditures being a slightly lower percentage of total expenditures than India.

In all countries, the nature of the supply network had important influences on final consumption patterns, e.g., defacto government rationing of LPG in India, subsidization of electricity and high prices for LPG in Costa Rica, or slow development of power lines in urban poverty area of Brazil.

1. Surveys Used and Country Background.

The specific residential energy use surveys analyzed in this paper are: a) Costa Rica: 1983 by the Energy Administration of the Government of Costa Rica. b) India: 1978 by the National Council of Applied Economic Research on contract with the Indian Oil Corporation. c) India: City of Hyderabad by the Resources for the Future and University of Osmania. These sources are the most complete and allow the fullest cross country comparisons. To provide additional reference points available material will be compared to a study of a shanty town

suburb of Campinas, Sao Pao Brazil (DeMartino 1986), Santiago Chile (Hortado, 1982) the country of Chile (CNE, 1981) and various sources on the U.S.

Table 1 provides some comparative statistics on income, and the quality of life, etc. in these countries. Table 2 provides definitions of the income classes used and the dollar value cut off limits for these income classes.

TABLE 1

Some Comparative Statistics[a]

	India	Costa Rica	Chile	Brazil	USA
Percapita GNP (US dollars)	260	1,190	1,700	1,720	15,390
Avg Anl Growth '65-84	1.6	1.6	-0.1	4.6	1.7
Life Expectancy	56	73	70	64	76
% Youths in Primary Education	85	102	111	102	100
Inequality Index	4.8	12.0	----	25.3	4.4
Percent Population Urban	25	45	83	72	74
All Sector Percapita Commercial Energy Consumption (Kg of oil equivalent)	187	486	796	753	8,575

a. All data are for 1984, except education for 1983, and LDC income distribution data 1971-1976, USA 1980.
b. Index of inequality = % personal income to top 10% divided by percent to bottom 20%.
Sources of Data: 1986 World Bank Report.

TABLE 2

Comparative Distribution of Annual Household Income and Family Size.[a]

Part I: Urban Costa Rica, National USA, Urban India, and a shanty town suburb of Campinas Sao Pao Brazil.

Income Class							Average Household size			
	Approximate Percentile		U.S. Dollar value of Upper Limit							
	LDC's	USA	CR	Brazil	Ind	USA	CR	Brazil	Ind	USA
1	0-35	0-18	2,400	1,300	370	b	4.2	4.6	5.0	2.6
2	36-80	19-60	5,800	4,000	750	23,000	4.5	6.0	5.6	2.6
3	81-92	61-79	8,200	11,000	1,500	31,000	4.0		6.3	3.5
4	93+	80+					5.3		7.6	3.6
All							4.5		5.7	3.0

Part II: Urban Costa Rica and City of Hyderabad, India

1	0-13	1,400	670	4.1	4.6
2	14-38	2,400	1,200	4.4	5.4
3	39-60	3,600	2,000	4.4	6.3
4	61-84	5,800	3,300	4.7	6.8
5	84-91	8,200	4,000	4.9	6.9
6	92+			5.3	8.2
All				4.5	6.3

a. Dates of survey: India national 1978, Hyderabad 1982, Costa Rica 1983, Brazil 1985, USA 1978; dollar limits for USA given in 1983$.
b. In poverty or below $3,000 1977 income.
Sources of Data: NCAER pp 43, 46 & 91, Hyderabad p 72, Landsberg/Dunkert p 30, DeMartino p 3.

2. Total Energy Consumed

2.1 By End Use.

As can be seen in Table 3 Total percapita useful megajoules (MJ) used for residential energy in India and Costa Rica are substantially lower than in the United States. A good part of these differences are due to the number and "depth" of end uses for energy. In some less developed countries (LDC's) like Chile and Korea space heating is an important end use. It is 48% of total residential energy in Chile as compared to 58% in the USA. In contrast it is only 1% in India and zero in Costa Rica. The number of appliances owned and the sophistication of appliances (eg frostfree vs manual defrost refrigerators) is a second important explanation of differences in consumption levels. Thus in low income India other end uses are only 2.9 percent of 191 MJ, while they are 42.1 percent of 261 MJ in middle income Costa Rica and 16 percent of 6,700 MJ in the USA. Another part of the difference in consumption levels is

TABLE 4

Percent of Urban Families Owning Selected Electric Appliances and Gas Stoves by Income for India, Brazil, Costa Rica and U.S.A.

Income Class	Country	Light	T.V.	Shower Water Heater	Wash Machine	Refrig.	Iron	Stoves Elec	Stoves Gas	Space Heating & Other
1	India	32		0				0	1	
1	Brazil	92	54	21		46	69	0	96	8
1	C.R.	98	79	5	22	55	71	57	16	
1	U.S.A.	100	94		62	98		95		
2	India	68		--				0	5	37
2	Brazil	96	75	43		71	85	0	100	
2	C.R.	99	93	17	45	78	90	72	15	
2	U.S.A.	100	96		73	100		97		
3	India	91		1				--	18	73
3	Brazil									
3	C.R.	100	99	27	67	91	96	77	16	
3	U.S.A.	100	98		89	100		99		
4	India	96		14				3	49	87
4	Brazil									
4	C.R.	100	96	27	80	95	95	85	13	
4	U.S.A.	100	98		91	100		98		
All	India	63		2				--	9	38
All	C.R.	99	88	14	41	72	84	68	15	
All	U.S.A.	100	97		78	99		52	46	
All	Santiago Chile	99	87		44	62		--	93	

a. Data for Brazil are for a shanty town suburb of Campinas, Sao Pao. Other country data is nationwide. Blank spaces imply data not available; hyphen implies less than 1/2 percent. Year of survey: India 1978, Brazil 1985, Costa Rica 1983, USA 1973, and Chile 1981.
b. For Brazil 41% of families in class 1 use wood in combination with LPG, in class 2, 32% do.
c. For definitions of income class see Table 2.
d. For U.S.A. in 1973 25% of income class 1 had a frost free refrigerator, while 69% did for class 4; 1973 data. In Costa Rica in 1983 virtually all refrigerators were manual defrost.
Sources of Data: NCAER Vol. II pp. 5, 14, 19; Newman & Day p57; Costa Rica computer tapes, De Martino p.5; CNE p 8 & 9.

Within countries more appliances are purchased as family income increases. For many cultural reasons T.V. is a basic good with 54 and 79 percent of low income families owning one in Brazil and Costa Rica - often a 12" black and white set. Besides stoves using commercial fuels which will be discussed later, the more common appliances by order of appearance, as income increases are: irons, refrigerators (found with 55 percent of low income families in Costa Rica and 95 percent of high income families), wash machines and shower water heaters. High energy appliances such as clothes dryers, and freezers are virtually non-existent in the Third World. Even with the most prosperous families this is true.

2.2 Consumption By Fuel Type.

In the United States virtually all residential energy end uses are met by superior commercial fuels, electricity, gas, and fuel oil. In the LDC's there is a marked transition from inferior fuels to superior fuels as national and family income increases. Fuels can be ranked on a scale from superior to inferior on the basis of income elasticity, and concerns such as convenience of use and energy efficiency. Electricity and gas are accordingly defined as superior, biomass fuels as inferior, and kerosene, coke and charcoal in the intermediate range. This movement from inferior to superior fuels can be seen in Table 5, especially by comparing Costa Rica and India, where the space heating end use is virtually nonexistent, and the cooking end use is dominant.

TABLE 5

Fuel Type as a Percent of Total Energy Consumption
Urban Residential Consumption, Corrected for Efficiency, By Income Class

Income Class	Country	Elec	LPG	Kero.	Wood	Soft Coke	Charcoal	Dung Cakes Crop Wastes
1	Ind	3.7	1.3	20.9	54.7	11.8	---	7.6
1	CR	76.8	2.6	0.4	16.4	0	3.8	0
2	Ind	8.2	4.5	24.6	38.4	18.1	---	5.7
2	CR	85.1	2.8	0.6	10.4	0	1.1	0
3	Ind	12.9	13.6	20.2	23.0	25.4	---	5.0
3	CR	91.4	3.5	0.2	4.4	0	0.5	0
4	Ind	19.2	30.6	16.3	13.8	15.1	---	4.8
4	CR	96.4	2.5	0.2	0.8	0	---	0
All	Ind	9.6	8.7	22.0	35.2	18.5	---	6.0
All	CR	84.6	2.8	0.5	10.3	0	1.7	0
All	Chile	8.2	29.3	27.1	31.9	----	3.3	0

a. Ind = India, CR = Costa Rica
Sources of Data: NCAER pp 46-86, Costa Rica Computer tapes, Chile: Hurtado Table 14.

In both countries electricity use increases and wood use decreases as income increases. However, between countries for the same income classes their use is quite different. Price and supply factors, of course effect these differences; these will be discussed later

If we compare Chile and Costa Rica for the all income classes we see the impact of the heating end use which increases the demand for LPG and kerosene.

2.3 Consumption By Expenditure.

Dollar expenditures on total residential energy in Costa Rica are considerably lower than in the United States, $162 vs $938 (see Table 6).

TABLE 6

Total Residential Energy, Average per Family Dollar Expenditures and as a Percentage of Family Income, By Income Class, National USA 1978, and Urban Costa Rica 1983

Country	Income Class			Expenditures on All Fuels	
	#	Percentile of Population	U.S. $ Value of Upper Limit	Average $US	as a % of Income
CR	1	0-14	1,440	68	9.1
US	1[a]	0-9	5,000	522	14
CR	2	15-38	2,400	87	4.9
US	2	10-27	10,000	627	8
CR	3	--	--	--	--
US	3	28-46	15,000	659	5
CR	4	39-60	3,600	81	3.2
US	4	47-64	20,000	769	4
CR	5	61-83	5,760	101	2.3
US	5	65-78	25,000	816	4
CR	6	84-91	8,160	118	1.8
US	6	--	--	--	--
CR	7	92-100	--	162	1.6
US	7	79-100	--	938	3
CR	All			96	4.0
US	All			724	8

a. Excludes Families in poverty
Sources of Data: Landsberg & Dukert 1981, p 30, Costa Rica data tapes.

Energy prices are given in Table 10 and will be considered later. For all but the highest income group Costa Rican expenditures are 11 to 14 percent of those in the US. From the highest group they increase to 17% of US total expenditures. These estimates are of course very exchange rate sensitive. If the 1982 rather than 1983 rate were used, the Costa Rican dollar figures would be roughly double.

Exchange rate movements of course do not effect energy costs as a percent of household income since both are in national currency. For both countries relative energy expenditures decrease substantially as income increases. Income class by income class relative expenditures are consistently lower in Costa Rica than in the US. However if we adjust for the fact that nearly 60 percent of U.S. expenditures are for space heating, and none in Costa Rica, relative expenditures of other uses are lower in the U.S. inspite of the significantly higher uses in levels of megajoules of useful energy.

TABLE 7

Cooking End Use, Average Monthly Household Energy Consumption, by Income, City of Hyderabad India and Urban Costa Rica

Income	Cooking Energy (millions of BTU's) Actual		Cooking Energy (millions of BTU's) Useful		Expenditure (dollars)		Expenditure as % of Household Income[a]	
	IND	CR	IND	CR	IND	CR	IND	CR
1	1.10	1.76	.298	.422	4.68	3.31	10.7	3.2
2	1.18	.97	.383	.445	5.77	3.94	6.7	2.2
3	1.25	1.00	.454	.507	6.61	4.06	5.0	1.7
4	1.22	.84	.498	.525	7.26	4.39	3.4	1.2
5	1.28	.86	.542	.548	7.74	4.83	2.5	0.8
6	1.36	.73	.613	.656	8.89	5.23	1.7	0.6
All	1.23	05	.454	.500	6.62	3.30	3.6	1.8

a. In urban Costa Rica 64% of wood is obtained outside of cash markets. In Hyderabad this percentage is miniscule. However, in Costa Rica wood use in urban areas is small except for income group 1. Using a shadow price for gathered wood in Costa Rica results in at most a 10% increase in this countries expenditure percentages, except for class one where the 3.2% in the table would increase to 4.4%.
Source of Data: Hyderabad p. 64 & Costa Rican data.

3. Energy for Cooking

Energy for Cooking is an end use found in all societies. Therefore focusing on it will provide some insights on energy used as family income increases, and development proceeds. Without correcting for the efficiency of fuel type or appliance, total energy used for cooking is quite constant among income classes for India, and actually decreases as income increases in Costa Rica. (See the "actual" columns in Table 7)

However with low income families there is a stronger predominance of biomass fuels while in the upper income groups electricity and LPG predominate. Since on average cooking with fuelwood is 18 percent as efficient as an electric stove, useful cooking energy (adjusted for efficiencies), increases as income increases for both countries. (Columns 3 & 4 of Table 7)

TABLE 8

Cooking End Use: Percent of Households Using Various Fuels by Income, City of Hyderabad India, Urban Costa Rica, and a Shanty Town Near Sao Pao Brazil.

Income Class	Country	Elec	LPG	Kero & LPG	Kero	Kero & Wood	Wood	Charcoal
1	Ind	--	6	1	33	24	35	--
1	CR	44	11	--	3	--	27	13
1	Brazil[a]		55				5	
2	Ind	--	7	10	45	20	18	--
2	CR	65	19	--	1	--	8	7
2	Brazil[a]		69					
3	Ind	--	21	20	28	20	10	--
3	CR	72	16	--	1	--	10	2
4	Ind	--	30	32	19	11	8	--
4	CR	73	14	--	2	--	7	2
5	Ind	--	28	40	19	8	5	--
5	CR	77	16	--	0	--	8	0
6	Ind	--	43	32	11	8	5	--
6	CR	85	13	--	0	--	1	1
All	Ind	--	21	21	28	16	13	--
All	CR	68	15	--	1	--	4	4

a. For Brazil Income class 1 40% use wood & LPG, class 2 31% do so. Source of Data: Hyderabad, p. 72, Costa Rican data tapes and DeMartino p. 7.

Within each country for the low income groups we find stronger use of the inferior fuels. Superior fuels dominate in the upper income groups. (see Table 8) Comparing countries, in more prosperous Costa Rica superior fuels are more common through all income classes than in India.

Dollar expenditures on cooking fuels increase as income increases, the top income group spends 60 percent more than the bottom one in Costa Rica, 90 percent in India. Expenditures as a percent of household income decrease markedly as income increases in both countries. They are consistently lower in Costa Rica.

Especially interesting is the similarity between useful cooking energy in these countries with that in the advanced countries. Annual household useful energy consumption for the top five income classes in Costa Rica ranges between 5.8 and 8.3 giga joules (GJ). In the early 1970's the average was 12.6 in the USA, but country averages ranged from 5.3 to 8.6 for Denmark, France, Netherlands and U.K. (Chateau & Lapillonne, p. 38). (The differences between the U.S. and other countries may be due to differences in uses of the ovens for home baking.)

In a previous study I reported on a comparison of results from some simple demand equations run on the Costa Rican data parallel to that reported in the Hyderabad study (Sazama, 1986, pp 11-13). Income elasticities for cooking fuels were low in both countries, although they were substantially lower in Costa Rica. On the other hand, family size is a more important explanatory variable in Costa Rica. Again this could be because we are working with a fixed end use, cooking which is closely bound to physical needs common to all humans. Thus once a certain minimum floor is achieved, given the necessary income to purchase it, consumption increases then become stronger linked to family size.

4. Price and Supply Conditions

Residential consumers have indicated a clear preference for the superior fuels over the inferior ones by opinion surveys and consumption patterns as income increases. However, actual market quantities used depend not only on a willingness to shift consumption patterns and the income increases, but they also depend on the prices for these fuels, cultural factors, supply conditions, and cost of appliances using the various fuels.

4.1 Price

Table 9 contains comparative price data on five principal fuels for Costa Rica, Chile, India and USA. Prices are given in terms of cost per million BTU's of useful energy. Electricity is used as a reference of 1.00 efficiency. Since wood for cooking is 18 percent as efficient as electricity, the actual fuelwood price is divided by .18 to obtain its useful energy price. The price data in Table 9 should just be used for crude comparison purposes because of: (1) the volitality of exchange rates in recent years, (2) the fact that prices are quoted in many different physical terms eg for wood in kilograms, cubic meters, and ox carts full, and (3) questions of precision on efficiency ratios. Given the above qualifications the price data is most useful on relative terms within countries. In Costa Rica given that the price of electricity is .47 that of

LPG, we learn of an important reason for the dominance of electricity in Costa Rica as a cooking fuel.

4.2 Supply of Electricity and Petroleum Based Fuels

In the LDC's electric and petroleum based energy prices are subject to more regulation than in the advanced countries. There are conflicting pulls on energy price regulation in LDC's. Besides the usual long run marginal cost pulls, and the need for financial roundness and investment capital, there is the dilemma of cheap energy because energy is a basic need vs high cost energy because it is a large component of the demand for scarce foreign exchanges.

Costa Rica and Chile both have excellent hydropower supplies. These are popularly considered as cheap power, inspite of the fact that costs are now high because of the foreign exchange needed to pay debts on past construction. One can imagine what Costa Rican national electricity officials went through when 40 to 60 percent of their costs are foreign debt service, and the exchange rate moves from 8 colones to 55 colones to the dollar in a three year period. At the same time the domestic energy consumer sees hydropower as a national resource, and for the vast majority their real incomes are decreasing during the same period, plus electricity is viewed as a basic necessity. As a consequence of the political pressures electric rates were increasing but substantially slower than the overall level of the consumer price index.

TABLE 9

Comparison of Dollar Equivalent Fuel Prices per Million of Useful BTUs

	Dollars				Price Ratio to LPG			
	Costa Rica	Chile	India	USA	Costa Rica	Chile	India	USA
Wood	4.53	9.35	20.32	--	0.29	0.31	1.39	
Charcoal	15.28	32.02	20.97	--	0.88	1.05	1.44	
Kerosene	19.97	4.97	11.52	8.54	1.15	0.16	0.79	1.01
LPG	17.36	30.46	14.57	8.48	1.00	1.00	1.00	1.00
Electricity	8.17	9.37	--	12.10	.47	0.31	n.a.	1.43

Sources of Data: Hyderabad p. 73, Energy Sector Administration, Costa Rica, Landsberg & Duckert p 23, and CNE p 21. Efficiency factors used to convert actual price into price of a useful BTU: Electricity 1.00, LPG .60, Kerosene .46, Charcoal .20, wood .18.

On the other hand in Costa Rica petroleum based fuel prices were allowed to increase fairly parallel with the international prices. First unlike waterpower here we are a short term imported good. Second its chief use among the poor is for fuel for public transportation which is strongly subsidized. As a consequence of the relative price shifts between electricity and LPG the survey found 10 percent of families shifted their cooking fuel from LPG to electricity in a three year period. This shift to electricity was strongest among the top 50 percent of income where its use was concentrated anyway, and where there was the most ability to buy a new appliance.

In India both kerosene and LPG are subsidized by the government inspite of their largely being imported. All cooking fuels are used through all income groups. However, LPG predominates among the upper income groups, kerosene with the middle income groups; and biomass fuels with in lower income groups. Ordinarily kerosene is in plentiful supply, but there is a de facto regulation of LPG. For this fuel there is a several year waiting list to get a contract from a supplier, but once a family has a contract they receive sufficient LPG.

In Brazil the political opening toward democracy is only recent. As a consequence of the equity policies of the previous twenty years, we find a lag in the development of electric power supply to low income urban areas as compared to Costa Rica or India. This is reflected in the results of the Sao Pao State Energy Counsel study (DeMartino 1986). Ninety five Pao State Energy Counsel study (DeMartino 1986). Ninety five percent of families in the shanty town did have electric lights. Comparing this with India where only 32 percent of urban low income families had electric lights, this is a high degree of availability which would seem a result of the higher income level of the country ($1,720 percapita vs $260).

Yet, going behind this 95 percent figure, we find that there is an average of 3.5 households per meter; 69 percent of households shared meters. The owners of the meter would sell electricity to neighbors, set up the mini distribution system to carry this out, and control the number of appliances which could be owned so as not to overload these mini-power systems. "As a consequence of this situation we find the presence of a demand for energy which is not being satisfied, i.e. inspite of the low income levels amongst this population there is scope for further penetration of certain appliances which otherwise could be purchased by them." (DeMartino, 1986, p4). In short the government again is having a defacto restriction of supply. This is further borne out by the fact that non meter energy consumers frequently pay the meter owner a premium for electricity used.

Electricity use by low income families in Costa Rica is an interesting contrast to that of Brazil. In Costa Rica, while there are distribution problems to the poor, there is a more active policy on behalf of the energy utility to meet their needs. The national utility does have a sliding scale by income for the cost of a meter hook up. The lowest cost is about U.S. $30, still a significant cost for the very poor. As a consequence of these policies in Costa Rica in the lower income group we find virtually no meter sharing and somewhat broader appliance ownership than in Brazil.

4.3 Supply of Biomass Fuels.

Unlike petroleum based fuels and electricity, biomass fuels appear to be sold in relatively competitive unregulated markets. Here the size of the city and relative scarcity of biomass in the region are important determinants in price and supply conditions.

Hyderabad, India is a city of 2.1 million people in an area of increasing wood shortage. Virtually all the wood was purchased, 55 percent of it being brought to urban markets by trucks from over 100 kilometers away (Alam 1985 p 207). Fuelwood is 41 percent of total energy used for cooking, 19 percent of useful (Sazama 1986 p 16 & 17). Sixty percent of low income households cook either totally or partially with wood. There is an increasing likelihood of deforestation becoming a serious problem. Besides its negative ecological effects, it would increase the price of an important fuel for low income families. Indian planners are confronting policy issues on whether, and if so how, to influence this market. Multiple intervention strategies are being discussed including: (1) reforestation, (2) design, distribution and subsidization of fuel efficient wood stoves, (3) urge the adoption of soft coal which is cheap and abundant in India, but is not a preferred fuel, and (4) subsidize kerosene or LPG further but how to get the foreign exchanges and how to focus the benefits on the poor. (For a further discussion of this see Alam, 1985 p 210-213)

Fuelwood in Costa Rica is still quite abundant, the largest city is 500,000 people. As a consequence nearly half of urban fuelwood consumed is gathered by the user. But fuelwood markets are increasingly developing, and prices on these markets have increased faster than the general rate of inflation over the last few years (Hess, 1983).

Given the normal economic development process consumers have shifted out of wood for cooking. (Rural and urban from 65 percent of families in 1963 to 34 percent in 1983, Sazama 1986 p 31) However, the world economic recession and their relative stagnation has been especially severe on the LDC's. Consequently this gradual process of moving out of wood, all else equal, has been stalled or even reversed. In this context development does not necessarily help the poor. Increased cattle grazing, improved technology in coffee growing which reduced the need for shade trees were just some of the causes restricting the fuelwood supply to the poor.

On the theme of the development process and energy for the poor, John Briscoe conducted an excellent study in Bangladesh showing detrimental effects of development on the fuel consumption levels of low income families. (Brisco 1979)

Given this set of problems Costa Rican policy makers would face choosing from some mix of: (1) incorporating the poor into the development process so they can purchase energy on their own, (2) subsidizing the energy needs of the poor, or (3) choosing not to concern themselves with this potential set of problems.

5. Conclusions

Considering total end uses of residential energy, while excluding geographically determined ones such as space heating, both the level of national income and family income have considerable influence on the total energy consumed in a specific household. However, if we compare energy expenditures as a percentage of family income for similar percentile income groups in the different countries there is a definite similarity among countries.

Concentrating on a fixed universal end use such as cooking in the lower income less developed countries (LDC's) we find relatively more use of fuels such as biomass in low income groups, kerosene in the middle groups and electricity and LPG in the upper income groups. As we move from low income LDC's to middle income LDC's income class for income class there is a higher concentration of fuels such as electricity and LPG.

Correcting for efficiency of fuel and appliances, we find that consumption levels for cooking in the high income groups of the LDC's parallel those of Western Europe. This and results reported of some previously done demand equation analysis imply that often a certain ceiling is reached. Family size becomes the most important determinant of the quantity of cooking fuel.

As development proceeded and family income increased there was a clear movement from inferior to superior fuels.

Also as both occurred and we moved beyond basic human needs like cooking, energy consumption increased primarily by families taking on additional end uses for energy, which is mostly reflected in the array of appliances owned.

The various countries demonstrated distinct supply and price policies that reflect the circumstances of their country. Also as economic development proceeded the lowest income group did not necessarily experience a concomitant increase in total physical energy use, This confronts energy policy makers in these countries with a set of decisions not unlike those faced in the USA of what combination of policies to use by either incorporating these groups into the economic growth process, subsidizing their energy needs, or ignoring their energy needs.

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A FORMAL APPROACH TO ANALYZING THE HOUSEHOLD SECTOR FUEL TRANSITION: THE CASE OF ZIMBABWE

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A FORMAL APPROACH TO ANALYZING THE HOUSEHOLD-SECTOR FUEL TRANSITION: THE CASE OF ZIMBABWE

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1. INTRODUCTION

In the past, the household energy policy strategies of developing countries have focused on improved woodstove efficiencies and rural afforestation efforts while ignoring the possibilities for inter-fuel substitution. This was at least partly so because of the dissenting view that households are too constrained to make any end-use demand decisions. Although rural household fuel-use decisions may well be supply-constrained, the higher disposable incomes of urban households and the existence of cash fuel markets suggest possibilities for meaningful fuel substitution in urban areas. Indeed, because of the strong correlation between rural and urban household fuel usage, urban energy policy resolutions may offer substantial support towards alleviating the fuel supply problems of rural households. As urban households move more toward the adoption of conventional fuels, the demand for fuelwood will decrease. The substitution component of Zimbabwe's household energy policy should focus on fuel substitution in the urban areas. In this context, an understanding of the transition between traditional and modern fuels in the urban household sector is paramount.

Existing empirical studies of household energy use in the cities and towns of developing countries have been documented in descriptive studies or presented in the form of standard regression estimates of fuel consumption levels (Alam et al., 1985; Hughes-Cromwick, 1985; and McGranahan. et al., 1980). In these studies, information on household fuel consumption level and fuel-mixes typically is presented in tabular form as the number and percentage of household consumers by income level. In examining urban household fuel use in Nairobi, Hughes-Cromwick (1985) used single equation multiple regression to estimate the household-level demand for electricity, charcoal, kerosene, and gas.

These conventional approaches have been limited in their capacity for analyzing the household fuel transition. Simple descriptive statistics or estimation of household fuel consumption relations by itself fails to adequately account for the importance of the household fuel acquisition decision. As a result, the question of how free are urban households in making end-use demand decisions has not been explicitly addressed.

Although logit analysis is a widely used approach, only a few studies have used logic analysis to analyze household fuel choices, in the developing country context --Tzeng (1984), Hosier and Dowd (1986), and Hadi (1982). With the logic framework, household fuel-related decisions are expressed in terms of a set of mutually exclusive and exhaustive fuel choice alternatives. However in reality, households make a second key decision on "how much" fuel to consume for a given fuel/appliance combination. Hadi (1982), performed an analysis of household energy use in rural West Java, based upon estimates of both choice of fuel and the estimation of the level of consumption once a fuel is selected by households in West Java (for four fuels, fuelwood, charcoal, kerosene and agri-wastes). He used a two step approach in which he first computed the probability associated with binary choice for each fuel type and second estimated the level of fuel consumption.

This paper, presents a representation of the fuel transition in urban households of Zimbabwe that is a modification of Hadi's two step approach. Our approach differs from his approach in that it involves an analysis of polychotomous choice, using a generalized logit formulation, rather than simple binary logic. Further, we estimate the level of fuel consumption for each fuel type.

We examine the fuel transition in terms of a construct of an "energy ladder". For Zimbabwe's urban demand centers, the relevant positions of the ladder are to gathered fuelwood, purchased fuelwood, kerosene, and electricity. At the top end of the ladder is electricity while at the bottom end is gathered fuelwood. Forward as well as reverse movements occur along the ladder. Economic theory and insights from relevant empirical studies indicate that as economic status increases (decreases), a consumer may be expected to move up (down) the energy ladder toward higher (lower) quality fuels. Associated with any particular shift in fuel type is a change in the quantity of fuel consumed. In general, the behavior of energy.consuming households is viewed in a broad decision context, as determined by social, economic and physical features of the household environment.

Empirically, the ladder concept is operationalized as a two-stage process. First, a conditional logic model of household fuel choice among discrete interfuel alternatives is estimated. Second, for each fuel position, a consumption relation is estimated. Both household fuel choice and consumption are expressed as functions of a variety of factors representing the supply/demand profiles of individual households. The inputs describe the individual household environment, and the outputs generated are fuel transition variables describing locations along the fuel ladder.

One purpose of the paper is to offer a formal illustration of the use of the polychotomous choice analysis as an aid to understanding the fuel transition in urban households of a developing country. An additional objective is to examine the factors which influence households level of fuel consumption. Representing the household fuel choice decision as a generalized logic rather than a binary logic, accounts for fuel transitions for the cases of multiple sources of movement. The choice situation involves the selection from among both commercial and non-commercial forms of energy. Biomass fuels may be either purchased

gathered. The logic approach presented in this paper, allows for the determination of factors influencing the household fuel acquisition decision for both non-commercial and commercial forms of energy.

2. THE FUEL TRANSITION AND HOUSEHOLD CHARACTERISTICS

2.1 THE HOUSEHOLD FUEL TRANSITION:

Previous studies of energy use in the cities and towns of developing countries have provided a useful empirical base for understanding the relationship between socio-economic status and level and composition of energy use. In the Indian city of Hyderabad, Alam et al. (1985), found that household fuel-choice decisions vary directly with income level. The higher the income level, the greater the tendency for households to choose petroleum-based commercial fuels over biomass fuels. In Kenya, Barnes et al. (1985), note that household fuel mixes vary according to the households' level of involvement with the monetary economy.

Chateau (1983), suggests that energy usage patterns observed for urban households is as much an expression of an "urban environment" as it is a result of new energy requirements. He further notes that the rhythm of urban life implies a change in the "level of intensity" of satisfaction of needs. One consequence of the change in level of intensity is a change in thequantity of energy consumed.

Thus, the literature offers evidence in support of the notion of fuel transitions observed in the household sector of developing countries are associated with increasing socio-economic status. In general, the transition is related to the differences in the socio-economic and physical conditions of households. Therefore, an understanding of the end-use demand behavior of the household in relation to the features of its environment is the key to a formal analysis of the household fuel transition.

A number of authors have suggested that decision-making in household energy consumption does occur. Briscoe (1979) notes that in rural Bangladesh. households do move along the energy ladder. However, the most visible movements are those of the poorer households switching either toward less sophisticated energy carriers or toward purchased fuels. Hosier (1985) argues that in Kenya, the household decisionmaker must make a two-stage decision in the energy arena. In the first stage. the decisionmaker decides which fuels to use. The second stage consists of the decision about how much of each fuel to use. The options in each case will depend upon the household's specific resource endowment -- the higher the economic status or the more integrated the household is into the monetary economy, the greater will be the options available to it.

Economic and non-economic factors alike have an important influence on the household fuel transition as it relates to fuel-use decisions. The important correlates of household fuel consumption and choice are generally found to be: income and prices; land-use; geographical and ecological factors; household structure (size and composition); and fuel supply

availability and accessibility. These factors either enhance or decrease the freedom to which households can exercise making end-use fuel decisions.

For a given household, movements do not occur along the entire space of fuel choice possibilities because various factors restrict fuel flows. From the policy point of view, the critical question involves the exploration of the tradeoffs between the various factors and their effects in determining the actual limits to movements along the energy ladder. The presumption is that any tradeoff between these factors will appear as a restriction on positional movements.

2.2 THE ZIMBABWEAN CONTEXT:

Zimbabwe, like most of the oil-importing countries of Africa, has a residential sector which is dependent on both imported petroleum and traditional forms of energy, such as fuelwood. Its central household energy policy concern centers around the question of how to reduce a growing fuelwood deficit in the face of balance of payments pressures and limited financial resources.

Domestic cooking consumes a substantial quantity of wood energy resources. Therefore, the most urgent area of policy concern surrounds energy use as related to the cooking activity. Two key urban household energy policy issues are how to reduce (i) the urban drain on woodfuel resources from surrounding rural areas and (ii) the demand for modern petroleum-based fuels. Hosier (1985) has projected an increase in the urban households' share of national consumption at 5% by the year 2002, with a continued dependence on electricity and wood.

Zimbabwe has one of the strongest economies in Sub-Saharan Africa (Stoneman, 1981). It has a well-developed national energy system which is comprised of woodlands, coal reserves, hydro. potential, an expansive electrical system and a successful ethanol program. Having a relatively diversified economy and energy supply system, Zimbabwe appears to have the resources at hand to support demand-related household energy policies. However, despite these strengths, Zimbabwe, like other African countries, may be required in the future to divert an increasing share of its export earnings to payments of crude oil imports. In addition, it depends largely on woodfuel to supply the energy needs of the residential sector. In 1982, wood used as fuel and in rural construction accounted for over 45% of the national end-use energy consumption (Hosier, 1986).

2.3 THE SURVEY CONTENT:

The data base to be used for analyzing the urban household energy transition in Zimbabwe is taken from a national household energy survey. Implemented by the Central Statistical Office (CSO) from March to May of 1984 as part of the Zimbabwe Energy Accounting Project, the National Household Energy Survey was a comprehensive residential energy survey. The survey instrument itself included questions about appliance ownership and utilization, fuel use, fuel procurement, demographics, perceived scarcity of fuelwood, income, and landholding. While the details of the survey itself are discussed elsewhere (Hosier, 1984),

the survey data serve as the basis for the analysis which follows. The empirical estimations are based on an urban sub-sample containing 453 households.

The urban residential sector in Zimbabwe consists of high and low income households separated into high and low density suburbs. The low-density areas house the more affluent households and their domestic workers (who frequently outnumber their employers). The high-density areas, previously called townships, contain the working classes and the less affluent households. Table 1 presents the results of the survey broken down by the two urban residential subsectors. The table contains both the consumption of each fuel by those using it and the percentage of households actually using each fuel.

TABLE 1 FUEL CONSUMPTION AND UTILIZATION BY URBAN SUBSECTOR

	SUBSECTOR		
FUEL	Hi-Density	Lo-Density	Total
n	322	205	527
Fuelwood			
% Using	19.2%	10.7%	15.9%
kg/day	5.6%	6.4%	5.9%
Kerosene			
% Using	28.3%	30.2%	29.0%
kg/day	2.45%	2.75%	2.57%
Electricity			
Load-limited			
% Using	60.9%	30.7%	49.2%
Metered			
% Using	10.6%	45.8%	24.3%
kwh/month	267.3	531.4	370.0

Note: Analysis of variance shows the above quantities and percentages to be significantly different from zero at the p=0.001 level.

The observed differences in both the penetrations and the level of consumption of each fuel may partially be attributed to the fact that the low density urban households exhibit higher socioeconomic status and thus have greater disposable incomes in comparison to households in high density locations. In fact, household energy consumption is normally assumed to vary according to the level of household income. The differentiation by income class lies at the basis of the energy-ladder concept: as income increases, the quality of the energy carriers selected can be expected to increase.

3. THE EMPIRICAL MODEL

The real question surrounding the energy ladder has to do with the household's choice among a number of domestic energy alternatives. For example, under what conditions will a household in Zimbabwe decide to cook with kerosene instead of wood? In order to more

precisely formulate this question, it is necessary to model both the household's decisionmaking environment and its preferences. Within the household decision context, the fuel transition is represented by logic odds of choice which are interpreted as the probability associated with a household's decision to undergo the transition from fuel position k to fuel position j in the conceptualized ladder. These transition probabilities depict the likelihood of movements along the ladder from various sources to destinations. Once estimated, they can be used to examine the effect of different factors on expected inter-fuel substitutions.

In the first step, the household end-use demand decision is only defined along a single dimension. In the second step, the each fuel consumption level is estimated. Positions along the ladder can be described by the probability ratio of the choice of one fuel alternative over another and by an estimated consumption relation for each fuel type.

Distinguishing the factors which influence fuel-type decisions from those which may influence fuel consumption gives the energy ladder a two dimensional structure. A major drawback of this scheme is its inability to explicitly estimate the fuel consumption decision jointly with the fuel type decision. This is likely to result in some degree of bias. Admittedly, treating the fuel choice and consumptions decisions as if they were independent gives a weak construct of a fuel ladder, but it nonetheless provides a useful first cut at examining the question of the fuel transition as it relates to interfuel substitutions.

A household faces a choice between a finite number of cooking-fuel options. Each fuel is distinguished by a range of attributes, such as price, efficiency, and convenience. Each household is distinguished by the particular features of its social, economic and physical environment. The modeling approach assumes that any particular household will make a given choice because it reflects the preferences and constraints inherent in its decisionmaking environment. This environment plays two roles in the choice process. First, it influences the preference structure of the household, and second, it imposes restrictions on the structure of the choice set. Therefore, the household energy decision is best determined by both a relevant choice set and the socioeconomic context of the household.

The assumption that households are free to exercise some basic choice about which fuels they will use underlies all of the following analysis. This is considered to be a relatively weak assumption. Although the choice set may be limited by high transactions costs, energy authorities cannot force households to use or not to use a specific fuel. For example, electricity may not be available or accessible to certain households. Not all households can decide among the full range of alternatives, as some may face a restricted fuel choice set. Therefore, the question facing the Zimbabwean energy authorities hinges upon the identification of those factors which can be influenced in order to encourage households to utilize the desired fuel. The model is intended to identify those factors which will most directly influence that choice.

In the remainder of this section, we outline a model of household choice of whether or not to move from one position along the ladder to an alternative position. Viewing the choice analysis in this way allows us to examine fuel transitions by source of movement. A multinomial logic model for polychotomous choice is developed for this purpose.

THE FUEL CHOICE MODEL:

The derivation of the conditional logic can be found in McFadden (1974). To describe the urban choice situation, we begin by assuming that each household faces a choice set comprised of the J fuel-types (J = 1 to 4). Each household makes only a single selection from among the J fuel alternatives available to it. Associated with each fuel choice alternative is a vector of attributes, X^J, and a utility, U^J. Similarly, associated with the ith household is a vector of descriptors, H_i, which characterize the household's socio-economic and physical environment.

Households are assumed to assign a value to the utility that is associated with each alternative and to select the alternative in the set having the highest level of utility. In general, each utility can be expressed in functional form as,

$$U_{ij} = f(Z_{ij}, B) + E_{ij},$$

where Z_{ij} is a function of both the attribute vector associated with each alternative and the vector describing the household's decision-making environment; B represents an unknown taste parameter common to all households; and E_{ij} represents unobserved factors.

Utility maximization implies that $U(Z_{ij}) > U(Z_{ik})$, $\forall\ j \neq k$. In the case of numerous alternatives, the probability, P_{jk}, of household i choosing alternative j over alternative k will depend upon the utility associated with each alternative. Their household will select alternative j over alternative k if and only if

$$P_{jk} = Pr(U_{ij} > U_{ik}),\ \forall j \neq k,$$

where U_{ij} and U_{ik} represent the utility of household i for alternatives j and k. respectively.

McFadden (1974) has shown that if certain assumptions are made about the nature of the error terms, the utility function assumes a logic form with the choice probability given by;

$$P_{ij} = \frac{Exp(Z_{ij}*B)}{\sum_j Exp(Z_{ij}*B)}$$

The probability, P_{ij}, depends on the vector of characteristics, X_j and H_i. By taking the logarithm of the ratio of any two choice probabilities and expressing the fuel utility functions as a linear function of X_j and H_{ij}, the model can be expressed in a convenient regression form with the unknown B coefficients estimated using maximum likelihood estimation. The logarithmic odds of choice is expressed as:

$$Ln(P_{ij}/P_{ik}) = C_O*(Z_{ij}-Z_{ik}) + B_1*(Z_{ij}-Z_{ik})\ B_2*(Z_{ij}-Z_{ik}).$$

$$+ B_3*(Z_{ij}-Z_{ik}) + \ldots + B_{n+1}*(Z_{ij}-Z_{ik})$$

where C_o represents the intercept, B_n are the coefficients, and Z_{ij} represent the vector of explanatory variables.

In the above generalization of the multinomial logic, the logarithmic odds of fuel choice is expressed as a linear function of differences in explanatory factors across fuel alternatives. Thus, in the general case, fuel transitions from the kth fuel to the jth fuel is represented by the logarithmic odds ratio, $Ln(P_{ij}/P_{ik})$.

As discussed in the previous section, not all households face the same alternative set. In the empirical estimation we specify household choice sets for each household under the assumption that they do face the full range of cooking-fuel options. For purposes of this analysis. electricity accessibility is accounted for by introducing a dummy variable constructed on the basis of within-cluster proximity to electricity supply zones (computed for each household). The electricity access index is set equal to 1 if a household is found to reside in a location within an electrical supply zone and 0 for households not having access to electrical connections. The electrical supply zones are mapped out by administrative area and division.

Although some low-income urban households could conceivably pay the connection fee to obtain electricity, electricity may not be perceived as a viable cooking fuel alternative because of the low income level. In this investigation, the transactions costs associated with the use of electrical supply are represented not by explicit cost factors. but are assumed to be folded into the effects of a household being in a particular administrative area and division.

The independent variables used in the urban analysis fall into three categories: household demographics, residential location, and characteristics of fuel attributes. The first group includes variables which describe household characteristics, such as household size and income. Four income classes are constructed and are represented by three dummy variables, with the default case being the lowest category. The second category includes a measure of residential location. represented by a dummy variable distinguishing households in the low-density areas from those in the high. density areas. Two natural region dummies are constructed (NRDUM2 and NRDUM3) representing ecological potential in order of increasing potential, with the default case being the region having the lowest natural potential for woodfuel growth. The third group includes the characteristics of the different fuel alternatives, such as efficiency adjusted price ratios, supply accessibility, and alternative-specific dummies. For the sake of computational efficiency, all independent variables are entered as dummies. with the exception of household size.

The response set and the independent variables used in the estimation are summarized in Table 2.

TABLE 2 DEFINITION OF VARIABLES USED IN THE MNL MODEL

VARIABLE	VARIABLE DEFINITION	FREQUENCY
Response Variables:		
	Households Using Particular Fuel-type	
P1	ELECTRICITY	260
P2	KEROSENE	127
P3	PURCHASED FUELWOOD	36
P4	GATHERED FUELWOOD	30
	TOTAL SAMPLE SIZE N =	453
Explanatory Variables:		
HHSIZE	Household Size (continuous)	453
RPRCAT	Ratio of Price of Kerosene to Electricity (Greater than 0.5 per equivalent MJ)	113
YCAT1	Monthly Income Dummy for Z$ 50-150	156
YCAT2	Monthly Income Dummy for Z$ 150-250	78
YCAT3	Monthly Income Dummy for ≥ Z$ 250	120
FWNDIFF	Woodfuel User's Subjective Assessment of the Ease of Collecting Fuelwood	24
HIDENDUM	High Density Area Dummy Variable	254
ACCESSEL	Electricity Access Index (Dummy=1 if household resides near an electricity supply zone)	407
FHEADED	Dummy Indicating Female Head of Household	36
NRDUM2	Dummy Indicating Natural Region II	277
NRDUM3	Dummy Indicating Natural Region III	62

The cooking fuel alternatives are gathered fuelwood, purchased fuelwood, kerosene, and electricity. The last column in the table gives the number of households using each of these fuel alternatives. Households corresponding to fuel choices for dung, agri residues, coal, LPG, and all mixed-fuel combinations were deleted from the sample because there were insufficient statistics for these particular fuel types.

Maximum-likelihood estimation was used to calibrate the logic model to the data. For the urban sample, the model is estimated for each of 233 combinations of distinct household decision-making environments. Maximum likelihood estimates of only the first three logist odds ratios (ie., comparisons to the first option, $Ln(P_1/P_4)$, $Ln(P_2/P_4)$, $Ln(P_2/P_4)$) are estimated directly. The remaining estimates are obtained from coefficient constraints which result from the requirement that the choice probabilities sum to unity.

THE FUEL CONSUMPTION EQUATIONS:

Multiple regression is used to estimate the consumption equations for gathered fuelwood, purchased fuelwood, kerosene, and electricity. A straightforward linear-in-parameters form is used for the estimation. The regression equations are defined as,

$$Y_j = b_O + b_1*Zl_{ij} + b_2*Z2_{ij} + ...+ b_{n+1}*Zn+1_{ij} + e_j$$

where,

Y_j = level of fuel consumption expressed in physical units Fuelwood kg/day (gathered wood, Y_{gwd} and purchased wood, Y_{pwd}); Kerosene liters/week (Y_{ker}); Electricity - kwh/month (Y_{elc})

Z_{ij} = explanatory variables for the ith household

b_O = constant term

b_n = regression coefficient of variables Z_{ij}

e_j = regression error term.

The explanatory variables used in the various regressions include those listed in table 2 as well as alternative-specific dummy variables for fuelwood (A1). kerosene (A2), and electricity (A3). The alternative-specific dummies are entered into the regressions to capture the effect of any excluded variables associated with cooking appliance attributes which may influence the level of fuel consumption. They are defined as follows:

A1 = 1 if household uses a woodburning stove or a mbaura with the default being an open hearth or a hearth with grate

A2 = 1 if household uses a pressure kerosene stove with the default being a wick stove

A3 = 1 if household uses an electric oven with the default being an electric hot plate only

In the next section, we apply the logic model to the data from the Zimbabwe urban household sample to predict positional movements along the fuel ladder as related to the cooking activity. The attributes of the alternative fuels and the characteristics of the household decisionmaking environment combine to determine the likelihood of any particular fuel transition in preference to another. After the logic estimates are generated we estimate each fuel consumption equation.

The effects of income on fuel choice are summarized by the coefficients of the income variables. For the urban areas, the income category variables have a positive influence on the transition to the commercial fuels, kerosene and purchased wood. Only in the highest income category do households demonstrate a higher probability of choosing electricity over gathered fuelwood. These results indicate that at the 5% level of significance, the energy-ladder effects of income with respect to transitions from non-commercial to commercial fuels in the urban areas are positive.

There are also some negative effects of income on movements up the energy ladder. For example, households in the Z$50-250 monthly range are likely to make a reverse transition from electricity to either kerosene or purchased wood. In the highest income categories, households might be expected to choose the higher quality energy carrier. However, our results actually show movements toward the lower quality energy carriers. This may reflect the fact that the step toward electricity away from kerosene is not one over which the household exercises total control. The extension of supply lines to households is paramount in determining a household's ability to cook with electricity. A large number of Zimbabwean urban households have load-limited connections with insufficient capacity to allow electric cooking. This factor makes kerosene's role a pivotal one in the household energy ladder in Zimbabwe. Although, increases in income above Z$50 per month encourage households to move to kerosene from gathered fuelwood, these same income forces are insufficient to encourage households to move away from kerosene towards electricity as a cooking fuel. This last step depends upon access to the electrical grid via higher amperage household connections, not the household's economic well-being.

Of the variables describing a household's location, the residential density dummy turns out to be insignificant in most instances. One exception is the transition from gathered to purchased wood where increasing density leads to a greater likelihood that such a transition will occur. For the transition from purchased wood to electricity, an increasing density has the effect of discouraging the movement towards electricity use.

4. ESTIMATION RESULTS

4.1 ESTIMATION RESULTS FOR THE CHOICE MODEL:

The coefficients and the T-statistics from the maximum-likelihood estimates of the household fuel choice model are listed in Table 3.

TABLE 3: LOGIT ESTIMATION RESULTS FOR URBAN HOUSEHOLDS

	DEPENDENT VARIABLE (Natural log of Odds Ratio)					
VARIABLE	P1/P4 EL:WD	P2/P4 KE:WD	P4/P4 PW:WD	P1/P2 EL:KE	P1/P3 EL:PW	P2/P3 KE:PW
INTERCEPT						
ESTIMATE	6.417	-2.228	0.314	8.645	6.103	-2.542
T-STAT	0.025	-2.380	0.265	0.034	0.024	-1.682
XTOTAL						
ESTIMATE	-0.169	0.193	-0.318	-0.362	0.149	0.511
T-STAT	-1.420	1.496	-2.338	-2.063	0.825	2.726
RPRCAT						
ESTIMATE	0.459	0.297	-0.857	0.162	1.316	1.154
T-STAT	1.319	0.820	-1.335	0.323	1.802	1.566
YCAT1						
ESTIMATE	-0.066	0.865	0.547	-0.931	-0.613	0.318
T-STAT	-0.210	2.529	1.302	-2.002	-1.168	0.587
YCAT2						
ESTIMATE	0.237	1.112	0.908	-0.875	-0.671	0.204
T-STAT	0.588	2.598	1.816	-1.488	-1.045	0.310
YCAT3						
ESTIMATE	1.012	1.208	0.866	-0.196	0.146	0.342
T-STAT	2.264	2.527	1.577	-0.299	0.206	0.470
FWNDIFF						
ESTIMATE	-9.110	-2.076	0.137	-7.034	-9.247	-2.213
T-STAT	-0.036	-4.289	0.373	-0.028	-0.036	-3.643
FHEADED						
ESTIMATE	0.605	0.719	0.218	-0.114	0.387	0.501
T-STAT	1.073	1.275	0.288	-0.143	0.410	0.630
NRDUM2						
ESTIMATE	0.242	1.137	1.060	-0.895	-0.818	0.077
T-STAT	0.858	3.765	2.857	-2.166	-1.755	0.161
NRDUM3						
ESTIMATE	-0.062	0.242	0.246	-0.304	-0.308	-0.004
T-STAT	-0.136	0.501	0.335	-0.458	-0.356	-0.005
HIDENDUM						
ESTIMATE	-0.095	0.057	0.552	-0.152	-0.647	-0.495
T-STAT	-0.310	0.180	1.187	-0.346	-1.162	-0.880
ACCESSEL						
ESTIMATE	1.060	0.835	-0.641	0.225	1.701	1.476
T-STAT	2.670	2.098	-1.477	0.400	2.892	2.507

Note: -2 Log Likelihood Ratio = 597.08; rho^2 = 0.48

Regional location appears to play a role in the household fuel transition. Being in Natural Region II increases the probability of a household making the transition to kerosene from electricity or gathered fuelwood. Also in this region, households are more likely to make the transition to purchased fuelwood from gathered fuelwood or electricity. At least for the transitions not involving electricity, these results may be attributed to the superior road infrastructure found in region II which makes for greater accessibility to kerosene and to cash fuel markets. For movements involving electricity, restrictive access costs may explain the tendency for households not to choose electricity in region II. This sort of argument is consistent with the argument put forth in the discussion of income effects. Even with adequate infrastructure in support of commercialized fuel usage, the access costs associated with electricity use remain prohibitive.

Increases in household size have an interesting reverse effect on the fuel transition, depending upon whether the source fuel position is non-commercial or commercial. In the case of fuel movements from gathered fuelwood, increased household size appears to have an inertia effect because it reinforces the tendency for the household decisionmaker to remain with the noncommercial fuel. For the case of kerosene, the opposite may be true. With increasing size of household there is an observed increase in the likelihood of a household choosing kerosene over any other alternative. It is not clear why this is should be the case, but the effect of household size is to encourage movements along the energy ladder toward kerosene while reinforcing the use of fuelwood for households whose cooking depends on gathered fuelwood.

Fuel accessibility does appear to have an effect on household fuel choice; however, not all of the estimated effects are what would be expected. If fuelwood is considered to be easy to collect, this discourages movements away from electricity or kerosene toward gathered wood. This is much as would be expected since households using commercial fuels are not likely to desire moving down the ladder to fuelwood even if it is an easily gathered common- property fuel. The more interesting question relates to whether or not, among the fuelwood users, a supply of easily gatherable fuelwood has any influence on the transition. The results from Table 2 indicate it does not, since the estimated coefficients corresponding to the movements between gathered wood and alternative fuels were not found to be statistically significant.

Turning to the effects of electricity accessibility, the estimated coefficients are significant for all transitions with the exception of the transition from kerosene to electricity. The general trends appear to be that households with access to electrical supply are more likely to make the transition away from lower quality fuels toward the higher quality carriers. In the case of electricity access, some enigmatic results remain. For the movement from gathered wood to purchased wood there is a negative coefficient, suggesting that households having increasing access to electricity may be expected to decide to move down the ladder. This result is counter-intuitive but the coefficient estimate was found to be statistically indistinguishable from zero at the 10% level. A more disturbing result is that the transition from kerosene to electricity with increasing access to electricity supply does not show up as being significant. A possible explanation may be that households using kerosene, may use it for cooking, with electricity reserved exclusively for lighting. Another explanation is that even with the physical

supply available, the access costs in terms of appliance purchase or connection fees may be too high. In any case, the estimated result suggests that even with increasing electricity access, these households will not move up the fuel ladder towards the use of electricity for cooking purposes.

Perhaps, more enigmatic to interpret is the effect of the variable representing the price of kerosene relative to the price of electricity. It shows no significant effect of price on fuel decisions among electricity and kerosene alternatives. This is an unexpected but nonetheless interesting result. It suggests that with increasing relative price of kerosene, households remain near the kerosene position on the ladder. There are two possible explanations for this result. First, this implies that there may be an important inertia effect in the case of kerosene. The suggestion being made is that kerosene is a strongly preferred fuel for cooking even in the presence of increasing fuel prices and even under conditions of increasing electricity access. The second explanation is that either the effects of price on fuel-choice decisions is relatively weak over the range of prices and decisions captured in the survey, or the variable is a poor one for summarizing its effects.

4.2 ESTIMATION RESULTS FOR THE FUEL CONSUMPTION EQUATIONS:

This section presents the results from the fuel consumption regression analysis. In the case of gathered wood, the estimation results from the sub-sample of 30 households is as follows: (T-statistics are given in parentheses)

$$Y_{gwd} = \underset{(4.56)}{5.29} + \underset{(4.98)}{1.32}*XTOTAL + \underset{(-2.72)}{-0.004}*INCOME + \underset{(-1.32)}{-3.39}*FHEADED$$

$$+ \underset{(-1.66)}{-1.96}*HIDENDUM + \underset{(-1.88)}{-2.59}*ACCESSEL + \underset{(2.87)}{7.18}*A1$$

$$R^2 = 0.61$$

where INCOME = total monthly household income expressed as a continuous variable.

The results for the sub-sample of 35 households that utilize purchased fuelwood is given as:

$$Y_{pwd} = \underset{(5.53)}{6.95} + \underset{(2.44)}{0.38}*XTOTAL + \underset{(0.01)}{0.00002}*INCOME + \underset{(-2.97)}{-3.81}*ACCESSEL$$

$$+ \underset{(-1.71)}{-2.50}*A1$$

$$R^2 = 0.28$$

The results for the sub-sample of 127 kerosene users is given as:

$$Y_{ker} = \underset{(1.69)}{1.11} + \underset{(2.13)}{0.19}*XTOTAL + \underset{(-3.24)}{-1.350}*RPRCAT + \underset{(-0.44)}{-0.0002}*INCOME$$

$$+ \underset{(2.18)}{1.31}*ACCESSEL + \underset{(2.40)}{1.00}*A2$$

$$R^2 = 0.18$$

The results for a limited sub-sample of 126 electricity users is given as:[1]

$$Y_{elc} = \underset{(-2.02)}{-191.44} + \underset{(1.87)}{25.041}*XTOTAL + \underset{(7.14)}{548.89}*RPRCAT$$

$$+ \underset{(0.17)}{0.015}*INCOME + \underset{(-4.41)}{-341.641}*HIDENDUM + \underset{(5.01)}{307.16}*A3$$

$$R^2 = 0.19$$

For all of the above regressions, the parameter estimates have the expected signs. The best results are obtained for gathered fuelwood where the $R^2 = 0.61$. For households which gather fuelwood, the parameter estimate corresponding to female head of household is significant. For the case of gathered fuelwood, the significance of the consumption coefficient together with the insignificance of the fuel choice coefficient (from the previous section) suggest that whether or not the household is headed by a female matters in consumption but not in fuel acquisition.

The most striking result is the insignificance of the effect of income on fuel consumption. For each of the four fuel consumption regressions, the estimated coefficient associated with income does not statistically differ from zero. These results are particularly surprising for electricity consumption, where a number of previous studies have demonstrated a significant income effect for electricity. Thus, our results indicate that income has a noticeable differential effect on household fuel usage in urban Zimbabwe. In the case of household fuel choice decisions, as expected, income has been determined to have a meaningful influence on fuel acquisition. However, it appears that income does not significantly influence the household's level of fuel consumption.

For both gathered fuelwood and electricity, the results of the regression analysis indicate that increasing residential density leads to decreasing patterns of fuel consumption. This is seen by the negative sign on the residential density variable HIDENDUM.

For each of the fuel consumption relations, household size appears to be an important determinant. However, it has a decreasing degree of significance across the different fuel types. This may suggest that the economy-of-scale effect in cooking has less relative importance for households which consume commercial fuels

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1. In the case of electricity, 134 cases were excluded from the regression estimation because, in the survey responses, consumption levels were entered as zero. These cases represent electricity users having the load-limited connections where electricity consumption levels more or less follow a fixed pattern depending on the type of load limiter. Ordinary least squares regression in the presence of a large number of zero consumption levels would result in severely biased estimates. For the purpose of this analysis, the zero level consumption observations were not included in the electricity regression estimation.

For both kerosene and electricity, the price of kerosene relative to the price of electricity shows up as being the most important determinant of consumption level. This result is useful because it suggests that pricing policy is likely to have an important influence in modifying the levels of fuel consumption of urban households.

5. DISCUSSION AND CONCLUSIONS

The results of this analysis of urban household fuel choice and consumption are only preliminary. They show that there are consistent patterns to urban household use of domestic cooking fuels in Zimbabwe. In most cases, increases in income will lead to a household choosing a higher quality fuel. Larger household size encourages the use of kerosene but reinforces the use of fuelwood for households that may already be dependent on gathered wood. Energy savings benefits obtained from economy-of-scale in consumption as associated with larger household sizes are likely to be realized less for the case of households which make the transition to commercial fuels. Unfortunately, the factors determining household fuel choices in the model, such as income and household size, are not easy to control.

