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Starting a Local Conservation and Passive-Solar-Retrofit Program

An Energy Planning Sourcebook

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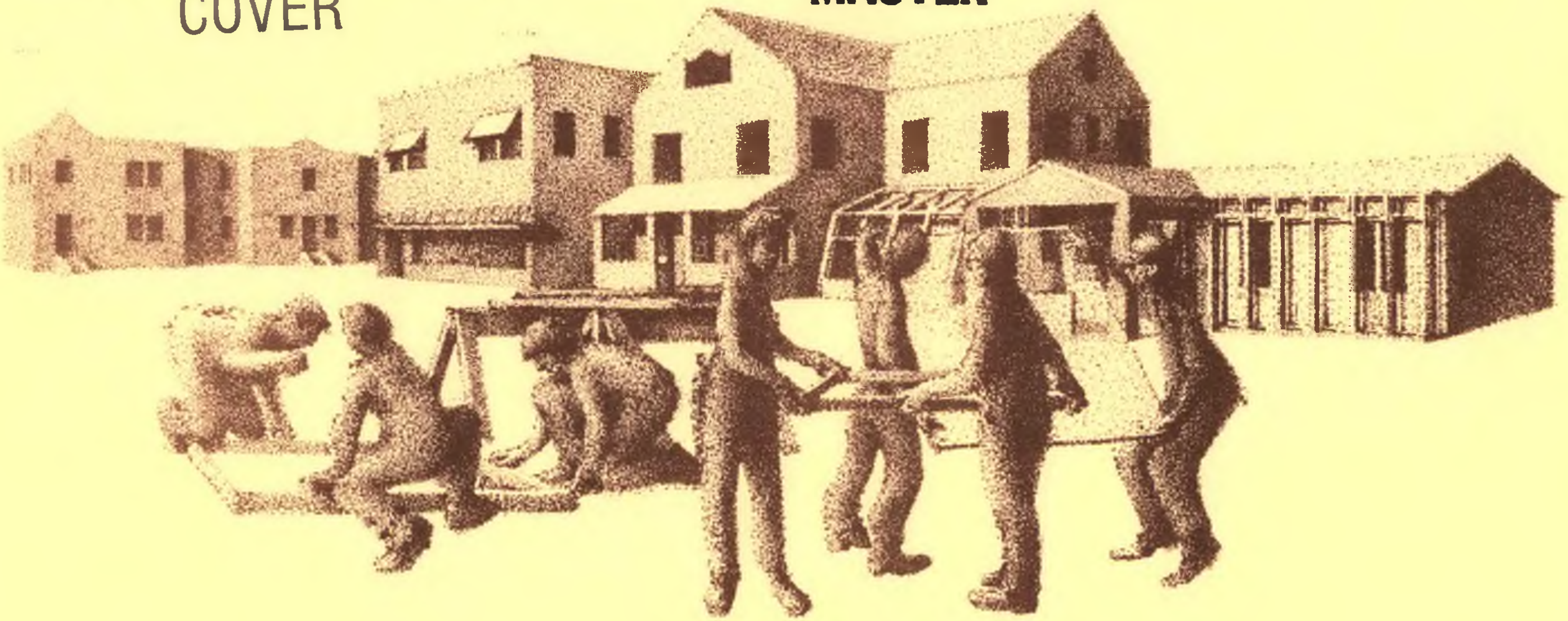

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Starting a Local Conservation and Passive Solar Retrofit Program

An Energy Planning Sourcebook

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Carol Came and staff—South Broadway Economic Development Corporation, Albuquerque, New Mexico

The many other citizens of Albuquerque who supported this project

Contents

ACTION An independent agency that administers domestic volunteer programs sponsored by the Federal government, providing services to minorities and the disadvantaged. VISTA is one such program.

ASHRAE American Society of Heating, Refrigerating, and Air-Conditioning Engineers (founded in 1894). The Society carries out a number of research programs on subjects related to maintaining comfort and health in buildings.

British thermal unit (Btu) The quantity of heat required to raise the temperature of one pound of water by one degree Fahrenheit; equivalent to the amount of energy produced in striking one match.

Building envelope The elements of a building (for example, walls, roofs, floors) that enclose conditioned spaces through which thermal energy may be transferred to or from the outdoors.

Business Alternative Energy Tax Credit Depending on the system(s) installed, a Federal income tax credit of 10% to 15% is available to businesses that install systems which heat, cool, provide hot water, or provide solar process heat. Passive systems are *not* eligible. See IRS Publication 572.

CAP Community Action Program. A CSA division, which allocates funds for CSA programs such as senior opportunities and services, community food and nutrition, and housing and human resources. Also, the name used for the local programs.

CDBG Community Development Block Grant. A grant that is the responsibility of the Assistant Secretary for Community Planning and Development within HUD; assists neighborhoods in rehabilitation and development.

CDC Community Development Corporation. A local urban or rural corporation that uses Federal funds to trigger new development in economically depressed areas; administered and funded by the CSA.

CETA Comprehensive Employment Training Act (passed in 1973). The Act provides funds to state and local units of government to develop and operate human resources programs conforming to Federal requirements; administered by the Department of Labor, Employment and Training Administration.

Cooling degree day	A unit of measurement of a cooling requirement that is expressed by the difference in degrees Fahrenheit between each day's average outdoor temperature and an indoor temperature base of 75°F.
CSA	Community Services Administration. A Federal agency that administers several different Federal and regional offices responsible for formulating policy and administering and allocating funds for social services; formed during the Johnson Administration.
Daylighting	The use of controlled natural lighting indoors through toplighting (skylights), sidelighting (windows), and/or uplighting (reflection).
Discount rate	A rate used to reflect the time value of money. The discount rate is used to adjust the future costs and benefits to their present-day value.
DOE	Department of Energy. Federal department that administers all programs and offices responsible for formulating energy policy and administering and allocating funds for energy development.
EUI	Energy utilization index. A measure for comparing energy consumption in buildings, obtained by dividing the total energy consumption in Btu per time period by the number of square feet in the building.
Exfiltration	Indoor air leakage to the outdoors through the building envelope.
FHA	Federal Housing Administration. An agency within HUD that insures mortgages, develops architectural procedures, monitors land development programs, implements environmental assessments as they apply to housing, and provides technical assistance.
Fossil fuels	Decayed matter stored within the Earth, transformed over millions of years into coal, petroleum, natural gas, and peat.

Heating degree day A unit of measurement of a heating requirement that is expressed by the difference in degrees Fahrenheit between each day's average outdoor temperature and an indoor temperature base of 65°F.

Heat loss The cooling effect on the building structure when the outdoor temperature is lower than the desired indoor temperature. It represents the amount of heat, measured in Btu per hour, that must be provided to a space to maintain indoor comfort.

Heat recovery The capture of waste heat from vents or drains to provide supplementary heat to a building.

Heat transfer The methods by which heat may be conveyed from one place to another. The methods are conduction, convection, and radiation.

HUD Housing and Urban Development. Federal department that administers all programs and offices responsible for formulating policy and administering and allocating funds for housing and community development.

Infiltration Outdoor air leakage into a building. It most often occurs at cracks around doors, windows, and other openings.

Insolation The solar radiation incident at the Earth's surface.

Insulation A material having a high resistance to heat flow, used to retard the flow of heat. Types of building insulation are batts, loose fill, reflective foil, and rigid board (polyurethane).

Internal heat gain That amount of heat gained by an internal space from all sources, including people, lights, machines, sunshine, etc.

IRS Internal Revenue Service. Federal agency responsible for taxation and revenue collection.

Kilowatt (kW)	A unit of power equal to 1,000 watts, or the power it takes to run three washing machines at one time, or an electric iron. Used to measure electricity consumption.
Kilowatt-hour (kWh)	Electrical energy equal to 3,412 Btu produced in 1 hour.
Life-cycle costing	Distributing the total one-time cost of a piece of equipment, including purchase, installation, and maintenance, over its estimated lifetime to calculate annual cost.
Microclimate	Climate at a specific site as defined by local variations in the regional climate caused by topography, vegetation, soils, water conditions, as well as human construction.
MSU	Municipal Solar Utility. A nonprofit organization, usually city affiliated, that encourages the use of solar energy by offering such programs as low- or no-interest loans, maintenance and warranties, extensive energy education programs, and demonstration projects; originated in Santa Clara, California, in 1975.
Passive solar system	An integral solar energy system or assembly of components in which no appreciable off-site energy is used to accomplish the transfer of thermal energy. Transfer can be achieved by using the building envelope itself to pick up heat from the sun. Materials inside the building (usually water, concrete, or brick mass) store the heat, and natural means of heat transfer take it to other parts of the building.
Payback period	The length of time required for the cummulative net revenue from an investment to equal the original investment. Often used in connection with outlay for energy conservation. If both the investment and revenues are discounted (see discount rate), the time is called the discounted payback period; if they are not discounted, it is called the simple payback period.
Present value	The current value of a future stream of costs or benefits calculated by discounting these costs or benefits to the present time. (See discount rate.)
Radiation	Energy in the form of electromagnetic waves, which is continuously emitted from the surface of an object. The sun warms through radiation, as does a wood stove.
Residential Conservation Tax Credit	A nonrefundable Federal income tax credit of 15% is provided to homeowners on the first $2,000 ($300 maximum) spent on energy conservation and other specified conservation devices. See IRS Publication 903.

Residential Renewable Energy Tax Credit — A Federal income tax credit of 40% is available on the first $10,000 ($4,000 maximum) that a homeowner spends on a renewable energy system. Solar, wind, or geothermal systems qualify where they are used to heat, cool, or provide hot water or electricity for the principal residence of the owner. See IRS Publication 903.

Retrofit — The physical modification of an existing building to affect energy consumption characteristics.

R value — The thermal resistance of a material to heat loss; equal to 1/U. (See U value.)

SMSA — Standard Metropolitan Statistical Area. A major city and its surrounding suburbs.

Solar energy — Energy received from the sun in the form of electromagnetic radiation.

Solar rights — The concept of having guaranteed access to solar radiation.

Solstice — The two times of the year when the sun is farthest north or south of the equator. In the northern hemisphere, the summer solstice occurs about June 21, the winter solstice about December 21.

Therm — A quantity of heat equal to approximately 100,000 Btu. Used to measure natural-gas consumption.

UDAG — Urban Development Action Grant. A HUD-sponsored grant developed in the Carter Administration to initiate urban development with private-sector participation.

U value — The heat-flow rate, or coefficient of heat transmission, through a given construction component, air to air, expressed in Btu per hour per square foot.

Ventilation — The process of supplying or removing air, by natural or mechanical means, to or from any space.

VISTA — Volunteers in Service to America. A program that provides full-time volunteers to aid communities in solving problems. The volunteer work must directly benefit the poor. Funded and monitored by ACTION.

YMCA — Young Men's Christian Association. A private nonprofit organization founded on the principle of encouraging Christian activities for youth within the community.

Abstract

A city planner or a neighborhood activist may wish to initiate a local conservation and passive solar retrofit program but may not have previous experience in doing so. This sourcebook is designed to assist interested individuals with their energy planning efforts, from determining retrofit potential, to financing and implementing the program. There are sections that provide an approach or methodology which can be applied to determine retrofit potential in single-family residences, mobile homes, multifamily residences, and nonresidential buildings. Case studies in Albuquerque, New Mexico, are given as examples. Guidelines are provided for evaluating the economic benefits of a retrofit program through benefit-cost analysis and economic base studies at the city and neighborhood levels. The sourcebook also includes approaches to community outreach, detailing how to get started, how to gain local support, and examples of successful programs throughout the US. The chapter on financing examines the need for financing, the development of a local strategy, public and private financing techniques, and community energy service organizations. The appendixes include, in addition to the Albuquerque case studies, a brief technology characterization, heat-loss calculations, economic tools, and a list of resources.

1 Introduction

The energy problem is National and even international in scope, but its effects are ultimately felt at the local level. The inflationary impacts of rising energy costs on local economies and their adverse effects on the economic positions of residents and businesses pose a threat to the current and future well-being of counties, cities, and individual neighborhoods. This problem could become even worse because of the susceptibility of localities to curtailments or sudden cutoffs of their energy supplies, which could create severe dislocations in the economic and social order of the community. Local governments and community organizations across the Nation have begun to develop strategies to deal with this threat to their well-being, strategies for improving the efficiency with which energy is used at the local level. Specific local planning efforts have focused on reducing energy consumption in local government operations, transportation, urban growth, and new and existing buildings.

Improving the energy efficiency of existing buildings offers a significant source of dollar and energy savings to the community. Nationally, between 36% and 40% of the energy consumed is used to heat, air-condition, light, and provide water for homes, commercial structures, and factories. The residential section alone consumes around 20% of this amount (Stobaugh and Yergin 1979, p. 166). Potential energy savings in existing buildings are greatest because of the size of this sector. For example, in 1972, a banner year for housing construction, new homes accounted for only 3.5% of all the Nation's housing.

Energy consumed in structures standing today generally represents the largest use of energy at the local level, besides that amount used for transportation. Improving the energy efficiency of existing buildings constitutes a means by which the community may achieve major energy and dollar savings, thus reducing its dependence on outside economic forces. The probability of achieving these savings is enhanced by the unique organizational, legal, and financial approaches and incentives that local governments can use to promote energy efficiency in local buildings.

Purpose

We wrote this sourcebook to assist community planners, government officials, neighborhood groups, and other individuals who may be interested in establishing a local program to improve the energy efficiency of existing buildings. Our analysis looks at the potential of conservation and passive solar technologies for reducing the space-heating requirements of single-family residences, mobile homes, multifamily buildings, and to a lesser extent, nonresidential buildings. Techniques to determine current energy consumption and the potential savings from conservation and passive solar improvements are presented here. A case study of Albuquerque, New Mexico, was undertaken to demonstrate how to apply these techniques at a city and neighborhood level. Our intention is to provide you with some ideas on how you would assess potential in your own community by taking into account the climatic conditions and the construction characteristics of buildings in your location. These factors, which are unique to every community, are fundamental in ensuring a reasonable measure of accuracy in your assessment of local energy-savings potential.

This sourcebook also looks at some of the unique organzational, financial, and economic aspects of implementing a local retrofit program. To that end, chapters on community outreach, financing, and evaluating economic impacts are presented. In short, we have attempted to develop a fairly comprehensive sourcebook meant to help anyone who is interested in upgrading the energy efficiency of existing buildings either at a community or neighborhood level. We have also included lists of references, organizations, and most important, programs that are currently operating in other communities. This list should be referred to as a means of increasing your knowledge about the technical, social, and economic issues surrounding the improvement of energy efficiency in existing buildings.

Funding for this sourcebook was provided by the US Department of Energy's Passive and Hybrid Solar Division through its Solar Cities Program under a contract with the Economics Group of the Systems Analysis and Assessment Division at the Los Alamos National Laboratory. It represents an outgrowth of earlier and ongoing work that is being done in the Division relating to the economic feasibility of passive solar technologies in existing buildings. This sourcebook attempts to address some of the basic concerns of the Solar Cities program, which relate to the feasibility and impact of solar technologies in urban environments along with their potential social and economic effects.

Objectives

This sourcebook is about retrofitting buildings. The word retrofitting is a space-age term that refers to the upgrading of a complex system through the installation of improved components. In buildings, this may mean physical improvements to the structure and/or modification or replacement of existing energy equipment so as to improve thermal or lighting efficiency (Stobaugh and Yergin 1979, p. 169). We concentrate on modifications to the structural characteristics of a building and do not discuss equipment replacement. This decision was made in response to program objectives, the potential magnitude of savings that can be achieved by implementing conservation and passive solar technologies, and the complexity and difficulty of assessing equipment modifications on a community scale. Our decision should not be taken as a sign that improving the efficiency of heating and cooling equipment, lighting, and appliances is unimportant. We emphasize that considerations relating to the improvement of equipment efficiency should be a component of an overall energy program for buildings, particularly multifamily and commercial structures.

Our analysis looks at the potential of conservation actions (addition of insulation, storm windows, caulking, and weather stripping) and passive solar technologies to offset space-heating requirements in residential buildings. At the National level, space heating for the residential building sector accounts for around 10% of the total amount of energy used annually (Carter 1981, p. 15). Space-heating requirements generally represent the largest end-use for energy in residential buildings. Approximately 53% of the total energy in a single-family home goes for heating (Stobaugh and Yergin 1979, p. 166). Implementing a program to reduce the amount of energy used for space heating consequently represents a most effective means of reducing energy consumption in the community and providing significant monetary benefits to residents and businesses.

We consider conservation applications in our assessments of retrofit potential because they are the most cost-effective measures to implement initially. In any event, they should be done first to improve the operation of the passive solar technologies that subsequently may be adopted. Passive solar technologies, rely on components of the building structure and natural means of heat transfer such as conduction, convection, and radiation to supply heat to a building. They are evaluated in an urban setting as a logical next step in augmenting the heating needs of residential buildings and reducing their dependence on conventional energy sources once conservation actions have been taken.

We use a slightly different approach in assessing energy-savings potential in nonresidential buildings. The potential in this building sector, which includes offices, retail stores, restaurants, warehouses, hospitals, and schools, is much more difficult to evaluate. In fact, conservation and passive solar retrofits may not be the most economically effective means of reducing energy consumption in these structures because space heating may not be the major energy use. The savings that can be achieved in these buildings will be related to the unique types of activities that occur in them and their particular energy requirements. For example, in offices significant savings may be achieved by improving lighting efficiency. In restaurants, savings may be obtained by improving the energy efficiency of cooking or refrigeration equipment. Hospitals may achieve large savings through the reduction of hot-water heating loads. An effective and useful assessment of energy-savings potential demands that comprehensive analyses be carried out on each building. Consequently, our approach first identifies energy issues in nonresidential buildings. Then an analytical procedure is outlined that can help you to determine appropriate ways to assess current energy usage and determine likely areas where savings might be achieved.

This sourcebook is oriented toward the person who has had little exposure to energy issues before. We attempt to keep the discussion as simple as possible while communicating the required information. The approaches that are discussed to determine community or neighborhood retrofit potential are meant to be "low cost or no cost" in nature. We realize that current budgetary considerations in most localities will not permit large expenditures of funds (or time) on an issue that currently may not be a pressing one in most communities. Our efforts in Albuquerque centered on identifying sources of information and areas of expertise that could be used to evaluate retrofit potential. We refer to this method as "leveraging community resources," and our experience suggests that it may be a useful technique in obtaining a general idea of what the community energy savings potential is. Creativity and resourcefulness in assessing the information sources that may assist you in your study are most important. We hope that our discussions and the examples presented by other community programs will stimulate your thinking about local informational sources along with public and private organizations that you can contact for assistance.

Although this sourcebook focuses on starting a community or neighborhood retrofit program, we see other uses for it as well. If nothing else, it may alert you to energy issues as they exist in buildings along with the particular organizational, motivational, and economic issues involved in encouraging energy efficiency in existing buildings. This knowledge may be important to you in addressing other community development concerns (property rehabilitation, job training, economic development). The discussions also may be useful in assessing the community energy-savings potential and possible need for solar access ordinances or perhaps the savings that could be achieved through the inclusion or modification of thermal standards in your local building code. Finally, the analysis may be useful if you are preparing an energy emergency preparedness plan, which requires you to assess how community energy needs can be offset. This sourcebook can be used in a variety of ways, and we encourage you to adapt the information to address your own particular needs.

Reasons for a Retrofit Program

The reasons for implementing a retrofit program, or at least considering the question of improving the energy efficiency of existing buildings, are basically economic. Rising energy bills represent a transfer of wealth out of the community; this transfer materially offsets the well-being of residents and businesses. As energy costs rise and consumers pay more, they are left with less money to spend in the local economy. This translates into declining sales levels for local businesses, which in turn can mean fewer jobs for residents. A downward spiral is created, which can lead to economic stagnation and declining living standards for community residents. This situation can breed frustration and discontent, which can adversely affect the nature of social relations in the county, city, or individual neighborhood.

Rising energy costs have the harshest impact on those residents and businesses who are least able to cope with them. Low- and moderate-income households and small businesses already sensitive to other economic pressures are faced with a new threat to their living standards and ability to do business. The possibility of declining local business activity generally means that layoffs, when they come, will hit the poorer and less-educated people hardest. The ability of the people to cope with the impact of rising energy costs is decreased even more under such circumstances. Small businesses will often find it increasingly difficult to compete. If nothing else, a local retrofit program should focus on the particular needs of these segments of the community to insulate them somewhat from the negative economic impacts of rising energy costs.

The impact of energy costs on local economies have been documented in a number of studies. In Washington, DC, it was found that $0.87 of every dollar spent on energy by residents and businesses went out of the local economy (Morris 1980, p. 3). In 1978, the estimated total energy bill for Albuquerque was $485 million (includes costs of gasoline, electricity, and natural gas). Of this amount, it was estimated that 40%, or around $194 million, was taken out of the community ("Energy Policies Action Program" 1981, p. 2). The prospect of rising energy prices most certainly will make local situations worse.

We can expect that many homeowners and businesses will take action to reduce their level of consumption in the face of rising energy costs, and their actions demonstrate the basic effectiveness of the market economy. For example, in 1977 nearly 11% of all households undertook a major retrofit of their residence, and almost the same percentage undertook one in 1978. This trend probably will gain strength into the 1980s; a survey conducted by Opinion Research for Dow Chemical found that 44% of the households interviewed were planning to take major energy savings actions during 1980-1981 (Solar Energy Research Institute 1981, p. 5).

The possible need for a local retrofit program is suggested by several considerations, however. First, many residents and businesses in a community simply cannot afford to undertake energy improvements, and at the same time find it increasingly difficult to pay rising energy bills. A retrofit program providing information on cost-effective measures and a sensitive financing approach can assist these community segments to stabilize and/or improve their economic situations.

Second, some individuals will have less incentive to invest in energy efficiency. Renters and landlords, for example, often have minimal interest in undertaking significant retrofit actions because of unique investment perspectives. The problem in the rental sector is particularly acute. The number of housing units occupied by renters and low- and moderate-income households is large, approximately 30% to 40% of all residential units (24 to 32 million). A study by the Mellon Institute divided the residential units into low, medium, and high energy-efficiency categories. They found that 66% of the low-income and 51% of the rental units fell into the lowest category (Solar Energy Research Institute 1981, p. 39). Encouraging and improving the energy efficiency of these buildings is difficult but clearly very important.

A final concern encouraging a retrofit program relates to information transfer in a market economy. People basically are not that informed on energy issues. Their lack of knowledge affects their ability to select retrofits that can provide the optimal savings for the dollars invested. Although utility responsibilities under mandates of the optional Residential Conservation Service program* address this concern somewhat, significant informational gaps still exist for the public. A coordinated retrofit program can address these informational gaps and potentially ensure greater community savings at a rate of return to individuals and businesses that is competitive with alternative uses of their funds.

The importance of reducing heating requirements in a local retrofit program is underscored by current National trends. Approximately 60% of households in the US heat with natural gas. The National average paid for heating a home during 1980-1981 was around $313 (Albuquerque Journal 1981, p. 3). Current estimates call for price increases ranging between 12% and 25% for 1981-1982. Wide disparities exist in the price paid for energy in various regions. Heating bills of around $618 are projected in New England for this heating season, whereas residents of Texas, Oklahoma, Arkansas, and Louisiana can expect to pay about $210.** The trend is definitely upward in gas prices, however; if anything, the situation in New England indicates the future for the rest of the Nation. The anticipated deregulation of natural gas can only result in further increases in the cost of heating homes and businesses as well as the cost of providing energy for other needs.

Ironically, many people think of conservation as a step backward in terms of technological advancement, and that somehow it means a sacrifice or lowering of living standards (Blumstein, Krieg, Schipper, and York 1980, p. 35). This simply isn't true. Adoption of conservation measures and, perhaps later, solar measures (depending on the local cost of heating fuel), can contribute significantly to the health and growth of local economies by reducing the drain of dollars out of the pockets of residents and businesses.

Perspectives

This section of the chapter attempts to convey some of the thoughts we had as we wrote this sourcebook. These relate to the limitations of our approaches to estimating energy savings, the emphasis placed on economic analysis, the importance of community outreach and financing, and the level at which the approaches presented here might best be applied.

It is important initially to state that the estimates of current energy consumption for space heating and the potential savings that can be achieved through a retrofit program are *not* absolutes. Significant variation may be expected between estimates and the savings that might be achieved under an actual program. The factors responsible for the differences are local weather conditions, the difficulties in assessing the performance of independent retrofit

*The RCS program has not received funding at the Federal level for FY1982-1983. Implementation of the program is left to the option of the states (see the "Utilities" section of Chap. 5).

**It should be noted that heating with fuels other than natural gas generally will be even more expensive. Deregulation of oil prices already has contributed significant increases to the cost of heating oil. This has had a harsh impact on New England, the Atlantic Seaboard, and many communities on the West Coast. Electricity is an expensive way to heat buildings. The typical 1,400-ft^2 home in Albuquerque consumes around 96 million Btu of natural gas for space heating. At a cost of $0.35/therm, this means a $340 heating bill. Electricity is more efficient, resulting in energy consumption of 53 million Btu for the same size home; but at a local cost of $0.065/kWh, the heating bill is around $1,000.

measures in combination with each other, shortcomings of the methodologies themselves, and perhaps most important, the unpredictable energy-use habits of building occupants. Consequently, we advise that a range of savings be developed in any analysis that is done at the local level to introduce some flexibility into your estimates and to ensure greater credibility for your efforts with local decisionmakers.

The approach we take in this sourcebook is somewhat different than that taken in other books on this subject, because we attempt to assess the economic effectiveness of retrofit measures. We tried to determine the value of a retrofit program to the community or to a neighborhood based on specified economic criteria. This type of analysis, in our opinion, can provide a more convincing argument to local decisionmakers in the public and private sectors about the merits of a program. The economic assessment technique that we use is benefit-cost analysis, and although it cannot be used to state definitively that a program should be implemented (this will depend on the local political situation), it can be useful in pointing out if a local retrofit program is, in fact, an effective expenditure of community capital. It also may be used as a tool to evaluate alternative retrofit programs. Such analysis may be needed where you are considering different systems, combinations of retrofits, and investment criteria. Our approach in the appendixes is to present different ways by which benefit-cost analysis can be used; in the process, we demonstrate the economic attraction of conservation and passive solar retrofits in Albuquerque at this time. The results of the analysis for your community will not be the same as those for Albuquerque because of different energy costs and climatic variables. We stress that you evaluate the particular circumstances of your own locale in determining the economic feasiblity of various retrofit measures.

In addition to assessing the economic merits of a retrofit program, we also discuss the use of economic base analysis as a means of determining the employment impacts of a community or neighborhood program, with Albuquerque as our example. Again, we caution you that the impacts in your community will depend on your local situation and the unique characteristics of your local economy.

The chapter on financing a local retrofit program is long because we see financing as an important element in a local retrofit program for two basic reasons. First, the low cost of energy in many parts of the Nation requires economic incentives or financing approaches that encourage retrofit actions now. Second, the financing needs of certain segments of the population (and certain businesses) cannot be met given the currently high interest rates and short repayment terms offered on loans by private financial institutions. Many people and businesses simply are unable to take retrofit actions to cope with rising energy costs because they cannot qualify for or afford conventional financing. This is a critical problem and perhaps the most important rationale behind implementing community (or state) financing programs. Recognizing current political and economic trends, we strongly advocate creative partnerships between local governments and the private financial sector and, whenever feasible, strict reliance on private-sector financing. Such approaches not only meet local financing requirements for residents and businesses but also guarantee the economic health of the community and, in the end, the economic viability of the private financial institutions themselves.

In the final analysis, we view the Community Outreach chapter as perhaps the most important part of this sourcebook. Current economic and political developments point toward reduced funding for Federal grant programs, which in the past may have been used to fund a local retrofit program. Capital is critical to the implementation of a local retrofit program, but organizational, educational, and marketing skills may be the basic determinants of local program success or failure.

There is a real need to inform the public about retrofit options and how they work as well as to tell them of the savings that can be achieved simply by setting the thermostat back at night. The skepticism that the public has about conservation and solar alternatives is somewhat understandable because of questions about performance and the work of unscrupulous contractors. These concerns must be addressed in the outreach program first. It is only then that we can expect the public to participate in and support the retrofit effort.

Adoption of conservation, passive solar, or other types of retrofit actions represent individual solutions to the Nation's total energy problem. Although we discuss a retrofit program at a community level and encourage such an approach if politically feasible, we feel a program is more practical and perhaps better suited for implementation at a neighborhood level. This feeling is based on the particular informational requirements of the approaches to estimate energy savings, the greater ease in organizing and coordinating the retrofit program on a small scale, the ability to develop program momentum as people see and hear about retrofit actions, and the unique needs that exist in certain neighborhoods because of economic circumstances. Neighborhood actions can be assessed as they progress under the retrofit programs, and successful aspects can be transplanted to other parts of the community. Because retrofits must be done building by building by individual owners, the best approach is to garner public support at the block and neighborhood levels. As the number of retrofit actions in the neighborhoods increases, a city-wide impact results.

Organization

The sourcebook is organized in the following manner to convey the ideas behind a retrofit program. Chapter 2 details the methodological approaches to assessing energy use in buildings. The practical application of the methodological approaches to the single-family residential, mobile home, multifamily, and commercial building sectors in Albuquerque is then presented in Appendix D. Background information on conservation and passive solar technologies in Appendix A, energy audits in Appendix B, and heat-loss calculations and means of estimating potential conservation and passive solar savings in Appendix C are useful in understanding the discussions of the specific methodologies. Chapters 3, 4, and 5 discuss techniques for economic evaluation, community outreach, and financing, respectively. Appendix E details the application of the economic evaluation techniques in Albuquerque to assess the effectiveness of a conservation and passive solar retrofit program at the neighborhood level and to assess the city-wide employment impacts of contractor-installed retrofit measures on single-family homes. Appendix F provides a list of references, general readings, and programs and organizations that may provide assistance or additional insights into starting a retrofit program. Changing priorities in the Federal budget at the time of this writing leaves the status of some listed programs in doubt. It will be necessary, in many cases, for you to verify the existence of various energy programs and funding sources.

Although this sourcebook is meant to be read as a whole, we emphasize that the chapters also may be read individually to address specific concerns. The appendixes necessarily depend on the initial discussions developed in the introductory chapters, however.

Whether you decide to concentrate on one block, your neighborhood, or the city as a whole depends on your interest, mission, and local situation. Be creative and flexible, and keep researching for more analytical tools to use as others perfect techniques in assessing energy-savings potential in buildings. We hope you can gain from our experiences and find the resources provided in this energy planning sourcebook useful.

2 Determining Retrofit Potential

Single-Family Residential Buildings

Mobile Homes

Multifamily Residential Buildings

Nonresidential Buildings

Introduction

We learned quite a bit during the course of our research about the nature of energy consumption in buildings and the pitfalls of applying conservation and passive solar retrofit measures uniformly across building types. Our original objective of assessing the community impact of a retrofit program on single-family homes (including townhouses and duplexes), mobile homes, multifamily (apartment) buildings, and nonresidential (commercial) structures was tempered in the final analysis by practical considerations. These considerations related to the energy use characteristics of these buildings, the unique climate of Albuquerque, and our own initial unfamiliarity with retrofit potential analysis and some of the more complex technical aspects of retrofits. At this point, we think it useful to discuss the particular objectives of the retrofit methodologies and the assumptions underlying our approaches. We hope that this initial discussion will clarify procedures that are outlined later in the individual methodologies and in the case studies in Appendix D.

The original objective of this sourcebook was to assess how a conservation and passive solar retrofit program could reduce energy consumption for space heating in buildings that are typically found in every community. Reduction in space-heating requirements was viewed as an especially important and effective way to reduce energy consumption at a county, city, or neighborhood level, because space heating is the biggest end-use of energy for residential dwellings located in moderate to severe climates. For example, in New Mexico, energy for heating is estimated to account for 58% of the total energy used in a typical home. Energy used for hot-water heating constituted the next highest end-use of energy at 18%, followed by appliances and lights 11%, cooking 6%, refrigeration 5%, and cooling 2% (Lumsdaine and Lumsdaine 1978). Of course, other energy end-uses could be considered for inclusion in a retrofit program (for example, solar hot-water heating), but they will typically not offer a similar magnitude of savings.

Our study is limited strictly to the analysis of how physical modifications (insulation, storm windows, caulking, weather stripping, and passive solar measures) to a building can affect energy consumption for space heating.* We do not look at important lifestyle considerations such as lowering the thermostat, keeping doors and windows shut on cold days, etc. The need to educate the public in these measures cannot be questioned, and such education would certainly add to the effectiveness of any local retrofit effort. How a community might deal with these issues is discussed to some extent in Chap. 4 on "Community Outreach."

During our analysis in Albuquerque, it became clear that a different analytical framework would have to be applied to nonresidential buildings. This is not to say that conservation and passive solar measures are not appropriate in many cases, particularly on small buildings (for example, office buildings and retail stores). The diversity and complexity of energy uses in nonresidential structures generally will require a more complex analytical framework to determine what areas of energy use can and should

*We should point out that the installation of insulation, storm windows, caulking, and weather stripping will also reduce the need for cooling. The amount of additional savings the program can offer will depend on the number of buildings in the community that use air conditioning.

be reduced, however. Although the primary area of energy consumption generally is space heating for residential units, the primary consumption may be related to the operation of equipment, lighting, or cooling for commercial buildings, depending on their particular function. Consequently, we decided to focus on a discussion of energy uses in commercial buildings and ways to determine consumption patterns. A planning approach was then developed that would assist local planners in undertaking a retrofit plan in a commercial area. We felt that this approach was much more practical and useful for anyone reading this sourcebook. The information presented can be assessed in view of your unique local circumstances and used to develop appropriate strategies for reducing energy consumption in your community's nonresidential buildings.

Our objective in developing the methodologies for the single-family residential, mobile-home, and multifamily building sectors is to provide you with some basic tools to estimate energy consumption for heating and then derive estimates of potential savings from a retrofit program. The level of detail involved in the techniques of assessing retrofit potential may exceed your particular needs. Consequently, we provide references to other approaches that have been tried by other studies.

The complexity of our approach is seen as necessary to derive estimates that reflect local weather conditions (length of heating season, available sunlight), building types, construction practices, and age characteristics of the buildings. In short, our approaches may enable you to derive more specific estimates of retrofit potential considering the unique characteristics of your locale. A localized estimate is fundamental to obtaining relevant figures with which community impacts can be assessed. These estimates can prove useful in defining local policy options relating to the retrofit measures that will be implemented in a program or related to whether a program will be implemented at all. Other policy choices may relate to what measures need subsidies and what types of structures in which parts of the community are most in need of improvement. Information obtained in such an analysis also may be useful in determining priorities and programmatic direction for a property rehabilitation effort or in assessing the need for solar access ordinances.

Two methodological approaches are detailed. A building type methodology is used for single-family residences and mobile homes; whereas the multifamily analysis relies on the examination of actual utility bills. The typological approach considers the age, construction type (masonry, frame), and physical characteristics (insulation levels, window area) of typical buildings in a community to derive estimates of energy consumption for space heating. Then a set of conservation measures and a passive solar application are evaluated on how much energy they could save if they were retrofitted to particular buildings.

The typology approach is useful where you want to develop an initial estimate of community energy use for space heating. It is relatively quick and easy to implement, because it does not require that existing energy use in homes or nonresidential buildings be obtained through a survey. The basic drawback of this approach is the accuracy of the estimate derived. This can be determined by comparing the values with utility data, estimates derived in other studies, and total consumption of the community as indicated in reports that may be available from the utility or the state Public Service Commission.

Analysis of actual utility bills is the approach used in the multifamily section. This approach could also be applied to single-family residential dwellings, mobile homes, and nonresidential buidings, where bills for representative samples were available. This is a preferred approach because actual consumption figures provide the foundation of assessing retrofit potential. The problem here relates to the time involved with obtaining a representative sample (which may involve a very large number of buildings) at the community level. Obtaining a representative sample is, of course, much more feasible at a smaller level such as the neighborhood or block. The advantage of a sampling procedure relying on actual utility information is that the accuracy of the data is verifiable.

We emphasize that the estimates you derive through the application of the retrofit potential methodologies be considered as very rough approximations of energy consumption and the savings that might be achieved. A number of considerations, which are related to the ways in which energy is used by households and businesses, varying weather conditions, and shortcomings in the methodologies themselves, make it very difficult to develop *exact* estimates of the amount of energy consumed and the savings potential for space heating in a community. We advise that you develop a range of savings based on the results of the methodologies to account for these considerations. We develop such a range in the case studies in Appendix D by relating estimated energy savings to economic criteria that we have established for the retrofit program. This range suggests the estimated savings from the application of the retrofit potential methodology as an upper limit and the level of savings that would just make the program economic as a lower one. Whether these savings would actually be achieved under a program is difficult to say. It seems plausible that the estimated savings may be reasonable as indications of the potential in a community, however, where the estimates can be corroborated with actual data.

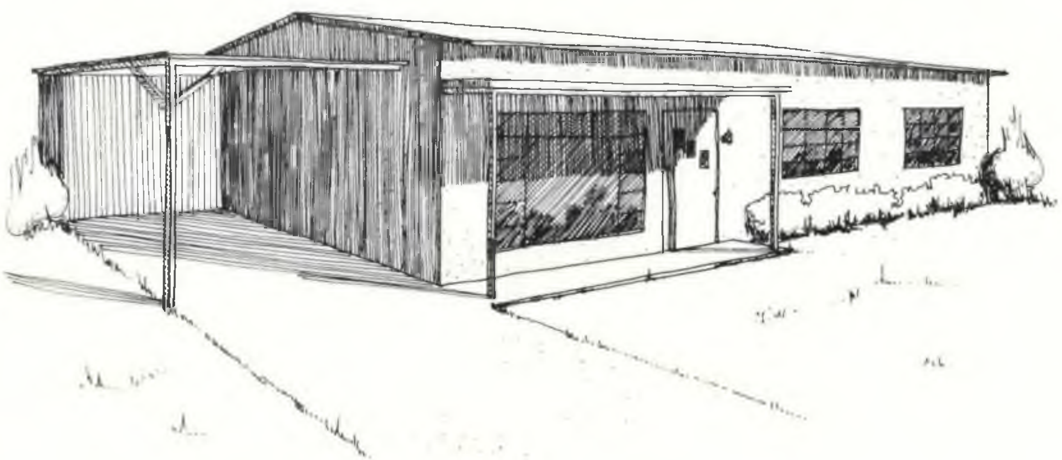
We used the City of Albuquerque, New Mexico, as a laboratory in which to apply the methodological approaches. Attempts have been made to develop accurate estimates given the information available. Our analysis of the City should be viewed only as preliminary because it is likely that we missed using data that persons more familiar with City informational resources would have known about. Our major objective in Albuquerque was to demonstrate how the techniques could be applied in a city, county, or neighborhood. Application of the approaches also suggests the type of information that is needed in a retrofit potential analysis. The following sections will now detail the issues involved in assessing retrofit potential and the particular approaches that were used for single-family residences, mobile homes, multifamily buildings (apartments), and nonresidential structures.

The Conservation Retrofit Potential

The energy-savings potential that exists within the single-family residential sector at the National level is enormous. There were an estimated 80 million year-round residences in the US as of 1979. Approximately 50 million of these units were detached single-family units. More than 33% of these homes were built before 1940 when there were few or no standards for thermal insulation (Stobaugh and Yergin 1979, p. 170). Only with the advent of electric heating and air conditioning in the late 1950s did builders start to include more insulation in the homes that they built. Storm windows and double glazing also began to gain acceptance at that time. Market demand for these features was small, however, because of the low cost of conventional fuels. The potential for energy savings in single-family homes is very real at this time. One study suggests that perhaps as many as 30% of the residences in the Nation are uninsulated and that altogether at least two-thirds need more thermal insulation (Godwin 1976, p. 456).

A number of studies have pointed to the significant savings that can be achieved through conservation retrofits. A study sponsored by Standard Oil of California of homes in Portland, Oregon, and Seattle and Spokane, Washington, concluded that 50% savings are possible in many structures while achieving attractive rates of return. An investment of $981 in a Portland home, for example, yielded a 50% reduction in energy consumption with a 25% rate of return (Stobaugh and Yergin 1979, p. 170). The most dramatic information has resulted from research in the fairly new suburban community of Twin Rivers, New Jersey. Researchers from Princeton University found that an annual savings of up to 67% in energy used for space heating could be realized through the installation of a relatively simple retrofit package. Measures installed included caulking, weather stripping, attic and basement insulation, along with other measures designed to reduce air leakage. These savings were achieved while owners realized a 10% rate of return based on natural-gas prices in 1979 (Stobaugh and Yergin 1979, p. 171). Conservation, though less glamorous than solar retrofits, is the starting point for economical energy savings.

Conservation retrofits to homes in Albuquerque are probably less economic to the homeowner than those to homes in most other parts of the Nation. This is attributable to the fact that it only costs about $340 annually to heat the average 1,400-ft^2 home with natural gas. Still, conservation measures are generally a necessary first step in promoting community energy efficiency, because conservation measures are more economic than passive solar applications at present and are necessary, in any event, to maximize the performance of the passive solar application. We ***emphasize*** the importance of sealing sources of heat loss first before attempting to draw on the sun for supplemental energy.



The Solar Retrofit Potential

Many people believe that solar applications are only appropriate to "sunbelt" locations with high levels of sunshine (insolation). This is not true; solar applications can perform well in a variety of regions and provide increasingly attractive rates of return to the owner as energy prices increase. Critical variables determining the effectiveness of the passive system, besides the amount of insolation, include the length of the heating season and the cost of conventional heating fuel.

Rising energy prices make it logical to consider passive solar applications to further offset the heating needs of single-family homes as well as those of mobile homes and possibly multifamily and nonresidential buildings in the coming years. We estimate that energy savings of 30% to 70% of the space-heating loads of single-family homes can be obtained by passive solar retrofits (when used with night insulation) in Albuquerque. These percentages assume that the homes have received conservation retrofits first. The economics of these retrofit applications are only marginally attractive now because of the extremely low cost of natural gas, which is the primary heating fuel in the City. Public acceptance of passive solar retrofits can be expected to increase as energy costs rise (and/or as solar applications are included in a retrofit program). They present a logical next step in reducing energy consumption after all of the economic conservation measures have been installed.

Passive solar applications are specifically examined in our analysis of retrofit potential because they can offset a significant portion of a building's heating load at a reasonable cost. In Albuquerque, we found that a $2,400 greenhouse or a $1,100 Trombe wall could provide approximately 45% or 30%, respectively, of an older masonry home's heating needs after conservation measures had been taken. By way of contrast, active solar systems may be designed to offset a larger portion of the home's heating load (can be 80% or more), but they cost at least $7,000 (depending on the region). Adding passive solar retrofits to conservation actions represents an affordable means for the average household (or business) to gain control of their energy costs. This is a particularly important consideration for the low- and moderate-income households or small businesses, who will be hardest hit by rising energy prices.

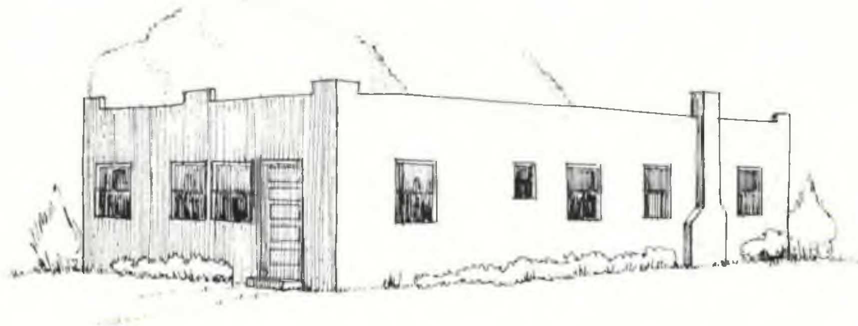
Another attraction of passive solar technologies is their simplicity. They rely on natural means of heat storage and transfer and do not usually depend on mechanical means of producing heat (the only mechanical part of a passive system might be a small fan to distribute the heat in some applications). The possibilities of mechanical failure, which can sometimes develop in even the best designed active systems are not a problem. The only problem would occur when the building occupant forgets to install or close the insulation panels on the system on a given night. In such a case, the system would perform less effectively and possibly even draw heat from the building for that evening.

In addition to their energy production potential, some passive systems can add appreciably to the livability of the existing building. A greenhouse offers attractive new living space and at the same time adds to the value of a home at the time of its sale. This works to improve the economics of installing the system. A greenhouse may provide food or plants for personal use or sale, which also contributes to its economic utility.

Finally, we evaluate passive solar systems in this sourcebook according to their potential to spur construction employment within a community. Although the impact of a local passive solar retrofit program on employment levels probably will be small, some jobs would likely be created in the construction trades as a result. This represents a positive side effect of a passive solar (and conservation) retrofit program. The employment impact is much less important than the energy savings that can be achieved which result in more dollars being retained in the local economy. These dollars provide the real stability that is important to the long-term economic health of the community.

Developing a Building Typology

We will be using a methodology to assess single-family residential retrofit potential that relies on the development of a building typology. This approach has been developed in large part through research that has been done at the neighborhood



level in Philadelphia under the Philadelphia Solar Planning Project (PSPP).* It also has been applied in the Roxbury neighborhood located in Boston.** Development of a typology is based on a consideration of the age and size of building type (single-family, townhouse, high-rise), construction type/thermal characteristics (frame, masonry, glass area, insulation levels), condition, type of heating system (electric, gas, oil), and the estimated efficiency of the system. Based on these considerations, energy consumption for space heating in typical buildings can be estimated by doing simple heat-loss calculations (see Appendix C). These estimates can then be checked against utility estimates or numbers derived in other studies to ensure their reasonability. If time permits, it may be possible to check the estimates against a representative sample of homes in the community.

These checks enable the analyst to check theoretical calculations with actual energy use, which always will be affected by the energy consumption habits of the residents. Potential energy savings from a retrofit program can then be estimated from a fairly reliable initial estimate of consumption levels. This contributes to a more reasonable final estimate of savings.

In Appendix D, we will be applying the typology approach at both a neighborhood and a city-wide level in Albuquerque, New Mexico. The neighborhood selected is composed mainly of single-family detached homes occupied by low- and moderate-income households. A community preservation and rehabilitation strategy, which is being developed, identifies energy retrofit as a key element. The strategy recognizes the harsh impact that rising energy prices will have on the budgets of neighborhood households.

Although the typology approach is perhaps most appropriately applied at the neighborhood level because of the large amount of information required, we also decided to apply it to the entire City. This decision was made because of the basic homogeneity of Albuquerque's single-family residential buildings. We estimate that 90% are single-story structures and approximately 60% have been built since 1956. The similarity of the structures and availability of data on construction characteristics make the application of a typology seem intuitively logical. The technique may have particular relevance to other communities in the South and West that have expanded rapidly over the past 30 years or so (for example, Phoenix, Tucson, Seattle, Portland, Salt Lake City, Denver, and Houston). Many of these communities have seen their housing built by large homebuilding companies that also tend to influence the construction practices of other builders in the area. We feel that the development of a typological model may have particular relevance in these types of urban settings. Housing types are similar and enough information still exists, through referral to old building codes and through conversations with builders and local officials, that educated guesses can be made about the construction and thermal characteristics of local housing.

*PSPP was funded under the US DOE's "Solar Cities" program and with grants from the Design Arts Program and the National Endowment for the Arts to inventory, analyze, assess, and assist the implementation of conservation and solar applications in Philadelphia. The study was administered as an interdisciplinary effort involving community groups, city agencies, educational institutions, and private consultants. PSPP reports can be obtained from the address listed in the "Organizations" section of Appendix F.

**In this case, the approach was initiated by the Greater Roxbury Development Corporation.

We'll now detail how we applied the typology methodology to single-family homes at both the city and neighborhood levels. A similar sequence of steps is followed at each level, so we will discuss the procedure as it applies to the city first and then discuss any considerations that are unique to the neighborhood. We should also point out the same basic approach is used for mobile homes and, to a lesser extent, multifamily units. We divide the methodology as follows:

- characterization of the buildings,
- estimation of typical heating loads,
- application of retrofit measures, and
- determination of solar retrofit potential.

Characterizing the Buildings

First, we need an accurate picture of the number of units and their age and construction characteristics. This information provides the basis from which the space-heating characteristics of the homes can be estimated. We discuss how to get these data in the following sections. You will have to be creative in your efforts because the information often is not readily available. For example, in Albuquerque we relied heavily on data from a survey, conducted by the New Mexico Energy Institute, assessing energy use in single-family homes (see the single-family section of Appendix D for a discussion). The relatively large size of the sample allowed us to make inferences about the housing that we could not otherwise have made. You may find that information is more readily available in your community through the examination of tax records, building-permit data, or planning department studies. The following pages detail the information that will be needed for the analysis.

Number of Homes. This information is obtained fairly easily from census information, planning reports, building department records, or tax files. If the information is not current, it can be brought up to date by adding information from new building permits issued since the last official count. This procedure should yield a relatively accurate estimate of the number of housing units in the community. Such an approach can also be used for mobile homes and multifamily units (apartments).

Age. Age characteristics of the buildings are less easily determined. Census data give these figures on a decennial basis. Again, local planning studies, tax files, or building department records may provide specific numbers or a means of deriving a reasonable estimate.

Construction Characteristics. Determination of the construction characteristics of homes in your community may prove to be the most difficult task presented to you even when there is great similarity in the housing types. The level of detail which you wish to adopt may vary according to your needs and time considerations. Our approach in Albuquerque relied on a characterization of the structural and construction types of homes in the City. We limited our analysis to single-story homes, because this is the major structural type (90% of total units), and to masonry or frame construction. Floor type was also considered. We assume that homes left out of the modeling analysis could achieve similar if not greater energy savings. Your own analysis might include ceiling types and two-story or split-level homes.

Average Floor Area. The average floor area in square feet for homes in your community can be determined fairly easily. This number often is available from the local homebuilder's association, Chamber of Commerce, or community planning or building department. You may want to account more specifically for size considerations by obtaining these data based on the age of the home. Houses tended to be smaller in the prewar years, got bigger during the 1950s and 1960s, and are now getting smaller again because of economic (cost), energy, and demographic considerations. An average floor-area value for typical homes in the community is basic to the estimation of energy consumption for heating. Although we didn't do it in Albuquerque, it may be possible to derive an average value for each age bracket of homes.

Construction Types. We divided Albuquerque's housing into the frame and masonry construction types. Frame buildings are built with wood framing and wood, brick, stucco, or aluminum siding. Masonry units include those built out of concrete block, cinder block, adobe, hollow clay tile, and brick. This information can be obtained through a review of building department records, conversations with local builders, and field surveys. The materials that a home is built out of affect energy consumption and have an impact on the type of retrofit measures that can be adopted.

Structural Types. Determination of home structural types is useful in assessing what type of retrofit can be undertaken. For example, the type of roof affects the cost and amount of insulation that can be installed. It is much easier to install insulation in a house with a pitched roof and attic. In addition, almost any amount of insulation can be added. Costs are kept down because of the relative ease of installing the insulation. Insulating flat roofs is more difficult. Holes must be drilled in the roof to install the insulation and then repatched, driving up the cost of the retrofit.

Floor type is another consideration. Is the home built on a concrete slab, over a crawl space, or with a full basement? Homes built over crawl spaces without floor insulation will tend to lose more energy than those built on slabs or with full basements. Addition of more insulation in a crawl space is a fairly easy and economic matter, however. This is not the case for slabs or basements, because the area around the foundation must be unearthed to add the insulation (generally rigid Styrofoam board). Consequently, the energy-savings potential for homes with crawl spaces may be greater.

Window Area. Another consideration that must be taken into account is the average amount of window area in the structure. A large amount of heat loss occurs through glass because of its low resistance factor. We estimated the amount of window area by referring to local building codes and by referring to answers given on a questionnaire that we had distributed through the Albuquerque middle schools. The amount of window area will vary by age and may reflect climatic considerations.

Insulation Levels. Once the basic construction characteristics of the units have been delineated, it is necessary to determine the insulation levels of the homes. The level will vary with age. Information should be available from local building contractors and government officials who are familiar with construction practices, building codes, and FHA requirements and/or, if time permits, personal inspection of a sample of homes. Estimation of reasonable insulation levels for typical homes in the community is essential to a reliable estimate of space-heating requirements. This is attributable to the modifications that insulation imposes on the thermal characteristics of a building.

Infiltration Levels. Modeling the average space-heating needs for a home based on construction type and insulation levels alone would be very unrealistic. Reality dictates that we consider the amount of energy lost through air infiltration. Heat is lost by movement of warm air out of the home through cracks around doors and windows and through all outlets, wall plates, fireplaces, vents, the duct system, and other obscure locations. Heat loss from infiltration can account for as much as 40% of the heat loss in a typical home (Ebeneezer 1980, p. 2).

We try to account for this factor by estimating the number of air changes per hour in local homes. This number may range from 3 air changes for a home in very poor condition, with minimal weather stripping and caulking, down to 0.5 changes for a new home in which every step has been taken to reduce leakage. Determining an appropriate factor is very difficult and applying the factor community-wide is hard. Basically, one would expect older homes to have higher levels of infiltration, because their structural condition will deteriorate over the years. This is not always true, however, because many people will maintain or upgrade their homes, reducing infiltration in the process. Estimates of this figure may be obtained from your local utility, the city building department, or local architectural and engineering firms.

Furnace Efficiency. An assumed furnace efficiency level must be determined for typical homes in the community. Electric heating (resistance) is approximately 100% efficient, meaning that no energy is wasted in heating the home. Gas or oil heating, on the other hand, may provide heat at an efficiency level of 40% to 80%. This means that some energy is lost in heating the home. Estimation of an average efficiency level for furnaces is needed to derive a fuel bill and to determine subsequent dollar savings to the community.

Estimating Energy Consumption for Heating (Modeling)

Once we have characterized the buildings, we then estimate the energy used for space heating in typical single-family homes through the use of heat-loss calculations that have been developed by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE).

The heat-loss calculations are applied based on the particular age, size, structural, and construction characteristics of typical housing units that are found in the community (or neighborhood). The modeling technique by which these heating loads were determined is discussed in detail in Appendix C. The advantage of estimating heating loads through a modeling process is that modeling gives you a somewhat better feel for heating loads for the building by age and construction type. For example, one would expect that older homes will tend to use more energy for heating. A modeling approach allows you to account for that fact. Knowledge of the estimated heating loads by age and/or construction type is useful later when you attempt to determine a feasible level of conservation and solar savings for buildings.

A special heating degree day correction factor is applied to the estimated level of consumption to account for internal heat gains (people, appliances, lights) and to adjust somewhat for solar gain. This factor generally lowers the estimated level of energy consumed for space heating and provides a more accurate estimate of energy use. Application of the factor to an ASHRAE steady-state heat-loss calculation is estimated to predict fuel consumption within 20% of the actual value for a home (ASHRAE 1980, p. 438). The accuracy of this value in our methodological approach would be related to the reasonability of the many assumptions that underlie the analysis.

Modeling of homes by age and construction type may seem overly presumptuous. We feel that informed guesses can be made where information is available on common building practices, however. The technique is most appropriately used when utility information is not available or is difficult to obtain. Still, a heat-loss calculation based only on ASHRAE calculations may be criticized because actual energy consumption values are not used. We feel, however, that the procedure outlined can be useful in providing the researcher with a "first cut" estimate of energy consumption for space heating while accounting for the various ages and types of buildings in the community. We strongly urge that these estimates be compared with actual utility data or the results of other studies when possible to ensure that they are reasonable.

Other Approaches to Estimating Space-Heating Loads. Several other studies have demonstrated approaches to estimating the amount of energy used in buildings for space heating. The approaches initially take an average number from community sources that denotes local energy consumption for heating. These numbers may be expressed in Btu per degree day per square foot or perhaps in therms, kilowatt-hours, or Btu consumed per square foot (see Appendix C) (Okagaki and Benson 1979; Morris, Beyer, Dana, et al. 1978). These units are then multiplied by an average floor area in square feet for the home in the community to obtain average consumption per home. This number can be multiplied by the total number of homes in the community to estimate the total amount of energy used for space heating in that type of structure. An assumed level of savings is then applied for conservation and solar retrofits. These procedures are attractive because of their simplicity and their utility in obtaining quick estimates of energy consumption for heating in the community along with potential energy savings. This level of approach may be suitable for your needs in many cases.

The problem with this approach is its tendency to overgeneralize and not account for some of the unique characteristics that may exist in local housing. This can obscure the real range of savings that might be available in the community. The approach also doesn't consider the economic attraction of conservation and solar applications to households or to local governments that might be considering investments in energy efficiency. It states the total potential savings that might be available in the community without examining whether investments in energy-efficient retrofits are an efficient use of local capital, given certain economic parameters (for example, discount rates, energy price escalation rates, and holding periods of homeowners or investors). Such studies are extremely useful in pointing out what the local potential energy savings are and how they might be achieved. They are less effective in dealing with the economic and practical considerations of implementing the measures.

Applying Retrofit Measures

Determining the energy savings that can be achieved through conservation and solar retrofits is the next step in the procedure. The amount of savings that can be realized ultimately depends on the age and construction characteristics of the home. We found that savings of up to 60% were attainable in older Albuquerque homes through conservation actions, whereas savings of only 5% were likely to be achieved in newer homes.

We followed the maxim of *conservation first, then solar* in applying the retrofits. Such an approach is based on the economic costs of the two options and the increased solar performance that can be expected when the home is already energy efficient.

Estimating Conservation Savings

Estimation of savings attributable to a conservation retrofit package is difficult because of problems associated with isolating the contribution of any one item. The estimated savings that can be achieved will also be affected by lifestyle considerations of building inhabitants and climatic conditions in the locale. You must realize that it is only possible to get a rough estimate of the potential savings attributable to conservation. The procedure that we used should provide reasonable numbers for assessing local potential.

Savings are estimated by calculating the percentage improvement that can be achieved by increasing the thermal resistance of a given building component. The procedure is applied to specific building elements considering the various retrofits that are to be installed (for example, wall, ceiling, and floor insulation; storm windows; caulking; and weather stripping). Total savings of the entire retrofit package are then aggregated and subtracted from the existing heating load. Community savings are determined by multiplying estimated savings per home by the total number of homes in the community. A detailed discussion of the required calculations along with the particular problems associated with estimating conservation savings is included in Appendix C.

The selection of conservation measures may be based on maximization of energy savings in the community and/or on economic criteria. The former enables you to estimate the total conservation potential that may exist as a point of reference or perhaps to establish a community goal. An evaluation of the economic return on various measures, assuming certain discount rates and escalation rates in the price of energy, is effective in defining which ones should be implemented, in defining policy options, and in determining capital allocations (see Appendix E).

Estimating Solar Savings

Estimation of the savings that can be achieved through passive solar applications is based on techniques detailed in "Passive Solar Design Analysis" by J. Douglas Balcomb et al., of the Los Alamos National Laboratory, which is Vol. II of DOE's "Passive Solar Design Handbook" (1980).

Once the housing has been weatherized, a reduced heating load is obtained. This number is used to estimate the potential contribution of the passive solar system. We used two generic designs, an 8- by 16-ft greenhouse and an 8-ft 9-in. by 20-ft thermal wall (Trombe wall) for the purposes of our analysis (see Appendix A for a description of these retrofits). A load collector ratio is determined by dividing the new energy consumption level for heating by the collector area of the passive system. Reference to a table of values in Appendix F of the "Passive Solar Design Handbook, Volume II" allows you to use this load collector ratio to determine the estimated percentage of the building's energy that can be supplied by a particular type of passive system. This is referred to as the solar-savings fraction. The energy savings that are achieved through a solar retrofit are then subtracted from the level of consumption that results after conservation actions to determine a final heating load for the home.

Solar-savings potential can be evaluated in the same manner as conservation-savings potential. Total savings to the community may be estimated by multiplying the number of particular systems with their particular savings level times the number of structures that are estimated to be retrofittable. You may also wish to evaluate the economic attraction of the passive solar system based on the same considerations that are discussed with respect to conservation applications.

Determining Solar Retrofit Potential

The final step in determining the savings that can be achieved through passive solar retrofits is to estimate the number of structures that can feasibly accept a system. A number of considerations enter into the assessment of retrofit potential, including the construction type of the home, the age and condition (which has been dealt with through conservation), home orientation, shading characteristics of nearby structures or vegetation, fuel type, and the type of home (one story, two story, etc.).

The material that the house or structure is built with will determine the type of retrofit that can be made. A masonry home, for example, can accept either a greenhouse or a Trombe wall, because its south wall can act as the thermal mass for storing the heat radiated by the sun. Frame houses will only be able to accept greenhouses that can incorporate additional mass storage (water barrels, rock beds) because frame construction does not retain heat well itself. A mass wall may be incorporated into the south wall of a frame home, but it is unlikely that a significant number of owners would go to this trouble or expense. Frame homes can also be retrofitted with Morse walls which are essentially Trombe walls without mass. Such applications optimally can provide solar-savings fractions of up to 25% in cold sunny climates.* They can only be used for day heating though, because of their inability to retain heat. Morse walls were not considered for Albuquerque because high levels of solar insolation into building components and through windows keep daytime heating requirements relatively low.

The physical condition of a home will tend to deteriorate with age. The rate of decline will be affected by local weather conditions, lifestyle habits of the occupants, and construction materials. An estimate of the remaining economic life of the structure should be considered in determining the feasibility for a retrofit. Older homes will tend to have a higher level of heat loss because of lower levels of insulation. Conservation measures are always an important first step for these structures.

*Conversation with Scott Morris, energy consultant in Santa Fe.

Orientation of the home will have a major impact on its suitability for a passive solar retrofit. This factor is usually accounted for by determining the direction that the front of the house faces. Obviously a north-facing house will possess solar retrofit potential in its back yard, which faces south. A home does not have to have a wall that faces directly south. Surfaces that are oriented up to 30° east or west of south receive almost the same amount of solar radiation as those facing due south. In fact, wall surfaces may face up to 45° east or west of south and still achieve a fairly significant amount of solar radiation. The reduction in solar gain will amount to 20% or so (Total Environment Action, Inc. 1980, p. 64). Placement of systems on walls with orientations of 45° or more is generally not recommended because of the decreasing level of performance relative to the dollar investment.* Construction of systems on extreme southeast or southwest angles also may result in overheating problems.

Shading characteristics must be accounted for in determining retrofit potential. You need to examine shading characteristics only during the winter, because this is when the heating potential of the solar system will be used. A relatively shade-free south-facing surface is needed to obtain the full benefit of the sun, which will be located lower in the sky. Two types of shading need to be accounted for: vegetative and nonvegetative. Nonvegetative shading presents the larger problem because it may be difficult to remove the obstruction (for example, other homes, fences, walls, garages, and other structures). Nonvegetative shading is a particular problem for homes located on north-south streets. They are often built fairly close together, thus eliminating passive solar potential for the most part. Vegetative shading can be divided into deciduous and evergreen, an important distinction. Shading from deciduous trees and bushes does not present a real problem because the leaves will fall off in the winter; evergreen bushes and trees will cause shading problems as they retain their leaves. If the need arose, these plants could be removed, however.

Finally, the type of home being evaluated can also have an influence in the type of system that is appropriate. For example, a one-story greenhouse may be inappropriate for a two-story home which needs heating for the upstairs bedrooms. Modifications of the generic system types can be introduced if needed to account for special house types.

Shading Characteristics—The Field Survey. To determine passive solar retrofit potential accurately, you need to conduct a field survey to determine the shading factors affecting the homes. It is impossible to determine access without examining the height of objects and their distance from a given building. It is also necessary to determine the nature of the object (structure, vegetation) to see if modifications can be made to improve access.

The scope of the study that you might undertake will depend on the time and resources at your disposal along with the size and geographic features of your community. In Appendix D, we present a fairly unsophisticated and easy means for determining access potential. We refer you to studies done in Seattle, Washington, (Bennett and Miller 1980) and Boulder, Colorado, (Pollock and Stolz 1981) as examples of more ambitious assessments of solar access potential.

A local solar retrofit plan must also consider how access for buildings will be protected. The ability of property owners to build or plant objects that would shade a neighboring building's greenhouse, Trombe wall, or other solar collector can jeopardize the effectiveness of the retrofit program. Cities across the Nation have begun to plan for this problem through zoning, subdivision regulations, and the encouragement of solar easements between private homeowners. We include sources on this extremely interesting and developing field in Appendix F.

The Neighborhood Study

The same approach that we outlined in the first part of this section is applicable at the neighborhood level. It may be possible to obtain a greater level of sophistication and accuracy because of the smaller size of this entity.

We added one step in our analysis; we attempted to account for the condition of the property in addition to other physical characteristics. This approach was suggested by the pioneering work of the Philadelphia Solar Planning Project. The idea behind this approach is that structures in poorer condition will tend to use more energy. We conducted a field survey of the 1,541 structures in the Albuquerque study neighborhood by car. Our analysis of structural conditions, which was rather rudimentary

*Installation of systems on walls that are more than 30° off due south will begin to show reduction in performance. In fact most theorists state that the wall orientation should be within 22.5° of due south with due south preferred.

because of time constraints, was based on a judgment that the building was in good, poor, or fair condition. The criteria that were applied included the following:

- good—high level of exterior maintenance; fresh paint; roof, windows, doors, and wall siding all in good condition.
- fair—evidence of deferred maintenance; peeling paint; some structural deficiencies evident, such as loose boards, missing shingles on roof, and cracks in plaster of walls.
- poor—deterioration obvious; roof sagging; missing plaster on walls; broken windows; and doors off hinges.

Our judgments about the conditions of structures in the Albuquerque study neighborhood cannot be accepted as those of experts but suggest considerations that might be incorporated into your own field study. We made major assumptions about levels of infiltration, for example. Such a generalization should be checked against actual building analyses to ensure better accuracy.

Summary

A methodology to assess conservation and solar retrofit potential will take the following form:

I. Characterize the buildings.
   A. Determine the number of single-family homes (and other types of residential units) that are located in the community.
   B. Determine the age composition of the housing.
   C. Classify the housing according to construction characteristics.
      1. Determine the average size of a home in the community.
      2. Determine the construction types of the homes in the community (masonry, frame, other).
      3. Determine the structural types of the homes in the community (number of stories, floor type, roof type).
      4. Determine the average amount of window area for the homes.
      5. Determine the level of insulation in the various elements in the homes.
      6. Estimate an appropriate infiltration level.

II. Estimate typical heating loads.
   A. Model the heat-loss characteristics of the average homes, varying insulation levels and infiltration factors to account for the age and construction of the home.
   B. Compare estimates to any studies or samples that may be based on actual consumption figures.

III. Apply retrofit measures.
   A. Conservation.
      1. Determine the energy savings that can be achieved in the average home through conservation retrofits (using calculations included in Appendix C) based on the age of the structure.
      2. Apply the analytical framework under which the measures will be chosen (gross energy savings, economic considerations).
   B. Solar.
      1. Determine the energy savings that can be achieved through passive solar retrofits based on the type of system for the average home. This analysis will be based on the use of the load collector ratio method as detailed in the "Passive Solar Design Handbook, Volume II."
      2. Apply the analytical framework under which the systems will be adopted (gross energy savings, economic considerations).

IV. Determine the passive solar retrofit potential.
   A. Determine the orientation characteristics of the housing through the use of questionnaires, maps, field surveys.
   B. Conduct a field survey to assess shading characteristics of the housing.
   C. Apply passive solar retrofit options to the homes based on considerations of solar access.

Mobile homes have been produced for over 25 years in the US. The acceptance of mobile-home living among the public has risen steadily over that time span. This trend has been encouraged through improved financing arrangements for mobiles, enhanced livability, and the lower cost of mobile homes relative to conventional housing. Mobile-home sales have been expanding even more rapidly in recent years because of these considerations. In 1975, mobiles represented only 4.3% of the Nation's total housing but accounted for about half of all new single-family housing produced for sale each year between 1970 and 1975 (Manufactured Housing Institute 1975). The number of occupied mobile-home units increased by 69% between 1970 and 1975; during this same period, occupied single-family detached units increased by only 10%.

Mobile homes have proven particularly popular in certain parts of the Nation. As of 1975, 44% of the total number of mobile homes were located in the South. The Western states had a 24% share, followed by 22% in the North Central states and 10% in the Northeast.

Albuquerque's experience is perhaps typical of that of many rapidly expanding cities in the South and West. In 1970, mobile homes accounted for 2.5% (3,700 units) of Albuquerque's housing (Traynor, Springer, and Ortega 1979, p. 1). By 1979, they had attained a 4.7% share of the local housing market with 6,075 units. This reflects an increase of 77% during the 9-year span. This remarkable rate of growth and the significant percentage of Albuquerque's housing that is represented by mobile homes require that they be considered in a local retrofit plan. Depending on your local situation, you may also find that the potential energy savings of mobile homes is an important consideration for your community conservation and solar retrofit program.

Issues

Retrofitting mobile homes with conservation and solar measures presents some unique technical and economic considerations. These factors can work in concert to discourage retrofit actions. They relate to the construction characteristics of mobile homes, master metering of the energy source used for heating, and the economic and psychological characteristics of mobile-home residents.

Construction Characteristics

Until about 1974, thermal standards for mobile homes were rather minimal. Consequently, many of the mobile homes are in need of conservation improvements. The possibility of making significant improvements is limited, though, because of the construction characteristics of mobiles. First-priority retrofits recommended by most experts generally include caulking, weather stripping, storm windows, the addition of insulation to hollow-core doors, and other actions designed to minimize heat loss from infiltration. Second-priority actions would be to add storm doors, install insulated skirting around the bottom of the home, perform maintenance on the heating unit, and insulate heater ducts (Wells 1981, p. 5). Addition of insulation to the ceiling or side walls generally is not economic (if done by a contractor) because of the difficulties of installation (removing side panel sections and roofing or applying the insulation from the interior) ("The New Mexico Mobile Homeowner's Guide" 1979). The economic attraction of these measures will improve if the owner has the skills to do this time-consuming work.

Master Metering

Many mobile-home parks distribute natural gas and sometimes electricity or fuel oil to park residents through a master-meter system. Total consumption for the park is divided by the number of homes and a flat monthly charge reflecting the cost of the gas and the expenses of the management is developed. This additional expense is then added to everyone's monthly space rental bill.* This billing approach does not encourage conservation actions by the homeowner or tenant because he or she doesn't realize the real cost of his or her energy consumption. Park residents also tend to pay a lower price for the particular heating fuel because the park management receives a bulk discount rate for purchasing large quantities. This further reduces the incentive for residents to be prudent in their use of energy.

Several alternative metering strategies exist that link the bill of the mobile-home resident more directly to the actual level of consumption. These approaches are discussed in the "Multifamily Residential Buildings" section of this chapter. One report (Walker 1979) states that savings on energy bills of up to 35% are feasible when households are charged directly for the energy that they use. A new metering policy for mobile-home parks (and many multifamily buildings) probably should constitute one element of a local energy conservation plan. A barrier to implementing direct metering has been the expense that it represents to mobile-home park managements (and landlords of multifamily buildings).

Ownership

Mobile homes in most cities and counties are located in parks or subdivisions. It is important that the distinction be understood. Households living in a mobile-home park own or rent their home but always *rent* the space (land) on which their home is located from park management. Because park management owns the land, they may place restrictions on the type or location of improvements that may be added to the mobile home. The rules work much like zoning or subdivision regulations. For example, one park in Albuquerque will not allow any type of addition (for example, greenhouse) to be built on the south end of a mobile home if that end fronts the street because of aesthetic and safety considerations.

In a mobile subdivision, residents own both the unit and the land on which it sits. Their situation resembles that of the owner of the conventional single-family detached home. They may have a greater feeling of permanency and have some additional incentive to undertake substantial improvements that add to the comfort and value of the home. Households living in subdivisions also tend to have higher incomes than mobile-home park residents, as indicated by their ability to purchase the lot on which the home is located. Consequently, these households are more likely to have the needed capital to invest in energy-efficient improvements.

Comments

In summary, the incentive for households living in mobile homes to undertake conservation and/or passive solar retrofits will be constrained if they aren't aware of the full cost of their energy consumption. It may be necessary to enact local ordinances requiring metering approaches that more directly assess households for the energy that they use. In your local program, you must pay attention to the particular perspectives of mobile-home residents. These relate to renting versus owning the home and the restrictions that may be imposed by park or subdivision land-use regulations. You can also ex-

*The master-metering approach is used predominantly in mobile-home parks. Mobile-home subdivisions will be more likely to use an individual-metering system.

pect that mobile-home occupants will have lower incomes relative to those of the rest of the community population. In Albuquerque, we noted that many mobile-home occupants were retirees living on fixed incomes. The income characteristics of mobile-home residents, in some cases, will restrict the residents' ability to implement conservation and possibly passive solar retrofits. Reductions in installation costs and financing terms may be especially important to mobile-home residents. Finally, the unique construction characteristics of mobile homes may prevent the mobile-home occupant from economically achieving the percentage reductions in energy consumption that the resident of a conventional home could achieve.

Methodology

The procedures by which mobile homes are evaluated for retrofit potential are essentially the same as those for single-family homes. The analysis relies on estimating the number of mobile-home units in the city, identifying the construction characteristics, applying the conservation retrofit measures, assessing solar potential, and applying the solar retrofit measures. The application of the procedure is presented in the "Mobile Homes" section of Appendix D.

The analysis of mobile-home retrofit potential differs in one respect from the procedure used for single-family residences. Mobile homes have unique construction characteristics that forced us to make an adjustment in our estimation of insulation levels. Single-family homes are built on site and reflect local construction practices (for example, levels of insulation) and the particular style of the builder. Mobile homes are built in a different way altogether. The mobile home is assembled in a factory and then delivered to the site. This construction approach allows manufacturers to keep labor costs low and achieve economies of scale through bulk purchase of materials. Specialized production processes further improve the efficiency with which the homes are manufactured.

These production methods enable manufacturers to keep the prices of mobile homes attractive to consumers. This is crucial because price is the major attraction of mobiles to buyers. Since mobile homes are built to appeal to a certain segment of the buying public, production-cost considerations are a primary concern to manufacturers. This has led to a situation where mobile-home construction characteristics have become somewhat standardized to keep costs in line with what the market will accept. Manufacturers will be unlikely to adopt more customized construction practices lest they lose their competitive position in the market.

The standardization of construction practices also is reflected in the thermal characteristics of mobile homes. Most homes are built with insulation levels and other energy-saving options that don't impose additional costs on the buyer. The sensitivity of buyers to initial cost has generally resulted in the installation of energy-efficient measures by manufacturers that just meet the requirements of various thermal standards which have been in effect over the past decade. Although the buyer can obtain an upgraded conservation package on a mobile home, it is probably safe to say that most purchase a standard mobile home because of its lower cost.*

*Telephone conversation with Lamar Glover, Production Engineer at Champion Homes, Dryden, Michigan, December 1980.

Consequently, calculations of insulation levels and other construction characteristics have been based on the minimum requirements imposed under the National Fire Protection Association/American National Standards Institute (NFPA/ANSI) voluntary standards begun in 1969 and the mandatory standards implemented by HUD starting in 1976. This approach may be questioned because of changing consumer perspectives on the importance of energy conservation measures in the last 5 or 6 years. We feel that it is a fairly simple and relatively reliable means to approach the analysis of mobile homes, however.

Multifamily Residential Buildings

Planning for energy efficiency in multifamily dwellings is a task that involves issues unique to this class of structures. The issues range from the physical properties of these buildings to the occupancy status of their inhabitants. The complexity of these issues has been cited as a reason for the lack of attention this type of housing has been receiving in discussions of energy conservation and solar retrofits in the residential sector (Bleviss 1980, p. 1). But even though it is difficult to achieve efficient energy consumption in multiunit housing, it is important that conservation is encouraged because one-third of all residential units in the US are in this category. In addition, some of the serious problems facing America's cities, such as neighborhood decline and landlord abandonment of apartment buildings, have been linked to escalating prices of fossil fuels.

As you begin to plan your local energy program, you will notice that efficient energy consumption in multifamily housing is difficult to achieve because of the characteristics of these dwellings. Forty-two per cent of these structures were built before 1940, an era when energy conservation investments were neglected because of the cheap and readily available supplies of fossil fuels. Eighty-four per cent of all multifamily units are occupied by renters, who tend to have low and moderate incomes and are less able to afford rising utility costs or increased rents caused by a landlord's higher fuel bills.