The basic policy question which needs to be addressed in the urban context is: "What policy-related factors can be used to "steer" desirable movements along the ladder in order to offset the negative impacts of increasing oil prices or growing fuelwood scarcity ?". Our results suggest that deliberate attempts to encourage fuel substitutions away from costly kerosene and fuelwood may not be easily obtained even within the urban household sector of Zimbabwe.

The most striking finding is the indication of strong inertia effects for non-commercial fuelwood and for kerosene. These effects are evidenced by the tendency for households to decide not to undergo a transition away from these fuels even when there may be opportunities for them to do so (opportunities in the form of physical access to electrical supply and reduced price of electricity relative to kerosene). Even though fuel choice and consumption elasticities have not been computed, there is a hidden suggestion that for fuelwood and kerosene, urban households may not respond well to policies designed to encourage transitions away from these two fuels. Both fuelwood and kerosene appear to be strongly preferred fuels in urban Zimbabwe.

The availability of cheap gathered fuelwood tends to encourage its continued use. but it does not encourage movements down the ladder. At the same time, it appears that more households would readily cook with electricity if the availability of metered connections were increased. This electricity supply bottleneck. rather than the household decisionmaking environment, appears to be one of the greatest obstacles to the increased use of electricity for cooking in urban Zimbabwe.

Although there does exist a tendency for households with a higher economic status to move to more sophisticated energy carriers, there are points at which this does not happen. For example, there appears to have been no significant effect of the higher income categories on

the choice between electricity and kerosene. All of the significant impacts were incorporated into the coefficients of the income categories representing monthly incomes less than Z$250. This would appear to mean that the household's decisionmaking environment ultimately does not determine fuel choice in these cases, but rather the capacity of the connection to the grid. Households with load-limited connections are less likely to cook with electricity, not because they cannot afford it, but simply because their electrical wiring cannot carry the necessary current. From this perspective, the extension of non-load-limited connections to urban consumers is paramount not only to the expansion of electricity users but also to the avoidance of the proliferation of illegal connections. Urban electrification appears as a critical policy initiative for Zimbabwe's energy future.

Kerosene does appear to play a critical role in the household energy sector in Zimbabwe. Income increases encourage households to move away from wood to kerosene, and yet are not strong enough to encourage them to move to electricity. As a result, kerosene serves as a holding pattern, particularly for urban households. This is the case in a number of other countries where the kerosene price is heavily subsidized (Pitt, 1985). While the Zimbabwean government does not provide subsidies, it applies a only minimal excise tax to its retail price when compared to the price of other fuels. As a result, this critical fuel has remained relatively affordable for those needing to use it.

The price of kerosene relative to electricity never demonstrated a significant effect on the choice between these two fuels. This is an unexpected result. The ratio of the price per energy unit of the two fuels may not have an important impact on the fuel choice decision but it does strongly influence levels of fuel consumption for kerosene and electricity.

The policy implications of this last point are both good and bad. The price regulatory system appears to be working well throughout Zimbabwe. There do not appear to be many cases of extreme price inequities in the different areas surveyed. This is a positive finding for the energy authorities. On the negative side, however, it means that controlling the price of domestic fuels is insufficient to encourage fuel switching between kerosene and electricity. To get households to move from kerosene to electricity will require a more active role for the electricity supply authorities.

The results of this investigation demonstrate that efforts at policy-induced fuel substitution should focus their attention on the urban households, where the decisionmaking environment is more amenable to the adoption of commercial fuels. However, it does not appear that desirable policy-induced transitions, in the form of movements away from kerosene and woodfuel toward electricity, will be easy to achieve.

The analysis has demonstrated several interesting points relevant to fuel-type decisions and fuel consumption in urban households of Zimbabwe. In general, the significant fuel transitions do appear to occur for the survey data examined. While the analysis presented here does go part way to demonstrate that this transition is taken, it is not complete for two reasons. First, to do so, it would have to incorporate a more direct test of these transitions as a continuum. Second, there has been no discussion of the reasons for this transition. Such a

discussion lies beyond the scope of the present paper, but would have to focus on the identification of those indifference points where households value equally the resources (both time and monetary) which are expended to obtain each fuel.

The fuel transition in developing countries differs markedly from the fuel transition in the US context. For the 'atter, fuel transitions are mainly related to household decisions among home heating services. The transitions involve gas, oil, and electricity. Further, there is known to be a strong interrelation between household heating systems and choices of appliance/fuel combinations. Shifts out of gas, oil, or electricity will be associated with the features of the environment of households. In the US context, one might expect the main economic factors to be the considerations of system and appliance acquisition, installation costs, operating costs in relation to household discretionary income, and the efficiency characteristics of the system. The non-economic considerations will likely be housing tenure, life cycle, cooling degree days, and convenience-related preferences.

For US households, important differences in fuel-related movements between black and non-black and between the young families and elderly couples are likely to be uncovered. Since black families as well as elderly families tend to have limited discretionary incomes, which implies a smaller opportunity set, they might be expected to show different fuel choices and more difficult transitions. In general, the nature and extent of US household fuel transitions will vary with the particular features of the household socioeconomic and physical environment. As such, a decision framework is certainly appropriate. To date, the most illustrative example is the EPI's REEP model (EPI, 1982), which uses a nested logic approach.

As these results are preliminary, a number of shortcomings in the method are recognized. For example, it is recognized that the separate estimation for fuel choice and consumption fails to account for any possible simultaneity between the two related fuel-use decisions. The estimation efficiency could certainly be improved if the choice of fuel mix and fuel consumption level are estimated jointly rather than in two steps. Another shortcoming is related to the transaction cost considerations. In the present study, the transactions costs associated with any given fuel transition were not explicitly represented. Given the importance of access cost as a constraint to fuel flows, the omission of such a variable could possibly be a source of misspecification. Improvements may be realized by adapting a specification similar to that employed by Dubin and McFadden (1984). Additionally, it may be possible to obtain sufficient price variation by developing a cost-price for each fuel, constructed on the basis of the interaction of local fuel prices and access costs.

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THE "NEW" GAS INDUSTRY AND THE LOW INCOME CONSUMER

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I. INTRODUCTION

In the past 10 years, utilities have witnessed an ever growing problem of non-payment of utility bills and growing debt by residential customers. Economic forces which drove up the cost of utility services, along with changes in the financial situation of those persons living on marginal incomes--whether through low-paying jobs or public assistance--have forced millions into a cycle of debt accumulation. Upwards of 20 million households are suffering from incomes inadequate for meeting basic energy costs.

The magnitude of the problem throws it into the arena of public concern, in which the energy distributor is a principal participant. The non-payment of energy bills by the poor poses a long-term social welfare problem and begs for long term solutions.

II. PROFILE OF THE NATURAL GAS MARKET

The natural gas industry is a major supplier of energy to homes, commercial businesses and industries. Natural gas provides nearly one quarter of all the energy consumed in the United States. When the transportation sector (fueled with petroleum) is excluded, natural gas accounts for about 30 percent of all U.S. energy use.

While natural gas is used in all sectors, it is in household use that gas is most visible. Some 55 million households have gas service--64 percent of all households--and 48 million homes use gas for heat. Natural gas is the dominant fuel for space heat and water heating, and is the cooking fuel in nearly 40 percent of all households.[1]

The majority of gas service is located in metropolitan areas. Eighty-three percent of all gas homes are in metropolitan areas, with 44 percent in central cities. A high proportion of low income households (i.e., below 125 percent of the poverty level) are gas customers. Some 60 percent of the nearly 20 million low income U.S. households have gas service and 53 percent heat with gas.

III. STRUCTURE AND REGULATION OF THE NATURAL GAS INDUSTRY

The natural gas industry is actually three separate industries, defined by function and type of regulation. Gas producers explore for and produce natural gas. While some gas prices at the point of production (wellhead) are regulated by the federal government, most gas is free of regulation, with prices determined by contract or; in the case of spot purchases, by market conditions. Gas pipelines transport gas from producing wells to local distribution companies, or end users. Interstate pipelines are federally regulated, through the Federal Energy Regulatory Commission. Interstate pipelines buy and then resell natural gas (sales function) or if they choose, offer only the transportation service (transport function). In the case of transport; the customer is responsible for purchasing the gas. Local distribution companies take gas from the pipelines and distribute gas to end use customers. There are major economies of scale in gas distribution, so to prevent wasteful duplication of facilities, the distributor holds a franchise for a given area. The operations of the distributor are regulated by the state. The status of the gas company as a regulated monopoly means that the gas company (as well as other regulated utilities) has a major responsibility with regard to its customers' welfare that goes beyond the usual responsibilities of a vendor.

Over the past ten years, there have some major changes in the way gas is priced and sold. Before 1978, gas prices at the wellhead had been held at very low levels by federal regulations. To put it simply, the federal prices were not high enough to encourage gas producers to look for and produce gas, and shortages developed. In 1978, Congress passed the Natural Gas Policy Act, which set out a schedule to raise gas prices to more realistic levels, then take controls off most gas in 1985. The NGPA was successful in bringing forth more gas supplies. In fact, there is now a surplus of gas available. The NGPA also allowed prices to rise to catch up to more realistic levels. All sectors of the gas market felt the impact of rising prices. For some residential customers, their stable gas bill started increasing to the point where it became unmanageable. At the other end, large industrial users who could use other fuels switched away from gas, putting more of a burden on local distribution companies and pipelines, who were trying to handle rising commodity (gas) costs and manage to run their systems with fewer customers. Eventually, gas prices in most parts of the country stopped increasing and started to come down. By 1986, the U.S. average gas price (about $5.69/MMBtu) was below the level it was in 1983.[2] To put the price in perspective, the average gas heated home uses about 100 million Btus of gas annually, so the annual fuel bill is about $570 in this example.

One way local distribution companies handled rising gas prices was to diversify their purchases. Instead of buying from only the pipelines that serve them, many distributors are buying their own gas, and asking their pipelines to transport the gas to them. Short term, or spot, gas prices for 30 or 60 day contracts are $.50 to $1.00 below average system prices. Thus, distributors are taking advantage of cheaper "spot" gas to lower the average cost of the gas they sell to residential and commercial as well as industrial customers. In 1986, distributors purchased an average of 18 percent of their gas on the spot market.[3] Spot purchases, as a percentage of total supply, for a distribution company was as high as 40 percent.

The ability of distributors -- or any customers of interstate pipelines -- to buy their own gas and obtain transportation service was made possible by several regulatory changes, including the federal transportation program, Order 436, state transportation programs, and a court decision based on a suit by the Maryland Peoples Counsel. These changes mean that gas distribution companies now have more flexibility in terms of gas costs than they had in the past.

Even with these recent positive developments in gas pricing and transportation, a great many consumers have trouble paying their gas bills. The next section describes the extent of the problem.

IV. EXTENT OF THE PROBLEM

Rising energy prices during the 1970s and early 1980s increased the burden of energy costs on low-income households. In 1972-73, low-income households spent approximately 7 percent of their income on residential energy.[4] By 1984-85, low-income households were spending 15 percent of their income on energy.[5] Since many families were unable to allocate such a high proportion of their income for energy bills, the effect on many companies providing essential energy services has been a steady rise in the number and amount of arrearages among residential customers. The gas industry is particularly concerned with the "working poor" -- families that live on the edge of poverty and juggle utility payments along with other pressing financial obligations. One response to rising energy costs has been to restrict utility terminations of residential accounts during the heating season. While this approach provides poor households time rather than money to meet their energy bills, it often amounts to a hidden subsidy by utilities and fails to resolve the basic payment problem.

The Federal Government has funded several assistance programs to aid low income households to retain essential energy services:

- The principal program is the Low-Income Home Energy Assistance Program (LIHEAP), which has been funded for the last three years at $2.1 billion. LIHEAP is administered by the Department of Health and Human Services, and is in the form of block grants to States to help eligible low income households pay their home energy bills.
- Low-Income Weatherization Assistance Program (LIWAP) is administered by DOE to weatherize the homes of low-income persons. Funding in FY 1985 was $191 million.

There are other federal programs that encourage conservation or make funds available on a case by case basis to augment energy supply needs.

State governments -- through legislation and regulations -- have responded to the growing non-payment problem in a variety of ways. The most widely used approach include seasonal moratoria on service disconnections. Gaining more and more attention are plans that guarantee

service based upon a percentage of income. A number of states provide supplemental assistance to low income households through various funding programs.

After increasing sharply for several years, residential energy prices peaked in 1983 and then leveled off. In 1986, all energy prices declined. The average residential natural gas price declined by 4 percent between 1985 and 1986, and is actually below the 1983 average price in current dollars. However, the stabilization of energy prices does not mean that the crisis is over for low income consumers.

There are many low income consumers that are unable to afford basic energy services even with lower prices. The average U.S. family uses 5 percent of their income to pay for household energy. The low-income family uses 15 percent of their income to pay for energy services.

The major federal assistance program, LIHEAP, is not funded at an adequate level and is only reaching about one third of eligible households. A.G.A. has estimated that in 1984/85 (the latest data available) an additional $8.0 billion of fuel assistance funding would have been required to reduce all low income energy bills to 7 percent of income -- the amount that low income households paid on average in 1972/73. An additional $10.6 billion would have reduced low income energy bills to the 5 percent level that American families paid on average in 1985. Funding for weatherization and state and private sources such as utility fuel funds can help, but total funding still remains well below needs.

While the funding levels have remained basically constant many states have been widening the scope of their programs to reach more families. Thus, a limited amount of money is being stretched over a broader base.

Finally, energy prices are stable today, but all energy costs are projected to increase moderately in the future. A.G.A. projects residential electricity prices to increase by an average rate of 2.7 percent per year above inflation between 1987 and 1995. The U.S. average residential natural gas price will stay low for the next several years but is projected to increase at 1.6 percent per year above inflation between 1987 and 1995.[6] With no oil supply or price problems, home heating oil is projected to increase by 2.4 percent per year above inflation through 1995. These growth rates will not have a significant impact on the average consumer whose income increases with inflation, but could be a hardship for the working poor families who are not assured of stable incomes.

V. HOW THE GAS INDUSTRY HANDLES THE SPECIAL PROBLEMS OF LOW INCOME CONSUMERS

Utility programs tend to focus on two essential elements, usage reduction and payment recovery. Usage reduction reduces the customer's monthly utility bills, cutting back on arrearages and other deliquencies. Usage reduction is accomplished through weatherization programs and/or conservation programs; A.G.A. is aware of 50 gas utility weatherization/education programs.

The most prevalent type of programs are the fuel fund programs. These funds raise money from voluntary contributors to assist consumers with the payment of energy bills. In the winter of 1985/86, A.G.A. received information on 33 company programs that raised $9.6 million in contributions. Many use the Salvation Army as a cosponsor, screening agency, distribution center, or some combination of all three. Nationwide, A.G.A. is aware of 66 gas utility fuel fund programs.[7]

Gas utilities also have special billing and collection procedures, and special rate programs. These range from budget programs that level out payments, to crisis intervention, third party notification, and credit counseling. The goals of these programs are to recognize the problem early before the delinquent bills get too large -- and to help customers make an effort to pay their delinquent bills.

CONCLUSIONS

Almost 20 million households in the U.S. have incomes at or below 125 percent of the poverty level. Most of these households are unable to meet basic energy costs. On average, over half of these households use gas as their primary source of heat.

A combination of federal, state and private funding has assisted low income consumers in meeting their energy costs. But the implementation of various responses has resulted in a confusing patchwork of programs. Not all low income families receive assistance. Federal funding for energy assistance is at risk of being reduced because of overall budget cutbacks. Further, there is a perception that the crisis is over because energy prices have stopped rising.

The gap between needs and available funds is too wide to be bridged by other than governmental sources. One of the major limitations of the federal program (LIHEAP) is that it does not provide energy suppliers and their customers with the expectation of resolving payment problems. The best approach to helping those at greater risk requires a combined effort of gas companies, federal, state, and local governments, public service commissions consumer groups, other energy suppliers and private organizations to develop workable programs. These programs should look at energy costs as a year-round phenomenon, cover primary and secondary energy sources, and include a conservation/weatherization component. To be most effective, they should provide for flexible funding, and a clear eligibility determination. The programs should also discourage long-term dependence on fuel assistance, through early problem identification, perhaps a cap on consumption, and a way to settle past debts and eliminate the need for moratoria.

While these recommendations make nice social policy, they also represent sound economic policy for the gas industry. It appears that: (1) future energy assistance funding is not likely to increase in aggregate; (2) the outreach of existing programs is increasing: and (3) all energy prices are likely to increase moderately in the future. All of these developments will combine to make providing energy to low income consumers a persistent problem for the customer, and the local utility. While energy prices are stable, it may be possible to develop and put

into place a wider and more effective solution than has been achieved in the past. However, the long term solution involves a complex mix of stakeholders, politics, finances and regulations and a great deal more study and commitment on the part of state legislators.

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METHODS OF ASSESSING HEALTH CONSEQUENCES OF RESIDENTIAL LOCATION, HOUSING CONDITIONS AND ENERGY DECISIONS

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METHODS OF ASSESSING HEALTH CONSEQUENCES OF RESIDENTIAL LOCATION, HOUSING CONDITIONS AND ENERGY DECISIONS

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INTRODUCTION

Residential housing is one of the most important components of the well-being of American families (Campbell, et al., 1976; Morris and Winter, 1978). Under conditions of rapid changes in housing prices, interest rates, and energy costs in recent years, many American families have been making individual decisions about their housing. Some of these decisions involve remodeling or retrofitting of the dwelling; others are related to energy use and conservation.

Of particular interest for this study are the consequences for human health emanating from attempts to increase the energy efficiency of housing, the installation of unvented space heaters and the use of wood, kerosene and other energy-and-money-saving fuels. It is likely that some homes are so tightly caulked and insulatd that potentially dangerous substances resulting from the use of new devices and fuels for space heating may pollute the indoor air sufficiently to pose a health threat (Eichner and Morris, 1982). Other houses may be situated along geologic formations which have a high level lof radium in the soil and groundwater. Exposure to radon and its radioactive decay product can produce lung cancer in humans and is generally considered responsible for most of the lung cancer risk to the nonsmoking public (U.S. EPA, 1968a). Through suction pressure, a house can pull soil gases inside, from openings in porous masonry materials and cracks in walls and floors in contact with the earth. Suction pressure varies among houses because of construction details and air handling equipment, such as furnaces and fans. The seriousness of the health risk from radon exposure has been recognized by the complex interrelationships among the factors involved have hampered attempts to solve this problem or even to define its extent.

Research on energy and residential housing during recent years has concentrated on the determinants of housing conditions and conservation behavior (Morrison and Gladhart, 1976; Gladhart, 1977, Gladhart et al, 1978; Morrison et al., 1979; Gladhart and Roosa, 1982). There has been some research on the adoption of solar heating systems (Combs, 1982a, Combs and

Tremblay, 1982). Other studies pay much attention to socioeconomic constraining factors that may limit the ability of families to improve their housing conditions or may serve as direct barriers to energy adjustment behavior (Morris and Winter, 1975; Combs, 1982b). While a great deal of research focuses on the determinants of housing conditions and energy decisions, analysis of the consequences of these conditions and decisions is still lacking.

The present study has been designed to examine the health consequences of energy-related decisions and to analyze relationships between radon exposure, residential location and some existing housing conditions. As part of these purposes, this paper attempts to provide methods of assessing three specific aspects of health consequences: radon levels in the house, indoor relative humidity and self-assessed health status of the respondent.

Due to a relative lack of housing regulations in rural areas, it is expected that experimentation in energy-and money-saving devices is more likey to occur in rural areas than in urban centers. As a result, there is an urgent need for research on health consequences of residential location, housing conditions and energy-related decisions in rural areas. This study is based on a sample of households radomly drawn from four non-metropolitan counties in western New York.

The second section of this paper discusses the detailed procedure used to select a random representative sample. The third section describes the measurement of health consequences. The fourth section details the rationale for specification of key variables used in statistical models, and the final section sets forth the implications for future research.

SAMPLING PROCEDURE

The study area includes 14 non-metropolitan counties in western New York. These counties are Allegany, Cattaraugus, Chautauqua, Chemung, Genesee, Livingston, Ontario, Orleans, Schuyler, Steuben, Tompkins, Wayne, Wyoming and Yates.

The research instruments used in this study involve a length self administered questionnaire, a radon test kit and an on-site measure of indoor humidity. In order to insure prompt collection of radon test kits, to measure indoor humidity accurately, and to assist respondents in completing the questionnaires, a decision was made to use a mail-out and personal pick-up procedure. Questionnaires and radon-test kits were mailed to sampled respondents first, and a week later, county agents of Cornell Cooperative Extension collected questionnaires and test kits at the homes of respondents; in the meantime, they also measured the humidity inside the home. This unique procedure made it very desirable to cluster the respondents by county and to select counties at random to represent different clusters.

A two-state stratified sampling technique was used in this study. First, non-metropolitan counties in western New York were stratified in the manners suggested by the use of cluster analysis procedure for pattern recognition. The basic approach of cluster analysis is explained at length by Tryon and Bailey (1970). The objective of this approach is to identify mutually exclusive sets of objects, within each of which sets all objects seem to have similar attributes. In our case, the objects are the non-metropolitan counties in western New York and the

attributes are six population and housing characteristics of the counties obtained from the 1980 census of Population and Housing: (1) persons per household (PERHSD), (2) proportion of housing units in milti-unit structures (MULTI), (3) proportion of housing units which are mobile homes (MOBILE), (4) proportion of housing units which are renter-occupied (RENTER), (5) proportion of housing units built prior to 1969 (PRI69), and (6) proportion of housing units built between 1960 and 1969 (B6069).

The data for 14 counties (Table 1) were analyzed using SAS's hierarchical cluster anslysis. The technique begins by forming one cluster for each object in the analysis. The two closest clusters are combined into a new cluster, then the two closest of the new sets are combined into another level of cluster, and so on (SAS Institute, 1979). Through this procedure, four clusters were finally identified (Figure 1): an urban cluster with two counties, Chautauqua and Chemung, contains the two major cities of the region, Jamestown and Elmira; a rural cluster includes Allegany, Schuyler and Yates counties; a mixed cluster consists of eight counties (Chattaraugus, Genesee, Livingston, Ontario, Orleans, Steuben, Wayne and Wyoming). Tompkins county, in which Cornell University and Ithaca College are located, and which is so unique that it does not resemble any other county in the area, is isolated as fourth cluster (not included in Fugure 1). Within each cluster, one county was chosen at random to represent the cluster. The counties so chosen were Chautauqua, Yates, Wyoming and Tompkins.

After the four representative counties were designated, the second step was to select representative urban, rural and farm households within each county, proportional to corresponding figures in the entire region (see Table 2, Panel I). The total sample selected includes approximately 120 urban households, 120 rural households and 50 farm households (The sample size was determined by budget constraints). Since a complete list of farm enterprises and their operators was available from the New York Crop Reporting Service/USDA Statistical Reporting Service, sampling farm households from this list was straightforward. Four sub-lists were first derived from a master list that included all farm households in each of the four counties, then a representative sample was drawn from these four lists. The original sample list of households was set large enough to (hopefully) yield about 50 completed interviews.

Listings of addresses, zip codes and telephone information for non-farm households were obtained from Survey Sampling, Inc. (SSI), a private organization which maintains telephone directory information in machine readable form. However, whether a household is located in an urban or rural place was not readily ascertainable. We decided to classify Minor Civil Divisions (MCD) which include cities, towns and Indian Reservations in New York state as rural if 50% or more of their population was rural according to the 1980 census, and as urban if their population was more than 50% urban. This classification procedure respects sub-county municipal boundaries. We then used zip codes to match the urban and rural classifications of MCDs within the four representative counties.

The classification scheme used in this study does not match exactly with the procedure used by the Census Bureau. The primary criterion for the census classification is population

density, its rural-urban designation is based on block data and does not follow local political boundaries. Nevertheless, the results of classifying population as urban or rural by MCD boundaries creates a fairly good adherence to the finer geographic distinction used by the Bureau of the Census. Not only are the total urban-rural population figures very close, but less than 10% of the total population in the 14-county study area was classified differently by the two classification methods.

The first contact with the sampled households was initiated by an advance letter, informing them of the nature of the survey, and stating that they would be called within a week to decide whether they were willing to participate in the study. The telephone list contained 640 households. After telephone contacts, 300 agreed to participate in the study. Among non-participants, 190 refused, 27 were ineligible because of a wrong number or number not working, and, for the remaining 47 households, the line was busy or there was no answer. Under the latter circumstance, the call-back procedure was to call up to six times. The distribution of participants is presented in Table 2, Panel II.

MEASURES OF HEALTH CONSEQUENCES

Human health can be adversely affected by conditions within the built environment that arise from building materials, construction techniques and connections to the external environment (National Research Council, 1981; Wadden and Scheff, 1983). Hazards associated with building materials include those from toxic and carcinogenic substances such as lead, formaldehyde and asbestos. Airtight construction techniques implemented without provision for adequate ventilation can contribute to high concentrations of airborne contaminants emanated from building materials and generated from household activities. Connections to the exterior environment can be responsivle for airborne contamination, through sources including water supplies and gases released from the soil in which a house is situated. The relationships among these factors and indoor air quality are of particular concern because many people may spend from 58 to 78 percent of their time indoors at home, and the elderly and the infirm, all of their time indoors (Walsh et al., 1984). Health measures involved in this study are those related to moisture, radon gas and self-assessed health status.

MOISTURE

Water vapor is always present in household air. An average household of four people generates between 3 and 6 gallons of moisture per day (ASHRAE, 1981). Moisture can also enter a house from external sources, including rain, snow, and ground water. The balance maintained among moisture gain, loss and storage is responsible for the level of relative humidity inside a home. Moisture-related health problems occur at both low and high levels of relative humidity. Sterling et al. (1985) reviewed relevant health literature on this topic and concluded that optimal conditions to minimize risks to human health occur in the relative humidity range of 40 to 60 percent. Below this range, dry skin and mucous membranes can result in irritations to the throat and other areas. The process of effective evaporative cooling is interrupted at high levels of relative humidity, increasing the likelihood of heat exhaustion and heat stroke.

Humidity levels can also affect health indirectly, through interactions with biological pathogens and chemical substances often present in household air. Studies of biological contaminants and humidity levels reviewed by Sterling et al. (1985) indicated that bacterial populations thrive at both low and high humidity levels but are minimized within the 30 to 60 percent relative humidity range. Viruses, including vaccinia (cowpox), measles, influenza and those responsible for acute respiratory infection, have all been found at low and high humidity, but risks to human populations are minimized within the range of 50 to 70 percnet. The undesirable effects of relative humidity levels also vary among different groups of people. For example, asthmatics, infants and the elderly have more health problems at low levels, while those with allergies have difficulty tolerating high levels. Further, the combination of high humidity and high temperature has been shown to increase the risk of adverse effects for certain groups of people. In light of these considerations, a relative humidity range of 40 to 60 percent has been used in the present study as the optimal zone of relative humidity for human health.

Relative humidity can be measured with a sling psychrometer, a device with both wet and dry bulb thermometers, readings from which can be used in conjunction with psychrometric charts to determine humidity levels.

RADON GAS

A colorless, ordorless gas that occurs naturally in low concentrations all over the world, radon is a radioactive product formed by the decay of radium-226. Exposure to radon and its radioactive decay products can produce lung cancer in humans. Lung cancer cases from this exposure may number 10,000 per year in the United States (Nero, 1986). Radium is present in trace amounts in groundwater, soil, and some building materials.

High concentrations in indoor air result from the decay of radium and emanation of radon from the soil in which a house sits. Contaminated groundwater can also be responsible for high radon levels, which occur when water is aerated at faucets and shower heads (Hasbrouck et al., 1983).

In a study conducted by Nitschke et al. (1985), 60 houses near Syracuse, Albany, Oswego and Utica, New York were monitored for indoor concentrations of radon, among other pollutants. Findings from that research suggested that houses built on upstate New York black shales are more likely to have high indoor concentrations of radon, while houses built over ventilated crawl spaces are less likely to have such concentrations.

The presence of radon is first tested with a screening measurement, which is conducted in the area of the house closest to the underlying soil (usually the basement) under "closed-housed conditions". the closed-house condition refers to a situation in which the house is made as air tight as possible for 12 hours preceding the start of the measurement period, and kept that way for the duration of the test. Charcoal canisters and alpha-track detectors are acceptable screening devices, although other instruments can be used as well. Charcoal canisters are

kept in place for 3 to 7 days and alpha-track detectors for up to 3 months. The former instrument is the chosen device used in this study. Not only does a charcoal canister require a shorter measurement period, but also it is easily sent and returned by mail, and instructions for the use are easy to follow by any householder. The cost per measurement is apparently well below that for competitive techniques. Most important, the sensitivity and accuracy of the device are adequate for monitoring radon levels in houses (U.S. EPA, 1986b; Cohen and Nason, 1987).

SELF-ASSESSED HEALTH STATUS

Conceptually, health is viewed as multidimensional in nature. A comprehensive definition was proposed by the World Health Organization in 1948: "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." to measure this broad concept of health, both clinical and survey methods can be used. For studies of the health status of the population in general, it has seemed advisable and more economically feasible to develop measures of self-assessed health status. Numerous studies have attempted to construct such measures based on survey data (Maddox, 1964; Belloc, et al. 1971; Hessler, et cal. 1971; Lawton and Cohen, 1974; Wan, 1976). Other studies have shown that measures of self-assessed health status are valid and reliable, and that they are an important element in measures of quality of life (Andrews and Whithey, 1974; Campbell, et al. 1976). In the Health Insurance Study conducted by Rand Corporation (Ware, et al., 1980), health status was measured not only in terms of its physical, mental and social dimensions but also by an integrative concept, general health perceptions. Measures of general health perceptions differ from other measures of health status in that they ask respondents for a self-rating of their health in general rather than focusing on a specific dimension of health status. Such an underlying general health concept, however, is considered to be related somewhat to each of the three dimensions of health status.

In this study, three questions on general health perceptions were included in the interview questionnaire. The first question refers to respondent's subjective assessment of his health today as compared with this evaluation of this health 5 years ago. The second asks respondents to compare their current health with that of other people of the same age. The third question, "What do you expect your health will be 5 years from now?" calls for a projected future health status. The five original response options for each of the three questions - "much better," "slightly better," "about the same," "slightly worse" and "much worse" - will be recorded into three categories (better, same and worse) for statistical analysis.

STATISTICAL MODELS

Radon levels, relative humidity and self-assessed health status are the three aspects of health consequences that will be examined in this study. Statistical models of reduced form are presented as follows:

RADON LEVELS

The variation in radon levels among different housing units will be analyzed using an ordinary least square model, as

$$RA = f(DF, PC, LC, ER) \quad \ldots\ldots(1)$$

where RA = A continuous variable that measures the extent of radon level within a given household (measured in picocuries per liter (PCi/l).

DF = A vector of demographic variables, including race, income level, household type, occupation, race X income, etc.

PC = A vector of physical conditions of the housing units, including housing types, basement or crawl space, structural deficiencies, etc.

LC = A vector of location variables, including community location, rural urban or farm, soil types of the lot, etc.

ER = A vector of energy conservation decisions such as insulation, temperature limitation, structural change or space reduction.

Of particular interest in this model is the interaction term between race and income (race X income). It is hypothesized that low-income minority groups tend to experience a higher level of radon gas than other groups because they have limited access to more desirable housing units and have less economic ability to correct existing housing deficiencies.

Studies investigating relationships between high concentrations of radon and levels of airtightness or energy efficiency of houses have indicated that no clear relationship exists between these two variables. Radon concentrations and infiltration rates were measured in 58 houses in four United States cities by Doyle et al. (1984), who reported correlations between air infiltration rates and radon concentrations. Nero et al (1983) reported similar findings from a sample of 98 houses scattered throughout the United States. Including energy conservation variables (ER vector) in this study represents an attempt to retest these previous findings.

MOISTURE

Variation in indoor moisture, as measured by relative humidity levels, will be analyzed in an ordinary least square model:

MU = g (DF, PC, ER, TE) .....(2)

where MU = A continuous variable that measures the degree of relative humidity inside the home (in percentage).

TE = A vector of indoor and outside temperatures on the same day that humidity was measured.

DF, PC and ER are described in the previous model.

SELF-ASSESSED HEALTH STATUS

Three logit models will be used to analyze the differences in general health perceptions. Since general health perceptions are measured as categorical variables (see measurement section), logistic regression is an appropriate statistical technique.

GH = h (DF, PC, $\hat{HC}$).....(3)

where GH = Measures of general health perceptions, based on respondents' self-rating of their overall health in the past, present and future.

HC = A vector of health considerations, including estimated radon and humidity levels derived from equations 1 and 2.

DF and PC are described in equation 1.

Since both radon and humidity were measured at one point in time, it is quite desirable to obtain some long-term figures. Unfortunately, these figures are not available from the current data set. Instead, we will estimate levels of radon and humidity from regressions 1 and 2. The estimated values may be considered average measures for radon and humidity. Further, the estimated values will be converted into categorical variables. For example, relative humidity will be classified into low (below 40%), high (over 60%) and optimum (40% to 60%); radon levels into high (over 4 PCi/l) and low 4 PCi/l or under). It is hypothesized that low and high humidity will have adverse effects on general health status and that high radon levels will be negatively related to general health status.

IMPLICATIONS FOR FUTURE RESEARCH

The present study not only generates current information on health consequences of housing conditions and energy decisions, but also provides a solid data base for future longitudinal analyses. For example, the screening measurement used in this study does not provide a

reliable estimate of average radon levels to which a household is exposed, because of seasonal differences in emission rates as well as variation in radon levels among the different rooms of a house. Results of a screening measure serve only as an indicator of a potential radon problem. Future follow-up measures can estimate the long-term average concentrations of radon in a highly reliable way. Follow-up measurements can be made over a 12-month period or over a few weeks. Those made over a longer period are much better estimates of annual average concentrations. A similar follow-up procedure can be applied to measurement of relative humidity through different seasons.

Since our preliminary results show that a significant portion of our sampled households (34%) had been exposed to radon concentrations beyond the recommended safety level (see Table 3), it is very important to follow up those households who had high levels of radon measured over a long period of time. The questions raised for future research are: Whether these households will take active means to reduce radon levels, or move to a new residence, or take no actions at all. If they indeed move, will the new buyer be informed about the radon level or their houses? What will be the long-term effects on the health of those who have been exposed to high levels of radon gas for a long period of time? These crucial questions can only be answered by means of a longitudinal panel study.

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Table 1: Mean Values of the Six Variables Used in the Cluster Analysis of 14 Nonmetropolitan Counties in Western New York

Clusters and Counties	Variables					
	PERHSD	MULTI	MOBILE	RENTER	PRI69	B6069
Urban Cluster						
(1) Chautauqua	1.25	20.39	6.72	26.94	10.84	85.39
(2) Chemung	1.60	18.78	6.42	27.43	12.46	84.51
Rural Cluster						
(1) Allegany	2.78	17.38	8.80	25.61	11.34	83.42
(2) Schuyler	3.37	16.54	9.37	23.54	11.86	83.86
(3) Yates	1.37	17.07	8.77	24.79	11.14	83.26
Mixed Cluster						
(1) Steuben	2.19	17.94	9.03	25.51	11.74	83.05
(2) Cattaraugus	2.66	18.43	8.19	25.94	10.85	83.72
(3) Livingston	3.37	17.73	9.08	26.32	13.50	82.50
(4) Ontario	2.66	18.32	8.24	26.11	13.03	81.51
(5) Orleans	3.72	18.13	7.64	25.44	11.46	84.19
(6) Wyoming	4.31	17.71	7.09	25.12	10.17	83.46
(7) Wayne	3.84	17.90	8.33	24.80	12.92	82.33
(8) Genesee	3.72	19.38	8.83	26.04	12.61	83.91
Unique Cluster						
(1) Tompkins	2.56	34.21	7.49	44.83	17.81	77.53

Figure 1: Profile of Clusters

No. of Clusters	Name of Counties													
	ALLEGANY	SCHUYLER	YATES	CATTARAUGUS	STEUBEN	GENESEE	ORLEANS	WAYNE	WYOMING	LIVINGSTON	CONTAIR	CHAUTAUQUA	CHEMUNG	
1	X	X	X	X	X	X	X	X	X	X	X	X	X	
2	X	X	X	X	X	X	X	X	X	X	X		X	
3	X	X	X	X	X	X	X	X	X	X	X		X	
4	X	X	X	X	X	X	X	X	X	X			X	
5	X	X	X	X	X	X	X	X	.	X			X	
6	X	X	.	X	X	X	X	X	.	X			X	
7	X	X	.	X	X	X	X	X	.	X			X	
8	X	X	.	X	X	X	X	X	.	X		.	.	
9	X	X	.	X	X	X	X	.	.	X		.	.	
10	.	.	.	X	X	X	X	.	.	X		.	.	
11	.	.	.	X	X	.	.	.	.	X		.	.	
12	.	.	.	X	X	.	.	.	.	.	.	.	.	
13	.	.	.	.	.	.	.	.	.	.	.	.	.	

Table 2: Comparisons of Urban, Rural and Farm Populations Between Clusters and Representative Counties

Unit	Urban	Rural	Farm
	(column percents in the parentheses)		
I. County Clusters			
(1) Urban Cluster	57,325 (40.28)	27,998 (14.28)	2,515 (18.35)
(2) Rural Cluster	6,819 (4.79)	21,491 (10.96)	1,946 (14.20)
(3) Mixed Cluster	64,052 (45.02)	131,081 (66.88)	8,677 (63.31)
(4) Unique Cluster	14,105 (9.91)	15,443 (7.88)	567 (4.14)
Total	142,301 (100.0)	196,013 (100.0)	13,705 (100.0)
II. Sampled Counties			
(1) Chautauqua	38 (35.51)	17 (13.93)	15 (21.13)
(2) Yates	5 (4.67)	9 (7.38)	9 (12.68)
(3) Wyoming	53 (49.53)	87 (71.31)	42 (59.15)
(4) Tompkins	11 (10.28)	9 (7.38)	5 (7.04)
Total	107 (100.0)	122 (100.0)	71 (100.0)

TABLE 3: Means and Ranges of Radon Levels for Selected Counties in Western New York (preliminary results)

	Chautauqua Yates, and Tompkins	Wyoming	Total
n	60	117	177
mean (pCi/l)	5.86	6.6	6.04
range (pCi/l)	0.6 - 51.4	0.5 - 118.5	0.5 - 118.5
n ≤ 4 pCi/l	39 (65%)	77 (66%)	116 (66%)
n > 4 pCi/l	21 (35%)	40 (34%)	61 (34%)

ENERGY DATA NEEDS FOR POLICY ANALYSIS

JOE ROOP
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ENERGY DATA NEEDS FOR POLICY ANALYSIS

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1.0 INTRODUCTION

The United States economy has changed dramatically since the early 1970's. Relative energy prices more than doubled on two separate occasions; price controls were applied then eased for the first time since the Korean War; legal requirements for pollution abatement were enforced; some multinational companies shifted production to lower-cost regions; and the U. S. trend toward a service-oriented economy continued. Each of these events has given rise to some policy discussion, if not debate. It is the objective of this paper to discuss data requirements that can be useful in such policy discussions.

Much of the data that enters into such policy discussion has little or no bearing on minorities, and is usually collected without regard to the distribution of minorities in economic activity. Despite this dearth of objective data, judicious layering of different data sources may shed some light on minority impacts. But before we get to that stage of the paper, there are several preliminary topics that move us from the general--energy data needs for policy analysis--to the specific: a discussion of minority impacts on energy use in the residential sector.

In moving from the general to the specific, we will cover a number of topics. As part of this introduction, the first subsection offers some definitions, the second a brief general discussion of data requirements for policy analysis. Then we move to an analytical study that characterized the type of information that is useful for policy analysis: a study of structural change in the U. S. economy over the period 1972-1977. This study is useful background information because structural changes can be attributed to the changes over time of decisions or choices of different economic agents: consumers, businesses, governments and the rest of the world. The method is illustrated by an examination of changes in labor requirements and changes in energy use in the U. S. over the period 1972-1977. The third section refocuses this idea of structural change to examine the effect of minorities on energy use in the residential sector. The final section moves back to the general with some suggestions on the layering of data sources and how multiple data sets may be used to shed additional information on minority impacts.

1.1 Definitions

The title of this paper at least requires that we explain what we mean when we talk about "policy analysis" or "energy data," and the title of this conference and session suggest several other definitions.

POLICY ANALYSIS

Policy issues, at least as they are treated within the Office of Policy, Planning, and Analysis at DOE, have certain characteristics that affect the type of analysis and data needed to pursue them successfully.

Timeliness - Policy is a time dependent variable. Issues arise quickly, and must be dealt with quickly, most often on a schedule not controlled by the analyst.

Disaggregation - Policy is often targeted at very specific components or subsectors of the economy - e.g., electricity use in rental housing. Analysts must be able to isolate that subsector and its characteristics.

Interactions - No policies, particularly energy policies, operate independently of other forces. An energy efficiency information program or renewable energy tax credits must operate in an environment of many other stronger economic and behavioral forces. The ability to characterize likely interactions is critical to developing effective policies.

Precision - In contrast to the characteristics discussed above, policy analysis frequently does not demand the level of precision required in other areas. Presentation of energy statistics, program evaluation, and financial management of expenditure programs are areas where a high level of precision is needed. Since policy development is most often carried out before-the-fact, i.e., "what if" type questions, a high degree of precision is not justified; small changes in assumptions can completely change the results. It is also the case that we can only expect small shifts to occur as a result of a given policy operating in an environment of other stronger forces. Because of this, it is frequently realistic to show only the direction and general magnitude of given policy. Policy makers have to be capable of operating in this environment.

With regard to this last point, we draw a distinction between policy analysis that is "before-the-fact" and that which focuses upon understanding what has happened in the past and identifying the causal factors. In this latter area, to which we devote a great deal of our efforts in the energy demand arena, a greater level of precision is possible than in prospective analysis and may be required depending on how fine a level of cause and effect we are seeking to identify. In fact, the examples presented in this paper are focused on retrospective policy analyses that provide a framework for prospective "what-if" analysis. However, even in this area, we often settle for less precision in a trade-off to achieve a greater degree of disaggregation and insight into interactions.

DATA CHARACTERISTICS

The characteristics of policy analysis obviously determine the kind of data needed for our work. The following is a listing of what we might call a "wish list" of data characteristics. It is readily apparent to all of those working in this area that the energy end use data sources that exist frequently don't meet these needs. Our point is not to criticize DOE/EIA or other data-gathering efforts, or to review critically what is available; that has been done in work presented in two reports in 1986. We simply recognize that the quality of the policy analysis is often limited by the data available. In this context we can examine the desirable characteristics of energy end use data:

Timeliness - We need current data, now. Political pressures often demand a policy response before adequate data or analysis is possible.

Detail - Energy use data by sector, subsector, geographic region, demographic factors such as income and ownership characteristics, are necessary.

End Use Specificity - In what appliances or industrial processes is the given fuel type being used? This is a particularly acute problem for electricity.

Consistency - Changes in definitions, sample frameworks, and even the people or institutions gathering or reporting the data create problems.

Length and Depth - While detailed, continuous time-series are perhaps the most desirable type of end use data, they are very costly to maintain and often need to be supplemented with cross-sectional data to identify short-run or non-economic underlying factors.

Access - Since policy analysis is often exploratory in nature, i.e., the direction of the task is frequently not fully defined until a good deal of data and theories have been explored, it is important to have easy and direct access to the full data base. This need, however, has to be balance against the responsibility of data-gathering organizations, such as EIA or the Census Bureau, to protect the confidentiality of data sources.

Rather that discuss these data needs any further in the abstract, the remainder of this paper will focus on a recently-completed data analysis tool in our office - "GNP Structural" - and an ongoing data analysis project, "Population Structural" - to illuminate how currently available data can meet the needs of policy analysis.

2.0 STRUCTURAL CHANGE IN THE U.S. ECONOMY

Conceptually the idea of structural change is quite simple; as a point of departure, consider the labor intensity of an industry. The labor requirements for that industry can be defined as:

$$L_i = l_i X_i \tag{1}$$

where: L is the total labor required to produce the output of industry i,
X is the output of industry i, and
l is the labor requirements for the production of a unit of output.

Now define a change in labor requirements as:

$$\Delta = L_t - L_{t-1}$$

$$\text{or } L_t = L_{t-1} + \Delta L$$

were the industry subscript has been suppressed. For time period t, then, the labor requirements can be written as,

$$L_t = l_t X_t = (l_{t-1} + \Delta l)\,(X_{t-1} + \Delta X)$$

$$\text{or } \Delta L = l_{t-1}\Delta X + \Delta l X_{t-1} + \Delta l \Delta X \tag{2}$$

i.e., the change in labor can be decomposed into three parts: the change in output evaluated at the previous period's labor intensity, the change in labor intensity evaluated at the previous period's output, plus the product of the two changes. By collecting terms in equation (2), the decomposition can be restated in two terms:

$$\Delta L = l_{t-1}\,\Delta X + \Delta l\,(X_{t-1} + \Delta X) = l_{t-1}\,\Delta X + \Delta l X_t, \tag{3a}$$

or,
$$\Delta L = \Delta X(l_{t-1} + \Delta l) + \Delta l X_{t-1} = \Delta X l_t + \Delta l X_{t-1}. \tag{3b}$$

The simple decomposition represented in equations (2) and (3), can be applied to the input-output structure of the economy, and has been used in a number of studies of structural change. The analogue of equation (2), applied to the standard input-output identity proceeds as follows:

$$X = AX + F \tag{4}$$

where: A is an nxn matrix of direct requirements coefficients,
X is an nx1 vector of outputs, and
F is an nx1 vector of final demands.

Equation (4) is first restated to solve for X, then the operations of equation (2) is applied to yield:

$$\Delta X = \Delta(I - A)^{-1}F + (I - A)^{-1}\Delta F + \Delta(I - A)^{-1}\Delta F \qquad (4')$$

Most of the input-output based decompositions of structural change use either equation (4') or its analogue transformed as in equations (3). From (4), the solution for X is obtained by:

$$X = (I\text{-}A)^{-1} F \qquad (5)$$

$(I\text{-}A)^{-1}$ is commonly known as the Leontief inverse.

We calculate factor use by industry as follows. Let E represent total factor use for all industries in the economy for a given year. Let C be a vector of factor intensities (for the same year) by industry. In matrix notation the factor use summation over industries is calculated as:

$$E = CX \qquad (7)$$

The matrix operations that converts from final demand to total factor use can be summarized in the following expression:

$$E = C\,(I\text{-}A)^{-1} F \qquad (8)$$

Equation (8) provides a starting point for the decomposition, but first relabel the and middle term so that $A = (I\text{-}A)^{-1}$, and attach a time subscript to each of the arguments:

$$E_2 = C_2X_2 = C_2(A_2)F_2 \qquad (9)$$

Where the subscript 2 indicates a 1972 date.

In moving from 1972 to 1977, all of the entries in equation (9) will likely change -- specifically, the distribution of final demands (F) will change, the input-output structure (A) will change, and the factor intensity of industry (C) will change. To decompose these changes, we construct the discrete analogue to the total differential of equation (9), to yield:

$$\Delta E = \Delta C\, A\, F + C\, \Delta A\, F + C\, A\, \Delta F - \Delta C\, \Delta A\, F \qquad (10)$$

$$- \Delta C\, A\, \Delta F - C \Delta\, A\, \Delta F = \Delta C\, \Delta\, A\, \Delta F$$

where: $\Delta E = E_7 - E_2$.

This equation has several advantages: it is mathematically exact; it can be calculated using either 1972 or 1977 as a base; and some of the terms can be further decomposed. For example, the third term in equation (10), the term that captures the major effect of the change in final demand, can be further decomposed into a scale change and a compositional change. Equation (10) has one major disadvantage. Although the first three terms represent the major effects of changes in only one variable, the remaining four terms are difficult to interpret as having any economic significance. Accordingly, they have been eliminated from the diagram, shown in Figure 1. Using 1977 as a base year, the figure shows the changes in labor requirements in the U.S. over the period 1972-1977, decomposed into three components.

Between 1972 and 1977, labor requirements increased by 12.5 billion hours, or about 10.8 percent. This compares with a growth of Gross National Product of 13.4 percent over the same period. If technology and labor productivity had remained unchanged over this period, the growth of purchases of goods and services in the economy (i.e., the changes in final demand) would have required an additional 18.4 billion hours to produce. Productivity improvements offset these additional requirements, reducing the amount of labor needed to product all goods and services by 5.3 billion hours. This 5.7 percent improvement amounts to a 1.1 percent productivity increase per year. Changes in the way businesses use materials saved an additional 600 million hours over the period 1972-1977.

Figure 2 is a figure similar to Figure 1, for energy use. With the size of the bars approximating the amount of the change, the figure highlights the differences between these two resource adjustments over this period.

Although the economy grew 13.4 percent between 1972 and 1977, energy use as an intermediate material in the production of goods and services actually declined by 0.1 quad. In the absence of any significant improvement in the way that businesses used energy, the goods and services produced in 1977 would have required an additional 4.11 quad if they had been produced using 1972 technology. A number of factors account for these energy efficiency improvements, of which two are shown here. Improvements in the way that industries use energy, represented by the energy productivity bar, accounted for a savings of 3.18 quad of energy between 1972 and 1977. These efficiency improvements are the result of: industry using newer, more energy-efficient equipment; substitution of waste materials for purchased fuel; and being more careful with the way that fuel is used. Changes in the purchases of materials that embody energy, represented by the bar labeled interindustry structure, account for more than an additional quad of energy saving over this period. One would expect these interindustry changes to occur if the costs of energy-intensive materials increased relative to materials that were less energy-intensive. Responding to higher costs of energy-intensive materials is likely the cause of the savings of 1 quad between 1972 and 1977.

The major difference between Figure 1 and Figure 2 is the magnitude of the net change in resource use over this period. Whereas labor requirements grew substantially over this period, energy use declined slightly. This very small net change in the case of energy disguises significant structural adjustments that are indicated by the height of the bars that represent

changes in the three major components. The compositional change that results from the growth of the economy (shown by the change in final demand) is an order of magnitude larger, and of the opposite sign, from the net change in energy use over the period 1972-1977. The other sources of change more than offset what would have been an increase in energy required as a result of economic growth.

From a policy perspective, there are two topics that warrant attention: the source of data for this analysis and the possible causes of such dramatic structural change. The detailed energy data are derived from the National Energy Accounts, maintained by the Office of Business Analysis in the U.S. Department of Commerce. Input-output tables are also available from Commerce, through the Office of Interindustry Economics. Manhours are available from the Bureau of Labor Statistics, Department of Labor. The final demands used to solve for output are provided with the input-output data.

There are a variety of causes of structural change; for example, the sharp increase in world oil prices. Such a dramatic shock sets in motion a chain of events that can substantially change the structure of the economy. As rational economic agents respond to this change, we would expect events to unfold as follows. An increase in the price of refined oil, stemming from the now higher price of crude, would be passed along both to ultimate consumers and to businesses that use refined petroleum products as intermediate materials. Businesses would substitute other fuels--coal or natural gas--for oil, thus bidding up the price of these other fuels. The price of electricity would also increase because coal is the primary fuel used to produce electricity. All fuels and electricity, now somewhat higher priced, would add to the cost of the commodities produced. When the full force of these cost changes are reflected in prices, consumers--individuals, businesses, governments, and foreigners-will find that less energy-intensive goods now have lower prices compared with more energy-intensive goods, and will substitute for the relatively cheaper commodities. Imported goods that do not fully reflect these higher domestic energy prices, for one reason or another, will likewise be relatively less expensive and thus more attractive.

The change in the composition of goods purchased by consumers from domestic and foreign industry will feed back to the domestic industries producing those goods. The result will be a shift in the volume and relative position of industries--energy-intensive industries will produce relatively less; less energy-intensive industries will produce relatively more. Because the less energy-intensive industries have had the least incentive to substitute other factors for energy, their energy use will change the least, but now their fraction of total output will be relatively larger. In short, both the consumer adjustments and the substitution mechanisms operational at the firm level will have the effect of altering the mix of goods sold to final demand and the selection of intermediate materials use in production; accordingly, the bill of final goods will change in response to a world oil price increase.

Thus, the adjustments made by economic agents -- the compositional shifts in final demand, the change in interindustry flows and the reduction in energy intensity -- nearly exactly offset the 19 percent increase in energy use that uniform growth would have required. And all of

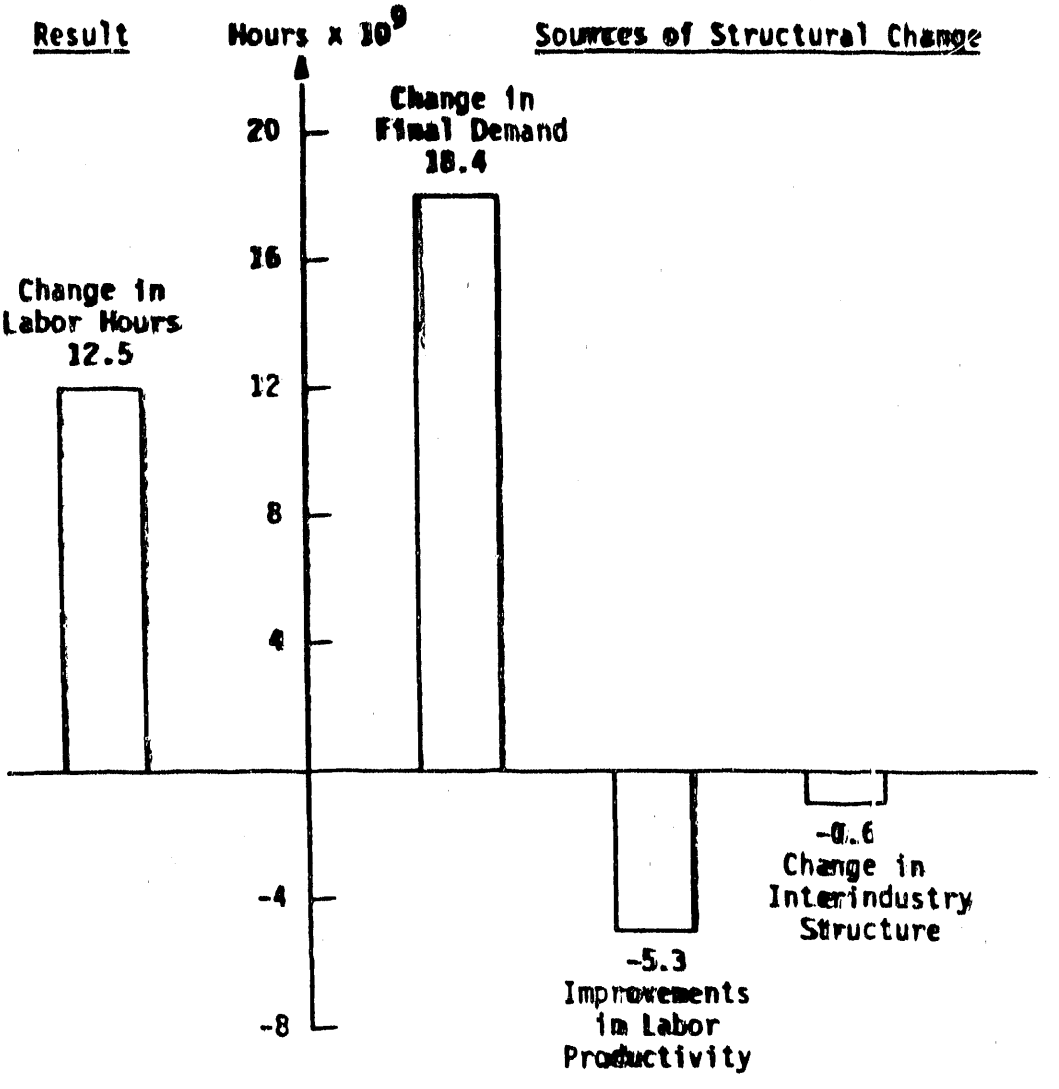


FIGURE 1. Decomposition of Total U. S. Labor Hours, 1972-1977

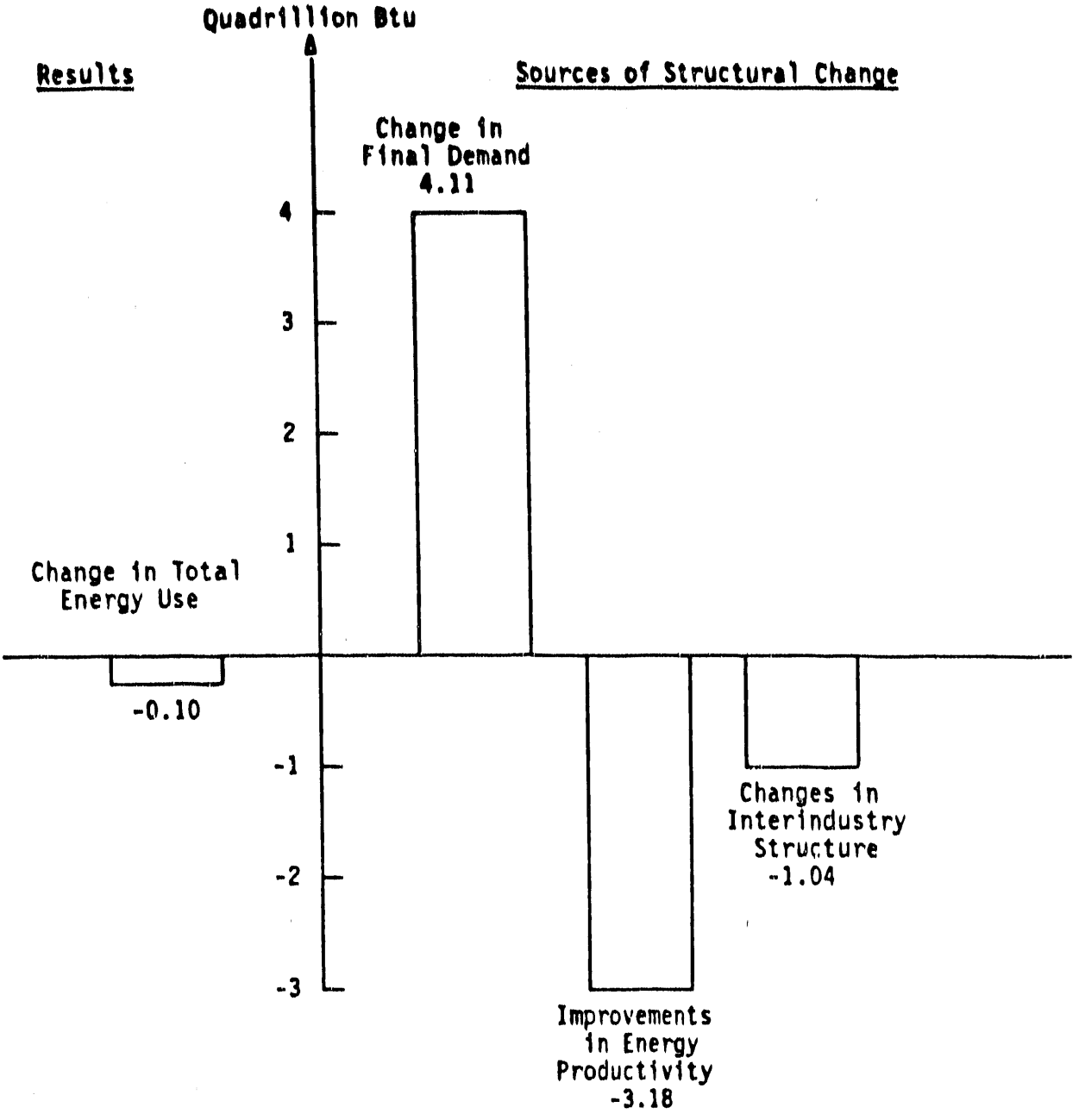


FIGURE 2. Decomposition of Total U. S. Energy Use, 1972-1977

this occurred within five years. This striking evidence belies the argument that lengthy periods are required for the economy to adjust to major changes in resource markets.

3.0 MINORITY IMPACTS THROUGH POPULATION STRUCTURAL

Using some of the lessons learned about industrial energy use in the GNP structural disaggregation analysis model, we moved to an analysis of some of the changes in residential energy use patterns. This is most definitely a description of a work still in progress. To assist you in following the exposition, some of the results from our preliminary runs will be presented, but they are just that -- preliminary.

Our basic analysis structure:

Change in residential energy consumption	=	Change attributable to population growth	+	Change attributable to per capita energy use

The change in aggregate residential energy use was first divided into the portion of the change attributable to population growth, and the portion attributable to more behavioral energy use pattern changes per capita. For example, residential energy use in 1977 was almost 9.9 quads for a population of about 220 million, or about 45 million Btu's per capita. Had the 1977 per capita residential energy use ratio remained constant until 1983 and been applied to the 1983 population of about 235 million, total residential energy consumption would have been almost 10.6 quads, or about 2.1 quads more than the actual consumption of approximately 8.5 quads. So, keeping per capita residential energy consumption constant, population growth alone would have added .7 quads.

Change in residential energy consumption	=	Change attributable to population growth	+	Change attributable to per capita energy use
-1.4 quads	=	+ .7 quads	+	Change attributable to per capita energy use

By subtraction, the change attributable to per capita energy use adjustments must be a decrease of 2.1 quads. The next step in the analysis was to examine the forces behind that change.

We did not have a residential energy input-output table from which to work, so we assembled a quarterly data base, spanning 1974 through 1984, to estimate the coefficients that we needed to disaggregate the changes in per capita energy use. The analysis was conducted for four residential fuel sources: electricity, natural gas, fuel oil, and coal. Our data sources included the Energy Information Administration, the Bureau of the Census, and the National Oceanic and Atmospheric Administration. The explanatory power of our regression equations was generally high, with R^2's from .88 to .93 for our electricity, natural gas, and fuel oil equations, but with a relatively low value of .58 for coal. Surprisingly, none of the quarterly regression displayed significant serial correlation.

Using the same four numbers for population and aggregate residential energy use already presented, we can examine the sum of the per capita energy consumption across fuel types:

Year	Population	Aggregate Residential	Per Capita Residential
1977	220 million	9.9 quads	45 million Btu's
1983	235 million	8.5 quads	36 million Btu's

In investigating the components of the change in per capita energy use patterns, the two most obvious forces for examination are the price and weather effects. Our preliminary results show that of the 9 million BTU per capita decrease, 5 million was attributable to decreased consumption in response to increased home energy prices. Applying the price portion of the per capita change to our base year population accounts for another 1.2 quads of our difference.

Change in residential energy consumption	=	Change attributable to population growth	+	Change attributable to per capita energy use
-1.4 quads	= + .7 quads +	Price change effect	+	Other changes in per capita energy use
-1.4 quads	= + .7 quads +	(-1.2) quads	+	Other changes in per capita energy use

While our analysis showed that home energy use was sensitive to weather conditions as measured by population-weighted heating and cooling degree days, there are negligible differences in heating and cooling degree days in comparing 1977 and 1983. Therefore, none of our difference is attributable to weather.

-1.4 quads	=	+ .7 quads	+	Price change effect	+	Weather change effect	+	Other changes in per capita energy use
-1.4 quads	=	+ .7 quads	+	(-1.2) quads	+	0 quads	+	Other changes in per capita energy use

Having controlled for energy prices and weather, we then began examining some possible correlations between residential energy use and the sociodemographic changes during the analysis period. After controlling for the price effect, energy use was not sensitive to changes in household income or the unemployment rate. The population-weighting of heating and cooling degree days eliminated any migration effects. To date, we haven't found a significant correlation between changes in energy use and changes in either the rate of female participation in the labor force or the average age of the population.

We have only found two significant relationships thus far. Residential fuel oil consumption was somewhat sensitive to the average number of persons per household, with fuel oil consumption increasing as household size decreased. This effect contributed an increase of 0.4 quads to our 1977 to 1983 energy use difference.

-1.4 quads	=	+ .7 quads	+	Price change effect	+	Weather change effect	+	Household size effect	+	Other changes in per capita energy use
-1.4 quads	=	+ .7 quads	+	(-1.2) quads	+	0 quads	+	.4 quads	+	Other changes in per capita energy use

All fuel types were sensitive to changes in the minority fraction of the population. But the effect of the increases in the minority fraction differed both in size and direction among fuel types, with a range of negative effects from almost negligible for coal to very large for fuel oil, and a large positive effect for electricity. The aggregate effect across fuel types for our 1977 to 1983 comparison is a decrease of 1.3 quads. The population growth effect on per capita energy use, as well as the effects of changes in socioeconomic variables, are shown on Figure 3.

-1.4 quads	=	+ .7 quads	+	Price change effect	+	Weather change effect	+	Household size effect	+	Minority fraction effect
-1.4 quads	=	+ .7 quads	+	(-1.2) quads	+	0 quads	+	.4 quads	+	(-1.3) quads

We intend to continue our analysis to determine how much of this minority fraction effect is attributable to minority population home ownership vs. rental rates, single vs. multi-family dwellings, and the age of housing units for the minority population.

4.0 SUGGESTIONS FOR FURTHER RESEARCH

The examples we have used illustrate how a variety of data can be used for policy analysis. Our examples have been chosen to highlight different types of data, but a common thread runs through both. In the first example, the interindustry structure of the economy (at the aggregated level) was decomposed to examine the sources of change in the use of energy as a result of the following: changes in final demand, changes in interindustry flows and changes in energy-use intensity. In the second example, changes in residential use of energy were decomposed into a variety of causes--changes in population growth, changes in energy prices, changes in weather effects, changes in household size, and changes in the minority fraction of the population. In this latter example, our measure of minority impacts is constructed from demographic variables. There are alternative ways to examine the effects of economic change on minorities.

Return to the original example of labor requirements for the economy. The Bureau of Labor Statistics collects information on the distribution of minorities by occupation and employment. One could disaggregate labor requirements by industry further by identifying such characteristics as sex, occupation, race, religious preference, or national origin. Once an appropriate set of characteristics was identified that adequately characterized the set of attributes of policy interest, then one could calculate intensity coefficients for this set of attributes. Then a decomposition of the sort outlined in Section 2.0 would allow the identification of those industries in which change would have the most (least) impact on minority employment. Such a decomposition could be useful for examining the effect of policy programs in terms of their minority impacts.

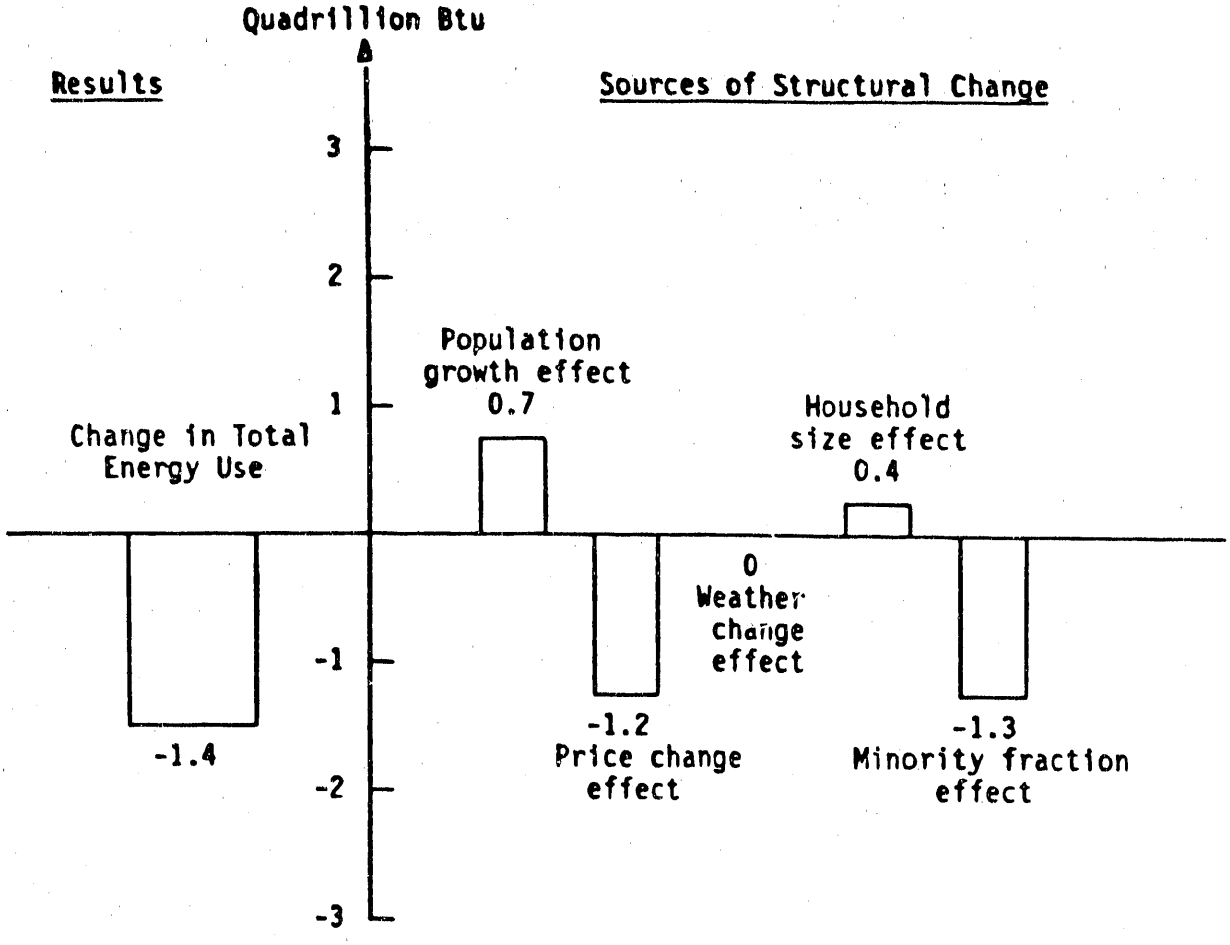


FIGURE 3. Decomposition of Energy Use, 1977-1983, Population Characteristics

REVIEW OF THE RESIDENTIAL ENERGY CONSUMPTION SURVEYS AND A COMPARISON OF ENERGY CONSUMPTION AND EXPENDITURE PATTERNS BETWEEN ELDERLY AND NON-ELDERLY HOUSEHOLDS

MARTHA JOHNSON

REVIEW OF THE RESIDENTIAL ENERGY CONSUMPTION SURVEYS AND A COMPARISON OF ENERGY CONSUMPTION AND EXPENDITURE PATTERNS BETWEEN ELDERLY AND NON-ELDERLY HOUSEHOLDS

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INTRODUCTION

Part 1 of this paper presents a brief description of the Residential Energy Consumption Surveys (RECS) that are conducted by the Energy Information Administration (EIA), Department of Energy. These surveys provide a major source of the data that are used in analysis of residential energy consumption and expenditures in the United States. Part 2 presents a description of energy consumption and expenditure patterns in two age categories, the elderly and non-elderly. Data are from the 1984 RECS.

Part 1: The Residential Energy Consumption Survey

Little information on residential energy consumption and expenditures was readily available when the United States was faced with the first oil embargo in the early 1970's. Two residential consumption surveys conducted by the Washington Center for Metropolitan Studies (WCMS) in 1973 and 1975 provided some initial data on electricity and natural gas consumption. More importantly, these studies indicated that data from consumers were needed to answer basic questions, not only on energy supply but on energy consumption and demand in the residential, commercial and industrial sectors. The RECS evolved because of this growing interest in residential energy use in the 1970's and the recognition that basic benchmark surveys were needed to determine energy consumption and expenditures patterns.

With the formation of the Federal Energy Administration (FEA), a multistage probability survey was designed to collect energy data in the residential sector. The group designing the consumption surveys was to become part of EIA when the Department of Energy was established. These data are collected from two sources, the household and the energy suppliers, similar to the pattern established in the WCMS surveys. The household data are collected in a personal interview. At the end of the interview, the householder is asked to sign a waiver permitting energy suppliers to provide the household's energy records. These energy supply data are collected from the suppliers with a mail questionnaire. The bills are

linked to weather data provided by the National Oceanic and Atmospheric Administration (NOAA). Incorporated into the survey is a separate transportation panel that provides vehicle consumption and expenditure data.

The first residential survey, fielded in 1978, was the National Interim Energy Consumption Survey. Subsequent to the 1978 survey, five national RECS have occurred. From 1978 through 1982 the surveys were conducted annually. Data were next collected in 1984. Currently, the survey is on a triennial schedule with the next RECS scheduled to begin collection of data in September 1987.

The basic design, content and data collection methods of the RECS, have remained relatively unchanged over the years. However, some changes in the phrasing or content of the questions have been made to improve the precision of the survey and to respond to shifts in priorities. Figure 1 shows the major similarities and differences among the seven surveys.

What Type of Energy Data are Collected by the RECS?

The principal data collected in the RECS are household energy consumption and expenditures. These data are collected from both the respondent and from the energy distributor. Other energy related data can be divided into six categories:

(1) Fuel and Fuel Equipment Characteristics;

(2) Dwelling Characteristics;

(3) Appliance Characteristics;

(4) Household Demographic Characteristics;

(5) Energy Programs; and

(6) Transportation Characteristics.

The first category, Fuel and Equipment Characteristics include: (1) questions about the main and auxiliary fuels that are used for space heating, water heating, and cooking; (2) questions about the type and age of energy-using equipment; and (3) questions about wood consumption.

The group of questions pertaining to the structural characteristics of the residence including the type, the age and the size of the dwelling is in the second category. This category also includes questions related to conservation features such as (1) the type and amount of attic, floor and wall insulation; (2) the type and number of storm windows, and storm doors; and (3) other conservation items such as setback thermostats, caulking, and weatherstripping. Beginning with the 1981 RECS, respondents were also asked several questions about

thermostat settings, and in 1982 they were asked their reasons for undertaking conservation improvements.

The third category includes questions on type and age of household appliances. This category has changed over time with the addition of new energy using appliances and the deletion of some appliances such as natural gas refrigerators and freezers that were used by a small percent of the population.

Demographic questions about the household are included in the fourth category. Respondents are asked about their employment; marital and education status; their ethnicity; the family income; home ownership; and the number and age of household members.

A fifth category of questions pertain to the households' use of energy programs that provide assistance for energy costs or conservation improvements. Programs considered are the use of residential energy tax credits, home energy audits and weatherization programs.

The questions included in the sixth category relate to the number, type, age and mileage of household motor vehicles. These data are published in the Residential Transportation Energy Consumption Survey reports.

Who are the Users of the Residential Energy Consumption Data?

The RECS provides energy data to a varied group of users. These users range from members of the U.S. Congress to manufacturers of energy equipment. Examples of Government agencies using the RECS data include the General Accounting Office (GAO), the Environmental Protection Agency (EPA), the Departments of Energy, Health and Human Services, Labor, Agriculture and Treasury.

Recently, data from the RECS were used to assess the impact of extending and changing the Residential Tax Credit legislation for the House Committee on Energy and Commerce. RECS data were used by the GAO to measure the prevalence of conservation measures in the residential sector and the potential for upgrading the thermal characteristics of the housing stock. The EPA's interest in emission standards for wood stoves led to the analysis of the RECS data on the demand for wood-burning stoves. The RECS also provides information to the Office of Family Assistance of the Family Support Administration in support of its administration of the Low-income Home Energy Assistance Program (LIHEAP).

Other Government users of the RECS data include the U.S. Coast Guard, the Solar Energy Research Institute, the Congressional Office of Technology Assessment, and the House Committee on Aging.

Users of the RECS data also include non-government agencies such as Public Utility Commissions, public interest groups, trade associations, utility companies and the media. The RECS data are available to the public in a variety of publications and on public use data tapes that have been screened to protect the identity of individual households.

1984 Residential Energy Consumption Survey

The initial sample for the 1984 RECS consisted of 7,658 housing units. Of this total, 906 units were ineligible because they were currently vacant, were used only seasonally or were not used for dwelling purposes. Personal interviews averaging approximately 52 minutes were conducted at 5,479 of the 6,752 eligible units, for a response rate of 81.1 percent. Mail questionnaires were sent to 1,042 of the households that did not participate in personal interviews. The total response rate for both personal interviews and mail questionnaires was 84.2 percent. A portion of households interviewed in the 1984 RECS had also been interviewed in the 1982 RECS. This panel sample was a result of the longitudinal design that was initiated in the 1982 survey.

Three supplemental data collections, conducted by telephone, were included in the 1984 RECS. One was a follow-up survey on kerosene consumption. The purpose of this follow-up was to obtain estimates of the amount of kerosene that wss used as a supplemental home heating fuel. These data were often difficult to obtain directly from fuel suppliers since a majority of the households using kerosene made cash and carry purchsses which were not recorded by fuel suppliers.

Two supplemental data collections were conducted for the Social Security Administrstion to collect family income data and information on government programs available in 1985 and 1986 to low-income households for heating and cooling assistance. Figure 2 shows the basic RECS structure.

Part 2: Energy Patterns Among the Elderly and Non-Elderly

Part 2 of this paper compares the energy consumption and expenditure patterns of two types of households, the non-elderly and the elderly. This comparison is a preliminary attempt to define some of the energy consumption and expenditures patterns in various socioeconomic and demographic groups. In this paper, non-elderly households are defined as households where the householder is less than 60 years of age and elderly households are defined as households where the householder is 60 years or older. Twenty-nine percent of the 86.3 million

1984 RECS households can be categorized as elderly households using this definition. It should be noted that the definition of elderly and non-elderly households is based on the age of the householder. Thus, some households defined as non-elderly may have an elderly household member living in the home and conversely, an elderly household may have a household member living there who is less than 60 years of age.

Little difference was found in the average consumption and expenditures per household between the elderly and the non-elderly households. Non-elderly households consumed an average of 105 million Btu per household while elderly households consumed an average 103 million Btu per household. Average energy expenditures for non-elderly households were $1,148 per household. Energy expenditures for the elderly households were approximately

Figure 1. Comparison of Residential Energy Consumption Survey 1978-1987 (Continued)

1978	1979	1980	1981	1982	1984	1987
Used respondents' estimate of square footage of dwelling.	Not collected	Used interviewers' measurement of square footage of dwelling.	Same as 1980	Same as 1980	Same as 1980	Same as 1980
Weather data obtained using long term averages adjusted by Census division for April 1978 through March 1979.	Weather data obtained using recorded daily highs and lows at the National Oceanic and Atmospheric Administration (NOAA) weather stations averaged within a division.	Same as 1979	Same as 1979	Same as 1979	Same as 1979	Same as 1979
Heating degree-days calculated using a base 65°F.	Same as 1978	Heating degree-days calculated using bases 50°F through 80°F.	Same as 1980	Same as 1980	Same as 1980	Same as 1980
All respondents were provided with a $2.00 incentive.	Same as 1978	$2.00 incentive was discontinued for personal interview, but retained for mail questionnaire.	Same as 1980	Same as 1980	$2.00 incentive was discontinued for mail questionnaire.	Same as 1984
Sample size: 4,081 Response Rate: 90.5%	Sample size: 4,033 Response Rate: 90.6%	Sample size: 6,051 Response Rate: 91.2%	Sample size: 6,269 Response Rate: 91.6%	Sample size: 4724 Response Rate 89.6%	Sample size: 5,682 Response Rate 87.2%	Not Available

Figure 1. Comparison of Residential Energy Consumption Survey 1978-1987

1978	1979	1980	1981	1982	1984	1987
Sample design was not specifically created for EIA's needs. Instead, it was created as an all purpose design.	Same as 1978	Probability sample design was created for collection of residential energy consumption and related housing characteristics.	Same as 1980 with additional oversampling in neighborhoods where low-income households are likely to be present.	Same as 1980	Same as 1981, redesigned to incorporate 1980 Census	Same as 1984
Sample design was a cross-sectional design. All housing units were in the survey for the first time.	Same as 1978	Longitudinal panel was incorporated into original design.	Same as 1980	Same as 1980 except one-half of housing units were in the 1980 survey.	Same as 1980 except one-half of housing units were in the 1982 survey.	Same as 1980 except one-half of housing units were in the 1984 survey.
Target population did not include households in Alaska, Hawaii, or on U.S. military bases.	Same as 1978	Target population included all households in the United States, including Alaska, Hawaii and U.S. military bases.	Same as 1980	Same as 1980	Same as 1980	Same as 1980
Geographic units were four Census regions: Northeast, North Central, South, West.	Same as 1978	The four geographic regions were divided into nine Census divisions.	Same as 1980	Same as 1980	Same as 1980	Same as 1980
Data were collected for a 12-month period, April 1978 through March 1979.	Data were collected for a 12-month period, April 1979 through March 1980.	Data were collected for a 12-month period, April 1980 through March 1981.	Data were collected for a 12-month period, April 1981 through March 1982.	Data were collected for a 12-month period, April 1982 through March 1983.	Data were collected for a 12-month period, April 1984 through March 1985.	Data will be collected for a 12-month period, January 1987 through December 1987.
Sources of information include: personal interview, billing data from fuel suppliers, and weather data collected from NOAA.	Same as 1978	Same as 1978	Same as 1978	Same as 1978	Same as 1978	Same as 1978

$85.00 less. However, in many instances, the income of the elderly is less than the non-elderly, so their energy expenditures as a percent of income are higher. In 1984 the elderly's energy expenditures as a percent of their income were almost double the amount of their younger counterparts.

Comparing only average consumption and average expenditures provides an incomplete picture of energy use since it shows only how much energy is used. It does not indicate how the energy is used. The next section will describe these patterns of energy consumption by end use in each age category.

Consumption and expenditures have been estimated for the following end uses: space heating, and cooling, water heating, and appliance usage. These estimates were calculated using a non-linear regression technique, they are not metered observations.[1]

The distribution of energy among the four end uses differs by age of households. The elderly consume more energy for space heating and less for other end uses. The remaining sections of this paper will discuss the associations between the space-heating consumption in the elderly and non-elderly households and the socioeconomic characteristics of the household.

Census Region

Initial results suggest that although both elderly and non-elderly households spent more for space heating in the North than in the South, the elderly spent a statistically significant greater amount of energy for space heating in the Northeast and North Central Census Region than non-elderly households in those regions. There was no significant difference in the amount of energy used for heating between the two age categories in the South and West Census Regions.

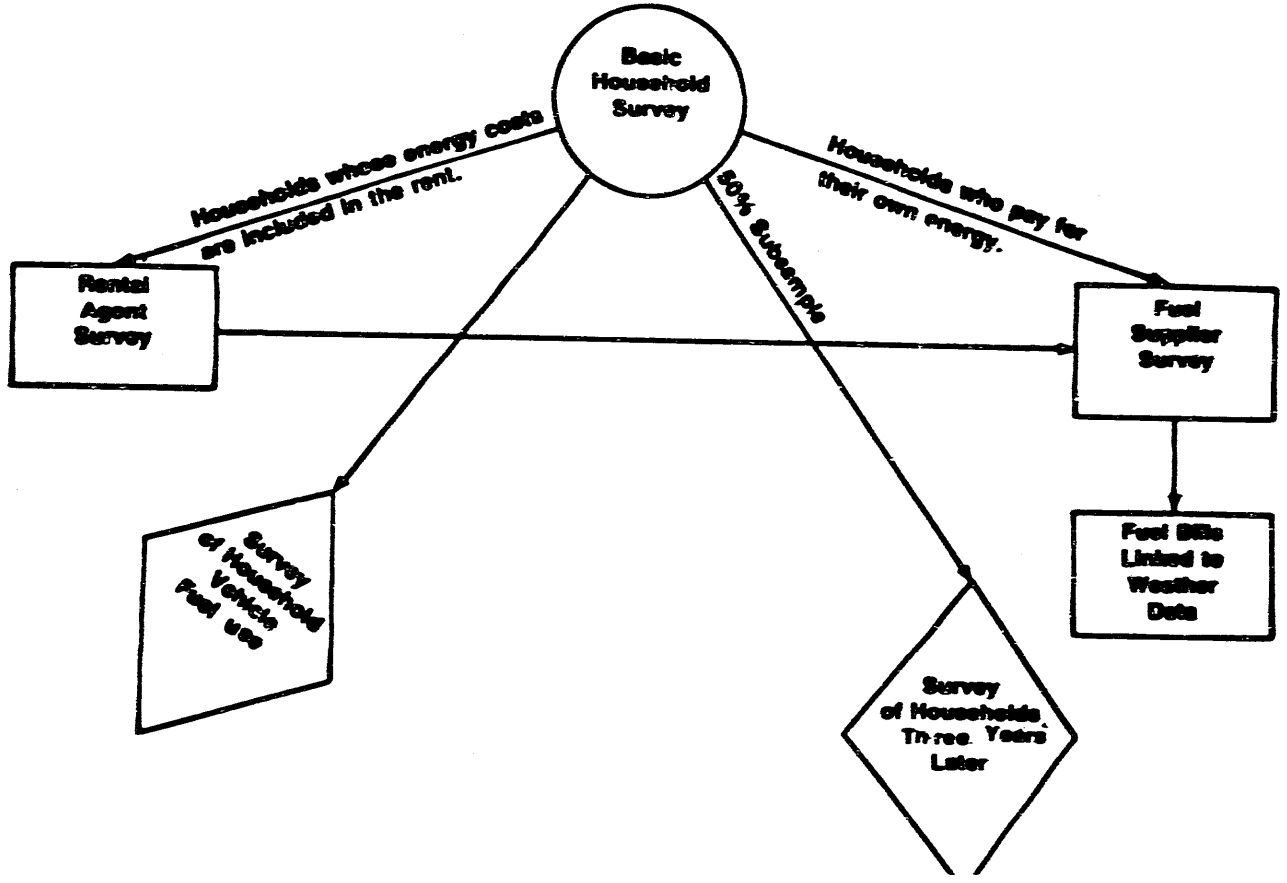
Income

The average per household consumption of energy for space heating did not differ statistically by income categories for the elderly households in 1984. The households with an income of $10,999 or less consumed approximately the same amount of energy for space heating as the households with an income of $30,000 or more. Among the non-elderly households, income was a factor in space heating consumption. Households with an income less than $22,500 consumed approximately 5 million more Btu per household than households with incomes over $22,500.

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[1]For a discussion of the regression methodology, see Energy Information Administration, Residential Energy Consumption Survey: Consumption and Expenditures, April 1984 through March 1985, Part 1: Regional Data, Appendix D. (Forthcoming).

Figure 2: **Residential Energy Consumption Survey Structure**



Average Energy Consumption and Expenditures by End Use

The average energy consumption patterns by end uses differ between the elderly and non-elderly (Table 1).

- Elderly households use approximately 7.7 million more Btu per household for space heating than do non-elderly households.
- Elderly households use approximately 4.8 million fewer Btu per household for water heating and approximately 4.5 million fewer Btu per household for appliance usage than non-elderly households.
- Elderly and non-elderly households consume approximately the same amount of energy for space cooling.
- The elderly's expenditures for space heating are approximately $56 more per household than the non-elderly's.
- Elderly households spent less for water heating, space cooling, and appliance usage than non-elderly households.

Table 1. Average Energy Consumption and Expenditures per Household by End Use and Age of Householder

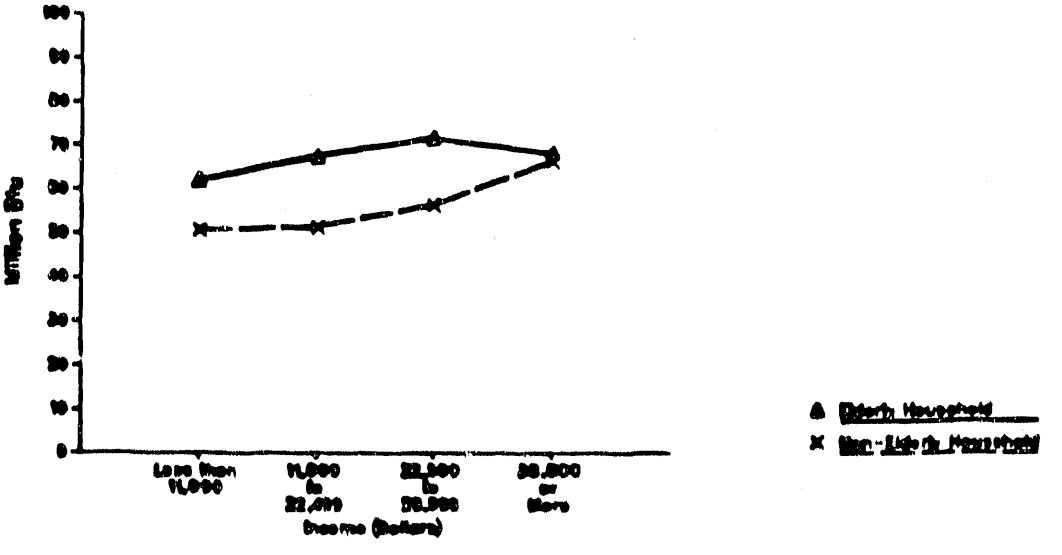
	Head of Householder Less than 60 Years	Standard Error	Head of Householder 60 Years or More	Standard Error
Total Households (million)	61.5	.9	24.8	
Consumption (Million Btu)				
End Use				
Space Heating	57.2	1.1	64.9	2.0
Water Heating	20.2	.3	15.4	.4
Space Cooling	4.5	.3	5.3	.3
Appliance Usage	23.5	.4	19.0	.4
Expenditures (Dollars)				
End Use				
Space Heating	411	7	467	13
Water Heating	182	3	141	3
Space Cooling	93	5	74	5
Appliance Usage	461	8	381	7

Note: End-use values are statistical estimates based on the 1984 Residential Energy Consumption Survey.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, the 1984 Residential Energy Consumption Survey.

The elderly at all income levels except the $30,000 or more consumed a statistically significant greater amount of energy for space heating than the non-elderly (Figure 3). Expenditures for space heating were also greater for the elderly than the non-elderly at all income levels except the $30,000 or more level, where there was no statistical difference.

Figure 3. Average Consumption of Energy per Household for Space Heating by Age and Income



Age of Residence

The age of the residence was a factor in the greater amount of space-heating energy used by the elderly. The elderly and non-elderly households living in homes built before 1950 consumed almost twice as much energy for space heating as those living in homes built in 1975 or later. However, because approximately four times as many elderly lived in older homes than lived in newer homes, they were more affected by the increased space-heating consumption associated with older residences (Table 2).

Table 2. Average Consumption of Energy per Household for Space Heating by Age of Householder and Year Residence Built

Standard	Number of Households (Million)	Standard Error	Average Space Heating Consumption (Million Btu)	Standard Error
Age of Householder and Year Residence Built				
Less Than 60 Years Old				
Residence Built				
Before 1950	21.1	0.8	76.8	1.1
1950 Through 1974	28.0	0.8	50.2	1.6
1975 or After	12.4	0.9	39.6	2.0
60 Years or More Residence Built				
Before 1950	11.1	0.5	80.7	2.8
1950 Through 1974	10.9	0.6	54.9	2.4
1975 or After	2.8	0.4	41.4	4.3

Note: End-use values are statistical estimates based on the 1984 Residential Energy Consumption Survey.

Source: Energy Information Administration, Office of Energy Markets and End Use, Energy End Use Division, the 1984 Residential Energy Consumption Survey.

Size of Residence and Weather

The size of the residence and the weather are two major determinants of the amount of energy a household uses for space heating. A conventional method of adjusting or controlling for both the weather and the size of a residence is to present the consumption in terms of Btu per heating degree-day per heated square foot of the residence. It is recognized that this adjustment method accounts for only two determinants of heating consumption. Other determinants like the thermal characteristics of the house, the thermostat setting and the behavioral characteristics of the household members are unaccounted for in this adjustment procedure.

Elderly households in 1984 consumed a significantly greater amount of energy for space heating per heating degree-days per square foot than non-elderly households.

Prevelance of Conservation Items

An analysis of the 1984 RECS by the EIA/Energy End Use Division looked at the prevalence of conservation items in single family homes by various household characteristics. (See Residential Conservation Measures, SR/EEUD/86/01, July 1986). The results suggest that the proportion of homes with attic or floor insulation or the presence of storm windows did not differ statistically by the age of the householder. There was a statistically significant difference in the amount of caulking, weatherstripping, wall insulation and storm doors used. A larger proportion of the non-elderly living in single family homes had either caulking or weatherstripping or wall insulation, while a large proportion of the elderly had storm doors.

Summary

A discussion of the differences in energy consumption and expenditures between the elderly and non-elderly households should not be limited to average per household figures. Further exploration into the patterns of energy use should occur. Results from the 1984 RECS data suggest that although the elderly and non-elderly may use the same amount of energy, there is a statistically significant difference in how that energy is used.

The elderly consume more for heating and less for water heating or appliance usage than the non-elderly. Income was not a factor in energy consumption in the age 60 and over category, but was a factor in the under age 60 category. Census region and age of the residence were also factors in space heating consumption in both age categories.

AN ANALYSIS OF ENERGY EFFICIENCY PATTERNS BY FAMILY LIFE CYCLE STAGE

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AN ANALYSIS OF ENERGY EFFICIENCY PATTERNS BY FAMILY LIFE CYCLE STAGE

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Concern with the effect of changing energy prices on the family prompted several investigators to examine the relationship between the household's stage in the family life cycle and the level of energy use or energy expenditures. Economists have long focused on the household as the basic decision-making and consumption unit in society; sociologists, meanwhile, have long used the concept of a family life cycle to study the interactions between different family units and the broader social and physical environments. The study of the energy behavior of households by family life cycle stage is a comparatively new area for energy researchers.

Previous studies using data from national or regional samples report that energy use patterns are associated with family characteristics, particularly the age of the household head, an important indicator of the family's stage in the life cycle. In an analysis of data from a 1972-73 Bureau of Labor Statistics survey, Fritzsche (1981) finds that reported energy expenditures increase through the child rearing years and then decrease after children leave the household. He also finds that single people report fewer energy expenditures than married people at each stage in the life cycle. Marganus and Badenhop (1984) present similar results in their analysis of reported household energy expenditures for a sample drawn from three Western states in 1980: families in the middle stages of the life cycle report greater expenditures on energy than younger or older families. They also report that married families have higher energy expenditures than unmarried families, though they attribute this difference to the presence of a spouse and children. Frey and LaBay (1983) find a different pattern when home heating expenditures are examined. Using data collected in New England in 1981, they find a positive relationship between households' reported heating costs and family life cycle stage: older consumers report higher heating expenditures. Newman's (1982) analysis of measured energy use from a national sample of households indicates that absolute level of consumption are lowest at the beginning and end of the family life cycle, but that per capita energy use is highest during these two stages. This finding implies that energy efficiency differences may be related to the family's stage in the life cycle.

To measure the efficiency level of the inefficient units, we hold constant the mix of inputs used by these units. This is equivalent to drawing a line from the origin through the frontier to point H_5. The point H_5 on the frontier represents the equiproportional reduction in input per unit of output, along each dimension, that will bring unit H_5 to the best practice frontier. An index of the relative efficiency of household H_5 can be calculated by dividing the length of the line segment OH_5 by the length of segment OH_5. The resulting index represents the efficient proportion of inputs needed for technically efficient service provision: that is, H_5 provides the same output as H_5 using only the fraction OH_5/OH_5 as much of each input. This ratio (OH_5/OH_5) will range from 0 to 1, with 1 denoting the presence of a unit on the frontier. The larger the index, the more productive the household compared to other households with the same mix of inputs. In this example we use only two input dimensions and one output. In general the method can accommodate multiple inputs and outputs, but the index range of 0 to 1 remains unchanged, and bears the same interpretation as in the two-input and one-output case.

Preparing the household data for analysis.

Data from the Household Screener Survey (see U.S. Department of Energy 1981a, 1981b) are used to evaluate household service provision efficiency in 1979. The HSS is designed as a follow-up to the National Interim Energy Consumption Survey (NIECS; see U.S. Department of Energy 1980). The aim of the survey is to measure annual energy use and energy expenditures from a national sample of households (excluding Alaska and Hawaii), as well as to collect data on household and dwelling unit characteristics associated with energy use. The data collected from each household include the end uses of fuels by the household, a limited range of energy conservation activities pursued in the previous year, and characteristics of the dwelling unit and household members.

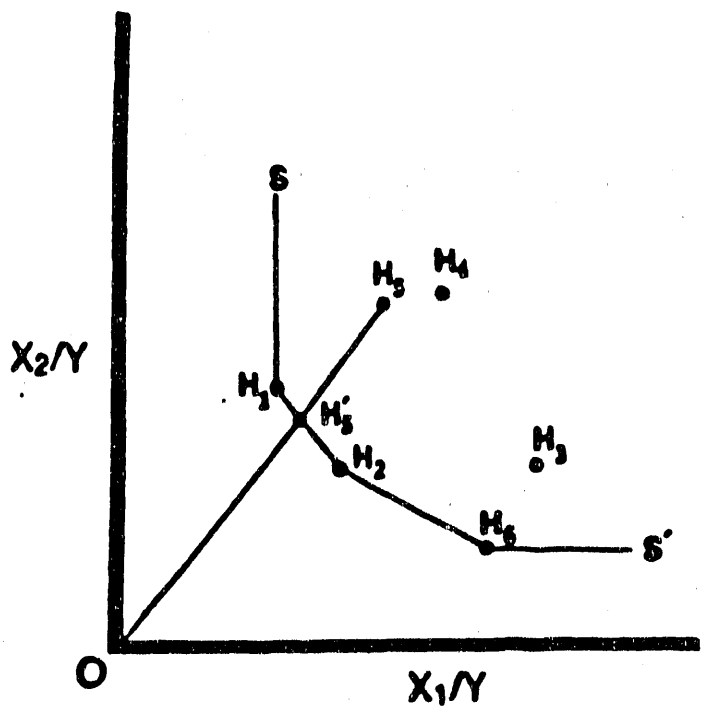
Individual households differ substantially in their levels of energy use. Even households with the same physical characteristics may have widely different energy use patterns because of the multitude of behavioral and structural factors involved. In order to ensure that the differences in household energy efficiency observed result from general factors, we have directed our attention to the performance of general categories of households, rather than that of individual households. A typology of households is constructed using the HSS data on individual households. Each type of household is defined using the set of eight variables listed in Table 1. Four of the variables permit explicit examination of various characteristics of the family life cycle (marital status, age and sex of the household head, number of children). Combinations of the values for the eight variables form the set of potential unique household types. As an example, one type of household is headed by a never-married female aged 18-34 years with no children and is located in the Northeast in a smaller single-family detached dwelling, which uses primarily natural gas for house heating, and does not use air conditioning. Over 18,000 unique combinations are possible from the values of the eight variables shown in Table 1.

Baxter et al. (1986) provide further details on the adaptation of the best practice frontier method to analyses of household energy efficiency.

The approach to measuring efficiency taken here compares a group of productive units (households) along several dimensions of input resources and service outputs. The comparison identifies a subset of households that are considered efficient because they require the fewest resources per unit of service provided. . These efficient households form a production possibility frontier of best practice in service provision. All other households are compared to this best practice frontier and their index of efficiency is based on their distance from that frontier.

The application of ANCOVA to the efficiency scores enables us to introduce the family life cycle variables to the efficiency analysis while controlling for other variables that are not considered input or output yet are related to energy efficiency. Our previous studies suggest that important covariate include such factor as climate, fuel prices, fuel availability, and type of dwelling unit.

To illustrate our approach to efficiency measurement, consider a household service provision process, such as water heating, requiring two inputs and resulting in a single output. Figure 1 shows 6 households (H_1 to H_6) distributed in an input-per-unit-output space and the location of the best practice frontier in that space. Each axis represents the input level per unit of output. For example, X_1/Y is electricity use per gallon of hot water generated and X_2/Y is the capital cost of the water heater per gallon of hot water generated. Households H_1 and H_2 are more efficient than H5 because they use fewer inputs than H_5 per unit of output. Similarly, H_2 and H_6 are more efficient than H_3 because they use fewer inputs per unit of output provided. The line segments combining H_1, H_2, and H_6 form the efficiency frontier, which represents a best practice pattern of service provision. Households H_3, H_4, and H_4 are inefficient relative to that frontier since households H_1, H_2, and H_6 (or a combination thereof) have demonstrated that it is possible to produce the same level of output with fewer resources.



Other studies have focused on samples drawn from a particular city or a neighborhood within a city. Morrison, Keith, and Zuiches (1979) studied the fuel use records from 1974 and 1976 of a sample of household from Lansing, Michigan. Lansing households in the middle stages of the life cycle use more energy than the younger or older families. Hackett (1984) and Hackett and Lutzenhiser (1986) analyzed the monthly electricity use in specific apartment complexes in Davis, California. Their focus on specific living sites enables them to identify the association of several family characteristics with energy use. Energy use differences related to the age and sex, and occupational and marital statuses of the occupants, as well as the presence of children in the household, emerge from their studies.

Though these studies of energy demand provide insight into the motivation of individual energy users, such measures may not be the most important focus for policy. Our earlier analysis suggests that important differences exist between low energy use households and efficient households (Baxter et al. 1987). The amount of energy consumed may, ultimately, be secondary to the efficiency of energy use.

This paper examines differences in household energy efficiency by family characteristics, particularly those that distinguish different stages in the life cycle. Our review of studies focusing on energy use differences by family life cycle and our earlier work on household energy efficiency (Baxter et al. 1986), lead us to propose three hypotheses, set out in the next section, on the relationship between energy efficiency and certain family characteristics.

HYPOTHESES

The above studies report that families in the middle stages of the life cycle use more energy than younger or older families. The first hypothesis we propose is based on two observations from our previous work: (i) in general, energy efficiency is negatively correlated with the level of energy use, and (ii) controlling for the age distribution of children in the household, energy efficiency is positively related to adult age.

H_1: Families in the middle life cycle stages, defined here as households with heads aged 35 to 64, have lower efficiencies than younger or older families.

The empirical work on energy use and energy expenditures reveals that fuel use increases as the family unit expands and decreases as the unit contracts. As an initial hypothesis, we anticipate just the opposite relationship between the family life cycle and efficiency.

Our second hypothesis concerns the marital status of the household head. Some evidence suggests that married families spend more on energy than single people, even those with children. Married families may occupy larger dwellings and, in most cases, will have more people than households headed by single individuals. In our analysis, households are standardized by dwelling size and the number of household members. Thus, if these two variables account for the bulk of the expenditure differences by marital status, we would not expect to observe efficiency differences between married families and their single counterparts.

H_2: Married families are as efficient as households with occupants who never married or were formerly married (i.e., those who are divorced, separated, or widowed).

Finally, a third hypothesis relates to the changing nature of the family economic base. The increased participation of women in the work force leads to increased numbers of multiple income households. Such households will be occupied fewer hours during the day and the occupants are more likely to obtain certain services; such as meals and entertainment, outside the household.

H_3: Households with a lower proportion of working adults will have lower efficiencies.

METHODS

The best practice frontier methodology.

The level of fuel use in a household is a function of the demand on the part of the occupants for certain services, such as heating and cooling of interior spaces, water heating for showers, dish washing and clothes washing, lighting for work and recreation, etc., and of the capacity of the energy-using equipment to convert fuel inputs into the desired services. Viewed from this perspective, the household may be treated as a firm producing various levels of services for the occupants. The dwelling unit and its energy-using equipment are the fixed factors of production, and the input of fuel is the variable factor. In the short run, the level of a particular household service, such as house heating, may be varied by modifying the input of fuel. In the long run, the level of a service such as heating may be modified by altering both the variable and fixed factors of production (by adding insulation or by installing a more efficient heating system, for example).

The methodological approach to measuring household energy efficiency entails two phases. First, a data envelopment technique is used to identify a frontier of best practice in energy use. Second, the distance of all other households from this frontier is measured. The result of these phases is an index reflecting the efficiency of energy use by households. We then explore .differences in this efficiency index by family characteristics, such as the age of the household head, marital status, and proportion of working adults in the household, as well as by a family life cycle classification proposed by Murphy and Staples (1979). Our three hypotheses are subject to statistical tests using analysis of covariance (ANCOVA) to control for variables related to physical and locational attributes of the dwelling unit and occupant characteristics that we previously found important in accounting for household efficiency differences.

The method used to measure efficiency is based on the Charnes, Cooper, and Rhodes (1978) data envelopment technique, which is a generalization of Farrell's (1957) measure of the technical efficiency of economic production. Schinnar's (1980) algorithmic extension of this method is the measurement tool for the empirical analysis presented here. Baxter (1984) and

Table 1

Variables Used to Construct the Household Typology

	Variable Definitions
Marital Status:	Respondent's indication of the marital status of the household head
Age of Household Head:	Respondent's indication of the age of the household head
Sex of Household Head:	Respondent's indication of the sex of the household head
Number of Children:	Number of people in the household who are under 18 years of age and are not household heads or spouse of household heads
Census Region:	Four major U.S. census regions as defined by the Census Bureau
Type of Dwelling Unit:	Interviewer's description of the residential structure
Main House Heating Fuel:	Respondent's indication of the fuel type used most for space heating
Air Conditioning Fuel:	Respondent's indication of the fuel type used most for space cooling

	Variable Values
Marital Status:	Married, Formerly Married (Divorced-Separated-Widowed), Never Married
Age of Household Head:	18-34 years, 35-49 years, 50-64 years, 65+ years
Sex of Household Head:	Male, Female
Number of Children:	0, 1, 2, 3+
Census Region:	Northeast, Northcentral, South, West
Type of Dwelling:	Mobile Home and Sing. Fam. Attach. units, Sing. Fam. Detach. (SFD) < 6 rooms, SFD > 5 rooms, Multi. Fam. (MF) 2-4 units, MF more than 4 units
Main House Heating Fuel:	Natural Gas, LPG, Fuel Oil, Electricity
Air Conditioning Fuel:	Not used, Natural Gas or Electricity

Households that do not report one of the values listed for each of the eight variables in Table 1 are dropped from the study. Approximately 1450 household types are identified in the HSS using the eight-variable typology. Households that do not represent at least four individual households from the HSS are deleted from the typology. The resulting 281 household types represent a common set of households in the continental USA exhibiting values of the eight characteristics used to select the typology. The household types contain an average of 7.5 individual households from the HSS. The typology represents a mainstream set of household types.[2]

The household type is the unit of analysis in this study. Certain characteristics for each household type, such as the number of occupants, income, energy use, etc., are defined using the average of that characteristic for the individual households forming a type. Our focus is on the differences in characteristics between different types of households and not on comparisons between similar households.

In summary, the units in the household typology represent at least four households from the HSS. For each unit, the values for such continuous variables as income, energy costs, etc., are defined as the means of the values for the individual households within each type.

MODEL SPECIFICATION

Specifying a model to estimate household energy efficiency involves selecting measures of resource inputs and service outputs. The efficiency frontier is estimated by determining which units require the fewest amount of input resources to provide a given level of service. A nearly complete service provision model should contain measures of both fixed and variable inputs, as well as measures of the most important services provided by the household. Measures of fixed inputs might include the characteristics of the building envelope, the appliance stock, and the heating and cooling equipment. Measures of variable inputs include the use of fuels measured in dollars or heat content.

Consideration of output measures necessitates specification of the output(s) for which resource inputs are being minimized. A wide range of output indicators may be formulated, such as the size of the area within the dwelling being heated or cooled, the interior temperature of the dwelling, the number of gallons of hot water used for bathing and household cleaning, the temperature of the hot water, the number of appliances and their use rate, the number of occupants, etc.

Our specification of a service provision model focuses on cost efficiency.[3] Annual expenditures for electric and non-electric fuels are used as the measure for the input resources in the cost efficiency model. The price of a particular fuel reflects roughly the cost to suppliers of converting natural resources, such as coal and crude oil, into usable fuel, such as electricity and fuel oil. Thus, fuel costs (that is, quantity used times the price) approximate the primary energy required by consumers to provide household services.

The service output indicators available from the HSS are indirect measures of service provision: the number of occupants and the number of rooms. The number of household members is related to the base load energy use of a household over an annual cycle; that is, the greater the number of occupants the greater the demand for hot water, etc. The number of rooms in a dwelling unit is a proxy for dwelling unit size. Given a set of climatic conditions, dwelling unit size is one key factor in determining the heating and cooling load of the structure, in conjunction with the thermal properties of the building envelope and the level of heating and cooling required by the occupants.

The model specification for the cost efficiency measure is summarized below:

Inputs

o annual electricity costs (1979$)
o annual non-electric fuel costs (1979$)

Outputs

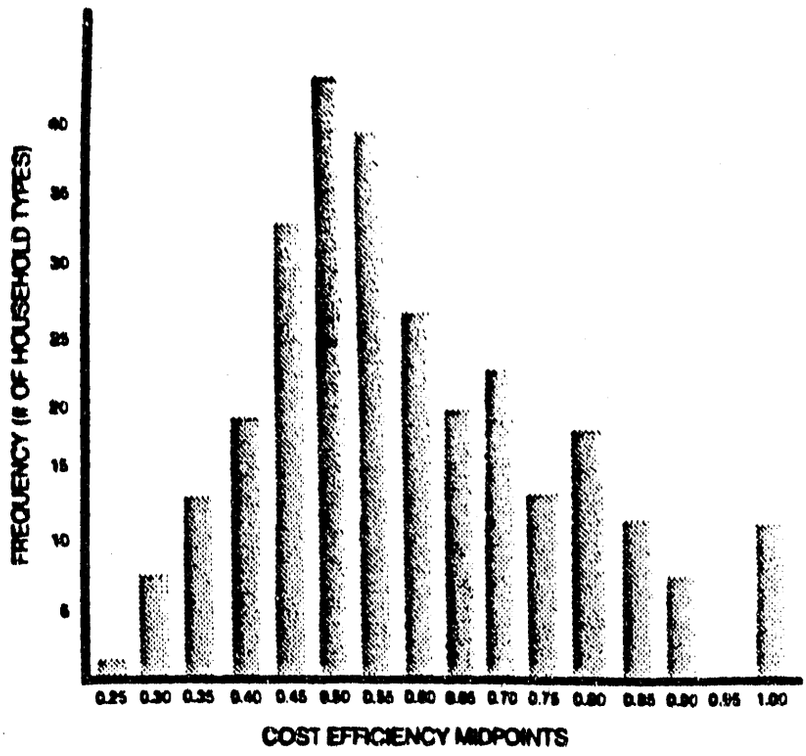
o number of rooms in the dwelling unit
o number of people in the dwelling unit

This specification is obviously incomplete. The lack of data on fixed inputs and direct measures of service outputs permits only a rough measure of efficiency. First, because fixed inputs are excluded, only one aspect of total cost, variable cost, is evaluated. Second, the indirect measures available for service output do not account for the variation in the range and level of many important service, such as house heating. This study is only part of the initial phase in our evaluation of household elderly efficiency.

Distribution of cost efficiency scores.

Efficiency scores for the household types are obtained from the two-input and two-output service provision model. Figure 2 presents a histogram of the cost efficiency scores. Units with scores of 1.0 form the efficiency frontier. Units with scores less than 1.0 are distributed away from the frontier: the smaller the score, the greater the distance from the efficiency frontier. The cost efficiency distribution is skewed to the right and exhibits substantial variation. Only about 25% of the units have efficiency scores above 0.70. The bulk of the units are located far from the efficiency frontier. The mean cost efficiency score is 0.59 (standard deviation = 0.17, N = 281). A unit on the efficiency frontier using the same mix of inputs as a unit with an efficiency score of 0.59 would use 0.59 as much of each input for the same level of service. In general, this cost efficiency distribution is similar to one derived in an earlier analysis, which used a somewhat different household typology (Baxter et al. 1986).

Figure 2. Histogram of cost efficiency scores



We perform a series of Statistical tests to determine if the relationships between the efficiency scores and family characteristics are significant. The first series of tests simply evaluate efficiency differences solely by family characteristics. Though these relationships are interesting, and enable us to compare our results to those of earlier studies, the simple tests do not control for the effects of other important variables. The second series of tests are designed to test hypotheses H_1 through H_3 while controlling for the influence of other variables.

Energy efficiency by life cycle stage: simple tests.

Table 2 presents mean cost efficiency scores by various family characteristics, including the three variables of most immediate concern here. We find that households with younger (age 18 to 34) and older (age 65 and older) heads are more efficient than middle age heads (age 35 to 64). Single individuals are more efficient than their married counterparts. Female heads of households are more efficient than male heads. Households with no children and those with three or more children are more efficient than two-child households. Finally, households with fewer than 25% of the adults working are more efficient than those with 75% or more of the adults working. These results suggest family characteristics may be related to differences in energy efficiency.

Table 2

Mean Cost Efficiency by Selected Family Characteristics

	N	Mean	Std. Error	t-Test Results
Age of Household Head				
18 - 34	97	.610	.016	**
35 - 49	61	.560	.021	ns
50 - 64	58	.542	.020	CG
65 +	65	.637	.023	***
Sex of Household Head				
Female	55	.677	.022	***
Male	226	.570	.011	CG
Marital Status				
Married	207	.567	.011	CG
Formerly Married	48	.671	.025	***
Never Married	26	.639	.032	**
Number of Children				
0	175	.600	.013	*
1	45	.576	.026	ns
2	32	.539	.021	CG
3 +	29	.622	.029	*
Proportion of Adults Working				
0 - .24	44	.673	.029	***
.25 - .49	32	.607	.029	ns
.50 - .74	88	.562	.015	ns
.75 -1.00	117	.578	.016	CG

CG = comparison group for two-tailed tests
ns = not significant
* = significant at $\alpha = .10$
** = significant at $\alpha = .05$
*** = significant at $\alpha = .01$

Table 3

Cost Efficiency Differences by Family Life Cycle Stage:
The Murphy and Staples Classification

Murphy and Staples Family Life Cycle Stages	Deviations from Grand Mean	N	Std. Dev.
Young Single	.048	26	.166
Young Married without children	.009	28	.177
Young Married with children	.011	40	.141
Middle Age Married w/children	-.039*	61	.160
Middle Age Married wo/children	-.086***	41	.120
Older Married	.003	37	.192
Older Single	.101***	28	.164
Young Single with children	.109	1	-
Middle Age Single with children	.086	4	.242
Middle Age Single	.063	13	.176
Other	-.125	2	.066
GRAND MEAN	.591	281	.168

* significant at $\alpha = .10$
** significant at $\alpha = .05$
*** significant at $\alpha = .01$

Table 4

ANCOVA Model 1 - Full Model

Analysis of Covariance

Source of Variation	DF	Mean Square	F-Statistic
Age of Household Head	2	.0227	1.837
Marital Status	2	.0172	1.391
Proportion Working	1	.0006	.052
Error	258	.0124	

Least-Squares Mean Efficiencies

	Mean Efficiencies	Std. Error
Age of Household Head		
18 - 34 and 65+	.559	.019
35 - 49	.545	.023
50 - 64	.521	.023
Marital Status		
Married	.560	.016
Formerly Married	.558	.025
Never Married	.506	.032

In an effort to provide a richer characterization of the family, we applied a revised family life cycle classification suggested by Murphy and Staples (1979) to our household typology. Table 3 reports mean cost efficiency differences by stage of family life cycle using the Murphy and Staples classification. Households in the Middle Age Married stages are significantly less efficient than the group as a whole. The Older Single stage is associated with greater than average levels of efficiency. Thus, we see evidence of an age effect for those that are married. The effect of marital status alone is equivocal; the Older Single group may be more efficient because they are older, or single, or both. We caution the reader from drawing conclusions regarding our original hypotheses from these simple tests. Univariate tests do not control for the influence of other factors on efficiency.

The association between the family life cycle and cost efficiency becomes more complex when aspects of the life cycle are considered jointly. In the next section, we focus on the three hypotheses of interest, namely, the effect of age, marital status, and labor force participation on household energy efficiency controlling for a number of other factors related to efficiency.

Energy efficiency by life cycle stage: a multivariate analysis.

Our motivation for the use of analysis of covariance (ANCOVA) is to attempt to disentangle the effect of different life cycle components as well as control for other factors known to be related to efficiency. Our earlier efficiency analysis (Baxter et al. 1986) revealed that numerous factors are related to household energy efficiency when nonexperimental data are used. In order to make more persuasive tests of the hypotheses we include those factors here as covariates in an ANCOVA design.