Furthermore, many multifamily dwellings receive natural gas or electricity through master meters. When this is the case, tenants have little incentive to conserve, because the cost of using each additional unit of fuel is zero. And in many master-metered buildings, there are central heating controls, or there is one main thermostat for the entire heating system, so that not everyone's preference can be met. Some tenants compensate for heat deficiencies by using personal space heaters in their units; thus additional inefficient equipment is used that contributes to energy waste (Teller 1979, p. 76). Even when units in a multifamily structure are equipped with separate meters, tenants may be legally or financially constrained from making conservation investments, because they do not own the units. Incentives for energy conservation investments in owner-occupied multifamily units, such as condominiums and cooperatives, are more visible, because the direct beneficiaries of the expenditures are the owner-occupants.

The following sections identify a planning procedure for assessing the potential for energy efficiency in multifamily residences. This procedure was developed from and is based on our experience with considerations that affect the thermal characteristics of multifamily structures in Albuquerque, New Mexico. The application of the procedure is detailed in Appendix D.

Classifying the Buildings

Your first step in planning for energy efficiency in your community's multifamily housing is to classify the buildings by age, number and type of units (how many one-bedroom units, how many two-bedroom units, etc.), size of each unit, and whether the buildings are owner-occupied (condominiums or cooperatives) or renter-occupied (apartments). It is also important to note building type (how many townhouses, how many garden apartments, etc.). Other information that is useful, but not always available, is the extent to which investments in energy conservation have been made in each building. How much and what types of insulation are in the structure's attic and walls? Is it equipped with tight-fitting storm windows and storm doors? Have cracks been caulked and/or weather-stripped? You also need to check the type of heating system used in the multiunit structure. Three points are important: (1) what type of system is it, (2) what type of fuel does it use, and (3) how is fuel usage metered?

Some of this information can be obtained from a visual inspection of each building. But often, insulation levels are hard to ascertain, because building owners are not always sure of the amounts and types of insulation that may have been installed. When this is the case, find out the date that the building was constructed; you can then estimate insulation levels from those that were required by the building codes that were in effect when the structure was built. Or, if you know the name of the general contractor who built the structure, contact that person for this information. Architects and city building or zoning officials proved to be valuable informational sources for us during our study of Albuquerque.

Another piece of information that will be helpful in assessing each building's conservation potential is the general direction in which it is oriented. If it has a south-facing orientation, note whether the southern exposure is unobstructed or whether it is shaded by other buildings or trees that might prevent a solar energy system from receiving necessary sunlight.

Estimating Energy Usage for Space Heating

The most accurate method for determining energy consumed for space heating in a building is through examination of actual utility bills or records for that building over several heating seasons. This is true regardless of the type of building, whether single family, multifamily, mobile home, or nonresidential. In this section, we examine how space-heating requirements can be estimated from the utility bill. Although the approach is applied to multifamily buildings, it could be applied to single-family homes, mobile homes, and nonresidential buildings as well.

A quick way to obtain information on energy consumption in apartments is to approach owners of buildings that are master-metered. In these buildings, the landlord pays all of the utility bills and passes on energy costs to tenants through their rents. The utility records of landlords provide excellent first-hand information on actual energy consumption. We contacted the Public Housing Authority and several property management firms, all of which managed a number of master-metered buildings of various ages and construction types in Albuquerque. This approach enabled us to obtain billing data on 1,276 units out of the total of 41,788 multifamily units in Albuquerque, or a 3% sample. Although the sample was by no means scientifically drawn, we feel it represents a range of ages and construction types. It also reflects a fairly diverse level of occupant incomes.

The management firms supplied us with information on the age characteristics, insulation levels, construction and unit-size characteristics, and heating types. This was useful information for our analysis because it enabled us to get a picture of typical units throughout the City. Census data, building-permit data, and data from the public housing authority can be added to this information to determine the total number of units and to estimate consumption and possible savings for the City as a whole. Care should be taken to impress upon your audiences in reporting consumption and savings the possible shortcomings of your data. A range of savings should be developed based on a conservative approach.

Once gross data are obtained, you need to separate out other energy uses; for example, energy used for cooking and water heating. This can be done by comparing summer levels of energy consumption with winter levels. You can assume, for example, if the building uses gas for space heating, cooking, and water heating, that the summer bill will reflect only gas used for cooking and water heating. This level of consumption can be compared with the amount of energy used in the winter, and a percentage reduction factor can be estimated. You can then reduce the winter bill by this percentage to estimate energy used for space heating alone. In addition, because the building is master-metered, you should factor out energy used in common areas such as swimming pools and laundries, if at all possible.

To determine total heat loss in the apartment building, you take the net number of therms used for space heating of units, multiply by 100,000 to arrive at a total Btu consumption for the heating season for the building.

Next, divide the total Btu consumption for heating by the actual number of degree days for the season.* The Btu per degree day are then divided by the aggregate square footage of the units in the building (minus the heated common areas such as lobbies and party rooms). The total consumption figure is then multiplied by an assumed furnace efficiency factor. For Albuquerque, we assumed 55% for buildings constructed before 1976 and 65% for those built after 1976.** The product of consumption and furnace efficiency factor is the heat-loss factor, which can be used for comparative purposes or to determine the heating load or bill for an average apartment unit.

A degree day adjustment factor should be applied to correct the heat-loss factor for the difference between the actual number of degree days per year and the average annual heating degree days for your area. To determine the adjustment factor, subtract the actual number of degree days from the average annual value and divide by the average value. This adjustment ensures a better estimate of the building's (or unit's) heating needs in a typical year and gives a more reasonable estimate of conservation savings. Application of this approach to a number of buildings of different ages, sizes, and construciton types should enable you to determine a range of heat-loss factors for buildings in the community.

Estimating Conservation Savings

Estimating conservation savings on an apartment unit is difficult because of shared walls, ceilings, and floors. The savings that result from adding insulation will vary from unit to unit. For example, adding ceiling insulation in an apartment building may

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*Degree day information is available from your local weather service.

**Furnace efficiency factors may be determined through reference to professional manuals and through consulation with your local utility.

reduce the heating bill of the second-floor tenant but may do little or nothing for the first-floor tenant's bill. Efforts should be made to contact local engineers or architects to ascertain potential unit savings attributable to the addition of various levels of insulation. It may be possible to develop an expected percentage reduction in the heating load of a typical unit.

Savings from the installation of storm windows, caulking, or weather stripping may be determined by estimating the typical percentage of an apartment's heating load that is lost through windows and as a result of air infiltration. This percentage is multiplied by the percentage improvement that is obtained through the conservation measures times the initial heating load of the unit (or building). The total conservation savings per unit then may be multiplied by the total number of units in the community to determine the total amount of savings.

Estimating Solar Savings

Estimating the energy savings from passive solar retrofits is more difficult because of the differences in multifamily building type, the technical means of heat transfer from south-side to north-side units, and local building and fire codes. The investment motivation of landlords represents another consideration in assessing local potential. Although it may be possible to analyze the potential of specific buildings on a neighborhood level, we feel it is extremely difficult to assess potential at a larger level, such as the city or county. Therefore, our community analysis in Appendix D does not examine city-wide savings in Albuquerque from such measures.

Estimation of a reasonable level of energy savings in multifamily buildings located in your community is a difficult task and not easily done without professional assistance. We advise that you seek the advice of individuals familiar with energy issues in these types of buildings when you are developing your estimation of savings potential.

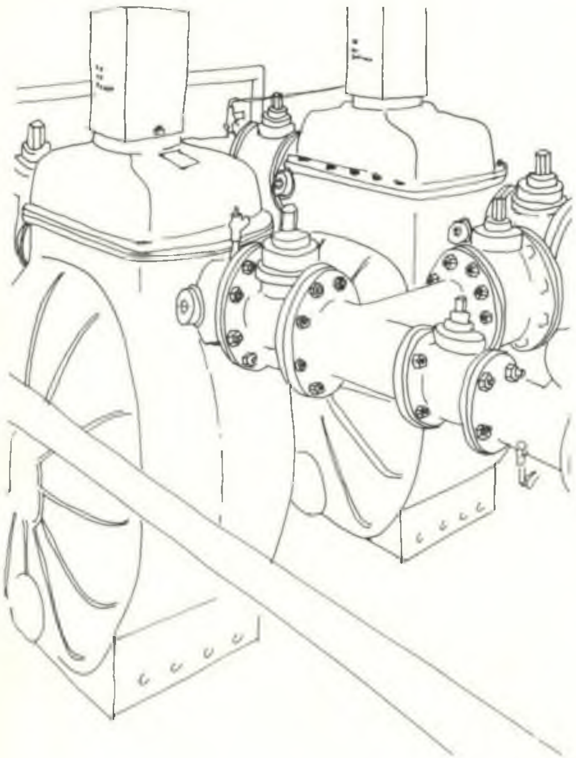
Alternative Metering Strategies

The way by which energy is metered in multifamily buildings will affect the amount of energy consumed. Booz, Allen, and Hamilton, Inc. (1979) identified three basic metering strategies that have been used to measure energy consumption.

(1) Master Metering. Under this system, a single meter is used to gauge energy consumption in an entire building. This meter is owned by the utility company, and payment of monthly energy bills is the responsibility of the building owner. Tenants in a master-metered building pay a fixed charge per month that includes both rent and energy usage.

(2) Individual Metering. Under this alternative, each apartment in a multiunit complex is equipped with a meter that is owned by the utility company. Tenants in an individual-metered building are directly responsible to the utility company for their energy usage and pay a monthly charge to the building owner for rent only.

(3) Submetering. This type of energy monitoring system uses a combination of the two previous methods. Energy usage of an entire building is measured by one meter that is owned by the utility company. In addition, each unit is equipped with a submeter that is the property of the building owner. In this way, each tenant's monthly payment to the landlord consists of two components, rent and energy usage. The building owner is then responsible for payment to the utility company.



Unit-Controlled Metering Versus Master Metering

As an alternative to making any direct conservation investments, owners of master-metered complexes may opt to invest in switching responsibility for energy payments to the tenants, through either individual meters or submeters. Both of these strategies have the advantage of making energy users responsible for the amount of energy they consume, thus creating incentives for conservation. But, because the tenants do not own the units they inhabit, these incentives face constraints. Any conservation initiatives that they may undertake, therefore, are likely to be limited but nevertheless can result in energy savings of up to 35% (Walker 1979). A conservation plan that relies solely on this metering strategy would decrease energy use somewhat, but would do nothing about a structure's inefficient design.

The Question of Incentive

Even though conservation investments can be shown to be cost effective through annual energy savings, these savings alone do not necessarily represent the incentives that must exist before such investments will be made in all multifamily dwellings. In the owner-occupied structures, the energy savings can be effective incentives, because the direct beneficiaries of expenditures for this purpose, the occupants, are the same people who would be making the investments. In apartment buildings, however, the situation is different. Potential energy savings can motivate an owner of a master-metered complex to weatherize, because this owner pays the fuel bills for the building. But if an apartment complex is equipped with individual meters or submeters, the building's tenants—not the owner—are responsible for the amount of energy consumed. So if the owner doesn't pay the fuel bills, why should he or she spend money to lower them?

Profit in Rental Housing

Although rental-housing owners may not be motivated by conventional fuel savings to invest in conservation measures or alternative energy systems, other factors may induce such courses of action. The criteria for investment decisions in rental housing are based on the different types of profit that can be received from this kind of venture. These include improved cash-flow and tax-shelter benefits during a building's operating phase and increased capital gains at the time of a building's sale. Therefore, an analysis of the economic feasibility of these investments should focus on the effects of these investments on these different indications of profit.

The most widely used ownership mechanism for multifamily rental projects is the limited partnership. Investors in such agreements treat all income or losses from the projects as additions to or deductions from personal income. Operating expenses, including property taxes, mortgage interest and insurance premiums, and depreciation, are all deductible business expenses. Tax laws regarding depreciation of rental property have been designed so that this particular expense can be calculated at larger than actual rates. This provision is known as accelerated depreciation and is the factor most responsible for tax-shelter benefits in rental-housing investments. A tax shelter exists when revenue streams from an investment can be shown to be less than actual cash flows. In this way, cash that investors receive from a rental project can be tax free, and if "paper losses" are large enough, income received from other sources can be "sheltered" from income taxes. In a review of a rental-housing investment possibility, then, projections that show a wide gap between cash flow and project income are preferable to those that do not.

In addition to cash-flow and tax-shelter benefits, rental-housing owners also are interested in maintaining or improving an apartment building's value, so that a profit at the time of a structure's sale, or capital gain, can be realized. One commonly used method for determining value for an apartment building is to divide the project's annual income by a capitalization rate. This rate is usually equal to the current rate of interest with a premium added for risk. The higher a project's income is, the higher is the building's value.

Investments in energy conservation can have a positive effect on the different types of rental-housing profit in the following ways.

(1) *Cash-Flow Benefits.* Assuming that tenants are indifferent to changes in components of monthly shelter costs, as long as total costs remain the same, increases in rent charges may be possible if utility costs decrease.

(2) Tax-Shelter Benefits. Increasing the value of a building by investing in conservation materials will expand the depreciable base, allowing for increased benefits through accelerated depreciation.

(3) Capital Gains. Increased revenue from higher rent payments will result in higher building value and greater profits at the time of sale.

In addition to the benefits cited above, Federal and state tax credits for energy conservation and renewable energy system investments can reduce income tax liability and improve cash-flow and tax-shelter benefits. Federal income tax credits include those available to homeowners under the Energy Tax Act of 1978 and the business energy investment credits under the Crude Oil Windfall Profits Act of 1980. As of August 1980, over 40 states have enacted legislation that provides similar credit to reduce state income tax liability.

At this point you can see that any plan for improving energy efficiency in a community's multi-family housing must be formulated so that it recognizes the criteria for investment in rental property. Tax credits or low-interest loan programs can be tailored effectively to rental-housing owners to encourage conservation investments (Levine and Raab 1981, p. 48). But because of forgone tax revenues and administrative expenses, such a course of action can be costly for the government. The benefits of decreased energy use will have to be weighed against these costs.

Local Initiatives for Conservation in Multifamily Housing

A review of programs designed to improve energy efficiency in multifamily dwellings and instituted at the local government level was prepared by Levine and Raab (1981, pp. 46-47). Most commonly instituted mandates include time-of-sale requirements for existing buildings and energy conservation construction codes for new buildings. In addition, some communities are attempting to pass legislation that requires specific levels of thermal integrity to be met in all structures by a certain date. Community officials plan to enforce provisions such as this with energy audits.

Time-of-sale requirements can be advantageous, because building owners can recapture their investments in energy conservation materials through sale prices that reflect the buildings' increased value. A potential disadvantage is that owners of some energy-inefficient structures may have no intentions of selling, so that some buildings will be unaffected. Requiring specified levels of conservation by a certain date is likely to be politically unpopular, because landlords will need to recoup their investments through higher rent charges. Tenants will have to understand that although their rent charges will increase, their utility payments will decrease, if such a program is to gain popular support.

You can see that instituting a plan to encourage energy efficiency in your community's multifamily housing will face significant obstacles unique to this class of structures. These obstacles are surmountable, but only if your plan is equitable to tenants and attractive to owners.

Sources of Energy Consumption in Buildings

If you want to develop a general energy plan, you need to understand the various building components that consume energy (either directly or indirectly) and the modifications that might be in order. Most nonresidential buildings were constructed when energy was cheap, and it did not seem to make sense to invest much money in energy-efficient systems. However, energy costs have changed radically in the past few years. It may mean serious economic hardships if we do not reevaluate these buildings and take appropriate actions.

The following discussion of energy consumption applies to most nonresidential buildings, including commercial, retail, government, hotels, hospitals, schools, and others. There are large differences between these types of buildings and often substantial differences between buildings of the same type [which is why energy audits are so important (see Appendix B)]. The total cost of energy consumption in larger buildings will often justify the cost of detailed energy audits, and even smaller buildings will benefit from walk-through audits. In either case, it will be helpful to have an understanding of the basic issues involved.

The Building Envelope

The portion of the building shell (walls, roof, or floor) that separates the heated or cooled sections from unheated or uncooled sections, or from the outdoors, is called the building envelope. Although the envelope does not consume energy directly, it is indirectly responsible for a major portion of the energy used in heating and cooling. There are three factors to consider.

Infiltration and exfiltration are the leakage of air into and out of the building. In most residences, a certain level of infiltration is tolerable because it provides ventilation. However, larger buildings usually incorporate a ventilation system as part of their heating and cooling equipment, so infiltration here is not desirable. During the heating and cooling seasons, any air leaking into the building must be heated or cooled, thus increasing the energy use for these functions. Older buildings, in particular, often have high infiltration rates because of poor-fitting doors and windows.

Fortunately, the solution to infiltration problems is relatively simple and is often one of the first recommendations of an energy audit report, because up to 20% of heating and cooling loads may be offset. Doors and windows must be properly fitted with weather stripping so that there are no cracks when they are closed. Caulking is usually necessary to seal holes and cracks around door jambs, window frames, and wherever beams, pipes, or ducts penetrate the envelope. Exhaust air ducts for stoves, dryers, and other equipment must be fitted with backdraft dampers to cut infiltration when they are not in use, and window-type air conditioners should be covered and sealed during the winter.

Although cold, drafty areas will alert the occupants to infiltration, many buildings with central heating, ventilation, and cooling equipment (abbreviated as HVAC) often are slightly pressurized so that cold infiltration drafts aren't noticed. However, the heat loss actually may be increased slightly by this method if the exfiltration is greater than what is needed for ventilation. To spot areas of serious infiltration and exfiltration, as well as other forms of heat loss from the envelope, we can use infrared photography and video techniques to "see" surface temperatures by color and thus identify problem areas in the envelope.

Unglazed areas of the envelope are also sources of heat loss and heat gain caused by conduction, the process by which heat moves through all materials. The amount of heat transferred by conduction, in any given situation, will depend directly on the insulating value of the material. This value is often called the R value, and the higher it is, the better the insulation.

The amount of insulation required in the building envelope depends on the climate. In mild climates, for instance, large amounts of insulation may not be cost effective. Typical standards often call for R-11 insulation in the walls, although R-19 is now recommended in cold climates. "Superinsulated" structures with R values of 40 to 50 may be very effective in severe climates.

You will probably notice that most codes and standards specify greater insulation values in the roofs of buildings than in the walls. This difference is specified not because the roof is subject to greater heat loss (although this may occur in buildings with particularly poor heat distribution) but rather because it has deep rafters or beams, which makes adding extra insulation easier and more cost effective.

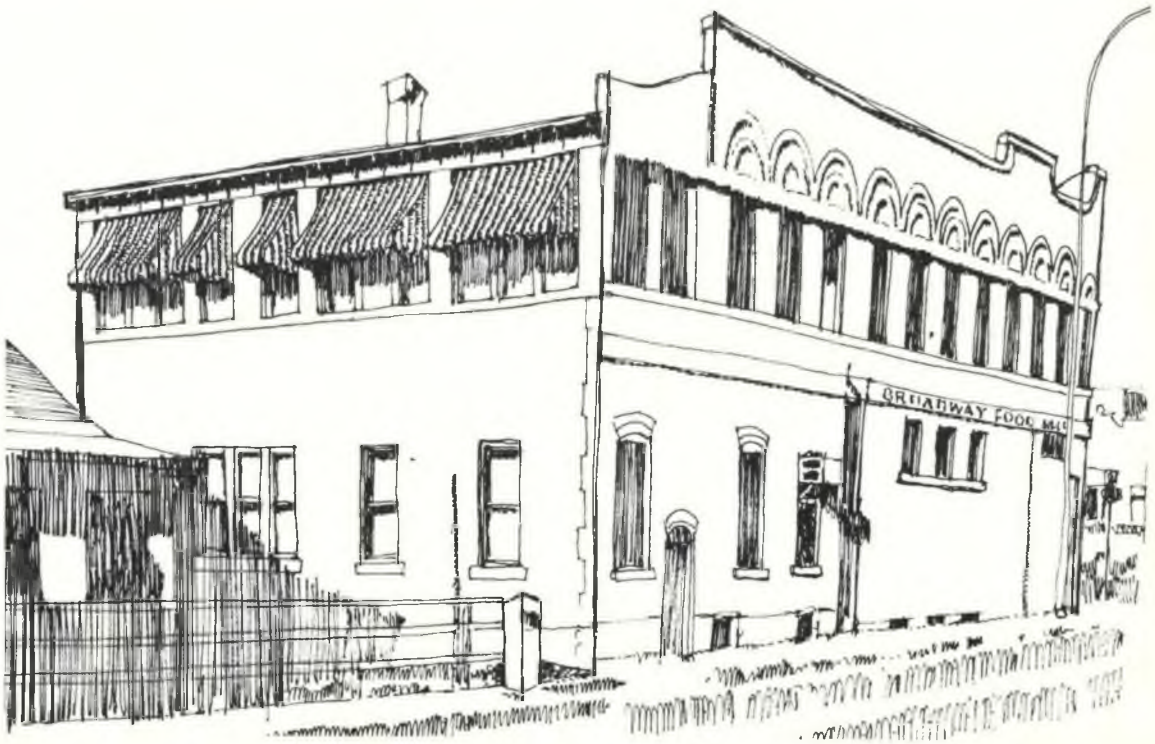
Existing frame buildings may be insulated with loose fill or blown-in insulation, a common technique that only requires small holes to be drilled through the sheathing so that the insulation can be blown into the void spaces. If a major renovation is in progress, it is often best to remove the interior plaster or wallboard and install batt insulation with a vapor barrier before refinishing the walls. Either technique is relatively simple and generally very cost effective.

Many older buldings, particularly the large masonry structures favored for public edifices, have little or no intentional insulation and very low R values. Occasionally these buildings were built with double walls, and it may be possible to fill the interior gap with loose fill insulation. If not, insulation can be added either on the inside or outside of the envelope. Each technique has disadvantages, however. Insulating the exterior requires scaffolding for high buildings and, of course, will usually change the appearance of the building. Insulating the interior does not provide results that are quite as good because of the inaccessible areas where walls and floors join the envelope. It can also be disruptive to the occupants.

In either case, insulating existing masonry buildings is generally expensive. Although much energy can be saved by insulating any building, such measures usually rank low on the list of priorities because of long payback periods. Exceptions exist, such as frame or double-walled masonry structures, and should be recognized by a competent energy auditor.

Glazed areas of the envelope, such as windows, glass walls, and skylights, are very important components of the building, because they often play a critical role in heating and cooling. The insulating value of typical glass sheets is almost nonexistent; the R values, which are usually listed at R-0.9 for single glazing and R-1.67 for double glazing, are mostly attributable to the insulating value of the still-air films on the surfaces of the glass sheets. Comparing the R values of glass to those of typical walls shows that single-glazed windows lose about 12 times as much heat during the winter season as a comparable area of wall insulated to the standard R-11. Double-glazed windows only lose about 6.5 times as much heat as the standard wall, but this loss is still substantial.

There are several ways to reduce wintertime heat loss through glazing. Excess windows, especially on



north walls, may be sealed off and insulated on a permanent or seasonal basis. Movable insulation, in the form of curtains, shades, or interior shutters, can be very effective if used every night, especially if they have good seals that prevent air movement against the glass. If the building currently has single-glazed windows, installing storm sashes or new double-glazed windows should definitely be considered.

Windows also allow sunlight to enter the building, which can be both good and bad. Natural daylighting is almost always welcome. Not only does it provide high-quality light, it also offsets the need to use electric lights and thus helps to conserve energy. In the winter, sunlight entering the building through glazed areas, especially on the south side, can be very effective in helping to heat the building and should be encouraged (see Appendix A).

But solar heat gain can also be a real problem for many buildings. During the cooling season, which may be a major part of the year for many large buildings, the sunlight entering the glazed areas will significantly increase the cooling load. Glass on the east and west walls, as well as on the roof, is particularly vulnerable in this respect. If you have ever wondered why many new buildings use tinted or reflective glass, it is to reduce the amount of solar heat gain; many of them would otherwise have to run their air-conditioning systems 12 months per year.

There are many types of solar control and shading devices that may be installed on existing buildings. These include reflective curtains, reflective films that are applied to the glass, and exterior fins or baffles designed to cut the amount of direct sunlight while still providing good, natural daylighting. In mild or hot climates, such solar control devices will often pay for themselves in 2 or 3 years ("New Mexico Energy Audit Training for Schools and Public Buildings" 1979).

Heating Equipment

One of the first actions that comes to mind when trying to conserve energy is to turn down the thermostat. This is an effective measure, because it involves no cost and can often save 10% or more on utility bills. Interior temperatures of 65°F to 68°F during the winter are usually recommended, but they may vary depending on the type of heating system, relative humidity, and other factors.

Another effective low-cost measure is to install timing control devices that vary the thermostat setting depending on the time of day. Thus, the temperature can be allowed to drop to 50°F or 55°F at night when the building is unoccupied. Determining the most effective night setbacks is somewhat complicated because of the thermal lags created by the mass in the structure. Generally a setback of 10°F to 15°F from 1 hour before closing to 1 hour before opening is used; however, an engineer's advice should be obtained for large, complex buildings.

There are many different varieties of heating systems, and although it is not our purpose here to elaborate on each type, there are several measures that may be taken to conserve energy in almost every type. All heating systems need proper maintenance, including repairs, cleaning, and fine tuning of component and controls. Just as a car gets better mileage after a tune-up, heating systems (as well as other equipment) only perform at peak efficiencies when properly maintained. Modifying the heat distribution system can also be helpful; then each area in the building gets only the amount of heat that it needs, when it needs it.

Possible modifications to the heating system include insulating hot pipes and air ducts, replacing pilot lights with electric ignition devices, and installing heat-recovery systems to recycle waste heat. If the owners are thinking of replacing an old central heating system, they should consider modular-type heating units because such units can often increase the system efficiency by about 10% (National Electrical Contractors Association 1979, pp. 26 and 27).

Cooling Equipment

Many of the recommendations for heating systems also apply here. Thermostats should be set at about 78°F during the cooling season, and timer controls should be installed. All air-conditioning equipment should be shut off during unoccupied periods, with the exception of that for rooms containing computers or other sensitive equipment that may operate at night. A system that uses an economizer cycle, however, should be left to operate full time because the cycle is energy efficient and will offset the need for extra air conditioning during the day.

If you live in a relatively dry climate, the use of evaporative coolers (often known as swamp coolers) should be encouraged. Although they do have limitations and are not applicable in humid climates, they use only a fraction of the energy required by air-conditioning systems to perform the same cooling task.

Where air conditioning is necessary, consider replacing old absorption-type coolers that require the boiler to run during the summer. Electrically operated centrifugal units often are more efficient.

Air motion can make people feel much cooler. Fans can, and should, be used to supplement the cooling system whenever possible.

Maintenance, again, is essential for peak performance, regardless of the type of equipment used. Even fans will run more efficiently if all parts are kept clean and well lubricated.

Ventilation Systems

Ventilation often accounts for a substantial percentage of heating and cooling loads because of the energy required to heat or cool the fresh air taken into the building. Sizable savings can be realized by reducing the amount of ventilation. Acceptable ventilation levels will vary, depending on how a space is used, and generally are governed by code. Although certain levels of ventilation are essential for health and safety, most authorities recognize that current codes call for excessive levels of ventilation. By working with your local code officials, you may be able to have these standards modified somewhat.

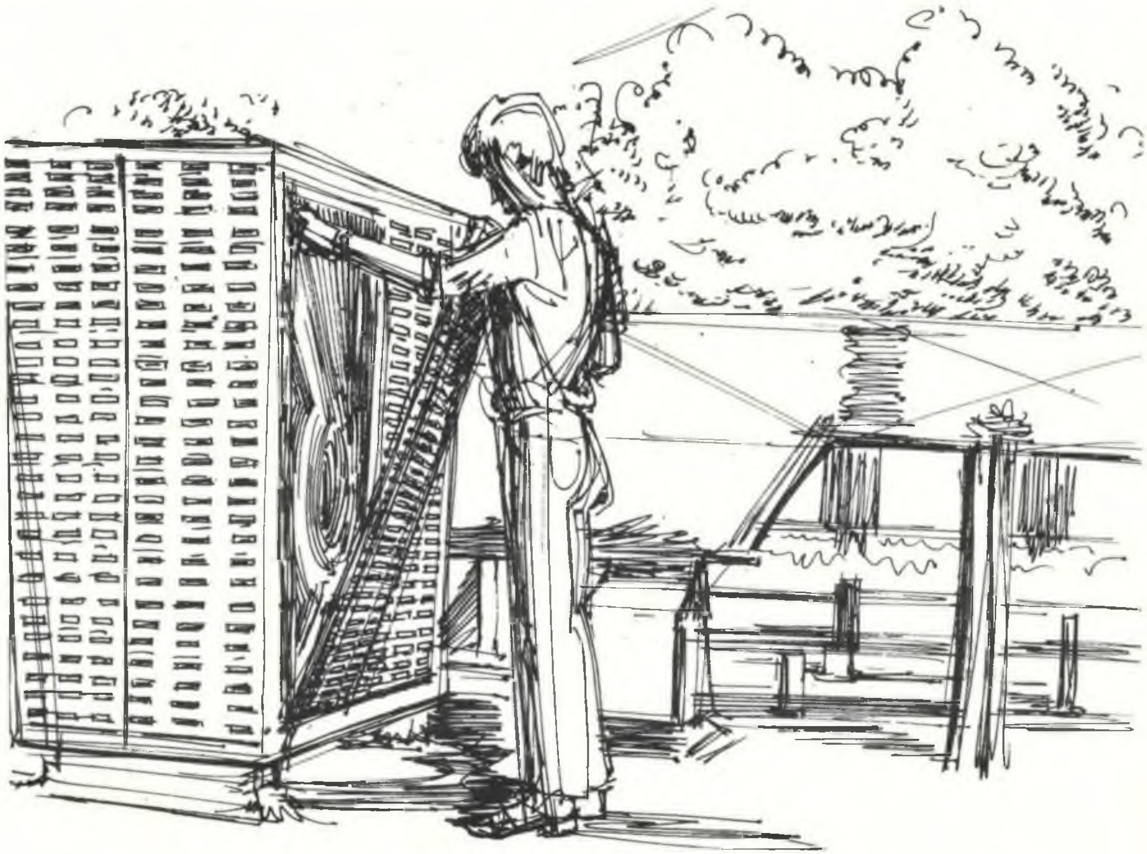
Ventilation levels should be checked carefully and reduced to acceptable standards. In areas that require high levels of ventilation for odor control, these levels can often be decreased by installing air-filtering equipment.

Natural ventilation through doors and windows is very desirable, but should not conflict with heating and cooling functions. If windows are left open during the heating or cooling seasons, a great deal of energy will be wasted. Opening of windows occurs when people feel that the air is uncomfortably hot or stuffy and indicates that a change in the heat distribution and/or ventilation system is needed.

If a building uses a great deal of energy because of ventilation, it is often economical to install a heat-recovery device. There are several types available, all of which operate by removing the heating or cooling potential from the exhaust air and using it to temper the incoming fresh air. The efficiency of these systems is usually between 40% and 80%, depending on type and quality (National Electrical Contractors Association 1979, pp. 42 and 43). The Smithsonian Institution installed such a heat-recovery device that paid for itself in the first few months; such systems are now quite common.

Lighting

Lighting in buildings is often one of the focal points of an energy audit because the opportunities for saving energy are substantial. Retail stores, for example, typically use 60% of their energy for



lighting (Thurmann 1979, p. 25); and because the energy required is electricity, lighting can be very expensive. Lighting can also be a major energy consumer in schools, hospitals, and commercial and government buildings of all types. Fortunately, there are many no-cost and low-cost ways to save energy on lighting.

Reducing unnecessary lighting is usually simple and effective. A good energy audit will include a lighting usage study detailing what light levels are necessary in different areas at different times.

The lighting system in many nonresidential buildings was designed without knowing exactly how each space would be used over time. Thus, the designers often were forced to design in maximum light levels throughout the building. In some areas this bright lighting may be needed, but in many, it is not. The light levels may be reduced by removing some of the lamps from their sockets; however, this should be done by a knowledgeable person when dealing with fluorescent lights controlled by a common ballast. The existing lights also can be replaced with lamps of a lower wattage, or dimmer controls can be installed to adjust light levels as needed. Choose a dimmer carefully; those that contain a silicon-controlled rectifier save energy, most others don't. In areas where bright lighting is needed in only a few spots, it is usually very effective to reduce the general light level and use brighter "task" lights where needed.

Increasing lamp efficiency should also be considered in most situations. Incandescent bulbs are very inefficient and rarely used in large buildings for just this reason. Fluorescent lights deliver 3 to 5 times as much light as incandescents, while using the same amount of energy (Thurmann 1979, p. 204). New fluorescent lights are available that are 14% more efficient than those in common use (National Electrical Contractors Association 1979, p. 33). As existing lamps need replacing, the more efficient type should be used.

There are several other ways to increase lighting efficiency. Lamps, reflectors, and glass or plastic covers should all be kept clean as part of a scheduled maintenance program. The color of walls and other surfaces in the room also is very important and should be light wherever possible. In tall rooms, lights suspended to within 8 or 10 ft of the floor will give better results than lights on the ceiling.

Timer controls on lights also can be very helpful where certain set usage patterns are obvious. In some cases, photocell switches are the best choice. Not only are these useful for outdoor security and advertising lighting, but they can also be very effective inside to switch off the lights when natural daylighting is sufficient.

Natural daylighting of interior spaces should always be encouraged because it not only saves energy but also provides the best quality light in most situations. The most desirable natural light is diffuse rather than direct. Diffuse light can be obtained in several ways, even if the window or skylight is subject to direct sunlight. Special diffusing glazing may be used, or translucent curtains can be drawn on very sunny days. Another good arrangement is to have the direct sunlight bounce off light-colored walls before hitting the work area. Usually, this can be done quite easily with skylight wells and clerestories.

It is often effective to add windows and skylights or clerestories to buildings that would otherwise need artificial lighting. When considering this option, solar heating should also be considered, because the two functions can be complementary. Much will depend on the balance between the heating and cooling loads of the structure, as well as the local climate (see Appendix A).

Although there are many simple and effective measures to reduce energy consumption for lighting, remember that lighting systems and their interrelationship with other energy functions in large buildings can be complex. Lighting often has a major impact on heating and cooling systems that must be considered before any major modifications are undertaken. A thorough energy audit that considers all ramifications of such changes is highly recommended for large buildings.

Water Usage

The use of water in buildings should not be overlooked when considering energy consumption. Not only is energy required to pump water, but also significant amounts of energy are needed to heat it for hot-water systems, cool it for water coolers, and, ultimately, process it in waste-water treatment plants. Indeed, the availability of water itself may become a major concern to many communities soon. Efficient ways to heat it, cool it, and use it are all very important.

Reducing the amount of water used can save energy, as well as lower water bills. Reducing usage requires paying special attention to the water fixtures in the building during a detailed energy audit. Pressure-reducing valves should be installed wherever the water pressure is above 40 lb./in.^{2} (National Electrical Contractors Association 1979, p. 36). Such measures eliminate the high-pressure blast of water that is so wasteful in most fixtures.

Special low-flow sink and shower fixtures are available that give good results with about one-half the volume of water. These are highly recommended because both fixtures dispense hot water, which should be conserved as much as possible. Water-conserving toilets are also available; they use as little as 1 gal. per flush, a savings of 80% over most toilets. This savings is appreciable because toilets account for the major portion of water use in many public buildings.

Improving the hot-water system can have a significant impact on energy consumption. Consider such measures as lowering the supply temperatures for all lavatories to about 100°F, which is adequate for hand washing. Areas that require higher temperatures, such as kitchens, should have separate heaters.

Hot-water tanks should be close to the hot-water demand, and both tanks and hot-water pipes should be well insulated. Demand-type water heaters that heat the water only as it is being used should be considered for new applications and where some appliance, such as a dishwasher, requires higher temperatures.

Controls on the hot-water system can also be very beneficial, both to reduce energy consumption during unoccupied hours and to reduce the building's peak demand. Consider installing timers that prevent the water heater from operating during unoccupied hours, except as dictated by demand factors (explained in the next section, "Fuels and Fuel Management"). Also consider timers for the pumps in systems that constantly recirculate hot water throughout the building. For buildings that consume large amounts of hot water (laundries, for example) heat-recovery systems that save up to 75% of the waste-water heat may be very economical in the long run.

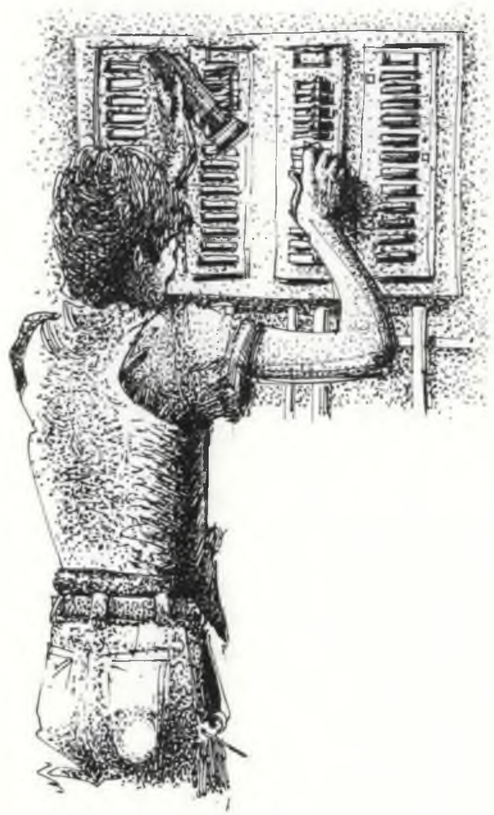
Fuels and Fuel Management

While conservation is generally the focus of energy studies for existing nonresidential buildings, fuel type and management also can be a factor in the economics of their energy systems. Renewable energy resources (discussed in Appendix A) should be encouraged whenever possible, but most of our existing buildings rely heavily on fossil fuels and electricity. When buying and using these fuels, there are several factors to consider.

Electricity is very expensive, both in dollars charged the consumer and in energy used in its production. Whenever possible, it is best to avoid the use of electricity in favor of other fuels.

Demand factors may have a major bearing on electric bills and the recommendations of energy auditors. The demand factor, which is usually applied to any large user, refers to the maximum electric usage during any period (usually averaged over 15 or 30 minutes) in the month. The higher the demand factor, even though it was for a short period, the higher the rate per unit of electricity consumed for the *entire* month. This reflects a very real problem that the utility companies have in supplying electricity during peak demand periods. Even though peak demand occurs rarely, they must have the generating capacity to provide for such periods, and this costs them dearly in paying for new power plants.

Consequently, it is advantageous for all concerned to avoid sharp peaks in electricity demand. For large buildings, whose rates often are determined by demand factors, various measures may be taken to dampen these peak periods. The starting of all equipment, which usually takes more power than keeping it running, should be staggered to prevent demand peaks. Also, such large consumers as electric heaters, including electric hot-water heaters, should not be operated when other major electric equipment (including lights) are started up. Both of these measures can be handled with timing devices or, in more complex buildings, with sophisticated energy management systems. These computer-controlled systems essentially regulate all energy functions in the building and compensate for demand factors as needed. Such a system may cost $150,000 to $250,000 for a very large building, but experience has shown that they can often pay for themselves in 2 or 3 years (National Electrical Contractors Association 1979, p. 42).



For some large buildings (50,000 ft^2 or more), where the need for heat matches well with the need for electricity, a total energy system might be considered. The owner(s) must invest in an appropriately sized electric generator with special heat-recovery devices to capture and use the waste heat from the engine. Although fuel is still required (usually diesel, liquefied petroleum gas, or natural gas), the overall efficiency can be more than 60%, which is quite good.

Methodology for Planning an Energy Study

An energy study of commercial areas may involve somewhat more time and effort than studies of residential areas, but the potential positive economic impact on your business community will justify the work. The results of our energy study of nonresidential buildings in Albuquerque are given in Appendix D.

Commercial areas often contain a great diversity of building types, with various functions, each with its own energy needs. Even in one block, energy consumption per square foot of building may vary by a factor of 30 or more from building to building (see Appendix D). Dealing effectively with such variations requires a fairly detailed study of energy use patterns, with substantial back-up information on climate, architectural types, indigenous businesses, zoning, codes, and other factors.

Very large buildings, especially those built after 1970, probably were designed with some energy conservation in mind. But small- and medium-sized structures, as well as older buildings, were often built with the idea of keeping the initial cost low and can benefit substantially from a reevaluation of energy use.

Gathering the Information

Because of the amount of work involved, it is often best to limit the study to one specific area such as a city block. If the program is successful, this block can be used as a model for the rest of the commercial district. The particular block to be studied might be chosen because it is typical of the commercial area, or because it is atypical in that it clearly needs help with energy issues, or would be more visible than other blocks.

Developing the study will require that you gather and evaluate information on:

- *Physical features of the study area.* You will need a good map of the study block, showing all buildings and any objects, such as trees, monuments, or other landscaping, that might shade the buildings.
- *Building data.* For each building, compile as much information as possible on size, number of floors, age, construction type, current use, general heat-loss and heat-gain characteristics, special energy-related features, and whether the occupants are owners or renters.
- *Energy-consumption data.* Generally, building occupants can provide you with only a rough idea of their energy use. If at all possible, the month-by-month utility bills should be examined and energy consumption recorded for at least a 12-month period. If occupants do not have all bills on hand, you may obtain them from the utility companies by having the occupants sign a release waiver (obtain these from the utilities).

Try to cover all energy consumption, including purchases of electricity, natural gas, propane/butane, steam, oil, and coal. Compile month-by-month itemized records for each building, plus monthly totals for each building and for the whole block. Monthly totals for the consumption of each fuel type by the whole block also are very useful.

- *Zoning and code information.* Many changes that might be made to conserve energy will be affected by various codes and zoning ordinances. Familiarize yourself with those that apply to the study area.
- *Climatic data.* To correlate energy use with weather conditions, as well as to assess the potential for renewable energy resources, you should have information on the number of heating degree days, the number of cooling degree days (defined in Appendix C), the insolation (available sunshine), and the wind speed and direction. These data can usually be obtained from the local utilities and/or the local weather service.

Evaluating the Information

Once all this information has been accumulated in presentable form, an evaluation can begin. Because of the diversity of size and use patterns, it is generally best to reduce the energy consumption data for each building into a value of Btu per square foot per month (or per year). This value is called the energy utilization index (EUI) and is found by dividing the total energy consumption by the number of square feet in the building. The index makes relative comparisons between buildings much easier. Because energy use depends highly on what functions the building accommodates, valuable comparisons can probably be made only between buildings of the same type (restaurants with restaurants, retail stores with retail stores, etc.).

Once the buildings are grouped by type, their respective EUIs will clearly identify the big energy users, which should be targeted for special attention. Physical features and building data may well reveal the cause of unusual EUIs. Particularly large electric bills in the summer, for instance, may be caused by large glass areas facing east or west; low winter fuel bills might be due to a south-facing facade. Consistently large electric bills in a retail store are often due to electric lighting.

To conduct your energy study, you will need the help of the building occupants and possibly a professional energy auditor. It is very important to maintain the interest and cooperation of the building occupants, because it is they who determine the energy consumption to a large extent. Make them aware of the potential savings that are available through technical fixes and changes in user patterns. Also make available information on tax incentives and loan programs that might help them.

If a particular building has a relatively high EUI and a total energy bill of over $1,000 per year, recommend a walk-through audit. Large energy users ($5,000 or more) will probably benefit from a detailed energy audit if their building EUI is higher than other buildings of the same type and if the occupants plan to remain in the building for several years.

3 Evaluating Economic Impacts

Benefit-Cost Analysis

Economic Base Study

The kinds of local energy conservation and passive solar retrofit programs being discussed in this sourcebook have important economic implications for the neighborhood, community, state, and the Nation. A specific program will possess both positive aspects (benefits) and negative aspects (costs) that should be recognized in discussing, planning, and evaluating that program. In fact, the positive aspects are likely to provide the basis for the arguments presented in support of the program, whereas the negative aspects may provide the basis for opposition to the program.

This chapter provides the conceptual framework for some basic economic tools, whereas Appendix E makes use of this conceptual framework for several applications* in the Albuquerque Case Study. It is our goal not only to define these tools for you, but also to provide you with a level of understanding sufficient for you to apply selected tools to a local energy program.

Three economic tools generally are applicable to these local energy programs. They are

- benefit-cost analysis,
- economic base studies, and
- input-output analysis.

Discussion has been limited to benefit-cost analysis and economic base studies because they provide the most straightforward approaches to the evaluation of alternative programs and, at the same time, they may be applied successfully and meaningfully by individuals who do not have any formal training in economics.

Input-output analysis, which provides a detailed description of the relationships between and among all the industries of the local economy, is likely to be beyond the budgetary limitations of smaller communities. For this reason and because the special expertise of an economist is required in the development of this approach, those wishing to pursue this approach are advised to contact university or consulting economists concerning its application.

Although benefit-cost analysis and economic base studies provide more aggregated results, there are approaches that you may apply with little or no outside assistance. The results obtained, as will be discussed below, nevertheless will provide valuable information to be used in the evaluation of local energy programs.

*These applications are made principally at the community level. Although the focus of much of this sourcebook is at the neighborhood level, the economic implications of most retrofit programs are community-wide. Therefore the evaluation of economic impacts potentially attributable to a local energy program will usually concentrate on the effects in the total community rather than within the more narrowly defined boundaries of a neighborhood. Benefit-cost analysis may be the one major exception, because components of both program benefits and costs can be (partially) established at the neighborhood level. This should become clearer in this chapter.

Benefit-cost analysis is a commonly used technique for evaluating alternative economic programs. This analysis not only provides an indication of whether a public program is worth undertaking but also may provide guidance concerning the extent to which a given program should be pursued.

Benefit-cost analysis is clearly applicable to and a valuable tool for use in evaluating programs designed to affect lower and moderate-income neighborhoods, for example, housing rehabilitation, energy conservation, solar retrofit, and related development programs.

Stated in its simplest terms, benefit-cost analysis is a method of comparing the advantages and disadvantages of alternative programs. More specifically, the analysis compares the benefits of a program (in some sense, the goods and services that a program is expected to yield) and the costs (a loss or a negative item in terms of goods and services) of the program. In benefit-cost analysis the costs and benefits associated with a particular program are expressed not in terms of physical units of goods and services but rather in terms of dollar values. Although, as will be seen, some potentially very important benefits and costs are extremely difficult, if not impossible, to value in money terms.

If the benefits (measured in dollars) of a particular program exceed its costs (measured in dollars), then the program is considered to be an economically justified use of public funds.

Although benefit-cost analysis is not a difficult concept to understand, there are important problems that may be encountered in its application. In the following sections, discussion is centered around three specific problems that you are likely to encounter in applying benefit-cost analysis to local energy programs. The problems examined are (1) the fact that benefits and costs may be spread over time, (2) the income redistribution effect of local energy programs, and (3) the difficulty involved in measuring costs and benefits. The discussion is designed both to familiarize you with the benefit-cost approach and to assist you in developing such an analysis for a specific program or set of alternative programs.

Benefits and Costs Over Time

It is clear that the benefits from a particular program and the costs associated with that program will not all be realized at a particular moment but normally will be spread over a period of time (perhaps many years). For example, the reduction in utility bills (a benefit) expected to result from a successful energy conservation program will be realized by participants month after month, year after year, as long as some impact of the program remains within the program neighborhood. Similarly, the costs of such a program will be spread over years. For example, maintenance costs will be expected to be incurred in the years following the initial installation of insulation, storm windows, weather stripping, etc.

Given these circumstances, it is necessary to recognize the time value of money (that a dollar available today is valued more highly than a dollar available one year from today) and to compare in benefit-cost analysis the *present value* of benefits and costs associated with a particular program.

The *present value of the expected benefits* is the dollar amount that would have to be invested now at current interest rates in order for neighborhood residents to be able to realize the same dollar value in benefits on the same time schedule as are expected to be realized from the program.

The *present value of expected costs* is the dollar amount that would have to be invested now at current interest rates in order to have funds available to cover the costs associated with a particular program as those costs are incurred.

A simple numerical example should help to clarify the concept and the calculations involved in dealing

TABLE 3-I. Calculating the Present Value of Benefits and Costs

	1 Benefits	2 Costs	*3* *Present Value of Benefits*	*4* *Present Value of Costs*
Year 1	5,000	20,000	*5,000*	*20,000*
Year 2	10,000	2,000	*9,091*	*1,818*
Year 3	10,000	2,000	*8,264*	*1,653*
Year 4	5,000	2,000	*3,757*	*1,503*
	30,000	26,000	*26,112*	*24,974*

with the fact that an appropriate application of benefit-cost analysis generally involves comparing future streams of benefits and costs.

Assume that a particular program is expected over a 4-year period to result in the benefits and costs recorded in columns 1 and 2 of Table 3-I. The program is expected to result in total benefits of $30,000 and total costs of $26,000 spread over the 4-year period. The timing of expected benefits and costs is such that a major share of the costs are expected to be incurred in year 1, whereas a major share of the benefits will be realized in years 2 and 3.

To evaluate the program accurately, it is necessary to discount the benefits and costs in years 2, 3, and 4 so that we may compare the present value of these future benefits and costs together with those expected in year 1. Using a 10% discount rate (as used in this example),* we can see that the present value of $10,000 one year from today (in year 2) is $9,091; that is, if $9,091 were invested at 10% interest, in one year we would have $10,000. Similarly, if we invested $8,264 now at 10% interest, we would have $10,000 in two years (in year 3), and by investing $3,757 now at 10% interest, in three years (in year 4) we would have $5,000.

By summing column 3, we find that the present value of the stream of benefits expected from the project is $26,112. This means that if we had $26,112 we could pay the $5,000 year-1 benefits *now* and, earning 10% interest on the balance, we would be able to pay $10,000 in benefits next year (the year-2 benefits), $10,000 in benefits in year 3, and have $5,000 left to pay out in year 4. Table 3-II should assist you in understanding this relationship.

The present value of expected costs are calculated in the same manner. The present value (assuming a 10% interest rate) of $2,000 in expected costs in years 2, 3, and 4 is $1,818, $1,653, and $1,503, respectively. The present value of the expected stream of costs thus becomes $24,974. With $24,974, assuming $20,000 in costs are incurred in year 1 and the balance is invested to earn 10% interest, we would be able to pay the $2,000 in costs expected in years 2, 3, and 4 (see Table 3-II).

On the basis of these calculations, it can be seen that the present value of the expected stream of benefits *exceeds* the present value of the expected stream of costs associated with the program. The program thus would be judged to be economically justified.

TABLE 3-II. Present Value of Benefits and Costs

Benefits

Present Value	Year 1	Year 2	Year 3	Year 4
$ 5,000 →	$5,000			
$ 9,091 plus $909 interest →		$10,000		
$ 8,264 — plus $1,726 interest →			$10,000	
$ 3,757 — plus $1,243 interest →				$5,000
$26,112[a]				

Costs

Present Value	Year 1	Year 2	Year 3	Year 4
$20,000 →	$20,000			
$ 1,818 plus $182 interest →		$2,000		
$ 1,653 — plus $347 interest →			$2,000	
$ 1,503 — plus $497 interest →				$2,000
$24,974[a]				

[a]Assumes a 10% rate of interest.

*The calculations presented in Table 3-I used a discount rate of 10%. The selection of the appropriate discount rate to be used to evaluate public investment has been the subject of considerable controversy. Using a simple average of the governmental bond rate and the return on private investment that seems to be in the same risk class as the proposed governmental investment has been suggested as a workable though imperfect solution (Herfindahl and Kneese 1974). In any case, the minimum discount rate that you should use is a rate equal to the expected rate of inflation plus a risk factor. Perhaps the best way of dealing with the question of the appropriate discount rate is to ask an economist or business-school faculty member at a nearby university or college to suggest an appropriate discount rate for use in your analysis.

The mathematics involved in the present-value calculations are summarized in the following equation:

$$PV = A_0 + \frac{A_1}{1+i} + \frac{A_2}{(1+i)^2} + \frac{A_3}{(1+i)^3} + \ldots + \frac{A_n}{(1+i)^n} \quad .$$

Here, PV is the present value of the benefit stream (or the cost stream) expected from the project; A_0 is the dollar value of the benefits (or costs) expected to be realized now; A_1 through A_n are the benefits (or costs) expected to be realized in years 2 through n; and i is the rate of interest (discount rate) appropriate for this program.

Applying this equation to the numerical example developed above would result in the following *two* present-value equations for benefits and costs, respectively:

$$PV_B = \$5{,}000 + \frac{\$10{,}000}{1.10} + \frac{\$10{,}000}{(1.10)^2} + \frac{\$5{,}000}{(1.10)^3}$$

$$= \$26{,}112$$

and

$$PV_C = \$20{,}000 + \frac{\$2{,}000}{1.10} + \frac{\$2{,}000}{(1.10)^2} + \frac{\$2{,}000}{(1.10)^3}$$

$$= \$24{,}974 \quad .$$

Income Redistribution Effect

Government programs designed to affect lower and moderate-income neighborhoods are likely to result in a redistribution of income. This redistribution occurs because the Government does not expect to be fully reimbursed by the beneficiaries of a program for the costs incurred in the program. More specifically, funds for a program may come from general tax revenues of the Nation, and the benefits may accrue largely to residents of the affected neighborhood.

The possibility of such redistribution effects suggests that you need to check carefully the recipients of specific benefits associated with a particular program. This is necessary if we are to be certain that the targeted neighborhood or residents are going to receive an appropriate share of the total benefits associated with the program.

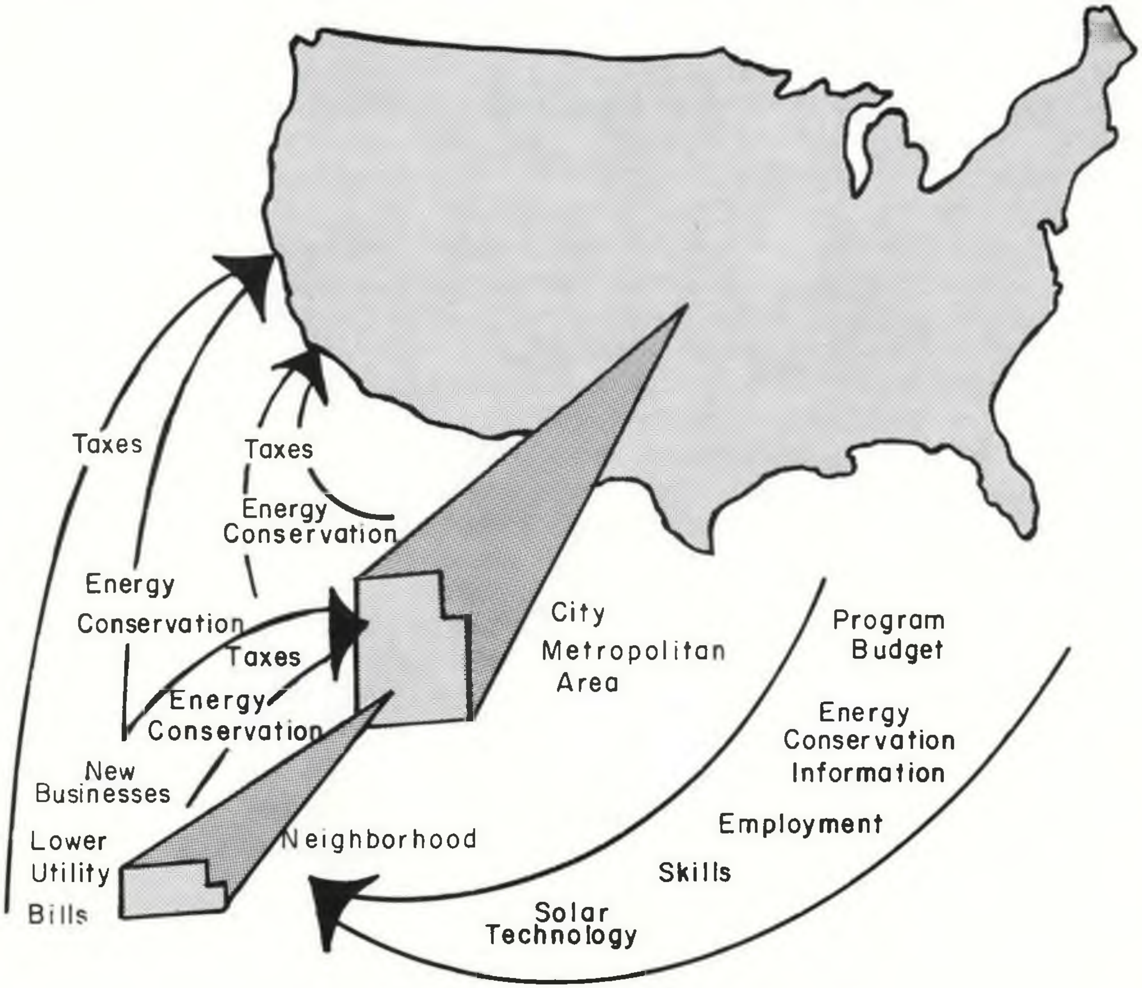


Fig. 3-1. Illustrating the flow of benefits and costs.

It is certainly possible that a program whose benefits clearly exceed its costs may not benefit the targeted neighborhood or residents in any significant manner. Such programs may thus be rejected not because they cannot be economically justified, but because they are not consistent with society's ideas about who should or should not be helped.

Figure 3-1 provides a simplified illustration of how the benefits of a program funded at the Federal level may affect a specific neighborhood and through the neighborhood affect the larger community and the economy as a whole. The question raised by the "income redistribution effect" is the dollar value of the benefits, both in absolute and relative terms, realized by the neighborhood, the community, and the economy as a whole.

Measuring Benefits and Costs

It is customary in the application of benefit-cost analysis to discuss *direct*, *secondary*, and *intangible* benefits and costs. These three categories of benefits and costs as associated with a local energy conservation and passive solar retrofit program are presented in outline form in Table 3-III.

Direct Benefits and Costs

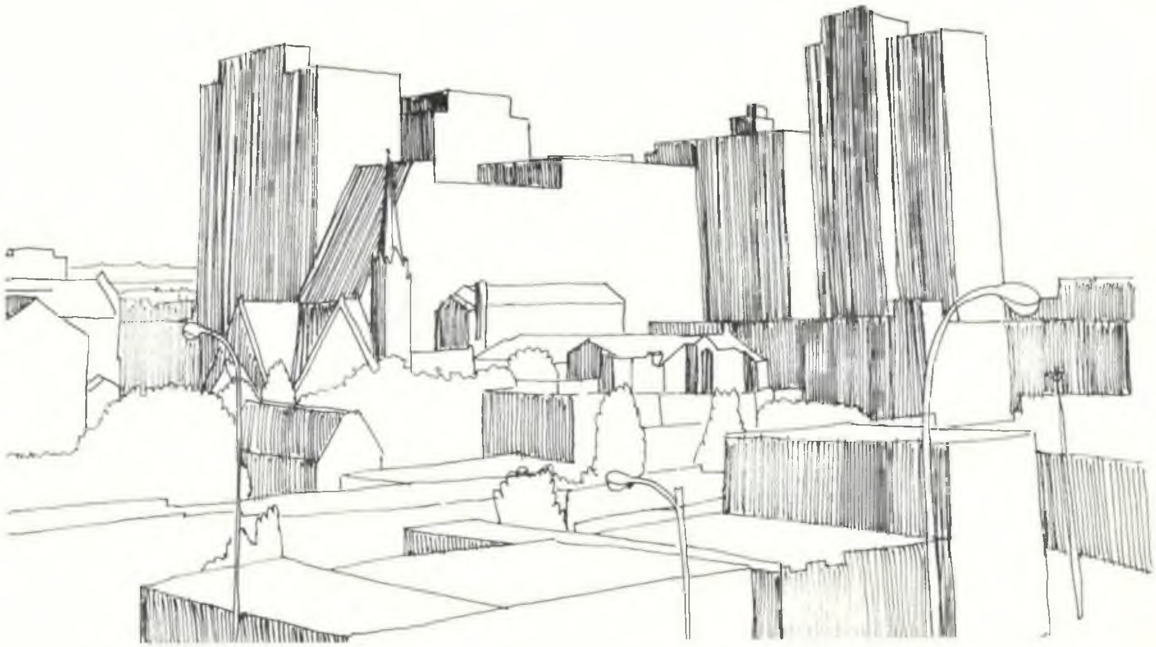
The direct benefits are the tangible or quantifiable benefits that result directly from the program. They can be expected to include the value of the products and services associated with the program. More specifically, the direct benefits would be expected to include the value of the solar technology applied in the retrofit program (greenhouses and/or Trombe walls) and the value of insulation, storm windows, and weather-stripping applications designed to improve the thermal quality of existing residential and nonresidential structures.

The value of these applications may be measured in terms of the dollar value of the fuel not consumed, or the reduction in fuel bills realized by neighborhood residents, or the savings (net of maintenance costs) realized by participants.

The construction of these estimates requires basic knowledge about the effectiveness of solar applications and conservation measures in reducing energy consumption and requires projections of future energy costs for neighborhood residents.

Another important direct benefit that would be associated with a local energy program would be the *employment opportunities* for neighborhood (and community) residents. The dollar value of this direct benefit is measured by multiplying the number of neighborhood residents employed in the program by the average increase in income realized by residents so employed.

The economy as a whole may also realize direct benefits from such a program. These direct benefits may include reduced government welfare and unemployment compensation payments to residents of the affected neighborhood. The dollar value of this direct benefit is measured by estimating the welfare and unemployment benefits that state and/or local governments will *not* be required to pay to neighborhood residents employed in the program.



Note that the reduction in welfare and/or unemployment compensation is subtracted from income earned by residents employed in the program to determine the direct benefit (in the form of increased income) realized by the neighborhood. The same reduction in welfare and unemployment compensation payments are a direct benefit to governments whose budget outlays are reduced as a result.

The *direct costs* associated with a local energy program will include the value of goods and services—land, labor, and materials—used in planning, operating, and maintaining the program. These costs are to be calculated on the basis of the market prices of the resources used in the program. For a Federally funded program, the direct costs will equal the dollar amount of the program budget plus maintenance costs expected to be incurred during the useful life of the conservation and solar retrofits (this assumes that neighborhood residents are expected to pay maintenance costs, and thus maintenance costs are not included in the program budget).

Secondary and Intangible Benefits and Costs

As presented in Table 3-III, the secondary and intangible benefits and costs associated with a local energy program are both diverse and potentially highly significant. The secondary benefits are said to be "stemming from" or "induced by" the primary elements of the program. The *secondary benefits* may include an increase in the "energy consciousness" of affected residents and the community at large. This greater awareness of the nature and impact of the energy problem and instruction concerning economically efficient responses to this problem may result in the more efficient use of *all* energy sources. For example, the program may stimulate interest in car-pooling, busing, and the conservation of electricity. The value of these secondary benefits will be measured in terms of the value of the gasoline, electricity, and natural gas that is *not consumed* as a result of these energy conservation activities. They may also be measured in terms of the savings realized by affected households as a result of reduced utility bills and/or transportation costs.

Other potentially important secondary benefits to result from the local energy program may include the following.

- Improvement in the space heating of residential structures (increased thermal quality and/or solar efficiency) may result in a more *healthful environment*. This benefit would be measured in terms of reduced medical bills and increased productivity with reduced absenteeism of members of neighborhood households.
- Increased expenditures at commercial establishments *within* the neighborhood may increase the profitability of neighborhood businesses and be a source of employment opportunities for local residents. Increased expenditures may result from income derived from new employment or from savings realized from reduced utility bills, car-pooling, and/or more effective budgeting practices.
- Skill development realized by participants in the neighborhood program (carpentry, masonry, landscaping, painting, etc.) may open more permanent employment opportunities. The net increase in income as a result of this employment provides a measure of the dollar value of this secondary benefit.
- The commercial potential of solar retrofit technology (hot-water and/or space heating) may encourage neighborhood participants with entrepreneurial ability to establish private businesses to promote, install, and maintain solar retrofits throughout the community or metropolitan area. The net increase in income realized by the owners and employees of new businesses provides a measure of the dollar value of these secondary benefits. Reduced energy consumption resulting from conservation and/or solar retrofits outside the program neighborhood represent additional secondary benefits from the program.

TABLE 3-III. Local Energy Program Benefit-Cost Analysis Outline

Direct Benefits	Direct Costs
Solar applications {Trombe wall, Greenhouse, Landscaping}; Improve thermal quality of existing structures — Reduced utility bills	Materials, Labor, Other (Rent, Utilities), Management — Project budget
Employment opportunities: Carpenter, Mason, Painter, etc.	Maintenance costs

Secondary Benefits	Secondary Costs
Increase in "energy consciousness": Car-pooling, Busing, Conservation of electricity and gas	The value of additional resources that must be consumed in order to realize the secondary benefits. For example: Transportation costs to work, uniform costs, the cost of incorporation, and the cost of a business license.
Improved health	
Increased expenditures at commercial establishments within the program neighborhood (and community)	
Skill development	
Establishment of new business concerns	

Intangible Benefits	Intangible Costs
Increase in usable "living space"	Increased noise level (temporary)
Increase in "comfort"	Increased traffic (temporary)
Rise in general educational level; improved budgeting skills	
Development of "pride of ownership"	
Development of "self-respect"	
Improved aesthetics of neighborhood and community	

The *secondary costs* (or indirect costs) are the value of additional resources that must be consumed in order to realize the secondary benefits. Examples of such secondary costs include the cost of automobile tune-ups, the cost of transportation incurred by neighborhood residents in getting to their new employment, and the cost of uniforms (work clothes) and tools required in the new employment. Other examples of secondary costs include the cost of replacing incandescent bulbs with fluorescent bulbs and the costs associated with establishing new businesses (for example, the cost of incorporation and the cost of a business license).

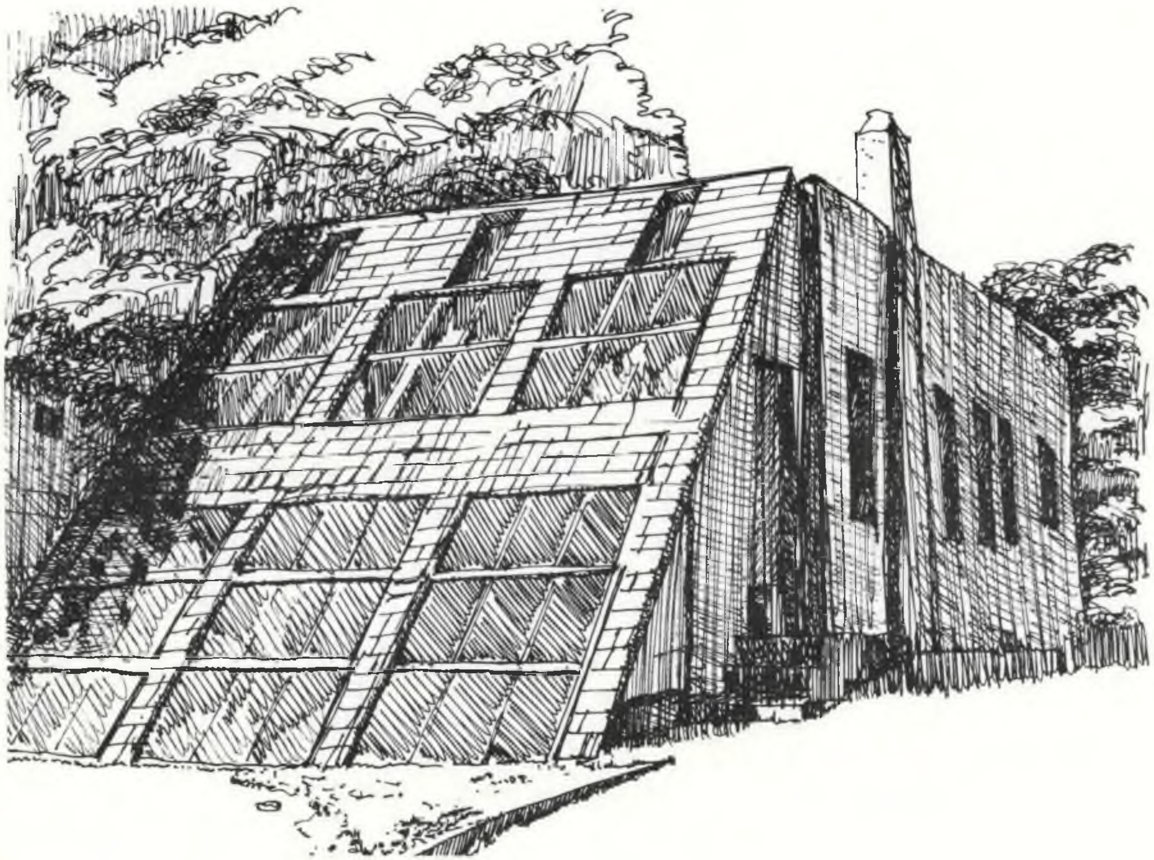
Intangible benefits and *costs* may be either direct or secondary results of a project. These categories of benefits and costs are in fact somewhat difficult to define because they include items that seem important on the basis of a qualitative judgment but are difficult or impossible to value in money terms.

As listed in Table 3-III, there are a number of potentially significant *intangible benefits* that may be associated with a local energy program. These intangible benefits may include:

- an increase in usable living space that results from the construction of a solar greenhouse.
- an increase in the "comfort" of the family during the winter months.
- a rise in the general educational level of resident-participants.
- the development of a feeling of "pride of ownership" and "pride in the performance" of their solar application by the residents whose homes are selected for solar retrofit.
- the development of a feeling of self-respect and pride in their accomplishments by the employee-participants.
- an improvement in the general aesthetics of the affected neighborhood.

- an increase in the resale value of affected neighborhood residential property.

Intangible costs that may be associated with the local energy program include increased noise level, commotion, and traffic associated with the construction component of the program.



The economic base study should be thought of as complementary to, rather than as a substitute for, benefit-cost analysis. To be more specific, the economic base study provides a method of estimating *secondary* income and employment effects associated with a specific neighborhood program. These secondary income and employment effects are likely to be community-wide, and therefore the estimation of these effects will generally focus on the broader community.

An economic base study of a particular neighborhood or community would begin by dividing the local (usually defined as community) economy into two segments: (1) firms and individuals serving markets outside the local economy, and (2) firms and individuals serving markets within the local economy. The firms and individuals included in the first group are considered as "basic," or "primary," sectors or industries. Those included in the second group are considered "nonbasic," or "secondary," sectors or industries.*

Implicit in this division of markets is the cause-and-effect relationship. Basic sectors are considered the prime movers of the economy. If employment serving the basic sectors rises or falls, employment serving the nonbasic sectors will be expected to move in the same direction. Similarly a change in income in the basic sectors will be expected to result in a change in income in the same direction in the nonbasic sectors.

*There are no precise definitions of basic and nonbasic sectors. Many firms have characteristics of both; they provide goods and services for sale outside the community while *simultaneously* providing the same goods and services to local residents.

In the local energy conservation and passive solar retrofit program we have been discussing, an increase in direct (basic) employment associated with the program** would be expected to result in a rise in employment in the nonbasic sectors serving the neighborhood (and community). Thus the increase in total employment will be expected to exceed the direct employment in the program.

This is generally referred to as a "multiplier effect." The important question that must be answered is how much nonbasic employment will be created if basic employment increases. That is, how large is the multiplier?

Because secondary employment (and income) effects will not be limited to the affected neighborhood but will be spread throughout the entire community, it usually will be desirable to develop and discuss multiplier effects in terms of the community rather than the neighborhood. A particularly strong case may be made for this more aggregative approach when the affected neighborhood is relatively small with limited commercial and industrial sectors. (In actual application, this more aggregative approach is the norm for economic base studies.)

In estimating the size of the multiplier, the economic base study assumes that over the long run the proportion of basic and nonbasic jobs will remain about the same. Thus an increase in basic jobs will eventually result in a proportionate increase in nonbasic jobs.

**Employment generated from a local energy program should be considered basic, although some employment increases may very well be in sectors that are partially nonbasic. The premise here is that the increased employment would not have occurred without some form of governmental support (action).

This clearly suggests that if you are going to be in a position to forecast the employment (or income) effects of a specific neighborhood program you must identify the basic industries in your study area and obtain employment (and income) data for both basic and nonbasic industries in the study area (or the community).

Identifying the Basic Industries

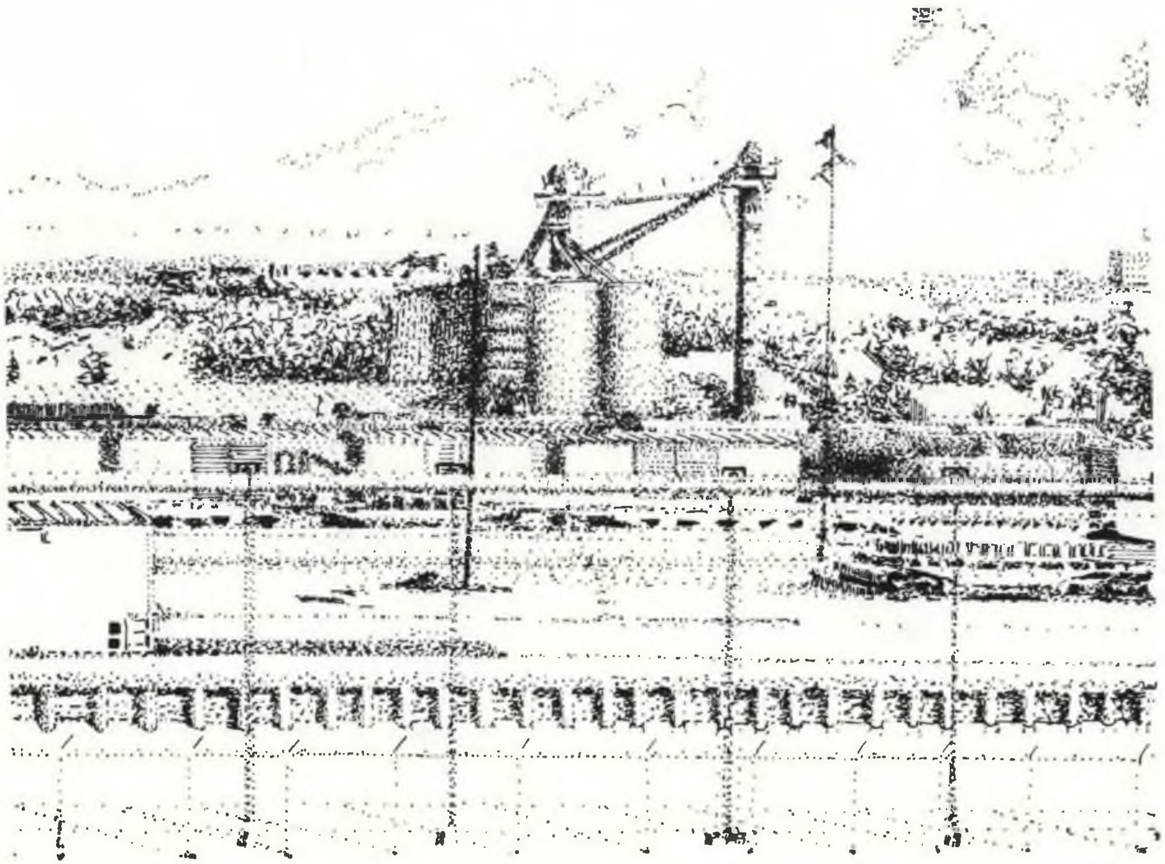
There are two approaches that are generally suggested for identifying the basic industries in an economy. Of the two, the "assumption," or "informed judgment," approach is the simplest. This approach assumes that a number of industries (economic sectors) are basic industries; that is, they export virtually all of their product or services outside of the economy under study. The usual assumption is that all manfacturing, mining, agriculture, and the various levels of government are basic sectors and all other sectors are nonbasic.

Although some manufacturing industries will serve local markets (for example, bakeries, dairies, etc.), this admittedly simplified approach may provide satisfactory results. For most study areas (neighborhoods) and/or areas with limited commercial and industrial sectors, the results are likely to be misleading. For this reason, it usually will be necessary to shift the economic base study and discussion of secondary employment and income effects from the neighborhood to the community. Moreover, acquiring the data needed to support application of an economic base study will usually dictate that a community-wide approach be undertaken.

A second approach for identifying the basic industries in an economy is the "location quotient" approach. The location quotient approach suggests that if a community is highly specialized relative to the Nation in the production of a particular commodity, the industry is presumed to be a basic industry for that community. To make this determination, a location quotient (LQ) is constructed for each industry in the community. This requires the calculation of two ratios:

(a) The ratio of a specific industry employment (income) in the community to the total employment (income) in the community.

(b) The ratio of the same industry employment (income) in the US to the total employment in the US.



The first ratio provides a measure of the industry's contribution to the community employment level. The second ratio provides an equivalent measure of the industry's contribution to the US employment level.

When the community ratio (a) exceeds the National ratio (b), the particular industry is termed basic to the community. If the two ratios are approximately equal or the community ratio is less than the National ratio, then the industry is considered to be nonbasic.

The actual LQ for the industry is computed by taking the difference between the community fraction (a) and the US fraction (b) and then dividing by the community fraction (a):

$$LQ = \frac{\text{community fraction (a)} - \text{US fraction (b)}}{\text{community fraction (a)}}$$

For example, if 10% of a community's employment is in a particular industry whereas only 5% of the Nation's employment is in the same industry, then 50% of the community's employment in that industry should be included in the basic total. Through this process community totals for basic and nonbasic industries may be obtained.

The exclusive use of location quotients on an industry-by-industry basis implies that no knowledge of the local economy is directly available. Where knowledge of the local economy is available, it is appropriate to adjust the purely mechanical results obtained from the construction of location quotients by the application of informed judgments. Put more simply, a combination of the two approaches, location quotients and informed judgments, is most likely to provide satisfactory results.

This chapter has presented a detailed (though somewhat limited) discussion of benefit-cost analysis and economic base studies. The application of these two tools should assist you in evaluating specific local energy programs.

Although the discussion has emphasized the steps involved in the quantification of benefits and costs associated with a specific program, it should be emphasized that the intangible benefits and costs may also be very important. Thus, any presentation of program benefits and costs should include a qualitative discussion of the intangible benefits and costs as well as the presentation of dollar estimates of direct and secondary benefits and costs.

The timing and geographic (or demographic) distribution of benefits and costs have also been identified as important elements in the program evaluation process.

We believe that the careful application of the concepts developed here will allow you, with limited outside assistance,* to develop material of considerable value in evaluating a specific program. For an example of applying benefit-cost analysis and an economic base study, see Appendix E.

*Seek the help of competent individuals with training in economics — local university or college professors, high school teachers, or recent college graduates.

4 Approaches to Community Outreach

Getting Started

Gaining Local Support

Examples of Successful Programs

Our collective energy problem is a National one but the solution must be local. Community action toward a more self-reliant energy future is no pipe dream in this country; there are concrete examples of how conservation and solar retrofits can reduce local energy consumption. This chapter will share the successful experiences of many local energy programs and give examples of tasks you can use for community outreach, the key to the success of any people-oriented solution.

People resist change, especially if it threatens their lifestyles, forces them to do something, or is misunderstood. If your community is not conserving energy or is not retrofitting for self-reliance, it is probably because the people have not perceived the change to energy self-reliance as an advantage over the old way of doing things. They don't grasp the potential for profit, comfort, or energy self-reliance that a local energy program can supply.

You can make a difference in your community's attitude, if the climate is right. This is not to say, however, that every community is ready, at this time, to be persuaded to "go solar." Conditions that must exist to ease the transition are high energy costs, a high level of community concern about the environment, local utilities that are interested in keeping their customer's energy costs down, and active local interest groups.

If energy costs are increasing rapidly enough in your community to concern people, you will have no problem selling conservation and solar retrofits. If not, the task is not impossible, but will be more difficult. Although some individuals may take energy saving actions because of social consciousness, most people simply will not take on an activity that is not cost effective. You may need to bide your time.

However, you can do something about the level of concern about energy in your community. Seek the support of credible groups and use their resources to persuade others. You must have the support of these groups and of the local utilities, politicians, and other citizen's groups if your program is to be successful and timely.

You are probably wondering how you know what group is best to approach first. Should you start with the city or county council or with the neighborhood leaders? There are proponents of both approaches. Eventually, you will need the support of both. To get the support of local groups and leverage their power to gain the support and *participation* of the community at large, you should:

- *Carefully identify the power/influence structure in your community.* Gather a list of target individuals/organizations. Also contact state and Federal energy offices and inform them of your efforts. Involve these groups in your strategy development efforts. Goals: To include citizen's participation in your process from the onset of the program. To ensure the success of the program by involving key individuals in the decisionmaking process.
- *Analyze the potential.* Conduct energy audits (see Appendix B) to determine how effective conservation and solar retrofits will be in reducing energy use in buildings and in creating local employment (use the help of the utilities, schools, the city, and neighborhood groups). Goals: To gain information to sell your program to local groups. To gather information to demonstrate how conservation and solar retrofits can reduce energy consumption within your community.
- *Approach your local interest groups.* Convince these groups to take on your program as a

group project (use the information from the audit). Goal: To establish task forces to carry out your program. You cannot do it alone.

- *Create jobs.* To teach audit procedures and retrofit skills (use the help of CETA, Job Corps, unemployment offices, unions, local builders, and contractors). Goals: To initiate a local job training program. To support your continuing audit procedures. To demonstrate solar job potential to the public. To involve more people in your activities. To create a pool of skilled workers.
- *Approach the financial institutions.* Discover or create financial options within the city (use the help of bankers, bonding companies, neighborhood cooperatives). Goals: To pay for all the program activities. To make use of local financial resources to pay for retrofit conversions, especially for the low- and fixed-income residents.

- *Market solar and conservation concepts and technologies.* Inform the public (use schools, media, word-of-mouth, demonstration projects, displays). Goals: To sell conservation and solar concepts to the public. To establish credibility for the technologies.
- *Consumer protection.* Compile a list of reputable contractors and suppliers (use the help of building trades people, real estate professionals, and code enforcers). Goals: To foster a dependable local energy industry. To protect the consumer. To maintain a good image for the technologies.

Attract people to a vision of how things can be. Real needs, defined by the community, being met by people in their own neighborhood open up a dialogue that grows and becomes more attractive (Morris and Hess 1975, p. 44). A greenhouse can provide more than just space heating—it can be a whole new recreational space for your family and can add fresh produce to your table. Begin with an audit, perhaps in one neighborhood, which will flush out people interested in immediate demonstration of the benefits. At this point, you might want to sponsor a workshop. Your task forces on training and marketing should be able to supply the teachers and materials. As you gather information on the energy-use characteristics of your city, market the ideas of comfort, profit, and convenience. Follow through with demonstrations of conservation and solar retrofits.

The city can demonstrate conservation and solar concepts on their buildings, but when they are demonstrated on a home/store and the *neighbor*/colleague tells others that the concepts work, then people see your energy program has merit. A demonstration is on a scale that people are comfortable with.

Use some of the financial approaches to support your audits and demonstrations. The people involved (the trainees and the people who own the building) should be active in the community and touch the lives of their neighbors; examples of the kinds of people you are looking for are a local politician, a priest, or a personality. In other words, the building for the demonstration should be visible; its inhabitants vocal.

Strive to match the demonstration to the needs of the participants. For example, in a low-income neighborhood you may want to have the task force set up a training and hands-on solar project, such as a greenhouse. For middle-income residents, you may only need to provide a list of reputable contractors who can do the work and provide tours of buildings with completed retrofits. The more affluent residents tend to follow local trend setters. If you can gain support of a personality, the more affluent will follow.

Your main function is coordinating the tasks. By involving many different people from different backgrounds in a common goal or project, you stimulate information sharing. You make sure that all the creative thinking from the task forces is put to use by those who can carry out the ideas.

The city, as a whole system, and the neighborhoods, as its parts, have a place in your solution. In fact, the success of the program rests with citizens' participation in whatever activities the city initiates.

How do you get from energy plan to a more self-reliant community that uses reliable, affordable, renewable energy? The planning process is the mechanism to help obtain a more energy-efficient community, but the success of a local energy program hinges on the support of the community at large. With involvement and backing from city government, neighborhood leaders, the local utilities, the financial and business communities, and other local institutions, the potential for conservation and solar energy mobilization can be realized. Without the support of the people, there is no program. You must use the planning process to help the community make the decision to mobilize; your efforts to gain their participation are tied to the decisionmaking process.

An example of the importance of citizen participation comes from the experience of Seattle's Director of Energy, Sam Sperry (President's Clearinghouse for Community Energy Efficiency 1980). Two approaches were taken with local energy legislation: (1) a building code that was written by a group of architects, builders, planners, and others directly affected by that code; and (2) a weatherization mandate that was developed without citizens' approval or involvement. The mandate failed to compel people to weatherize because it was opposed by all sectors; in contrast, the code, which took 2 years to write, unanimously passed council approval and is generally accepted and used by the people of Seattle. In organizing for a successful energy program, actively involve the citizens who will be responsible for implementing the planning program.

Unfortunately, the outlook is not good for funding sources for conservation and solar retrofits and for community development. To get the maximum return from a given number of dollars put into a local energy program, you must take the time to organize and manage the local interest groups. These groups differ from city to city. Strategies that work in one place may fail in others. The strategies given for each group we list have been used successfully to approach and convince local interest groups to make energy concerns one of their group projects. Once these leaders of the community are convinced that conservation and solar retrofits are necessary to ensure the well-being of the community, a "ripple effect" will occur, convincing the public at large.

When approaching any prospective interest group, be prepared. Although the slant on your campaign will vary from group to group, use the following basic guidelines when presenting your energy program to any group.

- Organize your presentation. Know facts, cite examples from other successful programs, preferably those that are geographically close to your community. Know your audience.
- Have your program summarized on paper, so it can be left with people.
- Be modest with your initial proposal. Your request should be specific, whether you are asking for support in time or money. Do not overpower them by specifying all the tasks that you see in the program.
- Emphasize how the program will benefit the community by providing jobs, energy savings, and self-reliance. Avoid a patriotic pitch that is too strong.
- Use as leverage a sympathetic committee, group of peers, or even a competing civic organization. For example, when approaching the city council, you mention that you have the support of the League of Women Voters; you would mention to the Kiwanis Club that the Civitans are participating. Peer pressure works wonders.
- Begin with a brief and simple technology description. Assume that there are some people in your audience who are wary of solar technology. Convince them from the onset that the technology is available and practical—that weatherization and passive solar retrofits are low-cost approaches within the grasp of every building owner in the city. Give examples, show slides, use your data from the initial analysis of potential for energy savings.

In this chapter, we write about interest groups and strategies for dealing with each interest group separately. However, these separate tasks must be initiated all at once for the program to be effective. All key groups and individuals must be contacted and invited to participate in the process and encouraged to become crusaders for your efforts. It is quite effective to bring more than one group at a time together to create an atmosphere of friendly competition.

The City/County

The city or county can exercise its authority to shape public policy. Support of the local government is essential. If the mayor, who approves programs, and the city employees, who carry out the programs, are on your side, your program will run more smoothly. People tend to respect a good example; so, if the city is trying to conserve and retrofit for solar heating, chances are the public will too.

One of the more obvious of city activities that affects solar planning is the ordinance. Many cities have initiated local solar-related legislation, which has been prompted by state enabling legislation. Most laws are in the area of financial incentives, such as property tax reductions, property tax exemptions, or low-interest loans. There are also initiatives in building regulations, conservation codes, retrofit ordinances, subdivision ordinances, and removal of zoning barriers (DeRosa 1981, p. 1389). For example, the Portland, Oregon, retrofit ordinance is designed to bring older buildings in the community up to more energy-efficient standards. Compliance with these ordinances is mandatory upon the sale of the home. After 1984, properties must be weatherized. If the requirements of the code are not met, the home (or commercial building) cannot be sold.

Challenges against the mandatory nature of the ordinances may be expected based on substantive due-process grounds. Does the city government have the power to force property owners to weatherize? If these initiatives are approached with citizens' participation, they can be powerful tools to be used to advance quickly toward energy efficiency.

Not so obvious, but just as powerful, are programs within the city that provide opportunity for demonstration. In addition to retrofits on public buildings, there is potential for solar projects within the city rehabilitation programs.

The City of Albuquerque has supported construction of several greenhouses, Trombe walls, and clerestory windows on target housing in low-income neighborhoods. This solar-related activity has come about, however, because Perry Wilkes, *one* of the rehabilitation staff, has vigorously pushed for it in his individual projects. Unfortunately, his opposition has come primarily from an uninformed public wary of the technology. The clients preferred conventional heating systems to passive solar retrofits and viewed wood stoves as a step backward.

The rehabilitation staff in Los Angeles, California, had a similar problem until the Los Angeles Community Resource Center prepared a manual for an energy-efficient housing rehabilitation training project. It presents basic information on costs and payback periods for various energy conservation projects (Steinberg et al. 1981, p. 1253).

Most cities have a person on their planning staff who deals specifically with neighborhood groups. This position has come about because these groups wield tremendous political power. Local politicians have initiated this position to provide the neighborhood groups with a city contact person. The person in this position helps with neighborhood plans, acts as a liaison between the city and public, and gives technical information to each group. This person should be included in the initial planning of your energy program.

Neighborhood Groups

During the past decade, a dialogue has developed between the local politicians, planners and administrative personnel, and the people. This communication has occurred because of the formation of neighborhood associations. Don't overlook their effectiveness.

When approaching the neighborhood groups, emphasize the benefits to their neighborhood. Conservation and solar retrofits can provide decentralized energy supplies that ensure a healthy, more self-reliant neighborhood. A local information program will result in an informed public that will not panic in an energy emergency. Energy projects, because of their nature, require cooperation, and the neighborhood can become more close knit as a result of this activity.

Begin with your assessment of the amount of fossil fuels consumed by the community. Measure the community cash flow associated with this consumption. Present your program emphasizing the results of community cash flow on neighborhood well-being. The dollars spent on conservation and solar retrofits generally stay in the immediate area.

Follow up with the potential for energy savings and jobs that conservation and passive solar retrofits bring. Explain how these retrofits can provide a small amount of work at many sites with home-improvement-type labor. This type of labor provides opportunities for disadvantaged workers who tend to have been occupying low-paying positions (Rose 1981, p. 1306).

Although we can provide guidelines, the grassroots leadership making the program a reality must come from individuals within the community. These people are easily identified; they are activists that are vocal and visible. They come forward in response to seeing a few well-placed fliers at stores, self-service laundries, bus stops, etc. Without their support, you will be considered an outsider coming

in as a do-gooder or troublemaker. These leaders may not come forward as readily as you would like, but remember, they have gotten burned by many, many programs, whatever the good intentions. Community control, not technical concerns, is the prime motivation for involvement by the neighborhood (Price 1981, p. 1366). Keep in mind that participation in and control of what happens must be in the hands of the community. You are merely a technician.

The neighborhood is the scale people identify with. By beginning small but visible projects within the neighborhood, demonstrations can mushroom into more activity throughout the city. Do not become frustrated with the time it takes to initiate this approach. The examples at the end of this chapter show that this approach succeeds.

Cooperatives, or Buying Clubs

The cooperative, or buying club, is a neighborhood initiative. The purpose of the cooperative is to obtain food, housing, and other goods and services through bulk purchasing or financing. It creates a group of consumers with much more power than a single family has. Those cooperatives that are successful view the operation as a commercial enterprise, although it was organized as a social movement. In some cases, interest in energy planning has been fostered through these existing cooperatives. Expertise has been drawn from management of other successful cooperative ventures (Healy 1981, p. 72). (See Appendix F under "Organizations" for existing energy cooperatives.)

Cooperatives are high-risk operations, dependent on heavy financial start-up burdens. Yet, they can reduce costs to members in the neighborhood. They can also provide volunteer labor, like old-fashioned barn-raising projects did.

Schools

The school is a long-neglected resource for transfer of energy information. When we visited the Albuquerque schools for information on residential heat loss (see Appendix B), what we found was more than data on city housing units. We found a gold mine for outreach. For very little time and expense, many people can be informed, and much information can be obtained. Don't neglect these in-place family-oriented institutions.

Teachers of young children generally are happy to find new material. Conservation and passive solar concepts provide a wide range of projects for learning the sciences, mathematics, and even philosophy. Simple batch hot-water heaters, sundials to find true south, and experiments with natural convection, conduction, and heat loss are a few examples of projects.

In addition to being a place to teach solar concepts, the school can be a resource for data collection, a source of volunteers for an energy campaign, or a building for demonstration projects. With a more steady flow of communication, the public schools could become an information center for the entire community.

For example, when we visited the Albuquerque schools, we gave the children information on housing characteristics and on heat loss and solar gain. The children of today are the consumers of the near future. When we finished our slide presentation, the children said that, when they went away for college, they wouldn't choose a rental home with a northern exposure and would check for insulation and window/door tightness.

Many states have initiated conservation and solar education in their school curriculums (Blair 1981; Langford and LaHart 1981; Lampert, Wulf, and Yanow 1981). In most cases, the programs consist of packets of "canned" projects distributed in teacher workshops of about 30 teachers at a time. Local experts could be asked to volunteer time, and a few well-versed teachers could take over the task, once initiated. Such is the case in Albuquerque with their "Fun in the Sun" program through the Teacher Learning Center (Clark, Evans, and Rauch 1980).

As youngsters learn, especially information that applies to their own house, they tend to take the information home and talk about it. They also love playing police officer with mom or dad; "Gee, isn't our thermostat set a little high?"

Vocational and technical schools can provide training in solar and conservation skills. The state of Illinois recently trained 650 students in passive solar building projects. The projects induced local solar events that included tours, workshops, fairs, and general community education in passive solar techniques (Donahue and Dean 1981, p. 1288).

Universities or colleges are beginning to offer solar-oriented classes in the architecture, planning, and engineering disciplines. The university is an excellent source for technical support. For example, our experience with the University of New Mexico architecture school proved that information exchange is valuable (see Appendix D under "Nonresidential Buildings"). In exchange for energy use information, the students had an opportunity to learn from people working in the field (the utility representatives) and to work on an interesting project.

The Business and Financial Community

The business community must be your most helpful ally in your energy program. Money, skills, and an air of respect can come with the support of bankers, business people, and labor leaders. If the public sees that this credible group of people back you, they are more likely to think the program is worthwhile.

The well-being of the community rests on the economic and reliable delivery of goods and services. Shortages of fossil fuels have immediate impact on businesses, employment, and services (Jenkins 1981, p. 1496). Sell the business community on the idea that renewable energy can ensure that businesses stay open and operating without disruption in supply. Stockholders and investors are more comfortable knowing that a business is stable.

Solar energy can create jobs and business opportunities, lower energy costs for the consumer, and add to municipal revenues. Compared to high-technology energy, solar energy has lower start-up costs and the sites are more numerous, with small amounts of work at each site. Solar retrofits open new markets, in addition to providing work for building trades people in the event of a new-housing slump.

Lenders should be made aware of the opportunity to increase the viability of neighborhoods. In addition to the obvious increase in property values, conservation and solar retrofits can leave more dollars in the pockets of the people as utility costs increase. Given the choice of freezing or paying the rent or mortgage on fixed incomes, people will go for comfort or will simply abandon the structure. The security of the mortgage or rent increases as energy expenses decrease. Energy efficiency will continue to be important to new tenants and home buyers; energy efficiency sells homes.

There are several examples of initiatives to involve the business community in local solar programs. The Northeastern Retail Lumbermen's Association in cooperation with the Northeast Solar Energy Center is marketing solar sunspace additions to builders. They put out a packet which includes design principles, case histories, blueprints, designs, lists of builders with experience in construction of greenhouses (a type of sunspace), a bibliography, and a products directory (Pierce 1981). The Georgia Solar Coalition is training builders in solar design and construction in a cooperative effort between the Atlanta Home Builders Association and the Southern Solar Energy Center (George and Salmon1981, p. 1249). The Southern Solar Energy Center also helped sponsor a solar hot-water awareness campaign. Local support came from the Chamber of Commerce, banks, credit unions, utilities, and libraries. The campaign was intended to inform consumers of the basics of domestic hot water heating and to assist them with informed purchase decisions.

Utilities

The National Energy Conservation Policy Act of 1978 established the Residential Conservation Service (RCS) program. Gas and electric utilities with a certain volume of sales were to provide home energy audits at the request of the customer, suggest energy-efficient retrofits specifying their benefits and costs, and provide the consumer with a list of resources for getting the work done (Sim 1981, p. 1342).

Funds at the Federal level to implement the program were eliminated in the 1982 budget. Responsibility for carrying out the intents of the RCS program now will go to the state energy departments. Utility participation now varies from state to state; for example, California and Florida are way out front. Nevertheless, the Act has forced the utilities to be involved in conservation efforts since 1978, and in some cases, the utilities are finding that a dollar spent on conservation activities goes much further than one spent on new plant construction (Davenport 1980, p. 19).

Your local utilities are in a central position in the existing distribution of energy; therefore, the utilities are in an excellent position to distribute conservation and solar information.

Public Service Company of New Mexico maintains an education resources program within their Community Affairs Department. The program offers classroom presentations, demonstrations, exhibits, tours, newsletters, speakers, pamphlets, community assistance, and audio-visual materials.

Another example of active utility involvement in the solar movement is the National Energy Conservation Partnership. The American Gas Association, CETA, and CSA have started local activities that include training programs, inserts in billings, slide shows, audits, financing, demonstrations, fairs, technical assistance, lists of reputable contractors, and basic educational programs.

Contact your local utilities and involve them in your planning process. They will be willing to cooperate and can provide many services at no cost.

A recent phenomenon on the county level is the municipal solar utility (MSU), which has appeared mostly in California. This nonconventional and very decentralized utility can offer services that reduce wariness of solar, the initial high costs of systems, provide affordable financing, and deliver consumer protection (Saitman and Garfield-Jones 1981, p. 1356). The MSU also can act as a medium for outreach by providing technical assistance and post-installation inspection and audits.

Service Organizations

VISTA, CDCs, and CAPs have been in existence since the Johnson Administration. These and other local service organizations have experience in organizing and managing local programs aimed primarily at low-income neighborhoods. Local energy programs are becoming a part of their efforts, and any outreach activities should include their participation. Their areas of expertise include training programs, self-help, access to low-income neighborhood leaders, grant proposal writing and administration.

These programs have traditionally received funds from CSA and ACTION (the future of both is uncertain). However in some instances, they have become such an integral and important part of the community that they have "gone public" with their funding sources and will not be affected by the current Administration's change of priorities.

Religious Groups

The clergy are generally very important people in a community; they are people who care about the well-being of their congregations, people who are trusted by the community. In some cases, they may be your only contact with some people. Religious groups also offer a source of labor, potential funds, and an existing organizational structure.

The Lafayette, Louisiana, Community Action Program recently pushed a weatherization program aimed at a low-income neighborhood. The people were not interested until the parish priest was won over to the benefits of the program and started mentioning it in services.*

The religious buildings provide opportunity for demonstration. People usually donate materials, time, and technical assistance to religious functions. This provides a chance for a low-cost, hands-on workshop in weatherization or passive solar retrofits.

Religious youth groups or auxiliaries are generally willing to participate in a worthy cause. Religious groups can provide legwork for campaigns or training sessions.

*Conversation with Frank Neelis of SMILE, Lafayette, Louisiana, June 1981.

Other Community Groups

Elks, Junior Chamber of Commerce, League of Women Voters, Sierra Club, the YMCA, and other groups of this type can provide labor and sometimes money to your program. Again, don't forget the element of competition and, in the case of special interest groups, political clout.

The Audubon Society recently let a grant for $12,750 to coordinate energy education and a demonstration project in Portland, Maine. The program consisted of retrofitting 17 homes with shutters and low-cost solar heaters and holding neighborhood classes to explain the technologies (George and Salmon 1981, p. 1252). Audubon's special interest is in reducing fossil-fuel consumption that can potentially reduce destruction of wildlife habitat. Keep in mind the interest of the group and key your approach to that interest.

Examples of Successful Programs

Once the commitment has been made publicly by the various interest groups within the community, you must begin immediately to initiate an outreach program aimed at the public at large, relying on the support you have gained from your initial sales pitch to community leaders. The clearest way for us to convey to you tactics that can be used is through examples of successful local energy programs. Again, just because a particular tactic worked in Davis or Boston or Toledo doesn't mean it will work in your community. Fit your program to the needs of your public.

The examples presented are not, by any means, an exhaustive list of the thousands of local efforts throughout the country. This sampling gives you some options. Use your judgment about what might be possible in your own situation, and most of all *be creative*!

Portland, Oregon

In 1973-74, a drought in the Northwest (where most energy is hydroelectrically produced) and the Arab Oil Embargo combined to make a serious local energy crisis in Portland. The mayor of Portland initiated a plan to reduce the amount of energy used in the community. In 1975, a grant from HUD enabled the City to prepare a comprehensive 11-volume study, which included descriptions of energy use, potential conservation measures, and code revisions and capital budgeting procedures to encourage using the measures (Policy Analysis Section, Bureau of Planning, City of Portland 1977).

Initially, 15 citizens were appointed to review and update the study. These 15 people created 6 task forces, one for each sector of energy use: business, industry, institutions, land use, transportation, and residential. The task forces were made up of 64 people from the community (not just city administrators), who actually established conservation policies. Their policies were presented to 40 of Portland's interest groups, modified, and submitted to the Council. The result was City Council Ordinance 148251.

The ordinance consists of six policies, which define the City's role in promoting conservation through education, incentives, and mandatory actions. For more information, contact the Portland Energy Office (see Appendix F under "Organizations" for the address and/or phone number of the contact for each example program).

Davis, California

The community of Davis is a pioneer in the local energy movement. Things happened in Davis (a 1973 strategy for Energy Conservation; a 1975 conservation and solar building code and handbook for using it; low-income solar homes; and new siting, subdivision, and landscaping standards) because a political coalition, the Greater Davis Planning and Research Group, which was greatly interested in the planning process, mobilized this conservative community into a "do-it-ourselves" attitude. *Citizen* working committees were formed; organizations, including the League of Women Voters, other women's groups, the Chamber of Commerce, churches, and the Rotary Club, all took the energy crisis seriously and took on conservation as a priority item. The schools were involved in the information dissemination.

A quarterly newsletter, delivered to the entire city, the two daily newspapers, public hearings, and seminars were the marketing methods in Davis. Once the public was mobilized, pride and peer pressure kept them going. For example, no one in Davis boasts if their utility bill is higher than their neighbor's.

There was little controversy about or opposition to the Davis Policy because of citizen participation in the process. The program, which was implemented with existing construction techniques and practices, actually reduced development costs in many cases. No one felt it to be an intrusion to privacy; and most importantly, any struggles resulted in a more informed public and created an atmosphere for more cooperative future efforts (Vine 1979). For more information, contact the City of Davis, Community Development Department.

Seattle, Washington

Seattle provides us with the classic example of the power and success of the citizen participation process. In the mid-1970s, Seattle's public utility had decided to join in the construction of new nuclear plants to assure future electrical capacity. The city council agreed to the original option, but before granting final approval, they demanded that the utility answer questions about the environmental consequences, forecasts of demand, and possible alternatives. The citizens of Seattle created a hot political issue out of the utility's potential involvement in the plants. When the utility failed to indicate alternative energy potential, the council voted to "produce" generating capacity through conservation. The mayor formed a decisionmaking, 28-member citizens group with 6 standing subcommittees. The subcommittees formed working groups to gather data and write proposals. Meetings with the public at large ensured that citizens' interests and values were reflected.

After the meetings, the citizens were asked to fill out a questionnaire. There was strong support for solar, conservation, biomass, and hydroelectric energy systems and general support for local actions ensuring nonprofit, community-based energy systems.

In addition to top-down city-initiated activities, there are neighborhood-based activities in Seattle. The Neighborhood Technology Coalition is supporting activities that tend toward self-help. One project was to complete a greenhouse and community garden in a low-income elderly neighborhood. Another project is holding workshops to train people in basic construction skills from the Seattle Opportunities and Industrial Center. A third is a bilingual training program of hands-on self-help workshops at which they produce insulated shutters and window-box greenhouses. For more information on Seattle, contact the Seattle Department of Community Development or the Neighborhood Technology Program.

Fitchburg, Massachusetts

What became the Fitchburg Alliance to Conserve Energy was, initially, a small group of individuals who started a working board and attracted enough interest to gain some in-kind resources for a small staff and eventually enough funding for 12 people. The Alliance is now a community-wide collective movement involving the media, college, community action groups, planners, the utility, industry, the Chamber of Commerce, neighborhood groups, the clergy, and civic groups in local energy action.

A very successful Alliance program was a series of hands-on training sessions demonstrating low-cost/no-cost conservation technologies. Volunteer teachers and work crews (to assist the handicapped and elderly) conducted the sessions in either neighborhood centers or commercial establishments, depending on the attendance. Materials were purchased in bulk and distributed at the sessions or centers. DOE and HUD provided materials to low-income residents. Within 3 months, 3500 people had attended the training sessions, 1800 conservation kits were distributed, and 350 people requested assistance from the work crews. Through this process, the many different sectors of the community were involved; many people donated time, expertise, and materials. For more information, contact the Fitchburg Alliance to Conserve Energy.

St. Paul, Minnesota

George Latimer has provided an example of what an interested and dedicated city official can do, given an equally interested and dedicated staff to work with, in initiating local energy activities. Following a visit from President Carter in August 1979, Mayor Latimer asked for volunteers to form a public comittee on energy. On recommendations from the committee, a city-wide campaign was undertaken to inform citizens about, and mobilize them toward, energy-efficient actions. The mayor closed down the City for 3 days and, using City personnel, set up a central information center that mailed out and collected, door-to-door, questionnaires on energy consumption habits and attitudes. Local businesses volunteered materials, transportation, and food to keep the City employees going. The campaign produced a more informed public and started many isolated conservation projects, which added up to a lot of activity city-wide. For more information, contact the St. Paul Energy Office.

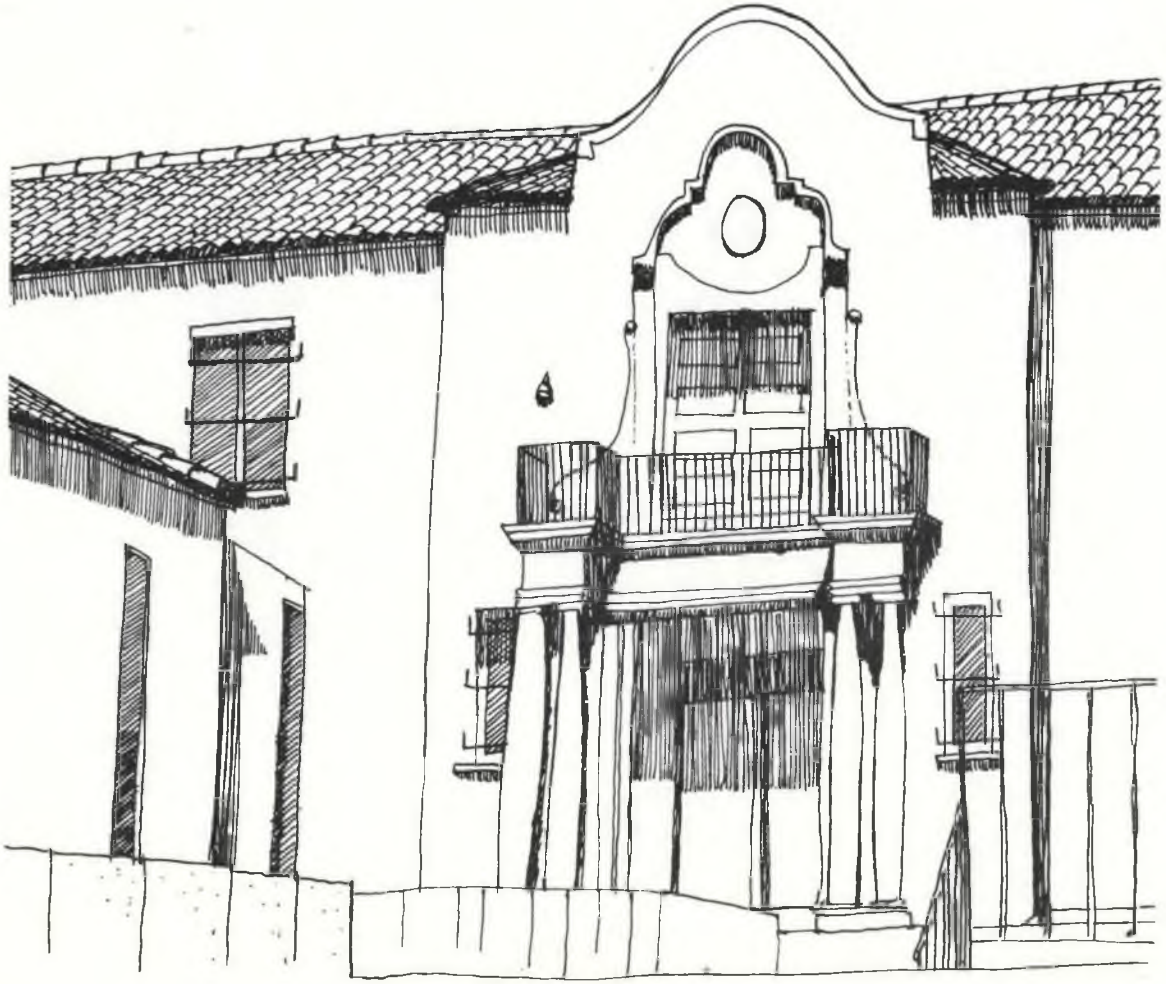
Chautauqua County, New York

Chautauqua presents a good example of how the media can be used effectively to attract the attention of the public. In a creative campaign, called the "great attic attack," a local newspaper and the County energy planner, Tom Duro, set out to inform citizens of the potential for energy savings. Some 900 people attended 3-hour clinics held during "Home Insulation Week." CETA auditors followed through with home energy audits.

Duro also started a low-interest conservation loan program for commercial establishments. The loans have allowed several small businesses to rehabilitate their buildings, which, in some cases, were consuming so much energy that the businesses' existence was threatened. For more information, contact the Chautauqua County Energy Office.

San Bernardino, California

The San Bernardino West-Side Community Development Corporation is one of the many CDCs in the country that has incorporated energy savings activities into the neighborhood rehabilitation program. The CDC, which is an outgrowth of the Welfare Rights Organization, was formed to improve the living conditions of the residents of West-Side, with emphasis on self-help.



The activities of the CDC have been focused on training the youth of the area in an attempt to give them marketable skills. Solar and weatherization demonstrations provide an opportunity to train the youth and, at the same time, give the residents a look at and *feel* for the results. These improvements not only provide more livable structures but also improve the chances for community neighborhood economic survival, especially for the young people.

Other CDC activities include construction of a centralized active solar system for 10 homes, a hydroponic greenhouse, and a sheet metal, solar panel, and machine shop (another youth training activity). For more information contact the San Bernardino West-Side CDC.

Roxbury, Massachusetts

Roxbury is another city with a CDC located in a low-income neighborhood. Their approach has been first to audit energy use, based on the building types, then to determine the demographic averages, occupancy of the building, and financial needs, and finally to propose a plan with three levels of retrofit carried out by demonstration, based on those needs.

Roxbury has initiated a block-by-block strategy where the residents can get involved in a hands-on activity. A training program coordinated by a local trade school and the CDC resulted in window-box heaters and solar porches for a six-family CDC-owned structure.

Roxbury plans to coordinate local energy efficiency research efforts with other neighborhood organizations in an attempt to gain maximum support with coordinated financial efforts. With seven other local groups, including cooperatives, a gardening club, solar professionals, and the community college, the CDC has applied for a grant to form a cooperative effort that will use appropriate technology at the local level to stimulate employment and economic development. They plan to build a community greenhouse farm. For more on Roxbury, contact the Greater Roxbury Development Corporation.

St. Louis, Missouri

St. Louis is another city that set up a CETA/CDBG coordinated training and weatherization program. Here, a professional consultant was employed to train 28 CETA employees to audit and weatherize homes. The employees did 10,000 audits in 1 year and weatherized about 2,000 homes. When CETA money ran out, the County retained and funded 11 of the original trainees, with 1 lead surveyor coordinating their work. The audit procedure has evolved to a walk-through with sit-down consultation where the homeowner suggests changes. A crew comes in to do the weatherization and the lead surveyor does a spot check after the work is completed.

St. Louis has had more effective results with word-of-mouth communication rather than with radio, TV, newspaper, or other media. Interest groups and individuals who had had audits performed on their homes were the most often cited resources. St. Louis also has tried a display in shopping malls where people could sign up for audits. For more information, contact the St. Louis County, Department of Human Resources.

Lafayette, Louisiana

The Community Action Agency of Lafayette (SMILE) is shifting emphasis from providing help to initiating self-help energy programs. They are finding it difficult to stop doing the work themselves, but eventually every CAP must do it; people can and will help themselves.

Lafayette has started hands-on workshops in several neighborhoods. These workshops emphasize weatherization and low-cost solar greenhouses, breadbox water heaters, and window-box heaters. The CAP hopes to start a small business to manufacture these improvements.

Local interest groups that were tapped include the community centers, Catholic Churches, Boy Scouts, and other youth groups. Additional funds were raised by these groups for the low-income and elderly residents. The Churches were particularly effective in bringing low-income residents into the program.

The CAP plans to form a locally owned energy cooperative to purchase bulk natural gas from an industrial plant. For more information, contact SMILE.

Franklin County, Massachusetts

The Franklin County Energy Project, initially an energy planning study, now is part of a five-county energy coalition. They organize solar tours, coordinate grassroots teaching/learning workshops, provide solar builders to instruct nonsolar builders in solar techniques, sponsor energy cooperatives that buy materials in bulk, and maintain a resource directory. Their first attempts at local financing were termed "good." The Project meets regularly with schools to help them develop energy curriculums. The County government is getting involved by providing a town-owned building for a CETA-constructed Trombe wall, again, as part of a training program.

The Franklin County Energy Project has coordinated its efforts with the local Energy Office, the County Task Force on Energy, and the Regional Energy Development Authority. This project is a good example of how communication can motivate the public toward a more self-reliant and supportive energy conciousness. Contact the Franklin County Energy Project.

DuPage County, Illinois

Project Sunshine is a result of funding from city, township, county, state, and Federal programs. They have found that the variety of funding has ensured cooperative efforts by the different interest groups.

Project Sunshine was basically a solar education program. High school and community college students participated in a training program that taught basic carpentry skills. The students weatherized low-income homes and built solar greenhouses on a senior citizens' community building and on the Boy Scout facilities.

The program involved the public schools, the community college, a youth agency, a senior citizens group, the private sector, and community service organizations. For more information, contact Project Sunshine, Milton Township Committee on Youth.

Toledo, Ohio

Crosby Gardens is a 43-acre urban park that just recently has become the site of many solar activities. The park is the location for the Environmental Library and for meetings of the Solar Opportunity League. The League recently sponsored a "Solar Week" that included the following activities:

- Solar Energy Use Symposium
- Public trade show
- Run for the Sun
- Astronomers Sun Spot Reviewing
- Sunshine Awards (commercial, residential, government applications, media, and education)
- Passive Solar Retrofit Workshop for builders, contractors, and homeowners
- Video tour of area solar homes.

The "Week" has had a multiplier effect in attracting people not only to the Environmental Library but also to the weekly Solar Opportunity League meetings. For more information, contact Crosby Gardens.

Evanston, Illinois

The Evanston Environmental Association and the City of Evanston have begun an urban demonstration program aimed at lower income homeowners. The project, called The Urban Ark, is designed to change the wary attitude that low-income people have toward solar energy.

Resources from grants and voluntary labor by citizens have equipped a building with solar and wind-powered energy systems. The hands-on demonstrations have helped to change attitudes.

In addition to the work on the Ark, the coalition has done low-cost solar retrofits on 10 homes. The passive solar retrofit project has provided a 40% to 60% energy savings over an 8- to 9-year payback period. These measurable results are helping the Ark to meet its initial goal of increasing solar awareness in the community. Weatherization workshops were given in two neighborhoods. Twice a month, a library, church, or other local institution provides a location for a one-time weatherization training session. Contact The Urban Ark.

Northampton, Massachusetts

The City of Northampton started a weatherization workshop, backed up by the entire community. The Boy Scouts volunteered to deliver the invitation fliers door to door. The homeowners were then contacted by telephone the next week to find out if they planned to attend the workshop. The homeowners that replied no were asked "why not?" Whatever their reason for not attending, the interviewer was prepared with a solution, such as a ride or a babysitter. The workshops, which were held at local businesses, were taught by volunteers from the utility and other organizations. Eighty-two per cent of the attendees actually did something to their homes. For more information, contact City of Northampton Energy Department.

Greensboro, North Carolina

Greensboro gives us an example of a cooperative and clever effort between the city and the utility. To start a residential audit and conservation program, the City used the City employees who spend a lot of time waiting for calls—fire fighters. Duke Power Company trained the fire fighters in audit procedures. Teams of three fire fighters (one stays in the truck to answer calls) visit a home and spend about 45 minutes analyzing heat loss and discussing the pros and cons of different weatherization materials. The audit information is sent to Duke Power where they determine present energy cost, recommend insulation levels, break down cost, estimate the energy savings and return on investment, and list contractors. The fire fighters return to each home with the results. The teams can audit about 3,500 homes a week. The City also practiced what it preached by starting a massive city-building conservation program (Ridgeway 1979, p. 160). For more information, contact Greensboro-Guilford County Emergency Management Assistance Agency.

Hutchinson, Kansas

When the small City of Hutchinson was invited by Wichita to praticipate in a thermography demonstration, they jumped at the chance. A thermograph is a photograph taken by an airborne camera loaded with infrared-sensitive film. These photographs, taken at night, show relative heat loss in buildings. Buildings with little or no heat loss show up black; poorly insulated buildings with a lot of loss show up white. From these photographs heat loss can be analyzed block by block.

Although a thermograph does not measure absolute heat loss, it is an excellent demonstration tool. Hutchinson felt that it was best not to show the photographs in public because the homeowners might get all kinds of sales pitches from various companies; instead show the photographs only to the owners. The City also personally contacted low-income people whose homes showed high heat loss and arranged financing for the insulating of their homes.

The program, which cost the City $3,700 in grant money, generated tremendous interest in conservation because a heat-loss problem was obvious to almost everyone. For more information, contact Hutchinson City Planning Department.

Boston Building Materials Cooperative

A small group of homeowners, trades people, community housing organizations, and activists formed the Boston Building Materials Cooperative. Initially the group set up a cooperative service organization to share skills. After 3 years, there are almost 500 members.

The Cooperative obtained a commercial bank loan for initial purchases. They feel a grant may have been a better source of financing because conservation is a seasonal concern, so it is hard to support their organization solely on weatherization. People tend to insulate only when they are cold. To wean from grant money (which is helping support the loan), the Cooperative will need to expand from weatherization to lumber and other materials. For information, contact the Boston Building Materials Cooperative.

Cambridge, Massachusetts

Cambridge has a community-owned weatherization company that receives support from CETA and CDBG. The corporation, started from grassroots and neighborhood initiatives, was founded

- to create employment for the neighborhood,
- to provide honest and well-trained people who could provide services for moderate-income people willing to pay for them,
- to create an enterprise that would make a profit, and
- to dovetail with rehabilitation efforts of the Riverside CDC.

The program has been successful, but it is not self-supporting. Like the Boston Building Materials Cooperative, it cannot wean from grants without more community support and less cyclic use of its resources. For more information, contact the Riverside/Cambridgeport CDC.

5 Approaches to Financing

The Need for Financing

Developing a Strategy

Financing Techniques - Public and Private

Community Energy Service Corporations

If you decide that an energy conservation and/or solar retrofit program is appropriate, whether on a community-wide or perhaps just a neighborhood scale, you will need to think about how the investments of residents and businesses will be financed. This chapter outlines some of the unique issues that are involved in starting a financing program for energy-efficient retrofits and lists financing mechanisms that might be used in a local effort. We don't try to tell you what method to use; instead, we hope to give you enough information so that you can judge which techniques or approaches may be most appropriate for your community.

The Need for Financing

Investments in energy efficiency on the part of the public have been discouraged, in part, by the artificially low cost of conventional energy supplies. Federal subsidies to producers and regulation of the price in the market have tended to hide the true costs to society of using up nonrenewable energy sources. This situation is aggravated by the pricing policies of utilities, which are based on average rather than marginal costs. The price that the consumer pays for energy represents the combined cost to the utility of existing supplies and newer ones, which are more expensive. Consequently, the price paid is always lower than would be the case if a household or business were to purchase energy at its true (marginal) cost in the market.* The price of energy to society is steadily increasing, in part, because of the effects of deregulation. In many parts of the Nation, costs are already high enough to encourage significant conservation actions (for example, in the Northwest and New England). The costs of energy in other areas are still relatively low, however. Consequently, incentives may be needed to develop momentum for the retrofit program.

Equally and perhaps more important than simply providing an incentive for energy-efficient retrofits is the ability of a financing program to make them affordable. Many families and businesses cannot afford to borrow money in the current economic environment. A financing program helps them to make the needed investments that will keep their utility bills manageable in the future.

*This is referred to as the marginal cost, which is the cost of the additional unit of energy that will just meet market demand. It is the price that the utility must pay for generating that additional unit of energy.

A local energy program tries to provide a vision of how the county or city can effectively deal with the problem of rising energy prices and their far-reaching effects on local social and economic viability. A financing program attempts to turn that vision into reality. The need for a financing program with a local energy retrofit program will be based on several points.

- Attractive incentives or low-cost financing with flexible terms can encourage local households and investors to look past the artificially low prices of conventional energy and to make investments in energy-efficient technologies now. An incentive and/or financing program encourages households or businesses to make investments in conservation and/or passive solar retrofits giving them some measure of control over the rising energy prices that can be expected in the future.
- The financing needs of low- and moderate-income households and many small businesses, which will be hurt the most by rising energy prices, can be addressed. It is often difficult for these segments of the community to secure conventional financing because they don't qualify under the usual credit standards of the lender. High interest rates and short repayment terms make it unattractive for those households or businesses that can qualify for credit to invest in retrofit measures, in any event. A program to deal with the problems and disincentives presented to lower- and moderate-income households and to small businesses should be a priority, if not the main concern, of any local financing program.
- The availability of attractive financing alternatives is particularly important in addressing needs in the multifamily and commercial sectors. The availability of money at a low cost and with flexible terms can help ensure that any rent increases which landlords may impose to recover their investments will be small. Such alternatives are important because renters generally will tend to have lower incomes than the rest of the population. The interest of businesses in energy retrofits will be measured against other investment alternatives. An attractive incentive or financing package can potentially provide the encouragement needed for them to invest in energy-efficient retrofit measures.
- Development of an effective energy retrofit financing program now can ensure the beginning of a movement toward community energy efficiency and economic stability. The program can provide immediate economic benefits in the form of jobs and additional capital being spent in the local economy. Long-term benefits also accrue to the community. Cash that formerly would have been used by utilities to pay for new energy supplies from out of the state (or overseas) is retained locally instead for the purchase of goods from community businesses, for maintaining or creating employment opportunities, and for local investment purposes.

The principal economic concern of a financing program is to present incentives or financing alternatives that make it attractive and/or affordable for the consumer to invest in the energy-efficient retrofit. This implicity suggests some sort of subsidy to overcome the economic advantages that conventional energy technologies have. It is important that you understand the investment motivations of the community segments which you are trying to serve. A knowledge of existing incentives and the particular economic considerations that homeowners, renters, investors, and business people respond to in evaluating conservation and/or solar retrofits is therefore crucial. Such an understanding enables you to develop effective incentives and financing mechanisms that can encourage residents and businesses to invest in energy efficiency.

The rest of this section examines the unique economic motivations of homeowners, renters, investors, and business people when they evaluate investments in energy efficiency.

Homeowners

The decision of a homeowner to invest in conservation or possibly solar measures may be affected by several considerations. Initially he or she would be concerned about the overall size of the investment and the down payment that may be required (for example, financing under a second mortgage). Tax credits offered by the Federal government and by many states deal with these concerns.* Credits, which can be subtracted directly from the tax liability of the individual, lower the amount of tax owed and in some cases eliminate it completely. The credit is somewhat awkward because it will not be available at the time the improvements are purchased to reduce the immediate cost (the amount to be financed) and eliminate the down payment. Depending on the tax liability of the homeowner, the credit may never be realized as cash, in any event, but simply result in a lower payment to the IRS. The basic economic impact of credits is to reduce the overall cost of the system by having the Government, in effect, pay for a portion of it. Credits do not deal effectively with the financing costs that arise when a loan has to be taken out by the homeowner, however.

Unless the owner pays for the improvements out of cash reserves, he or she will have to finance the improvements. This usually means obtaining a property improvement loan that most likely carries a short repayment term because of the small amount involved (for example, 18 to 24 months for a $2,000 weatherization loan) at a relatively high rate of interest (currently 16% or 17%). Estimated annual energy savings (cooling savings not included) for a $2,000 weatherization package on an older frame home in Albuquerque are approximately $170/year (see Appendix D for the calculation). Annual cost to the borrower for a 24-month loan would be approximately $1,187, a difference of over $1,000.

Negative cash outflows over the 2-year period thus overwhelmingly offset the economic benefits of the conservation measures even when an escalation rate is included for energy costs. This poses a major disincentive to the adoption of energy-efficient retrofits. Increased monthly expenses resulting from the cost of the loan will also pose another disincentive, because the household is forced to give up or cut back on other needs. Clearly, the motivations of households to invest in energy-efficient retrofits will be discouraged because of these factors.

Perhaps the most powerful incentive to conservation and solar retrofits is financing terms that allow energy savings to exceed, or at worst equal, the monthly expense associated with the loan. This implies a loan with a lower interest rate and a longer term.** A 15-year, 3% loan with a monthly payment of $14 would result in a small annual net benefit to the owner who has invested $2,000 for conservation measures in Albuquerque. Even though the borrower ends up paying more for the loan under a 3% rate and 15-year loan term ($114), that may be a small concern compared to the ability of the family to comfortably handle the cost of the loan in the monthly budget. This is a particularly important issue for low- and moderate-income households.

The high cost of conventional loans and their negative impact on the economic attraction of energy-efficient retrofits, along with the basic inability of many households to qualify for bank loans, suggests the need for a low-cost financing program. In addition, many lower income households don't have enough income to take advantage of the Federal income tax credits, or state credits where they are available. Consequently, these households have no incentive whatsoever to invest in conservation or solar retrofits. An affordable financing program that provides positive savings is particularly crucial to their needs, because they will be affected the most by increasing energy prices.

In summary, income tax credits, the basic incentives that are used in the Nation to encourage conservation and solar investments, reduce the initial

*The Federal tax credit for conservation measures is currently 15% of the first $2,000 in expenditures ($300 maximum). The Federal solar tax credit is currently 40% of the first $10,000 in expenditures ($4,000 maximum).

**Note that the average homeowner will move about once every 7 years (Andreassi 1977). This implicitly suggests that the homeowner will want to recover his or her investment in 7 years or less. Recovery of the investment will depend on the measures that are invested in, the local cost of energy, and its annual rate of increase. This investment criterion doesn't account for the higher price that the homeowner might receive upon the sale of the home because of its increased level of energy efficiency. It is likely that the real estate market will value energy-efficient homes more highly as energy prices continue to rise.

cost of a system and allow a homeowner to recoup all or a large part of any down payment that is made. These are important considerations in the purchase decision, but they don't effectively address the issue of affordability or realization of immediate positive economic benefits when a household has to take out a conventional loan. This can be an essential investment criterion for the typical household, however. Subsidized financing can address this major concern of homeowners, as well as make the improvements affordable to a major segment of the population that otherwise would not be able to adopt energy-efficient investments.

Renters

The energy retrofits that renters are interested in undertaking generally are limited to inexpensive measures that offer quick paybacks in terms of energy savings (caulking, weather stripping, plastic storm windows, and adjustment of thermostat). The renter won't make substantial investments because he or she has no financial interest in the property and is unlikely to remain there for a long period in any case. This generally short holding period significantly affects the renter's perspective on making a substantial investment in energy savings by taking out a loan. It is most likely that the renter won't occupy the unit long enough to enjoy the positive cash flows that begin only after the loan is paid off.

The renter's ability to undertake significant improvements in the structure also is limited in many cases by the physical characteristics of the building. For example, it would be impossible for a renter to add insulation to the wall cavity of his unit on the 24th floor of a 40-story building. Finally, the income levels of renters often are lower than those of average homeowners, placing an economic constraint on the renter's ability to undertake a significant investment in energy efficiency.

Structuring attractive economic incentives for this segment of the community is difficult. It may be that the only incentives that can be provided are educational efforts oriented specifically at renters and perhaps the provision of weatherization materials either for free or at a low cost. The DOE Weatherization Assistance Program, which provides grants to the states to assist low-income households (who may be renting) with weatherizing their homes, presents an example of a program that feasibly might be adopted at the local level. Outright grants of up to $1,000 are supplied to install conservation measures that reduce air infiltration, a factor that can cause up to 40% of the heat loss in a typical home.* The incomes of applicants must be at or below 125% of the Federally established poverty level. Local CAPs generally have been charged with the responsibility of carrying out the Program. Future funding for this valuable Program is in doubt as of this writing.

Landlords

Owners of rental properties, either residential or commercial, are only willing to make investments in energy retrofits when they are sure that they can regain the cash allocation through higher rents. Landlords also may require high rates of return to justify the cash allocation because they often have other investment alternatives.

*Caulking, weather stripping, plastic storm windows, and attic insulation are the major items that are usually installed.

The basic barrier to landlord interest in energy retrofit investments is the fact that he or she generally does not obtain the economic benefits, the renter does. Such is the case where the tenant pays the utility bills. Investment motivations for the landlord are consequently minimal. This is not so much the case when the landlord pays the utility bills, as in a master-metered building. However, the landlord's investment interest will be constrained to some degree because increasing energy costs can often be passed through to the tenant by charging a higher rent. Energy costs also may be deducted by the owner of the master-metered building on his or her Federal income tax return, in effect reducing the cost of energy by 30% to 50% (Morris 1979, p. 3).

There will be situations when the landlord of the master-metered building will invest, though. This occurs when it becomes difficult to pass on energy costs by raising rents and retain and/or attract tenants at the same time. The landlord may be motivated to invest in energy-efficient retrofits and equipment at this point. An increase in rent is passed on to recoup the investment in the hope that future increases (attributable to rising energy prices) can be kept in line with what the local rental market will accept. The landlord of the master-metered building will not invest if he or she cannot raise rents to cover his or her costs, however. This has proven to be a problem in many lower income neighborhoods.

Stimulating landlord interest in energy retrofit investments is extremely difficult and in some locales may have to be dealt with through mandatory means (for example, time-of-sale requirements). Such requirements may create the problem of inflating rents in the community because landlords of commercial and housing properties will probably raise rents to recover their investments. The availability of low-cost financing may mitigate the effects of these increases to tenants, however. A financing program for investors should certainly constitute a concern for local program organizers. Ultimately, energy-efficient retrofits in investor-owned structures assist those who most need assistance in reducing their energy bills—renters.

Commercial Business

Owners of commercial buildings, who use these structures for their own operations, also are likely to be hesitant to make energy investments in many cases. They, like investors, can deduct energy costs as an expense from their income taxes, consequently reducing the cost of energy expenditures to the extent of their tax brackets. They are particularly sensitive to their cash-flow positions because they may need to channel money from other business needs to pay for the retrofit. Consequently, they weigh the economics of delaying investments in other areas (new equipment, additional personnel, plant expansion, etc.) against those of the conservation or solar investment (Morris 1979, p. 3). Typically, commercial concerns favor investments in expanded sales or product development over energy investments. Although commercial businesses may be willing to accept a 15% return on their investments in market expansion or product development, they may require a 30% return on an energy investment (Morris 1979, p. 3). This implies a payback period of less than 3 years.

Local programs have to address these biases if they want to stimulate interest among owners of commercial businesses. Appendix F (General Readings) includes current incentives that are offered to businesses (and landlords) to encourage investments in energy efficiency. Depending on the type of energy investment, the Business Energy Investment Tax Credit is available at 10% to 15% of the cost of the improvement.

If you decide that a financing program for energy retrofits is appropriate in your city or county, you need to consider the unique needs of residents and businesses and the resources that you have at your disposal. In developing a strategy, you need to think about the following issues.

- What percentage of the community residents own their home and what percentage rent?
- What are the income characteristics of community residents?
- What types of financing techniques or incentives are most appropriate to the economic needs of residents and businesses? Can income tax credits meet those needs or is low-cost financing a better answer?
- Where will you obtain the money for a grant, loan, or subsidy program? Can you obtain CDBG or UDAG monies, use local reserves, or float bonds?
- What are the administrative capabilities of the locality? Can the program be carried out through existing agencies (for example, the community development or rehabilitation agency) or are new administrative structures required?
- What local, legal, or political considerations will affect the establishment of a financing program?
- What types of credit sources already exist for energy retrofits (for example, state, utility, or private)?
- What will be the role of private lenders in the financing program? Will they participate in joint public/private financing ventures or will they only make their regular loans? Would the private lenders be interested in assisting with the administrative aspects of the program for a fee or on a good-will basis (loan origination and servicing)? Will the private lender support public efforts through special promotions or perhaps rate reductions on energy loans?
- What role might local utilities be willing to play in the program?
- How can other community organizations (cooperatives, CDCs, neighborhood associations) be used to increase the effectiveness of financing efforts?

The concerns mentioned above represent only a few of the more obvious ones that you must consider in your financing strategy. You will undoubtedly determine a number of other considerations that are unique to your locality.

Federal Considerations

Several actions taken at the Federal level have implications for any local financing program. These actions relate to the ability of taxpayers to obtain income tax credits for passive systems, the prohibitions on double dipping in the Windfall Profits Tax Act of 1980, and restrictions imposed on subsidized financing by the Mortgage Subsidy Bond Tax Act of 1980.

Tax Credits for Passive Solar Systems

The current solar tax credit, which allows 40% of the cost of such systems (up to $4,000) to be subtracted from the individual's tax liability, unfortunately is oriented almost entirely toward active solar heating and hot-water applications. In general, the IRS allows only a small portion of a passive solar system to qualify for the credit (Wallenstein 1981, p. 10).

The IRS requires that a passive system include five components to qualify for the credit in the first place. These include (1) a solar collection area; (2) an absorber surface (for example, floor) to retain solar heat; (3) a storage mass, which is used to collect the energy and later release it in the home; (4) a method of heat distribution to encourage the movement of energy by radiant or convective means; and (5) heat regulation devices, which control the amount of heat coming into the home (awnings, fans, thermostats, venting mechanisms). The IRS allows the credit to be taken only for those parts of the passive system whose *sole* purpose is related to the operation of that system. If the particular component serves a dual purpose, such as interacting with the conventional heating system or serving a structural function, it is not eligible for the credit. Further, credits are allowed only for passive systems that are built solely to provide heat to the home. Greenhouses, which provide heat but which are also used to grow plants or vegetables, are not eligible.

These narrowly drawn IRS regulations do little to encourage the adoption of passive solar systems. The locality, if it wishes to encourage the adoption of passive solar applications, might consider establishing a local incentive (for example, property tax credit). The difficulty of obtaining a tax credit for passive systems also suggests that the locality ignore the double-dipping provisions discussed next. The small amount of credit for which the system might qualify, the potential legal difficulties to the homeowner in qualifying certain elements of the system, and the disqualification of greenhouses from consideration for the credit may make a locally subsidized financing approach more preferable to households (and businesses) as an incentive than the Federal income tax credit.*

Crude Oil Windfall Profits Tax Act of 1980—Restrictions on Double Dipping.

Sections 203 and 223 of the Crude Oil Windfall Profits Tax Act of 1980 prohibit homeowners, landlords, or businesses from taking Federal income tax credits for conservation and/or solar retrofits when these improvements are financed with subsidized loans or other similar forms of assistance that are extended by states, localities, and utilities. Such a ruling has a major impact on the adoption of conservation and/or solar systems because most studies identify favorable financing arrangements as a key element in accelerating their acceptance of the systems (Morris 1980, p. 67). The rationale behind inserting Sections 203 and 223 is outlined in the following statement made by the Congressional Conference Committee.

> "The conferees are concerned that if no such rules were adopted, the compound effect of various subsidized loan and grant programs could lead to a situation in which the taxpayer could purchase the property with very little expenditure of his own funds. A potential result could be the encouragement of inefficiency through expenditures for equipment, the production of which would require diverting substantial resources from more effective uses. The effect of the role provided is that the purchaser of the eligible equipment must choose between the tax credit, on the one hand, and subsidized energy loans and nontaxable grants, on the other hand." (Morris 1980, p. 68)

*Passive solar technologies do not qualify for the Business Energy Investment Tax Credit.

The definition of subsidized financing includes, but is not limited to, the use of tax-exempt bonds to finance energy improvements and would most likely also include any type of financing that uses CDBG or other funds provided by the Federal government to write down the cost of loans or provide outright grants to local residents and businesses. Subsidized financing does not include loan guarantees. The meaning of subsidized financing for business tax credits is defined under Section 223 of the Act. It states that the applicable credit for businesses (10% to 15%) will be reduced by one-half where subsidized financing is used.

The IRS, as of this writing, has not issued final regulations on the definition of subsidized financing. *You should obtain these regulations* when they become available to see how residents and businesses participating in a local energy financing program might be affected by IRS rulings. It may be possible, for example, to provide energy improvements through an existing low-interest housing rehabilitation loan program, because the principal purpose of that program is not to provide subsidized financing for projects designed to conserve or produce energy (Morris 1980, p. 68). The property owner could probably take the tax credits in this situation. Also, low-cost financing obtained from utilities will be exempt from double-dipping provisions because the loans are financed, in effect, by consumers and because the savings realized accrue to the entire utility system. The charge of subsidized financing might also be avoided where the locality or utility extends financing at its cost of capital (except where Federally subsidized tax-exempt bonds are used).

The loss of income tax credits because of the use of subsidized financing methods should be evaluated in terms of the economic needs of local households and businesses. Some households (and businesses because of writeoffs) may be little affected by this consideration anyway because they possess no tax liability. Still, others may prefer a subsidized financing approach because it offers a more affordable and attractive way to undertake energy-efficient retrofits.

Mortgage Subsidy Bond Tax Act of 1980

This piece of legislation imposes significant limitations on the ability of state and local governments to use tax-exempt bonds to extend financing to residents for the purchase of a home or for property improvements, including those for energy conservation or solar applications. As of December 31, 1983, all subsidized financing using tax-exempt bonds will be eliminated. This legislation imposes serious constraints on local governmens to use their bonding powers in formulating a financing program with below-market rates and favorable terms. The specifics of this piece of legislation are addressed in the "Bonds" section of this chapter.

Comments

The ability of a local government to finance a retrofit program for conservation and/or passive solar measures is subject to a growing number of limitations. It appears that many of the major Federal grant programs that local communities have traditionally relied on, such as Community Development Block Grants (CDBGs), Urban Development

Action Grants (UDAGs), and the Section 312 Property Improvement Loan Program, will be cut back, if not eliminated completely. The current political philosophy also suggests that more control over Federal grant funds will be returned to the state level of government. These developments suggest a declining level of community development capital for counties and cities. Financing for an energy conservation and passive solar retrofit program will have to compete for funding against other community development priorities.

The financing capabilities of many communities will also be affected adversely by provisions of the Mortgage Subsidy Bond Tax Act of 1980. Those counties and cities with the state-approved authority to issue bonds and with the subsequent power to lend those funds out are beginning to find it more difficult to make a bond issue workable because of certain aspects of this legislation. By the end of 1983, they will be unable to issue any type of revenue bonds that would be used for subsidized financing unless amendments to the legislation are made. In summary, the possibility of mounting a significant financing program backed with funding from the local government is an increasingly difficult task, given today's economic, legal, and political realities.

Where public funds are not available for the retrofit program, improvisation is of the utmost importance. Efforts should be undertaken to point out the tangencies of an independent retrofit program to other community development priorities (employment, income retained in the community, increased neighborhood self-reliance, etc.). Initiatives could also be undertaken to incorporate the basic objectives of the retrofit program into the existing housing rehabilitation program. Funding limitations might reduce the number of retrofits undertaken or the comprehensiveness of the individual applications, but at least some retrofits will be installed in the community. These retrofits provide concrete examples for other property owners and building contractors. The City of Albuquerque Urban Rehabilitation Department did this by building two low-cost passive solar homes to demonstrate the feasibility and economy of the concept to builders. They have also been willing to provide suggestions on the conservation and passive solar options that could be incorporated into a property rehabilitation. As a result, applicants for rehabilitation loans have shown increasing interest in the possibilities of including conservation and passive solar measures (greenhouses, clerestory windows, Trombe walls, additional insulation) in their homes.

An advantage to incorporating a retrofit program into an existing low-interest housing rehabilitation loan program is the possibility that the household may be able to obtain both subsidized financing and the tax credit. Two financial incentives improve the economics of the conservation or solar measures to the household. This will be important because most households involved in a subsidized housing rehabilitation loan program will tend to have lower incomes. They will often need the additional incentive that the credit can provide.

We also stress the importance of including private-sector organizations in the local financing effort. Local financial institutions such as banks, savings and loan associations, and credit unions should be drawn into the local program if at all possible. They may be willing to extend additional capital on first mortgages for conservation improvements or provide special terms on property improvement loans for energy-efficient retrofits. They also may be willing to participate in a cooperative financing effort, with the local government providing some sort of subsidy to either the borrower or lender. This type of approach can leverage the scarce capital resources of the local government agency or retrofit program. Cooperatives and utilities offer other private-sector approaches to financing and installing energy-efficient retrofits. Development of a private-sector financing capability should be a key component of the overall local financing plan.

We do not touch upon the roles of states in financing conservation and/or solar retrofits. Your local strategy must consider the potential capital resources that are available at the state level. California, Minnesota, Wisconsin, New Jersey, and Tennessee all have significant FHA Title I bond financing programs oriented toward property rehabilitation. These funds have generally included conservation and, in some cases, solar applications as eligible funding items.

The Vermont Housing Finance Agency purchased 80% loan participations from banks with excess reserve funds beginning in early 1980. Loans for energy-efficient improvements consequently were made available to state residents for amounts up to $3,000 with an 8.5% interest rate and a term of 3 to 5 years.

The State of New Mexico is currently lending $500,000 in state reserve funds to private financial institutions at a 2% interest rate for a solar energy loan program. The lenders will then originate and service the loans at an interest rate of 7% and repayment terms of 5 years, for amounts up to $3,500. The 5% spread is used to cover the lending institutions' costs.

Oregon has embarked on the most ambitious program of all. A $300 million bond program was established that will provide loans for small-scale energy projects undertaken by individuals, small businesses, nonprofit cooperatives, private corporations, and municipal corporations. This program is the equivalent of a $30 billion bond issue being enacted for the entire Nation.

The ability of Oregon and other states to issue bonds is provided for under the Windfall Profits Tax Act of 1980. These bonds are to be used to finance energy production from alternative sources, including solar (Sanger and Epstein 1980, p. VIII.16). There are no restrictions on how bond proceeds might be allocated. This would make it possible for funds to be passed down from the state to local units of government. Conditions on the bonds include the following.

- The bonds must be general state obligations.
- Sufficient taxes must be levied to provide for payment of principal and interest.
- The bonds must be issued pursuant to a small-scale energy projects program established by a state whose legislature has approved an authorizing Constitutional amendment.
- All such obligations outstanding must not exceed $500 million or one-half of 1% of the value of all property in the state (Sanger and Epstein 1980, p. VIII.17).

The taxing powers of states provide another means of potentially funding a loan program. Many Western states have established severance taxes to receive compensation from private firms for the nonrenewable resources that they extract from the land. These taxes apply to oil, natural gas, coal, uranium, and other mineral resources. Monies from this tax source logically might be used to improve the energy self-sufficiency of state residents and businesses. Many states in the East and Midwest have considered the use of gross receipts taxes on oil companies that do business within their borders. New York recently imposed taxes on oil company operations, with the $700 million in estimated revenues being targeted for improving mass transit. Such tax revenues could also be used to finance energy-efficient retrofits.

In the final analysis, states will possess the greatest ability to originate significant financing programs. This ability is attributable to their bonding capabilities, taxation powers, and relative freedom from a number of legal considerations that can hinder local efforts (for example, bonding restrictions and lending-of-credit problems). Clearly, local program organizers must consider how a financing plan at the community level could be integrated with any state initiatives.

Financing Techniques - Public and Private

This section will examine the public and private financing techniques that could be used for conservation and passive solar retrofits. Public approaches discussed include property tax incentives, grants and direct loans, borrower or lender subsidies, deposits with private lenders, credit agreements with private lenders, and bond issues. Most of these techniques have been used before for property rehabilitation, so it is likely that you will be familiar with some of them. Major sources of funding for these techniques have been CDBG funds, Section 312 monies, and, most recently, UDAG monies.

These techniques are particularly effective in addressing the financing needs of moderate- and, in some cases, lower income households.

Private financing sources discussed include financial institutions (banks, savings and loan associations, and credit unions), cooperatives, and utilities. We also discuss the concept of the community energy service corporation. This is a fairly new idea based on the experience of several California cities in setting up organizational frameworks to install solar equipment on local homes and businesses. The community energy service corporation may be organized as either a public or a private entity and could provide and finance conservation as well as solar retrofits.

The techniques and financing approaches that follow by no means represent the full range of approaches that could be tried. Instead, we present the more obvious ones in hopes of stimulating your thinking so that you can discover opportunities that might be available in your own community. You must determine the unique local political, legal, and economic considerations that would affect the development of a financing strategy for your program.

Public

Property Tax Incentives

The addition of a solar energy system to a dwelling may result in a higher tax bill for a property owner. Consequently, the adoption of solar technologies by the public is discouraged because of the incremental increase in the property tax bill attributable to the system. The economic attraction of the system is offset in several ways. The initial cost of the system is increased by the amount of the additional levy. The payback period is lengthened because the cost of adopting the system must be adjusted to include the cost of the additional taxes. Finally, life-cycle costs of the system are adversely affected, providing incorrect signals to the market about the value of solar retrofits and their effectiveness in reducing energy consumption.*

Types of Incentives. Property tax incentives may be provided by local governments in the following forms.

- *Exemption.* The additional value of the solar system will not be subject to property taxation.
- *Addit.* The addition of a solar system will not increase the assessed valuation of the property.
- *Deduction.* The amount by which the value of a property with a solar system exceeds the value of the property with a conventional system will be exempt from taxation.
- *Convent.* A property with a solar system will be assessed as if it had a conventional system.
- *Credit.* Installation of a solar system entitles the property owner to a reduction in his or her tax liability based on either a stated amount or percentage of the total tax bill or the difference between the value of the property with the system and the value without it.

Addits, deductions, and convents, as well as credits based on the difference between the value of the property with the system and the value without it, are essentially the same as exemptions. Although

*Conservation improvements are not considered because they generally do not lead to a higher tax bill for a property owner.

they differ in definition, they achieve the same purpose of keeping the property owner's tax bill from increasing as a result of the installation of a system. Henceforth, these approaches will be referred to as exemptions. A credit based on reducing the property owner's tax liability by a certain percentage or stated amount is altogether different, because the owner receives a monetary benefit as a result of a lower tax bill. Property tax credits of this kind and exemptions are examined separately because of their differences.

Exemption. Thirty-two states provide for some sort of property tax relief when a solar system is installed (see Table 5-I). Most of these approaches take the form of exemptions. State legislatures generally have been willing to establish enabling legislation for property tax exemptions at the local level for solar systems as a means of indicating their general support for solar technologies. The exemption approach has proven politically attractive because it does not significantly affect state revenues. Forgone tax revenues are borne largely by local units of government (Roessner et al. 1980, p. 51).

The basic utility of an exemption in promoting the adoption of solar retrofits is that the owner is not penalized financially for installing or building a system. In this manner, the initial cost of the system is reduced and the payback period and life-cycle costs of the system are improved.

The incentive provided by an exemption for the adoption of a system will vary from locality to locality. Consider the adoption of an 8- by 16-ft greenhouse. The addition of this improvement in Albuquerque, New Mexico, would increase the tax bill by approximately *$7.00*/year; whereas in Minneapolis, Minnesota, the total bill would be increased by *$28.00.** Clearly, the value of the incentive must be evaluated in the light of the local tax levy; the attraction of the exemption is higher in high tax jurisdictions. The exemption's attraction also is based on the particular psychology of the property owner when he or she evaluates the solar purchase decision. In many cases, the property tax ramifications of the decision may not be important, because the property owner may be more concerned with the social, aesthetic, environmental, and eventually economic (energy savings) value of adopting the particular system. Still, property owners on lower or fixed incomes (for example, the elderly) may be particularly sensitive to possible increases in their tax liabilities. Providing the exemption may be an important incentive to them.

The actual impact of the exemption on property owners' retrofit decisions is difficult to assess. It will likely be small, however, because of the small increment that solar collectors, greenhouses, and Trombe walls add to the assessed value of the property for tax purposes. Exemptions (or credits) are useful as psychological incentives for solar applications. Property tax exemptions indicate that the local government believes that solar is a viable and effective way for the property owner to reduce his or her energy bill. This may translate into increased consumer acceptance for passive and active solar energy applications.

Property Tax Credit. The property tax credit has been allowed for in varying forms in Maryland, Kansas, Oregon, and South Dakota. The credit can be a particularly powerful local incentive when the property owner is able to realize a direct reduction in his or her property tax bill. This reduces the initial cost of the system, shortens the payback period, and compensates the owner to some degree for out-of-pocket expenses for the down payment. Consequently, the effect of the property tax credit is similar to that of the income tax credit.

The property tax credit has been administered in several different ways. Credits as they have been provided for under enabling legislation in Maryland present a fairly strong incentive for the adoption of solar technologies. The legislation currently allows local governments (counties or cities) to provide for tax credits against any local real property taxes levied on residential or nonresidential buildings. Harford and Anne Arundel Counties are using the approaches as of this writing. Both Counties base the size of the credit solely on the property owner's tax liability. Harford County places an upper limit on the amount of the credit at $1,000, whereas Anne Arundel imposes no restriction. No taxpayer can take a credit that exceeds his or her tax liability. In other words, a person with a $500 annual bill would obtain a credit for that amount and no more.

In Harford County, passive systems are eligible for the credit if there is a demonstrated means of heat transfer. Anne Arundel County limits the credit to active systems. Until the end of 1980, Kansas provided a 35% credit on the total amount of property taxes paid by an owner if the solar system could provide 70% or more of the energy needed to heat or cool the building. The credit was made available in the initial year of construction and the succeeding 4 years. The major emphasis of the Kansas credit was on new construction as suggested by the large fraction of the building's space conditioning that the system had to provide.

Several other states have offered credits to encourage the adoption of energy-efficient

*Telephone conversations with Albuquerque and Minneapolis Assessor's Offices, November 1980.

TABLE 5-I. States Offering Solar Property Tax Incentives[a]

State	Incentive	State	Incentive
Arizona	Exemption	Minnesota	Exemption
California	Exemption	Montana	Exemption (limit on amount)
Colorado	Addit (expires 1989)	Nevada	Deduction
Connecticut	Deduction	New Hampshire	Exemption
Florida	Exemption	New Jersey	Deduction (expires 1983)
Georgia	Exemption (expires 1996) (local option)	North Carolina	Convent
		North Dakota	Exemption
Hawaii	Exemption	Ohio	Exemption
Illinois	Other[b]	Oregon	Deduction (expires 1997)/ Credit for conservation measures
Indiana	Deduction		
Iowa	Addit (expires 1985)		
Kansas	Exemption (credit expired in 1980)	South Dakota	Credit
		Tennessee	Exemption
Louisiana	Exemption	Texas	Exemption
Maine	Exemption	Vermont	Exemption
Maryland	Credit/Convent	Virginia	Other[d]
Massachusetts	Exemption	Washington	Convent
Michigan	Exemption	Wisconsin	Exemption (expires 1995)

[a]Information from Carmean (1980).

[b]The property owner who installs an alternative energy system on his or her property may request an alternate valuation of the property. The assessor shall then determine the value of the property with the alternative system and without the system. The lesser of the two values shall be the assessed value of the property.

[c]A taxpayer who claims and receives an owner property tax refund based upon household income and property tax liability for calendar year 1976 shall receive a refund for costs incurred for weatherization of his or her homestead. (Property tax refunds are based on income and property tax liability.) The taxpayer must meet the following guidelines.

(1) The household has been issued a voucher fitting the income guideline (less than a $7,500 household income).