The factors that we considered in our earlier analysis are related to household location, dwelling unit characteristics; and occupant characteristics. The covariates for household location are annual heating and cooling degree days, average price of electricity, non-electric to electric fuel cost ratio, the type of main heating fuel, and the presence of air conditioning. Dwelling unit characteristics refer to the type of structure, such as single-family or multiple-family structures. Relevant occupant characteristics include income, education, and rental status.[4] Joint hypotheses tests are performed for the age group and marital status subgroups, controlling for the above covariates. The proportion of adults employed is included as a continuous variable.

Results of an ANCOVA are presented in Table 4. Hypothesis H_1 cannot be supported on the basis of the joint hypothesis test. This suggests that the age of household head does not add new information about the variation in cost efficiency that is not found in the control variables. An examination of the least-squares mean cost efficiencies by age group[5], a mean adjusted for the effects of the control variables in the model, reveals that the difference in cost efficiency by age group narrows considerably when the influence of the other variables in the model are removed. Differences in efficiency are observed between households at middle age stages and those households at younger and older stages in the life cycle, but only the difference between the 50-64 group and the 18-34 and 65+ group is of borderline significance ($P = .057$).

The results of a joint hypothesis test of the marital status subgroups suggests that marital status is not associated with cost efficiency. Thus, hypothesis H_2 is supported. Differences in the least-squares means indicate, however, that the Never Married subgroup is now somewhat less efficient than the Married and Formerly Married subgroups, though these differences are not significant. These last two groups display almost identical efficiencies.

No relationship between efficiency and adult employment status is found. Hypothesis H3 is not supported by the results in Table 4. As Fritzsche (1981) notes, an income effect is incorporated in the family life cycle because income fluctuates in a predictable pattern over the cycle. We omit income as a covariate in the ANCOVA results reported in Table 5 to determine if the association between cost efficiency and family characteristics are changed.

Note the effect on the F-value in Table 5 for the age of household head variables. When information about household income is removed from the analysis a significant covariation between the household head's age and cost efficiency emerges. Least-squares mean cost efficiencies by age group are also provided. The range in mean cost efficiency increases. The 50-64 age group is still less efficient than the youngest and oldest age group and this difference is now significant ($P = .012$). The age variable appears to contain some of the information lost to the analysis when household income is removed from the model. Dropping the income variable from the model does not demonstrate conclusively that household income also captures any family life cycle effect. The results, however, are suggestive and we further explore the relationship between age, income, and efficiency in the next section by testing for efficiency differences by age within income groups.

Omitting income does not alter the result of the joint hypothesis test for marital status, though the relationship among the three subgroups does change. The Married group is now slightly less efficient than the Formerly Married group, though the difference is not significant ($P = .096$). The Never Married group still has the lowest efficiency of the three groups, but the differences observed are not significant. The results in Table 5 indicate that H_2 is supported.

The association between the proportion of the adults in the household employed is insignificant in the ANCOVA reported in Table 5 as well. The labor force variable does not add new information to the model once information from the control variables is included.

The effect of age by income group on efficiency.

Dropping income as a variable in the ANCOVA suggests that income and family life cycle stage may contain redundant information. The extent and nature of this covariance, and the relationship of each variable with energy efficiency, is not illuminated by simply omitting income as a covariate. For this reason we examine the effect of age on efficiency by income group.

Mean efficiency scores are estimated for joint income and age groups. The household types are divided into three income groups and four age groups, resulting in 12 joint categories. Table 6 reports the mean cost efficiency core for each joint age and income category. The

Table 5

ANCOVA Model 2 - Household Income Omitted From Full Model

Analysis of Covariance

Source of Variation	DF	Mean Square	F-Statistic
Age of Household Head	2	.0415	3.247**
Marital Status	2	.0216	1.693
Proportion Working	1	.0115	.901
Error	258	.0128	

** significant at $\alpha = .05$

Least-Squares Mean Efficiencies

Age of Household Head	Mean Efficiencies	Std. Error
18 - 34 and 65+	.583	.018
35 - 49	.555	.024
50 - 64	.533	.023
Marital Status		
Married	.551	.016
Formerly Married	.586	.024
Never Married	.533	.031

category with heads over 65 and High Income is omitted because there are only two units in this category and their efficiency is so much lower than the Young with High Income group that the two categories cannot be combined.

The hypothesis under consideration, H_1, is the same for each income group, namely, that the Middle Age groups (35-49 and 50-64 years, respectively) are less efficient than the Young (18-34) and Old (6) Age groups. Joint hypothesis tests are performed on the age groups within each income category. The results of the joint hypothesis tests are also presented in Table 6.

The joint hypothesis tests are significant only for the High Income group. High Income households exhibit significant differences in mean efficiency by age group. Middle Age households are significantly less efficient than Young households.

We did not conduct joint hypothesis tests for the effect of income differences within age groups. Table 6 does indicate, however, that within the Young Age group, the Middle Income group is less efficient than the Low and High Income groups. Thus, we observe an income effect, though the greater efficiency of the High Income group is not expected. For the Old Age group, Table 6 suggests that the Middle Income group is less efficient than the Low Income group.

DISCUSSION

Initial examination of the data, using the simple comparisons in Tables 2 and 3, reveals differences in mean cost efficiency by age of household head, marital status, and employment status. The pattern of the observed differences correspond only to the first proposition advanced at the beginning of the paper, namely, that families at Middle life cycle stages are less efficient than Young and Old families. Hypotheses H_2 and H_3 are not supported by this initial inspection. Instead we observe that Married families are less efficient than Never Married and Formerly Married families and that adult employment and efficiency are negatively related.

When examined in the multivariate context provided in Tables 4 and 5, however, the observed differences in cost efficiency are accounted for by the control variables and not the variables of interest, marital status, age of household head, and adult employment status. The multivariate analysis provides support for H_2, but not for H_1 and H_3.

In the case of age of household head, one of the key control variables may be household income. In the HSS data a strong association exists between income and the age of the household head.[6] Specifically, Young and Old families have lower incomes than Middle Age families. When income is omitted as a control variable in the multivariate analysis the hypothesized association between age of household head and efficiency emerges.

The examination of cost efficiency differences by income and age groups supports the suggestion that efficiency differences by age are, at least in part, a function of changing income levels. Our analysis reveals no significant relationship between age and efficiency within the Low and Middle Income groups. In addition, households in the Low Income group have

Table 6

Mean Cost Efficiency by Age and Income Groups

	Age of Head				Results of Joint Hypothesis Tests for the Effect of Age on Efficiency	
	Young	Middle Age		Old	F-statistic	Probability > F
Income ($1977)	18-34	35-49	50-64	65+		
Low Income	.646	.670	.561	.666	1.602	.203
	.187	.178	.129	.180		
0-$15,000	27	10	13	51		
Middle Income	.579	.517	.548	.546	1.062	.347
	.136	.103	.178	.180		
$15,001-$25,000	59	16	28	12		
High Income	.685	.548	.518	.442	3.937	.021
	.159	.174	.122	.097		
>$25,000	11	35	17	2		

KEY

Mean
Std. Dev.
N

higher efficiencies than households in the Middle group. These results lead us to reject hypothesis H_1 for the Low and Middle Income groups. Middle Income families may be less sensitive to price signals since energy purchases comprise a smaller portion of total household expenditures. Middle Income families, however, may also be providing a range of services not reflected by the indirect output measures used to estimate cost efficiency.

The exception to the above pattern is notable. Low Income households with heads aged 50-64 are less efficient than the Old Age with Low Income group. If low income households provide a more limited range of services, then any decrease in the range or level of service associated with the aging of children and their movement out of the household is more likely to be detected by our measure of efficiency. At higher income levels, where the range and level of service provided is greater, the change in efficiency due to family composition changes will be small compared to the effect of other important factors on efficiency, such as the type of dwelling unit.

Significant cost efficiency differences are observed by age in the High Income group, where the Young group is more efficient than the Middle Age groups. The comparatively high mean efficiency of the Young with High Income group is unexpected. This group's efficiency does not differ from the efficiencies observed in three out of four age groups in the Low Income group, including the Old Age with Low Income group.

Several characteristics may distinguish the Young with High Income group from the rest of the High Income age groups, and may also suggest why this particular group of households does not have lower efficiencies than the Low Income households. First, younger households tend to have younger children. As our earlier analysis of household energy efficiency revealed, households with younger children are more cost efficient (Baxter et al. 1986). Second, the Young with High Income households may not have invested in the full range of energy-using equipment that their older counterparts have already acquired. Third, young people earning high incomes may spend less time in the dwelling than those with low incomes. Many services that low income people provide almost exclusively within the dwelling, such as showers, meals, and entertainment, may be obtained by the Young with High Income group outside the home. A final and related point, if the thermostat is lowered during the heating season when the dwelling is unoccupied (or raised during the cooling season), our measure of efficiency for the Young with High Income group may be much greater than that for Low Income group, especially if the latter spend more time at home.

A different pattern emerges from an examination of the marital status hypothesis. The results in Table 2 reveal that significant differences in cost efficiency by marital status exist. Married families have lower efficiencies than other families, an observation that does not support hypothesis H_2. When examined in a multivariate context, marital status does not contribute to an understanding of cost efficiency differences. In addition to the outputs included in the efficiency measure (i.e., number of household members and dwelling unit size), key control variables in this case may also be household income and type of dwelling unit, though this latter variable is not examined in this paper. A change in marital status is often associated with either a change in residence or a change in income, or both. The HSS data do reveal an

association between marital status and type of dwelling unit. Specifically, Married families are less likely to live in multiple-family dwellings and Never Married and Formerly Married groups are less likely to live in large single-family detached dwellings. Our earlier analysis suggests that multiple-family dwellings are more efficient than single-family dwellings (Baxter et al. 1986). This association, however, does not suggest the direction of causality. Multiplefamily dwellings may have greater efficiencies due to structural features not captured by the regression equation or there may be an occupant component contributing to the efficiency difference, or both factors may be at work.

Initial observation from Table 2 concerning hypothesis H_3 reveal an inverse relationship between the proportion of adults in the household employed and cost efficiency. The multivariate analysis suggests that the labor force participation variable does not contribute to differences in cost efficiency. Households with higher proportions of adults working may indeed spend less time at home, but they are also receiving higher incomes. A trade-off may exist between time and energy in the household that depends in part on the wage rates of the occupants. Individuals with higher wage rates may be more likely to substitute energy for labor in the household in the form of washers, dryers, and other appliances, than are individuals with owner wage rates. This hypothesis cannot be tested using the available data, but is worthy for future examination.

CONCLUSION

Several earlier studies report differences in energy use or reported energy expenditures by age of household head and marital status, even controlling for income differences. Our results do not reveal differences in cost efficiency by age of household head, marital status, or proportion of adults working once the effects of other important factors are considered. An analysis of only age effects by income group reveals an association between age and efficiency within the High Income group. In this group, the Middle Age households are less efficient than the Young households. We also find that the Low Income group is more efficient than the Middle Income group. Thus, when considered in isolation, both age and income account for differences in cost efficiency.

The results of our study derive from data with a national scope; thus, our work is most directly comparable with those studies having a national or regional focus, such as Fritzsche (1981), Newman (1982), and Marganus and Badenhop (1984). Our work differs in two important respects, however, from these studies. First, we are interested in energy efficiency and not the level of energy use. Second, we attempt to control for the important effects of a much larger set of variables, such as weather, energy price, and type of dwelling, than these other studies. As a result, though our analysis reveals no association between energy efficiency and characteristics of the family at the national level, it would be premature to suggest that the family life cycle is unrelated to energy efficiency. Our study does not present a fully specified service provision model. In addition, unequivocal statements are difficult to derive from hypothesis tests using nonexperimental data. An alternate explanation for our results is, at the national level at least, the effects of differences in climate, fuel price and availability, income, and dwelling type account for much of the variation in energy efficiency. When the

problem is approached using data from a specific locality, the results may be quite different from the ones we present here. Indeed, in the few studies where the range of such variables as weather, dwelling type, energy price, and household income is sufficiently reduced, family characteristics emerge as strong predictors of energy use. A similar finding may hold with regard to household energy efficiency.

ENDNOTES

1. We do find important differences in characteristics associated with household energy use and those associated with efficiency. Baxter et al. (1987) provide further discussion of this issue. See Baxter (1984) for a complete discussion.

2. The choice of the minimum number of households represented by a household type is arbitrary. Setting the frequency boundary at four represents an attempt to balance the trade-off between the diversity of types and the economy of analysis. The selection of an arbitrary lower boundary raises concern about the representativeness of the household typology. Tests were conducted to determine if the distribution of the values for each of the eight variables differ significantly between the 281 units and the initial household level data from the HSS. The distribution of marital statuses in the 281 unit typology differs significantly from the distribution of marital statuses in the HSS (Chi-square=8.03, df=2, P). The typology contains more units that are married than expected from the HSS distribution.

3. Our use of the term cost efficiency should not be confused with the measurement of allocative efficiency. Allocative efficiency (price efficiency) requires a change in proportions among inputs that allocates inputs to their highest valued uses. Allocative efficiency thus introduces the opportunity cost of inputs to the measure of productive efficiency.

4. Certain modifications to the original ANCOVA specification were made to correct for the presence of multicollinearity. Two variables were omitted: (i) the number of occupants per room, due to its correlation with the type of dwelling unit (R = 0.85) and (ii) the price of non-electric fuels, due to its correlation with the type of heating fuel (R = 0.88). Two variables of special interest were also highly correlated: the proportion of employed adults in the household and the age of the household head (R = 0.87). Since the comparison of interest is between the middle age groups and the youngest and oldest groups, and since the difference in mean efficiency between the youngest and oldest groups is not significant, we combined these latter groups to form one category in the ANCOVA specification. This modification reduces the collinearity problem to acceptable limits.

5. See the presentation in Searle, Speed, and Milliken (1980) for further details about least-squares means.

6. Empirical support for the arguments in the discussion is omitted from the text due to space considerations. The authors will gladly supply interested readers with results of the background analysis.

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A DISAGGREGATION ANALYSIS OF BLACK-NONBLACK DIFFERENCES IN RESIDENTIAL ENERGY CONSUMPTION

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PREFACE

The U.S. Congress in 1979 created the Office of Minority Economic Impact (OMEI), as a component of the U.S. Department of Energy (DOE), out of concern for the effect of energy shortages and rising prices on citizens belonging to minority groups. The legislation [42 U.S.C., See 7141 (c)] defines a minority group as one consisting of black, Oriental, American Indian, Eskimo, or Aleut citizens or consisting of Puerto Rican or other Spanish-speaking citizens of Spanish descent. The legislation requires OMEI, among other things, to conduct ongoing research (1) to determine the average energy consumption and expenditure patterns of minority groups relative to other population groups and (2) to evaluate the percentage of disposable income spent on energy by minority groups relative to other population groups.

As part of its compliance with this mandate, OMEI commissioned Argonne National Laboratory (ANL) to conduct a multi-year research program to determine energy consumption and expenditures by minority groups. The ANL program consists of three tasks.

- Assemble a data base and develop the tools necessary to assess the effects of government energy policies and programs on minority groups;
- Assess the effects on minorities of government programs relevant to those groups and assess optional ways of changing the programs (e.g" with policy, regulatory, or legislative changes)to alleviate any hardships they may cause for the minority groups; and
- Provide market research assitance to energy-related businesses owned by members of minority groups.

The present report is one of a series produced by Argonne in the performance of these tasks. Further information concerning the overall research being carried out in this area can be obtained by contacting the research project officer for the DOE's Office of Minority Economic Impact, Georgia Johnson, or the program's principal investigator at Argonne, James A. Throgmorton.

We note that additional analyses are needed to address a number of issues raised by our findings. Standardization of additional variables, such as income, appears logical given the differences between black and nonblack households identified in this study. Race of householder has a strong relationship to energy consumption even when other factors are controlled, yet we have no adequate explanation for this relationship. Additional analysis of differences in black- and nonblack-occupied housing stock characteristics may shed light on this relationship.

Finally, we suggest that the data and methods employed here are appropriate for additional policy and program evaluation analyses. We illustrate this with a brief reference to the potential application of our findings for the U.S. Department of Energy's Weatherization Assistance Program.

1 INTRODUCTTON

Energy consumption in the home has been the focus of considerable research since the first oil supply interruption of 1973-1974. Relatively little of this research has focused on the topic of minority-majority residential energy consumption differences, however (Throgmorton & Bernard, 1985). Exceptions to this were early works by Newman & Day (1975) and Grier (1977), which showed that black households had relatively lower lvels of residential energy consumption and expenditures than their nonblack counterparts. This difference in levels of residential energy use was explained by majority-minority differences in average incomes, income-related housing and appliance characteristics, household size, and geographic location. Income, it was suggested, has both direct and indirect effects on levels of residential energy use. The direct effect is straightforward: poor households have less money to spend, and so are able to afford less energy than the wealthy. The indirect effects occur through the types of housing occupied and appliances owned by wealthy and poor households. Upper-income households are more likely to live in larger, more energy-intensive single-family homes, and to have more energy-consuming household appliances than poor households. Since black households have lower average incomes, it was not surprising that their average levels of energy use were found to be lower.

More recent work (Poyer & Teotia, 1982, Poyer, 1983, Poyer, 1984, Klein, et al. 1984) sponsored by the U.S. Department of Energy's Office of Minority Economic Impact (OMEI) has shown that black- nonblack differences in average residential energy consumption still exist, but are now in the opposite direction: black households consume on average more energy in the home than nonblack households. These differences were discovered in the development of a computer projection model (MEAM, or Minority Energy Assessment Model), for use in estimating the potential impacts of energy price changes and government energy policies on minority and nonminority households. The findings which follow examine the correlates of higher energy use and their importance in explaining differences in residential

energy use between black and nonblack households. These findings should thus be seen as a logical consequence of an extension to the earlier OMEI-sponsored research.

This study has two main purposes. The first is to shed additional light on the sources of the differences in average residential energy consumption between black and nonblack households. This is of potential interest to policy-makers and program officers whose actions affect energy consumption and housing choices of black and nonblack householders. This is part of the rationale of the enabling legislation which created OMEI, sponsor of this study. Identifying and explaining black-nonblack energy consumption differences is important for another reason: it sheds light on the extent to which blacks are economically disadvantaged by their position in the energy and housing markets. A topic of widespread and long-standing interest and debate has been the extent, causes, and logical or desirable political remedies (if any) for black-nonblack economic differences. It is hoped that the results of this study will be a contribution, however limited in focus and scope, to this discussion. For although no policies courses of action are proposed or advocated here, the formulation of sound policy must reflect relevant empirical findings such as those of this study..

The second purpose is to identify population subgroups with above-average levels of residential energy consumption, and to note their relative size in proportion to the total black and nonblack populations. This identification can be of value for future policy evaluation research, since one might wish to search for alternatives to policies which have disproportionately negative effects on such population subgroups. It can also help identify the relative importance of the factors explaining the differences in average black- and nonblack residential energy expenditures. For within each population category (black and nonblack) are subgroups of households (e.g. black, poor renters in multi-family units) with above- or below-average levels of energy consumption. The higher the percentage of the population category in subgroups with above-average consumption, the higher the average consumption level for the category as a whole.

The report which follows consists of four main sections. First, we briefly describe the data and methods employed in the study. Next we address two questions: does the average black household in the U.S. consume more energy than its nonblack counterpart? and if so, why? We examine differences in housing stock characteristics and other relevant demographic variables between black and nonblack households to explain the differences in residential energy consumption. In the third section we compare the distribution of black and nonblack households over a set of mutually-exclusive categories (e.g. owner vs. renter, single-vs. multiple-family unit, poor vs. not poor, etc.) based on many of the major energy-related variables under examination. This enables us to identify population subgroups with especially high levels of energy consumption, and to note their relative size within the larger aggregate numbers of minority and nonminority households. The report concludes with a brief summary of the major findings and their implications for future work.

introduced the technique on a general level. Siegel (1986) employed the statistical method in disaggregating the factors explaining black-white income differences. More recently, Bianchi (1981) has used this technique to show the differential effects of household composition on black-white rates of poverty. Standardization as a statistical technique of controlling for interval or ratio variables widely recognized. Since its use with nominal or categorical variables may be less familar, a brief example may help clarify the method and its assumptions.

Table 1 shows the percentages of black and white households living in owner-occupied housing units in each of the four regions and for the nation as a whole. As may be seen, the national percentage of black or white households in owner-occupied units is a weighted average of the race-specific percentages in each of the regions. Thus 31% of black households in the northeast region live in owner-occupied housing units, followed by 44.1%, 50.5%, and 40.2% in the other three regions respectively. Since black households are not evenly distributed over these four regions, however, one cannot simply add together these four percentages and divide by four to learn the national average of owner-occupancy for blacks households. Rather, one must take the weighted average, by multiplying the percentage of the national number of black households In each region by the region- and race-specific percentages of owner-occupied households for that region, and then summing over the four regions. As shown in Table 1, 19.4% of all black households live in the northeast region, and as noted above, 31% of these black households live in owner-occupied housing units. Multiplying .31 by .194 produces .06. Summing this with the other regional results gives 44.4 - so 44.4% of all black households live in owner-occupied housing units in the U.S. This 44.4% is the weighted average of the four regional percentages of blacks in owner-occupied housing units. The equivalent national percentage of white households in owner-occupied housing units is 67.8.

As should be clear from the above, the national percentage of black households in owner-occupied units is a product of two sets of numbers: the region-specific percentages of blacks in owner-occupied units, and the distribution of black households over the four regions. The same is true of the national percentage of white households in owner-occupied units. Since the percentage of households In owner-occupied units varies by both region and race of householder, one can ask: to what extent are the differences between blacks and whites in national ownership percentages due to differences in their regional distributions? To answer this question one ean simply "give" the black population the same regional distribution as whites, and then recompute the black weighted average. This is done in Table 2. As may be seen, the national percentage of blacks in owner-occupied units controlled for region is actually two percentage points lower than its uncontrolled counterpart. This is due to the fact that black households are disproportionately concentrated in a region (the South) with above-average percentages of households in owner-occupied units.

The final statistical technique employed in this study is cross-tabluation of two or more variables presented in contingency tables. The percentages of black and nonblack households distributed over the cells of these tables are then compared in order to estimate the relative numbers of households with above-average levels of energy consumption. This technique is

2 DATA AND METHODS EMPLOYED IN THE STUDY

Three sources of data are employed in this study. Household-level data on energy consumption and energy-related characteristics of the household and housing stock are taken from five national surveys conducted in the 1978-1983 time period. These surveys of residential energy consumption (the Residential Energy Consumption Surveys, hereafter RECS) were supported by the U.S. Department of Energy. They are ideally suited for our purposes, since they contain independent measures, provided by energy suppliers, of the levels of various energy fuels consumed by the households in the samples. We combine the five surveys to increase the number of observations available. This is necessary since the number of observations of minority households in certain years and for many of the population subgroups of interest is very limited (Klein and LaBelle, 1986, Wernette, et. al., 1984). Combining the surveys also helps to reduce the effects on our findings of the short-term energy price increases which were experienced during the time period. The survey data is subsequently used in regression analysis to estimate average level of residential energy consumption for the households in the population categories under study.

The second source of data used in the study is the published 1980 Census of Population and Housing. This data has the largest number of observations of housing stock and household characteristics of any source available. We combine this data with the regression coefficients estimated with RECS data to estimate residential energy consumption averages for black and nonblack households. The data is also used in the "standardization analysis" (described below), in order to show the indirect effects of region on level of residential energy consumption. The printed Census data, although ideal in terms of numbers of observations, is limited in terms of flexibility for use in identifying the numbers of households with specific combinations of demographic and housing stock characteristics. For this reason we also employ data from the 1980 Annual Housing Survey (AHS). The AHS has a large (over 50,000) but nonetheless manageable number of observations, and contains the demographic and housing stock variables of interest. Consequently it is well suited for determining the relative sizes of the various subgroups of interest.

Three main statistical methods are employed in this study. The first method is multivariate linear regression of the RECS survey observations. The resulting regression coefficients are combined with percentages of black and nonblack households that possess predefined energy-related characteristics to estimate average levels of residential energy consumption for these population groups. These percentages are calculated from the 1980 Census data. A number of the variables in the equation are categorical, and are entered as "dummy" (e.g. with the value of either zero or one for a specific record) variables. We also estimate the average levels of residential energy consumption of population subgroups by multiplying the regression coefficients for such variables by either one or zero, depending on the characteristic of the subgroup of interest. A detailed example of this method is given in Section 3.

The second statistical method employed in the study - standardization - is common in the statistical and empirical literature for analyses of cases in which two or more categorical variables are seen as jointly predicting the value of a dependent variable. Kitagawa (1955)

TABLE 1 Percentages of Black and White Households in Owner-Occupied Housing Units, and Distributed Over The Four Census Regions in 1980

Region/National	Percent in Owner-occupied	Percent in Region	Computing National Percent
	Black Households		
Northeast	31.0	19.4	6.0
North-Central	44.1	20.5	9.0
South	50.5	50.8	25.7
West	40.2	9.2	3.7
National			Total = 44.4
	White Households		
Northeast	63.2	22.3	14.1
North-Central	71.5	27.3	19.5
South	70.7	31.5	22.3
West	63.1	18.9	11.9
National			Total = 67.8

SOURCE: U. S. Bureau of the Census, 1980 Census of Housing, Detailed Housing Characteristics, HC80-1-B1

TABLE 2 Computing National Percentage of Blacks in Owner-Occupied Housing Units, Controlling for Region

Region/National	Black Ownership Percentages	White Regional Percentages	Computing National Percentages
Northeast	31.0	22.3	6.9
North-Central	44.1	27.3	12.1
South	50.5	31.5	15.9
West	40.2	18.9	7.6
National			TOTAL = 42.5

SOURCE: U.S. Bureau of The Census, 1980 Census of Housing, Detailed Housing Characteristics, HC80-1-B1

also used in a brief discussion of the percentages of households eligible for weatherization assistance.

3 EXPLAINING RESIDENTIAL ENERGY CONSUMPTION DIFFERENCES BETWEEN BLACK AND NONBLACK HOUSEHOLDS

As noted above, the work presented here is a continuation of earlier OMEI sponsored work which included the development of the MEAM projection model, as described in Poyer, 1983. Specifically, we employ a regression equation derived from MEAM as our analytic tool to analyze black-nonblack household energy consumption differences. MEAM consists of a set of fuel-specific regression equations, which are based on analysis of the RECS surveys of residential energy use. Detailed, fuel-specific analysis is appropriate for the projection purposes for which MEAM was designed. To analyze and understand the differences in average levels of overall energy consumption between black and nonblack households, however, it is necessary to have a more general equation, which includes data for all fuels used in households. The results of this more general regression analysis are presented in Table 3. These results are based on household observations of energy use, from the five RECS surveys. The dependent variable of the equation is the total residential energy consumed, in millions of Btus/year (hereafter MBtu), for the households in the combined samples. The equation explains 51% of the variation in total energy used by the surveyed households.

Most of the variables in the equation in Table 3 are nominal or categorical variables. For example, a household either is or is not owner-occupied, either uses natural gas or some other fuel for water heating, and either is or is not below 100% of the poverty line. Such variables are entered in the equation in "dummy" form, in that households which match the category of the variable shown in the equation have the higher (or lower, depending on the sign of the coefficient) average level of energy consumption, and households not in any of the categories have the "base" level of consumption. Thus households with incomes above 100% of the poverty threshold will consume an estimated 11.0 MBtu of energy more per year than those below 100% of the poverty line.

The regression equation in Table 3 can be used to estimate residential energy consumption for either individual households, or for population categories and subgroups. Our focus in this study entails the second application. Population categories (e.g. blacks and nonblacks) and subgroups (e.g., poor households in single family, rental units built before 1940) differ from individual households in that while a household will normally have only one of a set of mutually-exclusive characteristics (e.g.being above or below 100% of the poverty level, a category will frequently contain some households with one characteristic, and other households with the opposite characteristics. To estimate the mean average residential enegy consumption for a population category or subgroup we multiply the percentage of the households in that category with each characteristic by the regression coefficient for that characteristic, and then sum the results. Thus to estimate average residential energy use for black households, we multiply the percentage of black households with each characteristic, given in Table 4, by the appropriate coefficients from Table 3. This is shown, with its results and the black-nonblack estimated household averages, in Table 5.

TABLE 3 The Equation Used for Estimating Residential Energy Consumption Levels

Regression Coefficient	Variable Name
55.88	Intercept
-5.4	Energy Price
.013*CDD	Elcool (Use Elect. for Air Conditioning)
- 9.17	Poor (Below 100% of Poverty Line)
11.35	Natural Gas Hot Water Fuel
3.66	LPG Hot Water Fuel
38.57	Fuel Oil Hot Water Fuel
17.39	Owner Occupied
-13.34	Housing Unit Built 1940-1974
-18.74	Housing Unit Built Post 1974
11.97	Black Household
19.58	Single Family Detached Housing Unit
4.87	Mobile Home or Other Single Family Unit
-4.91	Year Survey Taken (1978=1, 1983=5)
14.94	Household Size (# Members)
.011*HDD	Natural Gas Space Heating Fuel
.010*HDD	Fuel Oil Space Heating Fuel
.012*HDD	LPG Space Heating Fuel
.005*HDD	Electricity Space Heating Fuel
- 0.54	Household Size Squared

Adjusted R-Square = .51

DATA SOURCE: U.S. Dept. of Energy 1978-83 Residential Energy Consumption Surveys Public Use Data Tapes

The first, fourth, and fifth columns of numerical values in Table 5 contain the information shown in Tables 3 and 4 above. The second and third columns show the weighted averages of cooling- and heating-degree-days for black and nonblack households. These cooling- and heating-degree-day values are multiplied by the appropriate values in the COEFFICIENT column, and the result is multiplied in turn by the percentages of black and white households having air conditioning or using the various fuels for space heat(e.g., 536 for "proportion of black populatlon" and the row "natura lgas space heat fuel") to produce the estimates shown in the black estimates and nonblack estimates columns. These estimated values show the change in the total average level of residential energy consumed by black and nonblack households due to the variable identified in the left-most column, as determined jointly by the coefficient and the percentage of black or nonblack households with that characteristic.

A caveat should be made at this point. The coefficients are derived from regression analysis, as noted above, of the combined U.S. DOE residential energy consumption surveys, in which households were categorized for analytic purposes as either black or nonblack. The black and white percentages shown in the fourth and fifth columns, in contrast, and in Tables 2 and 4 are from the 1980 Census of Housing, in which households were identified as black or white. Although most nonblack households are white, this is a source of minor error or discrepancy in the data employed in the analysis. Its effect is in the direction of reducing black-white differences in average residential energy consumed. In this paper we will refer to black-white averages and differences when using the Census data separately. When results are based on RECS or AHS data, either separately or comblned whh Census data, we refer to black and nonblack averages and differences.

The differences between the black and nonblack estimates are shown in the next to last column of Table 5. Since the nonblack estlmate is subtracted from hs black counterpart, a positive value means that this variable or characteristic has the effect of raising black household energy consumption relative to nonblack households. Negative values have the opposite effect. The values in this columns are in terms of MBtu/year, as are the values on the two columns Black Estimates and Nonblack Estimates from which they are derived. Finally, the effects of some of the variables are spread over two or more categories, as with water heating fuel (natural gas hot water fuel, lpg hot water fuel, and fuel oil hot water fuel), age of the housing stock, type of housing unit (single family detached, single attached/mobile h[illegible]s), and space heating fuel To show the combined effect of these categories on the estimated black-nonblack difference, the appropriate values are summed and shown in the right-most column of Table 5.

The results for the total at the bottom of the Black Estimates and Nonblack Estimates columns of Table 5 show that the average levels of residential energy consumption, as estimated by the procedure, are virtually identical for the two population categories: 124.4 MBtu for black households, and 124.9 MBtu for nonblack households. These findings differ from both sets of earlier results noted above. One possible interpretation is that using the combined 5 years of RECS data masks the shift in energy consumption patterns that appears to have taken place from the late seventies through the early eighties.

TABLE 4 Percentages of Black and White Households with Relevant Energy-Related Characteristics, 1980

Energy-Related Characteristic	Percent Black Households	Percent White Households
Energy Price	5.95*	6.40*
Use Elect. Air Conditioning	42.6	86.4
Poor (Below 100% Poverty Line)	29.7	10.4
Natural Gas Hot Water Fuel	59.5	51.2
LPG Hot Water Fuel	5.8	4.8
Fuel Oil Hot Water Fuel	8.5	8.0
Owner Occupied Housing Unit	44.4	67.8
Housing Unit Built 1950-1970	37.9	37.5
Housing Unit Built After 1970	17.9	26.3
Single Family Detached Housing	46.5	65.6
Other Single Family Housing	10.4	8.8
Natural Gas Space Heating Fuel	53.6	52.5
Fuel Oil Space Heating Fuel	15.4	18.8
LPG Space Heating Fuel	1.4	1.2
Electricity Space Heating Fuel	14.3	18.9
Household Size (# Members)	3.0	2.7
Average # Heating Degree-Days	4596.26*	4929.48*
Average # Cooling Degree-Days	1450*	1140*

* NOTE: these values are not percentages, but rather absolute values for each of the indicated variables

Data Source: U.S. Bureau of the Census, 1980 Census of Housing

TABLE 5 Estimated Average Residential Energy Consumption Levels of Black and White Households, and Black-White Differences, Using Regression Coefficients From Table 3 and Population Percentages from Table 4

Variable	Coefficient	Black Cooling or Heating Degree - Days	Nonblack Cooling or Heating Degree - Days	Proportion of Black Population With Characteristics	Proportion of Nonblack Population With Characteristics	Black Estimates	Nonblack Estimates	Black-Nonblack Estimate Differences	Summed Effects
Intercept	55.88			1.	1.	55.88	55.88		
Energy Price	-3.4			5.95*	6.4*	-32.13	-36.56	2.43	Poor = -1.77
Use Elect. Air Conditioning	0.012724	1450.	1140.	0.426	0.864	7.859614	12.53263	-4.67301	Water heating fuel = +.13
Poor (Below 100% Poverty Line)	-9.174			0.297	0.104	-2.72467	-0.95409	-1.77058	Owner occupied = -4.87
Natural Gas Hot Water Fuel	11.35			0.595	0.512	6.75325	5.8112	0.94205	House age = +.46
LPG Hot Water Fuel	3.66			0.058	0.048	0.21228	0.17568	0.0366	House type single family = -3.68
Fuel Oil Hot Water Fuel	38.57			0.058	0.08	2.23706	3.0856	-0.84854	Black householder = +11.97
Owner Occupied Housing Unit	17.39			0.444	0.678	7.72116	11.79062	-4.06926	Space heating fuel = -4.87
House Built 1950-1970	-13.34			0.655983	0.62263	-8.75081	-8.30588	-0.44492	Household size and size squared = +3.55
House Built after 1970	-18.76			0.06762	0.11572	-1.26719	-2.16859	0.901394	
Black Household	11.97			1.	0.	11.97	0.	11.97	
Single Family Detached Housing	19.58			0.465	0.656	9.1047	12.84448	-3.73978	
Other Single Family Housing	4.87			0.104	0.088	0.50648	0.42856	0.07792	
Year	-4.91			2.5*	2.5*	-12.275	-12.275	0.	
Household Size	14.96			3.0*	2.7*	44.82	40.338	4.482	
Natural Gas Space Heating Fuel	0.010516	4596.26	4929.48	0.536	0.525	25.90716	27.21516	-1.30799	
Fuel Oil Space Heating Fuel	0.009685	4596.26	4929.48	0.154	0.188	6.855275	8.973498	-2.12022	
LPG Space Heating Fuel	0.011557	4596.26	4929.48	0.06	0.0564	3.187138	3.213108	-0.02596	
Electricity Space Heating Fuel	0.005158	4596.26	4929.48	0.143	0.189	3.390173	4.805562	-1.41538	
Household Size (# Members) Squared	-0.54449			9.0*	7.29*	-4.90041	-3.96933	-0.93107	
Total						124.3562	124.8630	-0.50679	

SOURCE: U.S. DOE 1978-1983 RECS Public Use Data Tapes and 1980 Census of Population and Housing

*This value is not a proportion, but rather the actual value for the variable and population category combination in question.

Two caveats are necessary regarding the finding of equality of black and nonblack estimated residential energy consumption. First, our measure of energy consumption is the sum over all fuels used in the home. However, not all fuels are equal in terms of their value to the consumer. Specifically, electricity is of higher average efficiency per Btu consumed in the home for space and water heating (the two largest energy end-uses in the home, on the average) than are the other energy sources. Electricity constitutes a larger share of the average nonblack energy budget than for blacks, and is used more frequently by nonblacks for space and water heating (Poyer, 1983). Consequently black households, although consuming on the average the same estimated number of MBTus as nonblacks according to our findings, receive less average value per Btu.

The second caveat also concerns the meaning of our dependent variable: residential energy consumption. Energy consumption is of direct interest to energy planners and policy makers. Of greater interest to the average residential energy consumer, however, is energy expenditures, which reflect both energy consumed and the average price per MBtu of the fuels used. The findings of approximate equality in the estimated residential energy consumption averages of black and nonblack households do not necessarily mean that they have equal energy expenditure levels. Since electricity is generally the more highly priced energy source, and since nonblacks more frequently use electricity for space and water heating, average residential energy expenditures for nonblack households should, all else equal, be below the average expenditures of nonblack households. Since nonblack average family income is above that for blacks, however, the energy expenditures as a share of income are lower for nonblack households than for black households (Poyer, 1983). The point is that our dependent variable is only one of a number of such measures of residential energy use and its effects. As will be noted in the concluding section, future work should expand the focus to include these additional measures, which are beyond the scope of this study.

A second important finding of Table 5 is that the identical black and nonblack energy consumption averages are the resuh of a number of factors, the effects of which cancel each other out. For example,the effect of the energy price variable is to raise the black average 2.43 MBtu, relative to the nonblack average. This increase is largely offset, however, by the -1.77 effect of the variable POOR on the relative level of black household consumption. Finally, it should be noted that variables that make large contributions to average levels of energy consumption do not always have large impacts on the differences between black and nonblack levels of consumption. This is shown with the variables Energy Price and Natural gas space heating fuel both are important in determining the total average level of black and nonblack residential energy consumption, but their effects on the black-nonblack differences are relatively modest.

The most important variable in contributing to black-nonblack differences shown in Table 5 is the race of the householder, identified as BLACK in the variable column. This shows that the race of the householder, independent of all other factors shown, contributes 11.97 MBtu/year to the difference in black-nonblack consumption averages. Unfortunately our data provide no information for interpretation of this variable, beyond that its contribution is

separate from the other variables in the equation. Stated differently, if black and nonblack households were identical in terms of all of the other variables shown in Table 5, the estimated black average annual energy consumed in the home would be 11.97 MBtu higher than the nonblack counterpart. Behavioral differences, size and thermal integrity of housing unit differences, and differences in average efficiencies of energy-consuming appliances are possible explanatory variables, the effects of which may be subsumed under raee of householder. Additional work, beyond the scope of this study, will be necessary to test such possible interpreations.

Three other factors - household size, energy price, and the age of the housing stock occupied by black and nonblack households- also raise the estimated average level of black energy consumption relative to nonblack households. As may be seen in Table 5, this is because nonblack households pay on the average more per MBtu of energy (due to higher consumption of high-priced electricity) than do black households, and because a considerably smaller percentage of black households live in newer (post 1974) housing units. These four factors raising the black average, relative to the nonblack average, are shown in the left bar chart of Fig.l. As can be seen, the race variable contributes sixty-five percent of the 18.41 MBtu combined totla effects of the four variables displayed on this side of the bar chart.

The increases in average black consumption due to these variables are offset, however, by a number of factors which lower black energy consumption relative to nonblack households. These are, in order of declining importance: the combined effects of heating degree-days and fuels used for space heating; use of air conditioning and cooling degree-days; percentage of households in owner-occupied units; percentage of households in various types of housing units (single family detached, ete.); and percentages of households below the poverty line. As is shown in Fig.l, the first four of these are relatively equal in their levels of contribution to the black-nonblack difference in average energy consumption; they constitute over 90% of the 19.04 MBtu total of all factors reducing black consumption relative to nonblack households.

The percentages of black and nonblack households with the characteristics shown in the Proportion Black Population and Proportion White Population columns of Table 5 are national averages. Table 1 showed that the regional distribution of black households varies significantly from that for white households. This is also the case for many of the household and housing stock characteristics measured by the variables in our equations in Table 3. This raises an important question: are these regional concentrations of blacks and energy-relevant characteristics of the housing stock the main source of the black white differences in percentages of households shown in the Proportion Black and Proportion White columns in Table 5?. To answer the question we standardize for regional effects using the procedure described above.

In order to standardize one or more variables when a wide variety of variables are under study, it is necessary to determine first, ideally from a theoretical perspective, the causal ordering of the variables. One logically standardizes relatively early in the causal chain, in order to note the effects of standardization on intervening and dependent variables. A causal

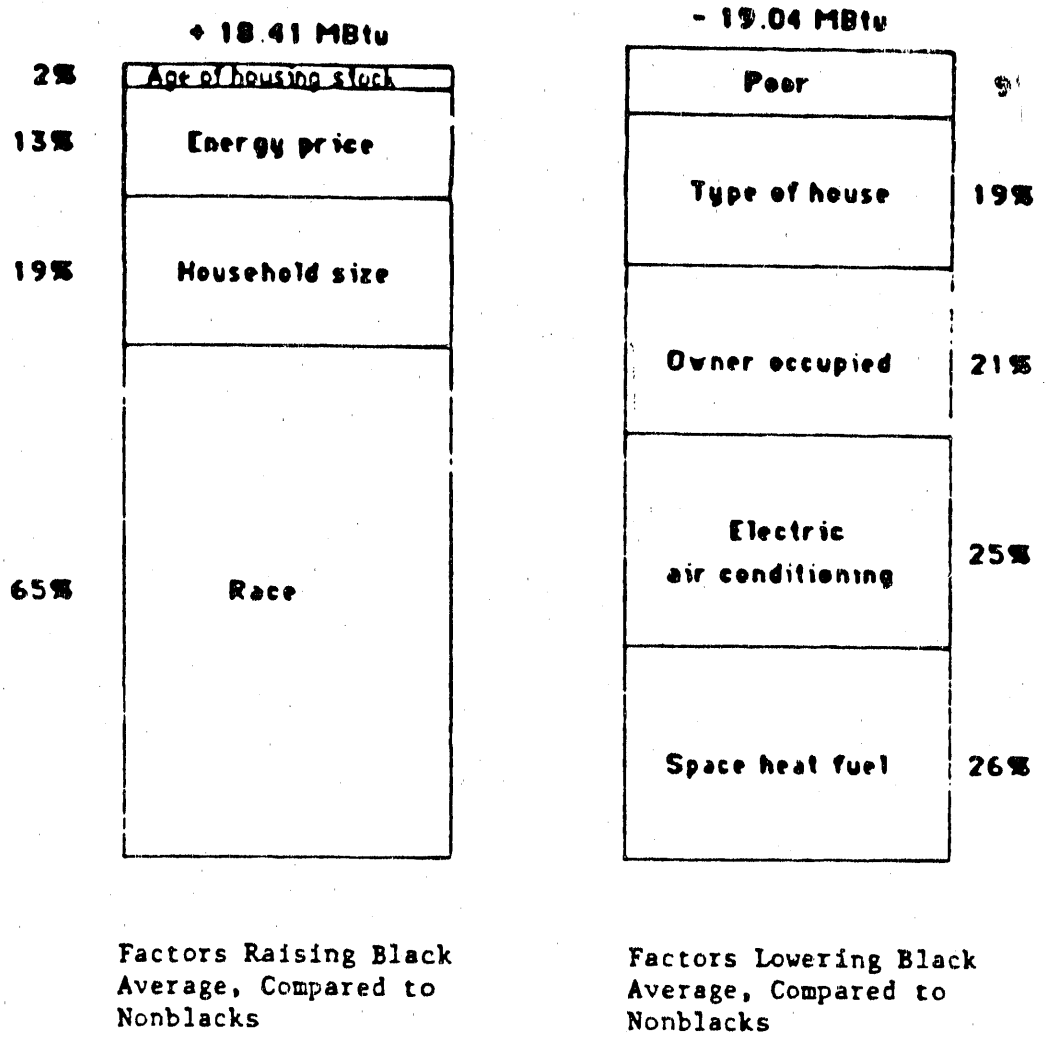


FIGURE 1: RELATIVE CONTRIBUTIONS OF FACTORS AFFECTING BLACK-NONBLACK DIFFERENCES IN AVERAGE LEVELS OF ENERGY CONSUMED IN THE HOME

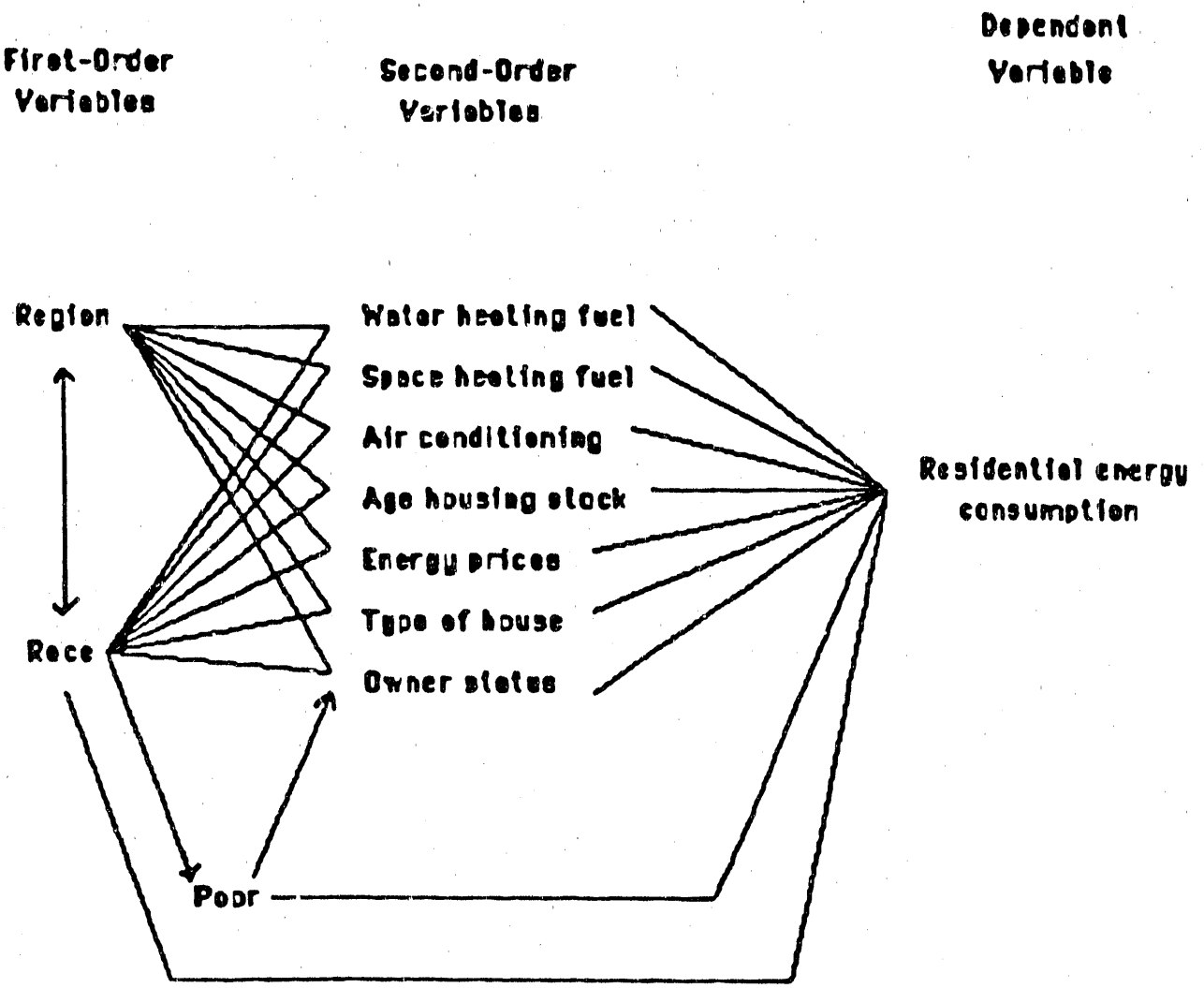


FIGURE 2 A Theoretical Ordering of the Variables of Interest

ordering of the variables under study here is presented in Fig. 2. Race and region are shown as first order or contextual variables - they are more likely to affect than be affected by the variables to their right. Figure 2 should not be interpreted to mean that either race or region "causes" poverty or any of the other second order variables in that figure. Rather a variety of social, economic, and historical factors link race and region to the second order variables. For example, both race and region are predictors of household poverty status, shown as the variable poor. While poverty may induce households to move, and thus affect regional distribution, the effects are more long- than short-term, and the association is likely to be weaker in that direction than in the region-to-poverty direction. Poverty, race, and region have separate and combined associations with the set of variables shown under the label "second order variables": the fuel, housing stock, and related characteristics. These variables in turn, together with the aforementioned race, region, and poverty variables, explain variation in the estimated level of household residential energy consumption, as has been shown above.

The Census of Housing data facilitate standardization by region, in terms of determining the associations of race with each of the second-order variables independent of region. For the variable Owner Status the data also enable the simultaneous standardization of region and poverty, to determine the independent association of race with home ownership. Given the fact that black household poverty levels are significantly above those of whites, one would expect that standardization of both region and poverty would significantly reduce the black-white difference in average ownership rates, as measured by percentage of households in owned units. Table 6, which shows the differences between controlled and uncontrolled black percentages of households with the energy-related characteristics under study, makes possible the test of this hypothesis.

Table 6 presents the changes in the percentages of black households with energy related characteristics which result from standardizing for region. No dramatic changes are evident in the percentages shown. Standardization for region changes most percentages only two or three points. Likewise the regional standardization has little effect on heating degree days. This is because standardizing for region simulates the movement of blacks out of one mild region -the South - and into another: the West. In contrast, we do see rather sizeable changes in the number of cooling degree days (a change of over 200 degree-days), and in the energy price variable, which declines by over two dollars per MBtu. To appreciate the significance of these changes, however, it is necessary to apply the standardized variables in estimating average levels of black residential energy consumption.

An examination of the values in Table 7, relative to Table 5, (and Fig. 3 relative to Fig. 1) shows one dramatic effect from standardizing for region or, in one case, both region and income combined. That effect is from the energy price variable, and is due to the fact that blacks are found in above-average proportions in the high-energy-cost Southern region. By standardizing for region we hypothetically "move" almost 10% of the black households from the Southern region to the lower-priced Western and North- central regions. In doing this we assume that the newly "transplanted" black households would respond to energy prices in terms of their consumption levels as other black households in those regions do: they would consume more energy on the average. The result is that average residential energy

TABLE 6 Comparison of Uncontrolled and Controlled (For Region) Percentages of Black Households with Energy-Relevant Characteristics

Characteristic	Uncontrolled Black Percentage	Controlled Black Percentage
Energy price	5.95*	3.89*
Use Elect. Air Conditioning	42.6	38.80
Poor (Below 100% Poverty Line)	29.7	26.9
Natural Gas Hot Water Fuel	59.5	65.2
LPG Hot Water Fuel	5.8	4.9
Fuel Oil Hot Water Fuel	5.8	9.2
Owner Occupied Housing Unit	44.4	46.9**
Housing Unit Built 1950-1970	37.9	37.0
Housing Unit Built After 1970	17.9	16.1
Single Family Detached Housing	46.5	43.4
Other Single Family Housing	10.4	9.6
Natural Gas Space Heating Fuel	53.6	55.9
Fuel Oil Space Heating Fuel	15.4	16.0
LPG Space Heating Fuel	6.0	4.5
Electricity Space Heating Fuel	14.3	12.3
Average # Cooling Degree-Days	1450*	1234.71*
Average # Heating Degree-Days	4596.26*	4592.45*

* This value is not a percentage, but rather the weighted average energy characteristic for black households. The standardization procedure is the same, however, as for the percentage statistics.

** This value is controlled for both region and poverty-level (i.e. above or below 100% of the poverty line). All other variables are controlled only for region.

SOURCE: U.S. Bureau of Census, 1980 Census of Housing, Detailed Housing Characteristics, HC 80-1-B-1

TABLE 7 Estimating Black and Nonblack Residential Energy Consumption Averages on the National Level, Region Controlled

Variable	Coefficient	Black Cooling or Heating Degree - Days	Nonblack Cooling or Heating Degree - Days	Proportion of Black Population With Characteristics	Proportion of Nonblack Population With Characteristics	Black Estimates	Nonblack Estimates	Black-Nonblack Estimate Differences	Summed Effects
Intercept	55.88					55.88	55.88		Poor = -1.52
Energy Price	-5.4			3.89*	6.4*	-21.006	-34.56	13.554	Water heating fuel = +2.06
Use Elect. Air Conditioning	0.012724	1234.71	1160.	0.388305	0.864	6.100446	12.53263	-6.43218	Owner occupied = -3.64
Poor (Below 100% Poverty Line)	-9.174			0.269135	0.104	-2.46904	-0.95409	-1.51494	House age = +.09
Natural Gas Hot Water Fuel	11.35			0.652531	0.512	7.406226	5.8112	1.595026	House type single family = -4.31
LPG Hot Water Fuel	3.66			0.068802	0.048	0.178615	0.17568	0.002935	Black householder = +11.97
Fuel Oil Hot Water Fuel	38.57			0.091956	0.08	3.546742	3.0856	0.461142	Space heating fuel = -4.83
Owner Occupied Housing Unit	17.39			0.468566	0.678	8.148362	11.79042	-3.64205	Household size and size squared = +3.55
House Built 1950-1970	-13.34			0.64174	0.62263	-8.56081	-8.30588	-0.25492	
House Built after 1970	-18.74			0.09713	0.11572	-1.82021	-2.16859	0.348376	
Black Household	11.97			1.	0.	11.97	0.	11.97	
Single Family Detached Housing	19.58			0.4342	0.656	8.501636	12.84448	-4.34284	
Other Single Family Housing	4.87			0.0955	0.088	0.465085	0.42856	0.036525	
Year	-4.91			2.5*	2.5*	-12.275	-12.275	0.	
Household Size	14.94			3.0*	2.7*	44.82	40.338	4.482	
Natural Gas Space Heating Fuel	0.010516	4592.45	4929.48	0.558983	0.525	26.99563	27.21516	-0.21952	
Fuel Oil Space Heating Fuel	0.009685	4592.45	4929.48	0.159505	0.188	7.094443	8.975498	-1.88105	
LPG Space Heating Fuel	0.011557	4592.45	4929.48	0.046847	0.0564	2.380252	3.213108	-0.83285	
Electricity Space Heating Fuel	0.005158	4592.45	4929.48	0.122832	0.189	2.909626	4.805562	-1.89593	
Household Size (# Members) Squared	-0.54449			9.0*	7.29*	-4.90041	-3.96933	-0.93107	
Total						135.3655	124.8630	10.50239	

SOURCE: U.S. DOE 1978-1983 RECS Public Use Data Tapes and 1980 Census of Population and Housing

*This value is not a proportion, but rather the actual value for the variable and population category combination in question.

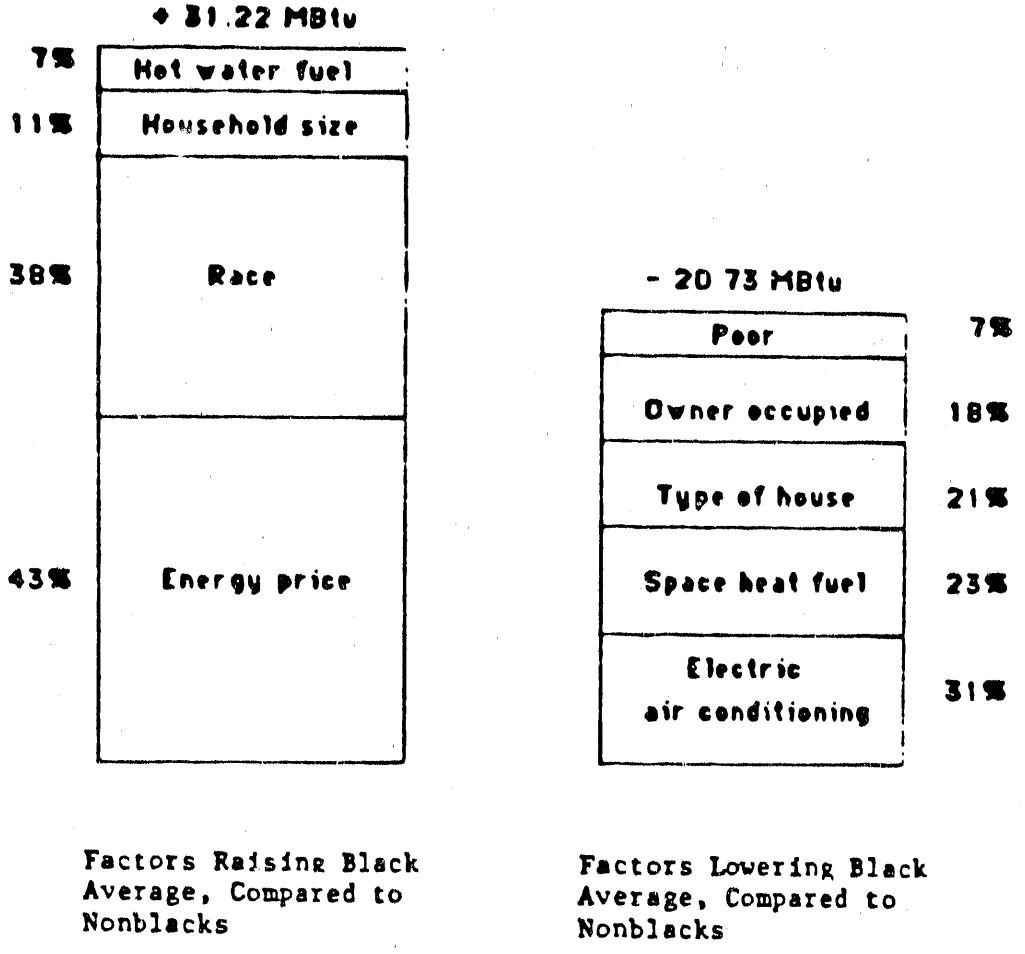


FIGURE 3 Relative Contributions of Factors Affecting Black-Nonblack Differences in Average Levels of Energy Consumed in the Home, Controlling for Region

consumption for black households increases by almost 23 MBTu due to this one variable, relative to the nonstandardized level in Table 5. By comparison, the indirect effects of region through the other variables are much less, as is shown in Fig. 3. The indirect effect through air conditioning/cooling degree-days lowers black energy consumption by 1.76 MBtu relative to nonblack. This is offset by 1.96 MBtu increase in estimated black residential energy consumption due to the indirect effects of region through the water heating fuels, relative to nonblack consumption. The main indirect effect of region, however, is through the energy price variable. This means that black estimated average energy consumption is "artificially" lowered due to black above average concentration in the high energy priced Southern region.