(2) Before January 1, 1980, the taxpayer presents a voucher for payment with evidence that he or she has incurred the costs in connection with weatherization; the taxpayer has weatherized his or her home to the extent of the costs; the taxpayer is not eligible for a Federal grant, aid, assistance, or other benefit for weatherization; the taxpayer is 60 years of age or older on January 1, 1977; and the taxpayer's liability for the homestead on which relief is granted reflects an assessed value of less than $30,000. The amount granted shall be the lesser of the costs incurred or $300.

[d]Certified solar energy equipment, facilities, or devices are declared to be a distinct class of property from other classifications of real or personal property. The governing body of any county, city, or town may, by ordinance, exempt or partially exempt such property from taxation.

technologies. South Dakota provides a credit to the residential property taxpayer in an amount equal to the assessed value of the real property with the system minus the assessed value without the system. The basic effect of this approach is to turn the credit into an exemption so that the property will not be assessed at a higher value. The impact of the credit is diluted over the following 3 years as it is reduced to 75%, 50%, and 25% of the base-year credit. In addition, it must be adjusted to take into account any Federal income tax credit that the property owner receives. The attraction of the credit is substantially reduced under this approach. The credit offered in South Dakota on commercial property is more attractive. The amount of the base credit is 50% of the actual installed cost of the system. As with the residential credit, it is reduced to 75%, 50%, and 25% of the base-year credit in the 3 succeeding years (Carmean 1980). Federal tax credits must also be taken into account for commercial applications.

The state of Oregon has used the property tax system to encourage elderly property owners to undertake conservation improvements. A refund of up to $300 is available for the costs incurred for weatherizing the home. Qualification for the refund is based on criteria specified in Table 5-I. Continued operation of the program is contingent upon the availability of funds.

Comments. Implementation of tax incentives at the local level requires that a number of issues be addressed. These relate to equity considerations, budgetary impacts, evaluative criteria, and the economic nature of the incentives that are offered.

- *Equity Considerations.* This issue may certainly arise at the local level because the tax base is being used, in effect, to subsidize the actions of certain segments of the community. In particular, property tax incentives do little to help renters, who tend to earn lower incomes and are often in the most need of assistance. Property tax incentives are somewhat biased in favor of higher income groups.

The exemption is perhaps the most equitable means of encouraging solar applications because it is related to the value of the improvement and is divorced to a large extent from the overall value of the property and from the tax liability of the taxpayer. Consequently, lower income property owners enjoy the same advantage as higher income owners.

A credit, on the other hand, tends to benefit higher income households, if it is administered as it is in Maryland. Those households with a higher tax liability will be able to take full advantage of the credit, whereas those with less cannot take a credit that is larger than their current bill. A fairer approach would be to apply a percentage credit to the cost of the solar energy system that could be deducted by taxpayers from the property taxes that they owe. A problem still arises where the amount of the credit would exceed the tax bill, thus limiting the ability of lower income taxpayers to take full advantage of the credit, however.

A refund approach like the one used in Oregon can be an effective way to assist certain segments of the local population that will be hit hardest by rising energy bills.

- *Budgetary Impacts.* The use of exemptions and/or credits will have an impact on the local budget. Exemptions are easier for the county or city to deal with because they constitute no loss in actual revenues. Instead, the locality forgoes taxes it might normally have collected. The amount may be fairly small (depending on how many households adopt solar measures) given the fact that the amount of tax revenue lost under an individual exemption usually is rather small.

The situation changes under a credit. Here, the locality is actually losing tax revenue that it would normally take in. If a large number of households and businesses decide to take the credit, serious cash outflows could result. Harford County has taken steps to deal with this problem by limiting the dollar amount of credits that can be claimed in 1 year to $150,000.*

Use of the property tax system to encourage the adoption of solar technologies at the present time will likely encounter political resistance in many communities because of forgone or lost revenues. This resistance is attributable to inflationary pressures in the economy, increasing local demands for government services, and expected cutbacks in Federal revenue sharing programs. A budget limitation is one way to reduce this problem and at the same time inject some predictability into the budgetary process.

- *Administering Property Tax Incentives.* A local program that uses property tax incentives as a means to encourage solar energy systems must also establish evaluative criteria to determine each system's quality. Determining the quality may impose an additional burden on the staff of the assessor's office, which is basically unfamiliar with the workings or relative merits of various solar systems. The

*Conversation with B. Packard of the Harford County Assessor's Office, October 30, 1980.

predictable solution to such a problem is the establishment of a standardized set of evaluative criteria. This approach risks denying the benefits of the incentives to unconventional systems that provide effective performance but vary from the stated criteria.

- *Impact of Federal Tax Considerations.* Property owners can deduct local property taxes from their Federal income taxes to the extent of their tax bracket. An owner would be able to deduct the usual amount if a property tax exemption were obtained because the tax bill would not be affected. This is not the case under a credit because of the reduction in the amount of property taxes paid. For example, assume that a homeowner pays $900 in property taxes yearly on his home in Annapolis, Maryland, and is in the 40% tax bracket. In a normal year, he or she would be able to deduct $360 of that amount on his or her Federal tax return. If the homeowner obtained the full $900 credit from Anne Arundel County, he or she would lose that deduction. The $900 credit is really only worth $540 to the property owner. The actual amount of the property tax credit will always be reduced by the percentage tax bracket that the property owner is in.

Property tax incentives can be an effective means for a local government to indicate support for solar technologies. A basic advantage of this approach is the fact that the administrative framework is already in place. Consequently, incentives can be provided to local residents and businesses fairly quickly once the evaluative criteria have been established. An exemption is an equitable means of indicating the locality's support for solar technology. An increase in the property owner's tax bill is avoided, thus improving the payback period on the investment. The credit provides a more direct incentive because it reduces the initial cost of the system, compensates the owner for at least part of the down payment, and can (if based on the Maryland models) significantly reduce the payback period. This total benefit depends on the property tax liability of the owner and the Federal income tax bracket that he or she is in.

Implementation of property tax incentives at the local level will depend on approval at the state level. State legislatures have generally been willing to let localities provide exemptions. Permission to extend credits will depend on the existence of any other incentives (income tax credits, deductions) that exist in the state, which duplicate, to any degree, the purposes of property tax credits. State legislatures also will be sensitive to the economic effects that credits might have on local governments.

Grants and Direct Loans

Grants and/or low-interest loans provide an effective means by which local governments can address the particular financial needs of lower income households. The advantage of these approaches lies in the fact that conventional credit sources are circumvented. The city or county can establish its own credit standards that can be used to qualify virtually any household for financing. Grants or low-interest loans may be the only financing alternatives for lower income households.

Grants and Deferred Payment Loans. The *grant* is provided to those lower income households that cannot qualify for conventional credit and that

would have trouble repaying a loan extended by the locality even if it were provided at a low interest rate with an extended term. A grant may be the only financial incentive that will induce low-income renters to adopt conservation measures.

A *deferred payment loan* (DPL) always should be considered as an alternative to the outright grant for low-income property owners. A lien is placed on the property when the grant is given. This lien requires that the dollar amount provided to the household be returned to the local program upon the sale or transfer of the property. The DPL enables the local program to regain funds that would otherwise be lost if provided as grants. The DPL imposes no burden on the low-income household because there are no monthly payments. Repayment of the DPL is generally secured from the proceeds of the sale of the property. The DPL is particularly well suited to the needs of households that are property rich but cash poor (such as many elderly households). Pacific Power and Light, an electric utility located in the Northwest, currently uses the DPL concept in financing weatherization measures for customers located in its service area. They provide a 0%-interest loan that is repayable upon the sale of the home.

Direct Loans. A *direct loan program*, administered by the locality, is an effective means of assisting low- and moderate-income households that cannot qualify for conventional credit but have the ability to repay a loan if it is extended at a low interest rate with a long repayment period. The direct loan approach is also useful for channeling funds to neighborhoods in which conventional lenders may be reluctant to extend financing. The direct loan approach

- provides program control over funds and relative ease of implementation;
- deals with the perception, real or imagined, that local lenders would be unwilling to participate in a principal reduction or lender subsidy program; and
- addresses the desire of local policymakers to maintain a long-term financial commitment to energy-efficient technologies.

This last consideration relates to a "multiplier" effect inherent to a loan program. As the borrower repays the loan, funds become available for additional loans. The recycling of loan repayments multiplies the impact of each dollar initially invested in the energy retrofit loan fund. Over time, that dollar can finance more and more energy improvements. The recycling and multiplication of funds consequently sustains an ongoing commitment to energy efficiency and can gradually expand the scope of the local program.

Terms of the loans may be tailored to the particular economic needs of the borrower. Interest rates for example, can be related to the income of the loan applicant. The repayment term of the loan also can be changed to account for the borrower's economic situation. An increase in the loan term, as a rule, reduces the monthly cost of the loan more than a decrease in the interest rate does. A grant or DPL may be combined with a direct loan; that way the loan is made more affordable to the applicant because the grant (or DPL) is used to reduce the amount that must be borrowed. Financing terms for a retrofit loan ideally are structured to allow estimated monthly energy savings to exceed the monthly loan payment.

Wichita, Kansas, has been using CDBG monies to make 0%-interest loans for home weatherization measures (usually attic insulation) since 1976. Terms of the loans range from 6 to 24 months, depending on the borrower's income. The average loan is usually between $500 and $1,000. Over 6,000 loans have been made since the program was started.

Administering Grant and Direct Loan Programs. Administration of grants or loans for retrofits logically might be handled by an existing agency such as the community development department or housing rehabilitation office. This arrangement would take advantage of the existing staff, the administrative procedures, and the experience of these agencies in dealing with the expected clientele for the program and in making housing-related loans or grants. Whether an existing agency is used to administer the program will depend on its existing work load, the support that it may be expected to provide to the retrofit program, and the emphasis that the community wants to place on reducing energy consumption. In any event, existing agencies should be strongly encouraged to include conservation and solar considerations in their current operations even if they don't operate the local retrofit program.

If a new organization is required, a staff of up to six persons might be needed if the program was operated along the lines of a Section 312 property rehabilitation loan processing system (Gressel 1976, p. 31). Program staff would include a director, construction supervisor, financial specialist, and three secretaries to assist with the paperwork. This organization could handle about 60 loans per year. The loan volume could probably be increased under a retrofit program because the improvements that would be handled would be less extensive and of a smaller dollar amount than those for housing rehabilitation. This system would assume that legal matters will be handled by the city or county law department and that loan servicing will be handled on a contract basis with a local bank or firm specializing in this type of function.

Technical Assistance. The level of technical assistance that the local program will provide to property owners (or renters) is a key consideration for program organizers. The extent of technical assistance that is provided on planning, construction, and installation (work write-ups, selection of contractors, construction supervision) affects the dollar amount and number of loans that can be channeled into the community. The program organizers may feel that this additional expense is justified to make sure that the retrofits provide effective performance and that program funds are spent in an effective manner. In the final analysis, the success of the local program will be tied to the energy and dollar savings that are achieved. Technical assistance and community education may well be needed to attain that goal. This consideration is particularly important to low- and moderate-income households who, because of economic circumstances, *must* see a reasonable return on their investment.

On the other hand, program organizers may attempt to reduce technical assistance functions by relying on outside organizations, such as neighborhood groups, cooperatives, and contractor's organizations, in order to reduce program costs.

Loan Origination and Servicing. Another administrative consideration for the program will be how loans (or grants) will be made to applicants. Development of an origination and servicing capabiity can add to program administrative costs and reduce the amount of cash available for loans.

Many local housing rehabilitation programs are contracting with local banks to service their loans. This approach takes advantage of the bank's traditional expertise in this area and their ability to service the loans at a low cost because of the economies that result from the scale of their lending operations. The program simply pays a monthly fee to the bank, or other financial institution, to perform this function. Some programs have deposited their funds with the lenders and allowed them to loan out the funds subject to the criteria that program administrators specify. This deposit is referred to as a "linked deposit" (see the discussion in the "Deposits with Private Lending Institutions" section of this chapter).

Comments. Establishment of a grant and or direct loan program is an effective way to assist households in the community that cannot qualify for, nor afford, credit. It is also a way to provide financing in neighborhoods that private lenders would be reluctant to lend in. The outright grant is most effective in encouraging low-income renters to undertake energy-efficient retrofits. The deferred payment loan provides an alternative to the grant and can be effective in meeting the needs of low-income property owners (or businesses). An advantage of the approach is the fact that the program can regain its capital for additional loans when the property is sold or transferred.

The direct loan can be an effective way to address the needs of lower income households who have some ability to repay. It should be stressed that a direct loan approach could be used to assist any income group in the community. An attraction of the direct loan approach is the ability for the program to multiply its loan fund as borrowers repay their obligations. This multiplication enables the locality to increase the size of the loan fund gradually and ensures a long-term commitment to financing energy-efficient retrofits.

Administering a direct loan program and/or a grant program for low-income households will fall to the locality because of the income groups being served. The decision needs to be made whether an existing agency will run the program or if a new administrative framework will be established. If a new one is formed, efforts should be undertaken to evaluate the costs of providing technical assistance and loan servicing functions. The ability of the new program to make more loans in the community can be improved when these functions are handled by other organizations or firms.

Subsidies

Local Subsidies to Supplement Private Financing. The subsidy approach relies upon a payment by the local energy program to the borrower or lender, which reduces the cost of financing to a more affordable level. The subsidy approach is an appropriate means of assisting those households that can afford and qualify for conventional financing to cover at least part of the retrofit cost. Taking advantage of each property owner's ability to borrow some private capital is a most direct and effective means of leveraging the impact of public assistance.

The attractiveness of the subsidy approach lies in

- the simplicity of the approach,
- the willingness of private lenders to participate,
- the flexibility of assistance in relation to each owner's needs, and
- the highly visible and immediate leverage of public funds (Gressel 1976, p. 35).

Lenders generally find the subsidy approach attractive because they are allowed to earn their normal rate of return and use their normal credit standards. As a result, however, it is difficult to extend loans to households that can't qualify for conventional credit even at a reduced rate or to channel capital to neighborhoods where conventional credit normally has not been available. Consequently, the subsidy is more effective in reducing the cost of private financing than in increasing its availability. This problem can be dealt with if the locality is willing to establish a loan guarantee fund or if guarantees can be obtained from other sources to protect lenders against losses on defaulted loans.*

Subsidy Approaches. There are two approaches by which the subsidy can be applied. The ***principal reduction*** approach relies upon a grant by the local energy program to the borrower to reduce the amount that has to be borrowed from the lender at market rates. This reduces the monthly payment and in effect reduces the interest rate charged on the loan. The ***lender subsidy*** approach uses a payment directly to the financial institution to cover the difference between the market rate of interest and the rate that the local program wants to charge the property owner.

Principal Reduction Approach. In its simplest form, the principal reduction grant may be provided as a flat percentage of the cost of the improvements. The City of Seattle will be using this approach to finance conservation measures for households that have incomes at or below 80% of the SMSA median and that heat their homes with oil or natural gas (the municipally owned electric utility provides low-interest loans to those households that use electricity for heating). The City has obtained a $319,000 UDAG, which will be used to provide 15% grants to qualifying households. A 5-year repayment term is allowed. The practical effect of the grant is to reduce the 17% market rate of interest, which the private lender is charging, to around 9.75%.

The principal reduction method also has been used in a number of other ways by communities across the Nation to finance housing rehabilitation for moderate-income households. Holyoke, Massachusetts, relates the size of the grant to the income level of the household. A more complex formula has been used in Providence, Rhode Island, where the grant is determined by the size of the household, the income level, and housing costs. Providence also ensures that no qualifying household pays more than a 3% interest rate on the loan, which in effect turns part of the subsidy into an interest reduction grant, another form of principal reduction grant. Hoboken, New Jersey, and Westchester County, New York, use the interest reduction grant to provide 3% loans. The interest reduction grant is a useful tool because a program can vary the subsidy to attain any interest rate that may be desired. This could enable an energy retrofit program to vary the subsidy based on the income level of the recipient. Such an approach can result in a more efficient use of program funds.

Calculation of the interest reduction grant needed to reduce a conventional interest rate of 17% down to 8% is illustrated by the following example. A 5-year repayment term is used. The amount to be financed is $4,000.

Interest Reduction Calculation

(a) Find the required monthly payment on a $4,000, 5-year loan at an 8% interest rate. This amount would be $81. This is the amount that the borrower would actually pay.

(b) Determine how much that payment would borrow at 17% (assumed to be a typical market rate for a conventional loan). This is calculated by dividing $81 by the loan constant for a 17%, 5-year loan; $81/0.02485 = $3,260.

(c) Calculate the required subsidy. Because the amount that can be borrowed from the private lender is only $3,260, a grant of $740 must be provided to the borrower to cover the full $4,000. The grant amounts to around 19% of the total cost.

The amount of the grant provided to the property owner will be closely related to the interest rate and terms of the loan. Borrowers will want to obtain a longer term because this increases the percentage of the cost covered by the grant. For example, if the term were extended to 10 years on the loan mentioned above, the subsidy would increase to about 30% of the cost. In some cases, the program may want to limit this benefit by calculating the amount of the reduction grant based on a standard loan term, regardless of the term the borrower actually obtains. This, in effect, turns the interest reduction grant back into a flat percentage grant.

Lender Subsidy Approach. The *lender subsidy* represents an alternative to the principal reduction. Here, the subsidy is provided directly to the financial

*Hoboken, New Jersey, and Westchester County, New York, use principal reduction approaches as a means of reducing the costs of housing rehabilitation loans to property owners. Private lenders improve the security of their lending positions by obtaining FHA Title I Property Improvement Loan Insurance. This insurance guarantees that the lender will be reimbursed by FHA for 90% of the outstanding balance on defaulted loans.

institution in an amount to cover the difference between the market rate of interest and the effective rate charged to the borrower. The lender subsidy may be provided monthly over the life of the loan or in a lump-sum payment when the loan is made. The former approach will result in less leverage for the program because a higher percentage of the cost of the improvements will have to be subsidized.

The program may obtain more leverage by prepaying the interest subsidy at the time the loan is made. This payment is referred to as a *loan discount fee.* It represents the present value of the stream of payments that the program would otherwise make over the life of the loan. The advantage of prepaying the subsidy instead of making monthly payments is illustrated in the following examples. Once again a $4,000 loan is assumed for a 5-year term.

Monthly Subsidy Calculation

monthly payment at 17% interest	=	$99
monthly payment at 8% interest	=	$81
difference—monthly subsidy payment	=	$18
loan term in months	=	$60
product of 60 × $18—total subsidy over life of loan	=	$1,080

Over the life of the loan, the program will make $1,080 in interest subsidy payments, which represents about 27% of the amount of the loan. This percentage can be reduced where idle program funds are invested in a passbook savings account or perhaps a certificate of deposit with the lender. Interest earnings over the term of the loan will in effect reduce the dollar amount of the subsidy that is provided.

Prepaid Subsidy Calculation

monthly subsidy payment	=	$18
loan constant factor @ 17%	=	0.02485
$18/0.02485—loan discount fee	=	$740[a]

[a]The actual figure obtained is $724, but this is attributable to rounding an actual monthly payment of $18.37.

The lender will be willing to lend approximately $740 against a monthly payment of $18. This figure represents 19% of the dollar amount of the loan, the same percentage that is achieved under the principal reduction approach. A discount fee of $740 would thus be provided to the lender as an inducement to make the loan.

The advantage of prepaying the subsidy lies in the fact that the program, in effect, is investing its funds at an interest rate of 17% as opposed to 0%, or perhaps 5%, which is obtainable if the funds are placed in a time deposit with the lender. Under this approach, the local program ends up investing at 17% by not borrowing at 17%. The market rate of interest on consumer installment loans will always be higher than the rate offered on passbook accounts or certificates of deposit. This fact ensures that better leverage will always be obtained by the program when it prepays the interest subsidy.

Portland, Oregon, is currently using the prepaid lender subsidy to finance conservation retrofits by writing down conventional loans to an 8% interest rate. A $3.1 million UDAG is being used to provide a portion of the subsidy. The UDAG money, in the end, will be leveraged by $15 million in private investment. HUD has indicated that use of UDAG monies for lender subsidies will be discouraged in the future. This action was taken because of HUD's interest in seeing private capital committed directly without an "up front" subsidy. Principal reduction payments as used in Seattle are apparently acceptable to HUD at this time.*

Some housing rehabilitation programs originate loans themselves rather than paying an immediate cash discount to the lender. After a period of time, they sell the loan to the lender at a discount, providing the required level of subsidy in the process. Several rehabilitation loan programs make loans and then keep them in their portfolio for a year or more. During this time, the borrower establishes a record of payment, proving his or her financial stability. This record then enables the program to sell the loan to the private financial institution. This approach is used to qualify households that would ordinarily not be able to obtain conventional credit.

Differences Between the Principal Reduction Grant and Prepaid Lender Subsidy. The mathematical computation of the principal reduction grant and its practical effect is essentially the same as that for a prepaid lender subsidy (loan discount fee). They are different, however, because the principal reduction grant lowers the amount that the owner must borrow whereas the lender subsidy is used to prepay interest to the financial institution. Consequently, the owner will be liable for a larger amount of money under the interest subsidy than under the principal reduction grant. This consideration is not important when an owner takes the full term to repay the loan. It takes on significance when the borrower prepays the loan or defaults, however. The borrower gains an advantage under the principal reduction approach when the cost of the im-

*Conversation with Harvey Zeitel of HUD, June 1981.

provements increases the value of the property beyond the outstanding balance left on the energy loan. This occurrence will depend greatly on how the real estate market values energy investments. In any event, the borrower feasibly could take the additional cash realized from selling the property and convert it into personal gain. This situation can be avoided through the use of a deferred payment loan, however (see the discussion in the "Grants and Direct Loans" section of this chapter).

The lender may profit if the borrower prepays the loan when a locality uses a prepaid subsidy. This situation occurs because the lender is given an interest payment that covers the full term of the loan. Early repayment of the loan by the borrower in effect converts the unearned portion of the discount into a grant to the lender. This problem should be dealt with when entering into a contractual agreement with the lender. The agreement should specify that the unearned portion of the discount be returned to the local government or energy program when prepayment occurs.

Comments.

Advantages to the Local Energy Program. The advantages of subsidies can be attributed to several factors. The local energy program can leverage scarce public funds by using them to attract a larger amount of private capital with which to generate a large number of loans in a very short time. For example, $100,000 of program funds could generate 135 loans if the interest rate is written down from 17% to 8% on individual loans of $4,000 each with a 5-year term. By way of contrast, only 25 loans could be originated from these funds under a direct loan program. Thus, public funds are used to finance only a part of the improvement. The basic drawback of the subsidy is that this leveraging effect is only achieved once. Loans made under a direct loan program, on the other hand, will be recycled allowing a growing number of loans to be made over the years. The "one shot" nature of subsidies may be addressed in part by extending them in the form of deferred payment loans. The retrofit program could regain its capital outlays as properties were sold in the market. A recycling effect would be created as the funds that are returned are used to make more loans. The size of this effect would depend on the rate at which properties were sold or turned over in the local real estate market.

Program organizers will need to decide how the principal reduction or lender subsidy program will be run. For example, will the program provide technical assistance to the homeowner (or business)? A basic advantage of interest reduction methods is the ability of a local program to get private lenders to handle loan servicing and administration. The program is consequently relieved of this time consuming function, which also requires a budget allocation. Relief from this responsibility enables the retrofit program to get more money out into the community.

The support of local lenders for the program is fundamental to its success. *It is important to determine if lenders will be willing to participate, particularly if the loans are small ones.* Fixed administrative and servicing costs tend to make small loans unprofitable to them. Banks and savings and loan associations may want to keep loan terms short to keep the loans profitable; this can result in a high monthly cost to the borrower, which may make the retrofit measures unattractive. Program organizers will need to negotiate with the management of financial institutions to see what arrangements can be worked out.

Advantages to Lenders. Private financial institutions may find the subsidy approach attractive because they require no change in their regular underwriting procedures and they still receive a market rate of return. In addition to these benefits, the institutions are able to make loans that they formerly would not be able to make. This means a new source of business, which potentially may expand as households improve their economic status and seek financing for other credit needs in the future. Financial institutions may find the prepaid subsidy to be particularly attractive because they obtain immediate use of the interest subsidy for other investment purposes. This fact should be recognized by program organizers and used as a bargaining chip with lenders to gain concessions (for example, longer terms, lower interest rates, qualification of lower income households, and commitments to provide financing in particular neighborhoods).

Advantages to Borrowers. A subsidy can be structured to achieve any desired interest rate. The interest rate could be tied to the income of the borrower and could work to qualify virtually any household that has the credit standing to obtain some amount of conventional credit. The subsidy approach traditionally has been used to lower the cost of financing. It is not viewed as a particularly effective means of increasing credit availability to households with poor credit records and/or inadequate incomes or to neighborhoods that have had conventional credit restricted or denied to them. This problem may be addressed where loan guarantees are provided by the locality and/or where the lender can use FHA Title I insurance to cover possible losses. In many cases, lenders may still be reluctant to exend credit to some households and neighborhoods. Then a grant or direct loan program operated by the local government will be required to meet these needs.

Deposits With Private Lending Institutions

Local governments (or retrofit programs) might find it advantageous to make lump-sum deposits with local lenders. These deposits could be used to establish an insurance guarantee fund for the conventional loans that a bank or savings and loan association makes for energy retrofits or to obtain special underwriting concessions from lenders (for example, lower interest rates, longer repayment terms, or the provision of loans in particular neighborhoods or to certain income groups). A particular advantage of deposit programs is the fact that lending institutions will be assuming the responsibility of originating and servicing the loans. This enables the program to devote more time to other objectives (for example, audits, educational and outreach programs, or monitoring construction).

Loan Guarantee Programs. A loan guarantee program is useful where the locality wants to direct credit to individuals or neighborhoods in the city that normally would not qualify for this type of financing. To do this, the locality establishes a loan guarantee fund with participating local banks or savings and loan associations to cover all or part of their losses on loans that go into default. The guarantee may also reduce the interest rate that the lender has to charge the borrower depending on the extent of the guarantee and the terms under which the guarantee fund is deposited with the lender. The community may appropriate local monies or use Federal funds (CDBG) to establish the guarantee fund.

The Loan Guarantee. The loan guarantee operates in essentially the same way as FHA Title I insurance. The lender receives the full amount of the guaranteed or insured portion of the loan in the case of default. This payment usually is a percentage of the outstanding balance remaining on the defaulted loan. The amount of the payment to the lender is adjusted to account for proceeds realized from the sale of the property, if any. Alternatively, the lender may assign all rights to proceed against the borrower to the locality and receive full payment of the claim. The amounts that a lender can claim for lost interest, collection costs, and interest on claims until paid are subject to negotiation between the locality and the financial institution.

Establishment of the Guarantee Fund and Definition of Acceptable Risks. The amount that is deposited in the guarantee fund is determined by the risk factor associated with the loans that are to be made. The lender will want more coverage where there is a good probability of default. The likelihood that a loan will go into default depends on the credit standards that are agreed upon by the lender and the local energy program.

A basic tradeoff exists between increasing the risk level on loans that the local program will guarantee and reducing the leverage that it can get from guarantee funds. If the lender is permitted to accept only risks that are slightly higher than those on unguaranteed loans, more leverage can be obtained for the amount of program funds put on deposit. This approach could deny credit to individuals and neighborhoods within the community that are in the greatest need of financing, however. Alternatively, the acceptance by lenders of marginal loans requires a larger guarantee, reducing the leverage of program funds. It is essential that the program define what level of risk lenders are to accept when making loans. Attaining high leverage should not be a major goal of the loan guarantee approach. This consideration should be secondary to providing credit to households or neighborhoods that normally would not qualify for conventional credit.

Comments. The basic attraction of the guarantee is to expand the availability of credit in the community. Most lenders will not reduce the interest rate charged to borrowers because of the guarantee. Subsidies are more effective for that purpose.

We should point out that establishing a locally sponsored guarantee fund may simply duplicate the purposes of the FHA Title I Property Improvement Loan Insurance Program. Many lenders already use FHA insurance to improve the security of any property improvement loans that they make.* The FHA will reimburse private lenders for up to 90% of the balance on defaulted loans. Program organizers should evaluate whether a local guarantee program is needed in view of FHA's current activity in this area. A local guarantee may be required in some cases for higher risk loans because of the basic conservatism of FHA underwriting criteria, however. A local guarantee fund may be needed in communities where local financial institutions are not active in FHA-insured lending.

*Title I Insurance can be used for commercial and multifamily properties as well as for single-family units.

The City of Dallas established a loan guarantee fund with 28 local financial institutions to insure home improvement loans made on a city-wide basis. The City allocated $535,000 in CDBG monies to capitalize the fund. This provided the necessary support for a $4 million lending pool sponsored by the local banks and savings and loan associations. The lenders also reduced their conventional lending rate by two or more points depending on the type of loan (Ehrman 1978, p. 63).

Linked Deposits. A local government agency or perhaps the retrofit program could deposit funds with a local bank or savings and loan association and specify the purposes and terms under which they are lent out. Funds deposited in this manner may be used to provide interest subsidies to write down the cost of conventional financing or to establish a direct loan fund that can be used to extend low-cost financing. The locality may choose to earn maximum interest on the deposited funds and make a larger number of loans in the community. Alternatively, it may decide to reduce or eliminate interest earnings in return for special lending concessions from the financial institution. Under the latter approach, the lending institution should be able to extend virtually any interest rate that a retrofit program might specify because the institution is not paying for the funds (as it would if it were paying interest). This would permit a larger number of households to qualify for loans. The local program might also be able to get the lender to commit some of its funds in the loans that the program might make. This goes back to the subsidy approach that was discussed in the previous section.

The big advantage of the linked-deposit financing technique is the ability for the program to achieve its lending objectives while having the administrative details handled by a private financial institution. Another consideration is that the lender will be subject to the risk of default, not the local government or program.

A variation of the linked deposit is referrred to as "compensating balances." In this case, the locality or program establishes two accounts with the financial institution. One is interest bearing and is used to guarantee a stated percentage (for example, 90%) of the losses that the lender might incur because of defaulted loans. The second account can be used to make loans directly. It is also possible for the lender to use the second account for investment purposes with any interest earned retained by the lender; then loans for retrofits would be made with other funds that the institution has on deposit. A subsidized rate to the borrower can be achieved under both the direct loan and the investment approach. In the former, the lender, in effect, pays nothing for the money that is put on deposit and would be indifferent to the rate charged to a borrower. In the latter case, the investor may invest in treasury bills and tax-exempt securities, for example, and pass on some of the earnings to subsidize the interest rate on the retrofit loan. A compensating-balance financing technique may be required where the program wants to extend loans with a higher level of risk.

Credit Agreements with Private Lending Institutions

An alternative to subsidizing or guaranteeing loans made by private lenders is the establishment of a credit agreement with local banks or savings and loan associations. Under such an agreement, the local energy program would borrow funds from these financial institutions and make loans to property owners itself. The advantage of this financing approach lies in the local program's intermediary role in the disbursal of funds. The local program can use the tax-exempt borrowing status of the local government to borrow funds at below-market rates. This enables the locality to reduce the interest rate that it must charge to borrowers. The Portland Development Commission and the Minneapolis Community Development Agency have used the credit agreement to finance housing rehabilitation.

Private lenders may be attracted to credit agreements because of the tax-exempt status of interest paid by the local program to the particular institution and because of various guarantees that may be provided by the locality as additional security for the loans. This additional security (in addition to payments received on the loans) may be a cash reserve fund, an FHA loan insurance policy, or a moral obligation to reimburse the lender in the case of borrower default. These guarantees consequently eliminate the need for the local government to pledge its full faith and credit (taxing powers) to cover possible lender losses in case of borrower default.

Advantages of the Credit Agreement. The credit agreement with local lenders is attractive because of the legal benefits and the reduced interest cost. The ability of the locality to use its tax-exempt status, and in effect get the Federal government to pay part of the interest cost on its borrowings, permits a lower interest rate to be charged to borrowers. This rate may range between one-half and three-quarters of the rate charged on equivalent nonexempt financing (Gressel 1976, p. 66). The interest rate that is charged will be subject to the terms of the locality's credit agreement with the lender and to the general market conditions at the time.

A number of legal benefits are presented under a credit agreement with a private lender. For example, the credit agreement is useful in situations where state law prevents the local government from borrowing on a general obligation basis (see the "Bonds" section of this chapter). A locality may consequently extend the benefits of tax-exempt financing without violating state statutes. For the many counties and cities that do have the power to use general obligation bonds to finance their needs, the power is limited in general by the size of the tax base and the current level of indebtedness. The credit agreement consequently presents a local government with a way to avoid having to borrow in the market when its level of debt is already at the upper limit or where there are other pressing community needs that require bond financing. Proceeds obtained under a credit agreement do not apply to the debt limit. The credit agreement also can save the local government money because they avoid the flotation costs connected with issuing bonds. Finally, the issuance of general obligation bonds has to be approved by the voters in most cases. A credit agreement can get around the political controversy that surrounds most local bond elections.

Credit agreements with a local lender(s) work best when anticipated program capital needs are small (under $2 million or so) (Gressel 1976, p. 73). There are two reasons for this. First, local financial institutions may have only a limited ability to absorb tax-exempt investments. Second, the costs associated with floating bonds do not really justify issues in amounts under $2 million. A credit agreement is an effective way to capitalize the smaller amount needed for the retrofit program.

Operating Procedures. A credit agreement is most logically entered into with lenders that are sensitive to housing rehabilitation/energy issues and are capable of absorbing a large number of tax-exempt loans. The lender(s) may choose to advance funds to the local energy program in a lump sum or as each loan is made. In the former, the lender relies substantially on the judgment of program personnel to distribute funds in a manner that is consistent with agreed-upon credit standards. In the latter case, the lender reviews each loan in the program according to the standards (or an agent performs this function, generally another lending institution designated by lenders) and advances funds contingent on approval of the estimated risk level. Once the loans are closed, they may be serviced by the lender or the local program. This decision should be made on the basis of who can do it most efficiently and with the least expense.

Security for the Loans. The advances that lenders make under the credit agreement are secured by the loans that a local retrofit program makes. In general, the note for each property owner is transferred back to the lender or to an appointed agent. The advances also are secured by a guarantee fund that the locality is required to deposit with the lender. This fund is used to compensate lenders for the outstanding value and accrued interest on loans that go into default. Additional security for the advances may be based on any other guarantees that the locality (or public agency) may be required, or willing, to provide.

The credit standards applied under the credit agreement are those of the lender based on the subsidized interest rate. This enables more households to qualify for credit. Still, a large segment of the local population will be unable to obtain credit. This problem can be addressed in part by adjusting the amount of the guarantee fund. A higher amount can be deposited to cover the higher risk that the lender perceives in serving lower income households.

The program might also provide a subsidy to further reduce the subsidized rate. The Minneapolis Community Development Agency adopted this approach under its property rehabilitation program; it varied the interest rate according to the income level of the owner.

The use of a subsidy with funds obtained under a credit agreement is an especially effective use of public funds. This is true because the amount of the subsidy required to reduce the tax-exempt interest rate is less than that needed to reduce a conventional (nonexempt) one. Combining a subsidy with a credit agreement can greatly expand the scope of a local program. For example, assume that the local retrofit program wants to make loans available at 3% for a term of 5 years. The amount to be borrowed once again is $4,000. A subsidy at 28% of the loan

amount would have to be made to reduce a conventional property improvement loan rate (17%), whereas a subsidy of only 18% would be required on a tax-exempt rate of 11.5%.* Subsidizing a conventional lending rate would enable the local program to make 45 loans at 3%, whereas it could make 68 loans by subsidizing a tax-exempt rate of 11.5%, if we assume a loan subsidy fund of $50,000. A locality might also use the subsidy approach in conjunction with a tax-exempt bond issue.

Structuring the Agreement. The local program needs to address the following concerns that a lender might have about the credit agreement.

- The lenders must be assured that the interest is indeed tax-exempt and that security provisions have been made for the loan.
- *It must be established that the local government and the local program have the authority to enter into an agreement with the lender(s).* Many states don't permit local governments to give or lend money to assist private individuals, associations, companies, or corporations. This restriction is often relaxed where assistance is to be provided to the poor or the infirm.
- The lender must feel confident that the local program has the technical capabilities to process, evaluate, and service the loans adequately.

Administrative Alternatives. Most of the programs that are operating currently make the loans themselves. An alternative approach would be to use borrowed funds to purchase loans made by other financial institutions. The local program might also contract with local lenders to originate and service the loans. Both of these approaches work to reduce administrative costs.

Credit Agreement vs Loan Guarantee. The risk of loss to the lender under a credit agreement will be essentially the same as under a loan guarantee program. This assumes that the guarantee funds under the credit agreement are established with similar terms and conditions. The difference between the two is that, under a loan guarantee program, lenders are providing the loans, whereas under the credit agreement, the locality is providing them. The ability of a locality to make loans at a lower rate under the credit agreement suggests that this approach be used if at all possible.

Comments. The credit agreement is one way a locality can use its tax-exempt status to reduce the interest rate charged to households or businesses that must borrow to make energy improvements. The ability of a local government to take this approach will be affected by several considerations.

- The Mortgage Subsidy Bond Tax Act of 1980 will impose certain restrictions on any type of subsidized (tax-exempt) financing.
- The program personnel must be capable of processing, evaluating, and servicing the loans if they do the administering. The willingness of lenders to commit funds to newly formed energy programs may be limited because of the inexperience of these organizations. An existing community development or rehabilitation department that makes loans is more likely to be trusted by the lender.
- The legal considerations unique to each locality and state must be understood to enter into a credit agreements (lending-of-credit restrictions).
- The ability to use this financing approach ultimately depends upon the support of private lenders. It may be difficult in some cases to gain their cooperation.

Bonds

Provisions in the Federal Internal Revenue Code enable states and their designated subdivisions to issue tax-exempt bonds for certain activities, which are found (legally) to meet a public purpose. The Federal government doesn't tax the holder of the bond on the interest earned. This action enables the bond to carry a lower interest rate while meeting the holder's investment objectives. The acceptability of a lower interest rate in the market translates into a lower borrowing cost for the state or locality. The interest rate that a governmental body or public authority must pay on its bonded indebtedness will vary depending on bond market conditions. Tax-exempt rates as of this writing were around 10.5% to 11.5%, whereas conventional rates were approximately 16% to 17%.

Bond Financing at the Local Level. The power of a locality to issue bonds, the proceeds of which can be lent for energy-efficient retrofits, adds appreciably to its financing capabilities. The availability of CDBG and UDAG monies is limited because of Federal allocation formulas. The current political environment also points toward a reduction in the level of funding for these Federal grant programs. The control of localities over these funds also may be lessened if plans are carried out to transfer more authority over block grants to the states. Credit agreements with local lenders are another possible

*Residents of Baltimore are currently obtaining 11.5% weatherization loans from a $2 million general obligation bond issue.

means of obtaining capital for a local conservation and passive solar retrofit program. Financial institutions, however, are limited in the number of tax-exempt investments that they can have in their portfolios because of the need to maintain diversity in their asset bases.

Bonds provide local governments or public authorities with the power to go beyond locally restricted (lenders) or defined (Federal government grants) financing sources to obtain capital. Bonds enable the particular unit of government to access capital markets that are National in scope. It will make sense for the locality or its designated agent to enter the bond market only when the capital requirements for the program are high. This is due to the underwriting and legal costs associated with a local bond issue. The use of bonds will consequently make the most sense when the amount required is in excess of several million dollars (Gressel 1976, p. 73).

A number of legal and procedural issues surround the use of bonds. These will be unique to the type of bond and the particular legal environment of the state. An especially important legal consideration relates to the ability of the local unit of government to use bond funds to make loans to private individuals, businesses, or corporations. Another factor affecting the ability of a locality (or state) to use bond financing for conservation and/or passive solar retrofits is the Mortgage Subsidy Bond Tax Act of 1980. This bill places restrictions on the ability of states and localities to use tax-exempt bond proceeds for home mortgages to individuals or for other financing needs. The following sections cover these issues in detail.

Legal Considerations. The power to issue bonds refers to the power of the locality to incur debt. *It must be established initially that the bonds which are issued meet a public purpose.* Legal precedent has generally established that the issuance of bonds for the rehabilitation of owner-occupied dwelling units within a community will meet the public-purpose requirement. It is likely that bonds issued for energy-efficient improvements would receive similar approval because of the harsh impact that rising energy prices will have on household incomes and the importance that has been attached to reducing energy consumption by the National leadership. The use of bond proceeds to finance improvements on investor-owned, multifamily rented complexes, or commercial and industrial facilities, although permitted in some instances, are subject to greater restrictions because of public-purpose considerations, however.

A local government must also have express authorization to issue bonds. This authorization must be specifically delineated or necessarily implied by the state. Many local communities may be prevented on this basis from issuing bonds.

The ability of a local government to issue bonds, if it is given the power, is subject to certain limitations. Some of these limitations are related to the type of the bond being issued; others affect all bond issues. These limitations must be understood by the locality before bonds are offered in the market. The following sections present brief examinations of the types of bonds that a locality might consider using to finance conservation and/or solar improvements. The particular attributes, advantages, and disadvantages of general obligation, industrial development, mortgage revenue, and assessment bonds are considered.

General Obligation Bonds. General obligation bonds (GOs) are perhaps the most flexible and least costly of all of the public borrowing methods. These features are attributable to the legal nature of the bonds. GOs must be backed by the full faith and credit of the issuing entity, and they must also be supported by the state or local taxing power. The combination of both of these traits is essential to the classification of the bonds as GOs. The issuing entity's promise to pay and reliance upon general tax revenues to support the issue greatly reduce the level of risk to the investor. This reduction in risk consequently enables GOs to be issued at a lower interest rate (relative to other types of bonds), reducing borrowing costs. Legal and administrative costs associated with the issue also can be reduced because there is no need to structure elaborate guarantees and establish special reserve funds.

Debt limitations of the locality constitute the primary restriction on the issuance of GOs. Limitations on the amount of debt that a locality can incur are stated by statute or in the charter. These limitations generally are expressed in one of three forms: a general limit on the indebtedness of the locality, a specific limit on the amount of bonded indebtedness, or a specific limit on the amount of indebtedness that a locality can incur for a specific purpose. Also, limitations on bonded indebtedness may be based on the assessed valuation of properties located in a city or county or on the amount of tax revenues that are collected.

In addition to debt considerations, a locality may be prevented from using GOs to finance conservation and solar improvements because of "lending-of-credit" prohibitions. Usually these are imposed by the state government and limit the ability of local governments to use their bonding powers to borrow money that will be lent out to private individuals, businesses, or corporations. The use of GOs also is subject to voter approval in most localities. The approval process can add to the time of putting an issue together or, depending on the mood of the electorate, can halt the use of the bonds altogether.

The City of Baltimore recently approved a $2 million GO bond issue to finance energy conservation measures (solar applications are eligible). Loans are available to residents at an 11.5% interest rate for a term of 7 years. Amounts between $500 and $3,500 can be financed. A $30,000 ceiling is placed on the applicant income. The City has worked out an arrangement whereby local financial institutions originate the energy loans. A commitment agreement between the financial institution and the City specifies the amount of the bond proceeds that the banks or savings and loan associations can lend out over 6 months. The City purchases the loan package from the lenders at that time, paying them face value on the loans plus 30-days simple interest. The lenders' costs are covered by a $50 origination fee and a servicing fee of 1% of the total amount of the loan, both of which are paid by the borrower. After the loans are purchased, the City continues to pay the lending institution a servicing fee of 1% of the unpaid balance on the loans each year. Plans are under way to issue another $3 million in bonds to expand the scope of the program.

Industrial Revenue Bonds. Revenue bonds are obligations of a government entity, which are payable from the revenues of the project(s) financed by the issue. They don't require a pledge of the full faith and credit of the locality (pledge of taxes for repayment) and consequently are not affected by the debt limitations of the locality under most circumstances. Payment for the facility or improvement financed by the bond(s) is secured from the user or beneficiaries rather than the taxpayers at large.

One type of revenue bond is the industrial revenue bond [also called the industrial development bond (IDB)]. An IDB may be defined as an obligation that is part of an issue in which all or a major portion of the proceeds are used directly or indirectly in any trade or business carried on by any person who is not an exempt person. An exempt person is defined by Section 103(b)(3) of the Internal Revenue Code as either a governmental unit or an organization described in Section 501(c)(3) of the Code (White 1980, p. 26).

The statutory definition of the IDB is based on two tests. First, the payment of the principal and interest on the bonds must be secured by or derived from some interest in property that is used in a trade or business (security interest test), and second, the major portion of the bond proceeds must be used in the trade or business of a nonexempt person (the trade or business test). If an issue meets both of these requirements, it will be classified as an IDB. Section 103(b) of the Code states that the interest on an IDB is *not exempt* from Federal income taxation because it is not treated as an obligation of a political subdivision or of a state (White 1980, p.26). The interest would be tax exempt where the bond qualifies under one of the special activities exemptions provided by Section 103(b)(4) of the Code or under the small-issue exemption provided by Section 103(b)(6).

The advantage of bond financing relates to the ability of the local government to pass on a lower interest rate to the borrower. Consequently, it is important to define those situations under which a bond might lose its tax-exempt status because of its classification as an IDB. This will occur when the issue meets both of the tests that have been set down in IRS regulations.

The security interest test is extremely broad, and it is likely that most obligations would meet its provisions. The fundamental concern thus lies in the qualification of the bond under the trade or business test.

Application of the Trade or Business Test. A bond will qualify under the trade or business test if it is established that most of the bonds (25% or more) are used in the trade or business of a nonexempt person. This section examines the potential qualification under this test of bonds extended to finance single-family residences, condominiums and cooperatives, multifamily rental buildings or complexes, and commercial and industrial buildings.

- *Single-Family Residences.* Provisions of bond financing for energy-efficient improvements for a single-family residence (defined as one to four units) will not qualify as an IDB as long as the owner lives on the premises. A problem would arise where bond proceeds were used to finance energy improvements on single-family rental properties in which the owner did not occupy at least one unit. In this case, the owner would be using the proceeds in his or her trade or business. Problems also might arise where the borrower uses a room in the residence as an office. This situation would probably occur infrequently and the tax-exempt nature of the bond would be upset only if 25% or more of the bond proceeds went to such properties.
- *Condominiums and Cooperatives.* Installation of conservation or solar improvements in a condominim cooperative should not cause a problem with the business or trade test. In this case, the improvements would provide a benefit to all of the residents of the building. A problem could arise where the bond proceeds are used to provide the improvement through a management organization. It could be argued that funds were being used in the trade or

business of the management in operating the building. Problems also could arise where more than 25% of the building's occupants use the units therein for business purposes. If there are retail or commercial establishments in the buildings whose combined floor area exceeds 25% of the total floor area, the trade or business test would again be met.

- *Multifamily Residential Buildings.* Providing conservation and solar improvements to rental complexes clearly would meet the test because the proceeds would be used by the investor/owner for business purposes. This assumes that the security interest test is also met.
- *Commercial and Industrial Buildings.* Providing bond proceeds to install, lease, or finance conservation and solar improvements for nonresidential buildings owned by investors would meet the trade or business test. Consequently, the bonds would lose their tax-exempt status because they would be classified as IDBs.

Special Activities Exemptions. If the bond meets the definitions of an IDB under the security interest and trade or business tests, it may still achieve tax-exempt status if it can qualify under a special activity exemption. Section 103(b)(4) provides an exemption where bond proceeds are used for

- residential real property for family units;
- sports facilities;
- convention or trade show facilities;
- airports, docks, wharves, mass commuting facilities, or storage or training facilities related to any of the foregoing;
- sewage or solid waste disposal facilities or facilities to supply gas or electricity locally;
- air or water pollution control facilities;
- facilities designed to furnish water, if available, on reasonable demand to members of the general public (White, 1980, p. 31).

The only exemption relevant to this sourcebook is the one that applies to providing residential real property for family units. Qualification under this exemption requires the improvement be supplied as a "family unit." A family unit is defined as a building or any portion thereof that contains complete living facilities that are to be used on other than a transient basis by one or more persons and facilities functionally related and subordinate thereto.

This exemption could be used to build a large rental building or complex (single-family or multifamily) that incorporates conservation and passive or active solar features. Recent amendments to this special exception under the Mortgage Subsidy Bond Tax Act of 1980 (PL 96-499) require that proceeds obtained under a tax-exempt issue be used for those multifamily rental projects in which at least 20% of the units are to be occupied by residents of low and moderate income for the term of the bonds. In areas of chronic economic distress, at least 15% of the residents must earn low or moderate incomes (see the Mortgage Subsidy Bond Tax Act of 1980, Section 1103).

A building also may be rehabilitated with bond proceeds as long as the previously mentioned requirements are met. Conservation and passive solar measures probably could be included as part of the rehabilitation. Financing conservation and passive solar measures alone probably would not be allowed. IRS regulations emphasize that the special exemption is applicable only when the improvement is supplied as a family unit. Providing improvements that are functionally related and subordinate to the family unit (for example, a conservation or passive solar measure) without providing the family unit itself probably would result in the bond losing its tax-exempt status (White 1980, p. 36).

Small-Issue Exemption. Section 103(b)(6) of the Code, or the small-issue exemption, possibly could be used to provide tax-exempt bond proceeds to multifamily residential rental projects and commercial or industrial enterprises. Here, the proceeds must be used for the acquisition, construction, reconstruction, or improvement of land or property where those improvements are subject to an allowance for depreciation under Section 167 of the Code. An exempt small issue is defined as one of $1 million or less. The $1 million limit must account for the face amount of the new bond issue and the face amount of other outstanding small exempt issues that were extended in the county or city.

The local government unit may decide to increase the $1 million limit to $10 million pursuant to Section 103(b)(6)(D) of the Code (White 1980, p. 34). The aggregation rule, which applies toward the $1 million limit, must also be referred to in this case. It is also necessary that the local government consider the capital expenditures made by the principal user of the facility or individual firms related to that user during the 3 years before and after the issuance of the bonds toward the $10 million limit. Violation of the $10 million limit within this 6-year period would result in the bonds losing their tax-exempt status.

Mortgage Revenue Bonds. Mortgage revenue bonds constitute another form of the revenue bond. The bonds are secured by payments from the facility or property financed and a mortgage that is placed thereon. In case of borrower default, the investor can foreclose on the property through an appointed trustee. This consideration contributes to the security, and thus the marketability, of these issues.

Revenue bonds have been used most often to finance home purchases for residents of the particular issuing entity (state or locality). Bonds also have been used in a number of states to rehabilitate housing and commercial properties. In general, the bonds are issued by state housing finance agencies or locally sponsored nonprofit housing corporations. This is done to limit the particular governmental unit's legal responsibility in cases of default. Issuing agencies take full responsibility for the legal and administrative aspects of the program. A reserve fund, based on a stated percentage of the bond proceeds, generally is established to take care of any defaulted loans, providing assurances to investors in the process.

FHA Title I Property Improvement Loan Insurance. An effective way to increase the availability of financing for small properties is accomplished through the use of FHA Title I Property Improvement Loan Insurance. The FHA will pay the lender (bank, savings and loan association, or public agency) 90% of the outstanding balance on loans that go into default. Title I guarantees have most often been used by private lenders (banks and savings and loan associations) to protect themselves against possible losses on the property improvement loans that they make. Governmental agencies (housing finance agencies or urban redevelopment authorities) may also be certified as approved FHA lenders. In this case, the Federal guarantee can be used to back revenue bonds that the state or local unit of government may wish to issue for the rehabilitation of small commercial or residential properties.* Issuing agencies use this guarantee to turn individual rehabilitation loans into marketable securities with known risk and value. Consequently, investors are assured that the loss on any one rehabilitation loan will be limited to the extent of the FHA guarantee. Minnesota, Wisconsin, Michigan, Tennessee, California, and Connecticut have obtained certification under the FHA as approved lenders. The Pittsburgh Urban Renewal Agency and the Redevelopment Authority of Allegheny County (the county surrounding Pittsburgh) represent local governmental entities that have obtained FHA certification.

FHA Title I regulations currently permit loans of up to $15,000 to owners and tenants (their lease must run at least 6 months beyond the term of the loan) of one- to two-unit residential or commercial structures. Where there are two or more units in the structure, a limit of $37,500 is enforced ($7,500/unit). A maximum repayment term of 15 years is permitted. Eligibility for Title I loans is generally based on the credit worthiness of the applicant as opposed to the appraised value of the property to be improved. Liens on the property are only required when the amount of the loan exceeds $7,500. This security can fall in line behind existing claims on the property. Filing of the lien does not require that a formal property appraisal and title search with the attendant costs be conducted, unless required by state law.

Conservation and solar energy improvements are eligible for FHA Title I financing. Greenhouses are not covered by current regulations, however. As of June 30, 1978, the Minnesota Housing Finance Agency had extended $64 million in loans. Of the first $50 million, $7.7 million, or approximately 16%, was devoted to energy-related improvements (Ehrman 1980b, p. 19).

In order for the governmental unit to be certified as an FHA lender, it must possess the legal power to conduct an installment lending operation. Many local governments are prevented by state law or local statute from lending their credit (funds obtained by borrowing). This consideration poses a particularly difficult legal problem for those governmental units wishing to use the FHA guarantee to issue bonds.

Even if the local unit of government can obtain certification as an FHA lender, it may be necessary to provide further assurances to bond investors as to the security of the issue. This can be accomplished by establishing a loan loss reserve fund, providing bondholders with additional protection against the 10% amount of the loan that is not covered by the FHA guarantee. The Minnesota Housing Finance Agency established a reserve fund that includes an amount equal to 25% of the uninsured portion of all the possible housing rehabilitation loans that the agency could possibly make. This fund was established through an appropriation by the State. Local governments could establish a fund with revenue sharing monies, or a local appropriation. The experience of the Minnesota Housing Finance Agency and many cities under loan guarantee programs suggests that this reserve fund need not cover the full 10%. If a local appropriation is used, it will have to be legally established that the community has the power to guarantee loans to individuals or businesses.

The attraction of the FHA guarantee should be examined in light of the restrictions that it may impose. FHA regulations require the lender to use the normal prudent underwriting criteria. The major

*The use of the FHA guarantee may enable localities (or states) to circumvent legal restrictions (for example, lending ceilings, terms, and neighborhoods ineligible for loans) imposed on bonds issued by state or local agencies. FHA-insured loans introduce some flexibility into the lending activities of issuing agencies.

consideration is the credit standing of the borrower. This means that current income sources and debt obligations will be examined because they affect the ability of the borrower to pay on the loan. Such criteria can end up disqualifying many low- and moderate-income households. In general, FHA Title I guarantees alone do not provide funding to individuals or properties that would not normally qualify for loans under conventional underwriting criteria.

The tax-exempt nature of the FHA-backed bonds significantly reduces the interest rate that must be charged to borrowers. This works to qualify households that would normally not be able to receive credit from conventional lenders at today's higher rates and shorter terms. The Minnesota Housing Finance Agency and the Pittsburgh Urban Renewal Agency attempt to qualify more applicants by providing subsidies to lower the interest rate even further. This reduced rate is tied to the income level of the applicant. In Minnesota, State monies are used for this purpose; in Pittsburgh, CDBG funds are used. Reducing the Federally subsidized interest rate on the revenue bonds is advantageous, because less public money is required to reduce the interest rate to the desired level (as opposed to the amount that would be required to subsidize a conventional loan interest rate).

Implications of the Mortgage Subsidy Bond Tax Act of 1980. Enactment of the Mortgage Subsidy Bond Tax Act of 1980 limits the ability of state or local governments to issue revenue bonds where the proceeds will be used directly or indirectly for mortgages on owner-occupied residences or for other financing. "Other financing" may be interpreted to mean property improvement loans. The major purpose of this legislation is to restrict growing revenue losses from the US Treasury because of the issuance of mortgage revenue bonds by state and local governments designed to assist the financing of homes for households residing in their political jurisdictions. The Act also ends up reducing financing assistance for housing rehabilitation and energy loans in the process.

The following considerations could affect loans made for energy improvements.

- A qualified property improvement loan under provisions of the Act is defined to mean financing (whether or not secured by a mortgage) that doesn't exceed $15,000. Guidelines determining the eligibility of improvements would be the same as under the FHA Title I program. Energy conservation and solar improvements would be covered.
- Financing must be provided only for single-family residences that can reasonably be expected to become the principal residence of the mortgagor. A single-family residence may include up to four units as long as one unit is occupied by the owner. Residences must be located within the jurisdiction of the issuing authority.
- A ceiling on the amount of bonds issued, which is the greater of 9% of the average of all the mortgages issued in the state in the preceding 3 years or $200 million, is established. This ceiling shall apply to any calendar year in which bonds are issued. Allocation of the ceiling between state housing finance agencies and local authorities with the power to issue bonds is essentially 50/50, unless some other allocation is established by the governor and/or state legislature. This limits the number of loans that could be extended in the state.
- At least 20% of the bond proceeds must be targeted with reasonable diligence toward providing owner financing in designated low- and moderate-income areas for at least 1 year after the proceeds of the bond issue are first made available.
- An issue will meet the requirements of the Act only if it meets arbitrage requirements. In this instance, the effective rate or mortgage rate cannot exceed the bond yield by more than 1%. This requirement severely impairs the ability of states and localities to issue bonds because the spread is not sufficient in many cases to cover the administrative expenses associated with the issue. Consequently, public agencies must look for additional funds to cover expenses (this may be subject to legal questions), or they may not be able to issue the bonds at all.
- No qualified mortgage bonds (financing) will be permitted after December 31, 1983.

Comments. Issuance of mortgage bonds by a state or local housing agency and/or use of mortgage bonds backed by the FHA Title I guarantee present attractive approaches to providing affordable financing to residents of a state, county, or city. Provisions of the Mortgage Subsidy Bond Tax Act will constrain the ability of localities to employ these approaches, however. First, arbitrage restrictions jeopardize the ability of any governmental unit to make a bond issue workable. Second, bonds qualify under the Act only if the proceeds are used for owner-occupied dwellings of four units or less. Multifamily units may also qualify when 20% of the residents have low or moderate incomes. Backing for commercial buildings is apparently eliminated.

Third, state ceilings will limit the amount of subsidized financing that can be extended. This restriction has already been a problem in Minnesota. Local housing authorities in St. Paul and Minneapolis are attempting to use their bonding power to establish an energy bank, whereas the Minnesota Housing Finance Agency wanted to obtain money to provide low-interest home mortgages (Morris 1981, p. 8). Finally, after December 31, 1983, the use of tax-exempt housing revenue bonds for any purpose would apparently be eliminated completely, unless the Act is amended before that date by Federal legislation.

Assessment Bonds. An assessment bond is used to finance special improvements within a designated area. The bond is retired through the levy of a special tax within the area receiving the benefit. Assessment bond financing conceivably could be used to finance conservation and/or solar improvements on a neighborhood or city-wide scale.

To qualify as an assessment bond, an issue usually must meet two main criteria. First, the improvement must provide a benefit to the public at large. Therefore, the public, acting through its government, could carry out the improvement without obtaining the consent of the individuals involved. Second, the improvement must extend a particular benefit to the properties that are being assessed to pay for the improvement. This benefit may be actually or presumptively received but if the improvement does not confer this special benefit, it may be assumed that the improvement is public in nature and could thus be supported by the general taxing powers of the local government. If the improvement benefits only the general public, the assessment will be invalidated. Determination of the special benefit usually is based on the notion that the value of the property will be increased because of the provision of the improvements.

Uses. Assessment bonds have generally been used to construct physical improvements such as streets, gutters, curbs, sidewalks, sewers, and parking lots. They have also been used in business districts to provide the same physical improvements as well as to finance items that improve the aesthetic environment of the area (bus shelters, trees, benches, etc.). Assessment bonds might be used to finance some solar or conservation improvements depending on the relevant state statutes. The assessment approach might be particularly relevant to neighborhood-scale systems (for example, solar ponds, district heating, or photovoltaic arrays for electricity generation). A general benefit to the community might logically result (reduced energy usage), and these improvements could be carried out without the express consent of any one individual, thus meeting the general public-purpose requirement. The facilities undoubtedly would confer a special benefit on the assessment district. It would have to be established that the improvements enhance the value of properties in the area to provide an economic basis for the assessment.

Installation of conservation or passive solar applications on individual houses may be more difficult to justify from a legal standpoint. Adoption of energy-efficient improvements would have to be defined as meeting the public purpose. It would then have to be established that the provision of what are essentially private improvements could, in fact, be compelled by the locality without the consent of the owner. This will likely prove difficult from both a legal and political standpoint. Relevant local statutes should be checked on this matter.

Private

Financial Institutions

Commercial banks, savings and loan associations, savings banks, credit unions, and mortgage banking firms can and should play a major role in local financing programs for conservation and solar technologies. The participation of private lenders in a local energy program is desirable in view of cutbacks that can be expected in Federal funding programs and fiscal pressures that currently constrain local government budgets. The ability of a local energy program to tap the considerable resources and particular skills of the private sector can greatly expand the level of financial assistance available in the community. The lending expertise of financial institutions can also be used to reduce the administrative burdens for energy programs where public/private lending partnerships are established. In the process, administrative and economic costs to the local energy program can be reduced. The support of private lenders for a local energy program is critical, particularly in today's economy. Program organizers should make a strong effort to determine appropriate roles for local lenders.

Securing the Support of Local Lenders. Program organizers should first take steps to educate the officials of local lending institutions about the potential benefits to their institutions of a local energy program. These benefits can take the following forms.

- *Improving the Security of Existing Mortgage Loans.* An energy conservation and/or solar retrofit lending program will assist local property owners in reducing their energy costs. Expected increases in energy costs through deregulation can be expected to add appreciably to the utility bills of homeowners, landlords, and business owners. A Minneapolis, Minnesota, study suggests that annual energy costs may exceed the annual mortgage costs of many homeowners across the Nation by 1983 (Lambert 1980). Such a development will place severe strains on household budgets and adversely affect the ability of many households (and businesses) to make the payments on their mortgage obligations. This will be a particular problem for low- and moderate-income households. Additionally, owners of master-metered multifamily buildings may just walk away from their buildings when rising energy costs cannot be recouped through increased rents. This situation places further stresses on the stability of older neighborhoods. Providing affordable energy financing now, in a coordinated manner, will reduce present energy costs and result in lower energy costs in the future. Reduced energy costs improve the security of loans that lenders have made in the past.

- *Increasing the Volume of Loans in the Community.* Lender support and participation in a local energy program can result in additional business. A coordinated and well-marketed energy retrofit program through cooperative efforts between the local program and lenders can generate new opportunities for conventional property improvement loans. The willingness of local lenders to participate in local subsidies, loan guarantees, credit agreements, bond programs, or other publicly sponsored lending efforts presents additional opportunities to the lender. In most instances, the lender will be able to earn a market rate of return (or a lower rate that is tax exempt) and employ the usual underwriting criteria. The lender can reduce the risk through the use of FHA insurance. These considerations enable the lender to make loans to a segment of the local market that it normally would not be able to serve, thus opening up a new source of business. A social goal is met in the process by helping many low- and moderate-income households and small businesses that are most in need of protection against rising energy bills.

- *Considerations of Local Economic Health.* Increasing conventional energy costs will promote transfers of wealth out of the community. Lessened community income translates into declining demand for local goods and services and threatens the ability of the local government to meet the needs of residents. The potential for a declining local economy will clearly affect the profitable operations of local lending institutions. Deposit growth may slow or even decrease, and demand for loans may decrease because of the increasingly precarious financial positions of residents and businesses. Consequently, participation in the local energy program not only generates business now, but also can help ensure the financial viability of the community in the future.

- *Civic Responsibility and Social Concerns.* Lenders may also be interested in supporting a local energy retrofit program because they feel it is their civic responsibility. This certainly has been an underlying motive for many lenders that have participated in housing rehabilitation efforts with community housing rehabilitation agencies (Ehrman 1980a). This sense of civic responsibility for banks and savings and loan associations has been strengthened by the mandates of the Community Reinvestment Act (CRA). The CRA requires Federal financial institution regulatory agencies to assess how well private lenders under their jurisdiction meet the credit needs of the communities that they serve. The CRA particularly emphasizes lender efforts designed to assess and meet the credit needs of low- and moderate-income households. The civic record of the lender is taken into account by the regulatory agency in its evaluation of the institution's application for new deposit facilities. CRA responsibilities also

will constitute an ongoing concern for regulatory agencies during periodic examination of lending institution operations. Thus, banks and savings and loan associations must always be sensitive to their CRA responsibilities.

Evaluative criteria of the CRA stress the desirability of cooperative financing arrangements with local governments that promote community revitalization and economic development, particularly in low- and moderate-income neighborhoods. Lender participation in a local energy program that addresses the needs of the community could greatly assist the lender in obtaining a favorable CRA rating.

The Federal Home Loan Bank Board (FHLBB) has sought to promote innovative lending policies among the Nation's savings and loan associations to meet local credit needs, particularly in low- and moderate-income neighborhoods. It has established a $10 billion Community Investment Fund (CIF) to be distributed between 1978 and 1983 to further this goal. The FHLBB will extend low-cost advances, which may be up to 0.5% lower than regular loans, to member associations to reward innovative lending programs. Lenders may retain the savings or pass them on to borrowers. Development of, or participation in, innovative lending strategies for energy retrofits may qualify lenders for these special advances.

Lender participation in an energy financing program to address a civic responsibility has another advantage. Public recognition of the lender's efforts may contribute to the positive image of the institution in the community. This can mean additional business to the lender in the future when residents need credit for other needs.

Types of Lenders.

Commercial Banks. Commercial banks are sometimes referred to as the "department stores" of the financial community because of the broad range of financial services that they offer (Ehrman 1980b, p. 13). They will provide interim construction financing for large-scale new development and rehabilitation projects, residential and commercial mortgages, and business and property improvement loans. Banks historically have been the major source of property improvement loans. Banks also are increasing their activities in longer term lending (first mortgages) because of recent Federal actions designed to deregulate the lending industry.

Savings Banks. Mutual savings banks currently are licensed in 18 states, primarily in the New England and in the mid-Atlantic regions. Most of them are located in New York, Massachusetts, and Connecticut. Savings banks invest a large percentage of their assets in real estate, mainly in first mortgages for one- to four-unit properties.

A number of these lenders are becoming more active in making property improvement loans. These lenders may also extend commercial mortgages on investor-owned multiunit buildings and to business property owners.

Savings and Loan Associations. Savings and loan associations historically have concentrated their efforts in extending first mortgage loans on one- to four-unit residential properties. In many cases, savings and loan associations have extended second mortgages for property improvements. Savings and loan associations do not make commercial loans and only recently have begun to become active in extending shorter term property improvement loans. Again, this indicates deregulatory trends within the lending industry.

Credit Unions. Credit unions are actually financial cooperatives. Nationally there are 22,500 credit unions with total assets of $54 billion. These are small lenders, in general; 70% of them have assets of less than $1 million. Credit unions were the fastest growing type of financial institution during the 1970s, doubling their asset base during that decade (Ehrman 1980a, p. 15).

The fact that credit unions are organized as cooperatives (nonprofit) means that depositors earn high interest rates on savings accounts and that interest rates on loans are lower. If surplus funds exist at the end of the year, they are distributed to members in the form of additional interest on savings or as rebates on loans. Approximately 85% of credit union investments are in consumer loans, of which property improvement loans constitute a large percentage. Credit unions are generally more willing to service smaller loans than private lenders are because of their nonprofit nature. This may be advantageous for energy improvements where some loans are likely to be below $2,000.

Typically, credit unions have been established at a place of work to serve the needs of employees. They have also been established to serve the needs of particular neighborhoods. Credit unions consequently serve the needs of special groups as opposed to a wider segment of the local population.

Changing Private Lender Roles. Deregulation of lending institution roles by Congress is beginning to blur the distinction between the traditional lending operations of banks and savings and loan associations. The traditional long-term investment orientation of savings and loan associations (first mortgage investment) and the shorter one of banks (property improvement loans and construction financing) are changing as each institution begins to pursue new lending strategies. These changes may present unique opportunities to energy program organizers. For example, savings and loan associations may be particularly interested in participating in a short-term loan program in which the local program provides a subsidy to the lender to ensure that a market rate of return is earned on the loan. The savings and loan association also might be interested in receiving lump-sum deposits from the local program with which it would make shorter term loans (5 to 6 years) under mutually agreed on criteria. The interest of the savings and loan association in such agreements would stem from the desire of management to gain experience in short-term lending and to show community residents in a dramatic fashion that it was willing and able to meet their short-term financing needs.

Types of Credit. The financing needs of homeowners and landlords can be met through first mortgages, second mortgages, and property improvement loans. The needs of commercial businesses also may be met by these types of loans.

First Mortgages. The first mortgage is used most often to finance the initial sale of a property. It also can be used to finance energy retrofits either at the time of sale or through refinancing.

The financing of conservation and/or solar retrofits at the time of sale has definite advantages because the first mortgage has a longer term (25 to 30 years) and lower interest rate (2% to 3% lower) than does the second mortgage or property improvement loan. For example, the monthly cost of financing an extra $2,000 for energy conservation measures under a first mortgage with a term of 30 years and a 15% interest rate would be about $25.00. Financing the improvements under a 3-year property improvement loan with an interest rate of 17% would, on the other hand, require a monthly payment of around $100.00. Clearly, it is advantageous for the property owner to finance with the first mortgage because the monthly expense is less and it is very likely that monthly energy savings (in dollars) will exceed the portion of the mortgage payment that is attributable to the energy improvements.

Nationally, about 6% of the residential housing units are sold annually (Andreassi 1977). Encouragement of energy retrofits at the local level at the time of sale could result in significant upgrading in the energy efficiency of the existing buildings. In Albuquerque, New Mexico, a 6% turnover rate would imply a potential of 5,200 retrofits for 1980. Of course, the rate of housing turnover will vary with location.

The Federal Home Loan Mortgage Corporation (FHLMC) will permit financial institutions from which it purchases mortgages to add $2,000-$3,000 to conventional home mortgages for energy improvements. The traditional borrower-income consideration that applicants must meet, in which no more than 25% to 28% of gross income can be devoted to the house payment, is waived. The loan-to-value ratio, which is generally 80%, also is modified. These changes in FHLMC procedures recognize that rising energy prices can only adversely affect the economic positions of property owners and that it is desirable to improve the energy efficiency of the property to protect the security of the loan. FHLMC policy also suggests that energy improvements will be fully valued by the market. Midland Savings (Des Moines, Iowa) has adopted the FHLMC philosophy and allows borrowers to add up to $2,000 to their mortgages for cost-effective conservation improvements.

A number of other lending institutions have reduced the interest rates on first mortgage loans when the borrower purchases an energy-efficient home. These reductions typically will range between 0.25% and 0.50%. A 0.5% reduction on a 15%, 30-year, $60,000 mortgage would save the borrower about $23 per month ($758 down to $735) or $266 during a year. This reduction, in conjunction with the potential energy savings, adds to the economic attraction of purchasing an energy-efficient home. Providing lowered interest rates on first mortgages is a good promotional tool for local lenders and emphasizes the importance of energy efficiency to community residents in the process. The willingness of local financial institutions to signify their support of energy efficiency can add appreciably to the credibility of the local program.

First mortgages may also be refinanced for conservation and/or solar retrofits where the property owner has paid off enough of the original loan. Few property owners would choose to refinance at today's interest rates, which may greatly exceed their original mortgage interest rate. Any savings realized from a more energy-efficient property would likely be absorbed by the higher house payment initially. If the borrower remained in the home for a long time, he or she would probably realize savings over the long run because of increases in energy prices, however.

San Diego Federal Savings and Loan (California) has developed a unique financing program designed to counter the problem of refinancing in a time of high interest rates. Instead of refinancing the mortgage, the owner is allowed to obtain a special advance of up to $3,000 on his or her existing mortgage to finance an approved solar domestic hot water system. The loan is extended at current residential mortgage prime rates and the interest rate on the existing mortgage is modified to take the additional cost into consideration. This raises the mortgage rate slightly. San Diego Federal will then recast the loan at 30 years if the borrower chooses, resulting in a monthly payment that is equal to or only slightly higher than the payment that the borrower was originally making. The mortgagee can finance the entire cost of the system and pays only a $200 processing fee. Under this arrangement, the borrower in effect may experience no monthly cash outflow for the solar system while obtaining energy savings that will grow appreciably in the future.

The advantage to the lender in this financing approach lies mainly in developing good will with the customer and in improving the security of the loan because of the reduced impact of rising energy costs on the borrower. The lender also earns the $200 processing fee and sees a slight improvement in the yield on the investment.

Energy program coordinators may wish to encourage banks, savings and loan associations, and credit unions in their communities to adopt a similar approach for solar and/or conservation retrofit actions. The willingness of lenders to adopt such an approach will depend on their particular management philosophies. Some lenders may refrain from making such loans, preferring instead to let demand develop and then serve that demand with more profitable property improvement loans.

Property Improvement Loans. Many owners of residential or business property probably will use property improvement loans to finance energy improvements. This financing mechanism carries an interest rate that is typically 2% to 3% higher than that of the first mortgage loan (about 17% to 18% at present) and a term that may run from 1 to 20 years. Property improvement loans are provided either on a secured basis (second mortgage) or unsecured basis (consumer installment loan) depending on the amount to be financed and the financial characteristics (income, credit history, existing debts, and number of dependents) of the borrower. If FHA Title I Property Improvement Loan Insurance is used, additional concerns must be addressed by the lender to ensure compliance with program regulations.

The second mortgage signifies the lender's interest in the property itself. If the borrower should default, the bank or savings and loan association can look to the property to satisfy the debt. The difficulties that a lender experiences in foreclosing on a second mortgage in order to recover the balance of a delinquent loan varies according to state law. If the borrower is delinquent on the second mortgage, it is likely that he or she is behind on the payments for the first mortgage as well. This enables the lender to foreclose (if the lender holds both obligations) or initiate a joint action with the financial institution that holds the first mortgage.

Most second mortgages are filed as "short form" liens. This approach eliminates the need for costly appraisals, title searches, legal fees, and other expenses associated with perfecting a first mortgage. This type of approach keeps both the lender's and the borrower's out-of-pocket expenses to a minimum. Most states recognize the "short form" lien as evidence of the lender's interest in the property. Federal regulations require that the amount of the first and second mortgages not exceed 90% of the the market value of the property (the current maximum under FHLMC regulations for secondary market purchases).

Second mortgages are generally used where the amount to be financed is large ($7,500 and up). FHA Title I insurance regulations require that liens be filed when the amount of the loan is over $7,500. Where second mortgages are filed for amounts over $15,000, more formal (and expensive) documentation will be required. Terms on second mortgages can run from 5 to 20 years.

Unsecured property improvement loans are handled by the installment lending divisions of commercial banks. Recent legislation now allows savings and loan associations to begin making these types of loans also. The primary consideration in making the loan to an applicant is his or her financial characteristics. The value of the property is of secondary importance because it is only considered as a part of the borrower's total assets should the lender have to go to court to recover the balance of the loan in the case of default.

Unsecured loans can be used where the amount to be financed is around $7,000 or below. This figure may vary according to the financial characteristics of the borrower. A term of 1 to 15 years is generally available. Because of the small dollar amount of many energy loans (under $5,000), the unsecured loan will probably become a major source of financing for retrofits.

The credit underwriting standards that private financial institutions use are hard to pinpoint because of the subjective nature of the lending process. It is generally held within the lending industry that total monthly debt payments (including that on the property improvement loan) should not exceed 36% of the borrower's stable monthly income. A very general rule of thumb states that the term of the loan should be 1 year for each $1,000 borrowed (Marino 1980, p. 5). These requirements will vary according to the institution, the borrower's financial characteristics, and the general credit conditions in the economy. These considerations, together with high interest rates, are pricing many households out of the lending market, however. This is a particular problem for low- and moderate-income households that may be in most need of energy conserving retrofits. Not only are many households priced out of the market, but also disincentives are placed on financing energy improvements as well. It is likely that the property owner will experience high negative cash outflows while he or she is repaying a short-term high-interest loan. This problem can be dealt with in part through a subsidy program. The problem can also be mitigated to some extent where the lender is willing to implement innovative lending plans.

A number of lenders have reduced the interest rates that they charge on their property improvement loans to signal their support for energy efficiency. Most of the reductions take 0.25% or 0.5% off the regular market lending rate (Marino 1980; Office of Community Investment 1980). Perhaps the most innovative lending program is offered by Continental Savings Bank in San Francisco. Solar T-Bills (money market certificates that are pegged to the yields of US Treasury bills) are offered to depositors and then aggregated into what is referred to as a Safe Energy Fund. These funds are used to make loans only for solar installations at an interest rate that is 1.5% above the average interest paid to depositors. A 20-year term is offered. This favorable financing technique makes the cost of solar energy systems immediately competitive with conventional systems using heating oil or electricity. Monthly payments on a $3,000 active solar hot-water system would come to about $37 on a 14% loan under Continental's program.

FHA Title I Insurance. Property improvement loans will probably be a major means of financing many energy loans in the future because of the small amounts involved. FHA Title I insurance, established in 1935, provides an incentive for lenders to make improvement loans for one- to four-unit residential or nonresidential buildings because the FHA will reimburse the lender for 90% of any losses caused by default on the part of the borrower. Lenders find the guarantee attractive, particularly when coupled with the fact that they can use their usual credit evaluation criteria and obtain a market rate of interest on the loan (the current interest ceiling is set at 18%). Loans of up to $15,000 may be made on single-family properties for up to 15 years. Loans under $7,500 may be unsecured, whereas those exceeding that amount must have a "short form" lien placed on the property. Multifamily properties are also eligible for Title I insurance with a maximum loan amount of $37,500 or $7,500 per unit.

Public/Private Lending Approaches. FHA Title I insurance is being used widely by lenders to insure their property improvement loans. A number of communities, principally in California, New York, and New Jersey, have structured lending partnerships with private financial institutions that combine interest reduction grants either to the borrower or lender with FHA Title I insurance to meet local housing rehabilitiation needs. This approach could feasibly be used to finance conservation and/or solar retrofits. They could be financed either through an existing rehabilitation program or through the creation of a special energy loan program.

Security Pacific Bank (California) is currently operating a financing program for housing rehabilitation with 100 communities across the state. The communities use their CDBG monies to reduce the interest rate to the borrower either through a reduction in the principal or an interest subsidy directly to Security Pacific. In general, communities will lower the interest rate to between 3% and 9%. Local rehabilitation programs identify target neighborhoods for the loans, determine eligibility requirements for applicants, select the effective interest rate at which the funds will be lent, and program supportive public improvements into the neighborhood. Security Pacific verifies the credit standing of the applicant and approves or disapproves the loan. If the loan is approved, the bank uses FHA Title I insurance to guarantee its lending position. The bank then services the loan at terms that may be as long as 15 years.

A major advantage of this approach is the fact that each participant's role is defined by what each participant does best. The local rehabilitation program identifies local objectives, establishes the terms, selects the applicants, and oversees the retrofit work. The lender's basic role is to service the loan, relieving the local rehabilitation staff of that potentially burdensome responsibility. An advantage to the locality, in addition to the leveraging of scarce CDBG monies, is elimination of the need to establish a loan guarantee fund. Local funds consequently can be used for more loans or other community objectives. Several advantages are presented to the lending institution under this approach.

- Lenders are able to serve a previously underserved market at a profitable rate. New business opportunities are generated in the process.
- The fact that the borrowers are already property owners and that the local rehabilitation program monitors the construction improves the security of the loans. Default and delinquency rates have been minimal under these types of programs (Ehrman 1980a).

- Support of local rehabilitation efforts and the attractive loan terms that are extended under the lending program can build good will in the community for the lender. This may result in additional business in the future.

Secondary Market Operations. Lenders will be more willing to make loans for property improvements or energy retrofits when they have a secondary market to sell them in. This sale enables the lender to quickly regain cash with which new loans can be made at the current market rate. The lender avoids being tied into a loan of 5, 10, or 20 years at a rate that may eventually become unprofitable in an inflationary economy. Secondary market operations assist in maintaining the profitability of the lending industry. They also ensure that there will be ready availability of credit for the consumer.

In general, the secondary market agencies have purchased first mortgages from lenders to ensure liquidity in the home lending market. The FHLMC started to purchase property improvement loans under a pilot program initiated in January 1981. A special objective of the program was to help lenders meet anticipated demand for energy retrofit loans. The Corporation will purchase loans of up to $30,000 on single-family properties and $60,000 on multifamily buildings (two to four units). The term of the purchased loan may be up to 20 years. The Federal National Mortgage Association (FNMA) is currently considering a program to purchase property improvement loans. The development of a secondary market for property improvement loans should work to encourage even greater lender interest in this type of credit transaction. Lenders may also be more willing to offer longer terms on property improvement loans because they will not be forced to accept a rate that may become unprofitable over the long term.

Comments. The participation and support of local lenders in an energy financing program on an individual level and/or in a cooperative financing effort with the local energy program can only be viewed as a positive development. These institutions are already in place and possess considerable capital resources that potentially could be used in a local energy program. Local program organizers should take into account the following considerations.

Lenders do not like to make small loans (under $1,500 or so) because they may be only marginally profitable and in some cases unprofitable. This is due to origination, servicing, and administration fees that remain fixed no matter what the size of the loan. Because many energy loans are rather small ($1,000 to $1,500), it may be necessary to develop a servicing operation to encourage lender participation in the local program. Such an operation would undertake the credit checks, approve or disapprove the loans, and service them. Such an operation could be conducted by the local government, a rehabilitation agency, a nonprofit corporation, or perhaps by the local program in cooperation with a local mortgage banking firm.

Innovative lending programs that offer interest rate reductions or favorable terms should be encouraged. These measures can significantly improve the economics of energy-efficient technologies. They are also a good means of communicating to the public the value and effectiveness of conservation and solar applications. The leadership roles that private financial institutions often fill in communities, backed by their active economic and local support, can add appreciably to the credibility of the local energy program.

Many lenders remain skeptical of the performance of solar applications because of lack of knowledge and perhaps because of experience with unscrupulous or incompetent contractors. The program staff must educate the officers of local lending institutions about how solar technologies operate, explain the benefits of a local energy program, and provide some assurances about the performance of passive systems.

Cooperatives

Existing cooperative organizations (housing, food, and electrical) or new cooperatives can be organized to provide weatherization and solar retrofits to community members. Cooperatives are based on democratic control and active participation by members. Those attributes make cooperatives particularly suitable for neighborhood initiatives where there is a strong level of commitment and spirit of cooperation among residents. The ability of cooperative organizations to reduce the costs of goods and/or services intuitively suggests that these organizations are particularly appropriate to the needs of low- and moderate-income neighborhoods, as well as the larger community.

Types of Cooperatives. A cooperative is people combining resources in the form of labor and capital to provide goods or services to themselves. There are basically two types of cooperatives: producer and consumer.

Producer cooperatives are organized around the manufacture or distribution of goods that are made by the members. Supply, marketing, and worker cooperatives are the three forms of producer cooperatives. Supply and marketing cooperatives are found primarily in the agricultural sector. Worker cooperatives have often been established in urban areas to perform manufacturing functions.

A worker cooperative may be formed by residents of a community or neighborhood expressly to provide employment opportunities for residents. Such an operation could feasibly be formed to produce weatherization materials (insulation, storm doors, and solar collectors), to provide design and technical services pertaining to energy-efficient technologies, or to install or construct energy retrofits. The Solar Center in San Francisco, which sells and installs solar energy systems, is an example of an extremely successful worker cooperative. A list of other worker cooperatives is provided in Appendix F under "General Readings."

Consumer cooperatives are organized to provide goods or services to their members. Most of these cooperatives have been established to reduce the costs associated with housing, food, health insurance, and electrical service.

Consumer cooperatives have been established and are now forming to provide energy materials and services. Energy cooperatives, if they are properly planned and efficiently run, can reduce the costs of materials for weatherization and solar retrofits. These savings can approach 15% to 20%. If the cooperative members also do the installing, the savings are even greater. In Albuquerque, we estimate such an approach could save up to 60% of the price of a contractor-installed retrofit.

In its ideal form, the weatherization and solar cooperative would provide volume discounts on materials, maintain and guarantee the performance of the energy improvements, offer a fully amortized repayment schedule to members, and charge members a nominal up-front cost for the improvements (*Cooperatives and Energy* 1980, p. 8). Reduction of the initial energy retrofit cost and extension of long-term low-cost financing are particularly important to the needs of lower income households. However, the ability of the cooperative to provide financing will be constrained by the difficulties that the cooperative often faces in obtaining capital in private markets and by the limited availability of resources from public or semiprivate organizations. Capitalizing the cooperative at a level to cover high start-up costs and a financing program, although not impossible, is a very difficult challenge for organizers.

A list of private and semiprivate organizations that could be approached about funding is provided in Appendix F. Public funding sources are listed as well.

Characteristics of Cooperatives. Cooperatives, whether they are oriented toward consumer or production functions, possess unique attributes that distinguish them from ordinary businesses. These attributes include the following:

- *Democratic Control.* The philosophical basis of cooperatives is the idea of member ownership and pursuit of democratically determined common objectives. Consequently, cooperatives are organized with each person having one vote. Members actively participate in the management and definition of policy through the exercise of their voting rights.
- *Service at Cost.* A basic objective of the cooperative is to reduce the cost that members pay for purchasing goods or that otherwise would be incurred in producing goods. Cooperatives attempt to achieve dollar savings by purchasing directly from manufacturers and by using the combined purchasing power of members to obtain volume discounts on materials. Any profits that the cooperative achieves belong to the members and are either reinvested in operations or returned as dividends to the membership. The proportion of return is based on the amount of business that each individual does with the cooperative.
- *Limited Return on Investment.* Capital invested in a cooperative is used to provide services to cooperative members not to create profits. In principle, profits are distributed to members in the form of savings on the goods or services that they obtain from the cooperative. Thus, the return on the investment of any cooperative member is restricted so as to retain income that can then be used to keep costs at their lowest possible level.
- *Member Owned and Financed.* The cooperative is member owned and financed. This membership determines the types of services and/or goods that are provided.

Existing Energy Cooperatives. A number of cooperatives have begun to appear across the Nation to address the problem of rising energy costs. A bulk-fuel purchasing cooperative named HEAT (Housing Energy Alliance for Tenants) was formed in New York City. HEAT purchases fuel oil in large quantities for apartment buildings that are generally tenant managed. The ability of the Cooperative to purchase in quantity enables it to obtain bulk discounts and favorable credit terms. Savings have approached 20%. HEAT also conducts energy audits, recommending improvements in building energy efficiency, and sponsors educational meetings on energy conservation. The Portland (Maine) Wood Fuel Cooperative provides 175 low- and moderate-income households with wood for heating.

During 1978 and 1979, a member household average of 960 gallons of heating oil was displaced by 3.5 cords of wood at an annual savings of $480.

Issues Affecting Energy Cooperatives in Lower Income Neighborhoods. Cooperatives would seem to be an excellent way to serve lower income households, which are most in need of weatherization improvements. However, problems arise because of

- lack of member capital,
- lack of technical or business skills,
- greater marketing difficulties, and
- limited incomes that can't cover the cost (even when reduced) of energy retrofits.

The experience of the Boston Building Materials Cooperative (BBMC) presents an example of the issues that an energy cooperative may face in lower income neighborhoods.

The Cooperative was founded in 1978 to provide weatherization materials and technical services to low- and moderate-income households. The Cooperative encourages members to install insulation, caulking, weather stripping, and storm windows on their own homes to further reduce costs and to foster community cohesion and power through the sharing of help and skills. The Cooperative assists those households whose incomes exceed levels set for Federal weatherization programs but who cannot afford the costs of commercial installation.

The BBMC initially sold storm windows and doors but then expanded to provide blown-in cellulose insulation, roof vents, caulking, and weather stripping. The Cooperative staff has also assisted homeowners by providing technical advice on installing the materials. As a service, the Cooperative decided to specialize in the installation of high-efficiency low-cost magnetic interior storm windows and blown-in cellulose insulation. The Cooperative sells these materials as close to cost as possible while still covering necessary administrative and delivery fees. The BBMC has been able to achieve prices that are 15% below retail. Technical services are provided on a sliding scale based on the income of the household.

Memberships in BBMC are secured through the payment of a $10 initiation fee and a commitment to share skills. Membership is open to homeowners, tenants, trades people, and community housing organizations. The responsibilities of Cooperative members are based on skill sharing rather than labor time. Skill sharing is achieved by working for the Cooperative directly, assisting other members, or by working for a housing organization. Members are asked to exchange 1 hour of skill (up to 3 hours per month) for every $30 of savings (over retail cost) that they realize through the purchase of Cooperative materials and services.

The BBMC has faced an uphill battle to attain financial stability. There has been a continual problem in obtaining adequate capital resources. The large capital need can be attributed to high start-up costs needed for planning, along with expenditures required to hire staff and purchase materials. This problem is compounded by the objective of the Cooperative to serve a low- to moderate-income clientele that has little discretionary income to spend on weatherization. The Cooperative staff has found that some sort of subsidy generally is necessary to serve the needs of lower income households. This subsidy is required to reduce the Cooperative price of materials to a level that these households can afford.

Another problem for the BBMC has been the lack of awareness and experience that many of the ~500 members have concerning cooperative structure and process. Consequently, maintaining the interest of members beyond the time when they have weatherized their homes has been difficult.

Finally, the Cooperative found that it needed to spend more time building up membership in the community in proportion to the time spent seeking public and private sources of funding. This new emphasis is thought to be needed to meet the financial needs of the Cooperative as well as to build credibility in the community.

The BBMC is attempting to overcome some of the obstacles that it faces. Cooperative organizers are trying to maintain the interest of members by expanding BBMC activities to home maintenance and repair materials. Members would then have an additional incentive to remain in and support the activities of the Cooperative after the "one shot" weatherization package was completed.

A need was also seen to redirect the client orientation of the Cooperative to include households of all income levels. Then the Cooperative could subsidize the needs of lower income members through a sliding scale of fees based on the income level of the member. Additional capital might also be obtained for the subsidy of lower income households and the stabilization of Cooperative finances by increasing the initial membership fee (for higher income households) and by generating a higher sales volume (because of an expanded membership with higher incomes).

The Cooperative organizers also keep trying to attract outside capital (for example, HUD and DOE monies). The BBMC also has sought to develop business contacts with local community action agencies to provide weatherization services to low-income households served by DOE's Weatherization Assistance Program.

The financial and organizational problems that the BBMC has experienced reflect the difficulties of operating in communities where dollars are scarce. Cooperative organizers have seen the need to obtain public and private subsidies to support current operations. There is a need to develop a self-sufficient operation that is free of unpredictable outside funding, however. An independent operation can ensure future stability for the cooperatives.

Other Issues Affecting the Establishment of Energy Cooperatives.

Unproven Performance. Although other types of cooperatives have some sort of track record, as of this writing, there is only limited experience in the formation, operation, and ultimately the financial viability of energy cooperatives. This will make it difficult for cooperative organizers to obtain initial funding, particularly from private lenders. Banks and other potential capital sources will be wary of extending money to untested concepts. Private lenders often are reluctant to provide financing to any cooperatives because of the unorthodox procedures under which cooperatives operate. These procedures do not rely strictly on profit objectives, but often incorporate political, environmental, and social concerns as well.

High Start-Up Costs. The unproven performance of energy cooperatives is complicated by high start-up costs to cover planning and marketing studies, hiring of staff, and purchase of materials. The capital requirements of cooperatives are extremely high and difficult to meet, particularly where the cooperative is orienting its operations toward lower income households.

The National Consumer Cooperative Bank. As of this writing, the National Consumer Cooperative Bank (NCCB), which was established in 1978, still appears to be a viable organization under the current funding pressures. The NCCB was established by Congress specifically to address the capitalization problems that cooperatives have faced in obtaining credit from conventional lending institutions. As stated in the NCCB Act (PL 95-351) of August 20, 1978,

> "...the bank is to deal with two major problems found to hamper the formation and growth of cooperatives: lack of access to adequate cooperative credit facilities and lack of technical facilities."

Although the NCCB will survive, it will most likely be a conservative lender, because it must go back to Congress for additional appropriations and to the bond markets to obtain further capitalization. Loans to energy cooperatives may be hard to obtain given the unfamiliarity of most NCCB officers with the concept. It is extremely likely that bank loans will go to existing organizations with established records rather than to speculative ventures.

Title II of the NCCB Act establishes an Office of Self-Help Development and Technical Assistance. This office could provide capital to new cooperatives or low-income cooperatives in the form of low-interest loans, interest subsidies, or equity-type capital investment advances where these cooperatives could not qualify for conventional loans under Title I. This Office would also provide technical assistance related to the organizational, developmental, financial, and management needs of new or existing cooperatives. Current reports suggest, however, that the activities envisioned under Title II will be cut back substantially if not eliminated altogether. This prospect may curtail the establishment of new energy cooperatives that are in need of affordable financing and that require help in formulating and executing start-up plans.

Utilities

A number of electric utilities, representing almost 20% of the Nation's generating capacity, are currently supporting conservation and/or solar programs designed to reduce demand for electricity.* Pacific Power and Light of Portland, Oregon, with a customer base of 630,000 (544,000 residential), is offering 0%-interest loans that are repayable at the time of sale of the property (see the discussion on deferred payment loans in the "Grants and Direct Loans" section of this chapter) to finance the installation of insulation and other conservation measures. As of April 1980, Pacific Power and Light had conducted 16,000 home energy audits and had completed 6,600 retrofits with 2,400 more in various phases of construction. The average retrofit costs around $1,500. The Tennessee Valley Authority (TVA) offers 0%-interest loans for the installation of insulation in ratepayers' homes. It also extends low-cost loans at its cost of capital (about 10.5%) for the installation of solar hot-water heaters or heat pumps.* Approximately $55 million has been invested by the TVA in the homes of its customers.

The Public Service Commission in California has established regulatory policies that encourage utilities to adopt strong commitments to energy conservation and renewable energy resources in their planning strategies. Pacific Gas and Electric, San Diego Gas and Electric, and Southern California Edison currently are participating in a demonstration solar financing program mandated by the Commission. This program will provide cash rebates

*Telephone conversation with Robert Steffy, Tennessee Valley Authority, November 1980.

or low-cost financing for the installation of solar hot-water systems. A goal of 375,000 installations by the end of 1983 has been set. Utilities in Washington, Massachusetts, Arkansas, Michigan, and Wisconsin have also adopted strong conservation programs.

History Leading to Utility Involvment. The reasons for utility interest in conservation and, in some cases, solar retrofits (primarily for solar hot-water heating) are primarily economic. Before 1973, utilities operated in an economic environment that was not subject to significant inflationary pressures. Consequently, they could build new generating units, retire less efficient ones, and because of increasing demand, reduce rates. The economic condition of the utilities was very favorable because reduction in rates encouraged increased usage, which in turn ensured growth in revenues.

This situation changed dramatically after 1973. Inflationary trends took hold in the National economy. Skyrocketing fuel prices, rising construction costs, and long lead times for new plant construction significantly affected the cost complexion of utility operations. This general increase in costs forced utilities to increase rates in order to pay for the construction of new power plants (nuclear and coal). These rate increases at the same time operated to reduce consumer demand. The financial stability of many utilities was severely threatened because they found it increasingly difficult to finance new construction without raising rates even further. Further increases would in turn work to depress demand to even lower levels. Conservation (and solar in California) retrofit programs became increasingly attractive to some utilities if they saw that the cost of saving energy (through investment in the homes of ratepayers) would be less than the cost associated with the construction of new power plants.

The National Energy Conservation Policy Act of 1978 (NECPA). Passage of NECPA provided a regulatory incentive for utilities across the Nation to undertake actions that would encourage energy conservation. Specifically, NECPA established the Residential Conservation Service (RCS) Program. RCS was to be implemented by electric utilities with sales in excess of 750 million kWh and gas utilities selling more than 10 billion ft^3 of gas in the 2 years preceding enactment of the legislation. Covered utilities would be required to conduct audits at the request of residential property owners (buildings of one to four units), to recommend cost-effective conservation measures, to provide a list of approved contractors to do the work (and inspect the result), and to arrange for financing. Under NECPA, utilities were prevented from installing, providing material, or financing (over $300) the conservation retrofits. Restrictions on direct utility installation and financing of energy-efficient retrofits were related to the concern that utilities could achieve a monopoly position in the installation of conservation and solar measures. A "grandfather clause" allowed utilities with existing or planned financing programs to continue their activities, however. Waivers could be obtained by other utilities for their progams when they were supported by the governor of the state.

Amendments under the Energy Security Act of 1980 now directly permit utilities to finance the installation of conservation of solar measures. This change was made recognizing the significant role that utilities could play in promoting conservation and solar energy.

Funding for RCS has been removed at the Federal level under the 1982 budget. Consequently, there will be minimal enforcement of the law and minimal technical support from DOE. Implementation of the RCS Program has fallen to state energy agencies. Some states appear to be carrying out fairly vigorous programs, keeping with the spirit of RCS (for example, California, Oregon, and Florida). It may be expected that others will be less aggressive in their efforts, however, because of a lack of funds in many cases. Some states also will be hesitant to tell utilities to adopt conservation as a specific management policy.

A Federally supported RCS Program could have been an effective way to encourage conservation on a National scale. Approximately 350 utilities serving 90% of the population would have been covered (Satlow 1981). A basic problem with encouraging the installation of conservation and solar technologies is the average individual's lack of basic knowledge about the subject and wariness of the claims that contractors might make about the performance of various conservation measures or solar systems. The RCS offered a way by which a credible source (the utility) could evaluate energy use for the homeowner, suggest cost-effective retrofit measures, and then ensure that the work was done properly.

Advantages of the RCS Approach. The RCS approach encourages energy-efficient technologies because it provides

- *credibility*. The consumer may be more likely to trust the utility to define cost-effective conservation retrofits. The trust may result from the standing of the utility in the community (integrity) and the knowledge the consumer feels the utility has about energy issues.
- *guarantee*. Under the RCS Program, the utility

would be required to provide a list of certified contractors. The utility must then inspect the work to ensure that the equipment has been installed properly. These actions may assure consumers that the money they are investing will result in actual savings.

- *access to financing*. This consideration presents a critical element in encouraging widespread adoption of conservation at a local level. Utilities can obtain money at a much lower cost in the capital markets because of their need for large amounts of capital at one time. The utility could significantly reduce the cost of financing to the consumer because of its borrowing power. The utility may also be able to offer a longer term for repayment as well, thus reducing the monthly payments even further. A favorable situation could result where energy savings exceed or at least equal the monthly payment. The cost and form of financing is also extremely important. Pacific Power and Light's 0%-interest loan program was widely accepted, whereas there were few takers for an earlier program sponsored by the State of Oregon that created 6.5% loans.

A unique financing approach has been devised in California for financing solar hot-water heaters. Utility customers have the option of accepting a 6%, 20-year loan from the utility (keeping monthly payments low) or a rebate (reducing initial costs). For the rebate, the utility makes a cash payment to cover the cost of energy that otherwise would have been provided through the construction of new generating facilities. These payments range between $500 and $1,000, in general. Households installing solar energy systems can also take the state and Federal tax credits, which in California can cover up to 55% of the cost of the system. Under the rebate approach, the consumer must arrange for conventional financing to cover the costs that cannot be met immediately by the rebate or credit.

- *convenience*. Utilities have the billing, distribution, and sales organization already in place that could be used in support of the RCS Program.

Disadvantages of the RCS Approach. The RCS Program has several limitations that could offset its effectiveness in promoting community-wide adoption of conservation retrofits.

- *RCS is a voluntary program.* The utility conducts an audit only if it is asked to by the customer. Even if the consumer asks for the audit, nothing guarantees that he or she will undertake the suggested improvements. Alternatively, the consumer may make some retrofits but not all; so the full savings potential is not realized in this instance.
- *Nothing in the RCS Program dictates that the utility has to provide financing*. As suggested earlier, the availability of affordable financing is basic to widespread adoption of conservation measures.
- *The RCS Program will not assist renters.* There is little incentive for landlords to participate because they generally do not pay the utility bills; therefore renters are denied the energy-savings opportunities offered through the RCS Program.

Comments. The RCS is a valuable program that should be accessed by the community to help address community energy needs. The ability of localities to tap utilities as potential sources of financing will vary by state because of public service commission regulations and the investment outlook or economic situation of the utility. It also varies because of the type of demand that the utility serves, which relates to the percentage of the utility's load that is attributable to heating. Electric utilities in the Northwest and Southeast see a large portion of their generating capacity going toward the heating of buildings. This is not the case in many other parts of the Nation, where natural gas or fuel oil is the predominant heating fuel. Electric utilities in these areas will consequently find it less economic to invest in insulating the homes of ratepayers. In these areas, approach the suppliers of natural gas and fuel oil.

Washington Natural Gas Company, which serves the Puget Sound area, began selling conservation kits for attic insulation at a cost of $200 in 1974. It installed, guaranteed, and financed the insulation and in the process achieved a 22% reduction in energy used for space heating in the average home. As of November 1977, 14,000 kits had been sold. A more advanced package is now available, which includes attic insulation, a pilotless natural-gas furnace, and an automatic day-night thermostat. This package is estimated to reduce heating bills by about 36% (Stobaugh and Yergin 1979, p. 171).

A local effort to secure utility financing of conservation and/or solar retrofits must recognize the particular investment objective of the local utility. Some will find investments in insulation or other heating energy conservation measures attractive whereas others may not. For example, they may find that investments to offset hot-water demand will be more economic. In conclusion, any utility financing program ultimately will depend on the local utility's perception of self-interest in participating and, to a lesser extent, on the state's regulatory environment.

Administering a Local Financing Program

The delivery of financing to local residents and businesses ultimately depends on the establishment of an administrative framework. You may feel that the program can be best handled by an existing agency within the local government. A housing rehabilitation or community development department, for example, may already have the needed staff and organizational strengths to handle the loan program. A cooperative effort with local lending institutions may also be structured relieving the fledgling energy retrofit program of significant loan origination and servicing functions entirely. Selection of the means by which a financing program will be carried out requires that you consider the capabilities of existing organizations in the community and the scope of the program that you wish to undertake.

You may find that existing public and private organizations are unwilling or unable to handle the details of an energy retrofit financing program. It may also become obvious that a special administrative structure will be needed to extend the financing because of the large number of loans that you wish to make or because of other legal, political, economic, and marketing considerations. The concept of a municipal solar utility (MSU) has been developed in California as an approach to finance, market, and in some cases guarantee solar systems (usually active) used for providing hot water or for heating swimming pools (Sanger and Epstein 1980; Saitman 1980).

The MSU concept need not be restricted to providing these applications alone; it may also be used to encourage the adoption of conservation, wind, biomass, and, perhaps later, photovoltaic applications as well. The wide range of energy technologies that could conceivably be encouraged under this type of approach makes the term municipal solar utility an overly restrictive definition. Henceforth, we will refer to this concept as the community energy service corporation (CESC).

Purposes of the CESC

The CESC's basic function is to encourge market acceptance of solar (under the MSU concept in California) and potentially other energy-efficient technologies, including conservation. The CESC concept includes a number of ways that this function could be carried out. Financing is but one objective;

additional objectives of the CESC could include installation and maintenance, consumer protection, and development of employment opportunities and job training. A basic objective of the CESC under the two of the three models outlined below is to extend attractive financing terms, however. This means financing that can allow the borrower to achieve positive savings after the cost of the monthly loan payment is subtracted from the monthly energy savings.

Three models for CESCs have been suggested in the literature (Sanger and Epstein 1980, p. 1).

- *Direct Service Model.* This approach involves the CESC in a full range of activities that are related to the installation or construction of retrofit technology. Possible responsibilities would include purchase of materials, warehousing, marketing, system design, on-site installation, consumer financing, billings and collection, and ongoing maintenance functions. These responsibilities could be handled by city staff or contracted out where feasible (installation work contracted to a local insulation and building contractor, billings and collections contracted to a bank).

  Costs to the consumer can be reduced through bulk purchase of materials, economies achieved through a large-scale installation program, and the provision of low-cost financing. Potential market interest may also be stirred by the possibility of reducing any operation or maintenance costs because of guarantees that the CESC may provide regarding maintenance functions. Guarantee of performance is a particularly important consideration for consumers who are unacquainted with solar and conservation technologies. The direct service model can address these concerns. Maintenance functions should be handled under a separate optional contract with the consumer. The cost of providing maintenance services could then be revised periodically through the insertion of renewal clauses to charge the user for the actual costs associated with the service. The maintenance and repair function is a particularly important consideration where active solar systems are being installed.
- *Low-Interest-Loan Model.* A CESC may be structured solely to provide financing to community residents and businesses. This function could be carried out through a direct loan program with the local government acting as the lender. A secondary purchase program might also be worked out with local lending institutions. Under this alternative, the program would purchase the energy retrofit loans that are made by banks, savings and loan associations, or credit unions. A third alternative would be to use "linked" deposits. In this case, the local government would deposit funds with a private lending institution, and the program staff would specify the terms under which the funds are lent out.

  A linked-deposit approach may be particularly appropriate for the program (Sanger and Epstein 1980, p. 3). Administrative responsibilities are left to the lender. The lender also has the responsibility of dealing with any borrowers that default on their obligations. The linked-deposit approach may be structured to operate on a self-supporting basis with new loans extended as existing obligations are repaid. The program might also provide additional subsidies to the lender or borrower to write down the cost of the loans to the desired levels. The amount or percentage of the subsidy could be based on the income of the borrower.
- *Facilitation Model.* This approach involves a cooperative effort between the CESC and the local utility to carry out the responsibilities that the utility was required to carry out under the Residential Conservation Service (RCS) Program. As mentioned in the "Utilities" section of this chapter, utilities were required under this Federal program to offer consumers home energy audits, provide lists of qualified contractors to perform the work and lists of sources of financing, and then ensure that the work was performed correctly. The utilities are encouraged to contract with city agencies and nonprofit corporations to perform these functions.

Implementation of RCS programs is now left to the states entirely because funds for enforcement and informational objectives at the Federal level have been eliminated under the 1982 budget. The vigor with which state public service commissions will pursue the original objectives of RCS will vary. California, Florida, and Oregon, for example, have already established fairly strong programs, whereas other states have yet to implement their programs formally. The establishment of a facilitation model for the CESC will ultimately depend on the regulatory environment within the state and the particular conservation outlook of the local utility.

A CESC established under the facilitation model would serve as a coordination point for utility conservation efforts. It would develop consumer and education programs, technical assistance to do-it-yourselfers, quality assurance for the products and workmanship, and post-installation services. The facilitation model envisions a strong marketing and educational role for the CESC, with the financing function left to other sectors within the community.

Ownership Forms

The CESC is a potentially flexible administrative means to address local energy retrofit concerns. A CESC could be set up under the sponsorship of the community government itself. This is the arrangement that has been used thus far in California's MSU Program because of the newness of the concept.

The City of Santa Clara pioneered the concept in 1976. The City's electric utility established a solar division that focused its efforts on renting solar swimming pool heaters. First costs of the system are reduced to the costs of the installation ($300). The rental rate for the system is based on an amortization term of 10 years at 7% on the retail cost of the system. This has the effect of reducing the pool owner's monthly payment to $28 or $30 per month for the average pool. This rate is only charged during the 6-month pool season (April—September). The cost of heating the pool in this way is 20% to 30% less than the cost of gas to do the same job. The economics are further improved because the annual cost of the solar system will remain constant whereas the cost of conventional energy can only be expected to increase. The utility also guarantees the performance of the system and provides periodic maintenance and servicing.

Other California cities that have or are in the process of establishing MSUs include San Dimas, Ukiah, Bakersfield, Palo Alto, Santa Monica, Oceanside, and Los Angeles. The organizational framework and particular objectives of the various MSUs are all different, reflecting the particular circumstances of the communities that they serve.

The City of Portland (Oregon) has established a nonprofit corporation with the name of Portland Energy Conservation Inc. (PECI) to administer its conservation program. PECI operates essentially as a "one stop" information source on weatherization for community residents. It acts as a broker not only for the services that it provides internally but also provides information on other public and private programs (for example, utility and state financing programs and tax credits). PECI answers consumer questions about conservation measures, arranges for energy audits, provides lists of certified contractors to perform the work, extends low-cost financing, and conducts other outreach activities designed to stimulate the community's awareness about energy issues. PECI is currently using $3 million in UDAG monies to leverage $15 million in private sector funds to finance the retrofit needs of homeowners and businesses. Homeowners are provided with 8% loans with terms of up to 10 years. Loans for retrofit actions are also available to landlords of buildings with five or more units. One-year loans at 0% interest may be provided to businesses and landlords of multifamily buildings to undertake energy audits. The loan will be turned into a grant to the owner to the extent of the percentage energy savings that are achieved through his or her investments. Thus, where 40% energy savings are achieved, only 60% of the loan would have to be paid back.

PECI provides an example of a comprehensively planned approach to encouraging the adoption of conservation technologies. It possesses the greatest similarity to the direct service model for the CESC.

A number of other innovative organizational structures may be used to initiate the CESC. A community organization (condominium or homeowner's association, cooperative, or neighborhood association) could feasibly establish a CESC. It could be operated on a nonprofit basis under a CDC or small business industrial development corporation; it could be structured as a joint venture with a private utility, with local installers and distributors, or with other local government agencies (housing redevelopment authorities or school boards); or it could be operated as a profitmaking firm. In short, the CESC could be structured in a variety of ways depending on local capabilities and needs.

Financing the CESC

Funds must be obtained to provide initial capitalization for CESC operations and to develop the desired lending capability to induce consumers to make energy-efficient investments. Development of a financing capability is perhaps most easily achieved where the CESC has a close relationship with the local unit of government, a municipally owned utility, or a privately held one. The establishment of the CESC as a new organization within the local government or as a nonprofit corporation sponsored by the local government is potentially advantageous because the locality can obtain low-cost capital through its bonding powers. The ability of the CESC to use these funds for lending purposes will be subject to legal considerations pertaining to the lending of public credit. The local government might also allocate to the city-sponsored CESC or nonprofit corporation other funds such as municipal reserves, CDBG funds, or UDAG monies as in Portland. These funds might be used to make direct deposits with local lenders (so that they may make loans), to operate subsidy programs, or to serve as a pool of funds with which the program could make loans itself. Utilities (publicly or privately owned) might provide funding for CESC activities through their bonding activities or by including the cost of the program in their rate base.

Capitalization of other CESC forms presents a more difficult challenge. A CESC operating under a cooperative type of organization might quality for CDBG funds (Oberg 1981, p. 174), as might one operating as a CDC. These types of organizations must look to private sources of financing (for example, membership fees, or stock sales) to attain economic viability in the long run, however.

The Oceanside, California, MSU has developed a unique financing relationship that permits private investors to lease solar collectors and equipment to homeowners and businesses. Individuals in high tax brackets will be interested because they can take the investment tax credit (10%), take the business energy investment credit (15%), and use accelerated depreciation methods. These considerations allow the investor to write off up to 81% of his or her investment in the first year and reduce other taxable income.*

The investor also receives an additional return in the form of lease income. Leasing arrangements, which have been common in other sectors of the economy, may provide a virtually limitless source of financing for CESCs. Note that lease financing can be used only for equipment that does not become a permanent addition to the structure. Thus, lease financing is particularly suitable for financing active solar collectors and related equipment that may be physically removed from the property if the need arose. It might also be used in commercial applications where cogeneration equipment is being financed.** Lease financing would not be applicable for conservation (insulation, storm windows, etc.) or passive solar improvements because they are incorporated as structural elements of the building. Consequently, the potential for lease financing is high for active solar applications and other equipment that might result in energy savings. Commercial banks and specialized lease investing firms are the major conduits for investor funds.

*Conversation with Chris Perry, New Mexico Energy and Minerals Department, August 3, 1981.

**Cogeneration equipment is used to capture waste heat from various processes in a building to produce additional power.

Comments

The CESC approach offers real advantages, particularly under the direct service model, to overcome significant barriers that currently discourage investment by households and businesses in renewable technologies. These barriers arise because of the lack of accurate information on the usefulness and economics of conservation and solar technologies, the lack of guarantees for performance, and the lack of attractive financing terms to counteract current market disincentives for investment. The CESC can deal with these problems by undertaking the following functions:

- *Communication.* The CESC acts as an information source for the community on conservation and other renewable technologies. Most people are unfamiliar with these applications and are hesitant to make substantial investments because of lack of basic knowledge or a skepticism about the performance of these systems. The CESC can develop brochures, workshops, community-wide conferences, neighborhood demonstrations, and other informational activities designed to educate the community about the benefits of energy-efficient technologies. The CESC may also arrange for audits and provide lists of certified contractors to perform the work. The communication role is vital to informing the public, which then can undertake effective energy-saving retrofits.
- *Consumer Protection.* A basic fear of consumers in the market at present is the perception that energy-efficient technologies (particularly solar) are unreliable and do not perform. This notion is encouraged in part by a lack of basic knowledge about these applications and by the poor work that has sometimes been done by unscrupulous or incompetent contractors. The CESC can deal with this problem by developing lists of approved contractors and by inspecting the finished work to ensure that it has been done properly. In the case of active solar installations, the CESC may offer a maintenance and servicing contract to ensure the proper performance of the system.
- *Financing.* This point has been well covered and there is little need to elaborate here. The effectiveness of the financing program will be enhanced where the consumer is well informed, however. Providing attractive and affordable financing may be the final impetus, after educational and guarantee efforts, that is needed to get the household or business to invest in energy efficiency.

6 Conclusions

Whether you choose to use the information in this sourcebook to initiate a comprehensive local energy program or you choose to concentrate on one neighborhood, you must pull together all the elements presented. You must have a coordinated approach to evaluating energy savings potential, community outreach, and financing.

The information we have presented here is generic in nature or is Albuquerque specific. You must check into the specifics of your own community. Find out about previous energy studies in your community. This will save time in data gathering and put you in contact with others interested in your local energy situation.

Contact other groups dealing with local energy matters—the state and local energy offices or extension offices, HUD weatherization office and any other groups with auditing experience, solar and environmental groups, architects, contractors, and so on. Search for good examples of energy savings or solar retrofits (such as an office building with a low-cost energy conservation program or a commercial laundry that has installed heat-recovery devices). Look for examples of passive solar greenhouses or Trombe walls in the residential sector or for other renewable energy projects, such as wind or hydroelectric generating facilities.

Get to know the people involved in these energy projects; ask them about investments, energy savings, and problems they have encountered. The experiences of the people in your locality in dealing with your particular climate and the local building styles and materials will be very helpful to you.

Become familiar with weather data for your area—cooling degree days, heating degree days, solar insolation, and wind speeds. Your local Chamber of Commerce or the National Climatic Center in Asheville, North Carolina, can help you get this information.

Familiarize yourself with as many of the pertinent construction codes as possible. Also, get to know the people who make and enforce these codes. It is best to do this during the planning stage of your program, rather than face them for the first time when you are in the implementation stage. In addition to problems with construction codes, less obvious problems may also occur. For instance, will building height restrictions, adopted with solar access in mind, contribute to the problem of urban sprawl?

Think beforehand about the problems that all proposed legislation, codes, and guidelines can create. Work closely with other interested groups in your community to change these documents when necessary. Some of the possibilities you may want to consider are:

- solar access laws to ensure that anyone using a solar energy device will not be shaded by new construction or landscaping,
- tax incentives to encourage the use of conservation and renewable energy sources,
- low-interest loans for energy-saving projects,
- minimum energy performance standards for new construction, and
- landscaping programs to help evolve more favorable microclimates.

In addition to seeking information and cooperation from other individuals and agencies, you may want to establish an energy information clearing-house for your community. There, you could compile and distribute literature on

- energy conservation,
- renewable energy resources,
- local energy consumption,
- financing and incentives for energy programs, and
- local demonstration projects.

There is a great deal of free literature available from state and Federal agencies that you will want to use, but be aware of the fact that people are generally more receptive to locally produced and oriented information.

If your intent is to create an overall energy plan, once energy codes are adopted, you may want to convince the local government to initiate an energy-savings program for public buildings. This will give you an opportunity for hands-on experience with audits and may allow for technical training of city staff. Once the audit is complete, present a report to the city council that includes recommendations and supporting economic data. Follow through with a conservation and/or solar demonstration project. Ideally, your initial work with government buildings will be so successful that the private sector will come to you for information about energy savings.

Do not be discouraged if your public does not immediately want to participate in your program. Be persistent, be patient, and above all be diplomatic, especially when approaching the owners or lessors of privately owned buildings. Many may view you as a do-gooder or a census taker. Take time to get off on the right foot with *all* the people involved in the energy savings program.

If your intent and interest in using this sourcebook is more neighborhood oriented, you will still want to apply the same techniques; only the scale and sheer volume of information and people involved will be reduced.

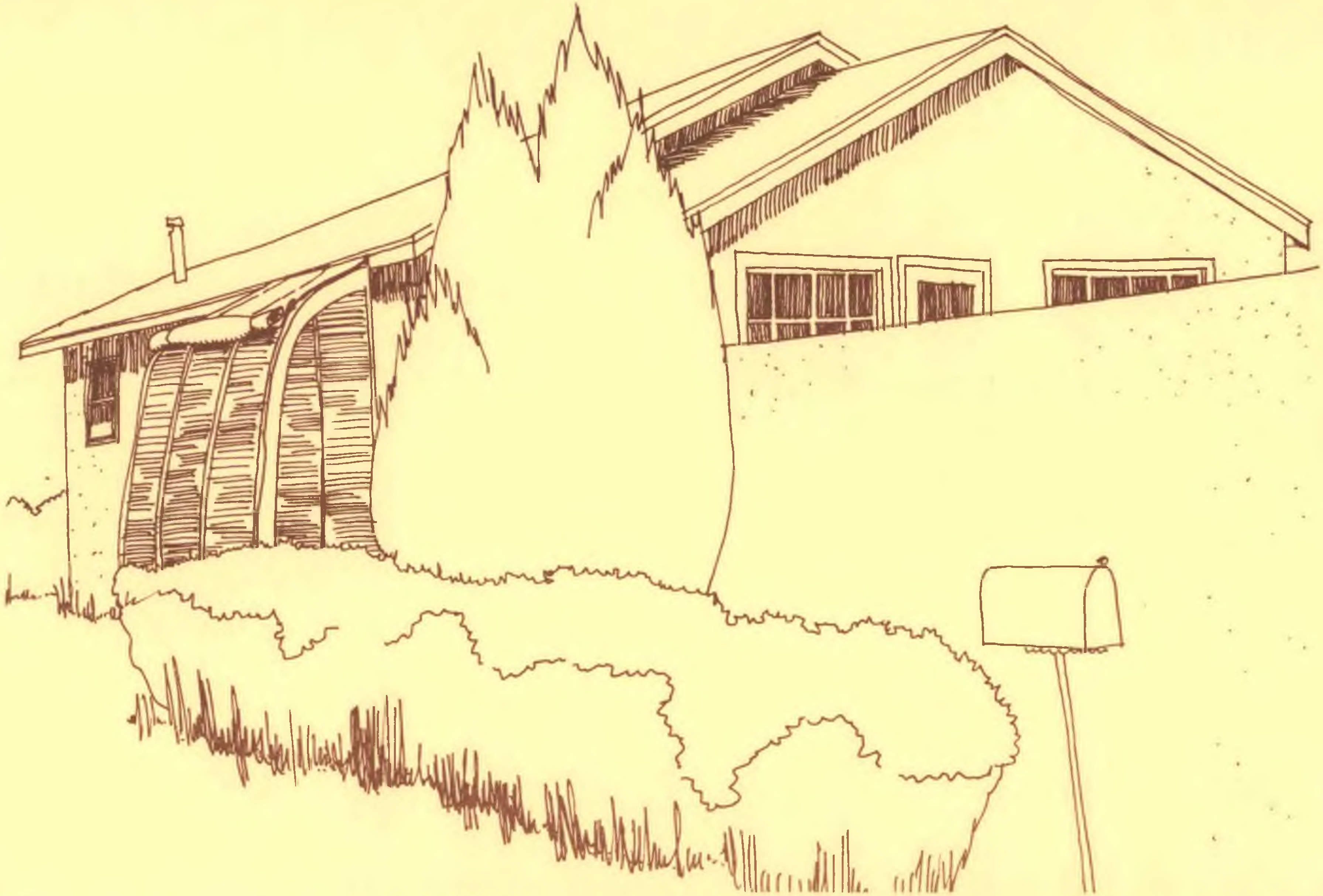
Whatever your energy-saving goals may be, we hope we have presented you with some resources to use in reaching these goals.

A Conservation, Solar, and Other Renewable Technologies

Conservation Technologies

Solar Technologies

Other Technologies



Most of us tend to think of energy efficiency in buildings in terms of the performance of the building envelope (walls, floors, windows, etc.) or of the heating or cooling equipment. Although these are important aspects of improving energy efficiency, they are by no means the only considerations. We need to think of energy efficiency in terms of the total building system in all seasons. How the building is situated on a lot (orientation), how the lot is landscaped, and how the building adapts to different seasons also are important factors.

Buildings now consume about one-third of the energy used in the US; energy demand for space heating and cooling dominates this consumption (Solar Energy Research Institute 1981, p. 11). By becoming aware of and applying technologies that can reduce this consumption in our buildings, we can reduce the overall consumption of energy in this country.

Heat loss and heat gain, or thermodynamics, are the basic principles to be grasped in understanding how conservation and solar energy technologies work. In the winter, we obviously want to reduce heat loss and enhance heat gain. Conversely, we want to reduce heat gain in the summer. A total building system, which is sensitive and adaptable to these principles by season, is our goal in obtaining energy-efficient buildings. The idea is to "weatherize" each building. This appendix will introduce you to the technologies that can achieve this goal. Because we have kept the descriptions brief, you may want to see Appendix F for further readings.

Heat loss/heat gain works on three basic principles of thermodynamics: convection, conduction, and radiation. Convection is the transfer of heat by a fluid in motion, either a liquid or a gas. Convective losses or gains, depending on the season, occur in the following areas: the chimney, open doors, and cracks around doors and windows. These losses and gains are also referred to as infiltration and exfiltration. Conduction is the transmission of energy from one molecule to another that results in a change in temperature. Conductive losses occur *through* materials in the walls, windows, doors, floors, and ceilings. The third heat-transfer principle, radiation, is responsible for the sun warming the earth. Radiation is the transfer of heat to an object by electromagnetic waves, which heat objects, not the air between the objects. It is the prime heat-transfer method in various types of radiant heaters, including fireplaces and wood stoves. Radiation is important in many types of passive solar heat storage systems, which will be explained later in this appendix.

We can determine the basic thermal performance of a building by doing heat-loss calculations based on the principles of convection and conduction. See Appendix C for an explanation of how to rate the thermal performance by determining the net heat loss of a building (an important aspect of an energy audit).

There are simple low-cost conservation options for dealing with heat loss/heat gain.

Landscaping should be carefully planned. Conifers or evergreens can be planted on the north side of the building to help cut down the prevailing winter winds. A berm (earth shelter) can also serve the same purpose. Deciduous trees, or trees that lose their leaves, can be planted to shade in the summer and to admit sunlight in the winter on the south side of the building.

Window and door coverings help us take advantage of the sun; open the draperies on the south side during the day in winter, close them in summer. Use insulating shades or shutters to control the flow of heat—open on summer nights, closed on the west side when the sun is not desired, closed on winter nights to avoid loss. Shading devices placed on windows can be oriented to allow winter sunlight to enter the room and summer sunlight to be deflected or shaded. Plastic or glass storm windows and doors can also act as buffers or increase the R value of the opening.

Caulking/weather stripping can reduce loss from infiltration, or convective heat transfer—either heat gain from the outside in (in summer) or heat loss to the outside (in winter). This option makes the building tighter by essentially plugging holes.

Insulation placed in the attic, walls, or around the perimeter of the foundation can cut down on conductive heat transfer. There is no material that will completely stop the flow of heat. There are materials, however, that inhibit or restrict this flow. Each of these materials has an R value that indicates how well the material resists heat loss. The higher the value, the more the resistance. An R-19 ceiling is more effective at reducing heat loss than an R-9 ceiling. Insulating an existing building can be more costly and time consuming than other weatherization options.

Heat-recovery devices capture heat that would otherwise be wasted. An example of where such devices are useful would be kitchen vent hoods and clothes dryer vents. In larger buildings that use a central ventilation system, heat-recovery devices also may be very effective. A heat-recovery device installed in any of these systems simply extracts the heating or cooling potential from the exhaust air and adds it to the incoming fresh air. Another example is a device for recovering heat from waste water, such as that found at large laundry facilities.

Efficient use of mechanical systems and equipment saves energy. Appliances, lights, furnaces, and air-conditioning equipment must be in working order. For example, most oil and gas furnaces run at about 40% to 80% efficiency. The rest of the heat goes up the flue, or fuel is wasted by inefficient pilot lights. Modifications can be made to the systems to bring them up to 75% to 80% efficiency. When replacing mechanical equipment and appliances, purchase ones with high energy-efficiency ratings.

Passive and active solar technologies can capture energy to assist in maintaining our comfort zones, or effectively controlling heat gain/heat loss to our advantage. This sourcebook emphasizes passive solar technoligies, but the other solar technologies are discussed so you will be aware of them.

Although some parts of the country receive more sunshine than others, the use of solar energy for heating has been shown to be effective in all sections of the US. In very sunny areas, it is often economical to supply a major percentage of a building's heating needs with solar energy; whereas in more severe climates with less sunshine, it is often better to concentrate on smaller systems that offset perhaps 20% to 30% of the heating load yet are cost effective.

Passive Solar Heating

Passive solar systems involve designs that collect, deliver, and/or store the sun's heat by natural means; no pumps, fans, or other devices requiring outside energy are used. Actually, any building that receives sunlight during the heating season is, to some extent, heated by passive solar energy; this is unintentional in most structures. Approaches to passive solar heating include the following.

Direct gain is the use of substantial amounts of glass on the south facade of a building. To operate effectively, provisions must be made for summertime shading and nighttime insulation of the glazing in very cold climates. If the glazing is sized to contribute more than about 20% of the building's heating needs, some form of thermal mass (usually masonry or containerized water) is needed to store part of the heat for the night. Mass also contributes to reducing temperature swings from day to night by stabilizing the air temperature. The daytime heat is absorbed in the mass and released at night back into the room.

Trombe walls and water walls are simply walls of masonry or containerized water directly behind south-facing glazing. Both systems are very effective because of the built-in thermal storage and the moderating effect they have on temperature swings inside the building. The solid masonry walls of existing buildings often make ideal retrofit Trombe walls. All that is needed is to frame out the south wall and add glazing (either glass or one of the numerous specially fabricated plastics).

Sunspaces are popular because they can serve as a greenhouse or solarium as well as provide heat. In essence, they are simple glass rooms that are built into (or added onto) the south side of a building. The excess hot air produced on sunny winter days is allowed to flow into the building, thus helping to offset the heat load; in the summer the excess hot air is vented to the outside. A miniature version of the sunspace is a window-box greenhouse, which can easily be moved from one location to another, making it the ideal retrofit for renters.

Thermosiphon air collectors (also known as natural convection collectors or convective loop collectors) are simple solar collectors that are built into or

retrofitted onto the south wall of a building. The heated air in the collector rises and flows into the building, drawing cool air from the building to be warmed in the collector. They are favored for retrofits on frame buildings and generally are sized to supply 20% to 30% of the heating needs. Larger thermosiphon systems, incorporating thermal storage, have also proved to be very effective. These passive solar collectors are especially effective in very cold climates, because the glass does not become a source of heat loss at night. Small thermosiphon collectors that fit into south-facing windows (often called window-box heaters) are simple retrofits which, like the window-box greenhouse, can be moved when the owner or renter moves.

Roof ponds use large shallow ponds of water on specially designed roofs to capture and store the sun's heat. Many variations of this system are possible; and some may double as passive cooling devices in the summer. They are generally suitable only for new buildings or new additions to existing buildings, because of the weight the water adds to the roof.

Active Solar Heating

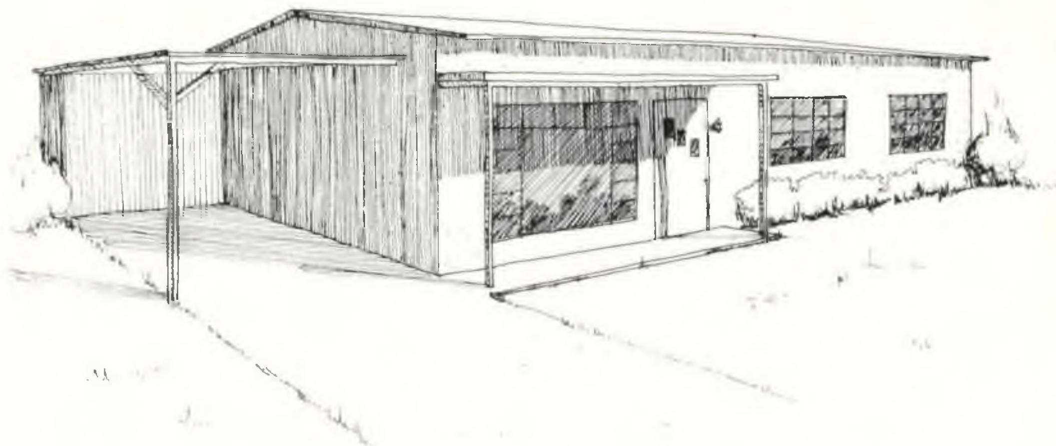
Active solar systems involve the use of special collector panels that have air or liquid pumped through them on sunny days. These systems are also referred to as solar furnaces. They usually incorporate special thermal storage, either rock beds or water tanks, to hold the heat until it is needed. Often, active systems will be used for both space and water heating. Various schemes to use active collectors for summertime air conditioning have also been tried, with mixed results.

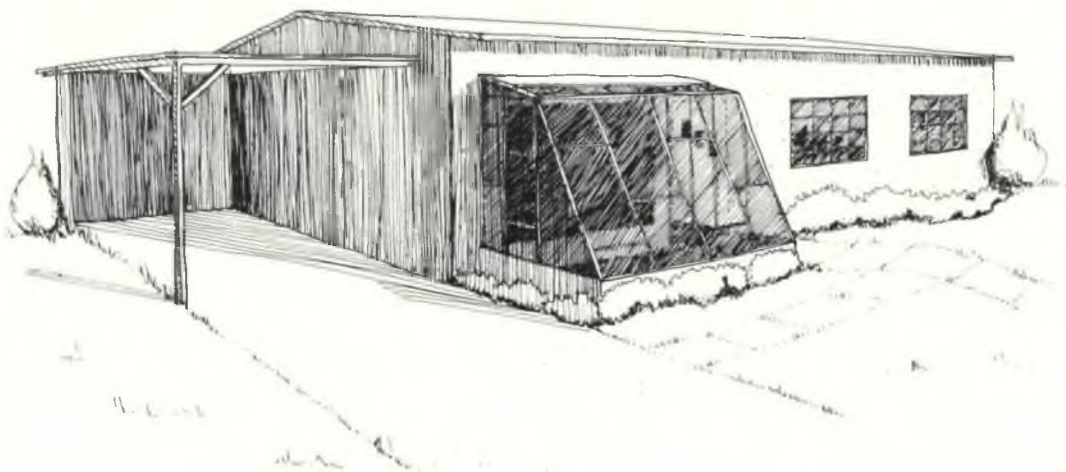
Active collectors are commercially available in all parts of the country (see your telephone book Yellow Pages). Generally, such a system is sized and installed by professionals after a thorough examination of the building and its heating needs.

Solar Hot Water

Solar hot water can be provided by either active or passive devices and is generally very cost effective because the system is used year round. Batch hot-water heaters (or breadbox water heaters), which are just black water tanks in glazed and insulated boxes, as well as thermosiphon water heaters, which use natural convection to circulate the water between collector and tank, are both simple and efficient passive systems that have been used for decades in this country and abroad.

Active hot-water collectors are most suitable where the collectors must be placed above the water tank. They are commercially available in many varieties. Very simple, often unglazed, collectors for heating swimming pools have enjoyed large commercial success. High-temperature collectors, which often use concentrating and/or tracking devices, have also shown promise, particularly for providing industrial process heat.





Solar Cells (Photovoltaics)

Sunlight may be converted directly into electricity at reasonable efficiencies (about 10%) with silicon solar cells. These cells are currently too expensive to compete with utility electricity, except in remote areas; however, the price has been dropping rapidly. Many people predict that within 5 or 10 years it will be cheaper to buy a photovoltaic system and produce your own electricity than to buy it from the utilities.

Wind Energy

Windmills and wind chargers have enjoyed a comeback with increasing fuel prices and new Federal laws that require utility companies to buy back extra electricity produced by wind machines (as well as solar cells and other devices). Wind systems for producing electricity generally are feasible only in locations that have an average annual windspeed of 12 miles/hour or more. There are also many codes and restrictions that may prohibit wind machines in developed areas.

Wood Heating

Wood burning stoves are a blessing in communities that have cold winters and plenty of trees. There are often concerns, however, about the long-term availability of wood in some areas and about the air pollution effects. If your community relies heavily on wood as fuel, it would be wise to conduct a study of the wood resources in your area.

Hydroelectric Systems

Small-scale hydroelectric plants have a long history of reliable and efficient performance. If a river or good stream exists in your area, especially one with an existing dam, find out who owns the rights to the potential power. There are many laws governing rivers and streams, but if you can work out the legalities, a small-scale hydroelectric plant is another good source of renewable energy.

Other Renewable Energy Resources

The list that we have started here goes on and on. Many agricultural products can be used to make alcohol fuels. Manure from domestic animals can produce biogases with high-grade fertilizer as a by-product. Heat and electricity can often be generated from geothermal sources, especially if you live on a thin part of the earth's crust. Ocean tides and waves, which contain enormous quantities of energy, are just beginning to be harnessed.

The limiting factors for renewable energy resources are economics and your creativity. The cost of energy from these resources will become more competitive as fossil-fuel resources continue to dwindle. Your creativity can have a major impact. Look around you. Your community was probably once energy self-sufficient. With a little help, it may be once again.

B Energy Auditing

Residential Audits

Nonresidential Audits

An energy audit is the examination of a specific building and its past records to identify its energy usage as well as its possibilities for conservation and solar retrofits. Energy audits are an extremely useful tool because they clearly identify energy consumption problems at hand and recommend specific solutions.

The energy audit is also a useful planning tool in that the combined information from individual audits can provide city-wide information about energy use in buildings. City or neighborhood energy use information is necessary to carry out an economic analysis. The audit procedure also provides an inroad for informing the community of the potential benefits from conservation and solar retrofits. As explained in Chap. 4, the audit is a very important aspect in initiating a local energy program. The audit can stimulate people to make individual choices that add up to a more energy self-reliant community as a whole.

The success of the audit is related to how much the individual building owner trusts your methods.* If you can demonstrate the potential for savings or comfort, your credibility will increase. One way to achieve this goal is to systematically approach all the homes or all the commercial buildings in a given neighborhood as a demonstration project. The effect is much more visible than audits and follow-through retrofits on buildings scattered throughout the city.

*Telephone conversation with Brian Angus of the Montachusetts Opportunity Council, July 1981.

Generally, detailed professional energy audits are not performed on single-family residences for two reasons. First, residences consume relatively small amounts of energy; thus, the potential for savings may not justify the expense. Second, residential energy use is generally controlled by one or two people who (we hope) understand the whole system and are not apt to make obvious mistakes, such as running the heat as well as the air conditioning at the same time.

A residential audit can range in detail from a simple walk-through to a more thorough heat-loss/heat-gain evaluation. A walk-through can be as basic as simply pointing out obvious energy-wasting areas, such as an uninsulated water heater, gaps under doors, or leaky windows. The more detailed residential audit includes an analysis of the building components to determine amounts of heat lost or gained. In any case, the audit should identify the problem areas and suggest solutions for them.

If a homeowner does his or her own audit, it is referred to as a Class B audit. Some of the information can be incorrect, because most homeowners are not trained in audit procedures. More accurate (Class A) audits can be obtained by people trained in performing audits.

In small comunities or neighborhoods, it is a good idea to train volunteers from existing organizational channels, rather than to hire and train a group of people to perform audits as an ongoing source of employment. The reason for this approach is that in a short time all the residences will have been audited and the trainees will be out of work.

In large communities, or in areas where the city would like to continue the audit procedures to monitor the energy saved from conservation actions, it may prove useful to initiate a training program or hire a group of professionals to oversee the on-going audit procedures. Thus, the audit should be tailored to fit the needs of the community and the resources you have at hand.

Surveys, which are a type of Class B audit, can be useful in obtaining information on energy usage in the city or county. A properly designed survey can give the local program an insight not only into the characteristics of the structures, but also into the "lifestyle" habits of the residents.

We used a survey in Albuquerque to obtain a "quick and dirty" view of energy consumption characteristics for the City's residential structures. We decided to distribute questionnaires through the Albuquerque Public School System to eighth grade students. We approached the middle schools because they provided us with an easy point of access into the community (we live over 100 miles from Albuquerque), with a way to obtain a fairly representative sample (assuming school districts represent a fair cross section of the population and building types), and with a means to educate both the students and their parents on the uses and benefit of conservation and passive solar technologies.

The children were first introduced to the concepts of heat loss and solar gain, then asked to take home a heat-loss questionnaire (reproduced at the end of this appendix). The questionnaire contained "information" questions that were designed to get the children to think about their home—for example, what is on the ground outside? In our discussion, we had explained how the type and color of material outside was related to heat absorption and reflection.

Answers to key questions (insulation levels, window and door sizes, construction types, etc.) were fed into a calculator program designed to evaluate thermal characteristics of the home (see Appendix C). We were able to come up with a range of heat loss based on the responses. In addition, the children received information about passive solar and conservation concepts. Their parents were provided with the estimated percentage of heat loss from various components of their home (floor, ceiling, walls, windows, doors, etc.), a performance rating of excellent to poor for the whole house, and a list of improvements that they might want to make (see the letter to parents at the end of this appendix).

The results of this approach were mixed. The following list details the advantages and disadvantages of the approach as we saw them.

Advantages

- The survey offers a means of obtaining information on the characteristics of the local houses and consequently can provide a basis from which to make informed assumptions.
- The survey can provide information on residents' attitudes toward conservation and passive solar retrofit technologies. It also may be used to determine local awareness of incentives and preferences for possible program forms.
- The survey can be educational to the community and stir their interest in conservation and solar technologies.

Disadvantages

- A survey method can be time consuming.
- It may be hard to get people to bring the questionnaires back. This may be a particular problem when children are responsible for getting the questionnaires home, filling them out with their parents, and then returning them.
- The accuracy of the data is questionable. Many people are unknowledgeable about the

construction and energy characteristics of their homes.

- Verification of the accuracy of the sample is hard to achieve without an inordinate expenditure of time.

If you use this approach, keep these points in mind.

- Be prepared to return the information quickly. We hadn't worked out the procedures for doing the calculations and returning the responses. By completing the procedures quickly, you can pick up the questionnaires and return the calculation results at the school, thus avoiding postage costs. The students also remember the project better and absorb the results more completely.
- Go directly to the teachers. We placed an ad in the teacher newsletter. This avoids some administrative costs and saves time. Teachers approach you because they are interested in the project not because it was forced upon them by their superiors.
- Use as many audiovisuals as possible and avoid lengthy technical discussions. Be brief, lively, and to the point. Provide the students with measuring tapes and paper. You might not get them back, but you'll get more accurate results.

We did not achieve a particularly representative sample at the schools from which to draw conclusions. This problem arose because we could not select the schools that would represent a cross section of the City. The schools that we surveyed (7 with a total of 128 questionnaires) were determined, in effect, by the teachers who were interested enough to invite us to their classes. You should ensure that you exercise greater control over the administration of the survey. This problem was complicated by the fact that the return rate on the questionnaires varied widely by school. This served to further affect the representativeness of our sample.

A survey may be a particularly useful tool in developing a data base, but you should be careful in how you design the questions (make them easy) and in how you administer it. We believe that the questionnaire may be particularly effective in analyzing energy characteristics at the neighborhood level, where the sample would be smaller and the houses more similar in age, type, and condition. The questionnaire can also be effective in transferring information to neighborhood residents and stirring their interest in a local retrofit strategy.

We also used a survey to determine the thermal characteristics of mobile homes. In this instance, we delivered the questionnaires directly to the occupants. We encouraged their participation by providing them with a free brochure about weatherizing mobile homes. The accuracy of the information was much better because we visited the homes personally, verifying heating unit types, orientations, window area, etc. The problem with this approach is the time required to distribute and pick up the questionnaires.

Other low-cost approaches that have proven effective in other communities all center around the volunteer method. People from the neighborhood can be recruited and trained to carry out the audit. Again, this approach can vary from a simple walk-through with no report, to a detailed heat-loss analysis. A most effective approach seems to be somewhere in the middle—a simple two-page form of calculations of the more cost-effective solutions. For example, in the Northeast, people can grasp that caulking and weather stripping will prevent heat loss from infiltration and that attic insulation will prevent heat loss. Each is an effective method of cutting back energy costs.

Volunteer auditors can come from many places. Here is a list to start with. Be creative.

- City employees—as a campaign to start off the local program (see the discussion about St. Paul in Chap. 4).
- Fire fighters and police officers, if they are not busy all the time.
- Boy Scouts/Girl Scouts—as a way to earn merit points.
- Religious and civic groups—people generally concerned about the well-being of their community.
- Schools and colleges—as a way to earn class credit or as an organizational project.
- Social workers—while on other assignments, they can point out energy problems.

For nonresidential buildings, there are many different variations and intensities of energy audits, from simple walk-through audits to detailed audits. The best audit, for any particular building, must be determined by size and complexity of its energy use.

For example, it would not make sense to perform a professional detailed audit on a small retail shop that has reasonably low utility bills. Although the result of such an audit might produce a 20% or 30% energy savings, the dollar amount would be small and probably not justify the initial investment. On the other hand, a simple walk-through audit performed by a trained auditor (or even the shop-owner with the appropriate literature) would probably be very cost effective because the investment is small.

Very large buildings, on the other hand, often consume vast amounts of energy and offer great potential for savings. Furthermore, their energy use patterns are often complex and not well understood by the users. For such buildings, energy audits are almost indispensable. The intensity of the audit can, and should, be varied according to the amount of energy consumption of the building in question. All nonresidential energy audits will address

- ventilation,
- infiltration,
- insulation,
- heating and cooling equipment,
- solar heat gain,
- lighting, and
- hot-water systems.

Aside from analyzing each particular system, a thorough audit will examine the interrelationship of all systems to determine the net effect of potential changes. This is very important, because each energy system will affect others. For example, take a government building that has excessive heating bills during the winter. At first glance, it might appear that they have two possible options, either replace their old heating system with a more efficient modern system or weatherproof the building (weather-strip, insulate, etc.). What they might not realize is that by weatherproofing the building, the heat load may be reduced enough so that a much smaller, and less expensive, modern heating system could handle the load. The difference in purchase price between the larger and smaller new heating systems may well offset much of the expense of weatherproofing the building; thus, the decision to perform both modifications is preferable to the decision to perform either one alone.

There are also many examples of what appears to be an energy conservation measure that actually increases the energy consumption of the building. Many modern cooling systems, for example, have an "economizer" cycle that directly introduces cool outdoor air into a building when the interior is too hot. When this cycle is run at night, it effectively cools the thermal mass of the interior, which offsets the need to run the air-conditioning units until much later in the day. However, in an effort to conserve energy, the whole cooling system, including the economizer cycle, may be shut off during the night when the building is unoccupied. Unfortunately, this will deprive the system of its ability to cool the building using cool night air and minimal power for the fans in the economizer cycle. As a result, the overall energy consumption of the building may increase because of the increased daytime use of the air-conditioning system.

Energy use in large buildings will also vary considerably depending on the type of building. Conservation measures that may be appropriate for an office building may be totally inappropriate for a hotel or die-casting plant. (In fact, DOE has published 17 separate books just dealing with the energy auditing procedures for 17 generic types of large buildings; see the "References" section of Appendix F.)

We hope the above discussion will not discourage you from dealing with large buildings, but rather make you realize the need to audit such buildings. Many of the measures recommended in an audit may seem obvious, but others will be more subtle. In any case, if the owners follow through on the recommendations, the cost of the audit will undoubtedly be paid for many times over in energy savings.

The Federal government has several programs designed to assist with energy audits. In addition to their audit books, which should be available through your state energy office, they also run training workshops for energy auditors, and will provide half the cost of detailed audits for most schools and hospitals.

When dealing with the owners of large buildings, generally the first step is to convince them of the value of doing an energy audit. Explain what will be involved and what they can expect as a result. Encourage them to start with a walk-through audit.

Walk-Through Audits

As the name implies, walk-through audits are usually quick and simple (also inexpensive). The auditor will need to review the building's utility bills for the past year as well as get information on typical usage patterns of the building (when people arrive for work, when certain equipment is used, etc.). The auditor will then proceed through the building with a checklist of questions and note the type and condition of various equipment and of the building envelope.

The purpose of a walk-through audit is to obtain an overview of the building's energy consumption with specific data on heating, cooling, ventilation, lighting, and other major energy-consuming functions. Once an energy profile of the building is established, possibilities for conservation and solar retrofits can be identified. Typical recommendations might include reducing the number of lights, using high-efficiency bulbs, installing timer thermostats to allow for temperature setbacks during unoccupied hours, installing time controls on the lighting system, improving maintenance on heating and cooling equipment, and upgrading the building envelope.

In most states, a person can take a 2-day course to qualify as an auditor for simple walk-through audits (check with your state energy office). *The level of expertise is not great, but the standard forms that these auditors generally use makes it difficult to go too far wrong.* In fact, such walk-through audits can generally be done by part of the building's own staff, if they are supplied with the necessary books and forms. Some utilities also provide auditors (see the analysis from such a walk-through audit performed by the Public Service Company of New Mexico included at the end of this appendix).

Although walk-through audits only address fairly obvious issues, the resultant recommendations for no-cost or low-cost changes can often cut energy consumption by 10% to 20% or more. They also can help pave the way for a detailed energy audit.

Detailed Energy Audits

Large buildings that use considerable amounts of energy will need to undergo a detailed energy audit to identify the best possible options for conservation and solar retrofits. The actual procedure involved is flexible and should be determined by the auditors and owners after a review of the size and complexity of the situation (often evident in the report of a walk-through audit).

Usually, a team approach works best for detailed audits. A very extensive audit team might include a mechanical engineer, an architect, a contractor(s), an energy consultant, an illumination engineer, and an appropriate member of the building's management or staff. Many situations can be handled primarily by an engineering firm familiar with energy audits. The information on the building and its systems that the auditor will need includes

- building plans and specifications,
- energy-consumption records (3 years),
- weather data for that area,
- operation and maintenance records,
- information on any changes to the building or equipment in the recent past,
- utility rate structures, and
- relevant building (and other) codes.

The audit itself will include a detailed study of the building and all relevant equipment. Tests and measurements are performed as necessary, and user patterns and maintenance schedules are examined.

When all the data are compiled, the auditor makes a thorough investigation of all possible modifications, looking for the proper mix that will result in the most economical solution for the building as a whole. For large, complex buildings, computers are often used to simulate the effect of various modifications.

The result of a detailed energy audit is a report that includes

- existing energy use patterns;
- quantified energy uses for various functions;
- recommended changes in
  - — user patterns,
  - — maintenance schedules,
  - — equipment, and
  - — the building envelope;
- potential for conservation and solar retrofits;
- interrelationship of possible changes;
- economics of changes; and
- recommended feasibility studies for particularly difficult or expensive changes.

The final report should be tailored to the requirements of the owners or managers concerning acceptable payback periods and maximum initial investment. The cost for a detailed energy audit can vary significantly but is often about $0.10/ft^2$.

As a planner, you may not be involved in the particulars of detailed energy audits, but an understanding of the procedures can be helpful. Whenever possible, review the final reports of such audits; they may provide some insights into energy consumption in your community and suggest potential remedies.

HOME HEAT LOSS QUESTIONS

Name ______________________________ Phone ____________________

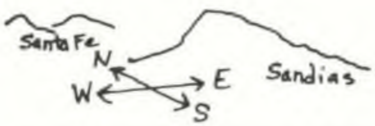
Address ____

Use a pencil so you can erase if you goof. Do your arithmatic on the paper we provided. Get your mom or dad to help and be careful when you measure. Don't fall!

1. When was your house built? year ____________________

2. About which direction does the front of your house most directly face?

- ☐ North
- ☐ East
- ☐ Northeast
- ☐ Southeast
- ☐ South
- ☐ West
- ☐ Northwest
- ☐ Southwest



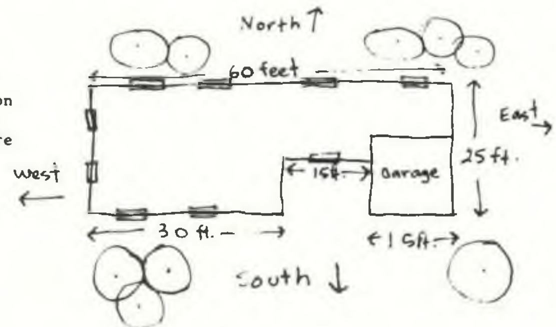
3. Is your house shaded on the south...

- ☐ by a tree that loses its leaves?
- ☐ by a tree that keeps its leaves?
- ☐ by another building?
- ☐ combinations; explain below.

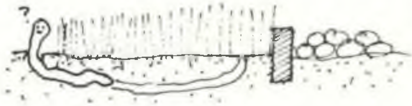
4. If your house is shaded on the south by another building, how close is it? feet ____________________

How tall is it? feet ____________________

5. Draw the floor plan of your house on the back of this page. Be sure to show where the windows and trees are located. Show the orientation, (N., S., E., W).



6. What is on the ground by your house?



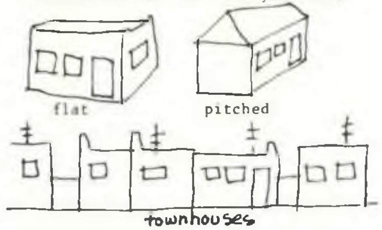
- ☐ grass or some other plants
- ☐ sand, gravel, concrete or a light colored material
- ☐ dark colored material

7. What color are the outside walls of your home?

- ☐ light (white, gray or pastels)
- ☐ medium (beige, tan)
- ☐ dark (dark red, brown, green, black)

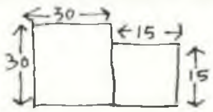
CONSTRUCTION

8. What kind of house do you have?



- ☐ 1-story flat roof ☐ 1-story pitched roof
- ☐ 2-story flat roof ☐ 2-story pitched roof
- ☐ apartment house ☐ mobile home
- ☐ town house ☐ duplex
- ☐ split-level flat roof
- ☐ split-level pitched roof
- ☐ other ____________________

9. What is the square footage of the <u>heated</u> living area in your home? (Don't include unheated garages or storage spaces.) To do this, think of your house as a box, or a couple of boxes put together. Measure the length and width of each; multiply to find the area and add together.

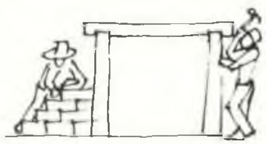


example: (see below)

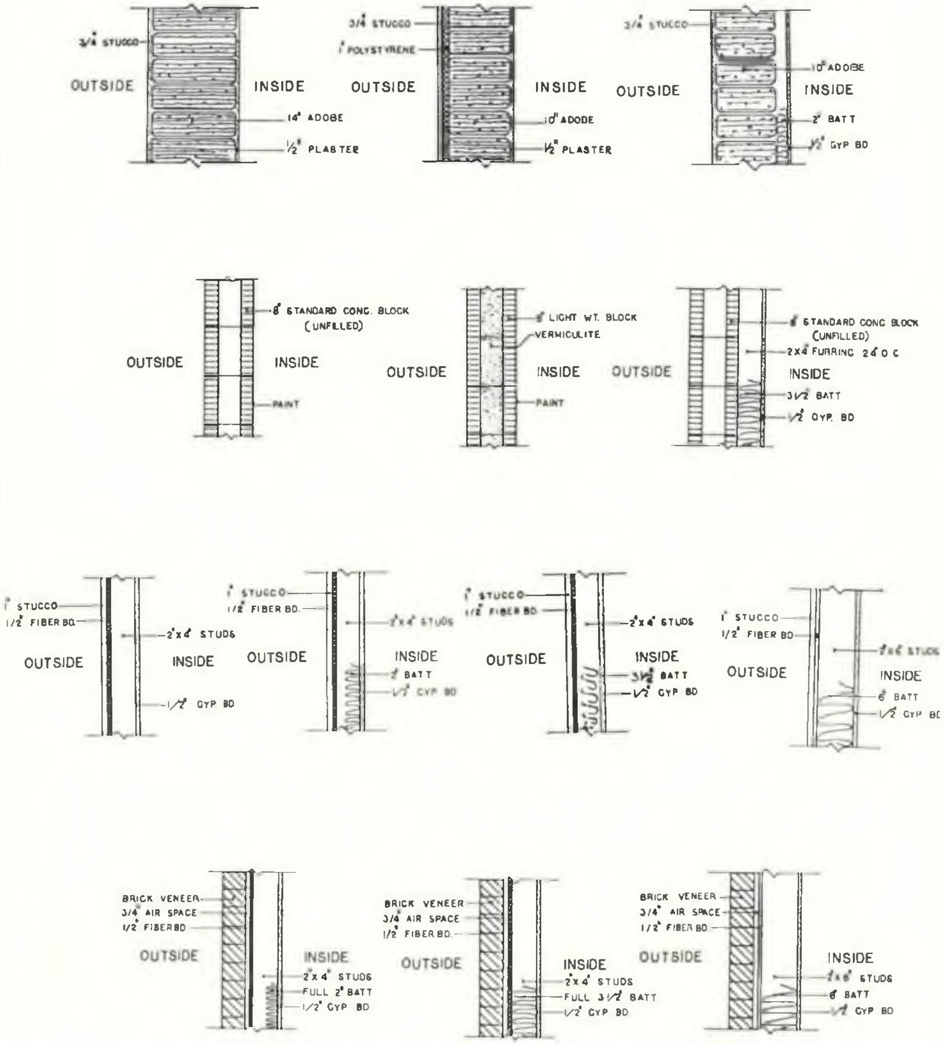
30 X 30 = 900 ← Box 1
15 X 15 = 225 ← Box 2
Total = 1125 ft (square feet)

answer ____________________

10. How was your house built?



- ☐ wood frame with
  - a. stucco
  - b. brick
  - c. metal
- ☐ concrete blocks or stone blocks
- ☐ cinder blocks
- ☐ adobe
- ☐ other ____________________



Circle your wall type.