4 DISAGGREGATION OF BLACK AND NONBLACK POPULATIONS BY ENERGY-RELATED HOUSING CHARACTERISTICS

The preeeding analysis identifies the housing stock and related characteristics that explain the statistical variation in levels of residential energy consumption for black and nonblack households. By multiplying the regression coefficients by the percentages of black or nonblack households with a specific characteristic, we have produced estimates of the average level of residential energy consumed by these population categories. It is also possible to use the regression equation to estimate average levels of residential energy consumption for subgroups of households within the larger categories. This is accomplished by multiplying the regression coefficient by either one or zero, depending on whether the dummy variable in question is a characteristic of the population category or subgroup of interest. This is illustrated for the race-specific variable "Black" in the calculations shown in Tables 5 and 7. There the coefficient is multiplied by one to produce the estimate for black households, and by zero to produce the estimate for nonblack households. In a similar fashion one can multiply the coefficient (-9.174) for poor (below 100% of the poverty level) by one to produce estimates for households below the poverty level, and by zero to produce the equivalents for households above the poverty level.

Table 8 presents the estimated average level of annual energy consumption for population subgroups on the national level. Because of the method of producing these estimates, there is a good deal more regularity in this table than initially meets the eye. This is because the effects of each of the variables shown in the row and column headings can be identified independently of the effects of the others, through comparison of cells for which only that variable has different values. An example will clarify this point. Examining the upper-left corner of Table 8, we note that poor black households living in pre-1940, single family, owner occupied units will consume on the average 152.43 MBTus per year. Households with all of these characteristics except that they rent consume 135.03 MBtus, or 17.4 MBTus less on the average. This 17.4 MBtu difference is constant for all comparisons between adjacent values in these first two columns, or for similar comparisons between other columns. Likewise the differences related to age of the housing unit are 13.34 MBtus for the pre-1940 to 1940-1974 comparison, and 18.74 MBtus for the pre-1940 to post-1974 comparison. Other comparisons in the table show that poor households consume on the average an estimated 9.17 MBtus less than their nonpoor counterparts, that households in multiple-family units consume on the average 24.45 MBTus less than those in single-family units, and that black

TABLE 8 Estimated Average Residential Energy Consumption of Black and Nonblack Households by Energy Relevant Characteristics

Poverty Status	Year House Built	Single-Family		Multifamily	
		Owner-Occupied	Renter-Occupied	Owner-Occupied	Renter-Occupied
			Black Households		
Poor*	Pre-1940	152.43	135.03	127.98	110.58
Poor*	1940-1974	139.09	121.69	114.64	97.24
Poor*	Post-1974	133.69	116.29	109.24	91.84
Not Poor	Pre-1940	161.60	144.20	137.15	119.75
Not Poor	1940-1974	148.26	130.86	123.81	106.41
Not Poor	Post-1974	142.86	125.46	118.41	101.01
			Nonblack Households		
Poor*	Pre-1940	143.89	126.49	119.44	102.04
Poor*	1940-1974	130.55	113.15	106.10	88.70
Poor*	Post-1974	125.15	107.75	100.70	83.30
Not Poor	Pre-1940	153.06	135.66	128.61	111.21
Not Poor	1940-1974	138.72	122.32	115.27	97.87
Not Poor	Post-1974	134.32	116.92	109.87	92.47

* Poor is defined as households with incomes below 100% of the poverty level.

SOURCE: U.S. DOE Residential Energy Consumption Survey Public Use Data Tapes, 1978-1983

households consume on average 8.54 MBTus more than their nonblack counterparts. This latter difference is less than the 11.97 MBTus from the regression coefficient for race due to the differential effects of the air conditioning/cooling degree-days, space heating fuels/heating degree-days, energy price, and household size variables on the estimated averages for black and nonblack households.

There is considerable variation in the estimated averages shown in Table 8, from the high average of 161.6 MBtus consumed by nonpoor blacks living in pre-1940, single-family, owner-occupied units, to the low average of 83.3 MBtus consumed by poor nonblack households living in post-1974, multiple-family renter-occupied units. Those are the extreme cases, with the estimates for the other cells are in between. Of note is the fact that four of the top five cells ranked by estimated energy consumption, and seven of the top ten such cells contain black households. In contrast only one of the top five, and only three of the top ten cells contain poor households. This suggests that programs which have as their main purpose maximizing energy savings in above-average consuming households should be of disproportionate benefit to blacks, but may have below-average benefits for poor households.

The estimated averages shown in Table 8 do not reflect the extent to which the black and nonblack populations of households are evenly or unevenly distributed over the cells. Tables 9 and 10 provide the information on the distribution. Both are based on cross-tabulations of 1980 Annual Housing Survey (AHS) data. Table 9 presents the percentages in each cell as based on the sum of both black and nonblack households in an cells. Thus 1.6 pecent of all such households consist of poor nonblacks living in pre-1940 built, owner-occupied single-family units. Most of the cells have low percentages, which is not surprising, given the number of cells (48) divided into 100%. Exceptions to this are found in the bottom half of the table. Approximately fifty percent of all households are nonpoor nonblacks living in owner-occupied, single-family houses, the vast majority of which were built in the 1940-1974 time period. The other large concentration of households is of nonpoor nonblacks renting multifamily units, which comprise approximately 15% of all households. As can be seen from the values for the column totals, black households are only 11% of all households in the country. Consequently it is not surprising that there are no significant concentrations of households on the top half of Table 9.

Table 9 is valuable in showing the overall distribution of households with the various characteristics of interest. It is not valuable for comparing black and nonblack household distributions over these characteristics, because the number of nonblack households is so much larger than that of blacks. Table 10 provides the percentage distribution of black and nonblack households over the housing stock and poverty level characteristics. Table 11 shows the over- or underrepresentation of black households, relative to nonblack households, in housing units with the characteristics under study. These values were computed by subtracting the values for nonblack households (in the bottom half of Table 10) from their counterparts for black households (in the top half of Table 10).

As is shown in Table 11 and in Figure 4, blacks households are overrepresented, relative to nonblacks households in the percentages living in multiple-family units, living in rental units,

TABLE Black and Nonblack Households with Selected Energy-Relevant Characteristics, as Percentages of All Households

Poverty Status	Year House Built	Single-Family Owner-Occupied	Single-Family Renter-Occupied	Multifamily Owner-Occupied	Multifamily Renter-Occupied
			Black Households		
Poor*	Pre-1940	.29	.37	.04	.70
Poor*	1940-1974	.54	.35	.14	.81
Poor*	Post-1974	.04	.02	.00	.08
Not Poor	Pre-1940	1.02	.49	.20	.98
Not Poor	1940-1974	2.17	.58	.11	1.45
Not Poor	Post-1974	.27	.04	.00	.19
	TOTALS	4.33	1.85	.36	4.18
			Nonblack Households		
Poor*	Pre-1940	1.62	.95	.15	1.64
Poor*	1940-1974	2.61	1.04	.10	1.44
Poor*	Post-1974	.423	.06	.02	.26
Not Poor	Pre-1940	12.27	2.92	1.49	5.12
Not Poor	1940-1974	32.90	4.28	1.40	8.34
Not Poor	Post-1974	7.59	.51	.40	1.77
	TOTALS	57.40	9.76	3.56	18.57

* Poor is defined as households with incomes below 100% of the poverty line.

SOURCE: 1980 Annual Housing Survey Data Tape

TABLE 10 Percentage of Black and Percentage Nonblack Households with Selected Energy-Relevant Characteristics.

Poverty Status	Year House Built	Single-Family		Multifamily		ROW TOTALS
		Owner-Occupied	Renter-Occupied	Owner-Occupied	Renter-Occupied	
			Black Households			
Poor*	Pre-1940	2.67	3.45	.33	6.51	12.96
Poor*	1940-1974	5.04	3.29	.13	7.52	15.98
Poor*	Post-1974	.36	.14	.02	.53	1.05
Not Poor	Pre-1940	9.58	4.56	1.87	9.11	25.12
Not Poor	1940-1974	20.24	5.41	.99	13.52	40.16
Not Poor	Post-1974	2.52	.37	.04	1.79	4.73
	TOTALS	40.41	17.22	3.38	38.98	99.99
			Nonblack Households			
Poor*	Pre-1940	1.81	1.06	.16	1.84	4.87
Poor*	1940-1974	2.92	1.16	.12	1.62	5.82
Poor*	Post-1974	.47	.07	.02	.29	.86
Not Poor	Pre-1940	13.74	3.28	1.67	5.73	24.42
Not Poor	1940-1974	36.84	4.79	1.57	9.34	52.54
Not Poor	Post-1974	8.50	.57	.44	1.98	11.49
	TOTALS	64.29	10.93	3.98	20.80	99.99

* Poor is defined as households with income below 100% of the poverty line.

SOURCE: 1980 Annual Housing Survey Data Tape

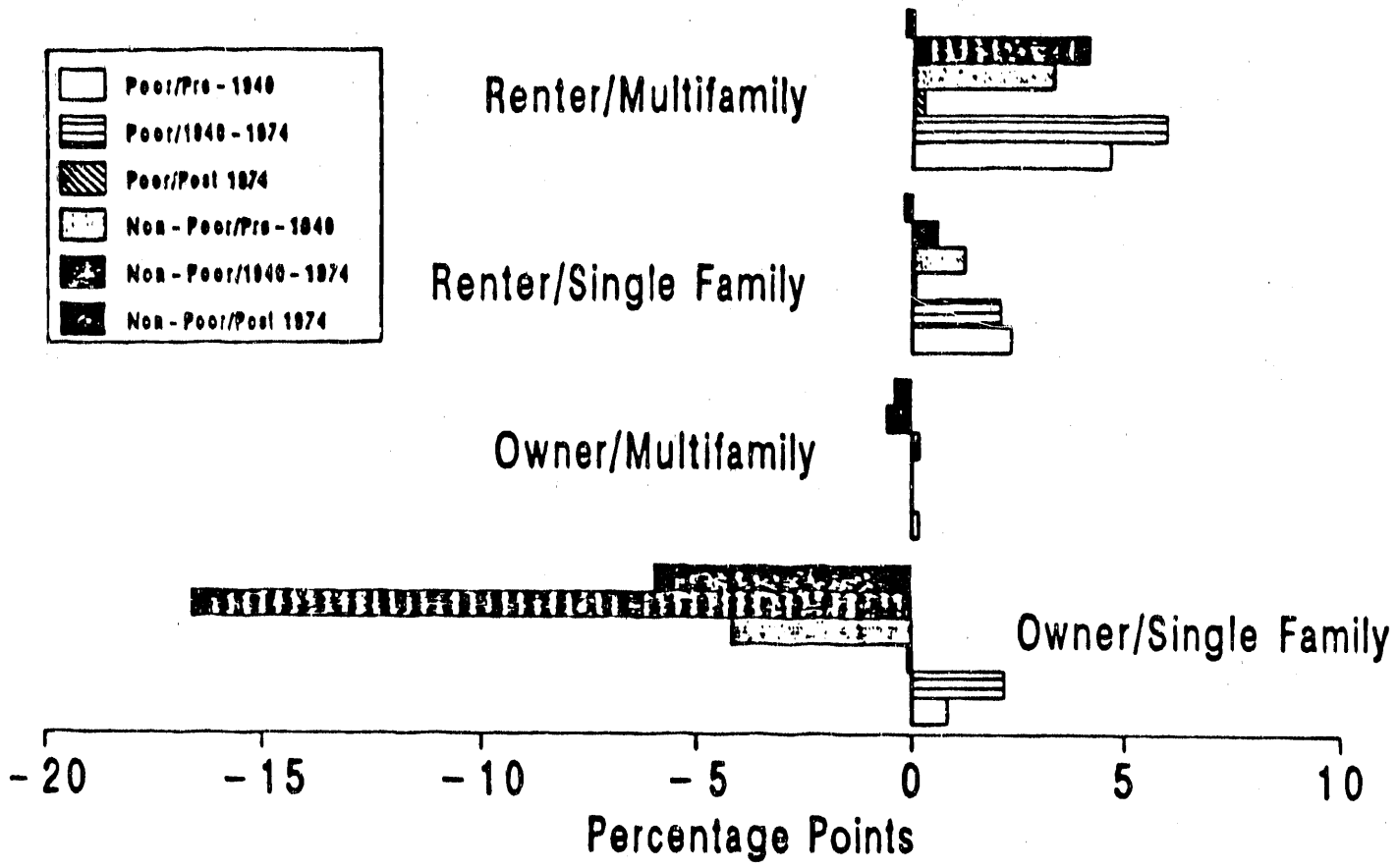


FIGURE 4 Over/Under-Representation of Black Households, Relative to Nonblack Households with Energy-Related Characteristics

TABLE 11 Percentage Over/Under Representation of Black Households Relative to Nonblack Households in Units with Selected Energy-Relevant Characteristics

Poverty Status	Year House Built	Single-Family		Multifamily		ROW TOTALS
		Owner-Occupied	Renter-Occupied	Owner-Occupied	Renter-Occupied	
Poor*	Pre-1940	.86	2.39	.16	4.68	8.09
Poor*	1940-1974	2.12	2.13	.01	5.90	10.16
Poor*	Post-1974	-.11	.07	-.00	.24	.20
Not Poor	Pre-1940	-4.16	1.28	.20	3.38	.70
Not Poor	1940-1974	-16.60	.62	-.58	4.18	-12.38
Not Poor	Post-1974	-5.98	-.20	-.40	-.20	-6.77
	TOTALS	-23.87	6.29	-.60	18.18	0

* Poor is defined as households with incomes below 100% of the poverty level.

NOTE: Positive values mean that black percentages in cells are greater than nonblack percentages

SOURCE: 1980 Annual Housing Survey Public Use Data Tape

living in units built before 1940, and in percentage below the poverty line. The overall differences in percentage distributions for black and nonblack households shown in Table 11 is 28%, which means that one would need to "move" or change the characteristics of 28% of either the black or nonblack households to make these two populations be identical. To summarize the major differences in Table 11, black overrepresentation relative to nonblacks is concentrated in older (pre-1940 and 1940-1974) multifamily rental units with poor (and to a lesser extent nonpoor) households. Over half (18 of the 28 percentage points) of the black overrepresentation is in the multiple-family rental column. The other concentration of black overrepresentation is in older single-family rental units occupied by poor households. Nonblack overrepresentation, in contrast, is found in nonpoor households living in single-family, owner-occupied units. Nonblacks are also overrepresented in the newest (built post 1974) units, especially when the household is above the poverty level.

The values shown in Table 11 are valuable in providing a picture of the aggregate differences between the black and nonblack populations across the dimensions of interest. They do not, however, provide a measure of the extent to which residential energy consumption differences are attributable to these population subcategories. Reference to the right-most column of Table 5 shows that each of the factors in Table 11 related to the black-nonblack energy consumption differences analyzed in Section 3. Specifically, black estimated average residential energy consumption is lowered 4.07 MBtus per year by the above-average concentration of blacks in rental units (shown in Table 5 as "owner-occupied"), relative to the nonblack average. Similar if somewhat lower effects are found for house type (-3.66 MBtus per year), which reflects black concentration in multi-family units, and poor (-1.77 MBtus per year) reflecting the lower average incomes of black households. Only black concentrations in older housing units (shown as house age in Table 5) raises the relative level of the black average by a slight .46 MBtus. We assume in this study that the coefficients for black and nonblack households are identical. Consequently, the effects of each of these variables (e.g., owner-occupied, house type, etc.) are due to the differences between the black and nonblack populations in terms of these characteristics. Table 11, by showing these differences, further elucidates the findings presented in Table 5.

The aggregation is based, as noted, on data from the 1980 Annual Housing Survey, to make it fit mid-point of the 5 years of coverage by the RECS surveys. More recent AHS data is available, and could be used to analyze the changes in both black and nonblack distributions across these and other variables relevant to residential energy consumption. For both black and nonblack populations are changing over time in their relative concentrations in various types of housing units, due to migration, household formation and dissolution, changing economic conditions, and other social and economic factors. Such an analysis could also help identify the extent to which black-nonblack differences are increasing or decreasing, and the extent to which population subgroups with above-average levels of energy consumption are growing or decreasing as percentages of the total population.

The findings presented above, and especially in Tables 9 through 11, are of theoretical interest, in helping to explain the differences in black - nonblack residential energy consumption levels, and in identifying specific population subgroups whose energy consumption totals contribute

disproportionately to the aggregate differences. These findings also have potential policy relevance. For it is possible to use them to assess the potential differential impacts on black households, relative to nonblack households, of various energy and housing related programs and policies. A brief discussion of one potential application follows.

The U.S. Department of Energy's Weatherization Assistance Program (WAP) is intended to reduce national energy consumption, particularly of imported oil, and to reduce the impact of higher fuel costs on low-income families. Funds for weatherization assistance are allocated to states under this program "through a formula which reflects the relative need for weatherization assistance among the States. The formula takes into account the number of low-income households, the percentage of total residential energy used for space heating and cooling, and the number of heating and cooling degree days in each State" (Federal Register, 1985, p. 708). The states in turn distribute the funds to eligible subcontractors for weatherization of housing-units which qualify under the program.

Previous research evaluating WAP has not had as its major focus WAP's relative impact on minorities. One exception was the earlier MI-sponsored work by Kier (1984) which assessed the impacts on Black and Hispanic households of various formulas for allocating funds to the States. Kier contended that the allocation forumla used by WAP could "be modified to increase dollar savings to WAP clients, to increase oil savings, and to increase funds allocated to states with high minority, low-income populations" (kier, 1984, pg. 1). Kier did not measure, however, the extent to which minority households are actually receiving relatively greater or lesser benefits from WAP.

More specific measures of differential impacts in black households were included in a DOE/EIA evaluation of WAP by Peabody (1984). His analysis of the 1981 RECS data showed that black households were 21% of all households below 125% of the poverty line, and thus eligible for WAP assistance, but that black households constituted 25% of all single-family households that actually received WAP assistance. Peabody also found that the average energy savings per household was slightly greater for black (11.2%, or 19.2 MBtus) than for white households (10.4 or 12.6 MBtus) receiving weatherization assistance. Finally, he found that although 40% of low-income households (below 125% of the poverty level) lived in houses built before 1940, 53% of the households receiving WAP assistance were in pre-1940 built structures. This is significant since, as was shown earlier, black households are disproportionately found in older housing units, and house age is one of the factors explaining the black - nonblack differences in residential energy consumption.

In contrast to Peabody's findings, the results of an earlier study of WAP for DOE by Urban Systems Research & Engineering cast doubt on the extent to which black households may be receiving benefits at disproportionately higher rates under this program. For this study noted that, "...in most states rental units have received little if any weatherization assistance. Local WAP agencies have been reluctant to weatherize rental units..." (Urban Systems, 1982, pg.9). Our findings show both that ownership status is an important factor explaining the differences in average black and nonblack household energy consumption, and that black households are disproportionately concentrated in rental units. Given these facts, the Urban Systems

Research findings imply that relatively fewer black households would receive WAP benefits than their nonblack counterparts.

Minor modifications would be necessary to employ the data and methods of the study to evaluate comprehensively the relative impacts of WAP on minority and nonminority households. One such modification would entail redefining the threshold of what is considered poor. In this study we have used at or below 100% of the poverty level as the definition "poor". The original WAP rules included households at or below 125% of the poverty level as eligible. This has recently been changed to 150%. Consequently it would be necessary to modify our equation and cross-classification tables to match these WAP criteria. A second modification of our approach would entail adding at least a regional, if not state-level dimension. This would be necessary to reflect the emphasis on saving energy, and especially imported oil, which is part of the WAP rationale. For as is shown in the basic equation, space heating and air conditioning are two of the major contributors to high levels of residential energy consumption. Finally, it would be valuable to note the variation in relative benefits to black households within and between the various states, since it is possible that an allocation formula would benefit black households in some states, and work to their relative disadvantage in other states. It is also possible, of course, that an allocation formula would benefit some subgroups of black households while hurting or lowering the benefits of other subgroups. The data and methods employed above would enable us to estimate such impacts on the subgroups under study.

Our discussion of Table 8 above pointed out that programs focused primarily on reducing energy consumption would disproportionately benefit black households, assuming that the program targets households with above-average levels of residential energy consumption. This is because four of the top five cells in Table 8, and seven of the top ten cells contain black households. We also noted that only one of the top five, and only three of the top ten cells in that table contain poor households. This suggests that the two goals of WAP - to conserve residential energy and to assist low-income households with their energy bills - may lead in at least partially different directions. This is because poor households consume below-average amounts of residential energy, as estimated by the methods of this study. These findings should be viewed as preliminary, however, since this brief discussion falls far short of a thorough analysis and evaluation of this topic. The disaggregation methodology and data employed in this analysis could identify the extent to which these goals are indeed contradictory. It could also show the potential effects on minority households of placing greater emphasis on either goal.

5 SUMMARY AND CONCLUSIONS

The purpose of this study has been to assess and explain differences in average levels of residential energy consumption of black and nonblack households. After a brief review of past literature and a discussion of the data and methods employed, we presented our major findings. Regression analysis showed that estimates of residential energy consumption levels for black and nonblack households are virtually identical. Controlling for regional distribution differences in the black and nonblack populations results in significantly higher

estimates of black consumption. We interpret this to mean that region has indirect effects on the race-specific levels of energy consumption, primarily through the variable of energy price. It is likely that other variables, such as income and household size, also have indirect effects on energy consumption. A standardization analysis for such variables was beyond the scope of this study, however. We also find that a number of demographic and housing variables explain the differences in residential energy consumption between black and nonblack households. Race of householder is the most important of these. We do not have a clear interpretation for this finding, and treat it as an "unexplained residual" needing additional analysis.

In the last major section of the report we compared the distributions and estimates of average levels of residential energy consumption for black and nonblack households over 24 mutually-exclusive categories. These categories are based on some of the more important housing stock characteristics identified in the previous analysis. Black households and energy consumption are disproportionately concentrated, relative to their nonblack counterparts, in low-income, rental, and older housing unit cells of the tables analyzed. Nonblack households and energy consumption, in contrast, are disproportionately concentrated in single-family, owner-occupied, and nonpoor cells. Finally we discussed the implications of these findings for, and the potential for expanding the analysis to include an evaluation of, the effectiveness and impacts on minorities of the Weatherization Assistance Program. Some of the past analyses of WAP have suggested above-average rates of participation in and benefits from this program for minority households. Findings from other analyses imply that some of the largest and most-needy segments of the black population (e.g. renters in multi-family units) may be unintentionally yet systematically excluded from the program, or receiving benefits at below average rates. The analysis and discussion in this study do not directly address this question, and are thus too preliminary to provide firm or conclusive answers. However, the data and disaggregation methods employed in this study could well be used in such an evaluation.

The findings presented above raise a number of important questions to be addressed in future research. The first of these is to find an empirically-based interpretation of the "race of householder" variable in the equation. Two competing, although by no means contradictory hypotheses to explain the effects of this variable could be tested. Black households may consume more residential energy due to the characteristics of their housing units and appliances, which may be older and less energy-efficient. This has been termed the "situational" hypothesis by Throgmorton and Bernard (1986). Although some of these effects may be captured by the age of housing unit, fuels used for space and water heating, and poverty variables, it is possible that the race of householder variable is reflecting black-nonblack differences not captured fully by these variables. In this regard it would also be of interest to study the extent to which the black-nonblack differences in housing characteristics are related to housing segregation.

The second hypothesis would focus on black-nonblack differences in energy-related behavior patterns, termed the "culture of poverty" thesis by Throgmorton and Bernard (1986). Direct measurement of such patterns is only possible in terms of energy-conserving home

improvements as provided by the available data. Examining differences in attitudes, as measured by opinion pools could complement this, in terms of informing DOE of differences in public perceptions of energy as a problem, and the viable solutions available.

A second topic for additional analysis would expand the analysis to include both greater numbers of income-groups, and the additional dependent variables of energy expenditures and expenditures as a percent of income. Income is included in the present analysis only through the categorical variable poverty, as defined by the combination of household size and income and above/below 100% of the poverty line. Obviously much detailed information on differences between the black and nonblack income distributions is lost in this process. Expanding the analysis to include five or more poverty-related levels (e.g. below 100%, 100-125%, 125-150%, 150-200%, and over 200% of the poverty line) would alleviate this limitation to the analysis, and would also make the findings more directly relevant to the Weatherization Assistance Program, which employs the 150% of poverty level criterion.

Finally, future research in this area could profitably employ the data and methods of this study for the evaluation of specific policies or DOE programs. As noted above, the findings, although by no means conclusive, have interesting implications for WAP. These data sources contain rich information on the extent to which various kinds of households have taken energy-conserving actions, such as weatherization, installation of insulation, etc. Information is also available concerning the extent to which minority-occupied structures already have energy-conserving features, such as insulation, storm windows, and storm doors. Given the fact that black households are concentrated in older housing units, it is likely that their potential demand for energy-conservation efforts is greater than for nonblacks. Only additional analysis will clarify whether this is indeed the case, and if so, what explains it. Although beyond the scope of this study, such analyses both address the effects of specific DOE programs, and shed further light on the extent and correlates of black-nonblack differences in residential energy consumption.

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USING THE MINORITY ENERGY ASSESSMENT MODEL TO ANALYZE ELECTRICITY DEMAND BY BLACK AND NONBLACK HOUSEHOLDS WITHIN A LINEAR EXPENDITURE SYSTEM FRAMEWORK

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USING THE MINORITY ENERGY ASSESSMENT MODEL TO ANALYZE ELECTRICITY DEMAND BY BLACK AND NONBLACK HOUSEHOLDS WITHIN A LINEAR EXPENDITURE SYSTEM FRAMEWORK*

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INTRODUCTION

The purpose of this paper is to present an analysis of electricity demand by black and nonblack households over the period covered by the five residential energy consumption surveys (EIA, 1980, 1981, 1982, 1983, and 1985) issued by the Energy information Administration (EIA) of the U.S.Department of Enengy (DOE). The analysis is based on research being conducted at Argonne National Laboratory under the auspices of the Research Program within the Office of Minority Economic Impact (MI) of the U.S. Department of Energy (DOE). A primary objective of our research was the development of an analytical tool to assess the economic impact of energy policy on American minorities. The outcome of that process has lead to the development of the Minority Energy Assessment Model (MEAM).

The analytical backbone of MEAM is the energy demand equation which relates the quantity of energy demanded to prices, income, and other energy related demographic and household characteristics. It provides information that is essential for assessing the effects of policy on energy demand, energy expenditures, and economic well-being. We of course begin with the assumption that consumers are rational and have a well behaved demand function which is relatively stable over time (see Deaton and Muellbauer, 1980 pp. 25-30). In the absence of this any discussion of the economic implications of government policy or for that matter any sort of price change becomes impossible.

THE MINORITY ENERGY ASSESSMENT MODEL (MEAM)

Before discussing the empirical findings, we'll first present a discussion of MEAM. An important consideration in our analysis is that all our empirical work be grounded in economic

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theory. The reason for this is two fold. First, the existence of a well behaved and stable demand function implies that certain conditions must be satisfied a priori - the value of individual demands must add up to total expenditures, demand is homogeneous in prices and income, cross-price derivatives of Hicksian demands are symmetric, and substitution matrix is negative semidefinite. Very Often ad hoc specifications violate either one or more of these conditions bringing into question the very existence of a well behaved demand system. Second, analysis which proceeds within a theoretically sound framework provides a clearer exposition of the problem under study.

In an earlier version of MEAM we used a CES type demand specification (Poyer, 1983). The derivation of the Hicksian compensating variation (HCV), associated with this was a tortuous exercise (Hausman, 1981). Even with the determination of this important measure of economic welfare the model still isolates the adding-up restriction (Brudge, 1971 p. 99). Finally, the issue of how to incorporate demographic and household characteristics is left unresolved when using this model. We therefore, decided to seek an alternative modeling approach (Poyer, 1987).

MEAM currently uses a complete demand system approach. Very simply this means the system of demand equations, of which electricity is one, satisfy the conditions required for a well behaved demand system. The demand system, upon which MEAM is based, is derived from the constrained maximization of the following utility function,

$$(1) \qquad u(q_t) = (\psi_e * q_{et} - \gamma_e)^{\beta_e} * (q_{ct} - \gamma_c)^{\beta_c}$$

here q_t = vector of goods and services consumed in period t, ψ_e = a quality index associated with electricity, q_{et} = electricity demand in t, γ_e = nondiscretionary demand for electricity, q_{ct} = demand for the composite commodity, γ_c = nondiscretionary demand for the composite commodity, β_e = the portion of nondiscretionary income spent on electricity, and β_c = the portion of nondiscretionary income spent on the composit commodity.

The model setup represented by (1) provides us with a clear theoretical framework within demographic and household characteristics can be incorporated. These factors are systematically incorporated into the model through their influence on a quality index. It is assumed that the quality index is determined by a linear combination of these various characteristics, that is

$$(2) \qquad \psi_e = 1 + \Sigma\, a_i * x_i$$

where x_i = the value of the ith demographic or household characteristic, and a_i = the coefficient associated with the ith characteristic. The quality index can either be quantity augmenting (Muellbauer, 1975).

(3) $$q_{et} = (\gamma_e + (\beta_e * \gamma_e / p_{et}) * (y_t - (p_{et} * \gamma_e / \gamma_e) - p_{ct} * \gamma_c)) / \gamma_e$$

From (3) electricity expenditures can be directly determined. The utility function shown in (1) has very nice duality properties. We use these to derive a "true" measure of the cost of living. The expenditure function associated with its

(4) $$e(u_o, p_t) = (p_{et} / \gamma_e) * \gamma_e + p_{ct} * \gamma_c + u_o * (p_{et} / \gamma_e)^{\beta_e} * (p_{ct})^{\beta_c}.$$

With (4) either the change in the cost of living or a cost of living index can be constructed over time.*

Dynamics were introduced into the model along the lines suggested by Phillips (1983, pp. 182-186). Very briefly, we assumed the demand structure shifted by way of changes in the nondiscretionary parameter. It was determined that the adjustment process was very rapid for both black and nonblack households (Poyer, 1986).

The model that we have briefly described allows us to measure changes in the cost of living associated with both changes in the price of electricity and the price of the composite commodity. It also allows us to simulate the marginal effect of changing electricity prices on the cost of living or economic welfare.

In the next section we will analyze the effect of changing prices and income on the standard of living of black and nonblack households between the period of the first EIA residential survey (1981) and its latst (1985). Also of concern to us is the marginal effect of changing electricity prices on economic welfare. In order to address this concern we will analyze a simulation where the price of the composite commodity is held constant.

THE COMPARATIVE EFFECTS OF CHANGING ELECTRICITY PRICES ON BLACK AND NONBLACK HOUSEHOLDS BETWEEN 1978 AND 1982

Demographic And Household Characteristics

In order to systematically capture the effects of demographic and household characteristics, shown in Table 1, a quality index was incorporated into the utility function (Muellbauer,

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*It should be noted that since we use the all-urban consumer price index (CPIU) as a proxy for the price of the composite commodity and electricity expenditures are a small fraction of household income, the cost of living index constructed using the expenditure function is approximately equal to the CPIU.

1975). The index was specified as a function of heating load, cooling load, and family size (Poyer, 1986). It may either be quantity augmenting or diminishing. Our empirical work found that all three variables were quantity diminishing. However, the rate at which demand was diminished with changes in any one of the three variables declined.

The RECS data indicates that electric heat use by black households fluctuated widely over the five year period being studied. It is suspected the wide fluctuation is either explained by variations in the occupancy of electric base board heated apartments or error in the data. On the other hand the proportion of nonblack households using electric heat remains rather constant. In every year, however, the proportion of nonblack households use electric heat exceeds the number of black households.

In the case of both black and nonblack households the proportion of households having air conditioning generally rises during the time period. In every period, as in the case of electric heat, the proportion of nonblak households with air conditioning is higher.

In both the case of black and nonblack households the average household size fell during the 1978-1982 period, with the average household size of blacks is larger than the average nonblack household in every period.

The measured quality index is larger for nonblack households in every period with the exception of the April, 1979 to March, 1980 period, when the indices are nearly equal. The difference in the other periods range from around seven to a little over twenty percent. As a result the quality index for nonblack households is in most cases less quantity diminishing.

Over the five year period the quality index for the two categories changes very little. However the relative variations in the index are different for the two population categories. The index experiences wider fluctuations in the case of black households. The demographic and household characteristic, which are specified in our quality index, therefore, play a relatively more important role in explaining annual variations in the quantity of electricity demanded by black households.

Income And Prices

Over the April, 1978 to March, 1983 period the net effect of price and income changes on electricity demand for both black and nonblack households was negative. As shown in Table 2, during the period the relative change in electricity price out paced the change in the all-urbanconsumer price index (which is used as a proxy for the price of all other goods and services consumed by households). Also changes in nominal income were outstripped by changes in the prices of electricity and the CPIU. The net effect of increasing electricity prices (along with the small variations in the quality index) was a slight decline in the amount of electricity consumed per household by black and nonblack households.

TABLE 1 Demographic And Household Characteristics For Black And Nonblack Households April 1978 to March 1983[a]

	Electric Heat (%)		Air Conditioning (%)		Family Size	
Year	Black	Nonblack	Black	Nonblack	Black	Nonblack
1978	11.1	16.3	12.6	22.3	3.31	2.78
1979	6.3	17.7	10.0	24.1	3.23	2.71
1980	10.0	18.5	13.7	26.7	3.17	2.76
1981	14.7	17.5	17.3	26.3	3.13	2.76
1982	9.2	16.9	16.8	28.7	3.05	2.69

[a] Source: EIA, 1980, 1981, 1982, 1983, and 1985.

TABLE 2 Household Income, And Prices For Black And Nonblack Households Between April 1978 And March 1982[a]

Year	Income[b] ($/hh)		Electricity Price ($/106 Btu)		All-Urban Consumer Price Index (1978=1)[c]
	Black	Nonblack	Black	Nonblack	
1978	12700	19200	13.10	12.00	1.000
1979	13800	20500	15.50	13.30	1.113
1980	13700	22100	17.90	16.20	1.263
1981	15000	24400	20.40	18.00	1.394
1982	14800	23700	21.60	9.60	1.463
% Change	16.5	23.4	64.9	63.3	46.3
Net PV (10%)	52700	82400			

[a]Source: EIA 1980, 1981, 1982, 1983, and 1985

[b]Income values are estimated from the interval data reported in the EIA surveys. The midpoint value is used to estimate household income in most cases. However at the lowest and highest intervals the upper and lower bounds are used respectively.

[c]Source: DRI, 1986.

TABLE 3 Electricity Demand And Expenditures For Black And Nonblack Households Between April, 1978 and March, 1983

	Electricity Demand (106 Btu/hh)				Electricity Expenditures ($/hh)			
	EIA[a]		MEAM		EIA[a]		MEAM	
Year	Black	Nonblack	Black	Nonblack	Black	Nonblack	Black	Nonblack
1978	26.2	33.0	26.2	33.0	344	395	344	395
1979	23.2	32.0	23.9	32.6	358	427	369	435
1980	23.1	31.0	24.0	31.3	415	501	431	506
1981	24.5	31.0	24.8	30.9	502	559	508	557
1982	23.2	30.0	22.9	29.3	501	589	495	575
% ch	(11.5)	(9.1)	(12.6)	(11.2)	45.6	49.1	43.9	45.6

[a]Source: EIA 1980, 1981, 1982, 1983, and 1985.

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Given the nature of the theoretical framework in which we analyze demand, the comparative changes in electricity price and income for black and nonblack households play a major role in explaining the difference in the relative change in electricity demand over the period between the two social groups. As shown in Table 3, the relative decline in the electricity consumed is slightly higher for blacks. Given the fact that the relative change in electricity price is about the same for both groups, the small difference is explained by the relative difference in income changes over the period. Because income increased at a somewhat higher rate for nonblack households, the relative decline in electricity consumption was smaller.

It should also be added the relative difference in the rate of decline in electricity consumption is not even greater because of a difference in the dynamic process associated with the level of electricity demand (see Poyer, 1986). The parameters of the demand function for electricity for both black and nonblack households are chaniging. Dynamics are considered in our demand system, as mentioned earlier, by way of changes in the level of nondiscretionary demand for electricity. The process can be assessed in terms which are analogous to those used when explaining the effect of the quality index on demand. In the case of both groups the demand curve shifts down over time due to a reduction in nondiscretionary levels of consumption. These dynamic changes can, like the quality index, also be characterized as quantity diminishing. The difference in electricity consumption would have been about 2% larger if it were not for this dynamic process. This suggest that nonblack households are living in homes which are progressively more efficient in terms of electricity consumption.

The Welfare Implications Of Changing Prices And Income

In Table 4 we show changes in the cost of living for black and nonblack households. Both the total change in the cost of living (net of nominal income changes) and marginal effect associated with the change in electricity price are measured. The expenditure function is derived by solving the dual problem associated with utility maximization. Therefore our measure of the cost of living refers to the level of expenditures required to maintain the same level of satisfaction in some base period which is, in our case, the April, 1978 to March, 1979 period. Very often this welfare measure is referred to as the Hicksian Compensating Variation (HCV).

The total change in the cost of living is, of course, influenced by both the changes in the price of electricity and the composite commodity. From Tables 2 and 3 electricity expenditure share of income can be derived. For black households the value ranges from 2.7 to 3.4 percent and from 2.1 to 2.4 percent for nonblack households. Consequently the expenditure share of income on the composite commodity is around 97 percent in both cases. As a result changes in the total cost of living will be dominated by changes in expenditures due to variations in the price of the composite commodity. Wherefore, explanations for annual changes in the total cost of living can be found primarily in the relative variations in nominal income and the price of the composite commodity.

It should be clear from the information given in the Table 4 that there was a severe erosion in the standard of living for both population categories over the five year period. With the severest declines in the standard of living occurring In the years of 1980 and 1982. These results are not surprising since in the former year the CPIU experienced its largest increase and in the later year nominal income for both black and nonblack households fell as a result of the July, 1981 - November, 1982 recession. In absolute terms the fall in the standard of living was greatest for nonblack households. However, the relative decline was higher for black households. The discounted change in the cost of living over the five year period was 5.2% of the discounted income stream (shown in Table 2) for black households compared to 3.8% for nonblack households.

The marginal effect of electricity on economic welfare is related to both the changing price of electricity and demographic and household characteristics. The relevant argument in the expenditure function is the quality adjusted price. The importance of this fact is highlighted by a marginal improvement in the standard of living of black households in 1982 after holding the price of the composite commodity constant. This occurred despite an increase in the price of electricity. The intuitive explanation is related to a reduced "dependence" on electricity consumption by the average black householder. In 1982, the percentage of black households using electricity for space heating dramatically declined. Also there was a slight decline in the number of black homes with air conditioning and the size of the average black household. All these factors worked to push up the quality index and drive down the quality adjusted price.

The direct contribution of changing electricity prices (meaning of course quality adjusted) to the overall decline in the standard of living was rather small both in absolute and relative terms. Once again, as it was in the case of overall changes in the cost of living, the absolute effect of changing electricity prices on the standard of living was higher in the case of nonblack households, with the relative decline higher for black households. In both cases the marginal effect of changing electricity prices on the cost of living was the same proportion of the discounted total effect, about 4.6%. This indicates, even though very small, the marginal effect of changing electricity prices on economic welfare was proportionately greater than its expenditure share of income.

TABLE 4 Measured Changes In Economic Welfare For Black And Nonblack Households Between April, 1978 And March, 1983

	Total Compensating Variation ($/hh)		Compensating Variation Composite Price Held Constant ($/hh)	
Year	Black	Nonblack	Black	Nonblack
1979	372	907	16	40
1980	1988	1295	83	84
1981	494	179	82	16
1982	962	2084	(26)	22
Net PV (10%)	2736	3139	115	134

CONCLUSIONS

The purpose of this paper was to analyze electricity demand by black and nonblack households and the effect of changing prices and income on their economic welfare over the April 1978 to March, 1982. Our analysis is done within the context of a complete demand system, where demand is characterized by the linear expenditure system. Given the nature of our theoretical framework, variations in demand, expenditures, and economic welfare can be traced to changes in price, income, and the "quality" of demand (or alternatively to changes in income and quality adjusted prices). The complications associated with the effects of demographic and household characteristic on demand are reduced to determining a quality index.

The effect of changing demographic and household characteristics on the quality index vary somewhat for the two groups. In general, with the exception of the April, 1979 to March 1980 period, the quality index for black households is smaller. The demographic and household characteristics for blacks can therefore be considered more quantity diminishing, this despite the fact nonblack households are more likely to have electric heat and air conditioning and to live in cooler areas of the country. The index was also less stable in the case of black households, thereby contributing more to the annual variations in energy demand.

Electricity demand for both groups decline slightly over the five year period, whereas electricity expenditures increased substantially. The negative effect of increasing electricity price was sufficient to overcome the possitive effects associated with spotty increases in income and the cross effect associated with increases in the price of the composite commodity.

Both, black and nonblack households, suffered severe decline in their standard of living over the five year period. Initially as a result of escalating prices and later as a result of a severe recession which pulled down family income. In absolute terms the deterioration was greater for nonblack households, however, in relative terms it was severer for black households.

The contribution of the marginal effect of changing electricity price on the total deterioraion is in absolute terms for both groups rather small (this of course should not be unanticipated, since electricity expenditures constitute such a small fraction of family income). Once again the absolute effect is greater for nonblacks and the relative effect is greater for blacks. Finally it is important to note that the relative contribution of changing electricity prices to the overall decline in the standard of living is proportionately greater than its expenditure share.

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MINORITY EMPLOYMENT IN THE ENERGY SECTORS OF THE U.S. GOVERNMENT: PROJECTIONS FOR THE 1990'S

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MINORITY EMPLOYMENT IN THE ENERGY SECTORS OF THE U.S. GOVERNMENT: PROJECTIONS FOR THE 1990'S

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I. INTRODUCTION

The profound changes experienced by the energy sectors of the U.S. economy in recent years have widespread implications. These changes are cited as a major cause of alterations in the way goods are produced, and of both economy-wide upturns and downturns. Concern for employment of minority group members requires that important trends such as these in energy sectors and non-energy sectors alike be monitored. There is a possibility that the energy sectors will provide substantial job opportunities for minority group members given historical patterns of hiring, occupational requirements, and skill levels of the minority labor pool. There is a possibility that sectors indirectly affected by the changing energy picture hold open these possibilities as well. Advance knowledge of potential trends can help signal remedial action when negative impacts are predicted, or affirmative action when windows of opportunity arise.

The stability of the relationship between production and employment has made is possible to use input-output (I-O) methods in labor market studies (see, e.g., Miernyk et al., 1970). The regularity of ethnic/racial employment patterns in individual sectors has served as a basis for extending I-O analysis into this area as welll (see, e.g., Rose et al., 1981). At the same time, the I-O framework can be modified to incorporate more flexible relationships associated with job attrition and replacement, manpower training, and affirmative action. Input-output analysis is especially valuable in employment analysis because it can be used to estimate the indirect impacts of any initial action. For example, a policy relating to a given energy sector may appear neutral with respect to its own minority employment, but that sector's linkages to the rest of the economy may generate a large number of new jobs in other sectors that have a strong tradition of hiring minorities.

The purpose of this paper is to explain and to illustrate the usefulness of input-output methods for making projections of minority employment in energy and related sectors in the U.S. economy. Three potential energy futures, or scenarios, are examined: (1) an oil embargo, (2) a major synfuels capability, and (3) widespread adoption of solar energy technology. Policy implications for minority employment are drawn from the analysis. The paper concludes with a discussion of how the model can be extended to incorporate a broad set of market processes, labor force policies and government interventions aimed at increasing minority employment.

II. BACKGROUND

Historical patterns of minority employment in individual sectors of the U.S. economy are varied between the major census years 1960, 1970, and 1980. One problem in the interpretation of these patterns is an operational criterion for identifying the key trends and cycles. Rates of change in minority employment by sector only partly reveal the more salient features underlying the different patterns. Certain sectors started from an exceedingly low level of minority employment in 1960 and displayed phenomenal growth. Other major sectors showed less dramatic relative growth, although the magnitudes of gains and losses in minority employment are quite large.

Proportional measures are preferred in this case, since they more explicitly reflect relative changes in employment opportunities. Therefore, we will make use of a measure of "Minority Representation," calculated as the Black, Hispanic, and other minority proportion of total employment in each sector, as a basis of analysis.

Changes in Minority Representation for a 27-sector dissagregation of the U.S. economy are classified into four categories in Table 1. Note that several sectors are characterized as stable where minority employment shares were comparatively level over at least half of the twenty-year period. The minority employment share in those sectors listed as cyclical also exhibited some stability in several cases if one looks at the entire twenty year period and ignores the interim upswing or downswing. With regard to energy sectors, the minority employment share in mining, for example, doubled from 1960 to 1970, but then dropped by 50 percent between 1970 and 1980. The minority employment share in the utility sector was relatively stable although its employment growth rates were somewhat erratic.

No thorough explanation of the direction and magnitude of these trends has been offered to date, nor is it the purpose of this section to summarize more than a few insights. Overall, minority employment in energy and related sectors is a result of a variety of economic and social forces, many of which are largely exogenous to the labor market. Historical trends in Black and Hispanic employment are irreversible elements from the heritage of time. Job skills, education and training credentials, and more general occupational characteristics interact with technologically determined employment requirements. Discrimination phenomena in terms of job access, wages, and employment conditions are an integral part of the minority employment picture. Other major exogenous influences include shifts and trends

TABLE 1. TRENDS IN MINORITY SHARE OF SECTORAL EMPLOYMENT, 1960-1980

Upward	Downward	Cyclical	Stable
Textiles	Agriculture	Mining	Forestry & Fisheries
Elec. Machinery	Ag. Services	Construction	Primary Metals
Transportation Equipment	Lumber	Food Products	Non-Electrical Machinery
Aircraft & Parts	Personal Services	Printing	Utilities
Communication		Fabricated Metals	Health Services
Finance		Motor Vehicles	
Real Estate		Transportation	
State & Local Gov't.		Trade	
Federal Gov't.			

Source: U.S. Bureau of the Census (1960, 1970, 1980).

in national demands for energy and energy-related output. These demand conditions are, in turn, affected by consumption and production substitution patterns in energy resource use, foreign energy sources, and price levels in world markets.

No doubt these factors have limited the potential of market interventions, such as protective labor laws and anti-discrimination programs. Most of the major programs and activities within this area have come from the federal levels of government. For example, the Equal Pay Act of 1963 and Title VII of the Civil Rights Act of 1964 made it illegal for any employer to discriminate against any individual in terms of compensation, terms, condition, or privileges of employment because of race, color, religion, sex or national origin. The implementation of these anti-discrimination acts and legislation, as they evolved primarily through interpretations in the courts, have been augmented by other policy actions. The Federal Contract Compliance Program initiated in 1965 extended many of the clauses and programs of the Equal Employment Opportunity Commission's efforts toward eliminating discrimination in the labor market. Still other policy instruments which dominate this more active intervention strategy include: job targeting and hiring agreements, and customized training to be discussed in Section V.

Market forces have no doubt had an effect on minority employment trends, though they too may have been limited due to exogenous factors and market imperfections.[1] Awareness of the latter inspired a number of remedial policies intended to improve the workings of the labor market. These include, labor market information and job opportunity clearing houses, supplemented by job search and relocation programs, and assistance payments. Workers retraining aimed toward an economically viable occupational and industry mix has been defined on the basis of growing labor demands. Moving allowances in the form of lump sum payments have been aimed toward enhancement of labor mobility in an effort to maintain a reasonably fluid labor market system. Another strategy has been to apply market-oriented incentives and publicly funded supplements to a variety of imperfections and rigidities that otherwise retard improvement in the rate of minority employment.

III. METHODOLOGY

Labor is a necessary input in every production process. Over longer periods of time there are significant increases in the ratio of capital inputs to labor inputs due to technological change. Also, even over short periods there are substitutions toward or away from labor in response to changes in wage rates relative to other input prices. Still, in many cases of moderate length, one observes a relative regularity of labor inputs per unit of output. This holds true even for individual occupational components when we disaggregate the general category of labor (see Freeman, 1980).

The concepts of a fixed total labor requirement or individual occupational requirement per units of output are consistent with the characteristics of inputs in general in an input-output model, which is a system of equations based on a tabulation of purchases and sales between all sectors of an economy necessary to fulfill production requirements. In the I-O model all inputs bear a fixed proportional relationship to each other and their respective output.

We will present a set of tools, called "minority employment distribution matrices," that can be used to project the demand for labor by ethnic/racial group. The basis matrices assume a regularity in ethnic/racial hiring practices, which is a reasonable approximation over the short periods of time given the discussion in the previous section. The advantages of this approach to employment forecasting stem from the properties of the I-O model, including its unique ability to trace indirect employment impacts. At the same time we acknowledge its disadvantage with regard to the insensitivity of input proportions to price changes. However, we will demonstrate how the model can be extended to include dynamic aspects of minority employment, including affirmative action and manpower training programs.

A. Basic Concepts

Our minority employment distribution matrices can be thought of as a further disaggregation of the industry-occupation matrix portrayed in Panel A of Figure 1. This matrix provides information on the occupational composition of employment in each industry of the economy. Panels B and C show the breakdown of the industry-occupation matrix into the ethnic-industry and ethnic-occupation matrices.[2]

Panel B is the ethnic-occupation matrix, which displays the number of persons in each of three major ethnic/racial categories employed in each occupation. Each column indicates the occupational distribution of employed persons of a specific minority group while, each row displays the minority distribution of employment by occupation.

Panel C is the ethnic-industry matrix, which shows the number of persons in each of the three major ethnic/racial groups employed in each sector of an economy. Each column displays the industrial employment distribution of a particular minority group, while each row shows the minority distribution of employment by industry.

Performing some simple mathematical manipulations of these matrices yields a valuable analytical tool. The regularity of employment patterns can be modeled as a constant proportion of workers from each ethnic/racial group within each industry or occupation, regardless of the scale of operation. For example, if the black/hispanic/white percentage of the labor force of the fabricated metals industry is 30/30/40 at a production level of one million tons of output, an increase in production to two million tons would leave these percentages unchanged. This means that each of the three tables can be expressed as a set of "fixed coefficients," representing the functional relationship between production and labor segmented along ethnic/racial lines.

In addition to the above matrices, which refer to actual employment, a matrix of the total experienced labor force disaggregated by ethnic/racial group and occupation or industry would also be useful. We might think of the employment matrices depicted in Figure 1 as "demand" matrices and the experienced labor force matrices as their "supply" counterparts. There is always a strong likelihood of a disequilibrium, i.e., demand may not equal supply. The resulting deviation serves as yet another set of matrices reflecting unemployment by ethnic/racial group.

The addition of these matrices enables us to relax, or improve on, our "fixity" assumption. For example, the experienced labor force matrix could serve as the basis of a full employment target for minority group members that an energy-related policy might hope to achieve. If the minority distribution of the unemployed differs from that of the employed, "marginal" minority/employment coefficients will differ from"average" coefficients, and the eventual minority distribution of the employed will likely change. On the other hand, a supply matrix would also serve as a constraint on the total labor force or on any of the minority labor force subcategories. It may be the case that a given industry has a limited capability for improving the employment of minorities in the short-run because it calls for skill categories in which there are few unemployed minority group members. In other cases, the constraint may have the effect of steering toward a greater equalization in the ethnic/racial distribution of employment. If an industry has a very large percentage of white employees, but there are only a handful of unemployed white workers in the occupations needed, new hiring would, out of necessity, give a higher weight to minority groups.

B. Data

The data needed to construct a basic minority employment projection model is available from a number of sources. For many years the U.S. Bureau of Labor Statistics has compiled industry-occupation matrices for the nation at a high level of detail, 331 sectors and 679 occupations (see, e.g., U.S. BLS, 1987). More recently the Bureau of the Census has generated these matrices for states and metropolitan areas (see, e.g., U.S. BOC, 1983). Related data on the total experienced labor pool and unemployed workers by industry and occupation can expand the base of the model to the entire labor market.

Industry and occupation data further disaggregated by sex, race and hispanic orgin are compiled annually by the BLS (see, e.g., U.S. BLS, 1987). The data are in the form of tabulations like those of the second and third panel of Figure 1. If they are consistent, the two data sets can readily be merged to create separate industry-occupation matrices for each ethnic/racial group. More detailed data on minority employment in the energy sectors is, of course, available from the Office of Minority Economic Impacts of U.S. DOE, and can be used to further sharpen the matrices.

The official U.S. Input-Output Table is compiled twice per decade by the U.S. Bureau of Economic Analysis. Unfortunately, there is usually a six to seven year lag between the calibration data and the full compilation of the table. For example, the most recent BEA table is benchmarked to 1977 (U.S. BEA, 1984). We have chosen to utilize a 1982 update of the BEA table undertaken by the U.S. Forest Service as part of its Impact Planning, or IMPLAN, System (U.S. Forest Service, 1986). As with the original table, the Forest Service update contains 476 sectors, but also adds more detail in the payments and final demand components.[3] Moreover, the IMPLAN System can provide 1982 based I-O tables for every state, county, and county grouping in the U.S.

A. Industry–Occupation Matrix

Industry \ Occupation	laborer	farmer	technician	. . .
agriculture	x	x	x	
chemicals	x	x	x	
steel	x	x	x	

B. Ethnic–Occupation Matrix

Occupation \ Ethnic Group	Black	Hispanic	White
laborer	x	x	x
farmer	x	x	x
technician	x	x	x

C. Ethnic–Industry Matrix

Industry \ Ethnic Group	Black	Hispanic	White
agriculture	x	x	x
chemicals	x	x	x
steel	x	x	x
.			
.			
.			

FIGURE 1. SCHEMATIC DEPICTION OF EMPLOYMENT DISTRIBUTION MATRICES

C. The Empirical Model

The keystone of our empirical model is the ethnic-industry matrix for the U.S.[4] Selected sectors of this matrix, divided into three major categories, are presented in Table 2. The largest employer in the economy is the Health, Education and Social Services sector, which also happens to be the largest employer of Whites and Blacks.[5] The largest employment concentration for Hispanics is in the Wholesale and Retail Trade sector. Also, note that the four energy sectors are responsible for only slightly more than 2.0 percent of total employment in the U.S. in 1986. Of course, the indirect employment these sectors stimulate is several times this size.

The ethnic/racial distribution of employment is more apparent in Table 3, which divides each element in a given row in Table 2 by its row sum. From the table we see that the ethnic/racial distribution of employment differs significantly from sector to sector. Interestingly, the coal industry has the lowest proportion of Blacks and Hispanics of any sector presented in Table 3, and in the economy as a whole. The highest representation of Blacks is in the Textile industry (not shown), while the highest representation of Hispanics is in the Agricultural Services sector (also not shown). Overall, the energy sectors as a whole have an underrepresentation of minority group members, while the energy support sectors generally have an underrepresentation of Blacks, but representative Hispanic employment (compare the entries in a given row with the total, and, also in this case, the average distribution listed in the bottom row of Table 3).

Table 4 presents the distribution of employment within each ethnic/racial group. It is computed by dividing each cell in a given column of Table 2 by its column sum. Analysis of the results provide insights similar to those noted in relation to Table 2; though Table 4 provides explicit proportions.

As useful as the basic matrices are, they only provide superficial insight when we consider the dynamics and interactions inherent in the economy. For example, a given energy sector may have a poor history of employing minorities, yet it may have several support industries, direct suppliers or indirect suppliers several steps removed, with high percentages of minority job opportunities.

To simulate this total impact we convert our direct ethnic-industry employment matrix (Table 2) to a <u>total</u> ethnic-industry employment matrix. The calculations involve two steps. First, we obtain an intermediate matrix giving us the ethnic employment distribution per thousand dollars of gross output in each industry:

$$\begin{bmatrix} e_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & e_n \end{bmatrix} \begin{bmatrix} w_1 & b_1 & h_1 \\ \vdots & \vdots & \vdots \\ w_n & b_n & h_n \end{bmatrix} = \begin{bmatrix} \bar{w}_1 & \bar{b}_1 & \bar{h}_1 \\ \vdots & \vdots & \vdots \\ \bar{w}_n & \bar{b}_n & \bar{h}_n \end{bmatrix}$$

TABLE 2. ETHNIC/RACIAL EMPLOYMENT IN THE U.S., 1986
(in thousands of persons)

BEA Code	Sector	Black	Hispanic	White	Total
	Energy Sectors				
7.	Coal Mining	2	2	188	192
8.	Crude Petroleum and Gas	25	47	464	536
31.	Petroleum Refining	17	10	142	169
68.	Electric and Gas Utilities*	171	65	1,219	1,455
	Energy-Support Sectors				
12.	Maintenance	371	380	4,683	5,434
69.	Trade	1,207	1,052	15,107	17,366
71.	Real Estate	128	133	1,664	1,925
73.	Business Services	492	292	4,027	4,811
	Other Sectors				
14.	Food and Kindred	254	180	1,303	1,737
37.	Iron and Steel	72	53	528	653
53.	Electronic Equipment	92	118	1,253	1,463
77.	Health and Social Services	2,536	1,023	18,615	22,174
	Total (all 80 sectors)	10,815	7,004	91,775	109,594

Source: U.S. BLS (1986).