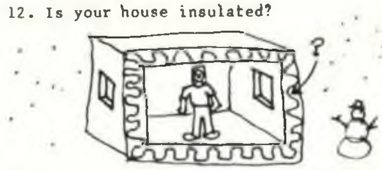
DECO UNM

11. What kind of floors are in your house?

☐ concrete slab ☐ concrete on wood beams
☐ wood on wood beam ☐ other ☐ don't know

12. Is your house insulated?

☐ yes
☐ no
☐ don't know



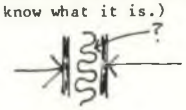
13. About how many inches of insulation are in the:

(State the R value of the insulation if you know what it is.)

walls ____________________

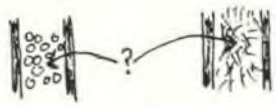
ceiling ____________________

floors ____________________



14. What does the insulation look like? (Place a W (for walls), C (ceilings), and F (floors) by the type of insulation that is in each.)

Blankets or batts ____ Rigid board____
Loose particles ____ None present ____
Foam ________ Dont't know ____



15. Touch the walls in your home during the evening. Are they warm or cool?

☐ cool
☐ cold

WINDOWS

16. How much draft can you feel around doors and windows on cold or windy days?

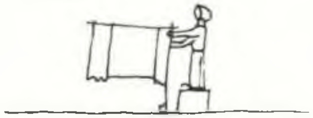
☐ quite a lot
☐ some
☐ very little
☐ none

Hold a candle in front of the window. What is the reaction of the flame?

☐ blows out
☐ flickers

17. Measure the windows in your house. Go from room to room and measure all of them. Find out how wide and how tall each of them is. What are they made of? (wood on the side, metal on the side)

Put a sunshine by the answers for windows on the south of your house!



window size	material
(example 20" x 30"	wood)

18. What type of covering is on the majority of your windows?

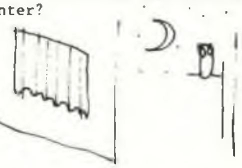
- ☐ heavy curtains
- ☐ light curtains
- ☐ plastic
- ☐ foam panels
- ☐ foil
- ☐ two windows/storm windows
- ☐ other

Do your parents remove the covering on the south side to let the warm sunshine in during the daytime?

- ☐ yes
- ☐ no

Do your parents usually close the window cover at night in winter?

- ☐ yes
- ☐ no



Circle your window type

DOORS

19. Now, measure the doors that go outside. What are they made of? (Wood, wood with glass windows, metal and glass)

Put a sunshine by the doors on the south of your house!

door size	material

How many of your exterior doors have storm doors? ______

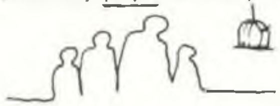
Are your doors or windows caulked or weatherstripped?

- ☐ yes
- ☐ no

LIFESTYLE

20. What temperature do your parents try to keep your house in the winter? day ________ night ________

21. How many people live in your home? Number ________________

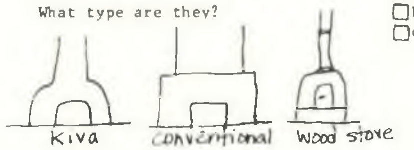


22. What kind of heat do you use in your house.
- ☐ gas
- ☐ electric
- ☐ wood

23. How much was your last months heating bill? amount ________________
What period of time did the bill cover (e.g., 9/5/80 - 10/10/80, 10/8/80 - 11/13/80 etc.) time ________________

FIREPLACES

24. How many fireplaces are in your home? number ________________
What type are they?
- ☐ kiva
- ☐ conventional



25. Do the fireplaces have heat recovery devices (e.g., tube type grates, heatilators)?
- ☐ yes (type of device) ________________
- ☐ no

Do your fireplaces have glass doors?
- ☐ yes
- ☐ no

Does your family use a wood stove for heating? (Which room is it in?)
- ☐ yes (location) ________________
- ☐ no

How often is the fireplace used?
- ☐ daily
- ☐ weekly
- ☐ monthly

FINANCING

Questions 26 and 27 are for your parents:
NOTE: Please answer them honestly. We are attempting to determine the public's knowledge of government financial incentives.

26. a. Are you aware of the Federal tax credit which allows 40% of the cost of approved alternative energy systems (maximum credit allowed is $4,000) to be subtracted from your Federal tax liability? ☐ Yes ☐ No

b. Are you aware of the Federal tax credit which allows 15% of the cost of approved energy conservation measures (maximum credit allowed is $300) to be subtracted from your Federal tax liability? ☐ yes ☐ no

c. Are you aware that the state of New Mexico offers a 25% tax credit on the cost of approved alternative energy systems (maximum credit allowed is $1,000)? This credit may be subtracted from your state income tax liability. A rebate will be provided if your tax liability is less than $1,000. ☐ yes ☐ no

27. If solar could help you save money on your energy bills, which way of financing its costs would you prefer?

a. Short term home improvement loan
b. Have the gas or electric utility finance the improvement and repay the debt as a portion of your monthly utility bill.
c. Mortgage extension
d. Use cash or savings
e. Have all costs transferred to the electric bill
f. Have costs transferred to the gas bill

28. Have your parents done any conservation or solar work on your house? Write about it below! ☐ yes ☐ no

THE END. THANK YOU VERY MUCH!

Los Alamos

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

Analysis and Assessment Division
Economics Group, MS-605
Reference: S-2/81-410

May 21, 1981

Dear Students and Parents:

Thanks for your help in filling out our questionnaire. The information that you have provided to us will prove useful in our work at Los Alamos.

The evaluation of your home was conducted utilizing ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers) steady state calculations. These figures are expressed in BTUs/Degree Day/square feet. This figure multiplied times the degree days for Albuquerque (4292) times the square footage of your home should theoretically determine the amount of BTUs necessary to heat your home. This figure may be divided by 100,000 to determine therms in the case of gas heated homes or by 3413 to determine KWH if the home is heated by electricity. The following intervals were used to rate the energy efficiency of your dwelling.

BTU/DD/Sq. Ft.	
1 - 6	Excellent
6.1 - 9.4	Good
9.5 - 11.9	Fair
12.0 - up	Poor

(Source New Mexico Energy Institute)

The actual amount of energy used by your home for heating must take furnace combustion losses into account. We assumed a general efficiency level of 60% for gas heated homes while electricity heated homes are assumed to be 100% efficient. We attempted to simulate real conditions in homes by adjusting the theoretical load mentioned previously for internal gains (people, appliances, light) and solar gains through south facing glass. This net figure was divided by .60 in the case of gas homes to determine the actual amount of energy used. The resulting number was then divided by 100,000 to obtain therms and multiplied by .35 (therm) to obtain a dollar cost for an eight month heating season. The amount of energy required to heat an electric home was determined by dividing the heating load by 3413 and multiplying by .07 (KWH).

This analysis should by no means be considered to be a guide from which to choose energy conservation options. It is only based on calculations derived from the ASHRAE Handbook, fundamentals which have limited ability to account for actual conditions in homes. These calculations are only designed to give us a general idea of the energy efficiency of Albuquerque's building stock. We cannot totally account for "lifestyle" considerations which heavily impact on energy usage. We also are dependent on the accuracy of the data which you have provided to us. The limited accuracy of our analysis is only correct insofar as the information that you have provided us is correct.

We feel that this analysis may suggest some possible areas where energy and dollar savings may be achieved. We strongly recommend that you contact an energy audit firm or one of the utility companies before you undertake any improvements however, they can perform an audit, or will be able to refer you to firms qualified to conduct the more comprehensive analysis necessary to determine the conservation and/or solar retrofit options most appropriate for your home.

Sincerely,

Virginia Parsons
Rick Mathews

Virginia Parsons
Rick Mathews

VP:RM:bl

xc: S-DO
Fred Roach

Name ______________________

Address ______________________

HEAT LOSS ANALYSIS

Heat Loss Coefficient ______________________
(Btu/Degree Day/Square Foot)

Rating	Excellent	Good	Fair	Poor
	___	___	___	___

Percentage Heat Loss by Component

	BTU/DD	%
Windows		
Doors		
Walls		
Ceiling		
Floor		
*Infiltration		
TOTAL		

OPTIONS

The conservation options that are presented below represent actions that you might wish to undertake to reduce energy consumption. The limitations of this analysis prevent us from making specific recommendations. The analysis presented above should only be used to give a preliminary idea of where energy savings might be achieved.

Thank you very much for your assistance in this project, we hope it has been as helpful to you as it has to us.

Estimated Energy Consumption for Heating (8 months) ______________ BTUS

Estimated Cost for Heating (8 months) $ ______________

*Cracks around doors, windows, door and window frames, wall outlets, other openings in building envelope

Windows	- close curtains or shades during evenings - for new window treatment select insulating drapery that fits snuggly against the walls - place plastic sheeting over windows during cold months - make storm windows utilizing plastic sheeting - install energy efficient shades or styrofoam panels over windows at night - install storm windows - install double pane windows
Doors	- install storm doors - weatherstrip - build a locking vestibule or entry room - enter and exit quickly
Walls	- install additional insulation (A detailed economic analysis should be undertaken before this expensive step is taken.)
Ceiling	- install additional insulation
Floor	- Floors above crawl spaces - install additional insulation - concrete slabs - install perimeter insulation
Infiltration	- place gaskets behind light sockets - caulk plus weatherstrip around doors and windows - Caulk 1. around windows and doors where frame meets brick, siding, or sheetrock 2. where wall meets wall 3. where wall meets roof overhang 4. around water faucets 5. between window panes and frames 6. where baseboard meets wall and floor (Best to do this where carpeting has not already been laid.) - Weatherstrip 1. around windows 2. around doors - place door sweep across bottom of door to reduce size of large crack that often exists here 3. attic entranceways

Mechanical Improvements
- insulate water heater (R-5) (when located in unconditioned space
- insulate duct work (R-5) (when located in unconditioned space)
- check furnace filter at least once a month. If unclean, replace or clean.
- make sure that supply air vents and return vents are not blocked by furniture or drapes
- if you use portable space heaters, choose these with thermostats, only use them for a short period of time and turn them off when you leave the room
- consider having qualified heating contractor inspect and tune your heating system. This can assure maximum savings on your heating bill.
- install clock thermostat

Lifestyle
- set thermostat at 68° or lower and leave it there. If you are leaving the home for several days set the thermostat around 55°.
- Learn to "climatize" yourself. Become more tolerant to temperature swings by experiencing them rather than leaving the home at constant 72°

If you think you might want to invest in passive solar for your home, you can get free expert technical advice before you invest from:

The Public Service Company of New Mexico
Albuquerque

The New Mexico Solar Energy Association
Santa Fe

The New Mexico Energy Institute
Santa Fe

PNM PUBLIC SERVICE COMPANY OF NEW MEXICO
ALVARADO SQUARE ALBUQUERQUE, NEW MEXICO 87158

March 9, 1981

Mr. Gary Mays
Yale Blood Plasma Inc.
122 Yale, S.E.
Albuquerque, NM 87106

Dear Mr. Mays:

Subject: Energy Consumption Yale
Blood Plasma Center

I would like to thank you for allowing our group to conduct an energy audit of your building. I am sure that the University of New Mexico Department of Architecture and the Los Alamos Scientific Laboratory appreciate the opportunity to use your building as part of their data base for their study.

In response to your request for an energy consumption breakdown of your various equipment, I have enclosed an itemized list of your lighting and equipment usage. I have also made certain recommendations that may help you in further reducing your energy consumption. I hope that they will be helpful to you.

If you should have any additional questions, please feel free to call me at 848-2729. Thank you again for allowing us to use your building in the commercial energy usage study.

Sincerely,

R. Frank Burcham Jr.

R. Frank Burcham, Jr.
Energy Conservation Engineer

RFB:wpc
Enclosures

	Consumption (Average)		
	kWh/Month	Cost/Month	& Consumption
Lighting			
Flourescent	697.1	$ 45.31	20.0%
Incandescent	37.4	$ 2.43	1.0%
Subtotal	734.5	$ 47.74	21.0%
Equipment			
Widman walk-in freezer	1,686.0	$109.61	48.0%
Sorvall centrifuge	944.0	$ 61.36	27.0%
Frigidaire refrigerator/freezer	79.0	$ 5.14	2.0%
Sebra tube sealer	37.9	$ 2.46	1.0%
Adams centrifuge	12.5	$ .81	0.3%
Subtotal	2,759.4	$179.38	78.3%
Hot Water			
Six gallon capacity	49.8	$ 3.24	1.0%
Total	3,543.7 kWh	$230.36	100.3%

	Seasonal Consumption	
Heating		
Gas furnace	0.7	$ 0.04
Cooling		
Evaporative	323.0	$ 21.00
Subtotal	323.7 kWh	$ 21.04

Note: These values are monthly averages only. Consumption will vary due to numerous factors: outdoor and indoor temperatures, hours of operation, preventive maintenance, and personal habits to name a few.

Insulation

An uninsulated or poorly insulated structure wastes energy by allowing heat to flow from conditioned to unconditioned areas or from unconditioned to conditioned ones. To retard this heat flow, insulation can be installed between the conditioned and the unconditioned environment. Studies indicate that 60 percent of a building's energy losses are due to this type of conductive heat flow.

Conductive losses occur in the walls, ceiling, floor, doors, and windows. The largest losses are due to the windows because of their very low resistance to heat flow. Storm windows (created by either an additional pane of glass or a sheet of plastic) can reduce these losses by almost half. Storm doors are also very effective in reducing these losses. Insulation can be applied to the existing building's walls, floor, or ceiling. Rigid board insulation can be attached directly to the surfaces or a batt or blanket insulation can be installed. For areas that are difficult to reach, a loose fill insulation may be blown into the structure (walls or ceiling). In each case, proper installation techniques are critical so that the insulation performs as designed.

Window losses can also be reduced through the use of roller shades, blinds, or shutters. Reflective film also reduces heat flow through windows; however, once it is applied to the window, it will reduce the warm, beneficial winter sun as well as the unwanted hot summer sun. It does not differentiate between the two. Shades, blinds, or shutters can be used to keep out the summer sun and opened to take advantage of the winter sun.

Caulking/Weatherstripping

Caulking and weatherstripping are the most cost effective conservation measures that one can take. It is generally less costly to pay for caulking and weatherstripping than to pay for the energy necessary to condition the air that leaks through cracks. This infiltration of air through the building envelope can contribute as much as 40 percent to the energy losses of a building.

Infiltration occurs in a number of areas--primarily at the soleplate joining the walls and the floor, around the windows and doors, and through any holes or openings in the wall (electrical outlets, pipes, vents, etc.). Caulking may be applied at the junction of the soleplate and the floor. It can also be used where the door or window frame meet the wall. Also, old putty around window panes should be replaced. Weatherstripping can be used in any area where movable surfaces come together, such as where doors and windows meet their frames. Foam or rubber gaskets can be inserted behind the electrical outlets; this can reduce infiltration losses by as much as 20 percent.

Presently, you have weatherstripping present on your door frames along with a door sweep. This is already a good step taken in the conservation direction. However, you should consider caulking around the door and window frames. Also, you should consider installing gaskets behind your electrical outlets. Both of these measures are relatively cheap and easy to do and are well worth your time. Any holes or penetrations through the walls or ceiling should also be caulked. Large cracks (wider than ¼ inch) should first be filled with insulation and then caulked.

Lighting

1) Storage/Processing Room
3 Ballast Flourescent
2 Tubes Each Ballast
96 Watts/Bulb

Each Lighting Fixture

$$2 \text{ bulbs} \left(\frac{96 \text{ watts}}{\text{bulb}}\right) = 192 \text{ Watts}$$

$$+ 20\% = \underline{\ 38} \text{ watts ballast}$$

$$230 \text{ watts/fixture}$$

Usage: 10 hours/day 5 days/week
Monthly Consumption:

$$230 \frac{\text{Watts}}{\text{fixture}} \text{ (3 fixtures)} \left(\frac{10 \text{ hours}}{\text{day}}\right)\left(\frac{5 \text{ days}}{\text{week}}\right)\left(\frac{4.33 \text{ weeks}}{\text{month}}\right) = 149{,}385 \frac{\text{watt hours}}{\text{month}}$$

= 149.4 Kilowatt hours each month = 149.4 kWh

$$@ \frac{6.5¢}{\text{kWh}} \text{ (149.4 kWh) = \$9.71 cost}$$

2) Clinic/Work Area
10 Ballast Flourescent
2 Tubes/Ballast
96 Watts/Tube

Each fixture consumes 230 watts (see above calculation)
Monthly Consumption:

$$230 \frac{\text{watts}}{\text{fixture}} \text{ (10 fixtures)} \left(\frac{10 \text{ hours}}{\text{day}}\right)\left(\frac{5 \text{ days}}{\text{week}}\right)\left(\frac{4.33 \text{ weeks}}{\text{month}}\right) = 497{,}950 \frac{\text{watt hours}}{\text{month}}$$

= 497.9 kWh each month

$$@ \frac{6.5¢}{\text{kWh}} \text{ (497.9 kWh) = \$32.37 cost}$$

3) Restrooms
75 Watt Incandescent Bulb
1 Each for 2 Restrooms

$$2 \text{ bulbs} \left(75 \frac{\text{watts}}{\text{bulb}}\right) = 150 \text{ Watts}$$

Usage: 1½ hours/day 5 days/week
Monthly consumption:

$$150 \text{ Watts} \left(\frac{1.5 \text{ hours}}{\text{day}}\right)\left(\frac{5 \text{ days}}{\text{week}}\right)\left(\frac{4.33 \text{ weeks}}{\text{month}}\right) = 4{,}871 \frac{\text{watt hours}}{\text{month}}$$

= 4.9 kWh each month

$$@ \frac{6.5¢}{\text{kWh}} \text{ (4.9 kWh) = \$.32 cost}$$

4) Reception/Waiting Area

1 Ballast Flourescent
2 Tubes/Ballast
96 Watts/Tube

Each fixture consumes 230 Watts

Monthly Consumption:

$$230\ \frac{\text{watts}}{\text{fixture}}\ (1\ \text{fixture}) \left(10\ \frac{\text{hours}}{\text{day}}\right) \left(5\ \frac{\text{days}}{\text{week}}\right) \left(4.33\ \frac{\text{weeks}}{\text{month}}\right) = 49{,}795\ \frac{\text{watt hours}}{\text{month}}$$

= 49.8 kWh each month

$@\ \frac{6.5¢}{\text{kWh}}$ (49.8 kWh) = $3.24 cost

1 Spot Light
150 Watt Bulb
Monthly Consumption:

$$150\ \frac{\text{watt}}{\text{fixture}}\ (1\ \text{fixture}) \left(10\ \frac{\text{hours}}{\text{day}}\right) \left(5\ \frac{\text{days}}{\text{week}}\right) \left(4.33\ \frac{\text{weeks}}{\text{month}}\right) = 32{,}475\ \frac{\text{watt hours}}{\text{month}}$$

= 32.5 kWh each month

$@\ \frac{6.5¢}{\text{kWh}}$ (32.5 kWh) = $2.11 cost

		Monthly Consumption
Flourescent Lighting		
Storage/Processing Room		
3 Fixtures @ 46 kWh each		149.4 kWh
Clinic/Work Area		
10 Fixtures @ 46 kWh each		497.9 kWh
Reception/Waiting Area		
1 Fixture @ 46 kWh each		49.8 kWh
Subtotal		697.1 kWh
Incandescent Lighting		
Restrooms		
2 Fixtures @ 2.25 kWh each		4.9 kWh
Reception/Waiting Area		
1 Fixture @ 30 kWh each		32.5 kWh
Subtotal		37.4 kWh
Energy Consumed Due to Lighting (At 6.5¢/kWh--$47.74)	Total	734.5 kWh

Energy Savings Potential

By replacing the existing flourescent tubes with more efficient tubes (Miser, Phantom, etc.), you can experience approximately a 15 to 20 percent savings in energy consumption.

Present consumption per month: 697.1 kWh. (Flourescent tubes only.)

Potential savings per month: (697.2 kWh) (17.5%) = 118.84 kWh savings each month.

At 6.5¢/kWh: $7.72 saved each month.

Potential annual savings: (12 months) (118.8 kWh) = 1,426.1 kWh saved.

At 6.5/kWh: $92.70 saved in one year.

Note: These projections are based on a 17.5 percent savings and an average energy charge of 6.5¢/kWh.

Savings due to the replacement of incandescent bulbs with more efficient bulbs would be minimal due to the small amount of lighting supplied by this type of lighting.

Passive Solar Retrofit (possible solutions)

(1) Clerestory modification to allow sun into center of building.

(2) Reflectors near windows take maximum advantage of sun's rays by directing them into the building space.

(3) Light shafts or skylights for additional lighting.

Heating and Cooling Systems

Heating System

1 Utility Natural Gas Heater
Model 150 UHF
Rating: 150,000 Btuh input, 120,000 Btuh output $\frac{120,000}{150,000}$ = 80% efficiency

Motor: 1/6 H.P. (Horse Power)

$$1/6 \text{ H.P.} \left(\frac{.746 \text{ Kilowatts}}{1 \text{ H.P.}}\right) = .124 \text{ Kilowatt Consumption}$$

Usage: 10-15 minutes/day in the morning--winter heating season only.

Consumption:

$$15 \frac{\text{minutes}}{\text{day}} \left(\frac{1 \text{ hour}}{60 \text{ min}}\right) \left(.124 \text{ kW}\right) \left(5 \frac{\text{days}}{\text{week}}\right) \left(4.33 \frac{\text{weeks}}{\text{month}}\right) = .67 \frac{\text{Kwh}}{\text{month}}$$

@ 6.5¢/kWh = $0.04 cost.

Obviously at the present usage and corresponding average cost of four cents a month to operate (electrically), there is no need for replacement. The advantage of replacement of the heater lies in the 80 percent efficiency of the present system. If the heater were to be replaced with a more efficient heater, the savings could be calculated by the following method:

$$\text{Percentage of savings} = 1.0 - \frac{\text{Present Efficiency (80 percent)}}{\text{New Efficiency}}$$

Example:

Replacing the old heater with a new heater with the following rating:

120,000 Btuh output, 133,333 Btuh input $\frac{120,000}{133,333}$ = 90% efficiency

$$\% \text{ savings} = 1.0 - \frac{\text{Present Efficiency 80\%}}{\text{New Efficiency 90\%}} = 1.0 - \frac{.80}{.90}$$

$$= 1.0 - 0.89 = 0.11$$

Potential Savings = 11%

The value of 11 percent would be multiplied by the present heating costs (obtained from the gas bills) to give the savings due to replacement of the heater. (Gas bill - Therms or Btus) (% of savings) = Energy Savings.

Your Widman walk-in freezer dissipates heat into the storage room as it operates. You may be able to make this work for you. Presently, you open the back door and window to cool down the room. If you incorporated a vent system to carry the already warm air to the front of the building during cold days to heat the entrance area, you would not have to open the back door and window to cool the storage room. You would have a cooler, more comfortable storage area and a warmer entrance area. During the warm summer months, your evaporative coolers must fight the heat given off by the freezer. If you vented the hot air to the outside, the room would remain much cooler and your coolers would not have to work as hard to keep the rest of the building comfortable.

Your present heating and cooling costs are not excessive by any means; however, as energy costs continue to climb, the savings realized by redirecting the warm air from the freezer to desired areas will undoubtedly increase.

Cooling System

2 Evaporative Coolers
1 H.P. Motor (Estimated due to inability to get up on the roof and check units)
1 H.P. = 746 Watts = .746 killowatts = .746 kW

Usage: 10 hours/day 5/days/week--summer cooling season only.

Consumption:

$$2 \text{ units} \left(\frac{.746 \text{ kW}}{\text{unit}}\right)\left(\frac{10 \text{ hours}}{\text{day}}\right)\left(\frac{5 \text{ days}}{\text{week}}\right)\left(\frac{4.33 \text{ weeks}}{\text{month}}\right) = 323.0 \text{ kWh each month}$$

@ 6.5¢/kWh (323.0 kWh) = $21.00 cost (About $10.50 for each unit to operate)

Again, the cooling costs are so low that very little can be done that would be cost effective and energy efficient. Evaporative cooling is by far the cheapest form of cooling available. Preventive maintenance is your most effective measure that one can take to ensure the most efficient operation of the unit--clean or replace the filters, clear the water lines, etc.

Passive Solar Retrofit (Possible Solutions)

(1) Shading over evaporative coolers during summer months.

(2) Shading over windows (awnings, roller shades, etc.) to keep out the unwanted hot summer sun on the east and west sides and to allow in the warm winter sun.

(3) Thermal mass storage wall to aid in the heating of the building (trombe wall, water wall, etc.).

(4) Deciduous shrubs or trees in front of the window areas to eliminate the summer sun and allow the winter sun into the building.

Hot Water Heater

A O Smith Water Heater
Glascote I
6 gallon capacity
Usage: Washing hands only
Assume 1 gallon/hour consumption

Energy required to heat one gallon of water hour to a temperature of 140°. A room temperature of 65° has been assumed.

$$Q = 1 \frac{\text{gallon}}{\text{hour}} \left(8.33 \frac{\text{lbs}}{\text{gallon}}\right) \left(1 \frac{\text{Btu}}{\text{lbm-}^{\circ}\text{F}}\right) \left(140-65^{\circ}\text{F}\right)$$

$$= 624.75 \frac{\text{Btu}}{\text{Hr}} = 624.75 \frac{\text{Btu}}{\text{Hr}} \left(\frac{1 \text{ Watt}}{3.413 \text{ Btu/Hr}}\right)$$

$$= 183.05 \text{ Watts}$$

Standby losses contribute to an additional 25 percent energy required to maintain the 140° water temperature.

(183.05) (1.25) = 229 watts = .23 kilowatts = .23 kW

Energy Consumption:

$$.23 \text{ kW} \left(10 \frac{\text{hours}}{\text{day}}\right) \left(5 \frac{\text{days}}{\text{week}}\right) \left(4.33 \frac{\text{weeks}}{\text{month}}\right) = 49.80 \frac{\text{kWh}}{\text{month}}$$

$$@ \frac{6.5¢}{\text{kWh}} \left(49.80 \frac{\text{kWh}}{\text{month}}\right) = \$3.24 \text{ cost}$$

If the hot water system was located in an unconditioned (unheated or uncooled) area and was larger and used more frequently, an insulation blanket could save you energy and money. Also, the hot water pipes could be wrapped with insulation. However, in your case, there is nothing that could be done that would be cost-effective in this area.

Equipment

1) 1 Refrigerator/Freezer
   Frigidaire FCD-170 T
   17.0 Cubic Feet

   Consumption: $\left(79 \frac{kWh}{month}\right)$

   $@ \ \frac{6.5¢}{} \left(79 \frac{kWh}{month}\right) = \$5.14$ month to operate

   or $61.67 annual cost

2) 2 Sorvall Instruments Centrifuge
   Model RC-3B

   Consumption: 4,360 watts = 4.36 kW

   Usage: $5 \frac{hours}{day} \quad 5 \frac{days}{week}$

   Monthly Consumption:

   $$4.36 \frac{kW}{machine} (2 \text{ machines}) \left(5 \frac{hours}{day}\right)\left(5 \frac{days}{week}\right)\left(4.33 \frac{weeks}{month}\right) = 944 \frac{kWh}{month}$$

   $@ \ \frac{6.5¢}{kWh} \left(944 \frac{kWh}{month}\right) = \$61.36$ cost/month ($30.68 per machine)

   or $736.32 annual cost ($368.16 per machine)

3) 1 Sebra Tube Sealer
   Model 1100
   110 Volt 50/60 Hz 2.5 amps

   Consumption: 175 watts = .175 kW

   Usage: $10 \frac{hours}{day} \quad 5 \frac{days}{week}$

   Monthly Consumption:

   $$.175 \frac{kW}{machine} \left(10 \frac{hours}{day}\right)\left(5 \frac{days}{week}\right)\left(4.33 \frac{weeks}{month}\right) = 37.9 \frac{kWh}{month}$$

   $@ \ \frac{6.5¢}{kWh}$ (37.9 kWh) = $2.46 cost/month

   or $29.55 annual cost

4) 1 Adams Readacrit Centrifuge
115 Volt 1.0 amp 50/60 Hz
Watts = (115 Volts) (1.0 amp) = 115 watts consumption = .115 kW

Usage: 5 $\frac{\text{hours}}{\text{day}}$ 5 $\frac{\text{days}}{\text{week}}$

Monthly Consumption:

$$.115 \text{ kW} \left(5 \frac{\text{hours}}{\text{day}}\right)\left(5 \frac{\text{days}}{\text{week}}\right)\left(4.33 \frac{\text{weeks}}{\text{month}}\right) = 12.45 \frac{\text{kWh}}{\text{month}}$$

@ $\frac{6.5¢}{\text{kWh}}$ (12.45 kWh) = \$.81 cost/month

or \$9.71 annual cost

5) 1 Widman Walk-in Freezer
Model EEP-120A

Usage: Continuous

Consumption: 2.31 kWh (estimated)*

Monthly Consumption:

$$2.31 \text{ kWh} \left(24 \frac{\text{hours}}{\text{day}}\right)\left(\frac{365 \text{ days}}{12 \text{ month}}\right) = 1,686 \frac{\text{kWh}}{\text{month}}$$

@ $\frac{6.5¢}{\text{kWh}}$ (1,684 kWh) = \$109.61 cost/month

or \$1,315,31 annual cost.

*Note: The estimated kWh of 2.31 is an average based on calculations using a 12' x 12' x 12' freezer with an R-factor of 45.4 for the walls and ceiling. An R-factor of 29.4 was assumed for the floor. A temperature of -40°F was used as the freezer interior temperature and a 75°F average exterior temperature was used. The consumption will vary on a monthly basis due to any fluctuations in the building temperature (a function of the outside temperature), the frequency of use (number of times the doors are opened), the amount and temperature of the material stored, and the operating and the maintenance procedures involving the equipment.

Calculations

Widman Walk-in Freezer

$q = UA\Delta t$

$t_i = -40°F$, $t_o = 75°F$ } $\Delta t = 115°F$

	U	A (Ft^2)	Δt	q
Roof	$\frac{1}{45.4} = 0.02$	144	115	364.76
Walls	$\frac{1}{45.4} = 0.02$	576	115	1,459.03
Floor	$\frac{1}{29.4} = 0.03$	144	115	5,63.27
				2,387.06 Btuh

Infiltration:

(Table 2) 1,580 + 980 = 2,560.00 Btuh

Product:

M = 100 lbs (estimated)

$\frac{(100)\ (.59)\ (115)}{24} =$ 283.00 Btuh

Heat grain from internal sources = 682.00 Btuh

Total 5,912.06 Btuh

$5,912.06 \text{ Btuh} \left(\frac{1 \text{ kWh}}{3413 \text{ Btu}}\right) = 1.73 \text{ kW}$

Assuming standby/equipment losses of 33%

1.33 (1.73 kW) = 2.32 kW

Consumption:

$2.32 \text{ kW} \left(24 \frac{\text{hours}}{\text{day}}\right)\left(365 \frac{\text{days}}{\text{month}}\right) = 1,686 \frac{\text{kWh}}{\text{month}}$

@ $\frac{6.5¢}{\text{kWh}}$ (1,686 kWh) = $109.61 cost/month

or $1,315.31 annual cost

ASHRAE 1977 Fundamentals
Chapter 27, pg. 27.5

C Calculating Heat Loss and Energy Savings

This appendix discusses the approach that we took in determining the space-heating requirements for single-family homes and mobile homes. The ways by which energy and dollar savings from conservation and solar applications can be estimated also are demonstrated. The techniques for estimating space-heating loads and conservation savings are detailed in the 1977 *ASHRAE Handbook of Fundamentals.* Solar savings are derived through calculations presented in the "Passive Solar Design Handbook Volume II: Passive Solar Design Analysis."

The approach that we describe is for those situations where a planner may have little information to rely on and needs a method to make some reasonable estimates. We stress that actual utility information or other reliable documentation be used whenever possible to support the estimates that may be derived from our approach. This ensures better agreement between reality and the calculations that are tied to certain assumptions about the characteristics of buildings.

The discussion that follows in this appendix will by no means make you an expert on energy issues that affect existing buildings. The only objective here is to give you some basic tools that you can use at the community or neighborhood level to assess conservation and solar retrofit potential. The material presented is oriented specifically toward the individual who hasn't done heat-loss and conservation- and solar-savings calculations before. Therefore, the discussion is necessarily basic in its approach.

More detailed treatment of the subject can be found in the *ASHRAE Handbook of Fundamentals*, 1977 Ed., Chap. 24, and the *ASHRAE Handbook and Product Directory, 1980: Systems*, Chap. 43. We also highly recommend *Other Homes and Garbage* (never mind the name) from Sierra Club Books (Leckie et al. 1975). This book gives a fairly technical discussion of heat-loss calculations in an extremely understandable manner. The readability of *Other Homes and Garbage* is enhanced by numerous charts and pictures that graphically get the basic concepts across. The "Passive Solar Design Handbook. Volume II" is a must if you want to become better acquainted with the solar-savings calculations and will be needed in any event to estimate the savings from passive solar retrofits. We also recommend Volume I of the same report, "Passive Solar Design Concepts," as a source for a basic overview of how passive solar energy systems work.

The calculations that we demonstrate may seem overly complex to you. It may be possible to adopt simpler procedures to suit your purposes. We encourage you to explore approaches that most directly meet your particular situation. Our objective is to outline a procedure that specifically accounts for local climatic variables and the construction and age characteristics of buildings in the community. A planner or neighborhood organizer then can better assess the potential savings available at the community or neighborhood level.

A number of calculations are necessarily involved in this approach. These can be done fairly easily on a calculator, however. To simplify the process further, we have included a program for heat-loss calculations that can be used on a Texas Instruments TI-59 calculator with a print-out capability. This program can significantly speed up the process for those who have access to a TI-59 and who have some knowledge about programming.

Calculating Heat Loss

Determining the Heating Season—The Degree Day

Local climatic conditions will determine the amount of energy required to heat a building. A unit referred to as the degree day has been developed as a way to describe those conditions. Basically stated, the number of degree days at a given location measures the severity of the weather, incorporating both temperature levels and duration. The more degree days there are in a given period, the more energy a structure will require to maintain a desired temperature indoors.

A heating degree day will occur for every degree that the outdoor temperature drops below 65° for a 24-hour period.* The 65° figure is used because it represents a good approximation of indoor temperatures, which usually range between 65° and 70°. It is generaliy held that internal loads (people, lights, applicances) will make up the 5° differential. If the temperature drops below 65°, we assume that heat will be required to maintain the desired temperature (65°) indoors.

The following example illustrates the concept of the degree day. Assume that the outdoor temperature stays constant at 35° for 24 hours. Under these conditions, 30 degree days would accrue for that day. If the temperature stayed at 35° for a month (assumed to be 30 days), 900 degree days would result. Of course, temperatures will not be constant over a 24-hour period, much less over a month. Professional tabulations take this consideration into account, however. Degree day information is available on a monthly and yearly basis for a number of locations across the Nation (and Canada) based on data that have been recorded over many years. The *ASHRAE Handbook and Product Directory, 1980: Systems* (Chap. 43) presents this information as does *Other Homes and Garbage*. The number of degree days for your location will be used to determine the heating load for the homes or other structures that you are analyzing. The way in which this number is used is demonstrated later in this appendix.

*A cooling degree day occurs for every degree that the outdoor temperature goes above 75° for a 24-hour period. All temperatures in this discussion will be in degrees Fahrenheit.

Characteristics of Heat Transfer

A basic discussion of heat transfer is useful at this point in order for you to understand more fully what heat-loss calculations are trying to do. The important principle to remember is that heat will always flow from a higher to a lower temperature. This tells us that heat will flow into or out of a building depending on whether the indoor temperature is lower or higher than the outdoor temperature. Further, the rate at which heat is transferred over a period of time (the rate of heat transfer) is proportional to the temperature difference between the indoor and outdoor environments. A large temperature differential will accelerate the transfer of heat from the warmer environment to the colder one. Where there is no temperature differential, there is theoretically no transfer of heat.

The rate of heat transfer is commonly expressed in Btu per hour. A Btu, or British thermal unit, represents the amount of energy needed to raise the temperature of one pound of water one degree Farenheit. We will use this term frequently when talking about heat loss as well as conservation and solar savings. More often, we will be talking about seasonal heat losses or energy savings rather than hourly rates. The heat-loss characteristics of various building materials are expressed in Btu per hour per square foot. The advantages of this notation will become evident in the next section.

Calculating Thermal Characteristics of Building Components

The basic elements used to evaluate the thermal characteristics of buildings are R values, which measure the tendency of a material to resist heat loss, and U values, which measure the tendency of a material to transmit (lose) heat. The U value is commonly referred to as the coefficient of transmission. Both R values and U values implicitly account for heat loss that results from the combined effect of conduction and convection (see Appendix A). The relationship that exists between R values and U values is unity, because they are reciprocals of each other, such that

$$R = \frac{1}{U}$$

and

$$U = \frac{1}{R} \quad .$$

From this relationship, a high R value implies a good insulating material whereas a low U value suggests the same. The opposite situation also is true.

You have probably heard of R values, because they are commonly used to rate the thermal characteristics of insulation (for example, R-11 and R-19). The R value also is used when it is necessary to compute the thermal characteristics of a building component that may not be present in a reference manual. Once the R value for the component is known, it is divided into 1 to obtain the U value, which expresses the heat-loss rate of a material in Btu per hour per square foot. It is the U value that is used in the heat-loss calculations.

It may be necessary for you to calculate the R value and U value for a particular building component at some point. This calculation is illustrated by the following example for a frame wall with stucco facing.

Component	Resistance (R) Between Framing	Resistance (R) At Framing
Outside surface (15-mph wind)	0.17	0.17
Siding, stucco, 1 in.	0.20	0.20
Sheathing, fiberboard, 0.5 in.	1.32	1.32
Air space, 3.5 in.	1.01	---
Nominal 2- by 4-in. wood stud	---	4.38
Gypsum wallboard, 0.5 in.	0.45	0.45
Inside surface air	0.68	0.68
	3.83	7.20

A 20% framing factor* is assumed for 2-by-4 construction at 16 in. on center; whereas a 10% framing factor generally is assumed for 2-by-6 construction at 24 in. on center. We will assume 2-by-4, 16-in. on-center construction in our example. The U value would be computed in the following way:

$$U_{av} = 0.8\left(\frac{1}{3.83}\right) + 0.2\left(\frac{1}{7.20}\right)$$

$$= 0.236 \text{ Btu/hour} \cdot \text{ft}^2.$$

The change in the U value attributable to a higher level of insulation is easily computed. This change can be evaluated as it affects a variety of wall, ceiling, or floor types listed in the *ASHRAE Handbook of Fundamentals*, Chap. 20. The change can be made simply by inserting the R value of the new material. Assume that we add 3.5 in. (R-11) of cellulosic fiber into the wall cavity of the previous example. The new R value would be 13.82,** with the new U value computed as

$$U_{av} = 0.8\left(\frac{1}{13.82}\right) + 0.2\left(\frac{1}{7.20}\right)$$

$$= 0.085 \text{ Btu/hour} \cdot \text{ft}^2.$$

*The framing factor is a measure of the wall area occupied by the framing material.

**Note that the R value of the air space (1.01) would not be included because the insulation fills the entire wall cavity.

This number tells us that the wall, with R-11 insulation added, will lose 0.085 Btu/hour · ft^2 compared with a wall loss of 0.236 Btu/hour · ft^2 without the insulation. This represents a reduction of 65% in the rate of heat loss.

It is likely that your local utility, state energy office, or perhaps the architectural department of a local university will have a table presenting the U values of various building components. The *ASHRAE Handbook of Fundamentals* (1977 or 1972 Ed.) also presents tables that allow you to determine U values for a variety of wall, ceiling, and floor types.

Estimating the Heating Load for the Typical Home

Use of the building typology approach (see the single-family homes section of Chap. 2) relies on estimates of energy use for space heating based on the age, construction characteristics, insulation levels, and assumed rates of infiltration (expressed in air changes per hour) for a typical home. The relevant equations for determining heat loss in various building components are presented below.

Heat loss through windows, doors, walls, ceilings, and floors over crawl spaces:

$$K = U \times A \quad ,$$

where

K = heat loss in Btu per hour

U = coefficient of transmission in Btu per hour per square foot

A = area of building component in square feet.

Heat loss through a slab on grade:

$$K_{slab} = f \times P \quad ,$$

where

K_{slab} = heat loss in Btu per hour

f = perimeter factor in Btu per hour per square foot

P = perimeter in feet.

Heat loss in the slab is not so dependent on the area as on the perimeter that is exposed to the outdoors. Perimeter factors obtained from the New Mexico Energy Institute and based on ASHRAE test values are presented in Table C-I.

Heat loss from air infiltration:

$$K_{infil} = \frac{0.432 \times C \times D \times H \times A_{ftotal}}{24} \quad ,$$

where

K_{infil} = heat loss in Btu per hour

C = air changes per hour

D = air density ratio

H = ceiling height in feet

A_{ftotal} = total area of all floors in square feet.

The air density ratio plot (Fig. C-1) for different elevations is included to account for other than sea-level conditions. An air change per hour figure may be obtained for buildings from local architecture or engineering firms or your local utility.

TABLE C-I. Perimeter Factor

Slab Type	R Value	Perimeter Factor (Btu/hour · ft^2)
Unheated	5	0.33
	3.75	0.5
	2.5	0.67
	0	0.81
Heated	5	0.45
	3.33	0.67
	2.5	0.90
	0	1.16

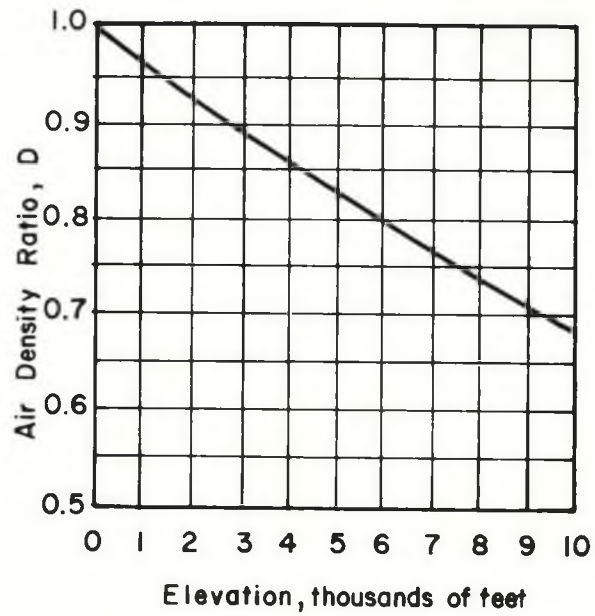


Fig. C-1. The air density ratio for different elevations. The sea-level air density is 0.075 lb./ft^3.

TABLE C-II. Sample Heat-Loss Calculation for a 1400-ft^2 Home

Component	A (ft^2)	U (Btu/hour · ft^2)	K (Btu/hour)	Per Cent
(6) Windows	140	1.13	158.2	17.66
(7) Doors	36.72	0.49	17.99	2.01
(8) Walls	1,020.61	0.24	244.95	27.35
(9) Ceiling	1,400.00	0.085	119.00	13.29
(3) Slab	---	---	121.23[a]	13.54
(5) Infiltration	---	---	234.22[b]	26.15
			895.59	100.

[a]Heat loss through the slab is calculated by the equation

$$K_{slab} = f \times P$$

$$= 0.81 \times 149.66$$

$$= 121.23 \text{ Btu/hour.}$$

[b]Heat loss from air infiltration is calculated by the equation

$$K_{infil} = \frac{0.432 \times C \times D \times H \times A_{ftotal}}{24}$$

$$= \frac{0.432 \times 1.4 \times 0.83 \times 8 \times 1{,}400}{24}$$

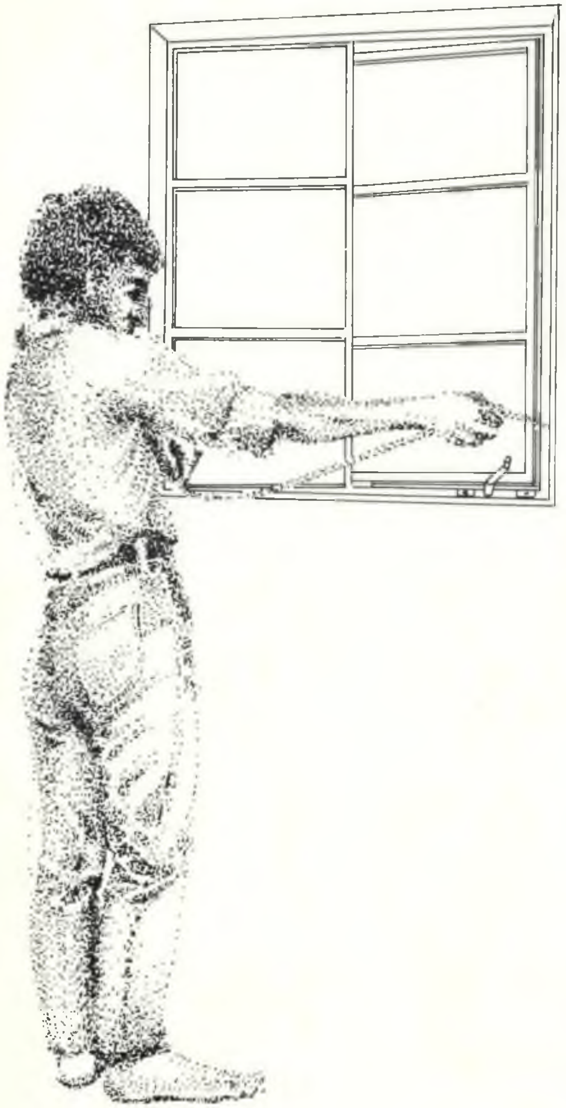
$$= 234.22 \text{ Btu/hour.}$$

Calculating Heat Loss for a Home

At this point, an example is useful to demonstrate the simplicity of the calculation (Table C-II). We will use a hypothetical one-story (with 8-ft ceilings), 1400-ft^2 frame home built on a slab located in Albuquerque, New Mexico. Window area represents 10% of the heated floor area, and there are two doors approximately 2 ft 9 in. by 6 ft 9 in. There are 2.5 in. (R-7) of fiber-glass batt insulation in the roof and none in the walls. This construction is fairly typical of construction in Albuquerque before 1955. The numbers beside each line in the table refer to the number of the equation used in the TI-59 calculator program, which is discussed in depth later in this appendix.

Determination of heat loss in a home or any structure involves measuring the area of various building components. To avoid double counting, you must subtract the areas of various components from others. In our theoretical example, there are 1,197 ft^2 of wall area, of which 140 ft^2 are windows and 36.72 ft^2 are doors. These components must be subtracted from the wall area to compute the separate U values. Keep this in mind when you are doing your heat-loss calculations or modeling.

If the floor was built over a crawl space, the area would be multiplied times the U value to obtain the Btu per hour lost. It is also necessary to account for the fact that the temperature differential (ΔT) between the indoor temperature and that in the crawl space (enclosed) will tend to be less than the ΔT between indoors and outdoors. The ΔT is simply the difference in degrees between the desired indoor



temperature (65°) and a locally-defined average for the minimum temperature generally reached each year. In Albuquerque, this temperature was 17°; thus a ΔT of 48° was used. For homes with crawl spaces, we assumed the ΔT would be 20° (65° − 45°). The temperature in the crawl space is higher because of the warming effect of the Earth and the insulating properties of the siding that encloses the crawl space. The U value was consequently reduced by 0.416 (or 20/48) to account for this consideration. The calculation for a home with a basement is described in the 1977 *ASHRAE Handbook of Fundamentals.*

Seasonal Heating Load

The estimate of the seasonal heating load (in Btu) for the home is derived through the use of the following equation:

$$HL = K_t \times 24 \times DD \quad ,$$

where

HL = total seasonal heat loss in Btu

K_t = the heat-loss total in Btu per hour

DD = number of degree days for the location.

Thus we have the following result for our sample calculation:

$$HL = 895.59 \times 24 \times 4{,}292$$

$$= 92{,}252{,}830 \text{ or } 92.3 \text{ million Btu.}$$

This number is based on the building components alone and does not account for internal and solar gains, which tend to offset this requirement to some extent.

The calculation presented above tends to overstate the amount of energy required to heat the home. Studies have indicated that solar and internal gains often are sufficient to offset some of the heat loss in a home when the temperature is below 65° (Harris et al. 1965, p. 50).

Application of the degree day calculation during the 1950s and 1960s primarily to electrically heated homes located in the South indicated that it would tend to overestimate the amount of heating energy needed by 30% (ASHRAE 1980, p. 43.8). A degree day correction factor (C_D) was developed to deal with this problem based on the number of degree days that occur in a given location.* A plot of C_D appears in Chap. 43 on p. 43.8 of the 1980 *ASHRAE Handbook and Product Directory, 1980: Systems* and also in this report as Fig. C-2. Application of the correction factor to the conventional degree day calculation is thought to provide an estimate of heating energy consumption that is within 20% of the actual consumption figure for a home (ASHRAE 1980, p. 43.9). Variation from the actual level of consumption is attributable to the assumptions that underlie the procedure and the lifestyle of the inhabitants.

*The correction factor has been developed only for single-family homes.

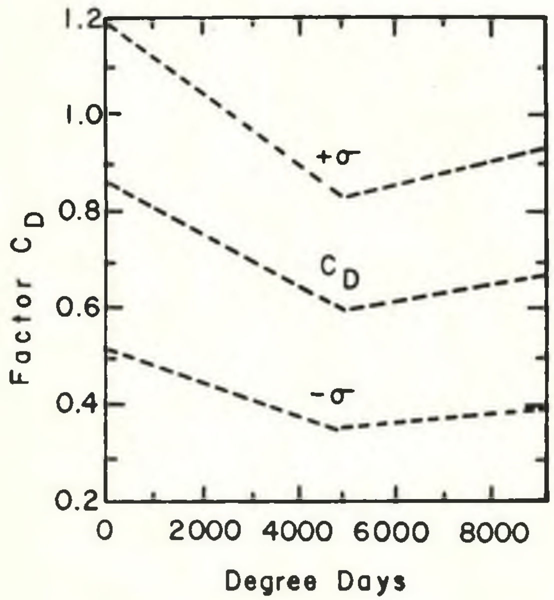


Fig. C-2. Correction factor, C_D, vs degree days. (Reprinted by permission from ASHRAE Handbook, Systems, 1980.)

A correction factor of 0.63 is used for Albuquerque, which has 4,292 heating degree days. Thus, we get

$$HL_{adjusted} = 0.63 \times 92.3$$
$$= 58.1 \text{ million Btu.}$$

We consequently estimate that 58.1 million Btu would be required to maintain the home at 65° over the 4,292-degree-day heating season.

Estimating Fuel Consumption and Dollars Spent on Space Heating

The preceding calculation tells us how much energy is needed to meet the heating requirements for the home heating season. It does not tell us how much heating fuel is actually consumed, however, because it does not account for combustion losses of the heating equipment. Natural-gas and oil furnaces typically operate at efficiency levels ranging between 40% and 80%. We looked at only natural-gas heating in Albuquerque because 95% of the homes use gas as the primary heating fuel. We assumed a furnace efficiency of 55% for older homes. Given this efficiency factor, we find that actual consumption is

$$c = \frac{58.1}{0.55}$$
$$= 105.6 \text{ million Btu.}$$

Use of the efficiency factor (for natural gas or other fuels) enables you to estimate the total number of Btu that can be saved in the community. It also enables you to determine a fuel bill for the average home. This allows you to turn energy consumption into dollars, which are the basis of any economic analysis.

Calculating the Fuel Bill

Initially, it is useful for you to know how many Btu there are in the units by which energy consumption is measured.

Fuel	Unit	Btu
Natural gas	therm	100,000[a]
No. 2 fuel oil	gallon	153,600
Electricity	kilowatt-hour	3,412

[a]Average figures for natural gas. The actual Btu may vary somewhat by region.

The energy unit is derived by dividing the annual Btu consumption figure by the relevant energy unit expressed in Btu. This is then multiplied by the price of the energy source to obtain the cost. We use prices for the predominant heating fuels in Albuquerque.

$$\text{Natural-gas fuel bill} = \frac{105{,}600{,}000}{100{,}000} \times \$0.35$$

$$FB_g = 1{,}056 \text{ therms} \times \$0.35/\text{therm}$$
$$\cong \$370$$

$$\text{Electricity* fuel bill} = \frac{58{,}100{,}000}{3{,}412} \times \$0.065$$

$$FB_e = 17{,}028 \text{ kWh} \times \$0.065/\text{kWh}$$
$$\cong \$1{,}106$$

Estimation of the fuel bill enables you to determine the dollar savings that come from a conservation and solar retrofit program.

Calculating the Bill Based on the Cost of Energy per Million Btu

An easier way to derive the bill, and the technique we will use from now on, is to calculate the energy cost per million Btu. For natural gas, we know that

*Electricity is assumed to be 100% efficient.

there are approximately 100,000 Btu in a therm and that 10 therms would add up to 1,000,000 Btu. The cost for a million Btu of natural gas in Albuquerque would consequently be $3.50 (10 therms × $0.35/therm). We can determine the delivered cost for gas by dividing the price above by the assumed efficiency level for the furnace. Division of $3.50 by our assumed efficiency figure of 55% would result in a delivered cost of $6.36/million Btu to the home. At 65% efficiency, the cost would be $5.38/million Btu. Depending on the efficiency level we assume, these dollar values could be applied directly to the heat-loss figure of 58.1 million Btu, giving us the same figures that are obtained in previous sections without having to divide by 55% initially and then convert into therms. Thus, we have the following:

$$FB_g = \$6.36 \times 58.1$$

$$\cong \$370$$

at a furnace efficiency of 55%.

The delivered cost of electricity in Albuquerque per million Btu is $19.04 [(1,000,000/3,412) × $0.065]. We know that electricity is approximately 100% efficient (resistance heating only), so

$$FB_e = \$19.04 \times 58.1$$

$$\cong \$1,106.$$

The dollar cost per million Btu can also be applied to determine conservation and solar savings, as we shall demonstrate in the following sections.

Estimating Conservation Savings

The percentage savings that can be achieved through conservation actions are estimated with the following equation:

$$S = \frac{U_n - U_o}{U_o} ,$$

where

S = fraction savings

U_n = U value of component due to retrofit

U_o = original U value of the component.

A negative number will result from this calculation. This is to be expected because the value that is divided represents a fraction reduction in the Btu per hour that are used. This fraction then is multiplied times the fraction of gross heat loss attributable to the particular building component times the gross heat-loss value to obtain total Btu saved.

To illustrate, let's assume that we want to add 6.25 in. (R-19) of loose fill fiber-glass insulation to the roof of the Albuquerque home in our example. This would increase the R value of the roof insulation to R-26 (actually R-31 including the surface air films and building components). We will calculate the savings based on the Btu required to maintain the home at 65° *before combustion losses*. This is done so that efficiency levels associated with different fuel types can be applied in the final calculations.

If we assume that

$U_o = 0.085$ Btu/hour · ft^2

$U_n = 0.031$ Btu/hour · ft^2

percentage $K_{ceiling} = 13.29\%$ (from Table C-II)

$HL_{adjusted} = 58.1$ million Btu,

then the conservation savings with natural gas (CS_g) is

$$CS_g = \frac{0.031 - 0.085}{0.085} \times 0.1329 \times 58.1$$

$$= -0.635 \times 0.1329 \times 58.1$$

$$= -5 \text{ million Btu,}$$

which in turn translates into a savings of 5 million Btu. Dollar savings, assuming furnace efficiency of 55% ($6.36/million Btu), would be

$$DS = \$6.36 \times 5$$

$$\cong \$32.$$

The conservation savings with electricity (CS_e) is also 5 million Btu. Dollar savings, assuming 100% furnace efficiency at a delivered cost of $19.04/million Btu, would be

$$DS = \$19.04 \times 5$$

$$\cong \$95.$$

This calculation of conservation savings is done only for ceiling insulation. Savings for other building components would be computed in a similar manner. The ceiling conservation savings are included in Table C-III, along with the other possible conservation and solar savings.

Calculating conservation savings (or solar savings) before combustion losses avoids confusion for you if your city housing relies on several different energy sources for heating. Dollar savings are obtained very simply by applying the relevant delivered cost for the heating fuel (which includes the assumed efficiency factor for the heating equipment). Total Btu savings are derived by dividing the conservation savings by the efficiency factor for the furnace (for example, if the fuel is natural gas, the total Btu savings are 5/0.55 = 9.1 million Btu).

Comments on Conservation Savings

It should be stressed at this point that estimation of conservation savings (or solar savings) is by no means an exact science. The conservation savings that are determined are based on a typical year. As stated earlier, the heating season for Albuquerque is based on 4,292 heating degree days. This number is an average that has been determined from observed weather data over the years. Some years have more severe winters, whereas others have milder ones. This makes it impossible to predict the actual savings attributable to a particular conservation measure or package. The calculation is further complicated by the difficulty in accounting for the lifestyles of building occupants and their particular energy-use habits. Finally, it is difficult to accurately

TABLE C-III. Conservation and Solar Retrofit Impacts on Energy Consumption for Space Heating

Initial Load (million Btu)	Conservation Savings[a] (million Btu) Ceiling Insulation	Wall Insulation	Storm Windows	Infiltration Reduction[b]	Total Savings	New Load (million Btu)	Solar Savings (million Btu)	Total Energy Savings (million Btu)	Final Load (million Btu)
58.1	5	11.6	5.2	4.3	26.1 (45%)	32	19.2 (33%)	45.3 (78%)	12.8

[a]Before combustion losses.

[b]From 1.4 air changes/hour to 1.0 air change/hour.

determine the total savings that will be achieved through the application of a set of conservation retrofit measures. This problem arises because of the difficulties in determining how the measures will interact with one another. The installation of one conservation measure will likely reduce the energy savings impact of another, thus total savings may be overestimated.

You probably are wondering why we even bother detailing the techniques by which conservation savings are determined if they have so many uncertainties. There are two reasons. First, the calculation of conservation savings based on the ASHRAE steady-state heat-loss calculation as we have presented it is an accepted approach among professionals. Second, it is easy to apply and is useful in deriving a rough estimate of potential community savings. The problems of overestimating savings can be dealt with by developing a range of savings to ensure the conservatism of your estimates.

Estimating Solar Savings

Once the conservation retrofit package has been installed on the home, solar savings can be calculated. The estimated savings that can be realized through the application of a passive solar retrofit is attributable to two factors, the building load coefficient (BLC) and the solar collector area. The BLC represents the additional energy in Btu per day required to increase the temperature inside the building by 1°F. It is obtained for our study by dividing the estimated heating load obtained after the conservation options have been applied by the number of degree days for the climate. This calculation should be done before combustion losses. Solar collector area, as we use it, refers to the glazing (glass or plastic) that admits and traps the rays of the sun to heat the building; framing is not included. The ratio of these two numbers is referred to as the load collector ratio (LCR).

$$LCR = \frac{\text{BLC (Btu/degree day)}}{\text{solar collector area (ft}^2\text{)}}$$

The number that is obtained here has a particularly strong bearing on the solar performance of the building. In essence, it determines the average increase in inside temperature over the average outside temperature. This relationship will have the greatest impact on the solar savings that can be achieved in the building. The LCR specifically considers energy conservation as incorporated in the BLC and integrates it with the amount of solar gain that can be obtained, which is determined by the area of the collector. This allows a solar-savings fraction (SSF) to be estimated. The SSF represents the estimated percentage of the building's heating load that can be supplied by solar energy.

The relationship that exists between the LCR and the SSF will vary with location. Influences on the relationship are the amount of incident sunshine and the number of heating degree days. Performance always varies depending on system type and whether night insulation is used.* "Passive Solar Design Handbook. Volume II" presents tables relating LCRs to SSFs for 209 locations in the US and 10 in Canada.

Table C-III presents the total conservation savings that are achieved in the Albuquerque home that we are using as an example. The estimated heating load has been reduced from 58.1 million Btu down to ~32 million Btu. If we divide this number by 4,292, we obtain a BLC of 7,456 Btu/degree day. An 8- by 16-ft solar greenhouse with a collector area of 144 ft^2 will be the passive solar system used for the solar calculation. For LCR, we then obtain

$$LCR = \frac{7,456}{144}$$

$$= 51.8 \text{ Btu/degree day} \cdot ft^2.$$

*Night insulation is installed by the building occupant nightly to prevent the heat gained during the day from flowing from the warmer house to the cooler night air. Usually polystyrene or, in some cases, fiber-glass insulated panels are used for this purpose.

The LCR that is obtained is compared to the LCR-SSF table for greenhouses that will be presented in Volume III of the "Passive Solar Design Handbook."** We assume that R-9 night insulation will be used to boost the performance of the system.† Entries for Albuquerque, New Mexico, relating LCRs to SSFs are presented here.

LCR (Btu/degree day · ft^2)	SSF (%)
164	25
132	30
109	35
92	40
79	45
69	50
60	55
53	60
47	65
41	70
36	75

The table indicates that the proposed greenhouse would deliver savings of close to 60% of the home's heating load or around 19.2 million Btu. Assuming a furnace efficiency of 55%, we would get a total energy savings of 34.9 million Btu. At $6.36/million Btu, estimated dollar savings would be about $122 for the heating season.

If the home were electrically heated, total energy savings would be that value initially defined, 19.2 million Btu. Dollar savings assuming an electricity cost of $19.04/million Btu would be $366.

**Scheduled for publication in early 1982.

†R-9 corresponds to about 1.75 to 2 in. of extruded polystyrene or 2.5 to 3 in. of fiber glass.

Why Conservation First?

The importance of conservation first is demonstrated by a calculation of solar energy savings for our example home before conservation measures are installed. The fraction is appreciably lower.

$$BLC = \frac{58,100,000}{4,292} = 13,536 \text{ Btu/degree day}$$

$$LCR = \frac{13,536}{144} = 94 \text{ Btu/degree day} \cdot ft^2$$

$SSF \cong 40\%$

The performance of the system drops by about 20%, which if we assume a cost of $2,400 for the greenhouse, would increase the simple payback period†† on the system applied to an electrically heated home from around 7 years to approximately 10 years. For the gas-heated home, the payback period would go from 21 years to 30 years.

The total energy savings for the Albuquerque home, which are attributable to the conservation and passive solar retrofits, are detailed in Table C-III. Installation of the retrofit measures *theoretically* would reduce the heating bill of the home from approximately $369 to around $81 annually.

††Simple payback period = system cost ÷ annual savings = years to recovery of investment.

Btu per Degree Day per Square Foot —A Measure of Performance

During our discussions in Appendixes D and E on the Albuquerque case study, we often refer to a value measured as Btu per degree day per square foot. This value simply provides a fairly understandable means to compare the heat-loss characteristics of the structure with an assumed standard or with other buildings. The value is easily obtained; for example, the original Albuquerque home in our example was estimated to have a heating load of 58.1 million Btu. We divide this value by the square footage and number of degree days to obtain Btu per degree day per square foot:

$$\frac{58,100,000}{4,292 \times 1,400} = 9.7 \text{ Btu/degree day} \cdot \text{ft}^2.$$

From now on, this number is referred to as the *heat-loss factor*. Assuming the 55% furnace efficiency factor, we know the home actually uses approximately 17.6 Btu/degree day $\cdot$ ft^2. This value is called the *consumption factor*.

After all of the conservation options described in Table C-III have been installed, the estimated heating load has been reduced to 32 million Btu. The heat-loss factor would be 5.3 Btu/degree day $\cdot$ ft^2, and the consumption factor would be 9.6 Btu/degree day $\cdot$ ft^2. The heating load after the solar greenhouse has been applied would be 12.8 million Btu. This results in a heat-loss factor of 2.1 Btu/degree day $\cdot$ ft^2, and a consumption factor of 3.8 Btu/degree day $\cdot$ ft^2.

Comments

If you do heat-loss calculations by hand for typical homes in your community, you may find this work sheet handy. The approach followed is the same as that used in the calculator program. It also presents means by which internal and solar gains can be calculated as well as a check of the monthly utility bill. These particular analytical techniques are discussed in the following section.

WORK SHEET FOR CALCULATING HEAT LOSS BY HAND

(1) Determining the perimeter

$\sqrt{\text{floor area, } A_{floor}\_\_\_\_\_\_}$ = ______ × 4 = ______ house perimeter, P (ft)

(2) Determining the heat loss from the floor

(a) Slab on grade
house perimeter, P ______ × perimeter factor, f ______ = ______ slab heat loss, K_{slab} (Btu/hour)

(b) Floor over crawl space
floor U value ______ × floor area, A_{floor} ______ × temperature adjustment factor ______ = ______ floor heat loss, K_{floor} (Btu/hour)

(3) Determining wall area

$\sqrt{\text{floor area, } A_{floor} \_\_\_\_\_\_}$ × 4 × ceiling height, H ______ – window area ______ – door area ______ = ______ wall area (ft^2)

(4) Calculating heat loss from infiltration

(0.432 × air changes/hour, C ______ × air density ratio, D ______ × ceiling height, H ______ × total area of all floors, A_{ftotal} ______) ÷ 24 = ______ infiltration heat loss, K_{infil} (Btu/hour)

(5) Calculating total heat loss for each component

(a) from (2) above = ______ slab (floor) heat loss (Btu/hour)
(b) from (4) above = ______ infiltration heat loss (Btu/hour)
(c) window area ______ × window U value ______ = ______ window heat loss (Btu/hour)
(d) door area ______ × door U value ______ = ______ door heat loss (Btu/hour)
(e) wall area ______ × wall U value ______ = ______ wall heat loss (Btu/hour)
(f) floor area ______ × ceiling U value ______ = ______ ceiling heat loss (Btu/hour)

(6) Calculating gross heat loss

from (5) above
(a) ______ + (b) ______ + (c) ______ + (d) ______ + (e) ______ + (f) ______ = ______ gross heat loss, K_t (Btu/hour)

(7) Calculating heating load

gross heat loss, K_t ______ × heating degree days, DD ______ × 24 = ______ heating load, HL (Btu)

(8) Calculating adjusted heating load

heating load, HL ______ × degree day correction factor, C_D ______ = ______ adjusted heating load, $HL_{adjusted}$ (Btu)

(9) Calculating heat-loss factor

heating load, HL ________ ÷ degree days, DD ________ ÷ floor area ________ = ________ heat-loss factor (Btu/degree day · ft^2)

(10) Calculating adjusted heating load (optional method)

(a) Calculating internal gain
(number of people ________ × 14,500 × number of days in heating season ________)
= ________ internal gain (Btu)

(b) Calculating solar gain
south window area ________ × daily insolation level ________ × shading coefficient ________
× number of days in heating season ________ = ________ solar gain (Btu)

heating load, HL ________ − internal gain ________ − solar gain ________ = ________ adjusted heating load, $HL_{adjusted}$ (Btu)

(11) Checking the monthly fuel bill

(heat-loss factor ________ × degree days in month ________ × floor area ________) ÷ furnace efficiency factor* ________ = ________ monthly consumption for heating (Btu/month)

(a) Calculating the natural-gas fuel bill

monthly consumption for heating ________ ÷ 100,000 × cost of gas per therm ________
= ________ estimated monthly heating cost

(b) Calculating the electricity fuel bill

monthly consumption for heating ________ ÷ 3,412 × cost of electricity per kWh ________
= ________ estimated monthly heating cost

*Factor is 1.0 for electricity.

A program for the Texas Instruments TI-59 calculator was created to reduce the effort of making so many repetitive calculations. Several simplifying assumptions went into the program to make the analysis easier.

Assumptions

Determining the Perimeter of the Home

A major assumption is that we look at each home or mobile home as a box. This is literally the truth in the latter case; it may not be in the former.

The perimeter of the home is calculated by taking the square root of the floor area (thus assuming the resulting number is the length of one side) and multiplying it by 4. We consequently look at every home as a square. The perimeter calculation will have an effect on the heat-loss calculations for the home that is built on a concrete slab and will also influence the heat-loss calculation for the walls in all homes. Depending on the building configuration of the 1,400-ft^2 home that we used, the actual perimeter may be 3% to 25% larger than the estimated perimeter of approximately 150 lineal ft. Because many homes in Albuquerque are rectangular and because this equation is for estimation purposes only, we felt the error could be permitted. The effect that the error would have, if incorporated into the equation, would be to increase the estimated heating requirements for the home, which would only add to the conservatism of our estimates.

Home Type

You will notice that our calculations are based only on single-story ranch homes or mobile homes. This type was chosen because it simplifies the approach and because single-story homes are the predominant housing type (90%) in Albuquerque. A calculation could easily be derived to deal with two-story structures. We assumed an 8-ft-high ceiling. This could be changed to the required height for the walls of a two-story building (for example, 16 or 20 ft).

An Alternate Procedure—Netting Out Solar and Internal Gains

You will also notice several items that we don't discuss. During the course of our work, we experimented with an alternate means of estimating the heating requirements for a building. We calculated heat loss from the building components in the same way but then subtracted internal gains and solar gains. Internal gains were computed on a per-person basis to reflect the energy contribution of people, lights, and appliances. The assumption underlying this computation was that the use of lights and appliances is directly related to the number of people residing in the dwelling. The number of people was multiplied times 14,500 Btu/day times the number of days in the heating season to estimate total internal gains.*

Solar gain was handled in a similar manner by multiplying the number of Btu falling on a square foot of south-facing glass per day (insolation level) times a shading coefficient times the number of days in the heating season. The shading coefficient accounts for the filtering effect of glass, since all of the solar insolation is not realized as heat to the home. Shading coefficients for various materials (for example, plastic) are presented in the 1972 *ASHRAE Handbook of Fundamentals,* Chap. 22, pp. 397-408. Insolation levels for various latitudes and surface angles are presented in Chap. 4, Appendix 4C, p. 160, of *Other Homes and Garbage.* You also may obtain these figures from your local weather service.

Netting out solar and internal gains in the Albuquerque climate did not give us what we felt were reasonable estimates of heating requirements. They generally tended to be high. This is probably attributable to our inability to account for the large amount of radiant gain that building components pick up in a climate that is characterized by high levels of insolation. We also were leery of relying on the window area as reported by respondents to our survey. Many questionnaires were returned with the windows (south-facing windows were to be identified separately) unmeasured. In the final analysis, the estimating technique using the ASHRAE degree day correction factor seemed best suited to our purposes. You may find that netting out internal and solar gains is an effective way of estimating heating requirements in your community, however.

Justifying the Estimate of Energy Consumption—The Monthly Utility Bill

The program also includes an entry for the number of degree days for the month. We did this thinking that we could spot-check our energy consumption estimate (hopefully justifying our estimate

* Conversation with Scott Noll of Resources for the Future, September 1981.

for the entire heating season) with an actual utility bill. We asked respondents to our survey to give us the amount of their latest heating bill and the time period that it covered. We then entered the actual number of degree days for the period (obtained from the National Weather Service). The program calculated an estimated bill for the month (before combustion losses and other end-uses such as hot-water heating and cooking are subtracted). We found that the estimated heating bill was seldom close to the actual consumption for the month (after combustion losses and other end-uses had been accounted for). This reflects the difficulty of attempting to estimate energy use over a short period. There is always the chance that some unique factor during that period could produce a deviation from the normal long-run pattern of energy use (ASHRAE 1980, p. 43.1).

Air Infiltration

Calculation of air infiltration is based on the air-exchange method because of practical considerations. Originally, we tried to use the crack estimation technique based on information that we obtained from questionnaires distributed to the Albuquerque schools (see Appendix B). This technique didn't work because of the unreliability of the reported data. We generally ended up with estimated infiltration levels that were extremely small, such as 0.4 to 0.6 air changes/hour. We thought this range was unrealistic for existing construction.

Consequently, we decided to assign a level of infiltration (air changes per hour) corresponding to responses to the survey question about the amount of draft felt in the home. We originally had hoped to base our estimates on building age, because we thought that older homes generally would have a higher level of infiltration. Survey responses suggested that just because a home was older didn't necessarily mean it was leakier. We consequently decided to assign an average air change per hour value of 1.4 to all homes built before 1976 (1.5 for mobile homes before 1977) and 1.2 for those built since the beginning of 1976 (1.3 for mobiles after 1977) based on the average of the responses. A lower value for new construction intuitively makes sense because caulking and weather stripping are still relatively new, and there is little compaction of the insulation. Determination of an appropriate infiltration value is important because this component of heat loss can account for as much as 30% to 40% of the total. The value you use should be determined locally.

Obviously, the program that we devised could be made more sophisticated. The present version proved useful to us in estimating the initial energy requirement of single-family residences and mobile homes. The percentage of the total heat loss attributable to each building component also allows the estimated conservation savings to be derived.

Operation

To run this program, you must have a TI-59 programmable calculator attached to a PC-100C printer. The program is written in two parts so that it can fit into the available memory space of the TI-59. These two parts are recorded on two separate magnetic cards. The first part of the program handles the data entry and computation; the second part provides the alphanumeric printing of the results.

A detailed discussion of the equations used in the program was given earlier in the first two sections of this appendix. Equation numbers are marked next to where they appear in the program listing. This appendix provides a complete program listing, a set of operating instructions, and a listing of the data register assignments. With this information, anyone familiar with the operation and programming of the TI-59 calculator can easily duplicate the operation of the program.

Two slightly different versions of Part I of the program were developed. The first is for use with "slab on grade" construction, whereas the second is for a "wood floor over crawl space" construction. The area of difference in the program is shown in Table C-IV, the program listing.

Table C-V is a summary of the data register assignments. This provides a guide to be used when inputting data and when debugging the program.

Table C-VI gives a set of step-by-step instructions for using the program. You should be familiar with the operating characteristics of the TI-59 calculator system before you run the program.

The output listings are shown in Table C-VII. Tape 1 shows the results of the heat-loss calculations for our example home (see Table C-II). The percentages can be used to estimate conservation savings. Tape 2 lists the data stored in each of the data registers.

TABLE C-IV. Heat-Loss Program Listing

PART I
(PROGRAM CARD I)

Step[a]	Code[b]	Mnemonic[c]
000	76	LBL
001	15	E
002	47	CMS
003	76	LBL
004	11	A
005	01	1
006	95	=
007	91	R/S
008	42	STO
009	01	01
010	02	2
011	95	=
012	91	R/S
013	42	STO
014	02	02
015	71	SBR
016	45	Y^X
017	43	RCL
018	03	03
019	44	SUM
020	10	10
021	43	RCL
022	04	04
023	44	SUM
024	11	11
025	91	R/S
026	76	LBL
027	45	Y^X
028	43	RCL
029	01	01
030	65	×
031	43	RCL
032	02	02
033	95	=
034	42	STO
035	03	03
036	53	(
037	02	2
038	65	×
039	43	RCL
040	01	01
041	54	)
042	85	+
043	53	(
044	02	2
045	65	×
046	43	RCL
047	02	02
048	54	)
049	95	=
050	42	STO
051	04	04
052	92	RTN
053	76	LBL
054	12	B
055	01	1
056	95	=
057	91	R/S
058	42	STO
059	01	01
060	02	2
061	95	=
062	91	R/S
063	42	STO
064	02	02
065	71	SBR
066	45	Y^X
067	43	RCL
068	03	03
069	44	SUM
070	10	10
071	44	SUM
072	12	12
073	43	RCL
074	04	04
075	44	SUM
076	11	11
077	91	R/S
078	76	LBL
079	13	C
080	01	1
081	95	=
082	91	R/S
083	42	STO
084	01	01
085	02	2
086	95	=
087	91	R/S
088	42	STO
089	02	02
090	71	SBR
091	45	Y^X
092	43	RCL
093	03	03
094	44	SUM
095	13	13

[a]Program step.
[b]Operation code.
[c]Operation mnemonic.

TABLE C-IV. (cont)

	096	43	RCL
	097	04	04
	098	44	SUM
	099	14	14
	100	91	R/S
	101	76	LBL
	102	14	D
	103	01	1
	104	95	=
	105	91	R/S
	106	42	STO
	107	01	01
	108	02	2
	109	95	=
	110	91	R/S
	111	42	STO
	112	02	02
	113	71	SBR
	114	45	Y×
	115	43	RCL
	116	03	03
	117	44	SUM
	118	08	08
	119	44	SUM
	120	13	13
	121	43	RCL
	122	03	03
	123	44	SUM
	124	14	14
	125	91	R/S
	126	76	LBL
	127	16	A'
(1)	128	43	RCL
	129	09	09
	130	75	-
	131	01	1
	132	07	7
	133	95	=
	134	42	STO
	135	17	17
(2)	136	43	RCL
	137	20	20
	138	34	√X
	139	65	×
	140	04	4
	141	95	=
	142	42	STO
	143	18	18
(3) d	144	65	×
	145	43	RCL
	146	15	15
	147	95	=
	148	42	STO
	149	19	19

[d] Use these steps 144-149 for "slab on grade" construction. Replace it with this code for "wood floor over crawl space" construction.

(3)	144	43	RCL
	145	45	45
	146	65	×
	147	43	RCL
	148	20	20
	149	65	×
	150	93	.
	151	04	4
	152	01	1
	153	06	6
	154	95	=
	155	42	STO
	156	19	19

	150	43	RCL
	151	22	22
(4)	152	53	(
	153	43	RCL
	154	20	20
	155	34	√X
	156	65	×
	157	08	8
	158	65	×
	159	04	4
	160	54	)
	161	75	-
	162	43	RCL
	163	10	10
	164	75	-
	165	43	RCL
	166	13	13
	167	95	=
	168	42	STO
	169	23	23
(5)	170	02	2
	171	93	.
	172	08	8
	173	06	6
	174	08	8
	175	65	×
	176	43	RCL
	177	21	21
	178	65	×
	179	43	RCL
	180	20	20
	181	55	÷
	182	02	2
	183	04	4

TABLE C-IV. (cont)

	184	95	=
	185	42	STO
	186	24	24
	187	65	×
	188	06	6
	189	00	0
	190	55	÷
	191	43	RCL
	192	20	20
	193	55	÷
	194	08	8
	195	95	=
	196	42	STO
	197	44	44
(6)	198	43	RCL
	199	10	10
	200	65	×
	201	43	RCL
	202	28	28
	203	95	=
	204	42	STO
	205	32	32
(7)	206	43	RCL
	207	29	29
	208	65	×
	209	43	RCL
	210	13	13
	211	95	=
	212	42	STO
	213	33	33
(8)	214	43	RCL
	215	30	30
	216	65	×
	217	43	RCL
	218	23	23
	219	95	=
	220	42	STO
	221	34	34
(9)	222	43	RCL
	223	20	20
	224	65	×
	225	43	RCL
	226	31	31
	227	95	=
	228	42	STO
	229	35	35
	230	76	LBL
	231	17	B'
(10)	232	85	+
	233	43	RCL
	234	32	32
	235	85	+
	236	43	RCL
	237	33	33
	238	85	+
	239	43	RCL
	240	34	34
	241	85	+
	242	43	RCL
	243	19	19
	244	85	+
	245	43	RCL
	246	24	24
	247	95	=
	248	42	STO
	249	36	36
(11)	250	65	×
	251	43	RCL
	252	16	16
	253	65	×
	254	02	2
	255	04	4
	256	55	÷
	257	01	1
	258	52	EE
	259	06	6
	260	95	=
	261	42	STO
	262	01	01
	263	02	2
	264	32	X⇌T
	265	43	RCL
	266	25	25
	267	67	EQ
	268	34	√X
	269	43	RCL
	270	01	01
	271	55	÷
	272	01	1
	273	95	=
	274	42	STO
	275	01	01
(12)	276	76	LBL
	277	34	√X
	278	43	RCL
	279	01	01
	280	42	STO
	281	37	37
	282	43	RCL
	283	27	27
	284	65	×
	285	01	1
	286	93	.
	287	04	4
	288	05	5
	289	52	EE
	290	04	4
	291	65	×

TABLE C-IV. (cont)

	292	01	1
	293	09	9
	294	06	6
	295	55	÷
	296	01	1
	297	52	EE
	298	06	6
	299	95	=
	300	42	STO
	301	38	38
(13)	302	53	(
	303	43	RCL
	304	12	12
	305	85	+
	306	43	RCL
	307	08	08
	308	54	)
	309	65	×
	310	02	2
	311	93	.
	312	09	9
	313	52	EE
	314	05	5
	315	65	×
	316	93	.
	317	08	8
	318	05	5
	319	55	÷
	320	01	1
	321	52	EE
	322	06	6
	323	95	=
	324	42	STO
	325	39	39
(14)	326	43	RCL
	327	37	37
	328	75	-
	329	43	RCL
	330	38	38
	331	75	-
	332	43	RCL
	333	39	39
	334	95	=
	335	42	STO
	336	40	40
(15)	337	65	×
	338	01	1
	339	52	EE
	340	06	6
	341	55	÷
	342	43	RCL
	343	16	16
	344	55	÷
	345	43	RCL
	346	20	20
	347	95	=
	348	42	STO
	349	41	41
(16)	350	65	×
	351	43	RCL
	352	26	26
	353	65	×
	354	43	RCL
	355	20	20
	356	95	=
	357	42	STO
	358	42	42
(17)	359	02	2
	360	32	X⇌T
	361	43	RCL
	362	25	25
	363	67	EQ
	364	23	LNX
	365	53	(
	366	43	RCL
	367	42	42
	368	55	÷
	369	01	1
	370	52	EE
	371	05	5
	372	54	)
	373	65	×
	374	93	.
	375	03	3
	376	01	1
	377	95	=
	378	42	STO
	379	43	43
	380	61	GTO
	381	35	1/X
(18)	382	76	LBL
	383	23	LNX
	384	53	(
	385	43	RCL
	386	42	42
	387	55	÷
	388	03	3
	389	04	4
	390	01	1
	391	03	3
	392	54	)
	393	65	×
	394	93	.
	395	00	0
	396	06	6
	397	05	5
	398	95	=
	399	42	STO

TABLE C-IV. (cont)

400	43	43
401	76	LBL
402	35	1/X
403	69	OP
404	00	00
405	02	2
406	07	7
407	03	3
408	02	2
409	01	1
410	03	3
411	01	1
412	06	6
413	00	0
414	00	0
415	69	OP
416	01	01
417	01	1
418	05	5
419	01	1
420	03	3
421	03	3
422	05	5
423	01	1
424	06	6
425	00	0
426	00	0
427	69	OP
428	02	02
429	00	0
430	03	3
431	00	0
432	00	0
433	00	0
434	00	0
435	00	0
436	00	0
437	00	0
438	00	0
439	69	OP
440	03	03
441	69	OP
442	05	05
443	98	ADV
444	98	ADV
445	98	ADV
446	91	R/S

PART II
(PROGRAM CARD II)

000[a]	76[b]	LBL[c]
001	11	A
002	58	FIX
003	02	02
004	98	ADV
005	98	ADV
006	69	OP
007	00	00
008	04	4
009	03	3
010	02	2
011	04	4
012	03	3
013	01	1
014	01	1
015	06	6
016	03	3
017	02	2
018	69	OP
019	01	01
020	04	4
021	03	3
022	00	0
023	00	0
024	02	2
025	07	7
026	03	3
027	02	2
028	03	3
029	06	6
030	69	OP
031	02	02
032	03	3
033	06	6
034	00	0
035	00	0
036	06	6
037	04	4
038	00	0
039	00	0
040	00	0
041	00	0
042	69	OP
043	03	03
044	69	OP
045	05	05
046	43	RCL
047	32	32
048	42	STO
049	01	01
050	71	SBR
051	33	X^2
052	69	OP

[a]Program step.
[b]Operation code.
[c]Operation mnemonic.

TABLE C-IV. (cont)

053	00	00	089	03	03	125	04	4
054	01	1	090	69	OP	126	00	0
055	06	6	091	05	05	127	00	0
056	03	3	092	43	RCL	128	00	0
057	02	2	093	33	33	129	00	0
058	03	3	094	42	STO	130	00	0
059	02	2	095	01	01	131	00	0
060	03	3	096	71	SBR	132	00	0
061	05	5	097	33	X^2	133	00	0
062	00	0	098	69	OP	134	69	OP
063	00	0	099	00	00	135	03	03
064	69	OP	100	04	4	136	69	OP
065	01	01	101	03	3	137	05	05
066	02	2	102	01	1	138	43	RCL
067	07	7	103	03	3	139	34	34
068	03	3	104	02	2	140	42	STO
069	02	2	105	07	7	141	01	01
070	03	3	106	02	2	142	71	SBR
071	06	6	107	07	7	143	33	X^2
072	03	3	108	00	0	144	69	OP
073	06	6	109	00	0	145	00	00
074	00	0	110	69	OP	146	01	1
075	00	0	111	01	01	147	05	5
076	69	OP	112	02	2	148	01	1
077	02	02	113	07	7	149	07	7
078	06	6	114	03	3	150	02	2
079	04	4	115	02	2	151	04	4
080	00	0	116	03	3	152	02	2
081	00	0	117	06	6	153	07	7
082	00	0	118	03	3	154	02	2
083	00	0	119	06	6	155	04	4
084	00	0	120	00	0	156	69	OP
085	00	0	121	00	0	157	01	01
086	00	0	122	69	OP	158	03	3
087	00	0	123	02	02	159	01	1
088	69	OP	124	06	6	160	02	2

TABLE C-IV. (cont)

161	02	2
162	00	0
163	00	0
164	02	2
165	07	7
166	03	3
167	02	2
168	69	OP
169	02	02
170	03	3
171	06	6
172	03	3
173	06	6
174	00	0
175	00	0
176	06	6
177	04	4
178	00	0
179	00	0
180	69	OP
181	03	03
182	69	OP
183	05	05
184	43	RCL
185	35	35
186	42	STO
187	01	01
188	71	SBR
189	33	X^2
190	69	OP
191	00	00
192	03	3
193	06	6
194	02	2
195	07	7
196	01	1
197	03	3
198	01	1
199	04	4
200	00	0
201	00	0
202	69	OP
203	01	01
204	02	2
205	07	7
206	03	3
207	02	2
208	03	3
209	06	6
210	03	3
211	06	6
212	00	0
213	00	0
214	69	OP
215	02	02
216	06	6
217	04	4
218	00	0
219	00	0
220	00	0
221	00	0
222	00	0
223	00	0
224	00	0
225	00	0
226	69	OP
227	03	03
228	69	OP
229	05	05
230	43	RCL
231	19	19
232	42	STO
233	01	01
234	71	SBR
235	33	X^2
236	69	OP
237	00	00
238	02	2
239	04	4
240	03	3
241	01	1
242	02	2
243	01	1
244	02	2
245	04	4
246	02	2
247	07	7
248	69	OP
249	01	01
250	03	3
251	07	7
252	03	3
253	05	5
254	01	1
255	03	3
256	03	3
257	07	7
258	02	2
259	04	4
260	69	OP
261	02	02
262	03	3
263	02	2
264	03	3
265	01	1
266	00	0
267	00	0
268	02	2

TABLE C-IV. (cont)

269	07	7	305	07	7	341	06	6
270	03	3	306	69	OP	342	06	6
271	02	2	307	01	01	343	03	3
272	69	OP	308	01	1	344	02	2
273	03	03	309	03	3	345	01	1
274	03	3	310	02	2	346	03	3
275	06	6	311	07	7	347	07	7
276	03	3	312	00	0	348	07	7
277	06	6	313	00	0	349	00	0
278	00	0	314	06	6	350	69	OP
279	00	0	315	04	4	351	02	02
280	06	6	316	00	0	352	00	0
281	04	4	317	00	0	353	00	0
282	00	0	318	69	OP	354	06	6
283	00	0	319	02	02	355	04	4
284	69	OP	320	69	OP	356	00	0
285	04	04	321	05	05	357	00	0
286	69	OP	322	43	RCL	358	00	0
287	05	05	323	36	36	359	00	0
288	43	RCL	324	99	PRT	360	00	0
289	24	24	325	98	ADV	361	00	0
290	42	STO	326	69	OP	362	69	OP
291	01	01	327	00	00	363	03	03
292	71	SBR	328	01	1	364	69	OP
293	33	X^2	329	04	4	365	05	05
294	69	OP	330	03	3	366	43	RCL
295	00	00	331	07	7	367	41	41
296	02	2	332	04	4	368	99	PRT
297	06	6	333	01	1	369	98	ADV
298	00	0	334	06	6	370	69	OP
299	00	0	335	03	3	371	00	00
300	03	3	336	01	1	372	02	2
301	07	7	337	06	6	373	01	1
302	03	3	338	69	OP	374	04	4
303	02	2	339	01	01	375	01	1
304	03	3	340	01	1	376	01	1

TABLE C-IV. (cont)

377	07	7
378	02	2
379	07	7
380	00	0
381	00	0
382	69	OP
383	01	01
384	00	0
385	00	0
386	01	1
387	04	4
388	02	2
389	04	4
390	02	2
391	07	7
392	02	2
393	07	7
394	69	OP
395	02	02
396	00	0
397	00	0
398	06	6
399	04	4
400	00	0
401	00	0
402	00	0
403	00	0
404	00	0
405	00	0
406	69	OP
407	03	03
408	69	OP
409	05	05
410	43	RCL
411	43	43
412	99	PRT
413	98	ADV
414	27	INV
415	58	FIX
416	91	R/S
417	76	LBL
418	33	X²
419	69	OP
420	00	00
421	01	1
422	03	3
423	01	1
424	05	5
425	03	3
426	07	7
427	69	OP
428	04	04
429	43	RCL
430	01	01
431	69	OP
432	06	06
433	53	(
434	43	RCL
435	01	01
436	55	÷
437	43	RCL
438	36	36
439	54	)
440	65	×
441	01	1
442	00	0
443	00	0
444	95	=
445	42	STO
446	02	02
447	69	OP
448	00	00
449	00	0
450	00	0
451	00	0
452	00	0
453	06	6
454	01	1
455	69	OP
456	04	04
457	43	RCL
458	02	02
459	69	OP
460	06	06
461	98	ADV
462	92	RTN

TABLE C-V. Storage Register Assignments

R1-R7	temporary storage	R27[a]	number of people
R8	south door area (ft^2)	R28[a]	window U value (Btu/hour · ft^2)
R9[a]	design temperature (°F)	R29[a]	door U value (Btu/hour · ft^2)
R10	total window area (ft^2)	R30[a]	wall U value (Btu/hour · ft^2)
R11	window perimeter (ft)	R31[a]	ceiling U value (Btu/hour · ft^2)
R12	south window area (ft^2)	R32	window heat loss (Btu/hour)
R13	door area (ft^2)	R33	door heat loss (Btu/hour)
R14	door perimeter (ft)	R34	wall heat loss (Btu/hour)
R15[a]	perimeter factor (Btu/hour · ft)	R35	ceiling heat loss (Btu/hour)
R16[a]	total heating degree days for the year	R36	total heat loss (Btu/hour)
R17	temperature adjustment factor	R37	heating load (Btu)
R18	house perimeter (ft)	R38	internal gain (Btu)
R19	slab heat loss (Btu/hour)	R39	solar gain (Btu)
R20[a]	floor area (ft^2)	R40	adjusted heating load (Btu)
R21[a]	air-change factor (air changes/hour)	R41	heat-loss factor (Btu/degree day · ft^2)
R23	wall area (ft^2)	R42	monthly consumption for heating (Btu/month)
R24	infiltration heat loss (Btu/hour)	R43	fuel bill ($)
R25[a]	fuel type	R45[a]	U value of floor over crawl space (Btu/hour · ft^2)
R26[a]	total heating degree days for the month		

[a]Input variables.

TABLE C-VI. Operation of the Heat-Loss Program

Entry of Input Variables

(1) Load both sides of Program Card I [see p. VIII-5 of the Texas Instruments Instruction Manual (1977) for loading instructions].

(2) Press [E] to initialize the data registers.

(3) Enter the design temperature and press [STO] [0] [9].

(4) Enter the perimeter factor and press [STO] [1] [5].

(5) Enter the degree days for the year and press [STO] [1] [6].

(6) Enter the floor area and press [STO] [2] [0].

(7) Enter the air-change factor and press [STO] [2] [1].

(8) Enter the fuel type (gas = 1, electricity = 2) and press [STO] [2] [5].

(9) Enter the degree days for the month and press [STO] [2] [6].

(10) Enter the number of people and press [STO] [2] [7].

(11) Enter the U value for windows and press [STO] [2] [8].

(12) Enter the U value for doors and press [STO] [2] [9].

(13) Enter the U value for walls and press [STO] [3] [0].

(14) Enter the U value for ceilings and press [STO] [3] [1].

(15) Enter the U value for the floor over a crawl space and press [STO] [4] [5].

TABLE C-VI. (cont)

Entry of Window Areas and Perimeters

(16) Press [A] and a "1" will appear in the display. Enter the width and press [R/S].

(17) A "2" will appear in the display. Enter the height of the window and press [R/S]. Wait until the "C" in the left-hand side of the display is gone. The number in the display is the perimeter of the window.

(18) Repeat steps (16) and (17) for all nonsouth windows.

Entry of South Window Areas and Perimeters

(19) Do steps (16) and (17) for each south window, and substitute the key [B] for the key [A].

Entry of Door Areas and Perimeters

(20) Do steps (16) and (17) for all nonsouth doors, and substitute the key [C] for the key [A].

Entry of South Door Areas and Perimeters

(21) Do steps (16) and (17) for all south doors, and substitute the key [D] for the key [A].

Computation

(22) Once all imput data registers are loaded and window and door data are entered, press [2nd] [A].

(23) When computation is complete the message "LOAD CARD 2" will be printed.

Output

(24) Load both sides of Program Card II [refer to step (1)].

(25) Press [A] and the output data will be printed.

(26) This completes the data evaluation for one home. Repeat steps (1) through (25) for each home.

TABLE C-VII. Output of Heat-Loss Program

TAPE 1

```
LOAD CARD     2

WINDOW LOSS =
       158.20      ACT
        17.66       %

DOOR LOSS =
        17.99      ACT
         2.01       %

WALL LOSS =
       244.95      ACT
        27.35       %

CEILING LOSS =
       119.00      ACT
        13.29       %

SLAB LOSS =
       121.23      ACT
        13.54       %

INFILTRATION LOSS =
       234.22      ACT
        26.15       %

K TOTAL =
       895.59

BTU/DD/FT²=
        15.35

FUEL BILL =
         0.00
```

TAPE 2

0.	08
65.	09
140.	10
48.	11
0.	12
36.72	13
38.	14
0.81	15
4292.	16
48.	17
149.6662955	18
121.2296993	19
1400.	20
1.4	21
0.	22
1020.610364	23
234.22	24
0.	25
0.	26
0.	27
1.13	28
0.49	29
0.24	30
0.085	31
158.2	32
17.9928	33
244.9464873	34
119.	35
895.5889866	36
92.25283034	37
0.	38
0.	39
92.25283034	40
15.35295406	41
0.	42
0.	43
1.25475	44
0.	45
0.	46
0.	47
0.	48

DATA INPUT SHEET

This sheet assists the operator of the program in entering the data. You will have to choose a floor type, either floor over a crawl space (45) or slab (15).

	Values for Home	Storage Register Number
design temperature (°F)	____________	9
perimeter factor (Btu/hour · ft)	____________	15
degree days for the heating season (for local climate)	____________	16
floor area (ft^2)	____________	20
air changes per hour	____________	21
fuel type (gas = 1, electricity = 2)	____________	25
degree days for the month	____________	26
number of people	____________	27
window U value (Btu/hour · ft^2)	____________	28
door U value (Btu/hour · ft^2)	____________	29
wall U value (Btu/hour · ft^2)	____________	30
ceiling U value (Btu/hour · ft^2)	____________	31
floor (over crawl space) U value (Btu/hour · ft^2)	____________	45

	Values for Home**				
	1st	2nd	3rd	4th	5th
window width* (ft)	________	________	________	________	________
window height* (ft)	________	________	________	________	________
south-facing window width (ft)	________	________	________	________	________
south-facing window height (ft)	________	________	________	________	________
door width* (ft)	________	________	________	________	________
door height* (ft)	________	________	________	________	________
south-facing door width (ft)	________	________	________	________	________
south-facing door height (ft)	________	________	________	________	________

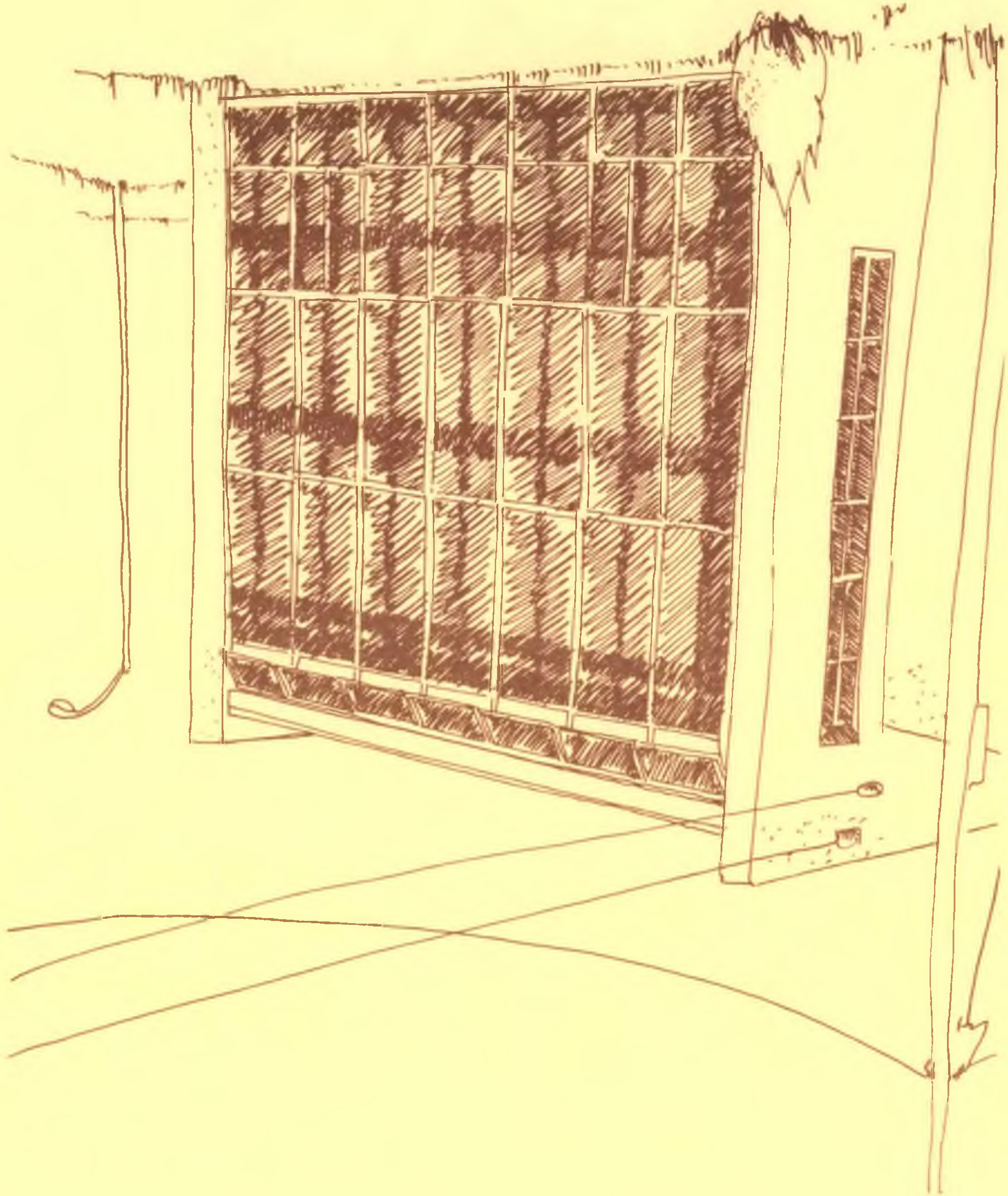
*Omit those that face south.

**Make a continuation page if there are more than five windows or doors.

When you run the program, you may find this data input sheet handy.

Conclusion

We hope this appendix has provided you with a basic understanding of how heat-loss calculations are done and the approaches by which conservation and solar savings can be estimated. The methodology presented in this appendix is general in nature but can provide some indication of community energy and dollar savings based on the age and construction type of the buildings. You may wish to make your own analysis more realistic by using information from specific buildings in your community. Such an approach might be particularly appropriate in a neighborhood analysis.



D Albuquerque Case Study in Determining Retrofit Potential

Single-Family Residential Buildings

Mobile Homes

Multifamily Residential Buildings

Nonresidential Buildings

Introduction

This appendix presents the application of the methodologies that were discussed in Chap. 2. We stress once again that these should be used only as one part in an analysis that looks at the local potential for a retrofit program. Every attempt should be made to substantiate estimates with local utility data or the actual energy savings that have already been achieved through the retrofit of buildings in the community. We also recommend that an estimated range of savings be developed in assessing retrofit impacts in order to address local policy options more conservatively. In short, exercise reasoned judgment in the application of the methodologies, recognizing their strengths and weaknesses. Such action can ensure the credibility of the figures that you ultimately develop in your particular analysis.

Emphasis is placed on understanding the economic aspects of various retrofit programs in this appendix. We feel that this is an important consideration in a retrofit program or in other policy endeavors that consider the possible ramifications of reducing energy usage in the community. Decision-makers will want to know if a given program is an economic use of the community's capital. This is a particularly important point if support for a program is to be garnered from public- and/or private-sector organizations. We refer you to Appendix E for a specific discussion of the steps involved in assessing economic aspects of a retrofit program. Benefit-cost analysis is a technique that has particular relevance in evaluating the local program.

In the following pages, discussions will implicitly assess the economic issues surrounding the retrofit program. These relate to the following considerations.

- *Selection of retrofit measures.* Economic criteria are used in the single-family residential and mobile-home sections to assess whether or not the conservation or passive solar retrofits on a typical dwelling unit are an efficient investment for the individual given certain criteria. Energy-efficient measures can then be chosen that reflect a practical and effective use of community capital.
- *Assessing the economic effectiveness of the retrofit program.* Benefit-cost techniques enable you to assess the overall economic effectiveness of a program for the community. This assessment may suggest possible roles for the public sector in extending financing or targeting other local resources. The technique could be used to assess the economic advantages/disadvantages of alternative programs, although it is not used that way in this sourcebook. For example, the benefits and costs of solar hot-water heater installations could be compared with those of passive solar retrofits. Be aware that any assessment of program effectiveness will be only as good as the data and the assumptions that underlie it.
- *Determining the point at which the program becomes uneconomic.* Techniques presented allow you to determine at what point a community program becomes uneconomic to implement. This point may be used as a lower boundary for determining a possible range of energy savings. This range could be compared to other estimates in order to determine the reasonability of the program in achieving certain savings given a specified level of investment.

- *Assessing program impacts on residents.* The multifamily section examines how mandatory retrofit programs for landlords may affect rents in the community. This analysis points out other economic impacts that may be imposed through the implementation of legal requirements to encourage energy efficiency in buildings.

The methodologies as they are applied do not necessarily suggest an optimal level of savings nor do they develop a specific list of the most cost-effective measures that should be implemented (only physical modifications of buildings are considered). The major objective is to demonstrate how community savings might be estimated related to specific investment criteria and how certain other objectives of the retrofit effort might be assessed. Contractor-installed conservation and passive solar retrofit measures are evaluated for the single-family residential sector to determine possible community employment impacts. The mobile-home section focuses on a "self-installed," cooperative approach as a means of reducing the costs of retrofit measures and making them more attractive in a community where the cost of energy is low. Finally, a simple conservation retrofit package is considered for multifamily buildings in view of the particular investment requirements of renters and landlords.

Employment impacts, cost reductions on retrofit installations, or economic impacts are important considerations in local retrofit efforts. Although we look at these issues as they might arise in specific building sectors, they could certainly be assessed as they apply to the other building sectors as well. A combination of these issues also could be evaluated as they affect one sector. For example, employment impacts might be evaluated for single-family homes assuming a certain proportion between contractor-installed and owner-installed retrofits.

Rather than attempt to provide a specific analysis of the energy savings potential in Albuquerque, we felt that it would be more effective to present a range of analytical approaches that you might find useful for your own purposes. The discussion of the approach for single-family homes is very detailed. The analysis in the mobile-homes section closely follows the approach developed in the single-family section. However, the analyses become much more complex for multifamily units and nonresidential buildings; thus more aggregate approaches were used. The primary objective in our Albuquerque discussion is to demonstrate how these approaches can be applied in a real situation. The techniques that are described feasibly could be expanded to consider other retrofit actions, such as furnace modifications or solar hot-water heater installation. You may also find it beneficial to examine the potential for other energy technologies such as wood or for those not necessarily related to heating, such as wind or photovoltaic. In summary, we hope our discussion and examples will be helpful in any analysis that you may undertake.

Albuquerque, New Mexico

Climate, Population, and Housing Characteristics

The City of Albuquerque is situated in central New Mexico on the Rio Grande just west of the Sandia Mountain Range. The major portion of the City rests on a mesa 5,314 ft above sea level.

TABLE D-I. Housing in Albuquerque, 1970-1980

Housing Type	1970 Number	1970 Per Cent of Total	1980[a] Number	1980[a] Per Cent of Total	Per Cent Change 1970-1980
Single-Family Units	62,963	80	86,624	64	38
Mobile Homes	2,068	3	6,075	5	194
Multifamily Units (Apartments)	13,757	17	41,788	31	204
	78,788[b]	100	134,487	100	

[a]Units for 1980 were estimated as of the end of the year.

[b]We allocated housing units somewhat differently for 1970 than is reported in the census. According to conversations with the Albuquerque Building Department, townhouses and duplexes were included in single-family permits. Multifamily units were defined as structures with three or more units. Consequently, townhouses and duplexes were taken from the 1970 multifamily figures and added to the single-family number to assess more accurately the growth in this sector. The multifamily numbers reflect buildings of three units or more, which we define to be apartments. This adjustment reflected a shift of 3,699 housing units.

The local climate is arid with annual rainfall averaging between about 8 in. near the river and 15 in. closer to the mountains. Daytime temperatures average around 50°F in winter and 90°F in summer. There are no muggy days; the annual humidity averages 43% (as little as 20% in the dryer summer months). The sun shines 75% of the daylight hours, and clear, sunny days predominate in the winter. The large number of sunny winter days and the moderately severe climate (4,292 heating degree days) make Albuquerque climatically ideal for a conservation and passive solar retrofit program. Passive solar applications are particularly effective in this region of the country because of the high levels of insolation.

A typical sunbelt city, Albuquerque has grown 35.7% in the past decade, from about 244,000 people in 1970 to its present population of approximately 332,000.

Local housing trends reflect Albuquerque's expansion as demonstrated in Table D-I.

Over the decade, 2,244 commercial building permits were issued with a value of approximately $500 million. This may be compared to 1,900 issued permits during the 1960-1970 decade with a value of about $100 million. The 1970-1980 permit figure represents an 18% increase in the number issued and a 400% increase in value.

To summarize, Albuquerque is a medium-sized city that is expanding rapidly because of an influx of retirees and high-technology industries. The growth of the City is anticipated to continue at the current rate through the 1980s.

Energy Consumption

The major fuel used for heating in the City is natural gas. The 1970 Census of Housing indicated that 95.5% of the City housing units used gas for heating, 2.5% used electricity, and 2% used other fuels (Martin 1981, p. 38). A survey done by the New Mexico Energy Institute in 1977-1978 of 2,686 Albuquerque single-family homes reported that natural gas was the heating fuel used in 95.3% of the homes. Electricity was the fuel for 3.5% of the homes; the remaining 1.2% heated with other fuels (coal, oil, wood, propane, solar energy). It is reasonable to assume that the proportion of fuel types will be the same for mobile homes and apartment units.

Recognizing the predominance of natural gas as the primary heating fuel in the City and our desire to keep the analysis relatively simple, we have confined our analysis to the determination of impacts on natural-gas usage in the City. (We included electrically heated units in the analysis because there was no easy way to separate them out from all the housing by age.)

Natural-gas consumption for Albuquerque in 1980 is presented in Table D-II. Total consumption for the City is 34.1 trillion Btu. We estimate that approximately 9.9 trillion Btu (29%) are used for space heating (single-family homes are estimated to consume 8.0 trillion Btu; mobile homes, 0.36 trillion Btu; and multifamily units, 1.5 trillion Btu).

The following sections will describe how consumption was estimated and the energy savings that were derived for single-family homes, mobile-homes, and multifamily units given certain retrofit program objectives. A concluding section examines how energy-efficiency considerations can be evaluated in a small commercial area.

TABLE D-II. Natural-Gas Consumption in Albuquerque, 1980[a]

Class	Average Customer Counts	Gas Consumed (therms)
Residential	128,028	121,058,445
Commercial	10,972	58,813,802
Industrial	51	126,829,526
Public Authority	646	34,258,890
	139,697	340,960,663

[a]Data were supplied by T. Rister of the Gas Company of New Mexico in a letter to R. Mathews, April 20, 1981.

As of the end of 1980, we estimated that there were 86,624 single-family homes in Albuquerque. Our estimate of city-wide energy consumption for space heating is 8.0 trillion Btu. This implies an average consumption level of around 92.0 million Btu per home and a resulting annual bill of about $320 at a gas cost of $0.35/therm. The energy consumption factor for a typical home of 1,400 ft^2 is about 15.3 Btu/degree day · ft^2, and the heat-loss factor is 8.4 Btu/degree day · ft^2.

A conservation and passive solar retrofit program could save up to 3.5 trillion Btu, or 44%, of the total estimated energy consumption used for space heating. Conservation retrofits would be responsible for 31% of this savings. Passive solar measures would produce an additional 13% savings based on retrofitting 42% of the City's single-family homes. City-wide consumption would be reduced in the process from 8.0 trillion Btu to 4.5 trillion Btu. Apportionment of the savings over all single-family homes would produce an annual consumption level of 52.2 million Btu per home at an annual cost of $183. Consumption and heat-loss factors would be 8.7 and 4.8 Btu/degree day · ft^2, respectively, at 55% furnace efficiency.

Our estimated average cost of the conservation retrofits on a per unit basis is about $1,400. Passive solar applications considered in the analysis are a greenhouse ($2,400) and a Trombe wall ($1,100). Our estimate for the average cost of a conservation and passive solar greenhouse package on a frame home is around $3,700. A combined conservation and greenhouse package on a masonry home is estimated at about $3,000, whereas the conservation retrofits plus the Trombe wall on a masonry home would be approximately $1,800.

Determining Single-Family Residential Characteristics

Age and Number of Homes

The estimate of 86,624 homes was obtained by referring to Planning Department estimates for 1979 and then updating that number by the 1,403 single-family building permits issued in 1980.

The age breakdowns of Albuquerque homes (and construction characteristics) were estimated using the results of the New Mexico Home Energy Analysis (HEA) program. This study was supported by the New Mexico Energy and Minerals Department in cooperation with the New Mexico Energy Institute at the University of New Mexico. The HEA study was aimed at assessing the energy consumption characteristics of New Mexico homes and estimating possible improvements that could result from conservation measures. Of the approximately 4,800 surveys returned from throughout the state, 2,686 were from Albuquerque residents, which represents a 3% sample of the entire City single-family residential housing. The surveys asked a number of questions related to home construction type, home type, age of the home, orientation of the home, and the fuel used by the home's heating system. These data will be referred to often in the single-family section because they provided us with information that was not readily available in Albuquerque. You may find that the data mentioned above are easier to obtain from the planning, tax, or building departments of your local government or through reference to local utility information.

The ages of homes were estimated using the percentage distributions for age that were determined in the HEA study. We assumed that the applicable percentages are relevant to the entire City population and that construction type is the same as reported in the HEA study as well. This approach may be questioned, but no other data were found to exist in such detail. Because of the method of determining the study distribution, we feel that the data are fairly representative of the construction characteristics of all the homes. The breakdown of units by age is presented in Table D-III.

The relative newness of the City's single-family housing is suggested by the fact that 58% of it has been built since 1956. More startling, but to be expected considering the rapid rate of population growth during the 1970s, is the fact that 30% of the housing was built between 1971 and the end of 1980.

Construction Characteristics

Average size of a typical single-family home in Albuquerque is estimated to be 1,400 ft^2. We arrived

TABLE D-III. Age Characteristics of Homes

Age	Number	Per Cent
Pre-1956	36,258	42
1956-1965	19,240	22
1966-1970	5,588	6
1971-1975	11,721	14
1976-1980	13,817	16
	86,624	100

at this conclusion after talks with the local home-builder's association and realtors.* This number includes only the heated area of the home.

Information from the HEA study was used to estimate construction characteristics of Albuquerque homes (Table D-IV).

*Conversations with D. Tinker of the Albuquerque Homebuilder's Association and J. Blatnik of John Blatnik and Associates.

A number of characteristics can be inferred about the housing based on the information in the table.

- *Housing Type.* Approximately 78,000 (90%) of Albuquerque's single-family units are one story. Only after 1956 did a growing number of two-story and split-level homes begin to appear in the City.
- *Construction Type.* The overwhelming majority (~65,000, or 75%) of Albuquerque homes are of frame construction. Masonry homes tend to be older, representing about 43% of the homes built before 1956. Use of masonry construction drops appreciably after the 1956-1965 time span. This generally reflects the growing impact of large builders in the City and changing consumer preferences.
- *Roof Type.* Pitched roofs are present on about 49,000 (57%) of the homes in the City and are more likely to appear on a frame home (62%) than a masonry home (21%). Older homes tend to have a larger percentage of the flat roofs;

TABLE D-IV. Homes by Age and Construction Type

	Frame Homes					Masonry Homes					
Age	1 Story FR[a]	Other FR	1 Story PR[a]	Other PR	Other Roof Types	1 Story FR	Other FR	1 Story PR	Other PR	Other Roof Types	Total
Pre-1956											
Per Cent[b]	30.7	1.8	22.8	2.1	---	27.2	1.1	13.5	0.8	---	100
Number	11,131	653	8,267	761	---	9,862	399	4,895	290	---	36,258
1956-1965											
Per Cent[b]	19.8	0.6	53.4	5.8	0.6	7.1	0.3	11.5	0.9	---	100
Number	3,810	115	10,274	1,116	115	1,366	58	2,213	173	---	19,240
1966-1970											
Per Cent[b]	16.8	2.6	57.6	7.9	4.4	2.9	---	6.9	0.9	---	100
Number	939	145	3,219	441	246	162	---	386	50	---	5,588
1971-1975											
Per Cent[b]	22.6	4.5	52.6	7.7	3.7	3.5	0.8	4.4	0.2	---	100
Number	2,649	527	6,165	903	434	410	94	516	23	---	11,721
1976-1980											
Per Cent[b]	23.7	5.2	56.1	4.3	3.0	2.1	0.7	4.4	0.5	---	100
Number	3,275	718	7,751	594	415	290	97	608	69	---	13,817
	21,804	2,158	35,676	3,815	1,210	12,090	648	8,618	605	0	86,624

[a]Roof Type: FR = flat roof; PR = pitched roof.

[b]Values are percentages of age-bracket totals.

63% of the pre-1956 frame homes have this roof type. Overall, pre-1956 homes have 59% of the total number of flat roofs in the City. The popularity of the flat roof during this period reflects the influence of the architecture characteristic to New Mexico and the Southwest. After 1956, the pitched roof becomes increasingly popular, reflecting the growing influences of new construction and changing tastes of the rapidly expanding local population. Other roof types constitute a negligible percentage (1.3%) of the City's housing.

- *Floor Type.* The information in Table D-IV does not give floor type. Conversations with local urban rehabilitation specialists and gas company officials suggested that floor types before about 1956 were broken down approximately 50/50 between slab construction and wood floors over crawl spaces.* Basements are rare in the City and usually are found only in the older homes. After 1956, we assumed that almost all homes were built on concrete slabs, again based on conversations with local people familiar with construction techniques.

Based on the information suggested in the HEA study, we can say generally that the typical home in Albuquerque was built after 1956, has one story, and is of frame construction. The roof is pitched, and the home is on a concrete slab.

Window Area. We conservatively assumed that 10% of the floor area, 140 ft^2, would be devoted to windows. This implies nine 3- by 5-ft windows for the modeled homes. Our single-family residential questionnaires distributed in the Albuquerque middle schools suggested that window area would vary from 8% to 25% of the floor area of the home. Older homes, particularly those built in the 1950s, 1960s, and early 1970s, tended to have a larger percentage of the floor area devoted to windows than did homes built before 1950 and after 1975. A 10% figure was used because it is fairly reasonable and meets the current building-code minimum. It is probably low, but we did want to inject some degree of conservatism into our estimate of heat loss and conservation savings. In all likelihood, the real average percentage lies somewhere between 10% and 20%.

Insulation Levels. The levels of insulation in homes were determined by age bracket based on conversations with local builders, city officials, and gas company representatives. We also referred to the HEA data (from the entire state) to check the basic validity of our estimates.

Estimating insulation levels based on the age of a home is difficult, and there will certainly be a good deal of variation within a given age bracket based on the construction type (frame versus masonry) and the cost of the home. There will also be overlap whereby the insulation levels of one age bracket extend over into another. Still, we found it possible to draw some general conclusions on insulation levels for homes in Albuquerque.

Homes built before 1956 generally had 2.5 to 3.5 in. of rock wool in the ceiling for an R value of approximately 7 to 11 (excluding structural components). Wall insulation was minimal or nonexistent in both frame and masonry homes. There was usually no floor insulation for those homes built over crawl spaces. Slab insulation also was nonexistent for homes in the pre-1956 bracket.

Many homes, especially those built before 1950 or so, often had no insulation whatsoever. This is particularly evident in homes built for lower income households. Concrete block and adobe construction, because of cost considerations, were particularly popular construction materials for these households; such construction effectively eliminates the possi-

*Conversations with P. Wilkes of the Albuquerque Urban Rehabilitation Department and T. Boudreaux of Gas Company of New Mexico.

bility of any type of wall insulation. Basically speaking, construction practices before 1956 reflect the low cost of energy to Albuquerqueans.

Between 1956 and 1965, the thermal characteristics of homes began to be improved. This was a period of great expansion in Albuquerque housing as the total number of units grew by almost 50%. This increase was attributable, in large part, to the construction activity of several large builders in the City. During this time, the use of R-7 in the walls and R-11 in the ceilings became more prevalent in tract-built frame homes.* This trend was more evident beginning in the latter part of the 1950s. A number of homes built during the 10-year span, particularly those that were built by owners or small contractors, still probably used a lesser amount of insulation, however. This generally meant a 3.5-in. fiber-glass batt in the ceiling and probably nothing in the wall. The construction of homes with basements or over crawl spaces largely stopped during this period. Slab construction became the predominant floor type.

The 1966-1970 time span saw the introduction of R-11 insulation to the walls so that the level matched that of the ceiling. This construction practice persisted into the early 1970s, when builders began to use R-19 in the roof.* The use of R-19 began to really take hold beginning around 1972-1973 and continues in new construction today.

The 1976-1980 period has been influenced increasingly by the New Mexico Energy Code, which started to exert an influence on builders in 1978. The use of R-11 in walls still predominates in new construction, although some builders are also using Thermax insulation board (polyurethane at R-4/in.) to boost wall values to R-19 in more expensive homes ($70,000+). Ceiling insulation typically runs from R-19 to R-30 at this time, with the latter value typically found in the more expensive homes. The use of double glazing (for windows) also began to take hold as a result of Energy Code considerations starting around 1978.

*Telephone conversations with W. Eskew of Bellamah Homes and F. Wolak, Sr., of the Federal Housing Administration, Albuquerque.

The thermal performance of masonry home walls improved as 1-in. bead board (polyurethane) was applied to the outside, boosting the wall R value to 9 or so.

Beginning in 1978, builders also started to use R-5 perimeter insulation on all homes. Based on our interviews of local individuals with knowledge about construction practices over the past 30 years, we determined the R values shown in Table D-V for heat-loss modeling purposes.

Obviously our generalizations about insulation levels may be questioned, particularly the levels before 1970. There will be overlaps where some builders use insulation levels common in one period in another period. We feel the values are fairly representative of the periods covered and implicitly account for higher or lower values during those times, however.

TABLE D-V. R Values by Age of Home[a]

	Frame				Masonry		
Age	Ceiling	Wall	Floor (CS)[b]	Floor	Ceiling	Wall	Floor
Pre-1956	11.7	4.2	3.3	1.2	11.7	3.3	1.2
1956-1965	15.4	10.0	---	1.2	15.4	3.3	1.2
1966-1970	15.4	12.5	---	1.2	15.4	3.3	1.2
1971-1975	20.0	12.5	---	1.2	20.4	3.3	1.2
1976-1980	25.0	12.5	---	2.4[c]	25.0	9.1	2.4[c]

[a]Includes building components.

[b]Floor type: CS = floor over crawl space; all other frame homes and all masonry homes are assumed to have slab floors.

[c]The value of 2.4 was used to reflect an average value for the age bracket. Half of the homes are assumed to have no insulation (R-1.2 pre-1978), whereas homes built after 1978 are assumed to have R-4.5 perimeter insulation.

Infiltration Levels. Infiltration levels for the homes were determined by averaging the values reported from our Albuquerque middle-school questionnaires. Although we had originally hoped to do this by age, we determined an average of 1.4 air changes/hour for pre-1976 homes and 1.2 air changes/hour after that time.

Furnace Efficiencies

We assumed a furnace efficiency level of 55% for pre-1976 homes and 65% for 1976-1980 homes. These numbers are used to calculate dollar savings.

They are felt to be justified given the findings of other studies [Martin (1981) assumes 55% furnace efficiency; Edgel (1979) assumes 60% furnace efficiency].

Estimated Heating Loads

Basing our conclusions on empirical observations and assumptions, we estimate that the heating loads in Table D-VI are fairly typical for Albuquerque homes by the specified age brackets.

The average heating load for a frame home in Albuquerque is estimated to be 48.8 million Btu and the heat-loss factor is 8.1 Btu/degree day · ft^2. A masonry home requires 56.2 million Btu for the heating season and has a heat-loss factor of 9.4 Btu/degree day · ft^2.

The weighted average heating load and heat-loss factor for Albuquerque homes, taking the estimated percentage of frame (74%) and masonry (26%) homes into account, are 50.7 million Btu and 8.4 Btu/degree day · ft^2, respectively.

These numbers are slightly low, based on the results from one study (Edgel 1979) and estimates from the Gas Company. The lower estimate only adds to the conservatism of our estimates for conservation and solar savings. Table D-VII details our numbers, the results from the Edgel study, and the Gas Company estimate.

Based on a comparison with the Edgel study and the Gas Company estimates, we conclude that our estimates are fairly reasonable for the City. The greatest difference is between our composite estimate and the Edgel figure (11.2%); our estimate is only 4% lower than the estimate given by the Gas Company, however. Although the Gas Company estimates that it costs $0.24/$ft^2$ to heat the average

TABLE D-VI. Estimated Heating Load for Single-Family Homes Based on Age and Construction Type[a]

Age and Construction Type[b]	Heating Load (million Btu)	Heat-Loss Factor (Btu/degree day · ft^2)
Pre-1956		
Frame (CS)	61.5	10.2
Frame	58.1	9.7
Masonry	62.1	10.3
1956-1965		
Frame	47.1	7.8
Masonry	60.3	10.0
1966-1970		
Frame	45.7	7.6
Masonry	60.3	10.0
1971-1975		
Frame	43.7	7.3
Masonry	58.9	9.8
1976-1980		
Frame	37.7	6.3
Masonry	39.4	6.6

[a]Before combustion losses.

[b]Floor type: CS = floor over crawl space; all other frame homes and all masonry homes are assumed to have slab floors.

TABLE D-VII. Derived Heating Loads and Heat-Loss Factors Compared with Those of Other Studies[a]

Source	Heating Load (million Btu)	Heat-Loss Factor (Btu/degree day · ft^2)
Our study		
Frame	48.8	8.1
Masonry	56.2	9.4
Composite	50.7	8.4
Edgel Study	57.1	9.5
Gas Company of New Mexico estimates	52.8	8.8

[a]Values before combustion losses for a 1,400-ft^2 house.

home (about $340/year), our estimate comes in at around $0.23/ft^2 (about $320/year).

Applying Retrofit Measures

Retrofit measures for single-family homes were assumed to be contractor installed. This was done to demonstrate the potential community economic impacts that a retrofit program might have. The low cost of natural gas in Albuquerque makes contractor-installed measures somewhat unattractive economically based on our modeled 1,400-ft^2 home. *We caution you not to accept the idea that all contractor-installed retrofits in Albuquerque are uneconomic at this time.*

Our analysis is oriented toward determining the total energy savings that can reasonably be expected to be achieved given assumed construction characteristics of typical homes and specified economic criteria. It is not meant to address the specific economics of individual retrofits. This can only be done considering the unique construction and thermal characteristics of a building and the lifestyles of the occupants. Actual levels of energy consumption for space heating and possible energy savings will vary above and below the estimates that we have derived for the City. In any event, we feel that conservative assumptions about window area and the manner in which the perimeter is derived (see Appendix C) tend to underestimate heating loads to some degree, thus lowering the potential level of savings for the home. This will affect the economics of retrofit measures (for example, storm windows and wall insulation).

The economics for the consumer had to be modified to account for the current economic situation as we see it in Albuquerque. The typical household (owner) will occupy a home for 7 years (Andreassi 1977). Ideally, we would advocate the adoption of those conservation and solar measures whose costs could be recouped or exceeded in that time, based on a 12% discount rate and a 16% annual rate of increase for natural-gas prices.* Our analysis suggests that the only economic propositions under those circumstances would be caulking and weather stripping for all homes and wall insulation for pre-1956 frame homes. To obtain a more significant level of savings, we extended the holding period for the homeowners to 15 years. This was done with the idea that the owner could obtain a 10- to 15-year FHA Title I insured loan for the improvements and that energy-efficient homes will be valued more highly in the real estate market as energy prices continue to rise. This suggests that the owner will be able to recover his remaining balance on the loan and perhaps make some money in addition upon the sale of the home. This approach allowed us to include ceiling insulation and storm windows for

TABLE D-VIII. Albuquerque Contractor Costs for Conservation Retrofit Measures[a]

Retrofit	Unit Cost ($/ft^2)	Cost to Homeowner ($)
Ceiling insulation		
(blown cellulose) R-11	0.20	300
R-19	0.29	400
Wall insulation		
(blown cellulose) R-11	0.60	600
Floor insulation		
(fiber-glass batts) R-19	0.50	700
Storm windows	5.00	700
Caulking and weather stripping		100

[a]Costs for a 1,400-ft^2 house. Insulation costs based on conversations with Duke Insulation, Triple A Insulation, and Keers, Inc. Caulking and weather stripping based on do-it-yourself cost from Public Service of New Mexico. Storm window cost estimate based on information from Coronado Glass Company.

*The selection of these criteria is discussed in Appendix E.

pre-1976 homes. We also assume that most households would apply for the 15% Federal Conservation Income Tax Credit. The estimated contractor costs for conservation retrofits for Albuquerque homes are presented in Table D-VIII.

The costs to carry out comprehensive conservation retrofits according to the age bracket of the home are presented in Table D-IX.

Estimating Conservation Savings

Table D-X details the energy and dollar savings attributable to the conservation measures. Selection of individual conservation applications was based on a 12% discount rate for the homeowner, a 15-year holding period, and a 16% annual escalation rate in the price of natural gas. Homes built before 1976 are assumed to have furnaces that are 55% efficient, whereas those built after that time have furnaces that are 65% efficient in the calculation of the estimated dollar savings.

As you examine Table D-X, it becomes obvious that the greatest amount of energy savings that can be achieved given the economic criteria is in the older homes of the City. The economics of investing are most favorable for homes built before 1956, which can achieve a high level of savings, and for the newest homes, which can achieve savings through relatively small investments. The economic attraction of conservation investments for homes built between 1956 and 1965 are less favorable, because existing insulation levels reduce the amount of heat saved per dollar invested.

Estimating Solar Savings

Passive Solar Retrofits—The Greenhouse and the Trombe Wall

We use two types of passive systems in our analysis of solar retrofit potential for Albuquerque single-family homes. The first is a Yanda style greenhouse with 2-by-4 framing (Fig. D-1). This design was provided by the New Mexico Solar Energy Association (NMSEA) The southern face has a 70° tilt to maximize solar gain. The roof has two sections. The lower section (below the cross-members) is translucent to admit sunlight during the summer. The upper section is built out of plywood and is insulated to ensure that the 385 gal.

TABLE D-IX. Estimated Cost of Conservation Retrofits by Age and Construction Type of Home

Age and Construction Type[a]	Estimated Cost of Retrofit Measures ($)	Cost with 15% Fed. Tax Credit ($)
Pre-1956		
Frame (CS)	2,500	2,125
Frame	1,800	1,530
Masonry	1,200	1,020
1956-1965		
Frame	1,800	1,530
Masonry	1,200	1,020
1966-1970		
Frame	1,800	1,530
Masonry	1,200	1,020
1971-1975		
Frame	1,700	1,445
Masonry	1,100	935
1976-1980		
Frame	100	85
Masonry	100	85

[a]Floor type; CS = floor over crawl space; all other frame homes and all masonry homes are assumed to have slab floors.

of mass storage, which is located in barrels against the back wall of the greenhouse, is not exposed to the high-angle summer sun. Summer exposure could create an overheating problem that might not be easily solved through venting. In the winter, when the sun is lower in the sky, solar radiation will hit the water-barrel mass storage directly, generating heat that is then transferred to the home by convection. The greenhouse is 16 ft long, 8 ft wide, and 9 ft high at the rear. The collector area, which is 144 ft^2, is used in determining the performance of the system. The greenhouse has 128 ft^2 of floor area, which is used to generate a cost estimate.

The second system considered for a retrofit application is the Trombe wall (Fig. D-2). This system design was also supplied by the NMSEA and is based on one that they developed for their low-income workshop program. A Trombe wall is essentially framing with double glazing (using glass, fiber glass, or plastic), which is attached to a masonry wall. The wall is painted a dark color to increase its ability to absorb the sun's radiant energy. During the day, the mass wall absorbs heat, and this heat then begins to move into the home by conduction through the wall. If no vents are incorporated into the design, the wall is referred to as a stagnating Trombe wall. The major portion of the heat absorbed during the day reaches the interior of the home during the evening because of a time-lag effect in the build-up of heat in masonry materials.

A daytime heating mode can be incorporated into the design by placing vents at the top and the bottom of the collector. Here, radiant energy becomes trapped between the glazing and the mass wall. A convective heating loop is established whereby cool air is drawn from the home through the lower vents and is heated in the space between the wall and the glazing by the sun and by some of the heat radiated by the mass wall. The air, now warmed, re-enters the home through the upper vents. Dampers, placed in the vents inside the home, are shut at night to prevent backdrafting, or the convective loss of the warm air in the building to the cooler night air. The convective (daytime) and conductive (nighttime) heating modes can work well together as heat

TABLE D-X. Estimated Conservation Energy and Dollar Savings[a] by Age and Construction Type of Home

Age and Construction Type[c]	Estimated Heating Load [million Btu ($)]	Retrofit[b]: CI [million Btu ($)]	FI [million Btu ($)]	WI [million Btu ($)]	SW [million Btu ($)]	C+WS [million Btu ($)]	Total Savings [million Btu ($)]	Total Savings (%)	Weatherized Heating Load [million Btu ($)]
Pre-1956									
Frame (CS)	61.5(391)	5(32)	9.7(62)	11.6(74)	5.2(33)	4.3(27)	35.8(228)	58	25.7(163)
Frame	58.1(369)	5(32)	---	11.6(74)	5.2(33)	4.3(27)	26.1(167)	45	32 (203)
Masonry	62.1(395)	5(32)	---	---	5.2(33)	4.3(27)	14.5(92)	23	47.6(303)
1956-1965									
Frame	47.1(300)	3.3(21)	---	---	5.2(33)	4.3(27)	12.8(819)	27	34.3(219)
Masonry	60.3(384)	3.3(21)	---	---	5.2(33)	4.3(27)	12.8(81)	21	47.5(303)
1966-1970									
Frame	45.7(291)	3.3(21)	---	---	5.2(33)	4.3(27)	12.8(81)	28	32.9(210)
Masonry	60.3(384)	3.3(21)	---	---	5.2(33)	4.3(27)	12.8(81)	21	47.5(303)
1971-1975									
Frame	43.7(278)	2.7(17)	---	---	5.2(33)	4.3(27)	12.2(77)	28	31.5(201)
Masonry	58.9(375)	2.7(17)	---	---	5.2(33)	4.3(27)	12.2(77)	21	46.7(304)
1976-1980									
Frame	37.7(203)	---	---	---	---	2.1(11)	2.1(11)	6	35.6(192)
Masonry	39.4(212)	---	---	---	---	2.2(12)	2.2(12)	6	37.2(200)

[a]Dollar savings calculated at 55% furnace efficiency for pre-1976 homes and 65% for 1976-1980 homes.

[b]Retrofit type; CI = ceiling insulation; FI = floor insulation; WI = wall insulation; SW = storm windows; C+WS = caulking and weather stripping.

[c]Floor type; CS = floor over crawl space; all other frame homes and all masonry homes are assumed to have slab floors.

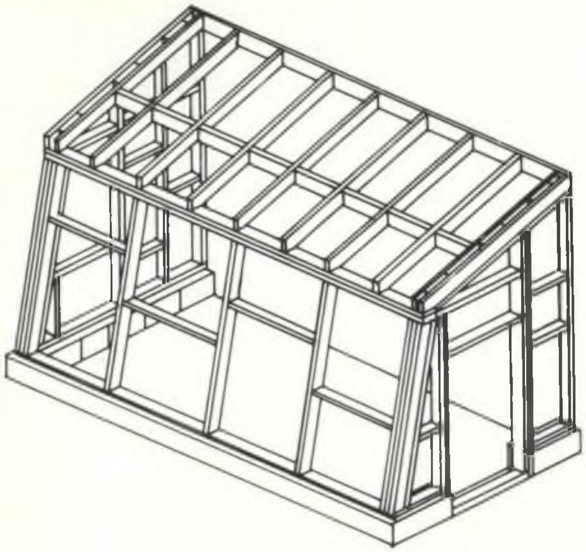


Fig. D-1. Greenhouse framing.

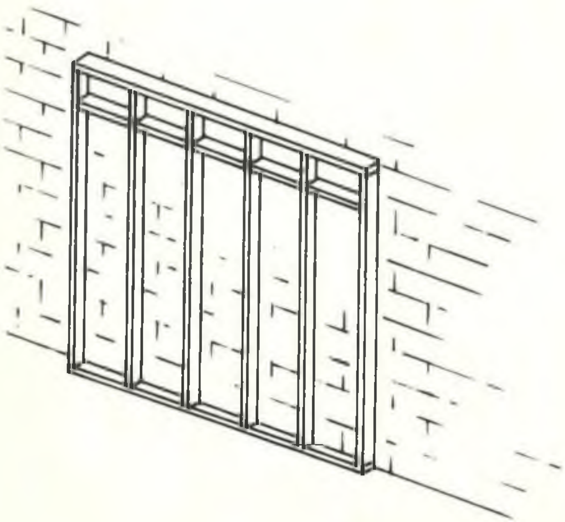


Fig. D-2. Trombe wall framing.

transferred by conduction begins to meet the home's needs once the vents (which have been open during the day) have been closed.

An overhang usually is incorporated into the Trombe wall design to block out the summer sun and protect against overheating. Vents to the outside also are included in the design to further reduce any heat build-up during the summer.

The design used in our study is 8 ft 9 in. high and is 20 ft long. Construction can be of 2-by-4 or 2-by-6. The gross area of the collector is 176 ft^2. Wood supports behind the double glazing reduce the collector area used to receive the solar energy to an effective area of 149 ft^2.

Determining the Directional Orientation

Initially, the directional orientation of homes must be assessed to determine their ability to accept a passive solar retrofit. This information may be obtained from aerial photographs, base maps of the community (for example, Sanborne maps), or if time permits, a field survey. We were able to obtain the orientations from information presented in two reports. We accept this information as being fairly indicative of single-family home orientations in Albuquerque. The two studies suggest some comparability in their findings. Home orientations are roughly distributed evenly, with east or west orientations slightly more predominant. This information is presented in Table D-XI.

Solar Access

In addition to determining the orientation of structures, we must also take into account solar access in studying the potential for passive solar retrofits. This concern relates to the shading effects that natural or constructed objects will have on a passive solar retrofit and their impact on system

TABLE D-XI. Estimated Distribution of Homes in Albuquerque According to Direction Faced

Direction Faced	Martin Study[a] (%)	Edgel Study[b] (%)
North	21.1	17.7
South	20.8	17.2
East	21.2	20.5
West	23.6	24.9
Skewed	13.3	19.8

[a]Martin 1981. This information was derived from HEA study data.

[b]Edgel 1979. This information was derived from FHA sales listings.

performance. Such considerations for Albuquerque single-family homes were assessed in "Economic Implications of Passive Solar Retrofit for Single-Family Residences in Albuquerque—A Case Study" by Steven W. Martin (1981). We will now detail the approach used in that work.

Martin initially considered several approaches in attempting to determine solar access potential. A question of the HEA surveys asked about the summer shading characteristics of the home. This question had little relevance because of the changing position of the sun in the sky over the seasons. For example, on June 21 in Albuquerque, the sun is approximately 78° above the horizon. On December 21, the sun is 30° above the horizon. (The angles for your community will depend on its latitude.) The winter shading characteristics of the home are of primary importance in assessing passive solar retrofit potential.

TABLE D-XII. Maximum Height of Objects vs Distance[a]

Distance, X (ft)	Maximum Height, Y (ft)
1	2.58
2	3.15
3	3.73
4	4.31
5	4.89
6	5.46
7	6.04
8	6.62
9	7.20
10	7.77
11	8.35
12	8.93
13	9.51
14	10.08
15	10.66
16	11.24
17	11.81
18	12.39
19	12.97
20	13.55

[a]Based on a 25% shading factor and a sun altitude of 30°.

Low-altitude aerial photographs of the City of Albuquerque were tried next. These photos were available at the scale of 1 in. to 1,000 ft. Vertical shading patterns could not be determined because of the lack of detail, however. Assessment of shading on a south wall by an object ultimately is determined by the height of the object, its distance from the wall, and the type of object (vegetation or other structure). Aerial photographs were of little help in determining these considerations.

In the end, it was decided that site visits were the most appropriate means of determining retrofit potential. Martin selected 540 homes at random from the total HEA sample of 2,686 (about 20%). Site visits confirmed that 91.3% of the respondents had correctly identified the direction that their homes faced. The remaining 8.7% were off by only 45° (they may have responded north when the actual orientation was northeast or northwest, etc.).

A procedure was applied against the sample of 540 homes to determine their shading profile. The height and setback of any object that might cast a shadow on the south wall was estimated. The nature of these objects (vegetation, buildings, walls, etc.) was also determined. If there was a garage on the south side of the home, it was assumed that no solar retrofit would be possible, because there would be no living space next to the solar retrofit that would be supplying the heat.

As mentioned earlier, the sun will be 30° from the horizon at noon on December 21 in Albuquerque. This is the lowest point in the sky that the sun will reach during the year. December 21 is also the time when passive solar systems will require substantial energy in order to meet the heating needs of the home. To assess the shading impacts that natural or constructed objects would have on a home, Table D-XII was developed, which lists the maximum allowable heights of objects at varying distances from the south wall. These heights were derived based on a shading coefficient of 25% or less. This means that on December 21 no more than 25% of the south wall of the home can be shaded out by an object on the south side. A shading coefficient of over 25% will not be accepted because of the decrease that could be expected in the performance of the system.

The vertical dimensions of the Trombe wall and the greenhouse are 8 ft 9 in. and 9 ft. respectively. A shading coefficient of 25% is equal to a vertical height of approximately 2 ft. If shading from a nearby object falls above the 2-ft level, the wall is assumed to be unretrofittable.

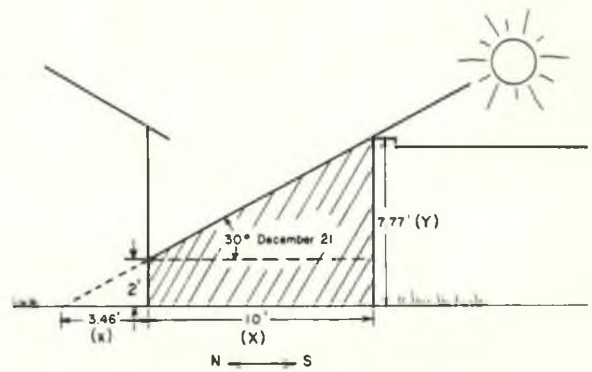


Fig. D-3. Determining maximum height.

For example, if an object casting the shadow is 10 ft from the south wall of the home, the maximum height of the object could only be 7.77 ft (see Table D-XII) to ensure a shading coefficient of approximately 25%. We determine this height (and those in the table) from the geometry in Fig. D-3. We know that the sun's angle to the ground is 30° and the height of the shadow is 2 ft. With these two parts of the small 30°-60°-90° triangle, we can determine the dimension along the ground:

$$\tan 30° = 2/x$$

$$0.577 = 2/x$$

$$x = 3.46 \text{ ft.}$$

Now we can determine the height (Y) of the object casting the shadow if we know its distance (X) from the wall. The equation for the large triangle is

$$0.577 = Y/(X + 3.46).$$

For our example, we have

$$0.577 = Y/(10 + 3.46)$$

$$Y = 0.577(13.46)$$

$$= 7.77 \text{ ft.}$$

Apportioning the Systems

To apportion the greenhouses and Trombe walls, it is first necessary to determine the distribution of Albuquerque homes by construction type. Table D-XIII presents the estimated breakdown based on masonry or frame construction.

Based on the random sample of 540 homes, the retrofit potentials in Table D-XIV were determined for south-facing yards. For the purposes of his study, Martin assumed that vegetative cover 10 ft high or less could be removed or transplanted. Buildings, other nonremovable structures, and larger vegetational matter were assumed to be permanent.

Once Martin determined shading characteristics, he assessed the legal considerations affecting retrofit potential. The retrofit potential is affected intimately by zoning and subdivision regulations. In Albuquerque, homes must have a minimum side-yard setback of 5 ft, meaning a minimum distance of 10 ft between homes. The 10-ft number varied by neighborhood, but it is safe to say that solar retrofit potential on side-yards generally will be much less than on the front or back yards.

Setbacks for homes from the street or the front of the lot line often are required by many localities. In Albuquerque, this distance is 20 ft. Conversations with the staff at the Albuquerque Zoning Commission revealed that 75% of the local contractors build up to the limit. The installation of a solar greenhouse that goes over the setback would require the homeowner to obtain a variance. The Albuquerque Planning Commission indicated that such a variance would be granted if it could be proven that

TABLE D-XIII. Distribution of Homes by Construction Type

	Number of Homes by Age Bracket					
Construction Type	Pre-1956	1956-1965	1966-1970	1971-1975	1976-1980	Total
Frame	20,812	15,430	4,990	10,678	12,753	64,663
Masonry	15,446	3,810	598	1,043	1,064	21,961
	36,258	19,240	5,588	11,721	13,817	86,624

TABLE D-XIV. Retrofit Potential by South-Facing Yard

South-Facing Yard	Per Cent of Total	Per Cent Retrofittable	Per Cent of Total Retrofitted
Back	23.7	89.8	21.3
Front	22.6	85.3	19.3
Side	43.9	63.7	28.0
Skewed	9.8	---	---
	100.0		68.6

the greenhouse was not injurious to the neighborhood and if there was a structural reason for its presence (for example, a south-facing exposure is needed for the operation of the system). These local land-use restrictions were implicitly considered in the final allocation of the systems.

Based on the results of retrofit potential analyses, approximately 68.6% of Albuquerque homes are considered to be retrofittable with at least one of the two passive systems that are described. It is now possible to estimate the number of homes with retrofit potential broken down by construction type and by south-facing yard for each of the five age brackets (Table D-XV). The retrofit percentages developed by Martin covered homes through the end of 1978. We feel it is reasonable to assume that the same percentages could be applied to homes built in 1979 and 1980 as well.

The totals in Table D-XV now are used to estimate the total possible number of greenhouses and Trombe walls that could be built. To do this, we need to make some assumptions about which systems are likely to be retrofitted onto which homes.

Greenhouses are the only systems that we assume are retrofittable onto frame homes. South-facing back yards are assumed to be retrofitted 100% with greenhouses. No greenhouses are assumed to be retrofitted onto south-facing side yards, because side yards are rarely wide enough to accomodate a greenhouse. Both front-yard setback requirements and aesthetic considerations will limit the percentage of south-facing front yards that could possibly be retrofitted with greenhouses. We assume a 60% retrofit possibility.

Masonry homes can accept both greenhouses and Trombe walls. We assume south-facing back yards are retrofitted 80% with greenhouses and 20% with Trombe walls. Although certain economic considerations place greenhouses and Trombe walls on an equal footing, greenhouses are assumed to be preferred because of other unquantifiable variables (including the "snob" appeal of owning a greenhouse and the amenities that it provides: additional living space, food, and plant propagation). South-facing side yards are assumed to be retrofitted 100% with Trombe walls. As with frame homes, only 60% of south-facing front yards are retrofitted with greenhouses. The remaining 40% are retrofitted with Trombe walls. The passive solar retrofit potential for Albuquerque is given in Table D-XVI.

Based on our apportionment of systems, we estimate that about 42% of Albuquerque's single-family housing units can be practically retrofitted with passive solar systems. The percentage is higher for masonry homes (68.6% of total masonry homes) than for frame homes (33% of total frame homes) because masonry homes can accept both greenhouses and Trombe walls. An additional advantage for masonry homes is their ability to accept side-yard Trombe wall retrofits.

In conclusion, assessment of solar retrofit potential can be expected to involve a field survey of units in the community. The technique that was used in this study, based on a sample of homes, might be questioned because the age of the home was not considered. We thus assumed that the retrofit percentages would be applicable to all home age brackets. This assumption may not be as unsound as it seems because, although many of the older homes are located in areas with mature stands of trees, most of them are deciduous. We recommend that you obtain copies of reports done by Seattle City Light (Bennett and Miller 1980) for the City of Seattle and by the Solar Energy Research Institute

TABLE D-XV. Number of Homes with Retrofit Potential

Construction Type and South-Facing Yard	Number of Homes by Age Bracket					Total Retrofits
	Pre-1956	1956-1965	1966-1970	1971-1975	1976-1980	
Frame						
Back	4,433	3,287	1,063	2,273	2,716	13,772
Front	4,017	2,978	963	2,060	2,461	12,479
Side	5,827	4,320	1,397	2,988	3,571	18,103
Subtotal						44,354
Masonry						
Back	3,290	812	127	222	227	4,678
Front	2,981	735	115	201	205	4,237
Side	4,325	1,067	167	292	298	6,149
Subtotal						15,064
TOTAL	24,873	13,199	3,832	8,036	9,478	59,418

(Pollock and Stolz 1981) for Boulder, Colorado, to provide additional ideas on assessing solar access potential.

Performance

The performance of the greenhouses by age and construction type of the home is presented in Table D-XVII. The passive solar measures are added only after the home has been weatherized in accordance with the economic criteria previously described. This ensures a more efficient level of performance. The use of night insulation can further improve the performance of the systems; in Albuquerque, night insulation can increase the solar-savings fraction of a system by around 10% over that of a system without it. This assumption may seem rather presumptious, because we are asking the average homeowner to go out every night and put up insulation panels. The point here is to maximize the savings that can be obtained on a contractor-built system, thus improving its economic attraction.

Greenhouses are estimated to cost around $19/ft^2, whereas Trombe walls cost around $6/ft^2.* Both of these are at contractor prices. We consequently estimate the cost of the greenhouse at $2,400 and the Trombe wall at about $1,100.

*Information from M. Wells of the New Mexico Solar Energy Association in a letter to R. Mathews, June 30, 1981.

Total Estimated Savings for Conservation and Solar Retrofits

The combined impact of conservation and solar retrofits is shown in Table D-XVIII, which details these savings before combustion losses.

The economics of the combined conservation and passive solar measures are presented in Table D-XIX. Economic criteria used in the evaluation include a 12% discount rate, 16% annual escalation rate for natural gas, and a 15-year holding period.

Based on the assumed economic criteria, we found that the conservation and passive solar retrofit measures are economic except for greenhouses on 1976-1980 homes. Particularly striking is the attractive return on conservation and Trombe wall retrofits, which return an additional $0.50 to $0.70 per dollar invested beyond the required rate of return of 12%. Conservation and greenhouse retrofits on pre-1956 frame homes also perform very well because of the reductions in energy consumption that can be achieved initially by conservation retrofits.

City Savings in Energy and Dollars

Once the savings for various retrofits have been estimated and their economic utility defined, it is possible to estimate total potential energy savings for the City (Table D-XX).

Our analysis up to this point implies that every home in Albuquerque would obtain the conservation savings estimated for its particular age bracket. This is obviously unrealistic because some homes will have already received conservation retrofits. We may consequently expect that the projected City savings will be somewhat less than predicted.

The assumption that all homes would achieve the projected savings was used for single-family homes (and mobile homes) as it was felt that home weatherization has yet to become a priority issue to most Albuquerqueans because of the extremely low cost of natural gas. The number of homes that have already been comprehensively retrofitted probably is small. Further, it is likely that those homes that have

TABLE D-XVI. Passive Solar System Potential

Construction Type and Passive System	Number of Homes by Age Bracket					Total Retrofits
	Pre-1956	1956-1965	1966-1970	1971-1975	1976-1980	
Frame						
Greenhouses	6,843	5,074	1,641	3,509	4,193	21,260
Masonry						
Greenhouses	4,421	1,091	171	299	305	6,287
Trombe walls	6,175	1,523	238	416	425	8,777
Subtotal	10,596	2,614	409	715	730	15,064
TOTAL	17,439	7,688	2,050	4,224	4,923	36,324

TABLE D-XVII. Estimated Solar Savings by Age and Construction Type of Home

Age and Construction Type[a]	Solar System	Heating Load After Conservation [million Btu ($)]	Building Load Coefficient After Conservation (Btu/degree day)	Load/Collector Area Ratio	Solar-Savings Fraction (%)	Passive Solar Savings [million Btu ($)]
Pre-1956						
Frame (CS)	greenhouse	25.7(163)	5,988	41.6	70	18.0(115)
Frame	greenhouse	32.0(204)	7,456	51.8	60	19.2(122)
Masonry	greenhouse	47.6(303)	11,090	77.0	45	21.4(136)
	Trombe wall	47.6(303)	11,090	74.1	30	14.3(91)
1956-1965						
Frame	greenhouse	34.3(218)	7,992	55.5	60	20.6(131)
Masonry	greenhouse	47.5(302)	11,067	76.9	45	21.4(136)
	Trombe wall	47.5(302)	11,067	74.0	30	14.3(91)
1966-1970						
Frame	greenhouse	32.9(209)	7,665	53.2	60	19.7(125)
Masonry	greenhouse	47.5(302)	11,067	76.9	45	21.4(136)
	Trombe wall	47.5(302)	11,067	74.0	30	14.3(91)
1971-1975						
Frame	greenhouse	31.5(200)	7,339	51.0	60	18.9(120)
Masonry	greenhouse	46.7(297)	10,880	75.6	45	21.1(134)
	Trombe wall	46.7(297)	10,880	72.7	30	14.1(90)
1976-1978						
Frame	greenhouse	35.6(192)	8,295	57.6	60	21.4(115)
Masonry	greenhouse	37.2(200)	8,667	60.2	55	20.5(110)
	Trombe wall	37.2(200)	8,667	57.9	40	14.9(80)

[a]Floor type: CS = floor over crawl space; all other frame homes and all masonary homes are assumed to have slab floors.