*Also includes Water and Sanitary Services.

TABLE 3. ETHNIC/RACIAL DISTRIBUTION BY SECTOR, 1986

BEA Code	Sector	Black	Hispanic	White	Total
	Energy Sectors				
7.	Coal Mining	.010	.010	.979	1.000
8.	Crude Petroleum and Gas	.047	.087	.866	1.000
31.	Petroleum Refining	.101	.057	.842	1.000
68.	Electric and Gas Utilities*	.118	.045	.838	1.000
	Energy-Support Sectors				
12.	Maintenance	.068	.070	.861	1.000
69.	Trade	.070	.061	.870	1.000
71.	Real Estate	.066	.069	.864	1.000
73.	Business Services	.102	.061	.837	1.000
	Other Sectors				
14.	Food and Kindred	.146	.104	.750	1.000
37.	Iron and Steel	.110	.082	.808	1.000
53.	Electronic Equipment	.063	.081	.856	1.000
77.	Health and Social Services	.114	.046	.839	1.000
	Total (all 80 sectors)	.099	.064	.837	1.000

Source: U.S. BLS (1986).

*Also includes Water and Sanitary Services.

TABLE 4. EMPLOYMENT DISTRIBUTION BY ETHNIC/RACIAL GROUP, 1986

BEA Code	Sector	Black	Hispanic	White	Total
	Energy Sectors				
7.	Coal Mining	0*	0*	0.002	0.002
8.	Crude Petroleum and Gas	0.002	0.007	0.005	0.005
31.	Petroleum Refining	0.002	0.001	0.002	0.002
68.	Electric and Gas Utilities	0.016	0.009	0.013	0.013
	Energy-Support Sectors				
12.	Maintenance	0.012	0.019	0.017	0.017
69.	Trade	0.112	0.150	0.165	0.158
71.	Real Estate	0.012	0.019	0.018	0.018
73.	Business Services	0.045	0.042	0.044	0.044
	Other Sectors				
14.	Food and Kindred	0.023	0.026	0.014	0.016
37.	Iron and Steel	0.007	0.008	0.006	0.006
53.	Electronic Equipment	0.009	0.017	0.014	0.013
77.	Health and Social Services	0.234	0.146	0.203	0.202
	Total (all 80 sectors)	1.0	1.0	1.0	1.0

Source: U.S. BLS (1986).

*Less than .0005.

where

e_i, is the employment per thousand dollars of gross output of industry i, computed from U.S. Forest Service (1986).

w_i, b_i, h_i, are the percentage of White, Black, and Hispanic workers in industry i;

$\bar{w}_i$, $\bar{b}_i$, $\bar{h}_i$ are the number of White, Black, and Hispanic workers per thousand dollars of gross output in industry i.

The total requirements matrix is then:

$$\begin{bmatrix} d_{11} & \cdots & d_{1n} \\ \vdots & & \vdots \\ d_{n1} & \cdots & d_{nn} \end{bmatrix}^T \begin{bmatrix} \bar{w}_1 & \bar{b}_1 & \bar{h}_1 \\ \vdots & \vdots & \vdots \\ \bar{w}_n & \bar{b}_n & \bar{h}_n \end{bmatrix} = \begin{bmatrix} \sum_i w_i d_{i1} & \sum_i b_i d_{i1} & \sum_i h_i d_{i1} \\ \vdots & \vdots & \vdots \\ \sum_i w_i d_{in} & \sum_i b_i d_{in} & \sum_i h_i d_{in} \end{bmatrix}$$

where

d_{ij} is an element of the total requirements (Leontief Inverse) matrix.[4]

Each cell of the right-hand matrix represents the direct indirect, and induced employment of a given ethnic/racial group throughout the economy as a result of one million dollars of final demand for good i. Thus, each row of the matrix on the right above represents the <u>total</u> ethnic/employment distribution for a given sector. The result of this computation for the U.S. economy is presented in Table 5. The size of any cell in the matrix is dependent both on the ability of the corresponding sector to stimulate the employment of a given ethnic/racial group, that sector's employment coefficient, and its overall employment multiplier.

A comparison between direct and total coefficients is facilitated by the use of summary indiactors called "Minority Share Coefficients," which, as noted in Section II, measure the proportion of minority employment to total employment ascribable to each sector. The results for both direct minority employment (i.e., results derived from Table 2) and total minority employment (results derived from Table 5) are presented in Table 6. Interestingly, the sectors that have the lowest and highest Direct Minority Share Coefficients, coal and miscellaneous textiles (not shown), respectively, also have the same rankings for the Total Minority Share Coefficients. However, the range between the two extremes has fallen from .021 and .355 to .105 and .262. In general, the Total Coefficients of most sectors have "regressed" closer to the economy-wide average, which is, of course, the same for both colums of Table 6. The reason for this narrowing of the range of Total Minority Share Coefficients is the commonality of support sectors within the economy. The effect of this phenomenon is to enhance the

TABLE 6. TOTAL RACIAL/ETHNIC EMPLOYMENT REQUIREMENT COEFFICIENTS

BEA Code	Sector	Black	Hispanic	White	Total
	Energy Sectors				
7.	Coal Mining	1.7	1.2	25.6	28.5
8.	Crude Petroleum and Gas	0.9	0.8	9.2	10.8
31.	Petroleum Refining	1.2	0.8	10.9	12.9
68.	Electric and Gas Utilities	1.7	1.0	14.8	17.5
	Energy-Support Sectors				
12.	Maintenance	3.0	2.5	30.5	36.0
69.	Trade	4.0	3.2	44.9	52.2
71.	Real Estate	0.7	0.6	7.4	8.7
73.	Business Services	3.7	2.3	31.1	37.2
	Other Sectors				
14.	Food and Kindred	3.4	2.9	30.0	36.2
37.	Iron and Steel	3.2	2.3	27.7	33.2
53.	Electronic Equipment	3.2	2.9	34.5	40.6
77.	Health and Social Services	6.2	3.0	48.1	57.4

TABLE 6. MINORITY EMPLOYMENT COEFFICIENTS

BEA Code	Sector	Direct	Total
	Energy Sectors		
7.	Coal Mining	.021	.103
8.	Crude Petroleum and Gas	.134	.151
31.	Petroleum Refining	.158	.157
68.	Electric and Gas Utilities	.162	.153
	Energy-Support Sectors		
12.	Maintenance	.138	.152
69.	Trade	.142	.140
71.	Real Estate	.136	.149
73.	Business Services	.218	.163
	Other Sectors		
14.	Food and Kindred	.250	.173
37.	Iron and Steel	.192	.166
53.	Electronic Equipment	.144	.151
77.	Health and Social Services	.161	.161
	Average (all 80 sectors)	.163	.163

Source: U.S. BLS (1986) for column 1; column 2 computed by the authors.

overall potential to stimulate minority employment in those sectors that themselves have hired only a small proportion of Blacks and Hispanics as part of their workforce. Referring to columns 1 and 2 of Table 6, respectively, the actual potential of the food and kindred products sector to stimulate minority employment is not 12 times as high as that of the coal industry, but only about 1.7 times as high.

Obviously, the Total Coefficients reveal the hidden potential of industries to stimulate minority employment and can be used to identify candidate industries when this becomes an active policy goal. However, the Coefficient is only a measure of proportion, and not necessarily a perfect relative measure of impacts. It tells us that if 100 new jobs are created throughout the economy as a result of a $1 million expansion of the natural gas industry, and if historical patterns maintain, about 23 jobs will be filled by minorities. However, an expansion of the same size in another industry may stimulate a larger absolute number of jobs, and even though the proportion going to minorities may be smaller, the absolute level may be larger. If the policy objective is to raise the overall level of minority employment, though not necessarily the proportion, the results Finally, we note that while we have used terminology such as "underrepresentation" in our analysis our intent is to steer away from value judgements. That is, underrepresentation by itself need not be bad if it refers to low status or low paying jobs. The results need to be supplemented by an occupational analysis before any judgements can be made about discrimination or preferred outcomes.

IV. FUTURE SCENARIOS

No segment of the U.S. economy has changed more drastically over the past one and one-half decades than the energy sectors. Moreover, there is no indication that the situation will stabilize in the near or distant future. As long as energy supplies are subject to geological uncertainties, technological risks, and political machinations, it is impossible to forecast a single, "most-likely" energy future for the nation with any reasonable degree of confidence. An alternative approach is to forecast the implications of a set of alternative scenarios, each based on a different set of background conditions. In this section, we present the minority employment impacts of three such scenarios: (1) an embargoes economy, (2) a synfuels-based economy, and (3) a solar-based economy. Each case is based on a stylized setting; therefore, our results should be viewed as an illustration of our model, yielding ball-park estimates that require further refinement and analysis.

A. Baseline Projections

In order to gauge the impact of any single scenario on minority employment in the future, we need a reference point, or "baseline" forecast. For this purpose, we utilize U.S. Bureau of Labor Statistics (1984; 1986) sectoral output and employment forecasts for 1995.[7] No forecassts are available on the ethnic/racial composition of the labor force on an industry by industry basis for 1995; hence, we have assumed that the composition for 1986 carries forward to the forecast date. The baseline will thus understate minority employment in many sectors to a small degree.

The baseline employment forecast for 1995 calls for a total working labor force of 112 million people. This total is composed of 10.6 million (9.87 percent) Blacks, 7.4 million (6.39 percent) Hispanics, and 94.1 million (83.74 percent) Whites and others.

B. Alternative Scenarios

The Embargoed Economy. We estimate that in 1996, the U.S. will be importing about 50 percent of its oil, 40 percent from OPEC countries that might potentially participate in an embargo. The projected response to any shortfall would be an increase in the production of domestic oil, natural gas, and coal, as well as reliance on emergency conservation measures. Each of these coping strategies are given equal weight, meaning that they each supplant 25 percent of the imported OPEC crude oil from the baseline case. It is also assumed that the alternative fuels are more expensive per equivalent unit and raise the Consumer Price Index (CPI) by 1.0 percent, thus lowering consumer purchasing power by that amount.

The actual modeling involves an increase in final demand for each of the three produced substitutes, equal to 25 percent of the total value of imported oil subject to embargo, or $5.885 billion (in 1972 dollars). The increased efficiency response (which is responsible for the adjustment to the remaining 25 percent shortfall) is subsumed within the 1.0 percent CPI index increase, in effect offsetting an even larger potential cost increase. The direct 1.0 percent decrease in the projected value of personal consumption expenditures is equal to $14,124 billion (in 1972 dollars).

Synfuels-based Economy. The possibility exists that rising oil prices and supply uncertainties would make the production of synfuels (coal liquefaction and coal gasification) an attractive option by the end of this century (see Rose et al., 1986). In order to provide a standard comparison across scenarios, we will utilize an admittedly high estimate of a 40 percent (30 percent foreign and 10 percent domestic) oil replacement by synthetic fuels. We also will assume this translates into an equivalent dollar value increase in the production of the coal feedstock.

We model this scenario with an increase in final demand for coal equal to 80 percent of the baseline value of imported OPEC crude oil, or $5,885 billion. In addition there is a decrease in final demand for domestic crude oil displaced equal to $1,471 billion. No distinct investment requirement for synfuels facilities is added, since we assume that conventional oil refinery investment as well as general plant and equipment investment of an equivalent amount if displaced. The second-order impacts of these various investments differ to the extent that they relate to different types of capital goods. However, since synfuels facilities are similar in design to refineries, the difference is likely to be minor.

Solar-based Economy. Solar energy for home and commercial heating and cooking can represent an attrative alternative to conventional fuels. Again, we utilize an admittedly exaggerated target level for 1995 equal to 40 percent of baseline oil production in value. The displacement in this case, however, is of 30 percent electricity and 10 percent natural gas.

Moreover, in this case, equipment purchases are included at a level equal to the discounted present value of the cost savings of the solar option.

The computations for this scenario involve a reduction in the personal consumption expenditure for electricity of $4.414 billion, and a reduction in gas utility demand of $1,471 billion.[8] Also, solar energy eqipment purchases and annual operating expenses (adapted from Rose et al., 1980) are entered as an increase in the investment column of final demand, with their total equal to $5,885 billion.[9]

C. Results

The impacts of the three scenarios on minority employment in twelve selected sectors and on the economy as a whole are presented in Tables 7, 8, and 9. The results in Table 7 indicates that the Embargo Scenario calls for an overall reduction in employment of nearly 1.0 million workers. Only the coal and petroleum sectors, which are stimulated to offset the embargo, show employment gains. The remaining sectors, including 68 sectors not shown in Table 7, suffer employment losses due to inflation-induced demand reductions.

The Synfuels Scenario shows an overall employment gain of 380 thousand, more that half of which arises in the coal industry (see Table 8). The petroleum sector and a few related industries (not shown) suffer downturns.

Finally, the Solar Scenario results in a net employment gain of about 80,000 (see Table 9). This means that the expenditures on solar energy equipment and operating costs have larger multipliers than the gas and electic utility sectors, which suffered an equivalent direct expenditure reduction. Note that several other sectors, including coal and petroleum, which are in effect "support" sectors in this case, also suffer significant employment downturns.

A comparison of the scenario results with an emphasis on minority employment implications is facilitated by Table 10. In addition to the differences in relative magnitude of total employment changes, there are sizeable differences in the minority employment implications of the three scenarios. Over 91 percent of the new jobs created under the Synfuels Scenario would go to Whites, if historical hiring patterns maintained, due in great part to the situation in the coal industry. This overall proportion of gains for White workers is about 10 pecent higher than in the other two scenarios. Also, interesting is the difference in relative positions of Black and Hispanic potential workers between the three scenarios. In the Embargo and Synfuels cases, prospects are relatively much better for Blacks than Hispanics. In the Solar Scenario the opposite is true. In this latter case, the fact that much of the solar energy equipment would be produced in light manufacturing sectors especially heating and plumbing equipment in the Sun-Belt, is picked up by the model.

Overall, the results incidate that the future employment of minorities in the U.S. is likely to be sensitive to the specific energy scenario that will take place. Moreover, the results are asymmetric in a disturbing way. Blacks, in the absence of changes in historical trends or remedial policies, would likely receive a disproportionately low percentage of potential new

TABLE 7. MINORITY EMPLOYMENT IMPACTS OF THE EMBARGOED ECONOMY
(change from baseline)

BEA Code	Sector	Black	Hispanic	White	Total
	Energy Sectors				
7.	Coal Mining	496	482	46,684	47,662
8.	Crude Petroleum and Gas	2,392	4,454	44,429	51,275
31.	Petroleum Refining	-338	-193	-2,827	-3,357
68.	Electric and Gas Utilities	-1,529	-581	-10,897	-13,006
	Energy-Support Sectors				
12.	Maintenance	-439	-449	-5,536	-6,424
69.	Trade	-14,801	-12,906	-185,245	-212,952
71.	Real Estate	-757	-786	-9,843	-11,386
73.	Business Services	-19,034	-11,296	-155,797	-186,127
	Other Sectors				
14.	Food and Kindred	-2,819	-2,002	-14,456	-19,277
37.	Iron and Steel	-212	-157	-1,555	-1,923
53.	Electronic Equipment	-18	-23	-245	-287
77.	Health and Social Services	-18,461	-7,450	-135,507	-161,418
	Total (all 80 sectors)	-100,674	-63,846	-788,159	-952,679

TABLE 8. MINORITY EMPLOYMENT IMPACTS OF THE SYNFUELS-BASED ECONOMY
(change from baseline)

BEA Code	Sector	Black	Hispanic	White	Total
	Energy Sectors				
7.	Coal Mining	2,106	2,043	198,057	202,207
8.	Crude Petroleum and Gas	-1,235	-2,299	-22,936	-26,470
31.	Petroleum Refining	174	99	1,457	1,730
68.	Electric and Gas Utilities	469	178	3,346	3,994
	Energy-Support Sectors				
12.	Maintenance	146	149	1,836	2,131
69.	Trade	2,391	2,085	29,926	34,402
71.	Real Estate	177	184	2,303	2,664
73.	Business Services	6,016	3,570	49,244	58,830
	Other Sectors				
14.	Food and Kindred	252	179	1,293	1,724
37.	Iron and Steel	263	195	1,927	2,385
53.	Electronic Equipment	73	94	992	1,158
77.	Health and Social Services	1,831	739	13,439	16,009
	Total (all 80 sectors)	20,602	12,899	346,914	380,415

TABLE 9. MINORITY EMPLOYMENT IMPACTS OF THE SOLAR-BASED ECONOMY
(change from baseline)

BEA Code	Sector	Black	Hispanic	White	Total
	Energy Sectors				
7.	Coal Mining	-102	-99	-9,578	-9,779
8.	Crude Petroleum and Gas	-1,652	-3,077	-30,689	-35,418
31.	Petroleum Refining	-174	-99	-1,455	-1,728
68.	Electric and Gas Utilities	-10,248	-3,895	-73,054	-87,197
	Energy-Support Sectors				
12.	Maintenance	-41	-42	-513	-595
69.	Trade	1,635	1,426	20,463	23,524
71.	Real Estate	54	56	702	812
73.	Business Services	1,993	1,183	16,314	19,490
	Other Sectors				
14.	Food and Kindred	241	171	1,236	1,648
37.	Iron and Steel	823	610	6,029	7,461
53.	Electronic Equipment	42	54	569	665
77.	Health and Social Services	1,686	680	12,377	14,744
	Total (all 80 sectors)	6,799	9,265	66,035	82,099

job gains, but would likely suffer a disproportionately high percentage of job losses should they arise.

V. POLICY IMPLICATIONS

Employment impacts from different energy scenarios offer a tangible linkage to labor force policies for the employment of minorities. The concern with increasing both the level and rate of employment among disadvantaged worker groups can be partially addressed through increased labor demand and its targeting on minority groups in the labor force. Traditionally, there have been three partially overlapping groups who have been the prominent targets of job and employment programs (Bendick, 1982).

Low-skilled adult workers with a lack of job credentials, training, experience, and contacts have been concentrated among members of minority groups and women. Their deficiencies and lack of work experience increase their probabilities of prolonged spells of unemployment. Wages and earnings for jobs typically taken up by these groups are low, pushing their household income to or below the poverty line. This poverty status for many low-skilled minority adults is aggravated by discrimination against minorities in the labor market. Disadvantaged youth with disproportionately high unemployment rates and low wage rates in comparison to adult workers is another prominent target group. And while skill deficiencies and a lack of work experience are characteristic of teenage and young adult workers, these problems are compounded by their transition from schooling to work. Inner-city neighborhoods and depressed rural areas are the geographic basis for the third target group. Workers in such areas are characterized by the minority, skill deficiency, and youth dimension of the other groups. High rates of unemployment and joblessness for these groups are partly due to a lack of worker mobility, which is compounded by a spatial mismatch between the location of jobs and workers' residencies in distressed areas.

Job creation and the diffusion of employment to target groups have been pursued through several policy alternatives. The market-oriented approach relies on the "trickle-down" of new jobs to disadvantaged workers. An increased level of total demand for a region's output accompanied by increases in employer's demands for workers may pick up unemployed residents in economically distressed areas (Dalomba, 1980; Thompson, 1980; and Bradley, Downs, and Small, 1982). Recent findings, however, indicate that faith in such effects, often used to justify Economic Development Administration and Urban Development Grants Projects, may very well exceed their potential (see Bassi and Ashenfelter, 1986).

Creating low-skill jobs with minimal education, training, and work experience requirements has been a second approach to increasing minority employment levels. This approach has at least two problems associated with it. First, the immediate employment relief offered by this approach may be outweighed by the longer term instability and low productivity attributes of jobs it offers. These jobs inhibit long-term human resource improvements and economic gains in labor productivity by diverting attention from the formaton of incentives and job-earnings advancement, which contribute to both individual and social striving for investment in human capital. Secondly, as suggested below, the creation of jobs aimed toward worker

TABLE 10. COMPARISON OF ENERGY SCENARIO IMPACTS, 1995

Scenario	Black	Hispanic	White	Total
1. Embargoed Economy				
Change in Employment	-100,674	-63,846	-788,159	-952,679
Ethnic/Racial Distribution	10.6	6.7	82.7	100.0
2. Synfuels-Based Economy				
Change in Employment	20,602	12,899	346,914	380,415
Ethnic/Racial Distribution	5.4	3.4	91.2	100.0
3. Solar-Based Economy				
Change in Employment	6,799	9,265	66,035	82,099
Ethnic/Racial Distribution	8.3	11.3	80.4	100.0

characteristics may be tkaen up by groups who are competitive with the targeted groups. In-migrants and new entrants to the labor force may take jobs and displace local disadvantaged residents.

A first example of a more direct approach to job targeting toward minority workers is offered by "first-source hiring agreements." These agreements between a company and the minority employment program stiuplate the hiring of a targeted group of minority employees, usually JTPA trainees or area residents, in exchange for governmental economic development assistance and incentives (Lawrence, 1985). Hiring agreements and targeted placement contracting originated under the Comprehensive Employment and Training Act and offer several benefits over and above any special incentives to employers. Prospective employees have already been assured of their skills and aptitude and have received pre-employment training.

Another direct approach to linking labor demand and worker supply is "customized training," in which job-specific skills designated by an employer are included in the design of training programs. As a form of human capital investment, customized training is a firm specific approach that focuses on the work force needs of an individual employer. An emphasis on training for a specific job is implemented by identifying trainees and teaching them the minimal skills needed for a specific job within a pre-identified company. Customized training as a labor force instrument for employment of targeted groups serves not only as a location incentive for incoming firms, but also as a program for the retention and expansion of existing employers. The skill and job specific orientation of customized training distinguishes it from more traditional forms of training programs, and is one example of providing a closer linkage between education and training institutions and industry.

In addition to other subsidy impacts, customized training represents a labor input subsidy to employers. And while one portion of the subsidy is in the form of wages, the large portion of the subsidy comes in the form of savings from the shifting of a firm's specific training costs. The "customized" content of the training is job-specific as negotiated between the employment and training specialists and the employer. This rather exacting specification of an employer's labor demand not only minimizes the uncertainty costs of satisfying that demand in the market place, but it lowers the firm's cost of specific training. [10]

There are also economic development programs that deal with targeting and the distribution of jobs in one manner or another and which might be adapted to the energy sector. Community Development Block Grants are mandated to direct at least 51 percent of the "benefits" to low and moderate income persone. These benefits presumably include jobs, although this has not been systematically assessed (Bendick, 1985). Regional development programs such as Model Cities, Urban Development Action Grants, Economic Development Administration (see, e.g., Martin, 1979) and, more recently, urban enterprise zones have contained a regional orientation of training policy (see, e.g., Sternlieb and Listokin, 1981). These various programs have been geographically targeted toward depressed regions, most of which have relatively large minority populations, based on a criteria of unemployment and household income.

Other policy instruments amenable to job targeting, including industrial revenue bonds and cost subsidies aimed at attracting private capital, could be modified by imposing hiring agreements and providing coordinated subsidies toward firms most likely to employ target groups (Lawrence, 1985). Worker recruitment through employment and training agencies for minority employment programs projects also could offset employers' reliance on the traditional market place. This would be consistent with increased jobs for minority workers in energy-related business, an employment objectives which is part of the mandate for the Office of Minority Economic Impact and its activities.

These potential intersections of minority employment and labor force policies through job targeting argue for a common, analytical view of regional labor market adjustments which recognize the interdependence between employment and development. A labor market adjustment model which can be applied to the general notion of job targeting is briefly outlined.

VI. MODEL EXTENSION

There are a number of simplifying assumptions within our basic input-output framework for projecting minority employment that impose significant restrictions on the analysis. As mentioned earlier, fixed input coefficients in general, and ethnic/racial employment coefficients, in particular, constrain the projection framework to fixed factor proportions with no allowance for substitution in production among different inputs. The linear homogeneity condition on the production technology does not allow for economies of scale in production nor dynamic change in that technology. But these are well known restrictions of any static input-output model and they can be accommodated by tempering projections of employment with the application of prudent caveats. Other restrictions focusing primarily on labor force status and labor supply conditions are more serious points of contention that should be addressed in the use of an input-output framework. Unemployment, new entrants into the labor force, in-migration of workers, and, probably most importantly, occupational mobility for minority workers are supply side characteristics and conditions which should be incorporated into any extensions of the current framework and model.

Such an extension can proceed by: (a) taking the input-output projections of minority employment by sector and (b) simulating the diffusion of these job vacancies through a labor supply model of economic responses to changing labor demands for minority workers as well as all workers. Such a model has been developed at a theoretical level by Seninger (1985), and could easily be adapted to the type of projections and employment impacts estimated in this study. The more salient features of what is essentially a Markov Chain model of occupational mobility for workers are summarized below.

The occupational composition of the employed work force and its inter-occupational mobility is an important characteristic on the supply side of the local labor market. As other studies (Wernett, et al., 1982) have suggested, the employment benefits of synfuel projects to the impacted region are quite sensitive to a) the degree of worker mobility among occupations,

and b) the magnitude of in-migration for the local labor market. We assume that occupations are stratified in a continuous fashion from top to bottom, with factors such as human capital and specific skill requirements characterizing high order occupations, and a subsequent dilution of these requirements taking place as one moves down the occupational order.

The occupational mobility of employed workers is a key adjustment characteristic of labor supply responses to job creation. The degree of interoccupational mobility depends on worker endowments of transferable general skills versus occupation specific skills, the availability and cost of training programs, expected paybacks from occupational changes, and institutional barriers to occupational shifts. The educational content of occupations also influences mobility in addition to the training and transaction costs of movement relative to pecuniary rewards. The clustering of occupations by similar education content may violate the condition of an evenly distributed, continuous occupational order. High order occupations with extensive, formal education and skill content may preclude upward movements for many potential entrants in the labor force although downward moves are quite possible.

Employed workers within occupations at an initial time period, together with interoccupational mobility features and labor force participation rates are the main characteristics of labor supply responses. Withdrawal from the labor force, changes from employed to unemployed, out-migration, and retirements and deaths comprise socio-economic-demographic outflows defined as attritions. The supply of employed workers by occupation in the following time period is equal to vacancy demand minus worker movements to vacancies in other occupations and the labor force attrition factor.

There are three sources of job vacancies in this representation of a labor market with each one representing varying degrees of susceptibility to policy intervention. Vacancies generated by attrition are largely determined by socio-demographic phenomena which are primarily exogenous to the system. Withdrawals from the labor force include discouraged workers, students, and part-time female workers who are responding to a variety of wage, hours, and non-wage conditions, and are not directly influenced by policy either. Shifts to unemployment (both voluntary and involuntary) are due to seasonal, frictional, structural, and cyclical factors with the latter two sources representing derived demand phenomena that may reduce the number of vacancies.

The labor market relations outlined above which are susceptible to policy intervention in some degree and that can be incorporated into the Markov model are: (a) the rates of occupational mobility for workers in the system, and (b) the policy induced increments in job vacancy changes. Most training programs focus either directly or indirectly on the enhancement of occupational mobility through the acquisition of new and marketable job skills as well as completion of formal education requirements (e.g., G.E.D. certification). In an applied policy context, these programs strive for both increased employability and higher, post-program earnings. These policy aims suggest "better jobs" and increased upward mobility, which should affect the pattern of transition rates in the occupational matrix (see Seninger, 1986).

VII. CONCLUSIONS

The energy sectors of the U.S. economy are likely to continue to be volatile throughout the remainder of this century. In general, there will probably be a drift away from oil, and an increased reliance on unconventional and renewable energy resources. This will result in the displacement of a large number of jobs in one key energy sector, and a major increase in job opportunities in several others. Also, since the energy industries place demands on other sectors of the economy, the total number of jobs at issue may be several times the number of direct job displacements and creations. The simulations presented in this paper indicate that the implications for minority employment may vary significantly between alternative energy futures.

We have presented a model that can serve as a solid basis for projecting minority employment impacts. The model is unique in its ability to make important distinctions among energy sectors at a detailed level, and to capture second-order effects in energy-support sectors as well. The present structure of the model is somewhat limited by its assumption of fixed total and ethnic-racial employment requirements per unit of output. However, we also indicated how the model could be broadened to take into account changes in employment structure brought about by policy action. Similar enhancements can be made to reflect changing market conditions relating to wage rate changes and productivity improvements. A related input-output modeling approach can also be applied to determining impacts on low-income groups within minority categories or for the population in general (see, e.g., Rose, Stevens and Davis, 1987).

Of course, minority employment is not the overriding concern that decision makers address in drafting energy policy. Still, minority employment goals can be furthered without detracting from energy policy if approached in the right manner. In the long-run it would appear that there are no dire tradeoffs between the two goals. If potential job openings can be predicted with reasonable accuracy and minority group members are able to receive the necessary training, they will be able to share in new employment opportunities. This paper has endeavored to offer a contribution to the set of tools that analysts and decision-makers can use to make the employment projections necessary to achieve important energy and social objectives.

FOOTNOTES

[1]Imperfect information, uncertainty, wage and price rigidities, and limited factor mobility obstruct the forces for restoration of equilibrium and realignments necessary for efficient reallocations of resources. In addition, capital market imperfections, such as limited access and high rates of interest, retard the financing of human capital investments necessary for overcoming technical determined barriers to occupational mobility for minority workers (see, e.g., Richardson, 1983).rdson,1988).

[2]We use the term "ethnic" as short-hand for "ethnic/racial" in labeling these tables.

[3]For an excellent introduction to input-output terminology and concepts the reader is referred to Miller and Blair (1985).

[4]Ethnic-industry matrices are preferable to ethnic-occupation matrices because of the direct sector correspondence with I-O categories.

[5]Note that the BLS data contains an overlap in tabulating Blacks that are of Hispanic origin. These individuals were assigned only to the category of Blacks for this study. Also, persons of Asian origin, Native American and Pacific Islanders are grouped with Whites in this classification.

[6]A closed inverse matrix was used in these computations that only included purely endogenous income and consumption components. Therefore, the estimates of second-order, or multiplier, effects are somewhat conservative.

[7]The BLS provides "low," "moderate," and "high" forecasts, differing according to demographic considerations, such as labor force participation, and economic considerations, such as productivity growth. We will utilize only the moderate forecasts in this paper.

[8]Of course, electricity production is based on a mix of primary fuel inputs. Also, note that electric and gas utilities are combined in Sector 68 in the I-O model used for our empirical analysis.

[9]Throughout the computations we have entered all scenario related expenditures as changes in final demand, whether they represent intermediate or final demand, or capital or operating costs. This has been done to avoid changing the basic technical coefficients of the model. It will, however, result in a slight inaccuracy of the forecasts.

[10]Indeed, the matter of targeting offers both a potential elements of commonality as well as a source of conflict between minority employment programs and employment and training policies. The latter incorporate targeting as an inherent feature of their policy mission, one which is typically mandated by state and federal programs. Examples of mandating under the Job Training Partnership Act include Title II training services for disadvantaged adult and

youth workers and Title III programs for dislocated workers. Targeted groups are also specified under the federally administered, Title IV programs and include veterans, Job Corps, Native Americans, and migrant farm workers.

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DOCTORAL SCIENCE AND ENGINEERING MINORITY EMPLOYMENT IN ENERGY-RELATED ACTIVITIES: DESCRIPTIVE DATA

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DOCTORAL SCIENCE AND ENGINEERING MINORITY EMPLOYMENT IN ENERGY-RELATED ACTIVITIES: DESCRIPTIVE DATA

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INTRODUCTION

Doctoral scientists and engineers represent the culmination of our education process and the vanguard of our technical economy. The energy sector is a prime example of "high tech" economic activity. Scientists and engineers account for over 10 percent of the energy sector employment as compared to about 3 percent in the total economy. Within the doctoral scientists and engineers group just over 11 percent are employed in energy-related activities. So, doctoral scientists and engineers are important to the operation and development of the energy sector, and the energy sector is a significant source of employment for doctoral science and engineering personnel. The U.S. Department of Energy recognizes this interdependence and, in addition to university-based research, supports a variety of programs directed at doctoral level scientists and engineers and graduate students. These include laboratory cooperative research activities for faculty and students, sabbatical and postdoctoral appointments at DOE laboratories, and fellowship programs.

All of these factors, plus my program unit's continuing work for DOE in energy-related science and engineering employment, led to my interest in doctoral science and engineering minority employment in energy-related activities. Another reason for focusing on doctoral level scientists and engineers is that they are less mobile between occupations (i.e., less field switching) than are B.S./M.S. personnel, so the effects of education on employment are more apparent and closely linked.

As noted in the title, this paper provides descriptive data, rather than statistical analysis. Unforeseen demands on my time made it impossible to perform the assessment and analysis activities I had originally planned. Still, I believe the descriptive data provide insights of interest which may help spur further actions related to minorities' education in science and technical areas.

DATA SOURCE

The data cited here are from biennial surveys of doctoral scientists and engineers conducted by the National Research Council under funding from the National Science Foundation, U.S. Department of Energy, and other agencies. The sample in the 1985 survey represented just

over 7 percent of all doctoral scientists and engineers. Within the minority groups, the sample sizes were approximately 8 percent for Asians and 15 to 20 percent for other minorities (Black, American Indian, Hispanics, and Others). The survey included questions about whether or not the respondents' work is energy-related.

The term "energy-related activities" includes involvement in energy R&D, in production and distribution of energy/fuels, in conservation and energy management/utilization, and in supporting and related work (such as architecture, engineering, and design activities, construction activities, equipment and instrument manufacturing and maintenance, government, and professional services).

DOCTORAL LEVEL SCIENTISTS AND ENGINEERS IN ENERGY-RELATED ACTIVITIES

Overview

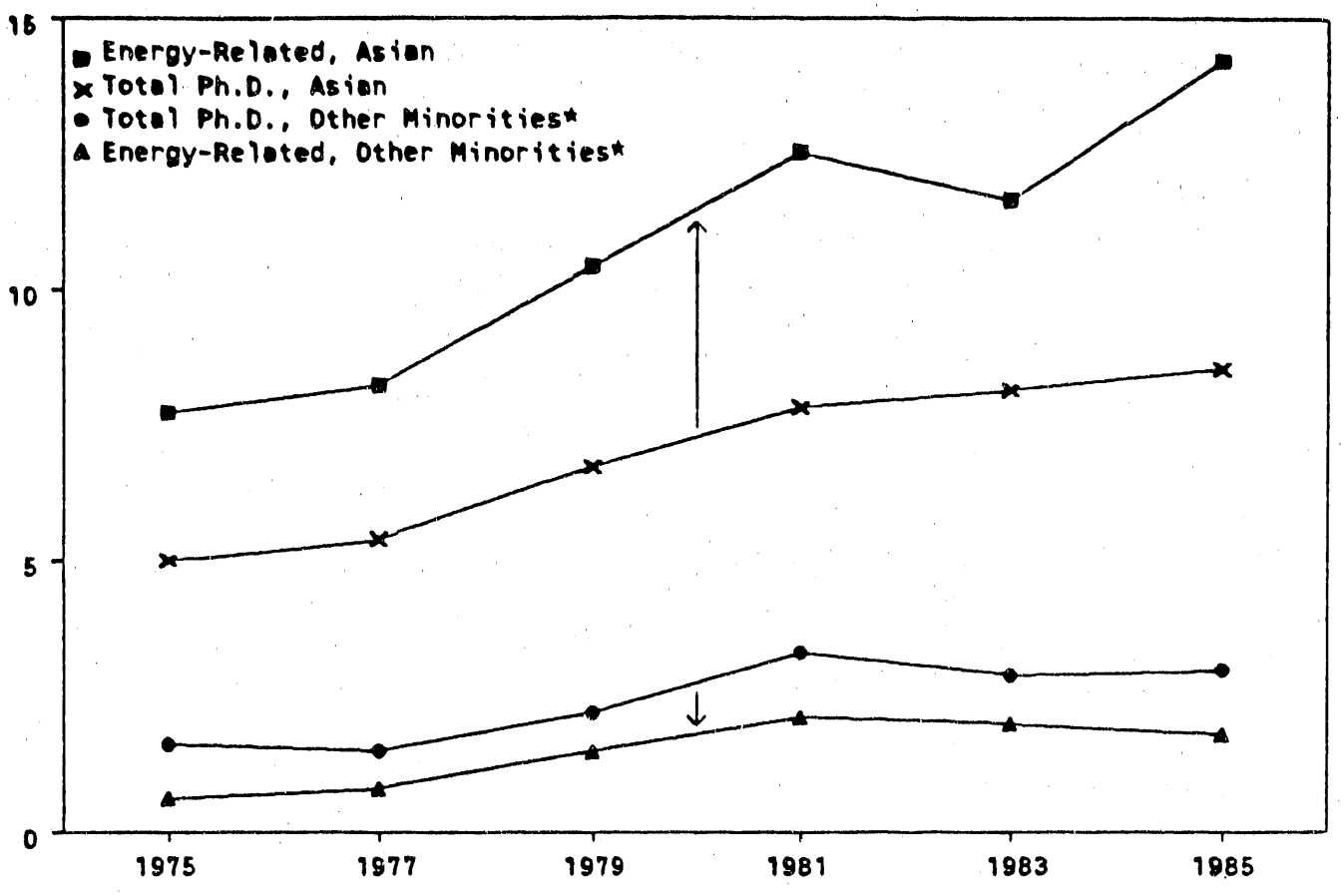
The data indicate that minorities are approximately 11.5 percent of all doctoral-level scientists and engineers and almost 16 percent of those in energy-related employment. These percentages probably cause many readers to react with a somewhat skeptical attitude as I did when I first encountered the data. The key to understanding these minority percentages is to look at specific ethnic groups. Here the data show a wide divergence in percentage involvement between persons of Asian ethnicity and other minorities (Blacks, American Indians, Hispanics, and Others). Almost three-fourths of the minority doctoral scientists and engineers are in the Asian ethnic group. This leaves other, non-Asian minorities as just 3 percent of all doctoral science and engineering employees.

This wide divergence in percentage participation rates between Asians and other minorities, plus the capability to separate data for Asians from the other minorities (because of the sample size), led to treating the minorities in two groups: an Asians ethnicity group and an all other minorities group. The sample sizes for the other minorities are not large enough to permit separating them into different groups. These other minorities are those more commonly thought of as "disadvantaged" in our society.

Turning to Figure 1, we see the 10-year trends in minority involvement in doctoral science and engineering employment both in the total economy and in energy-related activities. Several statistics are apparent.

Persons of Asians ethnicity have accounted for a substantially higher percentage of doctoral scientists and engineers than have other minorities over the whole ten year period. The Asians group has consistently had a higher percentage involvement in energy-related activities than in the total economy. Specifically, the relative participation of Asians among all doctoral scientists and engineers has increased from 5 percent in 1975 to 8.5 percent in 1985, and among energy-related doctoral scientists and engineers from over 7.5 percent in 1975 to over 14 percent in 1985.

FIGURE 1. DOCTORAL SCIENTISTS AND ENGINEERS (COMBINED), 1975-1985
PERCENT MINORITY, TOTAL AND ENERGY-RELATED



*Other minorities include Black, American Indian, Hispanic, and Other.

A quite different set of statistics is shown for the other minorities (i.e., Blacks, American Indians, Hispanics, and Other). The percentage involvement of other minorities is fairly low, and, while there was some increase in the percentages in the latter half of the 1970s, the percentages have been stable or slightly down during the first half of the 1980s. For the total population of doctoral scientists and engineers, the percentage involvement went from 1.5 percent in 1975 to over 3 percent in 1981 and settled back to 3.0 about 1985. For the energy-related population, the percentages went from about 0.5 percent in percent in 1975 to just over 2 percent in 1981 and back to just under 2 percent in 1985. In comparison, in the total U.S. economy in 1985, Blacks alone accounted for almost 10 percent of the total employed and persons of Hispanic for over 6 percent.*

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*Employment in Perspective: Minority Workers, U.S. Department of Labor, Bureau of Labor Statistics, Report 739, First Quarter 1987, Washington, D.C.

For this report, however, the main focus is on the consistently lower percentages in energy-related work for the other minorities group and the consistently higher percentages among persons of Asian origin. Figures 2 through 5 present information on the occupational patterns and percentages of doctoral scientists and engineers in energy-related activities versus in the total economy. Once we have reviewed these data, we will proceed to look at how much of the differences in the relative involvement of minorities in energy-related activities can be attributed to differences in occupational employment patterns and, hence, to education patterns for doctoral scientists end engineers.

Scientists and Engineers in Energy-Related Work

Figure 2 shows that employment in energy-related activities is concentrated much more in engineering and somewhat more in mathematics/computer science, physical science, and earth/environmental science than in all doctoral scientists and engineers employment. Conversely, energy-related work requires relatively fewer life scientists and social scientists.

Figure 3 provides the percentages of the aggregate doctoral scientists and engineers groups employed in 1985 in energy-related activities. Just over 1 out of 10 of all doctoral scientists and engineers are in energy-related work, but the percentages are vastly different for engineers (almost 3 out of 10 engineers are in energy-related employment versus about 1 out of 12 scientists).

Figures 4 and 5 show the percentages in energy-related work by more detailed occupational categories. Within the science occupations, almost one-half of the earth scientists are in energy-related employment, about one-seventh of the physical scientists and environmental scientists, but only about one-twentieth of the mathematics/computer scientists, life scientists, and social scientists. Within the engineering occupations, as would be expected, most of the petroleum, nuclear, and mining engineers are in energy-related employment, about one-half of the chemical and mechanical engineers, just over one-fourth of the civil and materials engineers, and about one-tenth of the electrical/electronic engineers.

The key point for this report, as shown in Figures 2 through 5, is that the percentage of scientists and engineers in various occupations involved in energy-related work varies widely from one occupation to another. Thus, in trying to understand the differences in percentages of minorities involved in energy-related activities, these differences in occupational requirements must be taken into account.

Energy-Related Minority Doctoral Scientists and Engineers

Figure 6 simply reproduces the data for 1985 that were shown in the line graphs in Figure 1. Overall, doctoral scientists and engineers of Asian ethnicity indicate much higher percentage involvement in energy-related work than the total doctoral population, while the other minorities indicate somewhat lower percentage involvement. These differences have held for a decade, even as the overall percentages of minority doctoral scientists and engineers have increased.

Figure 7 shows several groups of science occupations. Most of the differences in the percentage involvement of the other minorities are accounted for at the specific science occupation level. For the Asians group, however, the differences in percentages are still fairly large in most occupations.

Figure 8 provides data for specific engineering occupations. Excepting chemical and mechanical engineers, the same relative patterns occur as in the science occupations. That is, all or most of the differences in the percentage involvement of the other minorities in energy-related work are accounted for at the specific occupation level. For the Asians, however, higher percentage involvement in energy-related work (excepting chemical and mechanical engineering) still exists at the specific engineering occupation level.

SUMMARY AND IMPLICATIONS

For the other minorities (i.e., Blacks, American Indians, Hispanics, and others), most of the difference in percentage involvement in energy-related work is accounted for by the different mix of science and engineering occupations used in energy-related activities versus in the total economy. That is, the distribution of doctoral educational fields chosen by members of the other minorities group (their "human capital") is different from that used in energy-related work.

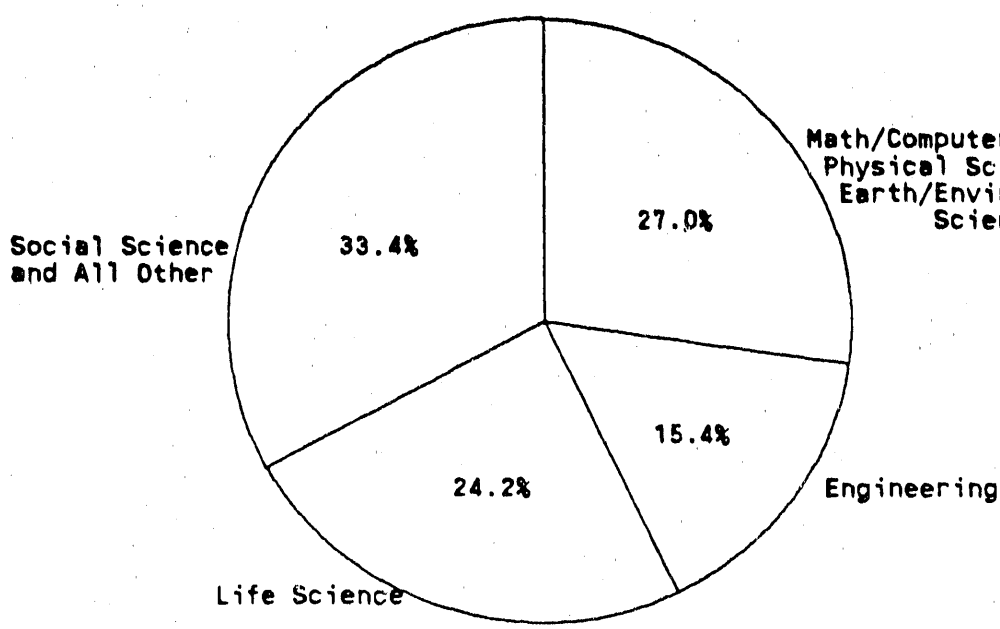
For doctoral scientists and engineers of Asian ethnicity, however, the higher percentage involvement in energy-related work is only partially explained by the relative differences in occupations used in energy-related activities versus the total economy. It is quite possible that even more detailed occupational data might explain all or most of the differences still shown at the basic occupation level (that is, data at suboccupation levels such as electric power fields within electrical engineering or plasma and atom and molecular subfields within physics).

For the other minorities these relatively lower participation rates in energy-related work, which result from mismatches between the human capital held (i.e., education background) and the occupational employment requirements, point to a potentially general problem. To the extent that the "high tech" fields of our economy (where much of the future job growth and R&D opportunities are thought to be) require relatively more engineers and physical scientists--similar to the energy field--then the human capital of non-Asian minority doctoral scientists and engineers may hold down their relative participation in these high tech activities.

Looking to the future in energy-related work, the implications for enhancing the participation of non Asian minority doctoral scientists and engineers appear to be fairly straight forward. First, more minorities will have to enroll in graduate education programs, and the pattern of these enrollments will have to be redirected toward the employment specifically used relatively more in the energy field, specifically, engineering and physical, earth, and environmental sciences.

FIGURE 2. ALL SCIENTISTS AND ENGINEERS, 1985

Percentage Distribution (N = 398,373)



ENERGY-RELATED SCIENTISTS AND ENGINEERS, 1985

Percentage Distribution (N = 44,607)

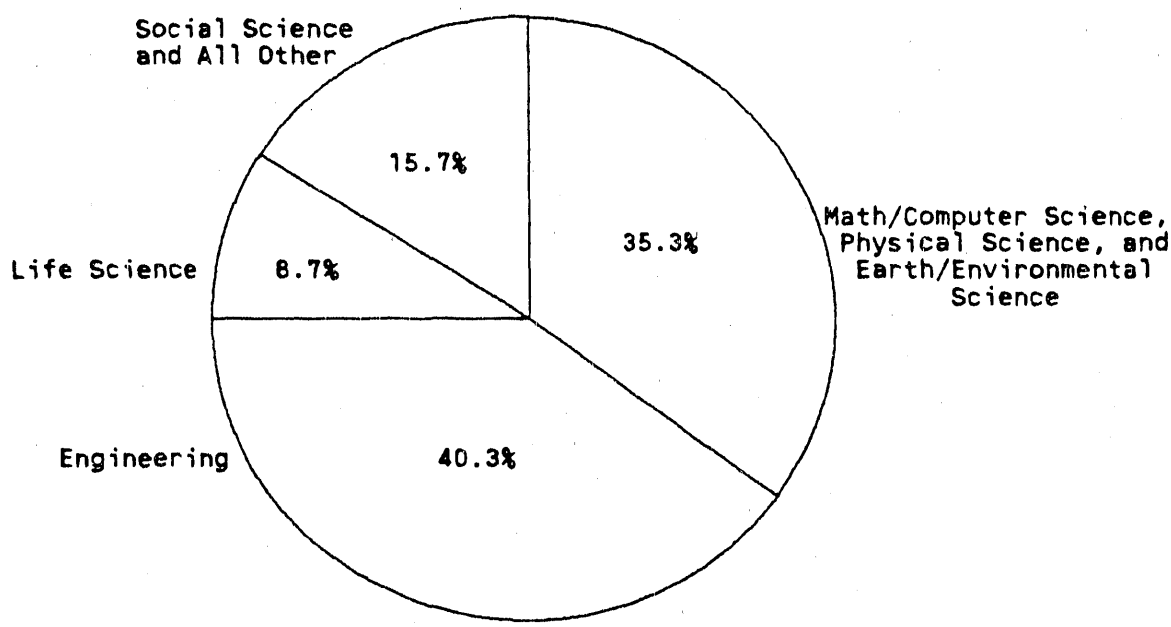


FIGURE 3. DOCTORAL SCIENTISTS AND ENGINEERS, 1985: PERCENT ENERGY-RELATED

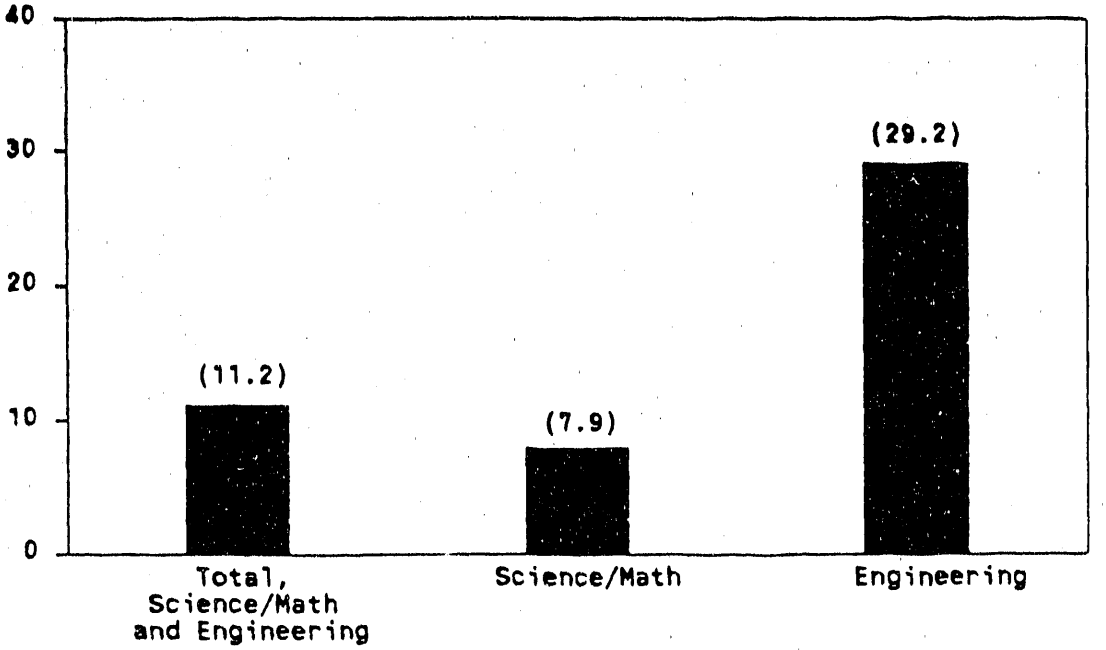


FIGURE 4. DOCTORAL SCIENCE AND MATH FIELDS, 1985: PERCENT ENERGY-RELATED

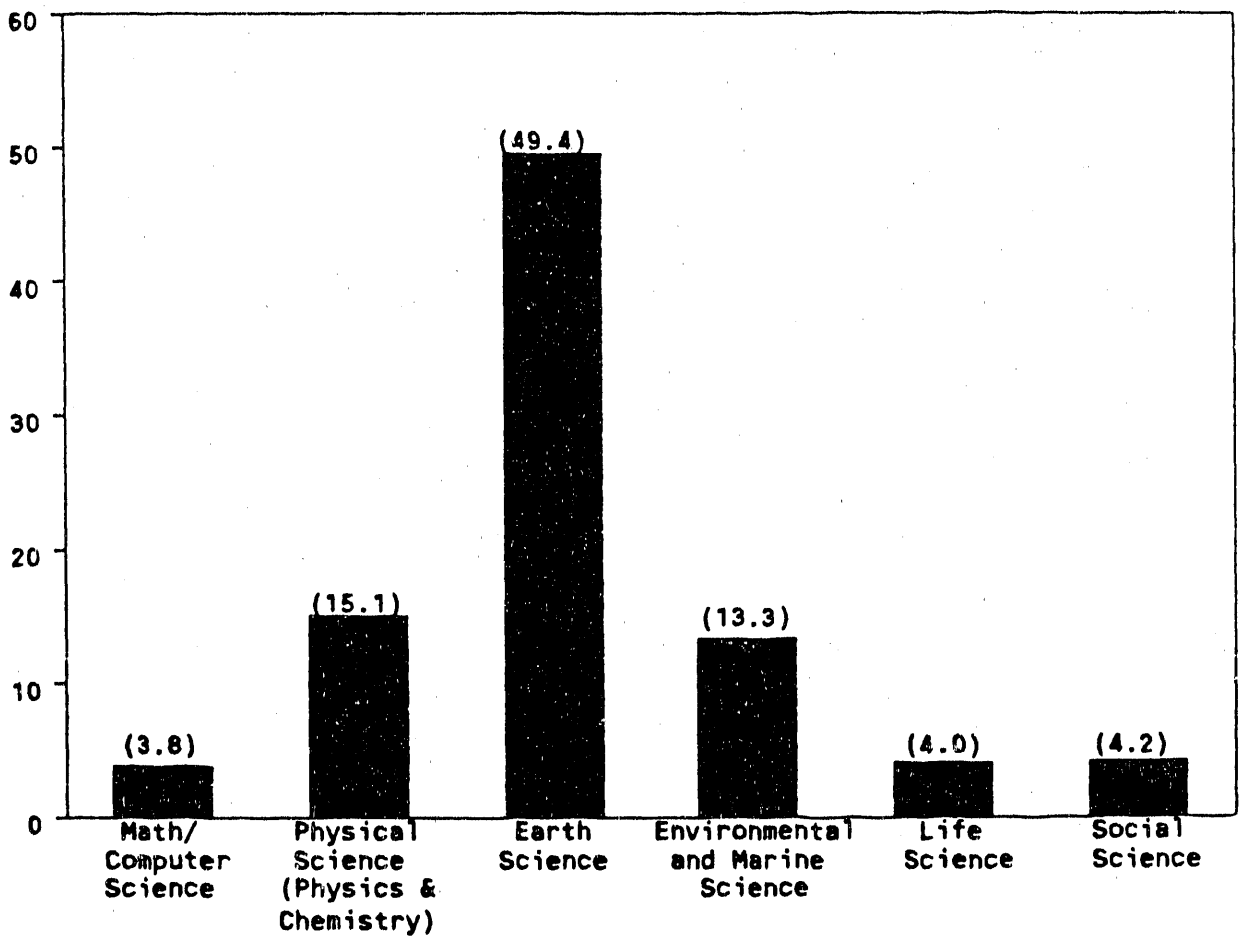


FIGURE 6. DOCTORAL ENGINEERING FIELDS, 1985: PERCENT ENERGY-RELATED

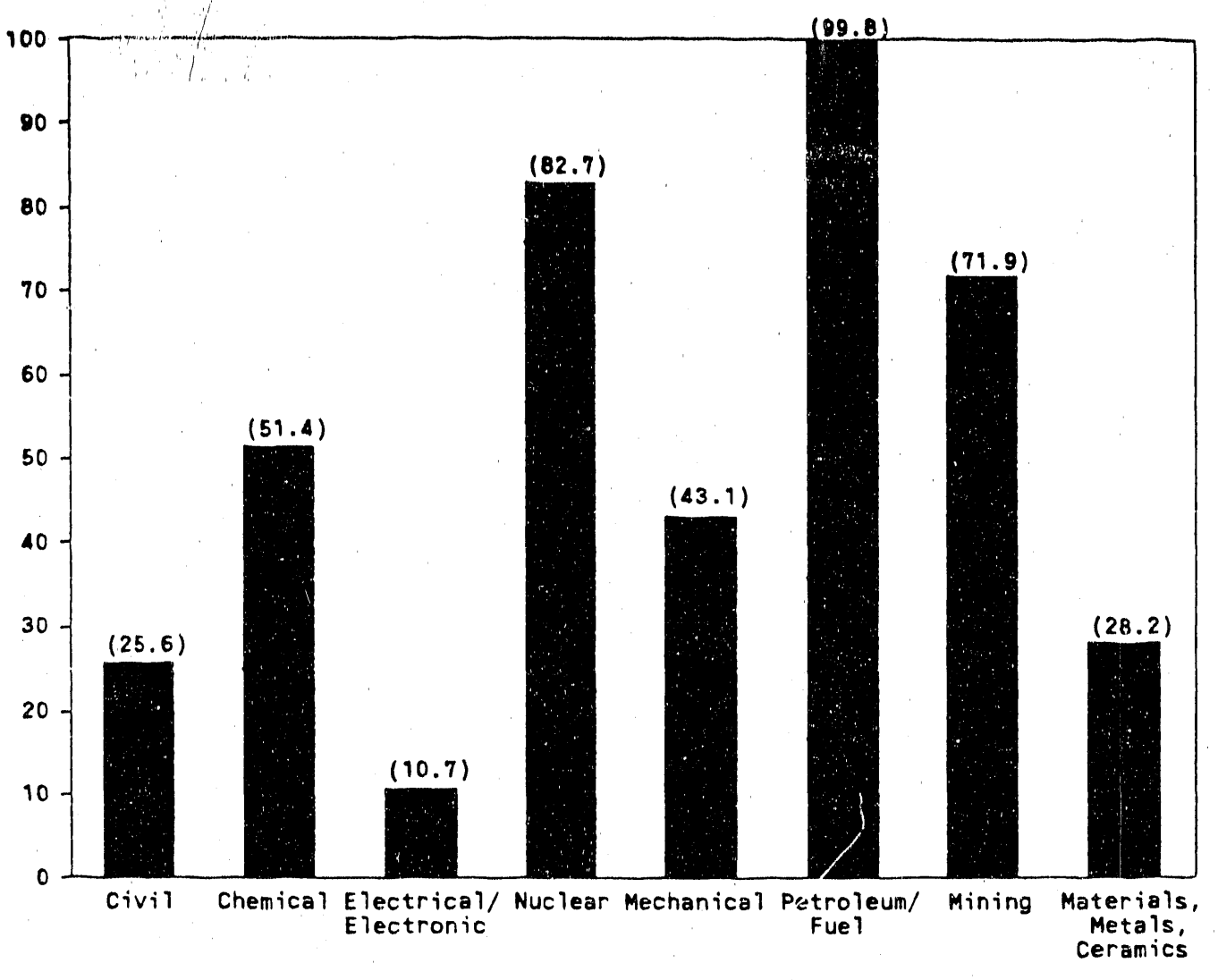
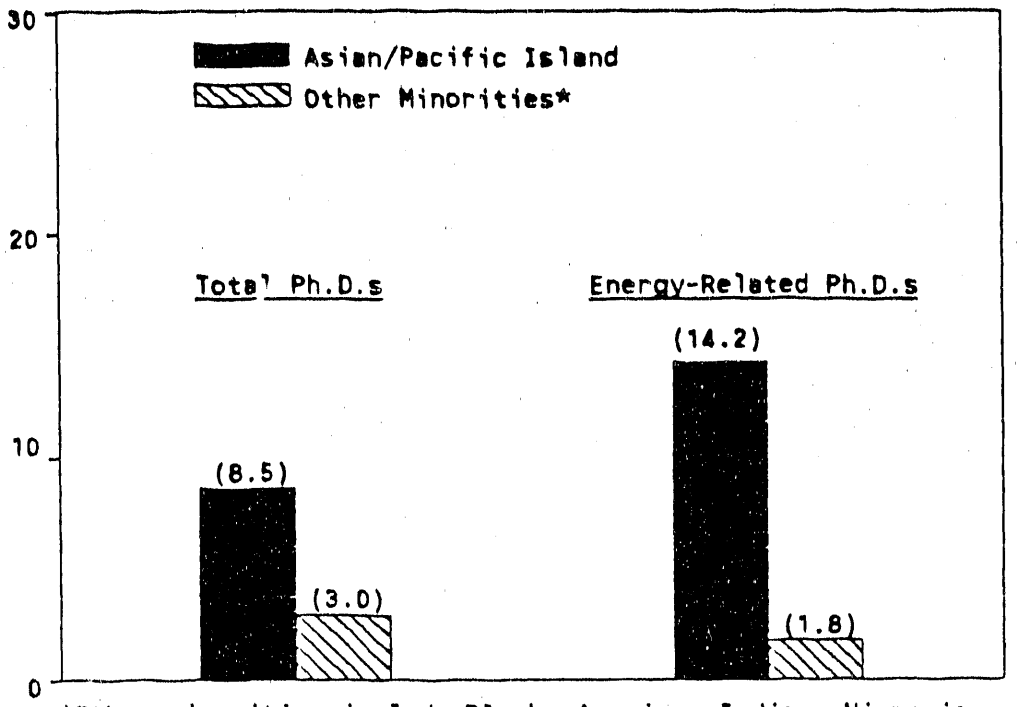
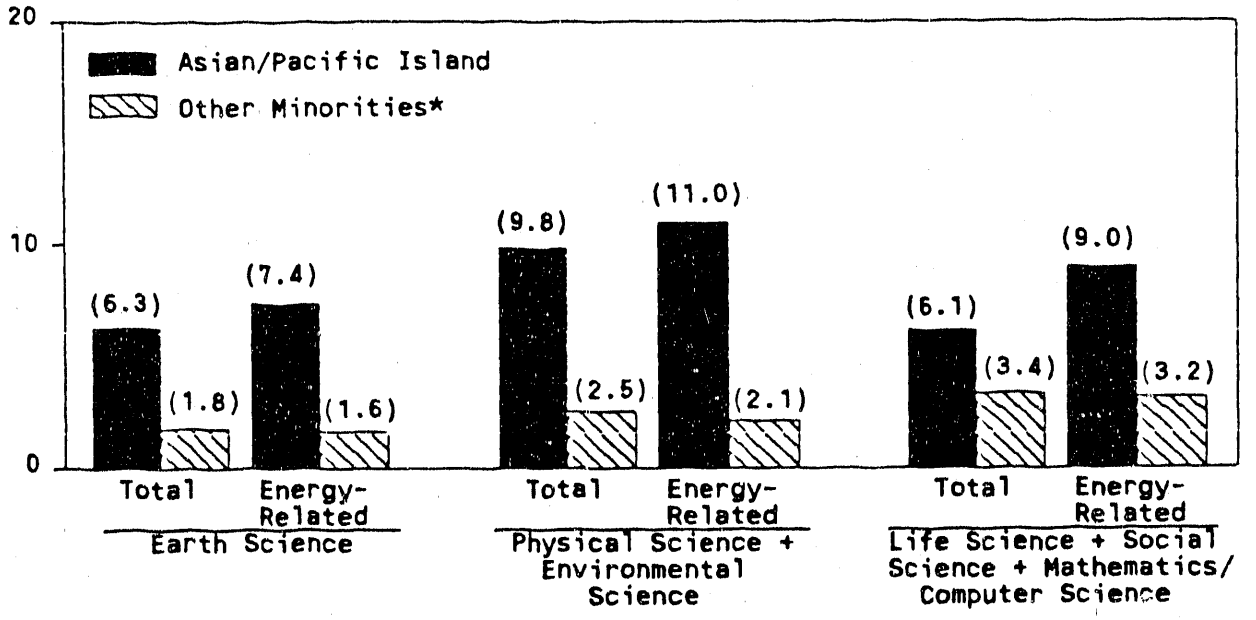


FIGURE 6. DOCTORAL SCIENTISTS AND ENGINEERS (COMBINED), 1985
PERCENT MINORITY, TOTAL AND ENERGY-RELATED



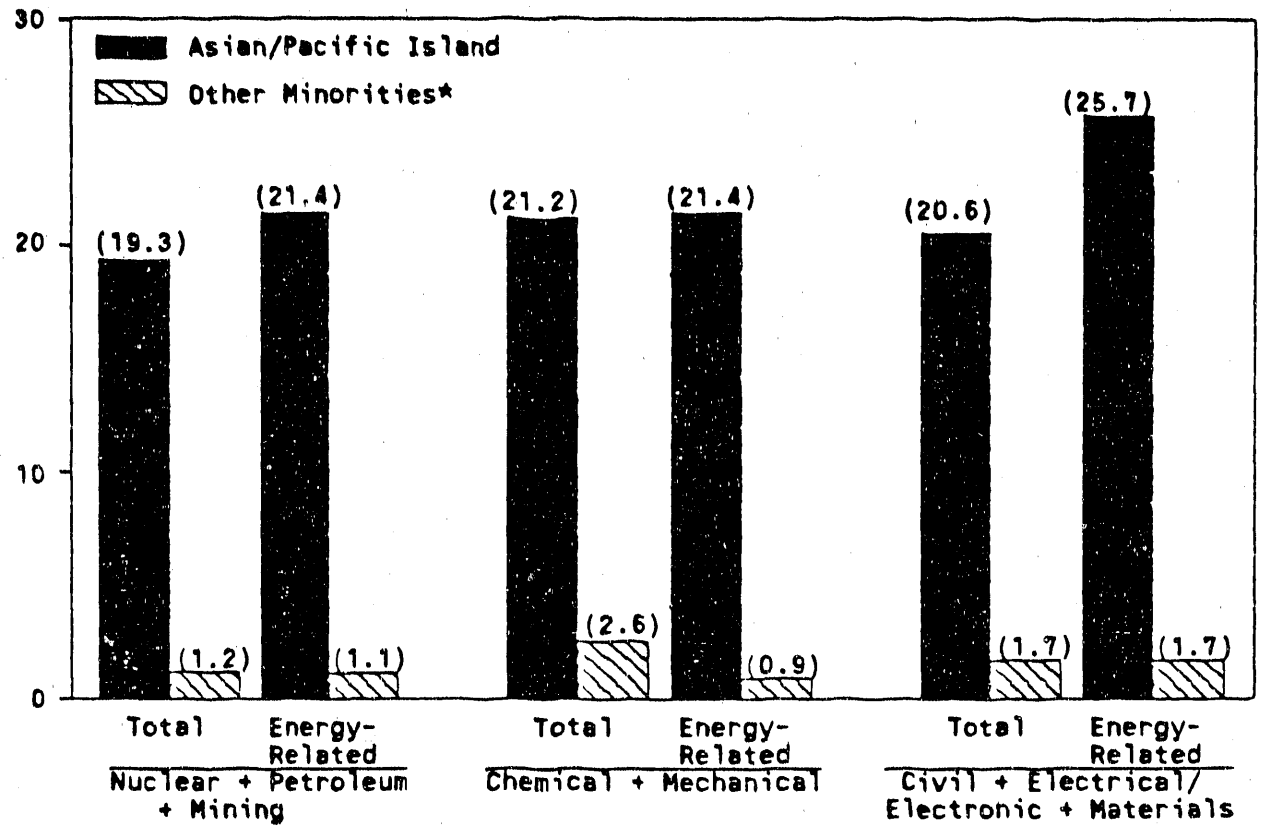
*Other minorities include Black, American Indian, Hispanic, and Other.

FIGURE 7. DOCTORAL MATHEMATICS/SCIENCE FIELDS, 1985:
PERCENT MINORITY BY TOTAL AND ENERGY-RELATED



*Other minorities include Black, American Indian, Hispanic, and Other.

FIGURE 8. DOCTORAL ENGINEERING FIELDS, 1985:
PERCENT MINORITY BY TOTAL AND ENERGY-RELATED



*Other minorities include Black, American Indian, Hispanic, and Other.

In order to bring more minorities into energy-related doctoral science end engineering fields, a number of things must be done to effect human capital, all of which are fairly common knowledge. First, information about employment requirements and career opportunities in the energy fields must be passed along to minority group members. Second, there must be more minority students who are better prepared in mathematics and science from elementary through undergraduate education programs and in engineering at the college level. This means expectations, opportunities, and support for education of minorities in energy-related fields must be enhanced. Such enhancement includes the use of role models and information programs as well as incentives for students, teachers, and guidance personnel.

One factor that affects efforts to encourage students (and their teachers) to become more interested in energy-related careers (or careers in any field) is the prevailing job market and outlook. For the energy field, especially at the doctoral level, this is currently a problem. The 5-year outlook (1987-1992) for energy-related employment of scientists and engineers does not indicate growing employment levels. In fact, most of the job openings in the energy field over the next 5 years are expected to result from replacement needs for people who have retired, moved out of science and engineering jobs or out of the energy field, or died. (See Figures 9 and 10.*) This employment outlook is based on the decreases indicated in the OMB 5-year, Federal budget schedules for energy R&D, on the outlook for little growth in private sector energy R&D because of continued moderation in oil prices into the early 1990s, and on the DOE, Energy Information Administration (DOE, EIA) outlook for U.S. energy production and consumption which are projected to increase only moderately over the next 5 years.

The lack of employment growth provides the opposite signal to that needed to get more minorities (or students in general) interested in careers in energy. The message is fewer job opportunities, less career growth potential, and less interesting and important work to be done. However, many projections, including that of DOE, EIA, are for oil prices to move up much more rapidly in the mid 1990s, and the new doctoral engineers and scientists for the mid 1990s are in the education pipeline now.

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*The figures and data are from a draft of "Energy-Related Science and Engineering Personnel Outlook, 1987," prepared by Oak Ridge Associated Universities for U.S. Department of Energy, Office of Energy Research, Oak Ridge, Tennessee, May 1987.

FIGURE 9. AVERAGE ANNUAL RATES OF CHANGE IN JOB OPENINGS FOR ENERGY-RELATED PH.D. SCIENTISTS AND ENGINEERS, 1986-1992

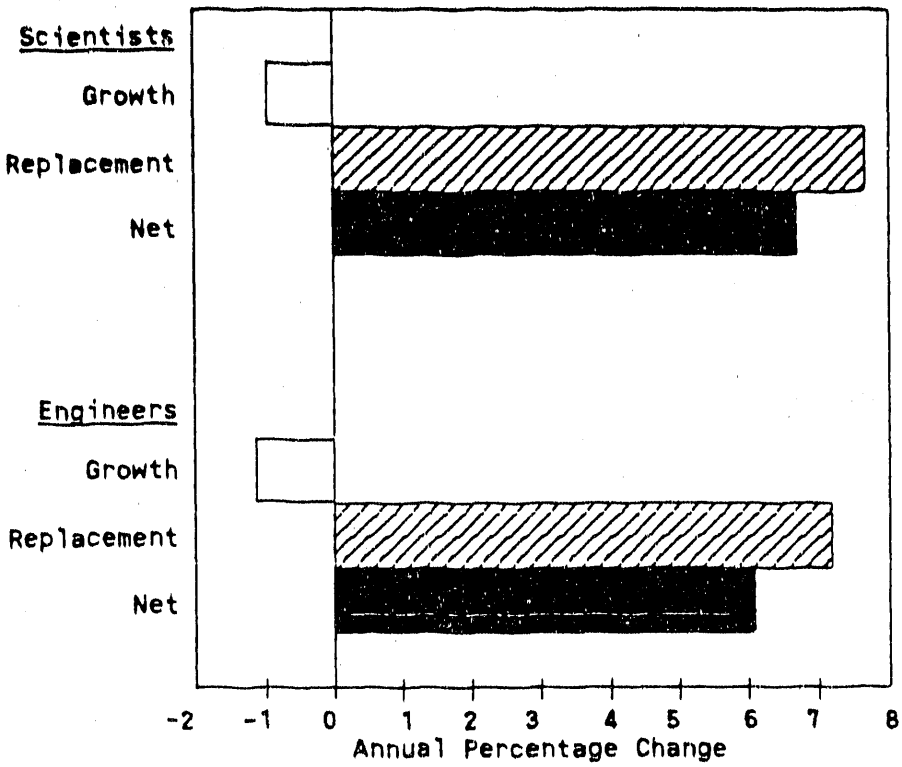
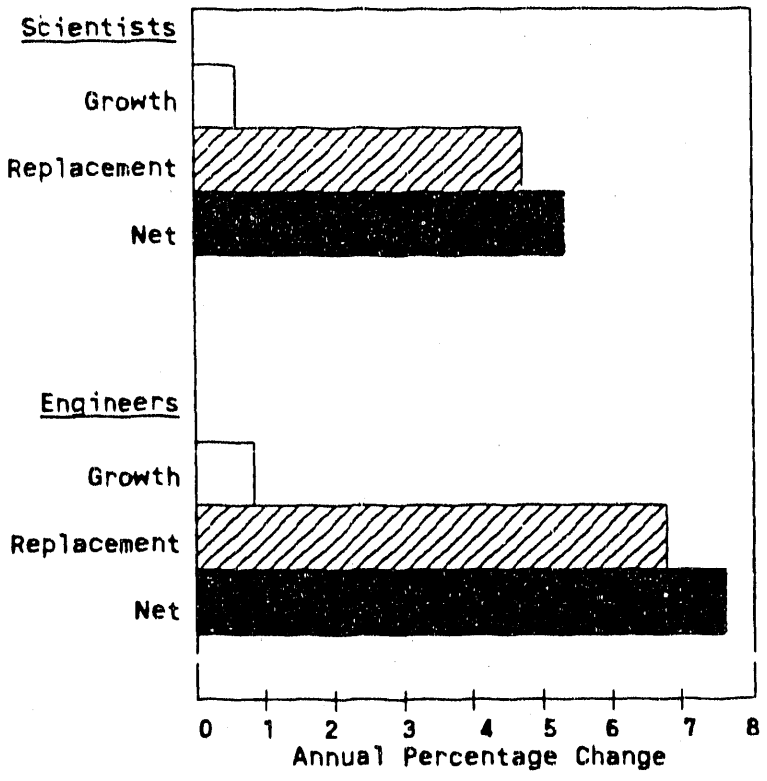


FIGURE 10. AVERAGE ANNUAL RATES OF CHANGE IN JOB OPENINGS FOR ENERGY-RELATED B.S./M.S. SCIENTISTS AND ENGINEERS, 1986-1992



MINORITY PARTICIPATION IN NEW ENERGY TECHNOLOGIES: A CASE EXAMPLE OF ELECTRIC HEAT PUMPS

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MINORITY PARTICIPATION IN NEW ENERGY TECHNOLOGIES: A CASE EXAMPLE OF ELECTRIC HEAT PUMPS

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ABSTRACT

Primarily because of technological improvements and sharp increases in energy prices after the energy crises of the 1970s, the sale of residential electric heat pumps rose ninefold from 1970 to 1983. However, growth has been uneven with respect to black, Hispanic, and white households, even after one controls for income and geography. This paper analyzes the growth in heat pump sales; estimates heat pump market share by key segments; and compares patterns of heat pump ownership by black, Hispanic, and white households. A discrete choice model was used to project the demand for heat pumps by black, Hispanic, and white households for new single-family and multifamily homes, which account for a major share of heat pump shipments to the residential sector. The study is based on several data sources, including the 1980 Census, the 1980 Annual Housing Survey, and the 1980-1981 Residential Energy Consumption Survey. Given the availability of consumer survey data, this model can easily be adapted to analyze the participation of different ethnic households in the growth of other new energy technologies.

INTRODUCTION

Technological improvements and sharp increases in energy prices after the energy crises of the 1970s were the primary causes of a ninefold increase in the sale of residential electric heat pumps from 1970 to 1983. However, growth has been uneven with respect to black, Hispanic, and white households. In 1985, the U.S. Department of Energy's (DOE's) Office of Minority Economic Impact (MI) sponsored a study at Argonne National Laboratory to analyze the historical and future demand for heat pumps across various ethnic households (1). The following approach was implemented in the study:

- The growth in sales of heat pumps from 1970 to 1983 was analyzed, and important factors contributing to that growth were identified and discussed.
- The market share in 1980 for heat pumps was estimated for key segments.
- 1980 patterns of heat pump ownership by black, Hispanic, and white households were analyzed.

- A discrete choice model was developed to explain variations in heat pump demand across various ethnic households. The probability of a heat pump being adopted by a household was determined as a function of key socioeconomic characteristics, technology attributes, and other relevant factors. Using the model, heat pump demand was projected for black, Hispanic, and white households for selected market segments.

The paper also comments on what the results of the study show in terms of current and future heat pump ownership patterns with respect to ethnic households.

HISTORICAL GROWTH IN THE MARKET FOR ELECTRIC HEAT PUMPS

Heat pumps are not new; the first operational system was developed in 1926. Development of small residential heat pumps progressed steadily over the next few decades until the early 1950s to middle 1960s, when significant numbers came into use. However, the poor reliability

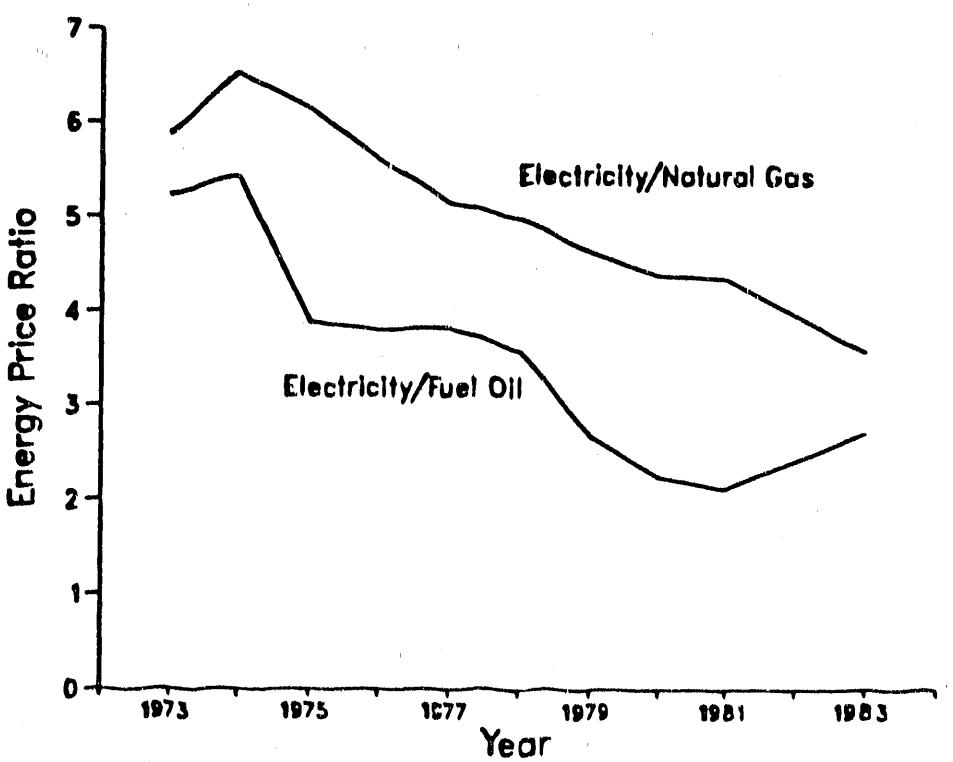


FIGURE 1 National Energy Price Ratios in the Residential Sector, 1972-1983 (Source: Based on Ref. 3)

and performance of these early systems soon forced the industry to improve its designs. By the 1970s, most of the technical problems had been solved, and heat pumps became more reliable and efficient. For example, the percentage of heat pumps with a seasonal energy efficiency ratio (SEER)* of 7.5 or more increased from 11% in 1976 to 86% in 1983 (2).

The sharp rise in energy prices after the Arab oil embargo of 1973 and the Iran crisis in 1978 also favored electric heat pumps over competing heating systems fueled by oil and natural gas. The price ratio of electricity to national gas declined from 6.53 in 1974 to 3.57 in 1983 (Fig. 1). The electricity-to-heating-oil price ratio also declined from 5.44 to 2.70 during the same period. Together with the technological improvements in heat pumps, these favorable trends in relative energy costs contributed greatly to the tremendous growth in residential heat pump use. Factory shipments increased ninefold between 1970 and 1983 (Fig. 2); however, this growth was not steady because it was also affected by other economic factors, the most important of which was the level of new-home construction, which fluctuated greatly because of the three recessions between 1971 and 1983 (Fig. 2).

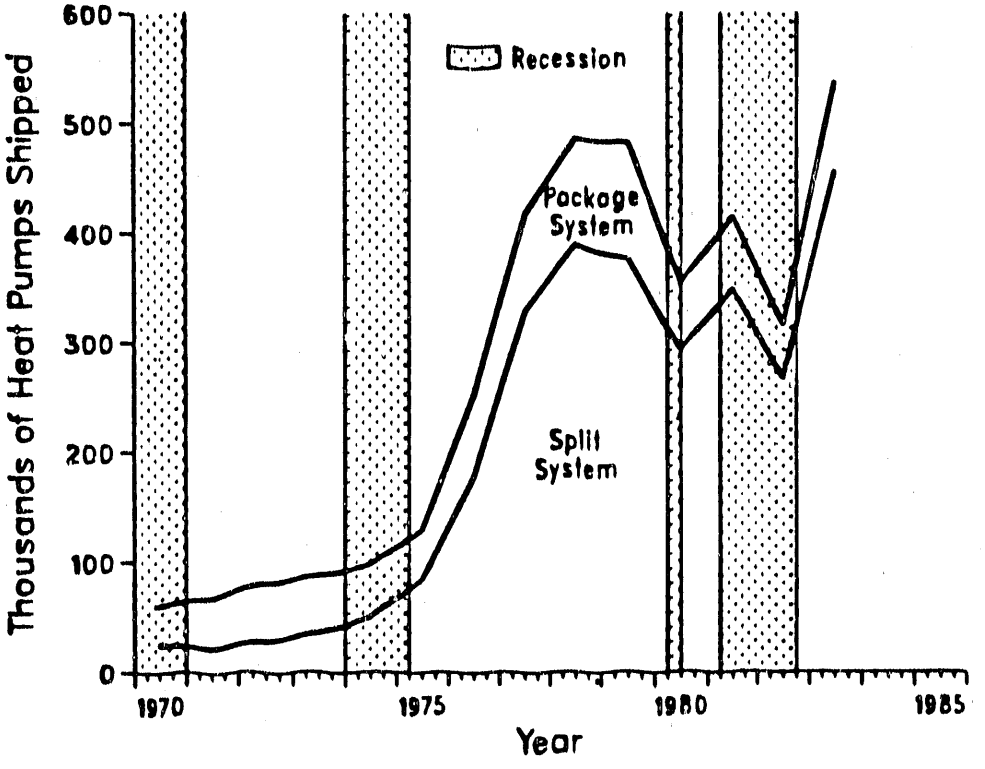


FIGURE 2 Factory Shipments of Residential Heat Pumps, 1970-83 (Source: Based on Ref. 2)

*The SEER is obtained by dividing the total cooling load (in Btu) during the season by the total electric energy input (in watt-hours).

CHARACTERIZATION OF RESIDENTIAL HEAT PUMP MARKET

The market share of heat pumps in key segments was estimated based on one or more of the following: the 1980 Census (4) 1980 Annual Housing Survey (5), and 1980-1981 Residential Energy Consumption Survey (RECS) (6). Highlights of the estimates are discussed below.

Market Share by Geography

Several factors with regional variations are expected to affect heat pump demand. For example, mild climates, lower electricity costs, and higher prices of competing natural gas and fuel oil -- singly or in combination -- are beneficial to heat pumps. Therefore, the market share was estimated by census region, state, and urban and rural areas. According to the 1980 Census (4), heat pump market penetration was 3.5% of occupied housing units in the United States; this percentage was equivalent to 2.835 million units. Market penetration varied widely across the four census regions: 6.5% in the South, 3.1% in the West, 1.9% in the North-Central region, and 1.2% in the Northeast. Factors favoring adoption of heat pumps in the South include its relatively mild climate, which results in greater heat pump efficiency, and its disproportionately large share of new housing construction in the late 1970s. The opposite is true for the Northeast, where the cold climate and below-average growth in new housing has limited the heat pump market.

In market segmetation of state, Florida ranks first in the United States, with its 15% heat pump market penetration (Fig. 3). The large cooling load in summer results in greater use of heat pumps throughout the year. Also, the mild winter means higher operating efficiency and less need for secondary heating equipment, which minimizes additional capital expenditures.

Heat pumps are popular in both urban and rural areas of the Unites States; market penetration was 3.3% in urban areas and 4.3% in rural areas. Rural locations favor heat pumps because of (a) the relatively greater accessibility of electricity compared with competing natural gas and fuel oil and (b) the generally higher cost of transporting either natural gas or fuel oil than electricity.

Market Share by Housing Characteristics

The economics of heat pumps also depends on the type of housing construction. Market shares for heat pumps were estimated for major market segments based on two housing characteristics: type of home and age of home. Figure 4 shows 1980 heat pump market penetration by type of home. Nationwide, penetration is highest in single-family homes (4.0%); multifamily homes and mobile homes rank second and third, respectively. Factors contributing to greater penetration in single-family homes may include the generally higher income of households and the tendency to own the house rather than to rent. Until 1980, heat pumps remained relatively more popular in single-family homes in all regions except the South, where penetration was about equal in single-family and multifamily homes. Most heat pump installations have been in new construction. For example, heat pumps were installed in about 333,000 new housing units in 1980 (7), compared to the industry's total shipment of

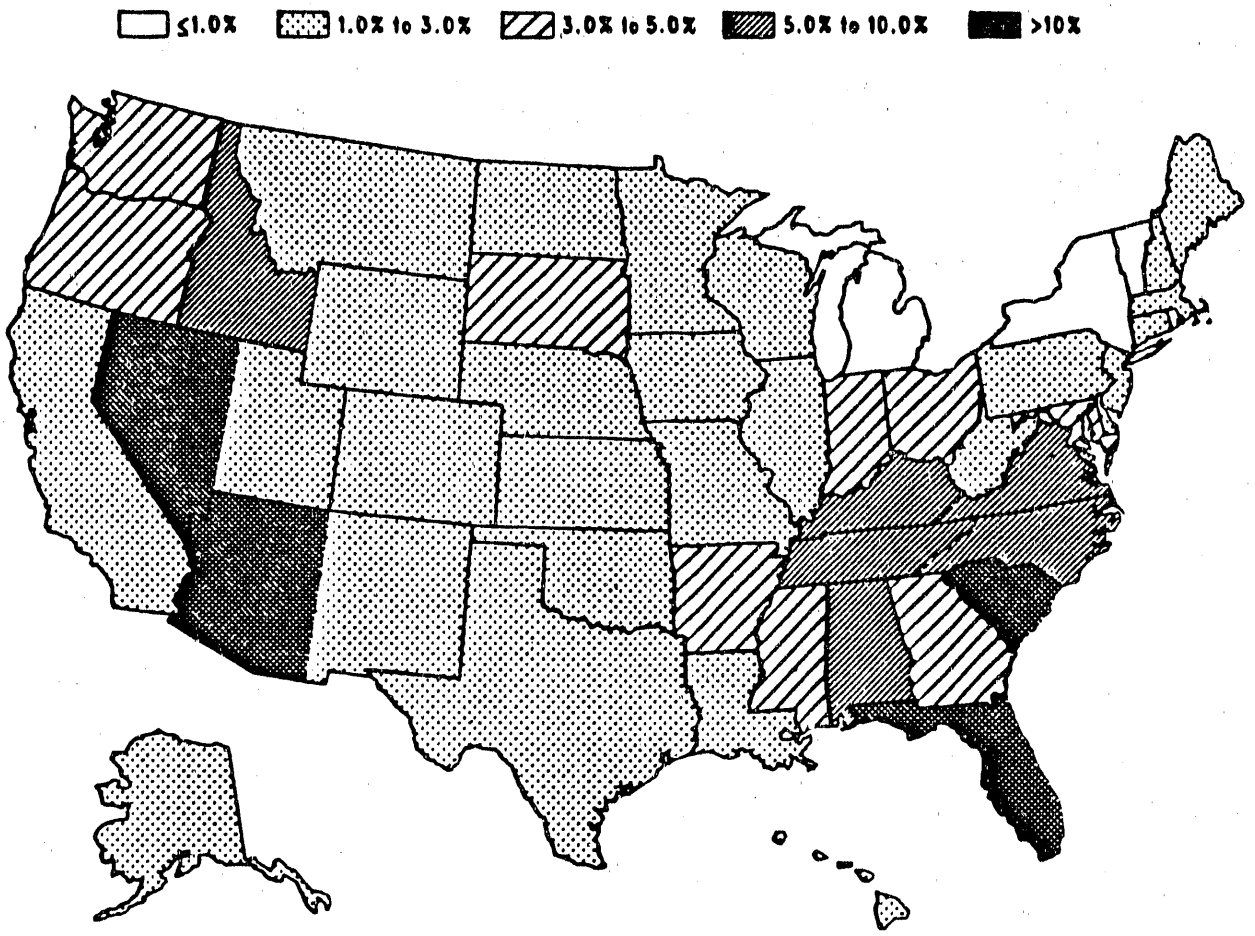


FIGURE 3 Percentage of Occupied Homes with Heat Pumps in 1980, by State (Source: Based on Ref. 4)

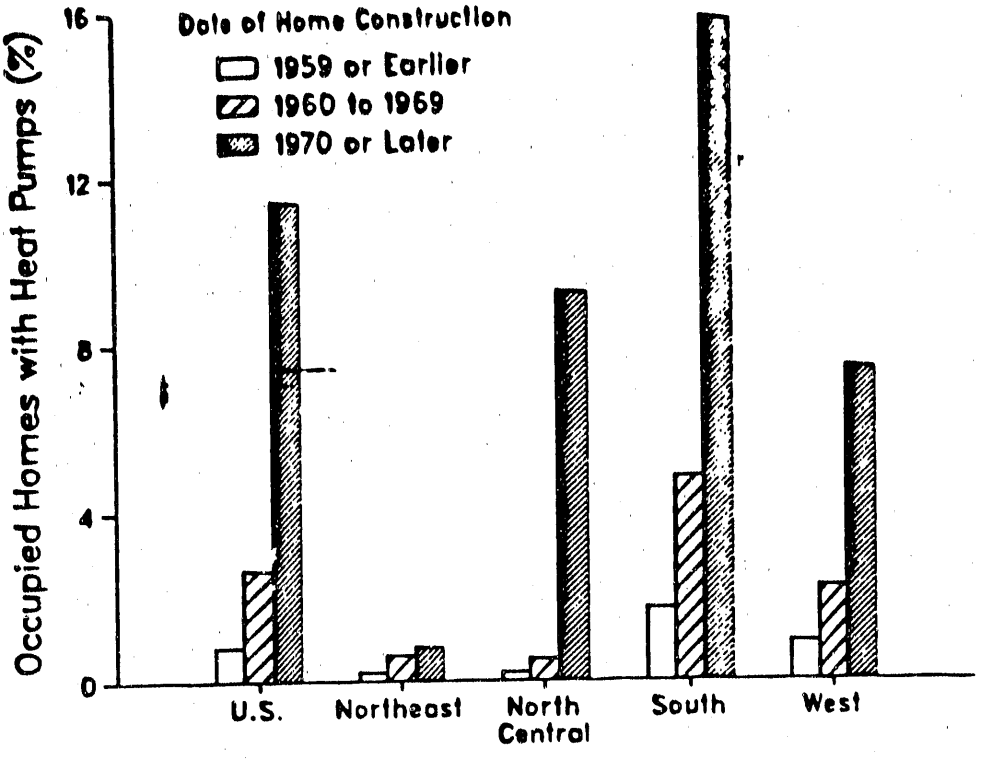


FIGURE 5 Percentage of Occupied Homes with Heat Pumps in 1980, by Date of Home Construction (Source: Based on Refs. 4 and 5)

The estimated 1980 market share by family income is shown in Fig. 6. As expected, penetration increases as income rises. This pattern continues across the four census regions.

As expected, higher educational levels among household heads tend to favor heat pumps. Nationally, for example, market penetration was 5.6% in households whose heads had an educational level higher than high school, 3.2% for high school only, and 1.4% for less than high school. This pattern also continues across the census regions.

Heat pumps are favored more by owners than by landlords. On the basis of the 1980 Census, heat pump share was 3.8% in owner-occupied units but only 3.0% in renter-occupied units.

MINORITY PARTICIPATION IN HEAT PUMP MARKET

To observe the effect of race/ethnic background on heat pump demand, market shares for black, Hispanic, and white households are studied. On the basis of the 1980 Census, white households had the highest market share, at 3.7% (Fig.7). Hispanic households had a 2.5% share, and black households had only a 2.3% share. To analyze these differences, several factors were reviewed.

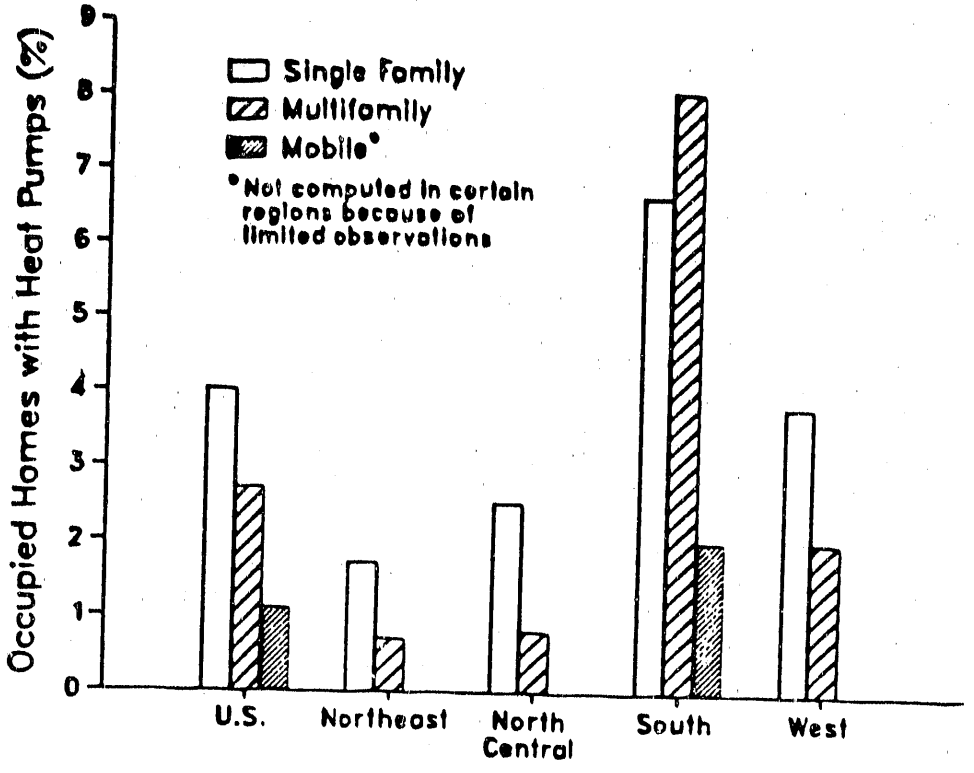


FIGURE 4 Percentage of Occupied Homes with Heat Pumps in 1980, by Type of Home (Source: Based on Refs. 4 and 5)

354,000 residential heat pumps that year (2). The economics of retrofitting older homes with heat pumps is limited by the generally poor thermal integrity of the older home and absence of a central duct system in many older homes.

Heat pump market shares were estimate for three housing-age categories: those built during 1970-1980, 1960-1969, and 1959 and earlier (Fig. 5). As expected, market penetration was highest (11.4%) for homes built during 1970-1980 and lowest (0.8%) for older homes (1959 or earlier). For the intermediate category of homes built during 1960-1969, penetration was 2.6%. As the figure shows, similar patterns occur across all four census regions.

Market Share by Household Characteristics

Heat pump market share is also expected to be influenced by several household characteristics. For example, higher household income may favor the adoption of heat pumps because that technology is more capital intensive than competing systems. A household head and family members with relatively high educational levels may also favor relatively complex technologies like the heat pump. Owner-occupants may prefer to install advanced heat pumps sooner than might landlords.

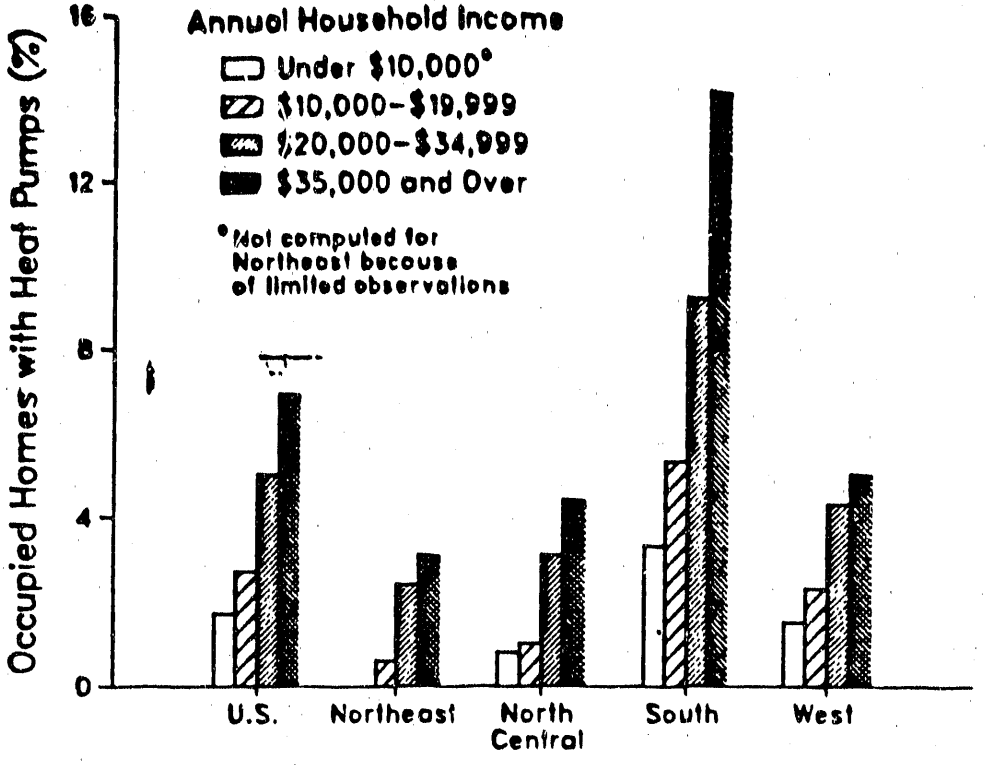


FIGURE 6 Percentage of Occupied Homes with Heat Pumps in 1980, by Household Income (Source: Based on Refs. 4 and 5)

The first factor was the geographical distribution of households. Climate and relative energy prices (electricity/gas and electricity/fuel oil), which generally vary across regions, play key roles in heat pump acceptance. A mild climate, lower electricity prices, and higher fuel oil and/or natural gas prices favor the heat pump over competing heating and cooling systems. To study heat pump ownership patterns, several comparisons were made by controlling geographical areas such as census region, census division, and state. Figure 7 shows this comparison for the four census regions. Penetration in white households exceed that in black and Hispanic households in the South, West and North-Central region, the three regions most important for heat pumps. In the South, which accounted for 61% of the U.S. heat pump market in 1980, this discrepancy reaches its maximum. The same pattern reaches its minimum in the Northeast, which was relatively few heat pumps. Moreover, few blacks and Hispanics have heat pumps in the Northeast.

The discrepancy pattern is seen even at a more localized level. As discussed in Ref. 1, the South Atlantic census division ranks first in the total heat pump market. Here, white household market penetration was 10.0%, compared with 4.0% for black households, the leading minority in this region in terms of population. As discussed earlier, Florida was first among the 50 states, accounting for about 20% of the total U.S. heat pump market. Again, market penetration was highest for white households (16.2%), with blacks having 6.0% and Hispanics 12.2%. This pattern of ownership is generally found in those states with relatively large heat pump markets.

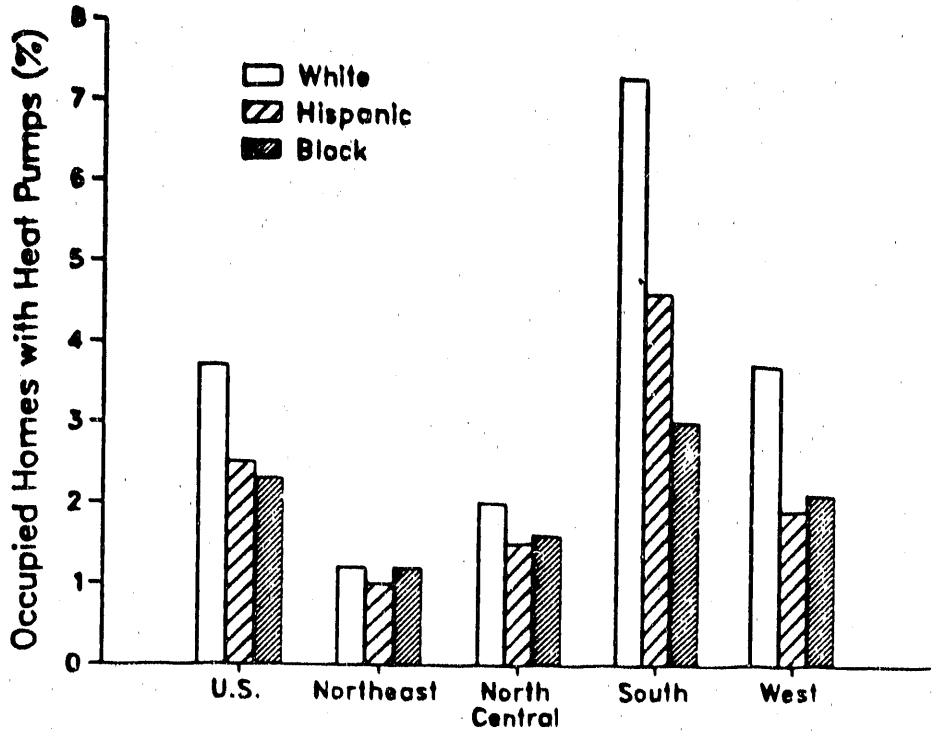


FIGURE 7 Percentage of Occupied Homes with Heat Pumps in 1980, by Race/Ethnic Origin of Household (Source: Based on Ref. 4)

The second factor is household income. As discussed earlier, higher income tends to favor heat pumps. To determine whether the differences between market penetration for different households are due to income variation, the market was analyzed by controlling for region and income of households. Based on 1980 AHS and 1980 Census data, Fig. 8 shows market penetration by income for white, black, and Hispanic households in the South. It is clear from this fugure that when both region and income are statistically controlled, penetration is greater in white households than in black. In the lowest income category (under $10,000 annual household income) in 1980, penetration is much higher in white households than in black (4.2% versus 1.4%). This difference may be because blacks disproportionately live in older homes at all income levels. These older homes have lower heat pump penetration because installation costs are much higher, particularly in homes with no central air duct system. Also, the thermal integrity of older homes is generally poorer than that of homes built after the energy crisis that began in 1973. Figure 8 also shows that the relative gap in the market penetration between white and black households narrows as income rises.

DEVELOPMENT OF THE MARKET PENETRATION MODEL

To project the demand for residential heat pumps across various ethnic households, several methods were reviewed and evaluated (1,8). A method based on a discrete choice model was selected as the most suitable in view of (a) forecasting objectives, (b) heat pump technology

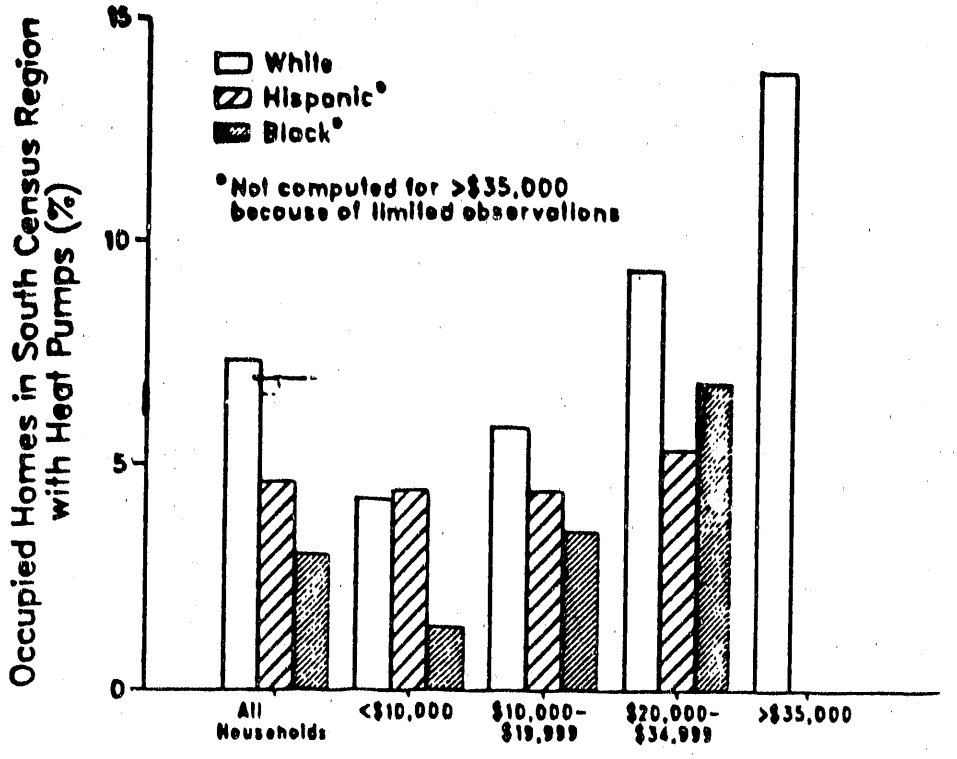


FIGURE 8 Percentage of Occupied Homes in the South Census Region with Heat Pumps in 1980, by Household Income and Race/Ethnic Origin (Source: Based on Refs. 4 and 5)

and market characteristics, and (c) available data sources. The other methods considered were subjective estimates, market surveys, historical analogy models, time-series models, econometric models, diffusion models, economic-cost models, and combined methods.

The total heat pump market comprises four distinct segments: new single-family homes, new multifamily homes, the retrofit market, and the replacement market. Three alternative household data bases (1980 Census (4), Annual Housing Survey (5), and RECS (6)) were evaluated for the discrete choice model. It was concluded that RECS is the most suitable of the three for the present purpose. It was also decided that three available RECS data sets (1980-1981 (6), 1981-1982 (9), and 1982-1983 (10)) should be pooled to maximize the observations. However, because of too few observations, discrete choice models could not be constructed or used for projecting heat pump demand in the replacement and retrofit market for various ethnic households. However, this limitation is not major, as most of the heat pump demand is concentrated in new single-family and multifamily homes. (In 1980, heat pump shipments to new homes accounted for more than 90% of all shipments to the residential sector (2,7).) The model is therefore specified for these new construction market segments only. Some of the explanatory variables considered in the model were family income, education of household head, fuel price ratios(electricity to natural gas and electricity to fuel oil), cooling degree-days, heating degree-days, seasonal performance factor, and capital cost ratio (heat pump versus gas furnace-central air system). Highlights of the specifications of the model and its estimates are provided below.

Discrete Choice Model Estimation: New Single-Family Home Market

Many of the advanced econometric textbooks (Maddala (11); Manski and McFadded (12)) and handbooks (Dhrymes (13)) discuss the theoretical framework for estimating discrete choice models. In addition, discrete models have been applied in many areas including (a) choice of travel mode (Charles River Associates (14), Domencich and McFadded (15)); (b) choices among energy-using appliances (Electric Power Research Institute (16,17); Tolley, Krumm, and Mensah (18)); (c) choices among space conditioning systems and new technologies (Burton, Jackson, and Kaserman (19); Reddy (20)); and (d) choice of durable goods (Electric Power Research Institute (21), Hausman (22)). Our logit model for the new single-family market can be represented as follows:

$$Z = e^{\left(B_0 + \sum_{i=1}^{6} B_i X_i\right)}$$

and

$$Y = \frac{Z}{1 + Z}$$

where:

B_i = constant,
X_1 = family income (thousands of constant 1980 dollars),
X_2 = education of the household head (years),
X_3 = electricity/natural gas price ratio,
X_4 = electricity/fuel oil price ratio,
X_5 = cooling degree-days (thousands),
X_6 = heat pump seasonal performance factor, and
Y = probability of heat pump adoption in a new single-family home.

The means and standard deviations of the explanatory variables are shown in Table 1. Among the explanatory variables listed earlier, only the capital cost ratio was not included for new single-family homes because earlier runs revealed an insignificant coefficient for this variable.

The procedure used to estimate the equation was the NLIN (nonlinear regression) procedure in the SAS User's Guide (23). The regression is based on 1458 observations from the pooled RECS data sets for homes built after 1974. The NLIN procedure is used to compute maximum-likelihood estimates for the logit model (24). Table 2 shows the parameter estimates derived by the NLIN procedure. All explanatory variables have statistically significant coefficients and the correct sign. The parameters associated with family income (B_1), education of household head (B_2), cooling degree-days (B_5), and seasonal performance factor (B_6) have a positive sign. This means that any increase in these variables will result in

a higher demand for heat pumps. The two price ratio coefficients (B_3 and B_4) have negative signs, implying that any increase in price ratios will decrease the demand for heat pumps. Table 2 also indicates the statistical measures of goodness of fit. The last two columns show asymptotic 95% confidence intervals (lower and upper) for each parameter. The range associated with these intervals is extremely narrow, indicating a tight fit.

On the basis of the information in Tables 1 and 2, the most influential variables are the price ratios of electricity/natural gas and electricity/fuel oil, cooling degree-days, and seasonal performance factor (a function of heating degree-days). A second category of relatively less influential variables includes family income. However, given ownership of a new single-family home, the model indicates that family income is not in the category of the most influential variables that affect heat pump adoption. Finally, education of the household head is significant (in statistical terms), but its influence on the probability of heat pump ownership is modest.

Discrete Choice Model Estimation: New Multifamily Home Market

Similar to that for new single-family homes, a model was developed to estimate the probability of heat pump adoption in the multifamily market. The logit model can be represented as follows:

$$Z = e^{\left(B_0 + \sum_{i=1}^{7} B_i X_i\right)}$$

and

$$Y = \frac{Z}{1 + Z}$$

where:

B_i = constant(s),
X_1 = family income (thousands of constant 1980 dollars),
X_2 = education of household head (years),
X_3 = electricity/natural gas price ratio,
X_4 = electricity/fuel oil price ratio,
X_5 = cooling degree-days (thousands),
X_6 = heat pump seasonal performance factor,
X_7 = capital cost ratio (cost of heat pump/cost of natural gas-central air system), and
Y = probability of heat pump adoption in new multifamily homes

The means and standard deviation of the explanatory variables are shown in Table 3. The parameters, estimates, and related statistical measures are provided in Table 4. The regression

TABLE 1 Statistical Measures for Explanatory Variables in the Model for New Single-Family Homes[a]

Variable	Code	Arithmetic Mean	Standard Deviation
Family Income (10^3 1980 $)	X_1	29.067	17.720
Educational Level of Household Head (yr)	X_2	13.285	2.717
Electricity/Natural Gas Price Ratio	X_3	3.837	1.446
Electricity/Fuel Oil Price Ratio	X_4	2.026	0.650
Cooling Degree-Days (10^3)	X_5	0.275	0.390
Seasonal Performance Factor[b]	X_6	1.601	0.327

[a]Source: Pooled data subset from three RECS.

[b]Seasonal performance factor = 2.3 - 0.00015 x heating degree-days (25).

TABLE 2 Logistic Regression of Market Data for Heat Pumps in New Single-Family Homes

Parameter[a]	Estimate	Asymptotic Standard Error	Asymptotic 95% Confidence Interval	
			Lower	Upper
B_0	-0.431	0.005	-0.442	-0.421
B_1	0.812×10^{-2}	0.003×10^{-2}	0.805×10^{-2}	0.818×10^{-2}
B_2	0.453×10^{-2}	0.023×10^{-2}	0.407×10^{-2}	0.498×10^{-2}
B_3	-0.351	0.001	-0.352	-0.349
B_4	-0.274	0.001	-0.276	-0.272
B_5	1.133	0.002	1.130	1.137
B_6	0.259	0.003	0.253	0.264

[a]Note the corresponding variable: X_1 = family income (10^3 1980 $), X_2 = education grade (years), X_3 = electricity price/natural gas price, X_4 = electricity price/fuel oil price, X_5 = cooling degree-days (10^3), X_6 = seasonal performance factor (2.3 - 0.00015 x heating degree-days) (25).

TABLE 3 Statistical Measures for Explanatory Variables in Model for New Multifamily Homes[a]

Variable	Code	Arithmetic Mean	Standard Deviation
Family Income (10^3 1980 $)	X_1	16.244	13.695
Educational Level of Household Head (yr)	X_2	12.841	2.991
Electricity/Natural Gas Price Ratio	X_3	3.795	1.398
Electricity/Fuel Oil Price Ratio	X_4	2.137	0.794
Cooling Degree-Days (10^3)	X_5	0.245	0.373
Seasonal Performance Factor[b]	X_6	1.604	0.342
Capital Cost Ratio[c]	X_7	0.868	0.088

[a]Source: Pooled data subset from three RECS.

[b]Seasonal performance factor = 2·3 - .00015 x heating degree days (25).

[c]Cost of heat pump/cost of gas furnace-central air system.

is based on 617 observations from the pooled RECS data sets. All explanatory variables have the correct signs and are statistically significant. As expected, a positive coefficient is estimated for the parameters associated with family income (B_1), education of household head, (B_2), cooling degree-days (B5), and seasonal performance factor (B_6). This means that an increase in any of these four variables will result in greater heat pump demand. In contrast, parameters associated with three variables have negative signs. These are price ratios of electricity/natural gas and electricity/fuel oil, and capital cost ratio of heat pump/gas furnace-central air system. The implication is that an increase in any of these three will result in lower heat pump demand.

By considering the information in Tables 3 and 4, the variables with relatively larger influence on the probability of heat pump adoption in new multifamily homes can be identified. The climate factors are identified as the most significant and are followed by three cost-or price-related variables. These three variables (with negative signs) are price ratios of electricity/natural gas and electricity/fuel oil, and cost ratio of heat pump/gas furnace-central air system. Finally, family income and education of household head positively, but modestly, affect heat pump demand.

TABLE 6 Logistic Regression of Market Data for Heat Pumps in New Multifamily Homes

Parameter[a]	Estimate	Asymptotic Standard Error	Asymptotic 95% Confidence Interval	
			Lower	Upper
B_0	-2.224	0.021	-2.264	-2.183
B_1	1.517×10^{-2}	0.007×10^{-2}	1.504×10^{-2}	1.530×10^{-2}
B_2	1.111×10^{-2}	0.034×10^{-2}	1.041×10^{-2}	1.173×10^{-2}
B_3	-0.079	0.001	-0.081	-0.077
B_4	-0.262	0.002	-0.266	-0.259
B_5	0.751	0.003	0.745	0.757
B_6	1.485	0.006	1.474	1.496
B_7	-2.113	0.018	-2.148	-2.079

[a]Note the corresponding variables: X_1 = family income (10^3 1980 $), X_2 = education of household head (years), X_3 = electricity price/natural gas price, X_4 = electricity price/fuel oil price, X_5 = cooling degree-days (10^3), X_6 = seasonal performance factor (2.3-.00015 x heating degree-days) (25), X_7 = cost of heat pump/cost of gas furnace-central air system.

By considering the information in Tables 3 and 4, the variables with relatively larger influence on the probability of heat pump adoption in new multifamily homes can be identified. The climate factors are identified as the most significant and are followed by three cost- or price-related variables. These three variables (with negative signs) are price ratios of electricity/natural gas and electricity/fuel oil, and cost ratio of heat pump/gas furnace-central air system. Finally, family income and education of household head positively, but modestly, affect heat pump demand.

The estimated income coefficiency (B_1) of the multifamily model is almost twice that of the single-family model, that is, 1.517×10^{-2} versus 0.812×10^{-2}. This means, as one would expect, that faimly income is even more important for heat pumps in the case of new multifamily homes.

PROJECTIONS OF MINORITY PARTICIPATION IN NEW SINGLE FAMILY/MULTIFAMILY HEAT PUMP MARKET

The approach used to forecast heat pump demand in future years can be mathematically expressed as follows:

$$\begin{pmatrix}\text{Projected heat pump demand in the new single-family/multifamily segment in each future year}\\ [3]\end{pmatrix} = \begin{pmatrix}\text{Probability of heat pump adoption in new single-family/multifamily homes in each future year}\\ [1]\end{pmatrix} \times \begin{pmatrix}\text{Number of new single-family/multifamily units in each future year}\\ [2]\end{pmatrix}$$

Items 1 and 2 in the equation must be estimated.

The probability of future heat pump adoption (Item 1) was estimated by using the 1982-1983 RECS data base. All households built in or after 1970 that did not already have a heat pump were identified, along with their values for all the explanatory variables. The explanatory variables were then projected into the future at the household level using information provided in DRI's (Data Resources, Inc.) "Energy Review: Winter 1984-1985" (26). The DRI document provides information on most of the key variables by geographical region and, hence, projections for the explanatory variables could be adjusted for the census division of each household. The Argonne National Laboratory report (1) provides further details on how each explanatory variable was projected into the future using the DRI information. The projected values of the explanatory variables for each future year, a probability of heat pump adoption was thus obtained for each household. Probabilities of adoption were then averaged for black, Hispanic, and white households to be the market share of the heat pump in the new single-family/multifamily market.

The number of new single-family and multifamily homes in future years (Item 2) was also obtained using the DRI information (26). This item essentially indicates the size of the target market. The product of Items 1 and 2 (market share times size of target market) then yields the number of heat pumps demanded in future years.

Table 5 shows the heat pump market estimated by the discrete choice models for 1984-2000. Results are shown by black, Hispanic, and white households. Across different households, heat pump shipments demonstrate a weakness in the near term (1984-1986). Total shipments decline from 483,000 units in 1984 to 430,000 units in 1986. The cause is primarily the increased price ratios of electricity and natural gas, and of electricity fuel oil. This is occurring because (a) the real prices of natural gas and fuel oil are declining in the current oil-glut environment and (b) the cost of electricity is rising because more expensive capacity such as

new nuclear power plants is coming on-stream. These negative factors overwhelm the changes that are positive for heat pump growth in this short period; namely (a) a relative increase in heat pump performance, (b) a slight increase in new home construction, and (c) an increase in family income.

By 1987, with the projected turnaround in real crude oil prices, with modestly escalating prices thereafter, an increase is seen in heat pump demand. Total factory shipments to the single-family/multifamily homes will rise to 468,000 units/year by 1990 and to 514,000 units/year by 2000. Also, advances in heat pump technology are expected to allow the use of heat pumps at an even lower threshold ambient temperature. On the basis of the models, heat pump market penetration in new single-family and multifamily homes is projected to grow fastest in the Northeast (from 36,000 units in 1984 to 84,000 units in 2000).

TABLE 5 Projected Heat Pump Demand in New Homes, by Race/Ethnic Origin of Household, 1984-2000

Category	Thousands of Heat Pumps						Average Annual Rate of Change (%)	
	1984	1985	1986	1987	1990	2000	1984-1990	1990-2000
New Single-Family Homes								
White	258	245	231	234	261	298	0.2	1.3
Black	28	24	22	22	25	26	-1.9	0.4
Hispanic	14	13	12	12	13	14	-1.2	0.7
Total	306	287	270	272	302	343	-0.2	1.3
New Multifamily Homes								
White	146	137	131	132	137	139	-1.1	0.1
Black	17	16	15	15	15	15	-2.1	0.0
Hispanic	5	5	5	5	5	6	0.0	1.8
Total	177	167	160	161	166	171	-1.1	0.3
All New Homes								
White	404	382	362	366	398	437	-0.2	0.9
Black	45	40	37	37	40	41	-1.9	0.2
Hispanic	19	18	17	17	18	20	-0.9	1.0
Total	483	454	430	433	468	514	-0.5	0.9

As was true for the total population trend in new single-famny and multifamily homes, heat pump demand for black and Hispanic households is weak in the near term. In the new homes category, black and Hispanic households account for 9.3% and 3.9% of the total market, respectively. Heat pumps estimated for black households amount to 45,000 in 1984, declining to 37,000 in 1987. The turnaround in energy prices in 1987-2000 enables the demand to recover to 40,000 by 1990 and to remain stable thereafter. For Hispanics, heat pump demand slips from 19,000 in 1984 to 17,000 in 1987. The turnaround then pushes demand to more than 20,000 by 2000. Similar trends are observed for the two detailed segments of new single-family homes and new multifamily homes.

CONCLUSIONS

This paper documents the phenomenal growth in the use of heat pumps in the 1970s. The market share analysis shows that historically heat pumps have had their greatest penetration in the South, in single-family homes, in newer homes, rural areas, and in owner-occupied housing. In addition, the heat pump market share increases with family income and with the educational level of the heat of household. This paper also demonstrates that, compared with white households, black and Hispanic households have lagged in adopting heat pumps. This disparity varies by region, with the key South region accounting for the greatest disparity (Fig. 7). Even when controlled for both region and family income, black and Hispanic households lag behind white households (Fig. 8).

The binomial discrete choice model presented in this paper projects heat pump demand in new single-family and multifamily homes occupied by white, black, and Hispanic households. These projections show that the dispartiy between white and black/Hispanic households will widen because heat pump demand between 1986 and 2000 is projected to increase by about 21% for white households but only about 11% for black and 18% for Hispanic households. These findings have important implications in terms of their effect on the future energy consumption and expenditures patterns of white, black, and Hispanic households. These effects should be studied in detail. Also, the binomial discrete choice model could be expanded to a multichoice model to include other heating and cooling systems. This type of model could be estimated by a multinomial logit model (Maddala (11), Manski and McFadden (12), Domencich and McFadden (15)).

Finally, with the availability of appropriate consumer survey data, the discrete choice model used in this study could easily be adapted to analyze the participation of different ethnic households in the growth of other new energy technologies and products.

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ENERGY EFFICIENCY IN RENTAL HOUSING

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ENERGY EFFICIENCY IN RENTAL HOUSING

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ENERGY CONSERVATION AND ECONOMIC DEVELOPMENT

Price and availability of energy can be significant determinants of a state's economic future. Where indigenous resources comprise a small amount of a state's energy supplies, most money spent on energy is transferred to export economies, reducing expenditures for goods and services in local markets. Preventing this transfer through conservation actions can increase household disposable income and exert substantial impacts on local sales, investments, jobs, and the local tax base. A strong relationship can therefore exist between economic development and energy efficiency in the various sectors of a community.

Kirschling and Pnazek (1982) described the economic impact of energy expenditures in a community with respect to the frequency of dollar turnover or recirculation. A given dollar spent on energy has a smaller impact on local economic growth than does a dollar spent on other goods and services. While a dollar spent on local goods and services can turn over up to five times before it leaves a city, this turnover may occur only once with a dollar spent on energy, resulting in minimal productive impact on a local economy.

Another concept which can be used to measure impacts of growth or development resulting from energy conservation in a local economy is that of the economic multiplier. Multipliers are used to estimate direct and indirect effects of respending money generated from development or other stimulus in a local economy. These effects result from interactions among businesses, households, and government agencies as they purchase goods and services from each other. Multipliers are calculated through an estimation of the portion of money introduced to an area that remains and is respect, after accounting for the portion that leaves the local economy, or leakage. Multipliers are used to estimate the magnitude of an economic impact or change on income, business, and employment (Lewis et al., 1979).

In addition to benefits which can be estimated through turnover or multiplier effects, local economic development and community revitalization can benefit from the impacts of an expanded energy conservation industry meeting the needs of goods and services related to energy efficiency (Scales and Popkin, 1983; Butterfield and Eisen, 1987). A reduction in

energy demand through efficiency improvements can also be viewed as an environmentally benign mechanism for increasing energy supply without the need for additional generating facilities. Meier (1982) used the concept of supply curves of conserved energy to illustrate the "energy producing" aspects of energy conservation.

The consequences of given levels of energy efficiency in a community clearly extend beyond the individual to the community as a whole. "From the policymakers' point of view, the return on investment in retrofitting homes to make them more energy efficient should be compared with such supply-enhancing investments as off-shore drilling rigs and nuclear plants. Viewed in this framework, investments to improve energy efficiency are no different from coal mines or geothermal wells. They are merely alternative investments that ultimately will contribute to the health of the economy and to reduction of oil imports." (Sawhill and Cotton, 1986; p.5)

In some sectors of a local economy, price signals to energy end users are instrumental in achieving optimal levels of conservation. Such is the case with owner-occupied housing in the residential sector, where a clear relationship exists between investors and beneficiaries of energy conservation measures. But a number of institutional barriers in rental housing markets which can be viewed from economic, social, and political perspectives, are conducive to low levels of energy efficiency in a substantial portion of a community's housing stock, which is in many cases inhabited by those who can least afford anticipated energy price increases.

INSTITUTIONAL ISSUES

Although the proportion of rental housing varies regionally in the United States, nationwide over one-third of the residential housing stock is comprised of rental units. In New York State, 51 percent of year-round housing units are renter-occupied (Division of Housing and Community Renewal, 1984). In comparison with owner-occupied housing, the rental sector provides shelter for a higher proportion of low income and elderly households, with the poorest of these households often responsible for fuel bills in units characterized by the lowest levels of energy efficiency (Bleviss and Gravitz, 1984).

The achievement of optimal levels of energy efficiency in rental housing is problematic for reasons that have been described by Counihan and Nemtzow (1981), Levine and Raab (1981), Suchy and VonZuckerstein (1982), and Bleviss and Gravitz (1984). The very nature of rental housing gives rise to a split incentive: those who make decisions about a building's level of energy efficiency are not the same people who use energy within that structure. State building codes resolve this problem in new construction by requiring that minimum standards for energy efficiency be met. But for existing structures, many of which will be standing well into the next century, owners can pass along energy cost increases to tenants, regardless of inefficiencies in a building's thermal envelope and mechanical systems.

The manner in which energy costs are allocated to tenants can influence consumption as well as decisions made about energy conservation. Properties can be master metered, with tenants

seeing rising energy costs as increases in overall rent payments. In such cases, subject to possible constraints through rent control ordinances, owners can pass along energy price increases to tenants. In individually metered buildings, tenants are directly responsible for utility payments and can make behavioral changes that affect energy conservation, but available options are limited. Orpin (1981) described obstacles faced by property management firms when addressing conservation issues in rental housing. Tenants apathy in master metered buildings can be difficult to counter with education programs along. But addressing the issue through individual apartment metering or submetering may be prohibited by state or local govenments. One consequence of rent control provisions that prohibit rent increases in proportion to utility cost increases is inadequate cash flow to allocate to energy conservation measures.

Major efficiency improvements to the building shell or mechanical systems are not likely to be undertaken by tenants for legal and financial reasons, and owners can lack incentives for undertaking them. Owners of rental housing represent a diverse group with various motives for property ownership. They include individuals, partnerships, corporations, and government housing authorities. Although tax incentives that facilitated the development of rental housing have been eliminated or curtailed, profit motivations for these groups include capital gains and cash income, or a combination of these considerations. Investment criteria for energy efficiency can include improvements to a property's cash flow, requirements for meeting specified payback times, or in some markets, increases in the marketability of properties.

From their research involving a purposive sample of rental property owners, Levine et al. (1982) reported that landlord options for overcoming barriers to energy conservation varied on the basis of building metering strategy, number of units owned, intended length of ownership, existence of subsidies and rent control ordinances, and availability of favorable financing or other incentive programs. Tenant appeasement to minimize turnover was also cited by owners of buildings with few units. But these authors noted that even if preferred incentives are easily available to landlords, substantial energy conservation measures are unlikely to be implemented in separately metered properties. They concluded by noting that state and local governments need to mandate standards in order to achieve energy efficiency in rental housing. They caution that such an approach should be undertaken with a simultaneous provision of financial incentives and technical assistance.

TECHNICAL OPTIONS

In addition to substantial institutional barriers to rental housing energy efficiency, technical issues pose problems as well. A greater understanding of efficiency improvements to the building shell and mechanical systems of single family homes and little demand for energy efficiency services in the rental sector has contributed to a lack of technicians experienced in multi-family housing energy efficiency (Bleviss and Gravitz, 1984).

One problem facing the implementation of energy efficiency, technical issues pose problems as well. A greater understanding of efficiency improvements to the building shell and

mechanical systems of single family homes and little demand for energy efficiency services in the rental sector has contributed to a lack of technicians experiences in multi-family housing energy efficiency (Bleviss and Gravitz, 1984).

One problem facing the implementation of energy efficiency improvements in the rental sector is a general lack of documentation regarding their effectiveness in multi-family housing, which comprises 70 percent of the rental stock. Goldman and Greely (1986) reported that an ongoing effort at Lawrence Berkeley Laboratory is addressing this situation through compilation and analyses of economic data on energy efficiency improvements in multi-family buildings. In addition to behavioral changes implemented through operations and maintenance procedures, typical conservation strategies implemented for buildings in this sample were improvements to heating system efficiency through modification or replacement of equipment or controls. Although storm and replacement windows were cited as frequent conservation measures undertaken, improvements to the thermal envelope were not as common as those made to heating systems.

Because different combinations of energy efficiency improvements are typically used when a conservation strategy is implemented for a multi-family structure, savings from individual measures are difficult to predict. But as reported by Goldman and Creely (1986), data have been gathered from buildings where individual measures were installed. Outdoor resets and cutout controls have demonstrated 13 percent reductions in space heating energy consumption in buildings with hydronic systems. Because these controls work by inversely varying boiler water temperature with outdoor temperature, tenant comfort is also increased. Another situation that affects tenant comfort and energy consumption is uneven heat distribution in steam-heated buildings. Steam balancing, through the installation of main line air vents, new boiler controls, and thermostatic radiator valves, has been shown to improve heat distribution and generate annual savings of about 6 percent. High efficiency boilers were shown to reduce energy consumption by 50 percent in a public housing project when they replaced an oversized system that sacrificed efficiency to meet domestic hot water needs in the summer. Thirty-two modular boilers now operate in place of the large single boiler, but only 8 of those are fired for summer hot water needs.

Reducing energy demand through tenant participation in a conservation program is the strategy on which check-metering is based. Because check-meters record energy use at specific locations in a building, tenants can be provided with feedback about their consumption. Such an approach has been used in conjunction with conservation education and rebate incentives for tenants, and has resulted in energy savings of 30 percent (Haun, 1985).

Linteris (1986) analyzed the conversion of twelve 11-unit apartment buildings in a public housing complex from central space heating and domestic hot water (DHW) systems to individual utility services. A gas-fired furnace with a seasonal efficiency rating of 64 percent and a gas-fired water heater with a service efficiency of 44 percent was installed in each apartment. After estimating gas consumption by the complex, the performance of the installed systems was compared through simulation with systems capable of higher efficiencies. These

included a direct vent high efficiency hydronic system; an integrated hydronic heating and DHW system; a combination condensing furnace and high efficiency combustion chamber water heater; direct vent space heaters in combination with combustion water heaters; and an electric furnace/electric water heater combination.

The results of Linteris' study demonstrated savings from each of the decentralized gas systems, with slightly higher savings from the more efficient options. An interesting result of this study was that the highest level of savings was estimated for the strategy using direct vent space heaters. Space heaters offer advantages of greater area temperature control and low initial costs. Their use with direct vent water heaters can substantially reduce energy consumption. Because these systems require no chimney connection, they may be feasible for various types of multi-family buildings.

LOCAL RESPONSES

Under ideal conditions, competitive markets in a local economy establish optimal levels of energy efficiency that minimize economic leadage from various sectors. Rental housing markets seldom operate under such ideal conditions. Recognizing this and the consequences of economic leakage, state and local governments have experimented with educational, incentive, and regulatory programs to achieve acceptable levels of energy efficiency in rental housing. Other motivations for upgrading energy efficiency in this sector have provided impetus for the contributions of public housing authorities and energy service companies in this regard.

Goldman and Ritschard (1986) discussed the effectiveness of a modernization program operated by the U.S. Department of Housing and Urban Development to improve building envelope and mechanical system efficiencies of properties operated by local public housing authorities. These authors analyzed utility bills over a three-year period from five housing projects of the San Francisco Housing Authority. Data from one year covered by the analysis represented utility bills following implementation of energy efficiency improvements. Energy savings were found to vary from between 9 and 20 percent of pre-retrofit consumption. Variation in savings was attributed to occupant density levels, malfunctioning heating system controls, and building configuration. Overall, however, the authors concluded that this energy conservation program was effective at reducing consumption and improving tenant comfort levels. Calculated savings represented net benefits of $400,000 over the economic lifetime of the retrofits. This project demonstrated the feasibility of implementing an energy conservation program in publicly funded multi-family dwellings, where benefits accrue not only to tenants and operators, but also to taxpayers.

The reduction of energy costs in rental properties through retrofits and improved management practices has also been undertaken on both a profit and non-profit basis through energy service companies. Although the structure of these companies vary, they perform energy efficiency analyses, implement conservation measures, and derive their fee from resulting energy savings. While the proft-making companies have concentrated on properties housing higher income people, non-profit organizations have addressed the more difficult problems facing

buildings with moderate and lower income tenants. These properties are generally older and in need of more improvements to the building shell and mechanical systems, resulting in more extensive and riskier energy conservation investments. With the assistance of grant support to finance operations, non-profit energy service companies are serving this sector in some areas.

State and local governments have also implemented programs to address rental housing energy efficiency. New York City, for example, has taken steps to reduce energy consumption in many of the buildings it has acquired through abandonment. These properties are generally in need of extensive energy efficiency improvements. Programs within the City's Department of Housing Preservation and Development have addressed these needs through education of building superintendents and tenants, arrangements with energy service companies, and rehabilitation programs that include improvements to building shells and mechanical systems. In conjunction with the local utility, the city of Minneapolis has developed an energy audit program for buildings with 5 to 50 apartments, which is being offered to landlords at a subsidized cost. A state rental code in Minnesota and favorable financing terms for energy efficiency retrofits help to make this program effective.

Where incentives to encourage improvements to rental housing energy efficiency through landlord investment or landlord-tenant cooperation are given little chance of success and the importance of energy conservation in the rental housing sector is recognized, a regulatory approach by state or local governments has been followed. As reviewed by Butterfield and Eisen (1987), this has been the case in a number of U.S. states and cities. Residential energy conservation ordinances differ from typical building energy standards, because they apply strictly to existing housing. Provisions of these ordinances vary according to implementation, compliance, and enforcement, and reflect local climatic conditions as well as conditions of the local housing stock. Minnesota and Wisconsin have implemented statewide standards for energy efficiency in existing rental housing, but even before these were developed, the city of Madison had developed an energy code for this sector. South Dakota's ordinance applies to dwellings financed through the state housing authority. While San Francisco's energy conservation ordinances applies to all dwellings, more stringent standards must be met by buildings with more than 5 units. In addition to other mandated energy conservation codes and ordinances, the city of Davis, California has a retrofit ordinance which specifies conservation measures which must be in place before a unit is sold. Some cities, such as Chicago, have worked with utility companies to develop low interest loan programs for financing energy conservation measures in rental housing.

Community objectives in establishing residential energy conservation ordinances usually relate to the selection of conservation measures that will be enforced, the establishment of procedures for implementation, and the development of methods for certifying compliance. Conservation measures chosen for enforcement are typically selected for their applicability to a particular climate, their suitability given the age and condition of the existing housing stock, and the ease with which selected measures can be identified for compliance. Operational procedures for a conservation ordinance usually include specifications of the effective date, investment limits or options, measures covered usually include specifications

of the effective date, investments limits or options, measures covered and/or excluded, and exemption procedures. Compliance certification procedures are also specified, and typically involve routine housing inspections, time of sale clauses, or participation in a utility energy analysis program. Preliminary reviews of the effectiveness of energy conservation ordinances have indicated that they are cost-effective and generally perceived as reasonable mechanisms for implementing energy conservation strategies.

THE EXPERIENCE OF ITHACA, NEW YORK

Price and availability of energy are significant determinants of New York State's econor future. In 1982, state residents paid 26.7 billion dollars for energy, as compared with 7 billion in 1972 (New York State Energy Office, 1983). Because indigenous resources comprise less than 10 percent of the State's energy supplies, most of the 26.7 billion dollars were transferred to export economies, reducing local expenditures for goods and services. Ithaca, New York, is a small city with a large student population (attending Cornell University and Ithaca College). In 1984, rental units comprised 65.4 percent of the total housing stock and exhibited a two percent vacancy rate. Not all renters in Ithaca are students. Low income households, who may often have fewer financial resources than students, are also included in the category. This high proportion of renters coupled with such a low vacancy rate contributes to a tight rental market. A breakdown of housing units by structure type is shown in Table I.

TABLE I
Rental Housing Units Per Structure

Number of Units in Structure	Number of Units	Percent of Total
1	905	14%
2	1079	17%
3 and 4	1265	20%
5 or more	2969	48%
mobile home	12	0.1%

Source: 1980 Census of Population: Characteristics of People and Housing

Having implemented a successful energy conservation program in municipal buildings and outdoor lighting systems, members of the Ithaca Energy Commission decided to examine the issue of rental housing energy efficiency within the city. This topic had been studied by the commission three years earlier, and a proposal was made to the City Planning Department that the Municipal Housing code be amended to include a weatherization ordinance. For a number of reasons, the proposal had not been implemented, and the Commission decided to pursue it with a renewed effort. A committee was established to investigate the issue and make recommendations.

The rental housing committee began its task by reviewing the original ordinance proposal. The recommended ordinance consisted of prescriptive standards for insulation in attics and

in floors above unheated spaces as well as on water heaters. Attic ventilation, storm windows, and weatherstripping were also addressed in this version of the ordinance, as were exemptions for certain conditions. The committee agreed in this version of the ordinance, as were exemptions for certain conditions. The committee agreed that alternatives to regulation should first be explored before reviving the idea of a weatherization ordinance. Meetings were held with university administrators in charge of providing off-campus housing information to students. The situation was described as follows: Competition among students to locate apartments for the next academic year, beginning in late August, starts in March of the previous year. Apartments are rented quickly, with energy efficiency being of little concern to prospective tenants, who instead select on the basis of distance from campus and monthly rent. A program to increase student awareness of energy efficiency as a criterion for apartment selection was recommended to the Commission. This led to the development of an Energy Commission brochure that is distributed at student housing fairs and information centers entitled, "Check Out Energy Efficiency."

Meetings were alo held with representatives of the local utility, New York State Electric and Gas (NYSEG) and the county Department of Social Services (DSS). A continual problem faed by DSS concerns renter households receiving public assistance. DSS assumes responsibility for utility bills where a rental unit occupied by one of these households is individually metered. These units are often single family dwellings or mobile homes with low levels of energy efficiency. DSS has no mechanism for establishing minimum levels of energy efficiency in the units it subsidizes. And because the households are not responsible for utility bill payments, they have little incentive to conserve. As documented by NYSEG, DSS is its second largest customer, after Cornell University.

Although Commission members believed the long run solution to the problem of energy efficiency in rental housing depends on educated tenants who express demand for efficient units, institutional problems within Ithaca's rental housing market justified government intervention. Alternatives for mandating energy conservation were considered. Discussions regarding one of the alternatives, amending the Municipal Housing Code, were held with the City Building Commissioner. Concerns over such an ordinance expressed by this official included inadequate staffing to handle an ever increasing workload. Current duties included housing and building code inspections, complaint responses, building permit reviews and inspections, zoning appeals, processing, state-mandated inspections, and more. He did not favor the idea of yet another ordiance to enforce. In a later memo to the mayor and members of Common Council, he stated:

> "At a time when the Building Department is already being overtaxed ith new alws from the State (requiring installation of smoke detectors, evacuation plans for hotels, motels, etc., inspection of solid-fuel- burning equipment), not to mention the difficulties of enforcing our zoning-map-of-the-week Zoning Ordinance, it seems to me ludicrous to pile on another ordinance of questionable enforceability." (Hoard, 1986)"

Although the Building Commissioner did not support the idea of an ordiance that required specific levels of energy conservation, he advised that if one were to be developed, ease of enforceability should be a primary consideration. Any required measures should be simple to identify, with identification easily integrated into the city's three-year cycle of inspections. Through further meetings and discussion and a data collection effort, a proposed amendment to the Municipal Housing Code was drafted which specified that all exterior windows in rental units not already double-glazed should be provided with a second layer of glazing. Data were collected by City Building Inspectors during their routine housing inspections in the period of January 17 to February 14, 1985, and are summarized in Table II.

The proposed ordinance was far less comprehensive than the Energy Commission had originally hoped to include in an ordinance. It quickly became known as the "Storm Window Ordinance" in the local and regional newspapers that covered meetings of Common Council's Charter and Ordinance Committee. Landlords attended a public hearing on the proposal and were divided in their positions. Some objected to being singled out by such an ordinance, and felt that it should apply to owner-occupied dwellings as well. Others thought it represented unnecessary government intrusion into what should be a free market. Others thought that improving energy efficiency in rental dwellings was a misguided effort, because tenants often keep windows open during the coldest days of winter. Some supported the proposal, but thought it should be more comprehensive. Based on these discussions, Common Council voted not to support the ordinance.

Another verison of the energy conservation ordinance was developed over the next several months and subsequently approved by Common Council. Ongoing discussions with landlords and members of the Council led to the drafting of an ordinance that covered more items than simply storm windows, but the standards are minimal. The full text of the ordinance is presented in the Appendix. Essentially, it pertains to all dwelling units within city limits, and requires that in order to obtain a Certificate of Compliance with the Housing Code, each unit must meet at least one of the following requirements: A minimum R-value of 19 for attic or roof insulation; two or more layers of glazing on all exterior primary windows of habitable spaces; or a 75 percent combustion efficiency of a gas-or oil-fired heating system. A Certificate of compliance is currently required for all rental units, and is issued following the inspection that occurs every three years. For owner-occupied units, the certificate is required at time of sale. This method of implementation allows for a relatively simply enforcement for the Building Commission, since it is incorporated into the ongoing inspection cycle. Vertification of required measures can be provided through a NYSEG (or comparable) energy survey and receipts for completed tests to materials. This amendment to the Municipal Houing Code became effective January 1, 1987. Shortly after the implementation date, NYSEG expanded its low interest loan program for energy conservation improvements to include multiple family dwellings eith more than five units. Prior to this, only buildings with up to four units were covered by the program.

TABLE II
Summary of Data Collected by Ithaca Building Commission

Number of Buildings Inspected	73
Number of Usable Surveys	53
Number of Units in Usable Surveys	148
Average Glazed Area Per Unit With Double Glazing	74%
Number of Exterior Doors	202
Number of Exterior Doors With Storm Doors	97 (48%)

	Good	Fair	Poor
Condition of Exterior Finish	27	24	2
Condition of Caulking & Weatherstripping	16	28	9

Utility Metering

Master Metering:	19 (36%)
Individual Metering	34 (64%)

Conclusion

Ordinances that mandate energy conservation may present the only way to assure that minimum standards of energy efficiency exist in tight housing markets. The relationship between energy efficiency and local economic development justify government intervention to educate the public on this issue, and to mandate conservation if necessary. Although the energy conservation ordinance finally adopted by the City of Ithaca represents minimum standards, it stimulated a high degree of public awareness and discussion on the topic, and allows tenants some measure of control over the levels of energy efficiency in their rented homes or apartments. Local and regional newspapers as well as the broadcast media covered the issue throughout its development. The New York State Energy Office and the U.S. Department of Energy presented the city with an award for innovation in energy efficiency. It is hoped that other cities throughout the state may follow a similar approach.

In an analysis of the effectiveness of Ithaca's energy conservation ordinance, conservation savings were projected using the data collected by the Building Commission (Durland, 1986). Annual savings were calculated to be $115,000 per year from storm window installation, $165,000 per year from attic insulation, and $145,000 per year from improvements to heating system efficiencies. These savings were projected assuming that all required measures would be implemented where they are lacking. Future research after the ordinance has been in effect for a period of time will allow the calculation of more precise estimates and the application of appropriate multipliers.

As a starting point for encouraging energy conservation in rental housing, the approach used in Ithaca may be suitable for other communities with tight housing markets and a high proportion of renter-occupied units. Although slight rent increases may occur to cover the cost of conservation improvements, any increases are likely to be minimal. Current development projects in Ithaca are increasing the rental housing stock; and the expansion of NYSEG's low cost financing for energy conservation improvements limits the cost to landlords of meeting the minimum standards. But the ordinance may not be appropriate for other cities where multiple family dwellings may still be excluded from utility energy conservation programs or where rent control regulations prohibit rent increases to cover the cost of such improvements.

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APPENDIX

Text of Ithaca's Energy Conservation Ordinance

2/20/86

XIII. CHARTER AND ORDINANCE COMMITTEE - AGENDA B

ORDINANCE NO. 86

AN ORDINANCE AMENDING CHAPTER 27 ENTITLED "HOUSING CODE" OF THE CITY OF ITHACA MUNICIPAL CODE.

BE IT ORDAINED AND ENACTED by the Common Council of the City of Ithaca, New York as follows:

Section 1. That Chapter 27 entitled "Housing Code" of the City of Ithaca Municipal Code be amended as follows:

That a new Section to be known and designated as Section 27.45 to follow Section 27.42 is hereby added to said Chapter to read as follows:

27.45 Energy Efficiency

A. Purpose.

It is the purpose of this section to encourage energy efficiency and conservation in the City of Ithaca. The City finds that this ordinance: will encourage the conservation of a finite public resource; will improve the quality of life for all residents by generating more affordable housing, more comfortable dwellings and a cleaner environment; will encourage landlords to make energy improvements for utility paying tenants; will reduce the flow of energy dollars out of the local economy.

B. Compliance.

No certificate of compliance shall be issued for any dwelling unit after January 1, 1987, unless there is full compliance with this section.

C. Requirements.

1. All dwelling units shall have one of the following:

a. Attic or roof insulation with a minimum R-value of R-19; or

b. Permanently or seasonally mounted storm windows, as a second covering, on all exterior primary windows of habitable spaces from November 1st to April 1st of each heating season. Windows with two or more layers of glazing are acceptable. Other acceptable alternatives are: interior treatments including polyethylene or acrylic systems. The use of Lexan is unacceptable; or

c. Heating system(s) with a verified minimum annualized fuel use efficiency (AFUE) of 65% or combustion efficiency of 75% as verified within the preceding two years. This alternative does not apply to dwelling units whose primary heating system is electrical; such units shall meet either requirement B1 or C1 above.

2. Actions to meet the foregoing requirements must be consistent with the New York State Uniform Fire Prevention and Building Code.

D. Verification.

Evidence of storm windows can be verified by visible inspection by a city building or housing inspection, or an owner's Affidavit of Compliance with this section; other items can be verified by:

1. New York State Electric & Gas Corporation (NYSEG), or comparable audit report on building or apartment; or

2. Receipts for completed tests, work or materials.

In the absence of the foregoing verifications provided to the City Building Department, dwelling units will be assumed to be not in compliance.

E. Penalties.

Notwithstanding any other law to the contrary, failure to comply with this section shall be punishable only by the non-issuance of a certificate of compliance for the dwelling unit. This provision shall not reserve or diminish any requirement for obtaining a certificate of compliance, or any penalty which can be imposed for failing to obtain a certificate of compliance.

F. Appeals.

Appeals for exemptions from these requirements may be made in writing to the Housing Board of Review. Exemptions may be granted under the following demonstrated conditions:

1. Financial hardship; or

2. The measures are not cost-effective; or

3. The measures create unsafe conditions.

LEVERAGING OIL RESTITUTION FUNDS FOR MINORITY COMMUNITY AND ECONOMIC DEVELOPMENT

LISA POSNER

LEVERAGING OIL RESTITUTION FUNDS FOR MINORITY COMMUNITY AND ECONOMIC DEVELOPMENT

Lisa Posner
Director of Program Development

Consumer Energy Council of America Research Foundation
Washington, DC

BACKGROUND

Recent settlements of oil company overcharges have resulted in a massive distribution of $4 billion to state treasuries, with billions more to come. The courts have ruled that these funds, allocated to states based upon their historical petroleum consumption[1] must be used for "restitutionary programs"[1] which "benefit, directly or indirectly, consumers of petroleum products within the State."[2]

The oil overcharge funds have various stipulations for their use. Exxon funds must be used for five strictly regulated federal conservation and fuel assistance programs: Weatherization Assistance Program (WAP), Low-Income Home Energy Assistance Program (LIHEAP), Institutional Conservation Program (ICP), State Energy Conservation Program (SECP), and Energy Extension Service (EES). Stripper Well funds may go to any existing or new conservation or fuel assistance program. Table 1 presents a breakdown of funds distributed to the states as of April 1987.

Minority organizations in each state will clearly benefit from any of the oil overcharge funds supplementing federal programs. Each of these programs reaches a minority audience, whether targeted to low-income groups (WAP and LIHEAP), to schools and hospitals (ICP), to a number of residential, commercial, industrial, institutional, or transportation pilot programs (SECP), or small-scale energy users (EES). For example, the Department of Health and Human Services (HHS), the only federal agency collecting such figures, estimates that 73 percent of LIHEAP funds reaches whites, including Hispanics, 25 percent goes to blacks, and 2 percent goes to other minority groups (FY 1985 estimates).[3]

Some states are targeting funds to specific minority groups, in most cases Indian tribes. This is especially true for the Stripper Well funds which have fewer "strings" attached to their use. Virtually all of the states are targeting funds to LIHEAP which reaches a large minority population. Of the 17 states that have filed Stripper Well plans with DOE as of April 1987, four have targeted funds to Indian tribes, and 13 have targeted funds to LIHEAP.[4]

TABLE 1:

STATE ALLOCATION OF EXXON OIL OVERCHARGE AND
STRIPPER WELL SETTLEMENTS BY STATES
(Distributed as of April 1987)

State	% Share (a)	EXXON $2.098 (b) (In $ Millions)	STRIPPER WELL $727 (c) (In $ Millions)	TOTAL TO DATE $2.825 (In $ Millions)
Alabama	1.53	$32.2 (d)	$11.6 (d)	$43.7
Alaska	.39	8.3	2.9	11.2
Arizona	1.03	21.6	7.7	29.3
Arkansas	1.27	25.9	9.6	35.5
California	9.15	194.7	69.1	263.8
Colorado	1.08	22.7	8.1	30.8
Connecticut	1.70	34.9	12.8	47.7
Delaware	.47	9.9	3.6	13.5
District of Columbia	.24	4.6	1.8	6.4
Florida	4.62	98.1	34.9	133.0
Georgia	2.22	46.6	16.8	63.4
Hawaii	.69	14.5	5.2	19.7
Idaho	.41	8.7	3.1	11.8
Illinois	4.59	96.1	34.7	129.8
Indiana	2.46	51.6	18.6	70.2
Iowa	1.30	27.4	9.8	37.2
Kansas	1.12	23.9	8.5	32.4
Kentucky	1.28	27.4	9.7	37.1
Louisiana	2.38	51.5	18.0	69.5
Maine	.74	15.1	5.5	20.6
Maryland	1.79	36.4	13.5	49.9

State	% Share (a)	EXXON $2.098 (b) (In $ Millions)	STRIPPER WELL $727 (c) (In $ Millions)	TOTAL TO DATE $2.825 (In $ Millions)
Massachusetts	3.42	70.3	25.8	96.1
Michigan	3.41	71.0	25.7	96.7
Minnesota	1.74	36.1	13.1	49.2
Mississippi	1.37	28.4	10.3	38.7
Missouri	1.97	41.5	14.9	56.4
Montana	.45	9.6	3.4	13.0
Nebraska	.74	15.5	5.6	21.1
Nevada	.41	8.8	3.1	11.9
New Hampshire	.47	9.8	3.5	13.3
New Jersey	3.69	75.4	27.9	103.3
New Mexico	.66	13.7	4.9	18.6
New York	7.74	159.9	58.5	218.4
N. Carolina	2.24	47.0	16.9	63.9
N. Dakota	.37	7.7	2.8	10.5
Ohio	3.76	79.7	28.4	108.1
Oklahoma	1.24	26.2	9.3	35.5
Oregon	.99	20.7	7.5	28.2
Pennsylvania	4.66	96.8	35.1	131.9
Rhode Island	.40	8.0	3.0	11.0
S. Carolina	1.19	25.2	9.0	34.2
S. Dakota	.36	7.5	2.7	10.2
Tennessee	1.62	34.6	12.2	46.8
Texas	7.38	157.2	55.7	212.9
Utah	.59	12.4	4.5	16.9
Vermont	.24	5.0	1.8	6.8

State	% Share (a)	EXXON $2.098 (b) (In $ Millions)	STRIPPER WELL $727 (c) (In $ Millions)	TOTAL TO DATE $2.825 (In $ Millions)
Virginia	2.57	53.4	19.4	72.8
Washington	1.53	32.1	11.5	43.6
West Virginia	.60	12.9	4.5	17.4
Wisconsin	1.76	37.0	13.3	50.3
Wyoming	.41	8.9	3.1	11.9
American Samoa	.02	.4	.1	.5
Guam	.15	3.1	1.1	4.2
N. Mariana Islands	.01	.2	.1	.3
Puerto Rico	.95	20.1	7.2	27.3
Virgin Islands	.46	9.9	3.5	13.4
TOTALS	100.00	$2.098	$754.9	$2851.8

Sources:

(a) DOE chart, "Stripper Well Calculation of Ratios and Distribution of Alleged Crude Oil Violations Funds," Aug. 7, 1986.

(b) DOE News, "DOE Makes an Arrangement to Pay States Their Share of Almost $2.1 Billion in the Exxon Overcharge Case," March 6, 1986.

(c) DOE chart, "Summary of Funds Distributed or Allocated to States, Territories and Possessions," undated.

(d) All amounts have been rounded to the nearest $ hundred thousand.

THE OIL OVERCHARGE POTENTIAL

While the potential exists for minority groups to be among the major beneficiaries of the oil overcharge settlements, to a large extent this potential is not being realized. Many of the eligible locally based minority organizations that could most benefit from these programs are totally unaware that they are eligible or have no idea how to apply to the state for funding. With access to information on the funds, however, these community groups, neighborhood housing agencies, schools, hospitals, and low-income groups could use oil overcharge funds to develop programs that leverage local public and private dollars and provide long-term assistance for the largest number of minority citizens.

The procedures that each state uses to distribute the funds and the program areas eligible vary considerably state by state. Especially for those minority community organizations outside the traditional energy grant "network," preparing a winning proposal targeted to the correct state decisionmakers can become a nearly impossible undertaking.

If local minority organizations can get past this information void, they are faced with an unparalleled opportunity to ensure that over $4 billion in oil overcharge funds are used to constructively address pressing community needs. Energy savings generated by oil overcharge projects free tight operating budgets for better uses -- needed equipment, expanded programs, new personnel, and other goods and services. In addition, oil overcharge funded projects can be used to train youth and unemployed persons, develop new businesses and revitalize local economies.

By placing energy conservation in the larger context of community and economic development, minority organizations can leverage the oil overcharge funds to improve the quality of life. This approach has been used successfully in the state of Nebraska where the Energy Office created the Nebraska Community Energy Management Program (NCEMP) designed to:

- "Help a community actively shape its economic future;
- Pull together previously fragmented community efforts;
- Pursue larger social goals such as 'quality of life' or an expanded employment base."[5]

Evaluations of the NCEMP program show that the project not only saved energy for local communities, but met community goals of increasing economic activity locally and statewide. The program is viewed as "a 'win-win' tool"[6] that has become "a pillar of (the) state's development policies."[7]

This approach has also been advocated by the Corporation for Enterprise Development, a non-profit organization working to promote economic development. CFED advocates putting welfare monies to work for long-term community revitalization through enterprise development programs' rather than using the funds for one shot welfare payments.[8] This

approach applies to the oil overcharge funds which may be used more effectively for program with long-term benefits rather than for one time fuel assistance programs.

Through our work in developing innovative conservation and community development programs, structured around building coalitions among the public, private and nonprofit sectors, the Consumer Energy Council of America (CECA) Research Foundation hears again and again from cities, minority organizations, community groups, and social service agencies across the country: "Do we qualify for oil overcharge funds?" or "We know nothing about energy management. How do we prepare a proposal to the state energy office?" or "What programs do we qualify under?" or "Think of all the additional programs we could undertake if we could cut our operating costs by 30 percent!"

To meet the information and technical assistance void, CECA has established the National Clearinghouse for Oil Restitution Funds. The Clearinghouse serves several purposes: 1) to offer a central comprehensive source of information on state-by-state oil overcharge activities; 2) to gather information on innovative project ideas; and 3) to provide technical assistance to local groups in the areas of coalition building, development of project ideas and proposal preparation.

Through the Clearinghouse, CECA is working with a number of local organizations interested in applying for oil overcharge funds. To help these groups marshal their resources most effectively, CECA has developed a model for these groups to use in applying for oil overcharge funds, an approach that leverages oil overcharge funds so that the largest number of projects may ultimately be undertaken. This paper will outline this approach to developing a community-based, oil overcharge-funded program. Local minority organizations can propose this model to the state or, state or regional organizations can apply for funding to replicate the model in a number of localities. The paper will then profile a project, using this approach, in the city of Fort Wayne, Indiana, that was recently funded with state oil overcharge doliars.

THE OIL OVERCHARGE MODEL

As a first step, a local minority group or an organization representing minorities, such as a community social services agency, or the "organizer", would need to assess how the community could best be served by an energy management economic development program. For example, the organization might target for energy conservation assistance a group of mental health clinics serving a minority community, based upon their current energy use patterns, their plans to build new facilities, the need to rehabilitate old facilities, their influence n the community, their need for increased financial resources to better serve the community, and the opportunity to implement a pilot project that may later be conducted on a larger scale throughout the city, the county or the state.

Next, the organizer would discuss possible project options with state officials in order to "wire in" the project ahead of time. This way, the organization knows how to best design the project to meet state as well a, local objectives.

Based upon this intelligence, the organizer would discuss various project options and work to set up a coalition of politically influential organizations that will support the project. Appropriate coalition members would include local government agencies, foundations, businesses, banks, utilities, and community groups.

The organizer would then conduct focus meetings with the coalition members to educate them on the possibilities and constraints of state oil overcharge funding. These meetings would serve to determine priorities and select the types of projects that should be pursued. For example, the coalition might decide that the project most appropriate to the community at large is to conduct energy efficient renovations of five mental health clinics operating in the area, with part of the savings in operating costs going to finance a new vanpooling service that will serve elderly or handicapped citizens needing transportation to the clinic.

The coalition would then assess project needs and coalition resources. For example, a comprehensive energy management system for the group of mental health clinics might cost $200,000 to implement and produce $90,000 per year in savings. The utility and the local chapter of the Association of Consulting Engineers might provide in-kind technical assistance, while the local Jaycees could offer in-kind non-technical assistance. The local health supply distributor might donate $10,000 in cash. The bank could set up an energy trust fund to match the savings in operating costs and help to finance purchase of the vans; as the program continues to generate energy savings, the trust fund can be replenished to finance other community projects.

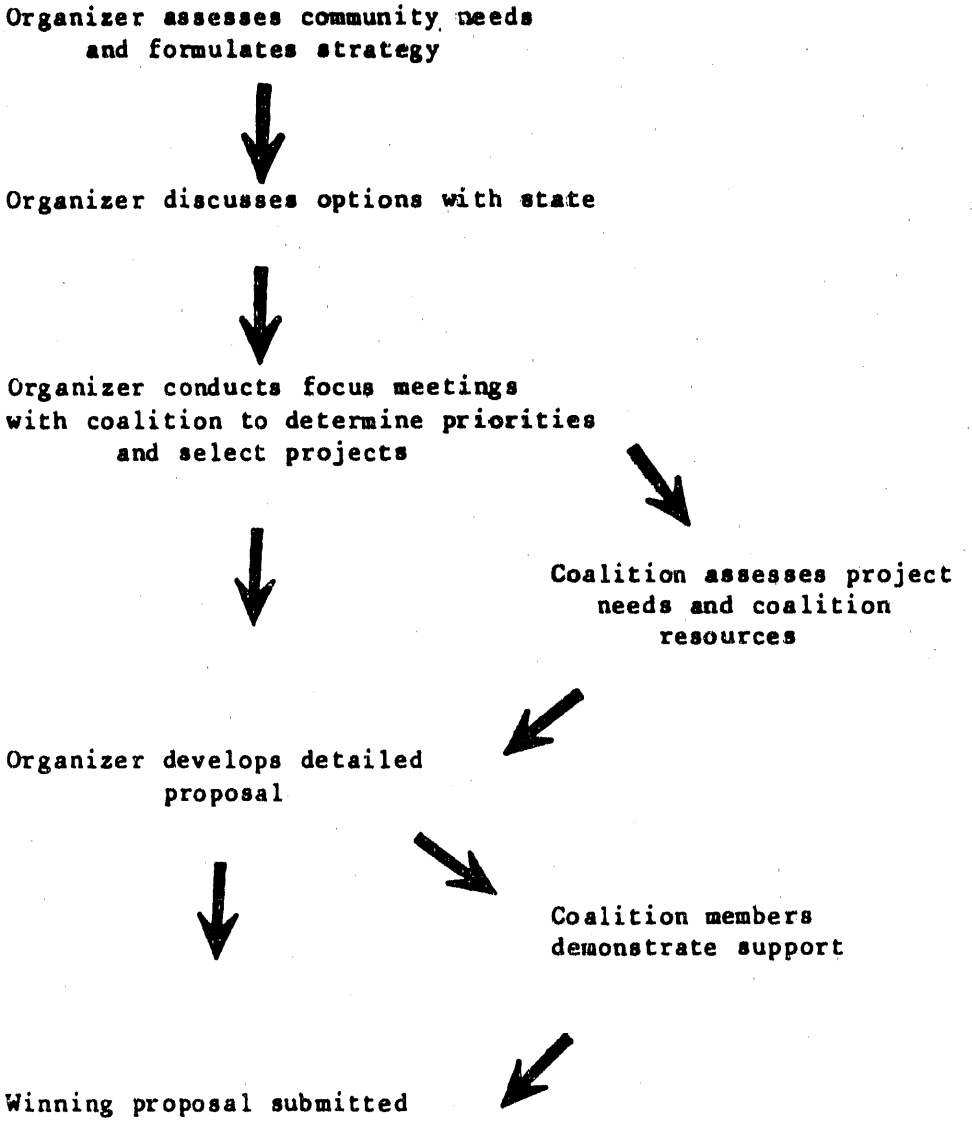
These matching funds from local sources may mean that the organizer asks the State for $130,000 to conduct a $200,000 project, or for $1 million to conduct a $2 million project, and the savings generated -- $90,000 or $200,000 or $500,000 a year -- can be used to increase services, train personnel, hire more health care professionals and expand services and operating hours.

Next, to help ensure State support of the project, coalition members would flex their political muscle by making telephone calls, writing letters and making personal visits to state decisionmakers, if needed and appropriate.

And finally, the organizer would prepare a detailed proposal for submission to the State. The proposal would have a very high chance for successful oil overcharge funding. It has been wired in beforehand through advance negotiations with the state. It leverages oil overcharge funds with local resources so that a far bigger project than the State alone could fund can be undertaken. It illustrates what new goods and services can be purchased through energy savings. And, state decisionmakers would find it difficult to say no to a proposal backed by so many organizations -- community, utility, corporate and government, with diverse interests, united around a common goal. The oil overcharge model is presented as Table 2.

TABLE 2:

OIL OVERCHARGE MODEL



FORT WAYNE, INDIANA

Fort Wayne, Indiana is a city of 172,196 persons. According to the 1980 census Report, 33,444 of these households were built before 1950, during an era when energy was inexpensive. Consequently, many of these houses are not energy efficient. This problem is compounded by the fact that these houses are concentrated in census tracts where the majority of households are low- or moderate income (incomes less than 80% of the area median). The city estimates that 15,000 households occupied by low- and moderate income persons need weatherization improvements. Eighteen percent of these households, or 2700 homes, are occupied by minorities.[9]

The city's Housing and Neighborhood Services agency identified the need for low-income home energy improvements. To meet this community need, the agency, with assistance from CECA, developed a proposal to use state oil overcharge funds to finance a low- and moderate-income conservation program. The city's application to the state's oil overcharge funded "Big City Residential Energy Management Program" received a perfect score, and the city agency received $110,000.

Fort Wayne's proposal had three major components: (1) home weatherization improvements, including complete audits, for 225 low- and moderate-income households; (2) distribution of 2000 low cost/no cost weatherizatin kits through neighborhood workshps designed to teach homeowners how to install caulking and other materials; and (3) energy conservation education through individual audits and workshops. The program is designed to reach the same percentage of minorities as live in the geographic area covered -- 18 percent.

Why was the city's prposal so successful? First, the city's Housing and Neighborhod Development Services agency researched state procedures, funding levels and targeted programs. Second, the agency built a coalition of project supporters, including Indiana and Michigan Electric Cmpany, Northern Indiana Public Service Company, the Fort Wayne Jaycees, the Rainbow Community Organization and the Fort Wayne Women's Bureau. Coalition members demonstrated their support for a comprehensive and community wide effort to conserve energy by writing letters of endorsement.

And finally, coalition members contributed $140,000 of in-kind administration, personnel, educational materials, weatherization materials and volunteer labor. Thus, the community was able to leverage oil overcharge dollars to fund a $250,000 project, and it cost the state only $110,000.

Oil overcharge dollars allowed the city agency to fund programs that would have had to be discontinued due to the decrease in Community Development Block Grant Funds. The program thus frees city funds for other important uses. It also generates energy savings for low- and moderate-income homeowners for whom energy costs are a large percentage of household budgets.

The resulting project benefits the grantee organization and the community as well. The process of building the coalition is as important as the actual implementation of the project, for it

builds bridges within the community and creates lasting ties among community leaders. These ties will mean that similar projects can continue to happen in the future and can happen much more easily and naturally, based upon existing mutually beneficial relationships.

CONCLUSIONS

Oil overcharge funds can serve as a catalyst. They can help a minority community make economic and community development projects happen and can help a community put in place a lasting mechanism for economic development. To achieve this goal, minority organizations need access to information, and they need the technical assistance tools to develop and implement winning project ideas.

It is the objective of the Clearinghouse to help minority organizations and other local groups put the oil restitution funds to their best possible long-term uses, benefiting the largest number of consumers. As local projects are funded, the Clearinghouse will gather a wealth of information on the most innovative programs, programs that may later be replicated nationwide, using oil overcharge funds, or energy savings achieved, or other monies. In this manner, the oil restitution funds will leave a lasting legacy of positive community change.

FOOTNOTES

1. United States District Court for the District of Kansas, Final Settlement Agreement In Re: The Department of Energy Stripper Well Exemption Litigation, M.D.L. 378, p. 8.

2. Ibid.

3. Telephone conversation with Jan Mucka, Low-Income Home Energy Assistance Program, U.S. Department of Health and Human Services, April 15, 1987.

4. States which have submitted Stripper Well plans to the Department of Energy as of April 1987 include: Alabama, Arkansas, California, Colorado, Connecticut, District of Columbia, Georgia, Government of Guam, Hawaii, Illinois, Iowa, Nebraska, New Mexico, Ohio, Oklahoma, South Dakota and Wisconsin.

5. Skip Laitner, "Nebraska's Community Energy Management Program: An Economic Development Strategy to Build on Community Goals," presented to the 1986 Meeting of the Association for Evolutionary Economics, December 30, 1986, p. 3.

6. op. cit., p. 10.

7. Ibid.

8. The Corporation for Enterprise Development, Expanding the Opportunity to Produce: Revitalizing the American Economy Through New Enterprise Development, edited by Robert Friedman and William Schweke, 1981. See also The Corporation for Enterprise Development, Building the New Economy:

9. City of Fort Wayne, Indiana, "Big City Residential Energy Management Program Application," December 19, 1986.

OFFICE OF SCIENTIFIC AND TECHNICAL INFORMATION: PRODUCTS AND SERVICES

M. CATHERINE GRISSOM

OFFICE OF SCIENTIFIC AND TECHNICAL INFORMATION: PRODUCTS AND SERVICES

M. Catherine Grissom
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U. S. Department of Energy

The mission of the DOE Office of Scientific and Technical Information is to provide direction for DOE's cross-cutting scientific and technical information program and to furnish a centralized base of support to asset departmental elements in managing their scientific and technical Information programs (STIP). OSTI also manages DOE's information to make it available as appropriate, provides assistance to DOE program offices such as MEI, and collects worldwide technical information for use by DOE scientists and engineers.

Since information is one of the Department's most important products, the DOE's STIP mission is to manage, control, and disseminate, as an integral part of DOE's research and development effort, the scientific and technical information produced from the Department's R&D investment. It is also a mission of the STIP to employ the most effective and efficient mechanisms and systems to make available to those managing and conducting DOE's R&D programs the scientific and technical information needed to do their work, regardless of its source, and when appropriate to share this information with other government agencies and the private sector.

The objectives of OSTI are:

- To coordinate the establishment, communication, and implementation of policy, procedures, and standards for managing of STI in the Department.
- To manage and provide access to energy and nuclear defense information.
- To advise and assist other program offices in planning, developing and implementing STIP activities.
- To represent the Department and participate in interagency, international, and domestic activities.

OSTI receives reports from DOE and its contractor organizations for abstracting and indexing for data bases including the Energy Data Base or limited or classified data bases. Other US information for the Energy Data Base is obtained in specified format from contractors and

through exchanges with other government agencies. We also obtain information from foreign governments with whom we have exchange agreements and from international organizations.

The Energy Date Base is available on the DIALOG and STN Commercial on-line retrieval services. A one-year window of the most current information in EDB is available on OSTI's Integrated Technical Information Systems (ITIS). Nuclear science and basic research information constitute 61.0% of EDB. Fossil and new and renewable energy research information make up the remaining 39.0%. The US input accounts for 46.1% of the total.

In 1986 EDB input of 193,357 came from the following sources:

OSTI	17200
International Energy Agency	10000
Nordic Consortium	3300
Italy	440
Netherlands	7400
France	3600
US Government Agencies	14200
West Germany	13300
United Kingdom	1600
International Atomic Energy Agency	36900
Other US input (contractors)	85700

The subject content of EDB is shown in Figure 1.

OSTI's regular publications keep science, industry, the government, and the public up to date on worldwide energy information. Abstract journals and bulletins cover scientific and technical reports, journal articles, conference papers and proceedings, books, patents, theses, monographs, etc. All of this information is included in the Energy Data Base. Other data bases are used to produce a meetings list, directories, and program bulletin. Unless otherwise indicated, publications are available by subscriptions from NTIS.

- Energy Research Abstracts - semimonthly journal announcing DOE-originated literature and foreign and domestic energy reports received through exchanges; available from the Government printing Office.
- Energy Abstracts for Policy Analysis - a monthly journal covering policy-related literature, e.g., articles and reports dealing with policy, legislative, and regulatory aspects of energy; available from the Government Printing Office.

- DOE Patents Available for Licensing - a semiannual journal announcing DOE patent literature.
- Energy Meetings - a monthly calendar of energy-related conferences, symposia, workshops, etc.
- Specialized abstract bulletins produced semimonthly:

  Acid Precipitation

  Buildings Energy Technology

  Coal-Based Synfuels

  Coal Combustion and Utilization

  Coal Preparation and Pollution Control Direct Energy Conversion

  Energy from Biomass

  Geothermal Energy Technology

  Heavy-Ion Reactions

  Laser Research

  Nuclear Fuel Cycle

  Nuclear Reactor Safety

  Radioactive Waste Management

  Solar Thermal Energy Technology

  Transportation Energy Research

  Unconventional Petroleum

- Energy Conversion and Utilization Technologies: A Program Bulletin - a bimonthly journal containing a feature article, citations to literature, research in progress, and meetings.

The Integrated Technical Information System (ITIS) was developed and is maintained by OSTI for DOE and its contractors. ITIS provides access to the OSTI on-line information

retrieval system (OARS), serves as a gateway to other government and commercial on-line systems, enables merging information to create customized products, and provides electronic mail and a customized current awareness bulletin services.

A major component of ITIS is OARS, a computerized information storage and retrieval system for DOE data bases. OARS provides access to the Energy Data Base (EDB) for the current year only, DOE Research-In-Progress (RIP), and various specialized data bases. With OARS a dialog can be conducted directly with the OSTI computer from a remote terminal to search current references to energy literature and description of research projects, review search results at personal computer terminal, and download data or order printed copy.

As a gateway, ITIS provides access to such other systems as DOD/DTIC, NASA/RECON, and commercial data base retrieval systems. Data can be downloaded from these systems, merged into a common format, and checked for duplicate references to produce custom bibliographies.

The electronic mail capacity creates a communication link among users of DOE's scientific and technical information system, providing on-line ordering of documents and direct access to technical assistance.

The custom bulletin service provides the user with references to current literature in a specific area of interest. After a user-specific "profile" is established, the user can review citations on-line or receive a printout of items of interest. The system also allows users to order energy reports or to download citations to create a personal reference collection.

Figure 1

STATUS OF EDB FILE 2/9/87

File Size	Subject to Categories
21,300	Advanced Automotive Propulsion Systems
149,700	Biomedical Sciences
97,400	Chemistry
146,300	Coal and Coal Products
49,900	Conservation, Consumption, and Utilization
14,400	Conversion
33,200	Electric Power Engineering
78,800	Engineering
60,700	Environmental Sciences
5,200	Explosions and Explosives
60,000	Fusion
16,800	General and Miscellaneous
17,200	Geosciences
20,300	Geothermal Energy
1,400	Health and Safety
4,400	Hydro Energy
9,100	Hydrogen
41,600	Instrumentation
5,600	Isotope and Radiation Source Technology
124,500	Materials
23,200	Natural Gas
47,700	Nuclear Fuels
105,500	Nuclear Power Plants
61,000	Nuclear Reactor Technology
14,200	Oil Shales and Tar Sands
20,300	Other Synthetic and Natural Fuels
24,700	Particle Accelerators
102,000	Petroleum
285,000	Physics Research
59,000	Policy
79,700	Solar Energy
17,600	Storage
1,200	Tidal Power
8,100	Wind Energy
1,807,500	

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