TABLE D-XVIII. Total Estimated Savings for Conservation and Solar Retrofits in Btu and Dollars[a]

Age, Construction Type, and Passive Retrofit[b]	Initial Load [million Btu ($)]	Conservation Savings [million Btu ($)]	Solar Savings Based on Conservation Load [million Btu ($)]	Total Saved [million Btu ($)]	New Load [million Btu ($)]
Pre-1956					
Frame (CS)	61.5(391)	35.8(228)	18.0(115)	53.8(343)	7.7(48)
Frame	58.1(369)	26.1(166)	19.2(122)	45.3(288)	12.8(81)
Masonry (GH)	62.1(395)	14.5(92)	21.4(136)	35.9(228)	26.2(167)
(TW)			14.3(91)	28.8(183)	33.3(212)
1956-1965					
Frame	47.1(300)	12.8(81)	20.6(131)	33.4(212)	13.7(88)
Masonry (GH)	60.3(384)	12.8(81)	21.4(136)	34.2(217)	26.1(167)
(TW)			14.3(91)	27.1(172)	33.2(212)
1966-1970					
Frame	45.7(291)	12.8(81)	19.7(125)	32.5(206)	13.2(85)
Masonry (GH)	60.3(384)	12.8(81)	21.4(136)	34.2(217)	26.1(167)
(TW)			14.3(91)	27.1(172)	33.2(212)
1971-1975					
Frame	43.7(278)	12.2(77)	18.9(120)	31.1(197)	12.6(81)
Masonry (GH)	58.9(375)	12.2(77)	21.1(134)	33.2(211)	25.7(164)
(TW)			14.1(90)	26.3(167)	32.6(208)
1976-1980					
Frame	37.7(197)	2.1(11)	21.4(115)	23.5(126)	14.2(76)
Masonry (GH)	39.4(212)	2.2(12)	20.5(110)	22.7(122)	16.7(90)
(TW)			14.9(80)	17.1(92)	22.3(120)

[a]Before combustion losses.

[b]Floor type: CS = floor over crawl space; all other frame homes and all masonry homes are assumed to have slab floors. Retrofit type: GH = greenhouse; TW = Trombe wall; all frame homes are assumed to be retrofitted with greenhouses.

TABLE D-XIX. Discounted Payback Period and Benefit-Cost Ratio of Conservation and Passive Solar Retrofits

Home Age, Construction Type, and Passive Retrofit[a]	Estimated Cost ($)	Annual Savings ($)	Discounted Payback (years)	Benefit-Cost Ratio[b]
Pre-1956				
Frame (CS)	4,500	343	10.9	1.5
Frame	3,900	288	11.2	1.4
Masonry (GH)	3,400	228	12.2	1.3
(TW)	2,100	183	9.8	1.7
1956-1965				
Frame	3,900	212	14.4	1.1
Masonry (GH)	3,400	217	13.0	1.2
(TW)	2,100	172	10.3	1.6
1966-1970				
Frame	3,900	206	14.7	1.0
Masonry (GH)	3,400	217	12.7	1.2
(TW)	2,100	172	10.3	1.6
1971-1975				
Frame	3,800	197	14.9	1.0
Masonry (GH)	3,300	211	14.4	1.1
(TW)	2,000	167	10.6	1.6
1976-1980				
Frame	2,500	126	15.5	0.98
Masonry (GH)	2,500	122	15.6	0.95
(TW)	1,200	92	10.9	1.5

[a]Floor type: CS = floor over crawl space; all other frame homes and all masonry homes are assumed to have slab floors. Retrofit type: GH = greenhouse; TW = Trombe wall; all frame homes are assumed to be retrofitted with greenhouses.

[b]Total savings divided by total costs (see Appendix E for the computational procedures).

been weatherized could use further improvements, providing additional savings. Finally, in our concluding analysis we allow for the possibility that not all of the projected savings will be achieved by calculating a lower limit of energy savings that will just make the retrofit program economic to the community. Consequently, there is some flexibility in our final estimate. We also suggest that if conservation actions have already been taken, they will serve to reduce the community investment cost, which poses a tradeoff to reduced benefits. In theory, the underlying economics of the analysis may still be correct.

In many areas of the country, homeowners have already undertaken actions to curb rising fuel bills. In your own analysis, it may be possible to obtain local estimates on the extent of homeowner retrofit actions. This information can be used to adjust the figures that you derive for total community savings.

Adjusting the estimate for previously installed passive solar systems is viewed as a very minor problem, because relatively few have been installed in Albuquerque.

The City-wide conservation and passive solar retrofit program as depicted in Table D-XX could save around 3.5 trillion Btu (44%) of the total estimated consumption of around 8.0 trillion Btu used for space heating. Conservation would generate about 31% of this savings, and the passive solar applications would be responsible for an additional 13%. Annual savings to Albuquerque would be approximately $12.25 million of which $8.6 million would be attributable to conservation measures and the remaining $3.65 million to the passive greenhouse and Trombe wall retrofits.* The estimated City-wide dollar investment needed to achieve this level of savings is determined in Table D-XXI.

*In 1981 dollars.

TABLE D-XX. City-Wide Energy Savings from a Conservation and Passive Solar Retrofit Program[a]

Home Age, Construction Type, and Passive Retrofit[b]	Number of Homes	Heating Load (million Btu)	Est. Total City Consumption (billion Btu)	Conservation: Est. Savings/Unit (million Btu)	Conservation: Est. City Savings (billion Btu)	Passive Solar: Number of Retrofits	Passive Solar: Est. Savings/Unit (million Btu)	Passive Solar: Est. City Savings (billion Btu)
Pre-1956								
Frame (CS)	10,406	111.1	1,156.1	65.1	677.4	3,421	32.7	111.9
Frame	10,406	105.6	1,098.8	47.5	494.3	3,422	34.9	119.4
Masonry (GH)	15,446	112.9	1,743.8	26.4	407.8	4,421	38.9	172.0
(TW)						6,175	26.0	160.6
1956-1965								
Frame	15,430	85.6	1,320.8	23.3	359.5	5,074	37.5	190.3
Masonry (GH)	3,810	109.6	417.6	23.3	88.7	1,091	38.9	42.4
(TW)						1,523	26.0	39.6
1966-1970								
Frame	4,990	83.1	414.7	23.3	116.3	1,641	35.8	58.7
Masonry (GH)	598	109.6	65.5	23.3	13.9	171	38.9	6.7
(TW)						238	26.0	6.2
1971-1975								
Frame	10,678	79.5	848.9	22.2	237.1	3,509	34.4	120.7
Masonry (GH)	1,043	107.1	111.7	22.2	23.2	299	38.4	11.5
(TW)						416	25.6	10.6
1976-1980								
Frame	12,753	58.0	739.7	3.2	40.8	c	c	c
Masonry (GH)	1,064	61.4	65.3	3.4	3.6	c	c	c
(TW)						425	22.9	9.7
			7,982.9		2,462.6 (30.8%)			1,060.3 (13.3%)

[a]All values include combustion losses.

[b]Floor type: CS = floor over crawl space; all other frame homes and all masonry homes are assumed to have slab floors. Retrofit type: GH = greenhouse; TW = Trombe wall; all frame homes are assumed to be retrofitted with greenhouses.

[c]Uneconomic under the assumed economic criteria.

TABLE D-XXI. Estimated City Investment Requirement for Retrofit Measures

Home Age, Construction Type, and Passive Retrofit[a]	Conservation			Passive Solar		
	Number of Homes	Cost/Unit ($)	Total Cost (million $)	Number of Retrofits	Cost/Unit ($)	Total Cost (million $)
Pre-1956						
Frame (CS)	10,406	2,100	21.9	3,421	2,400	8.2
Frame	10,406	1,500	15.6	3,422	2,400	8.2
Masonry (GH)	15,446	1,000	15.4	4,421	2,400	10.6
(TW)				6,175	1,100	6.8
1956-1965						
Frame	15,430	1,500	23.1	5,074	2,400	12.2
Masonry (GH)	3,810	1,000	3.8	1,091	2,400	2.6
(TW)				1,523	1,100	1.7
1966-1970						
Frame	4,990	1,500	7.5	1,641	2,400	3.9
Masonry (GH)	598	1,000	6.0	171	2,400	0.4
(TW)				238	1,100	0.3
1971-1975						
Frame	10,768	1,400	14.9	3,509	2,400	8.4
Masonry (GH)	1,043	900	0.9	299	2,400	0.7
(TW)				416	1,100	0.5
1976-1980						
Frame	12,753	100	1.3	[b]	[b]	[b]
Masonry (GH)	1,064	100	0.1	[b]	[b]	[b]
(TW)				425	1,100	0.5
			110.5			65.0

[a]Floor Type: CS = floor over crawl space; all other frame homes and all masonry homes are assumed to have slab floors. Retrofit type: GH = greenhouse; TW = Trombe wall; all frame homes are assumed to be retrofitted with greenhouses.

[b]Uneconomic under the assumed economic criteria.

The estimated investment needed to attain the 44% energy savings for space heating is about $175 million. This results in a discounted payback period on the contractor-installed measures of about 11.7 years based on $12.25 million annual savings. A benefit-cost ratio of about 1.4 would be achieved by the end of the 15th year. Conservation measures are the more economic now, achieving a discounted payback by the 11th year and a benefit-cost ratio of 1.50 by the end of the 15-year holding period. The passive solar measures generate a benefit-cost ratio of 1.09 by the 15th year, just meeting the economic criteria we have established for single-family homes.

Adjusting the Estimate

A number of factors may act to reduce the level of savings that we have projected for Albuquerque. Electrically heated homes (approximately 2,600) were not specifically accounted for in the analysis, although they were included in the total computations. This overcounts the potential savings.* Weather conditions, lifestyle considerations of home occupants, improper installation of the retrofit measures, or improper operation of the passive solar systems also could reduce the estimated savings level.

Our analysis indicates that projected savings could be reduced by 26% and City-wide retrofits would still be economic.

*Electrically heated homes will typically be better insulated and use less energy because their heating systems (resistance) are about 100% efficient. However, it is likely that some savings would still be realized in those homes as well, thus reducing our overestimate to some degree.

A 26% reduction in potential savings would imply total savings of about $9.03 million annually. In this case, a benefit-cost ratio of 1.00 would be achieved in the 15th year based on the same investment of $175 million.

In conclusion, a conservation/passive solar retrofit program would be economic in Albuquerque assuming a discount rate of 12% for the average household, a holding period of 15 years, and a 16% annual rate of increase in the price of natural gas. The hypothetical program would be economic to the City if estimated annual savings reached $9.0 million in 1981 dollars. Our analysis suggests that savings of $12 million could be realized in Albuquerque. These dollar figures translate into energy savings of between 2.6 and 3.5 trillion Btu in space heating annually. These figures represent percentage savings of 33% to 44% of the total estimated consumption of 8.0 trillion Btu for space heating.

Implementation Schedule

Table D-XXII details the annual dollar investment required as well as the energy and dollar savings that would be achieved at various implementation rates. We use 5%, 10%, and 20% levels for demonstration purposes. The 5% and 10% levels, which assume the attainment of total community savings in 20 years and 10 years, respectively, represent numbers that might be achieved through market forces and a moderately ambitious outreach program. A 20% annual retrofit level, implying achievement of total community energy savings in 5 years, is also presented. This might constitute an upper limit for the attainment of Albuquerque's potential, if the City decided to establish a vigorous energy program with financial incentives, community organizing, and marketing efforts. Investment requirements in addition to energy and dollar savings are based on an equal distribution of retrofit measures by the age of the home and passive solar system type as detailed in Table D-XXII.

TABLE D-XXII: Annual Investment with Energy and Dollar Savings at Differing Implementation Rates

Implementation Rate (%)	Homes Retrofitted per Year	Investment Required[a] (million $)	Energy Savings[b] (trillion Btu)	Dollar Savings[a,b] (million $)
5	4,331	8.8	0.13-0.175	0.45-0.6
10	8,662	17.5	0.26-0.35	0.90-1.23
20	17,325	34.0	0.52-0.70	1.8 -2.45

[a]Values are 1981 dollars.

[b]The ranges are based on realization of a 12% discount rate, 15-year holding period, and a 16% annual increase in the price of natural gas.

There are approximately 10,000 mobile homes in Bernalillo County according to records maintained by the Tax Assessor's Office. We estimate that 6,075 of these are located within the city limits of Albuquerque (Traynor, Springer, and Ortega 1979, p. 3). Our estimate of total energy consumption for space heating is 0.36 trillion Btu. This implies an average consumption rate of approximately 60.9 million Btu per mobile home, which results in an annual bill for space heating of $213 at $0.35/therm. The consumption factor for the typical home of 850 ft^2 would be 16.7 Btu/degree day · ft^2, resulting in a heat-loss factor of about 9.2 Btu/degree day · ft^2 at 55% furnace efficiency.

A conservation and passive solar retrofit program could save approximately 40% of gross energy consumption for space heating in mobile homes, or about 0.15 trillion Btu. Consequently, the estimated City-wide consumption level would be reduced to 0.22 trillion Btu. This number would indicate an average consumption level for the individual mobile home of 36.2 million Btu annually at a cost of $127. Consumption and heat-loss factors would be 9.9 and 5.5 Btu/degree day · ft^2, respectively (at 55% furnace efficiency).

Determining Mobile-Home Characteristics

Age and Size

Age and size characteristics of the mobile homes were obtained by examining County tax records. We assumed that the age and size characteristics of the mobile homes in the County applied to the City as well. The number of homes located in the City is approximately 60% of the County figure. Consequently, we apportioned the County total to the City on this basis. The average size of a home was determined through the use of an aggregated weighted average accounting for the size and number of homes for each year in the age bracket (Table D-XXIII).

Because mobile-home construction is homogeneous, it is fairly easy to model. The basic consideration to account for is the increasing size of manufactured homes. In Albuquerque, we found that the average size of mobiles went from about 565 ft^2 before 1969 to 980 ft^2 in 1980. In Albuquerque, the 14- by 70-ft unit (980 ft^2) represents a large portion of models shipped during the latter part of the 1970s. An increasing number of double-wides (24 by 60 ft) also began to appear locally, starting around 1970 and continuing on into the decade.

Construction Characteristics

Mobile homes typically are built using 2-by-4, 16-in. on-center sidewall construction and 2-by-6 floor and ceiling joists. Siding usually is aluminum and, in some instances, decorative wood fiberboard. Since the oil embargo, manufacturers have started to offer special energy packages in their homes; they may include 2-by-6 sidewall construction and additional space for insulation in the ceiling. Storm windows usually are offered as an option and are required in all homes that are to be sold in Albuquerque after mid-1976.

Window Area. We estimated average window area for mobile homes using information obtained from questionnaires that were distributed in several mobile-home parks located in Albuquerque. We

TABLE D-XXIII. Mobile Homes in Albuquerque, 1980

Age	Number	Per Cent	Average Size (ft^2)
Pre-1969	1,270	21	565
1969-1973	2,791	46	890
1974-1976	749	12	950
1977-1980	1,265	21	980
	6,075	100	850[a]

[a]Weighted average.

TABLE D-XXIV. Average Window Area in Mobile Homes

Age	Floor Area (ft^2)	Per Cent	Window Area (ft^2)
Pre-1969 (9)[a]	565	15	85
1969-1973 (16)	890	12.5	111
1974-1976 (5)	950	12.5	119
1977-1980 (14)	980	10.7	105

[a]Number of questionnaires.

found that the window area of mobiles tended to be less in newer models based on the results of 44 questionnaires that were distributed to mobile-home occupants. The percentages in Table D-XXIV were adopted for the purposes of our analysis.

Insulation Levels. Between 1969 and June 15, 1976, thermal standards for mobile homes were prescribed by the National Fire Protection Association/American National Standards Institute (NFPA/ANSI). These standards were voluntary but generally were followed within the industry. After June 15, 1976, HUD's Mobile Home Construction and Safety Standards were put into effect. Thermal standards are covered in Subpart F, which discusses allowable heat transmission losses and allowances for infiltration heat loss. The Nation is divided into three zones under the HUD standards, which roughly correspond to the Southern states, Northern states and southern areas with relatively severe winters (Albuquerque), and Alaska. The HUD standards are currently mandatory.

TABLE D-XXV. Insulation Levels by Age of Home[a]

Age	Ceiling (R value)	Floor (R value)	Wall (R value)	Windows
Pre-1969	8.2	5.3	5.0	single pane
1969-1973 (NFPA/ANSI)	9.9	7.2	6.5	single pane
1974-1976 (NFPA/ANSI)	16.0	10.6	8.2	single pane
1977-1980 (HUD)	13.6	8.6	9.8	double pane[b]

[a]The values include all building components.

[b]Double-pane windows are required in Zone II, which includes the Rocky Mountain West.

Insulation levels for Albuquerque were determined by referring to the thermal standards that were applicable for a particular period. The standards are based on minimum requirements. An assumption was made that the typical mobile home would be built to meet these minimum provisions. This decision was made based on a conversation with a company representative, who stated that manufacturers will only include those options that meet the minimum standards because of the competitive nature of the industry.* He noted that most manufacturers now offer an energy-savings package for their homes as an option to buyers (R-11 walls, R-22 ceiling, R-11 floor). These units make up a lesser percentage of sales, however. The sensitivity of consumers who purchase mobile homes to the higher initial cost of these units and the reluctance of manufacturers to overproduce a product that won't sell enforces a basic industry unwillingness to go much beyond a minimum level of weatherization.

Our heat-loss calculations are based on levels of insulation that will just meet the provisions of the applicable NFPA/ANSI or HUD standards. The age brackets in Table D-XXV reflect the time spans during which particular standards were generally in force. Insulation levels before 1969 were estimated based on information supplied by Champion Homes. These values are generally in the range of 2 to 2.5 in. in the ceiling (R-7), 1 in. in the floor (R-3.5), and 1 to 1.5 in. in the walls (R-5).

*Conversation with Lamar Glover of the Engineering Department, Champion Homes, Dryden, Michigan, February 1981. John Stevens, an engineer in HUD's Office of Mobile Home Standards, reports that the average mobile home today has R-7 walls and R-14 ceilings (Rawlings 1980, p. 23).

Infiltration Levels. Infiltration heat losses were estimated using results from the questionnaires that have been discussed previously. We asked the same question used in the single-family home study that we conducted through the middle schools about the amount of draft that could be felt coming through windows and doors. Air changes per hour were assigned based on these responses with 2 as the upper limit and 1 as the lower. As noted in Appendix C, this is a highly subjective way to assess an extremely important element of heat loss. However, we felt that our estimates should be fairly reasonable, given the range that we used. As with single-family homes, we were reluctant to assign high or low infiltration values based on age. Although one would intuitively expect older mobile homes to have a higher infiltration factor, we again did not discern this in the mobile-home questionnaire responses. We thus assigned average values based on an aggregation of questionnaire answers. Homes delivered before 1977 were assigned a value of 1.5, whereas those delivered after that time were given a value of 1.3 air changes/hour.

Estimating Heating Loads

Based on the characteristics above, we estimated the following heating loads for mobile homes located in Albuquerque using the heat-loss modeling process described in Chap. 2 and the techniques presented in Appendix C. These loads, which are given in Table D-XXVI, are before combustion losses.

Applying Retrofit Measures

Our objective in applying retrofit measures to mobile homes was to keep the costs as low as possible. This is done recognizing the fact that natural-gas costs in Albuquerque ($3.50/million Btu, $6.36 delivered at 55% furnace efficiency) often make contractor-installed applications economically unattractive.

The mobile-home retrofit program will be based on a do-it-yourself approach with homeowners (or members of a neighborhood group or cooperative) doing the installation of conservation options and construction of the passive solar systems. We further assumed that a building materials cooperative could be formed, which would reduce the cost of materials to members by 20%.* This approach is taken to demonstrate the positive benefits that can come about through coordinated community action. A self-help effort at the neighborhood or community level can be beneficial in increasing the economic attractiveness of energy-efficient technologies, providing some jobs, and fostering community self-confidence in the process.

We do not necessarily advocate a cooperative do-it-yourself approach for mobile homes in particular, but apply the approach to them to illustrate the effect that cost reductions can have on the economic attraction of retrofit measures. You may find that such an approach is appropriate to the needs of your community or a particular neighborhood because of the income levels of residents, energy prices, or both.

A do-it-yourself approach is also particularly appropriate to mobile homes because most recommended weatherization measures can be installed fairly easily by the occupant. The unique construction characteristics of mobiles also will limit the practicality of contractor-installed measures in most instances (except the passive solar retrofits).

Estimating Conservation Savings

Conservation options evaluated include caulking and weather stripping (to reduce heat loss caused by air infiltration), plastic storm windows (6-mil polyethylene), and floor insulation (see Table D-XXVII). These options were chosen based on what realistically could be installed by the average individual. Ceiling and wall insulation could probably be included in the retrofits but this would be a much more ambitious undertaking (Cormier 1980, p. 36). You may wish to assess the potential for higher insulation levels in the analysis that you make.

Dollar and total Btu savings will be computed based on an average furnace efficiency of 55% for pre-1977 models. Mobile homes delivered between 1977 and 1980 are assumed to have furnace efficiencies of 65%.

Selection of the conservation options was based on the premise of achieving a simple payback period of 7 years or less. This period is assumed to be the typical amount of time that an individual or family will reside in a home (Andreassi 1977). A simple rate of return of around 14% is implied. Simple payback periods of under 4 years were achieved in all cases.

It turned out that the simple payback period for floor insulation was the least economical of all the options; payback periods extended out to 17 years for the 1974-1976 mobile homes. This is attributable to the small amount of heat lost through this building component. After 1977, floor insulation was not added because it increased the overall payback period beyond 7 years.

TABLE D-XXVI. Estimated Mobile-Home Heating Load[a]

Age	Heating Load (million Btu)	Heat-Loss Factor (Btu/degree day · ft^2)
Pre-1969	32.4	13.4
1969-1973	36.7	9.6
1974-1976	34.0	8.3
1977-1980	28.7	6.8

[a]Before combustion losses.

*The Boston Building Materials Cooperative was able to achieve a 15% reduction in the cost of materials below retail (see the "Cooperatives" section of Chap. 5). Conversations with building supply wholesalers in Albuquerque indicated that prices charged to building contractors ranged from 10% to 30% below retail prices. We feel that 20% is a reasonable estimate of potential savings where the cooperative is efficiently run and where it can obtain a contracting license (Albuquerque sources: J. C. Baldridge Lumber and Blueher Lumber).

Storm windows as retrofits were not considered for mobiles after 1977, because HUD Zone II standards now require storm windows for all homes that are sold in Albuquerque.

Estimated energy savings attributable to conservation measures (before combustion losses) were 8.2 million Btu (25%) for the pre-1969 homes; 9.2 million Btu (27.5%) for the 1969-1973 homes; 9.1 million Btu (27%) for the 1974-1976 homes; and 2.3 million Btu (8%) for the 1977-1980 mobile homes.

Comments

Conservation investments in mobile homes, when done by the occupant with material cost discounts, are an extremely economic proposition, even in a low-energy-cost area like Albuquerque. A benefit-cost ratio greater than 1 will result in every case based on a 12% discount rate, 16% escalation rate for the price of natural gas, and a 7-year holding period. Simple payback periods of less than 4 years were obtained for conservation retrofits in each age bracket. The effect of the 15% Federal Conservation Tax Credit was not considered in this analysis, but would only serve to improve the economics of the conservation measures even further.

TABLE D-XXVII. Estimated Conservation Retrofit Costs for Mobile Homes by Age

Age	Caulking and Weather Strippng ($)	Storm Windows 6-mil polyethylene (@$0.08/ft²) ($)	Floor Insulation (@$0.15/ft²) ($)	Total Estimated Cost ($)	Estimated Cost with 20% Discount ($)
Pre-1969	50	7.00	90	150	120
1969-1973	55	9.00	140	200	160
1974-1976	60	10.00	150	220	176
1977-1980	55	---	---	55	44

Estimating Solar Savings

Determining Directional Orientation of Mobile Homes

The first step in assessing the solar-savings potential for mobile homes was to estimate how many could accept a passive solar retrofit. Orientations were determined initially by referring to aerial photographs of the City. From the map we counted 3,548 mobile homes, a 58% sample of the 6,075 total. The orientations of these homes were noted, and the percentage distributions were assumed to apply to the total population of homes. With no other information, we also assumed that the distribution applied to each age bracket of homes as well. These decisions may be questioned, but without an actual field survey of all City mobile homes, there was no other choice.

The following percentage orientations were noted from the aerial photographs: 31.7% east-west; 29% north-south; 9% northeast-southwest (greater than or equal to 45° off due south); 8.3% northeast-southwest (less than 45° off due south); 16.7% northwest-southeast (greater than or equal to 45° off due south); 5.3% northwest-southeast (less than 45° off due south).

Apportioning the Systems

Two passive solar energy systems are considered for retrofitting mobile homes. The 8- by 16-ft greenhouse with 128 ft² of floor space and 144 ft² of collector area as described in the single-family section of this appendix will be used on the long sidewalls of mobile homes.

A passive system has also been devised that can be built on the ends of mobile homes. This system is referred to throughout the rest of this section as a solar furnace; it is so designated because it contains no living space. It has a 70° tilt on the southern face and has insulation in the sidewalls, in addition to the night insulation, to retain heat for use in the home at night. We assume that the typical mobile home is 12 ft wide and 10 ft tall. The front of the furnace extends out 7 ft from the base of the mobile home.

This configuration provides 144 ft^2 of collector area and 84 ft^2 of space inside.* Thermal mass is provided by 385 gal. of water (as in the greenhouse). A blower also is included for this system to distribute heat from the front of the home to rooms further back.

Apportionment of the systems was done on the following basis. Greenhouses are used on all mobile homes that are oriented east-west. Furnaces are used on all units that are oriented north-south and those oriented less than 45° off due south. Furnaces and greenhouses are distributed 50/50 for mobile homes that are oriented 45° or more off due south. It is generally assumed that furnaces will be used when the home is less than 60° off due south, whereas greenhouses will predominate as the angle increases. These assumptions were made with the idea of maximizing system performance.** The basic north-south orientation of Albuquerque mobile homes is suggested by the larger number of units that end up being retrofitted with solar furnaces. Figure D-4 demonstrates the basic allocation of systems with reference to due south.

*Dimensions of the system could be altered to attain a similar level of performance on smaller or larger mobile homes.

**In reality, a solar access study ideally would account for true solar south, which will vary by location. This is not specifically considered for the purposes of this generalized analysis.

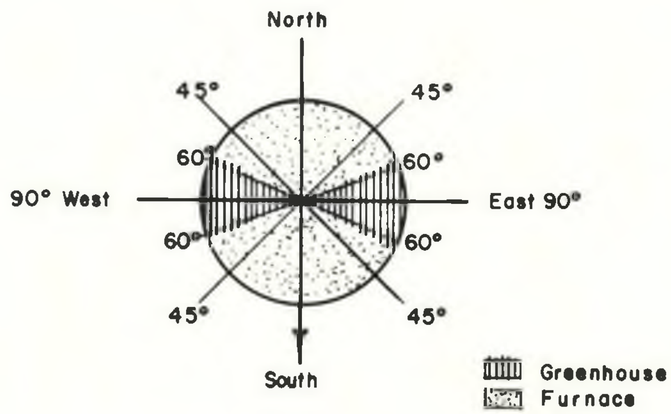


Fig. D-4. Allocation of passive solar systems based on mobile-home orientation.

We assumed that about 40% of the mobile homes in the City could be retrofitted with passive solar systems. This estimation was based on a field survey of five mobile-home parks.† Solar access in the mobile-home parks surveyed is fairly good because of the general lack of vegetation in some areas and the predominance of deciduous vegetation where it is present. Access also is good because mobile homes are usually only about 10 to 11 ft tall. This enables a mobile home that has an east-west orientation to achieve a shading coefficient of 25% or less when there is an open area of at least 14 to 16 ft between it and the next home on the south. This criterion was met fairly easily in the parks that were surveyed. We recognized that some parks tend to be laid out in a more compact form, limiting access possibilities, however. Mobile homes also possess another access advantage even when they are located on a north-south axis or have a skewed orientation (less than 60° off due south). Both the field survey and the aerial photographs revealed that the end of the home is often facing directly on the street. Shading obstructions generally posed no problems in that situation, and a solar furnace could easily be installed.

In summary, we feel that the 40% retrofit number is fairly realistic, and is, in fact, probably conservative. Application of this percentage would result in the construction of 2,430 systems. This percentage was uniformly applied to the age bracket of the mobile home and the orientation (see Table D-XXVIII).

†Manzano, Coronado Village, Rio Grande, North Hills, and Green Acres.

TABLE D-XXVIII. Passive Solar Retrofit Potential[a] for Mobile Homes by Age and Orientation

Age	E-W (Greenhouse)	N-S (Furnace)	NE-SW <45° (Furnace)	NE-SW >45° (50/50)	NW-SE <45° (Furnace)	NW-SE >45° (50/50)	Total Retrofits
Pre-1969	161	147	46	42	85	27	508
1969-1973	354	324	100	93	186	59	1,116
1974-1976	95	87	27	25	50	16	300
1977-1980	160	147	46	42	84	27	506
	770	705	219	202	405	129	2,430[b]

[a]Assuming 40% of all Albuquerque mobile homes could be retrofitted.

[b]Greenhouses = 936 (38.5%); solar furnaces = 1,494 (61.5%).

Costs of the Systems

A contractor-built greenhouse or furnace is estimated to cost $18/ft^2, whereas the individual could build one for approximately $9/ft^2 buying materials at retail.* This number can be reduced to around $7/ft^2 using the 20% discount that potentially could be obtained through membership in a cooperative. The 128-ft^2 greenhouse would cost about $900, whereas the 84-ft^2 furnace would cost about $600. An additional $500 needs to be added to the furnace cost to cover the cost of a blower for distributing the heat, bringing the total cost to $1,100.

*Letter from M. Wells of the New Mexico Solar Energy Association to R. Mathews, June 30, 1981.

TABLE D-XXIX. Total Estimated Savings[a] for Conservation and Solar Retrofits

Age	Initial Load [million Btu ($)]	Conservation Savings [million Btu ($)]	Conservation Savings (%)	Load After Conservation (million Btu)	Solar Savings[b] [million Btu ($)]	Solar Savings[b] (%)	Total Saved [million Btu ($)]	Total Saved (%)	New Load [million Btu ($)]
Pre-1969	32.4 (206)	8.2 (52)	25	24.2	17.9 (114)	74	26.1 (166)	81	6.3 (40)
1969-1973	36.7 (233)	9.2 (59)	25	27.5	18.7 (119)	68	27.9 (178)	76	8.8 (55)
1974-1976	34 (216)	9.1 (58)	27	24.9	17.7 (113)	71	26.8 (171)	79	7.2 (45)
1977-1980	28.7 (154)	2.3 (12)	8	26.4	17.9 (96)	68	20.2 (108)	70	8.5 (46)

[a]Before combustion losses.

[b]The percentage was based on the heating load after the conservation measure had been implemented.

Total Energy and Dollar Savings from the Conservation and Passive Solar Retrofit Program

The combined impact of the conservation and solar retrofits discussed above is given in Table D-XXIX. The economics of the combined conservation and passive solar measures are favorable (Table D-XXX). Benefit-cost ratios greater than 1 are attained in every case except for homes delivered during the 1977-1980 period.

TABLE D-XXX. Discounted Payback Period and Benefit-Cost Ratio of Conservation and Passive Solar Retrofits

Age and Retrofit Type[a]		Estimated Cost ($)	Annual Savings ($)	Discounted Payback Period (years)	Benefit-Cost Ratio[b]
Pre-1969	(G)	1,020	166	5.7	1.3
	(F)	1,220		6.2	1.1
1969-1973	(G)	1,060	178	5.5	1.3
	(F)	1,260		6.4	1.1
1974-1976	(G)	1,076	171	5.8	1.2
	(F)	1,276		6.7	1.0
1977-1980	(G)	944	108	7.7	0.9
	(F)	1,144		9.1	0.7

[a]Retrofit types: G = greenhouse; F = furnace.

[b]Total savings divided by total costs (see Appendix E for the computational procedures).

City Savings in Energy and Dollars

The aggregate energy and dollar savings that can be achieved by retrofitting mobile homes is significant as illustrated in Table D-XXXI. Note that only savings attributable to conservation retrofit measures are included for mobile homes after 1977. This is because passive solar applications will not meet the economic criteria that we have used thus far in the analysis.

The total space-heating demand for mobile homes is estimated at 0.36 trillion Btu (approximately $1.3 million). A conservation and passive solar retrofit program is estimated to provide savings of around 0.15 trillion Btu, or approximately 41% of gross consumption. Conservation measures account for 23% of that savings and the passive solar retrofits the remaining 18%.

Estimated Investment Required to Achieve Savings

The estimated City-wide investment to implement the conservation and passive solar retrofits would be approximately $2.8 million. Approximately $0.8 million of the cost would be attributable to the conservation measures and $2.0 million would be due to the construction of the passive solar greenhouses and solar furnaces.

Annual savings (if the measures were all implemented at once) for space-heating energy consumption as a result of the 41% savings level would be around $525 thousand ($0.35/therm × 1.5 million therms). The total City program suggests a 6-year simple payback period and would generate benefit-cost ratios in excess of 1.0 based on a 12% discount rate, 16% natural-gas cost escalation rate, and a 7-year holding period. The conservation investment is extremely economic at this time, providing an annual savings of approximately $300 thousand. This generates a highly favorable benefit-cost ratio of 2.34 based on the 7-year holding period. The passive solar applications would generate estimated savings of $225 thousand annually, which results in a benefit-cost ratio of 0.78.

Obviously, the conservation measures support the economic attraction of the solar measures now. As energy prices increase, we can expect the solar measures to become increasingly cost effective, however. We stress that, taken as a package, owner-installed conservation measures along with the passive solar greenhouse and furnace are economic in Albuquerque at this time.

TABLE D-XXXI. City-Wide Energy Savings from a Conservation and Passive Solar Retrofit Program for Mobile Homes[a]

Age	No. of Homes	Heating Load (million Btu)	Est. Total City Consumption (billion Btu)	Conservation: Est. Savings/Unit (million Btu)	Conservation: Est. City Savings (billion Btu)	Passive Solar: No. of Retrofits	Passive Solar: Est. Savings/Unit (million Btu)	Passive Solar: Est. City Savings (billion Btu)
Pre-1969	1,270	58.9	74.8	14.9	18.9	508	32.5	16.5
1969-1973	2,791	66.7	185.2	16.7	46.6	1,116	34.0	37.9
1974-1976	749	61.8	46.3	16.5	12.3	300	32.2	9.7
1977-1980	1,265	44.2	55.9	3.5	4.4	[b]	[b]	[b]
	6,075		362.2		82.2 (23%)	1,924		64.1 (18%)

[a]All values include combustion losses.

[b]Uneconomic given the assumed economic criteria.

TABLE D-XXXII. Annual Investment with Energy and Dollar Savings at Differing Implementation Rates[a]

Implementation Rate (%)	Homes Retrofitted per Year	Investment Required (thousand $)	Energy Savings (billion Btu)	Dollar Savings (thousand $)
5	304	40	5.0- 7.5	17.5- 26.3
10	608	280	10.0-15.0	35.0- 52.5
20	1215	560	20.0-30.0	70.0-105.0

[a]The ranges are based on realization of a 12% discount rate, 7-year holding period, and 16% annual increase in the price of natural gas.

Adjusting the Estimate

The retrofit program would still be economic even if energy savings were as low as 0.10 trillion Btu (28% of total consumption). This implies annual savings of $350 thousand. This lower limit allows for the possibility that measures might be installed or operated improperly, for lifestyles of residents, and for local weather conditions, which will vary over the years. This lower limit also compensates for our inclusion of electrically heated homes in the overall analysis. Energy savings would not be as great in these homes because of their generally higher insulation levels and lower energy consumption. We consequently can state that a benefit-cost ratio of 1.0 is still achievable if estimated energy savings were as much as 33% lower than our projection.

Implementation Schedule

Achievement of the total energy-savings potential requires a schedule. Table D-XXXII details the number of retrofits, investment requirements, energy savings, and dollar savings that would accrue at different implementation rates.

We assumed that the retrofits are carried out equally across the various age categories with the 40% apportionment of passive measures and the percentage breakdown of passive solar systems by type implicitly being accounted for in the calculations.

TABLE D-XXXIII. Multifamily Housing in Albuquerque

Year	Total Number of Units	Per Cent of Entire Housing
1950	3,855	12.6
1960	4,798	7.9
1970	13,757	17.4
1980	41,788[a]	31.0[a]

[a]Estimated.

TABLE D-XXXIV. Multifamily Units[a] by Age[b]

Age	Estimated Total	Per Cent
Pre-1951	4,680	11
1951-1960	1,438	3
1961-1970	10,132	24
1971-1975	13,939	34
1976-1980	11,599	28
	41,788	100

[a]Three or more units per building.

[b]Numbers will differ from those in Table D-XXXIII to some degree because the census reports the number of units through the end of April for the decennial year.

Multifamily housing (apartments), defined in this section to include buildings with three or more units, has become increasingly important as a housing alternative for Albuquerque residents. Table D-XXXIII demonstrates this trend. The number of multifamily units as a percentage of the total housing has increased from a low of 7.9% in 1960 to an estimated 31% at the end of 1980.

The number of multifamily units in the City increased dramatically during the 1970s, from 13,757 units at the beginning to an estimated 41,788 units by the end of 1980. This represented an increase of 204%, which suggests the high rate of population growth occurring in the City during the 1970s and the growing need for multifamily units to meet that expansion.

Determining Building Characteristics

Age

The age categories for the units were determined by referring to building-permit records and census data. Building-permit information was used to determine the estimated number of units for the 1971-1975 and 1976-1980 age brackets. The number of units built before 1971 were estimated by subtracting the total number of dwelling units in buildings with three or more units from the total number of dwellings for the next decade. This provides an approximation of the number of units built over the 10-year period. Table D-XXXIV vividly demonstrates the expansion of this segment of the housing market after 1960. Approximately 86% of the multifamily buildings have been built in the last 20 years, and 62% have been built since 1970! The growth in the number of multifamily units may be seen in part as a response to the City's population growth of 35.7% during the 1971-1980 decade. Construction of multifamily units also represents a response to the changing demographic, economic, and lifestyle characteristics of the local population.

Construction Characteristics

The estimated average size of typical multifamily unit is 780 ft^2 in Albuquerque. This number was determined based on a sample of 1,276 master-metered apartment units in the City and checked for reasonability with local realtors and property management firms.*

Larger multifamily buildings in Albuquerque are either of masonry (concrete block or hollow clay tile) or frame construction. Masonry buildings tend to be older, although there are many exceptions. Frame construction seems to have become more the norm beginning in the 1960s. This characterization was based on personal observation along with conversations with local architects and engineers.

Insulation levels for buildings by age are presented in Table D-XXXV.

*Telephone conversation with John Blatnik of John Blatnik and Associates, August 1981.

Window Area and Air Infiltration. We assume that the window area for a typical unit is approximately 10% of the floor area of an average unit of 780 ft^2. Infiltration is estimated at ~1.3 air changes/hour for pre-1976 units and 1.1 for units built thereafter. These numbers are lower than those for single-family homes because of a smaller amount of window area and a lesser amount of surface area being exposed to the outside. These estimates are used later to determine potential conservation savings.

Estimating Heating Requirements for Multifamily Units

Heating requirements for the multifamily units were determined by obtaining natural-gas utility bills for 1,276 master-metered rental apartment units in Albuquerque. We concentrated our efforts on this sector because of the unique issues that surround investments in energy conservation and passive solar measures for landlords and renters. The utility information was obtained from three local real estate management firms and the Albuquerque Public Housing Authority. The age of the buildings ranged between 1940 and 1979, and the number of units in the buildings (or complexes) ran between 5 and 315.

Actual energy consumption as reported on utility bills was used for the analysis because this method is the most accurate way to estimate space-heating requirements. It also is much easier to use this information than it is to do ASHRAE steady-state heat-loss calculations on large buildings where energy consumption characteristics are complex. Master-metered utility information, which represents the aggregate amount of energy consumed by all units in the building (or complex), can provide a closer approximation to the actual level of consumption for space heating once other uses that rely on the particular energy source are factored out.

A major consideration to watch for in using master-metered data is the tendency of the data to present a high estimate of energy consumption. This reflects the fact that tenants are not charged directly for the energy that they use, but instead pay the cost through their rents. Consequently, steps should be taken during the analysis to account for this bias. One study suggests that energy consumption can be reduced by up to 35% when individual meters are installed (Walker 1979). Such a percentage could be used to adjust the numbers that you derive from your analysis of master-metered data.

The Gas Company of New Mexico reports that the split is approximately 50/50 between master-metered and individually metered units in Albuquerque.* This allocation is changing in favor of

*Conversation with T. Rister of the Gas Company of New Mexico, July 1981.

individually metered units as the master meters in existing master-metered buildings are converted to individual meters. Individual meters are also being installed on most new apartment units, which forces additional change in the distribution.

For purposes of demonstration, we have developed an arbitrary allocation of individually vs master-metered units. All units built before 1970 are assumed to be master-metered, a 65/35 distribution is used for individual meters/master meters between 1971 and 1975, and all units built after 1975 are assumed to be individually metered. This allocation approximates a 50/50 allocation between individually metered and master-metered units.

Estimating Hot-Water and Cooking Energy Consumption

All of the buildings in our sample were heated with natural gas, so gas bills provided the relevant cost data for the case study. We felt that this sample was fairly representative of the Albuquerque multifamily housing because utility company officials indicated that 98% of all of the units heat with this fuel.*

TABLE D-XXXV. Estimated Insulation Levels for Multifamily Buildings[a]

Age	Ceiling (R Value)	Walls (R Value)
Pre-1951	0	0
1951-1960	7	0
1961-1970	11	0
1971-1975	11	11
1976-1980	11	19

[a]Conversation with H. Hoshour, Albuquerque architect. The buildings included contain three or more units.

We found that most buildings in the sample also used gas for hot-water heating and cooking. The amount of energy used for these activities was estimated by comparing the average consumption level (in therms) for the summer months of June through August to the average for the winter months of December through February. The summer level of consumption is assumed to reflect energy use for water heating and cooking only. It is further assumed that these uses remain fairly constant over the course of a year. We found that the average summer consumption level for Albuquerque multifamily units was typically in the range of 17% to 30% of the winter consumption. Therefore, we decided on a value of 25% to account for water heating and cooking. If the unit had an electric stove, the adjustment factor was reduced to 20%. We should point out that this technique could also be applied where you are evaluating utility bills for single-family homes or nonresidential buildings.

Calculating the Heat-Loss Factors

Heat-loss factors for the apartment units were determined through the use of utility bills for the 1979-1980 heating season.** Total energy consumption was ascertained initially and then reduced by the applicable percentage (20% or 25%) to account for hot water and cooking. Therms were then converted into Btu through multiplication by 100,000. Total estimated Btu consumption for heating was then divided by the actual number of heating degree days for 1979-1980 (4,188). Btu per degree day were then divided by the aggregate square footage of the units in the building. (No common areas, such as lounges, or common appliances, such as swimming pool heaters, that required gas were included.) The consumption factor was then multiplied by an assumed efficiency factor for the furnace. A 55% factor was used for pre-1976 units, whereas 65% was used for units built after 1976.

A degree day adjustment factor is then applied to correct the heat-loss factor for the deviation between the actual number of degree days and the average annual figure of 4,292. This is done by computing the fraction by which the actual number differs from the average. For the 1979-1980 heating season, the adjustment factor is

$$\frac{4{,}292 - 4{,}188}{4{,}292} = 0.024 .$$

This number tells us that the heat-loss factor has to be increased by 2.4% to reflect an average year for heating. Heat-loss factors for the buildings in our study are presented in Table D-XXXVI.

Results from our sample of master-metered multifamily units reveal a wide divergence in estimated heat-loss factors regardless of age. This indicates the impact that living patterns can have on energy use and the impossibility of accounting specifically for the unique characteristics of the building, site, and heating equipment as they affect energy consumption. We still attempt to generalize, however, and

*Conversation with T. Rister of the Gas Company of New Mexico, July 1981.

**The season essentially runs from October through the end of April.

suggest that the heat-loss factors in Table D-XXXVII are relevant for apartment units by the given age bracket. An average unit size of 780 ft^2 is used in the calculation. A 20% reduction factor is used to adjust heating requirements for individually metered units. This factor is used only for buildings built after 1970 and is felt to be fairly reasonable given the results of other studies (Walker 1979).

Estimating Conservation Savings

We decided to examine potential conservation savings in a rather modest way. The analysis does not determine the total savings that could be achieved or the amount that would be saved under certain economic criteria. Instead, we consider the possible effects of a modest retrofit program and its particular interaction with renter and landlord investment objectives. This retrofit program would be instituted at the local level as a mandatory provision. There are two parts to the program, with renters being responsible for one set of actions and landlords for the other.

An infiltration reduction retrofit application is proposed for tenants. This program would be similar to the program enacted in Fitchburg, Massachusetts (see the discussion on Fitchburg in Chap. 4). Tenants would purchase (or be supplied with) caulking and weather-stripping materials. Plastic also could be supplied, which could be placed over the windows or could be used to construct storm windows. The approximate cost of the measures would be around $50 to $60 per unit.

Landlords would take part in a City-sponsored ceiling insulation program (levels would be raised to R-30), possibly with low-interest loans being ex-

TABLE D-XXXVI. Heat-Loss Factors for Sample of Multifamily Buildings

Year of Construction	Insulation Level Ceiling/Walls (R Value)	Number of Units	Unit Size (ft^2)	Heat-Loss Factor (Btu/degree day · ft^2)
1940	0/0	12	721	10.6
1956	11/0	5	1,600	6.1
1960	7/0	8	729	8.3
1964	11/11	316	715	6.7
1967	11/11	106	688	3.3
1972	26/11[a]	152	536	5.7
1972	26/11[a]	140	734	5.5
1974	11/11	180	917	6.4
1974	11/11	138	837	6.9
1976	26/11	101	703	5.6
1976	[b]	38	605	10.8
1977	[b]	62	550	5.8
1979	19/19	10	800	5.6
		1,268	780 av	6.7 av

[a]Insulation added to roof to increase R value from 11 to 26.

[b]Unknown; values from Table XXXV assumed.

TABLE D-XXXVII. Estimated Annual Heating Requirements of Master- and Individually Metered Apartments[a]

Age	Heating Load (million Btu)		Heat-Loss Factor (Btu/degree day · ft²)		Estimated Heating Bill ($)	
Pre-1951	28.4		8.5		181	
1951-1960	25.1		7.5		160	
1961-1970	23.4		7.0		149	
1971-1975	21.8	*17.4*	6.5	*5.2*	139	*111*
1976-1980	18.4	*14.7*	5.5	*4.4*	99	*79*

[a]Values for individually metered apartments are in italics.

TABLE D-XXXVIII. Percentage Energy Savings Attributable to Conservation[a]

Age	Ceiling Insulation (%)	Plastic Storm Windows (%)	Caulking and Weather Stripping[b] (%)	Total (%)
Pre-1951	8	9	5	22
1951-1960	4	9	6	19
1961-1970	3	8	6	16
1971-1975	3	8	6	16
1976-1980	2	4	3	9

[a]Calculations based on two-story, eight-unit building. Insulation information provided by H. Hoshour, Albuquerque architect; estimated conservation-savings percentages calculated by J. LaQuatra.

[b]Assuming the air infiltration rate is reduced to 0.75 air changes/hour.

tended by the City for financing. Table D-XXXVIII presents our conservative estimate of the possible savings that might be achieved by unit through the tenant/landlord actions. The savings attributable to ceiling insulation are highly speculative because of the difficulties of allocating energy savings to any one unit. The numbers presented are estimates of the total savings as allocated to each unit. Apartments on the second floor could be expected to save more, whereas those on the first would save much less or possibly nothing at all.

Estimating Solar Savings

We did not determine the potential savings that could be achieved through passive solar retrofit systems for several reasons. First, there are a number of technical difficulties in applying systems to larger multifamily buildings and, in fact, even to the smaller buildings such as triplexes and quadraplexes. Units, at least in Albuquerque, are often on opposite sides. Delivery of heat to units on the north side could present technical difficulties (for example, a blower would be required). Second, building- and fire-code regulations would impose a number of constraints because the system might affect ingress and egress from the building along with lighting and ventilation. Finally, landlord interest in an improvement that may be subject to additional upkeep and possibly vandalism will likely be minimal (unless perhaps the landlord lived on the premises).

This is not to say that there is no retrofit potential in the multifamily sector. On the contrary, there is a fair amount based on our observations in Albuquerque. A basic consideration, however, is what is practical given tenants' sensitivity to rent increases and short periods of occupancy and given the investment requirements of landlords. We consequently chose to focus on an extremely practical conservation program, which for a small investment can produce fairly significant savings. Quick return is a primary consideration for both landlords and tenants.

City Energy Consumption and Potential Energy Savings

In Table D-XXXIX, we extrapolate from our sample to all the multifamily units (three or more per building) in Albuquerqe.

Based on the mandatory conservation program previously described, we estimated conservation savings at 0.24 trillion Btu or 16% of the total multifamily energy consumption for space heating of 1.5 trillion Btu. This is a small savings and one that probably could be done meeting the unique investment requirements of landlords and renters. Obviously, a local program for rental units could be carried much further.

TABLE D-XXXIX. Estimated City Energy Consumption and Conservation Savings

Age	Heat-Loss Factor (Btu/degree day · ft^2)	No. of Units	Est. Consumption per Unit[a] (million Btu)	Total Consumption (billion Btu)	Conservation Savings per Unit (million Btu)	Total Savings (billion Btu)
Pre-1951	8.5	4,680	51.6	241.5	11.4	53.3
1951-1960	7.5	1,438	45.6	65.6	8.2	11.8
1961-1970	7.0	10,132	42.5	430.6	6.8	68.9
1971-1975	5.7[b]	13,939	34.7	483.7	5.6	78.1
1976-1980	4.4[c]	11,599	22.6	262.1	2.0	23.2
				1,483.5		235.3

[a]Combustion losses included.

[b]Reflects a 65/35 individual-meter/master-meter allocation.

[c]Assumes all units are individually metered.

The Economic Impact of a Mandatory Ceiling Insulation Program

A basic consideration for the local program in instituting a mandatory weatherization program will be to assess the impact that it has on rents in the community. Landlords of individually metered units will try to recover their investments in ceiling insulation fairly quickly (for example, in 2 to 3 years) implying simple rates of return in excess of 33% annually. Owners of master-metered units, although directly realizing the energy savings, may wish to increase rents so as to reduce the payback period on their investment. The following example, which examines the impact of investment in ceiling insulation, demonstrates how you might evaluate the effect of a mandatory conservation retrofit program on rents in your community.

We will use a two-story, pre-1960, eight-unit building (size of units is 780 ft^2). Estimated annual heating load for each unit is 25.1 million Btu, or 200.8 million Btu for the entire building. This implies a total heating bill of about $1,300 at a furnace efficiency level of 55%. Heat loss through the ceiling represents about 18% of the total loss. Increasing the ceiling insulation from R-7 to R-30 would result in conservation savings for heating of

$$CS = \frac{0.033 - 0.085}{0.085} \times 0.18 \times 200.8 \ ,$$

or 22.1 million Btu. At 55% furnace efficiency, this implies savings of about $140 for the heating season. The cost of installing the ceiling insulation (blown cellulose R-23) is estimated at $1,100 (3,120-$ft^2$ roof at $0.35/$ft^2$). This cost assumes that there are no major obstacles that would increase the difficulty of the installation. The installation of the ceiling insulation would mean a simple payback period of 7.9 years.

The landlord of the individually metered units will not realize this payback period unless he or she raises the rent to regain the investment in ceiling insulation. If this action were not taken, the tenants alone would receive the monetary benefits in the form of lower energy bills. For the landlord to regain the $1,100 investment within the 7.9-year period, he or she would have to increase the monthly rent by about $1.50 per unit. This is figured by dividing the cost of the ceiling insulation ($1,100) by the payback period (7.9 years) by the number of months in the year (12) by the number of units. We assume that the landlord would distribute the cost of the improvements equally among the units and over all of the months. This is a simple calculation, but it needs to be done to demonstrate the economic considerations to the landlord. An investment with a 7.9-year simple payback period implies a simple rate of return of around 12.7% annually. It is more than likely that the landlord will require a higher rate of return and thus a shorter payback period.

Investments in improvements that enhance the livability, structural soundness, or energy efficiency of a building without contributing substantially to the building's value are low on an investor's list of priorities. The investor will want to be able to recoup this investment quickly through adjustments in the rent that, at the same time, must not be so large as to upset the full-occupancy status of the building. A building owner's time perspective will be short because of other investment alternatives. These circumstances keep landlord interest in energy improvements low. Referring back to the ceiling insulation investment, a landlord may require a payback period of 3 years or less. Such a requirement would result in a monthly rental increase to tenants of around $4.00 per unit. This is computed in the same way as the previous example except a 3-year payback period is used.

A landlord of a master-metered building realizes the energy savings directly from an energy investment. He or she may also choose to increase the rate of return by raising rents, however (shortening the payback period in the process).

Comments

Our example demonstrates how landlords might react to a program that mandates certain conservation (or solar) actions. Rental increases (unless prevented by a local ordinance) can be expected. The increases suggested under a theoretical ceiling insulation program in Albuquerque would appear to be small. The amounts would increase where a more comprehensive weatherization program (or passive solar program) was implemented. The benefits of the program should be considered in view of the costs that they may impose on community residents.

Finally, it is optimistic to assume that the energy savings hypothesized in this example would actually be that which is achieved in a real-life situation. It is extremely difficult to draw general conclusions about the impact of various conservation (or solar) measures on multifamily apartment buildings because of the complex energy relationships that exist between units in these structures. We caution you to gain more knowledge about the energy characteristics of multifamily buildings, and the potential savings that would be achieved, by talking with local architects and engineers. Such knowledge is crucial to assess possible program economic impacts on both landlords and renters.

An energy-use case study on one city block in Albuquerque, New Mexico, was performed in early 1981 by the Los Alamos National Laboratory and the School of Architecture and Urban Planning at the University of New Mexico. The block chosen, which was directly across from the University campus, contained several restaurants and many retail stores.

The owners of 16 of the 21 nonresidential (commercial) buildings on this block agreed to sign the utility release waivers so that we could obtain month-by-month electricity and gas consumption data from the utilities (see the form at the end of this appendix). Maps were also prepared to show various physical features.

Figure D-5 is a map of the block showing all buildings; they are numbered for identification. Figure D-6 is a map of shadow patterns created by buildings and trees during the winter months, which is very helpful in determining the potential for solar energy systems and possible solar access regulations. A similar map may be constructed to show summer shadow patterns, which is useful in evaluating the beneficial effect of summer shading. Figure D-7 shows the solar absorption factors for the roofs of the buildings; solar absorption is often worth considering because of the unwanted solar gains during the summer months.

Albuquerque has a semiarid climate with moderately cold winters (about 4,300 heating degree days) and hot summers. Natural gas is the main heating fuel because it is relatively cheap ($0.35/therm). Electricity costs about $0.065/kWh, or $1.90/therm (direct conversion), and is generally avoided for heating. Table D-XL shows the annual Energy Utilization Index (EUI, usually defined as the energy consumption of a building in Btu per square foot per year) for each building, as well as the building number and type. Several observations can be made.

- The highest EUI (819,071 Btu/ft^2 · year for building #1) is over 36 times as much as the lowest (22,303 Btu/ft^2 · year for building #18).
- The five restaurants tend to have very high EUIs (406,399 Btu/ft^2 · year average).
- The nine retail stores have relatively moderate EUIs (56,337 Btu/ft^2 · year average).

It is clear that the restaurants are the biggest energy consumers, with typical energy consumption of over 7 times that of the retail stores. Restaurants are very energy-intensive buldings because of all the cooking and refrigeration equipment. Fast-food restaurants often have glass facades that face the street, regardless of the building's solar orientation, and thus usually contribute to heavy heating and cooling loads. Lighting levels inside and advertising lighting outside also consume much electricity in these buildings.

Although most of this energy consumption can be justified on the basis of increased business, even small percentage decreases in fuel use can make a large difference. Building #1, for example, is a 4,675-ft^2 fast-food restaurant that has an annual energy bill of about $35,000. A 10% energy savings, which usually can be accomplished quite easily with no-cost or low-cost measures, would amount to $3,500/year. One of the DOE energy audit books

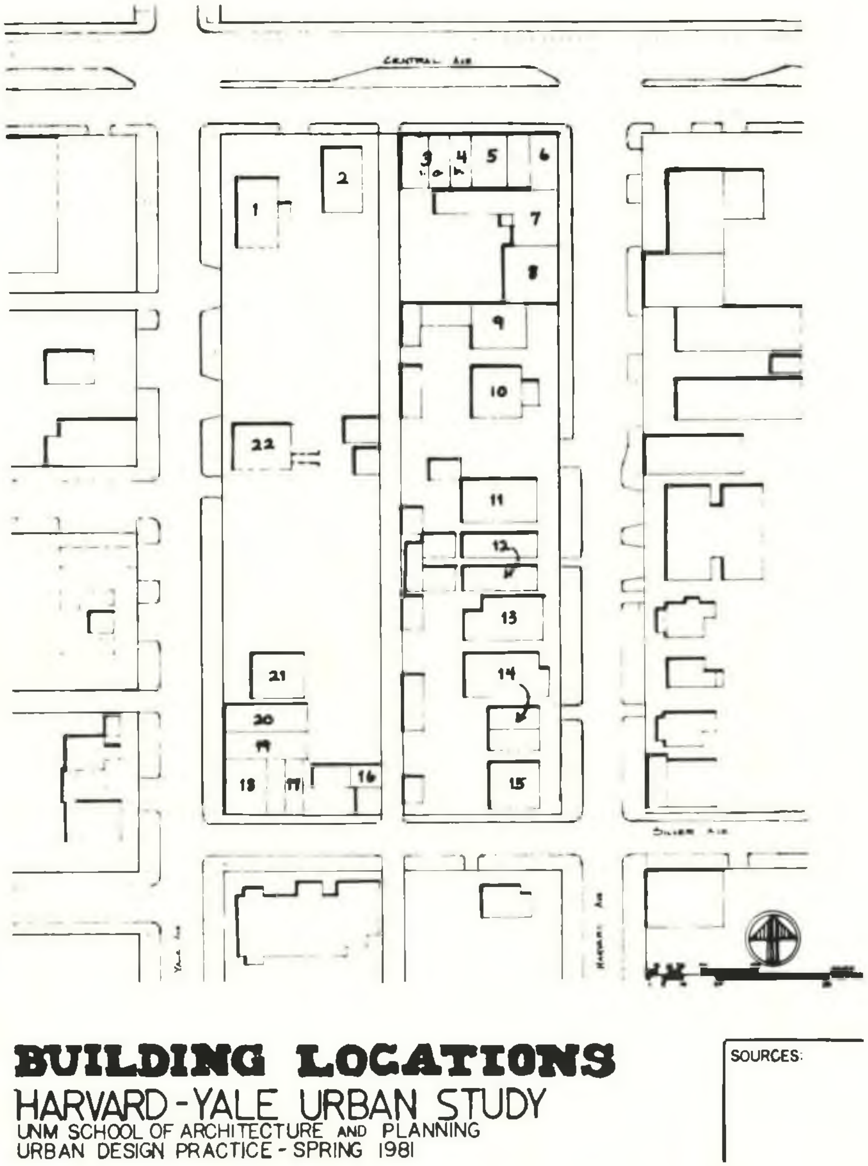


Fig. D-5. Map of the block with building identification numbers.

("Energy Audit Workbook for Fast-Food Stores" 1980) deals exclusively with restaurants and would be a good investment for local restaurants.

The retail stores have EUIs ranging from 22,000 to 67,000 Btu/ft^2 · year with the exception of building #8, which has an EUI of 117,046 Btu/ft^2 · year. Because this particular building consumes over twice the average for retail stores, it should also be targeted for special attention.

Figures D-8 through D-11 are related to the energy consumption of the 16 buildings examined. Figures D-8 through D-10 show energy usage for all buildings and the total usage minus the usage of the five restaurants; Fig. D-11 shows energy costs for all buildings.

Although the greatest energy use occurs during the winter months (Fig. D-8), the greatest energy costs are incurred during the summer months (Fig. D-11), because of the higher cost of electricity. The increase in electricity usage during the summer (Fig. D-10) is clearly due to the cooling load. Most of the retail buildings use evaporative coolers, which are very efficient, but the restaurants generally use air-conditioning units, which draw large amounts of electricity.

For those buildings that seem to be spending considerable sums for summer cooling, measures such as installing window shading devices, landscaping with shade trees, and painting the east and west walls and the roof a light color would all provide welcome relief.

Although heating costs are relatively low at present, because natural gas prices in Albuquerque are low, these costs are expected to rise 50% or more as gas prices are deregulated. Albuquerque has an excellent climate for solar heating, so inexpensive passive solar retrofits are very effective. Many of the buildings studied are masonry and would be suitable

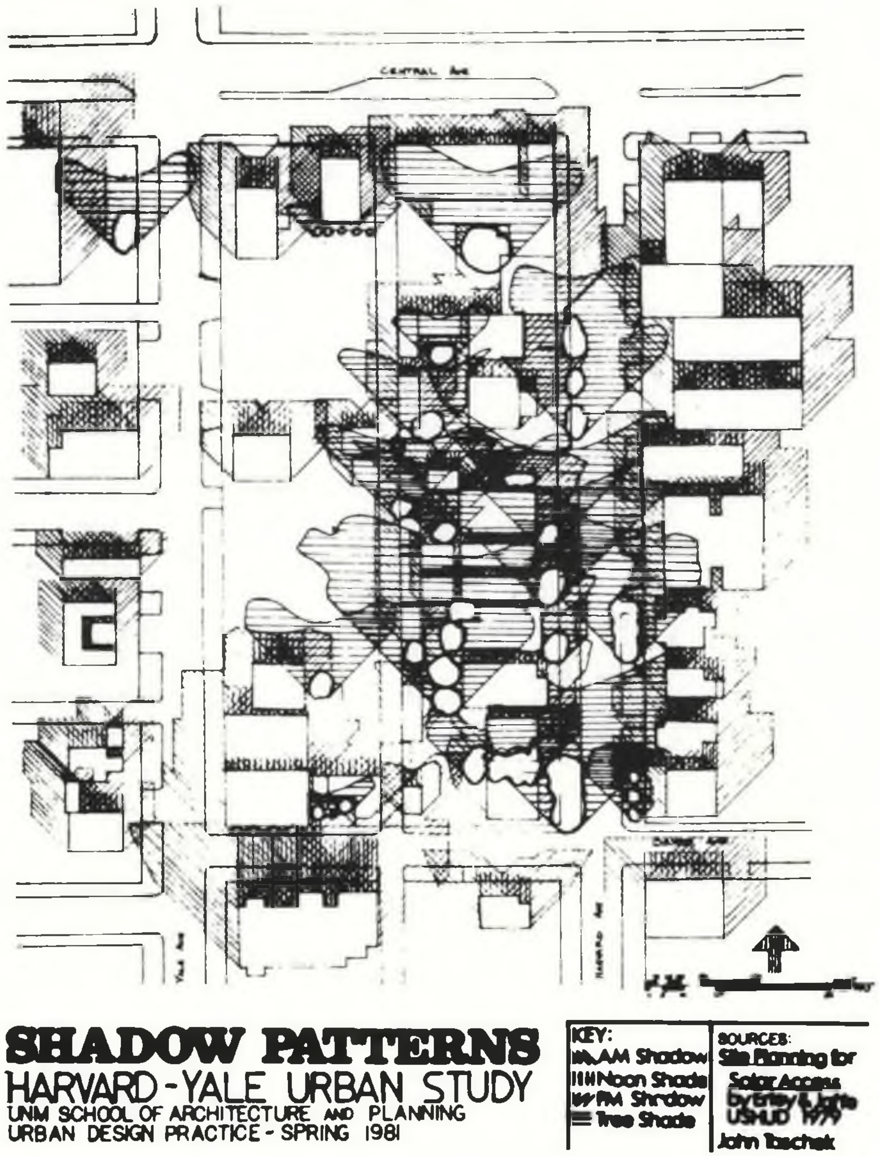


Fig. D-6. Map with shadow patterns.

for Trombe wall systems. The frame buildings would do well with thermosiphon air collectors, because they provide all their heat during the day when these buildings are occupied. Direct gain windows on the south would also be quite effective and would help provide natural daylight. Building #18, which has a large amount of south-facing glass, has the lowest EUI on the block.

Solar hot-water heating, another cost-effective retrofit in this area, would be particularly advantageous for the restaurants, which generally use large quantities of heated water. Some of the restaurants would probably benefit from a simple heat-recovery system that captures the waste heat from waste water and vented air.

TABLE D-XL. Building Energy Consumption

Identification Number	Building Type	EUI (Btu/ft^2 · year)
1	restaurant	819,071
2	restaurant	751,784
3	retail store	59,396
4a	retail store	67,000[a]
4b	retail store	67,049
5	restaurant	197,183
6	retail store	63,190
7	b	b
8	retail store	117,046
9	restaurant	39,885
10	retail store	38,815
11	restaurant	224,071
12	b	b
13	retail store	30,618
14	b	b
15	b	b
16	b	b
17	retail store	41,568
18	retail store	22,303
19	medical building	88,793
20	office building	130,853

[a]Estimated.

[b]Didn't participate in the study; data not available.

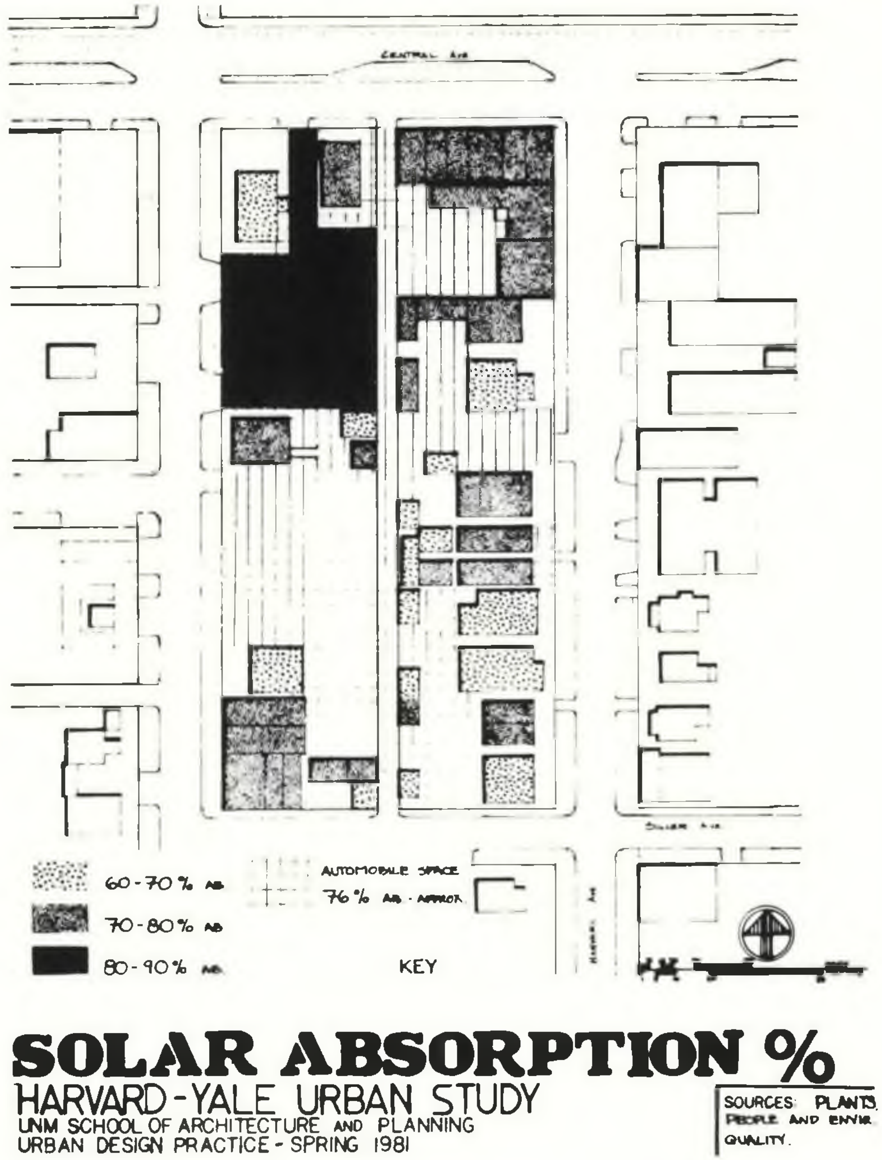


Fig. D-7. Map with solar absorption values.

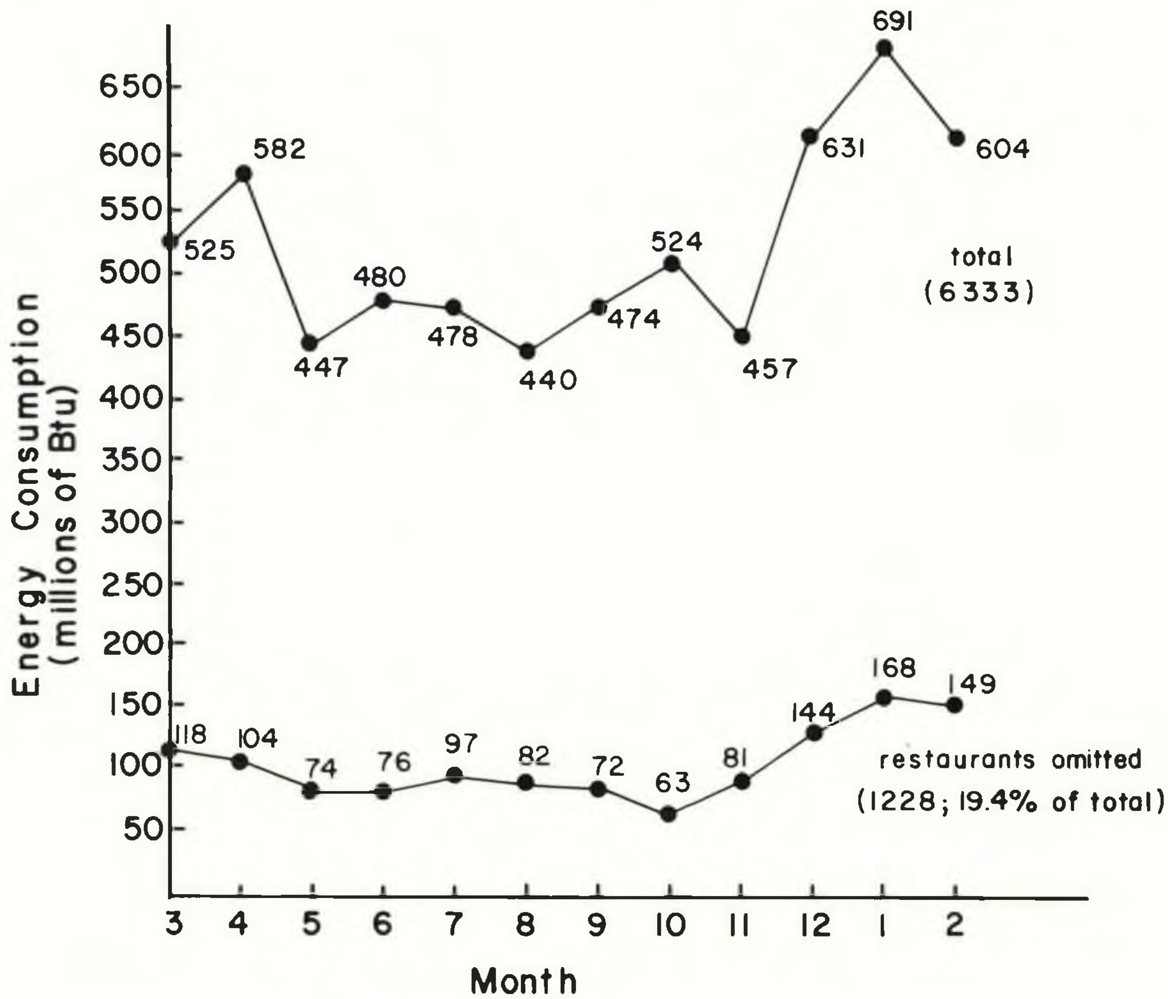


Fig. D-8. Total energy consumption from March 1980 to March 1981 for the entire block.

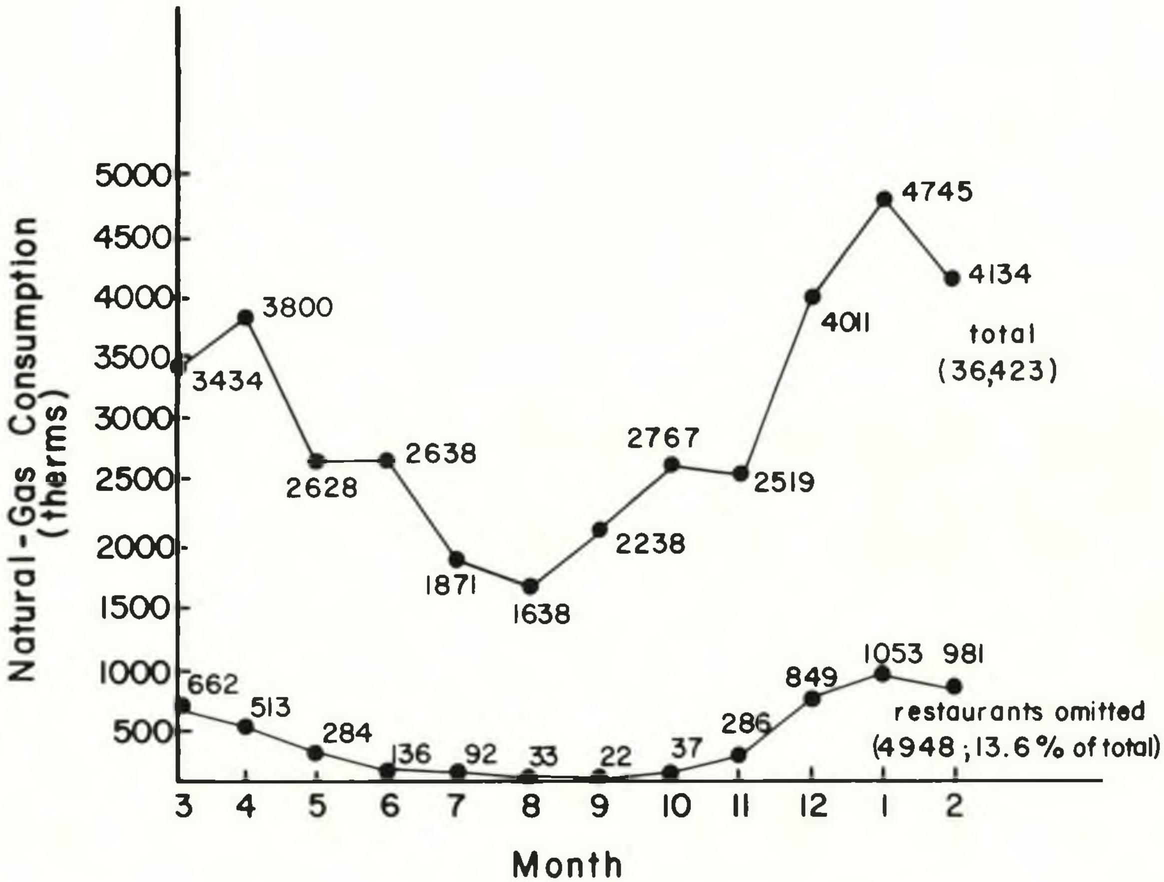


Fig. D-9. Natural-gas consumption from March 1980 to March 1981 for the entire block.

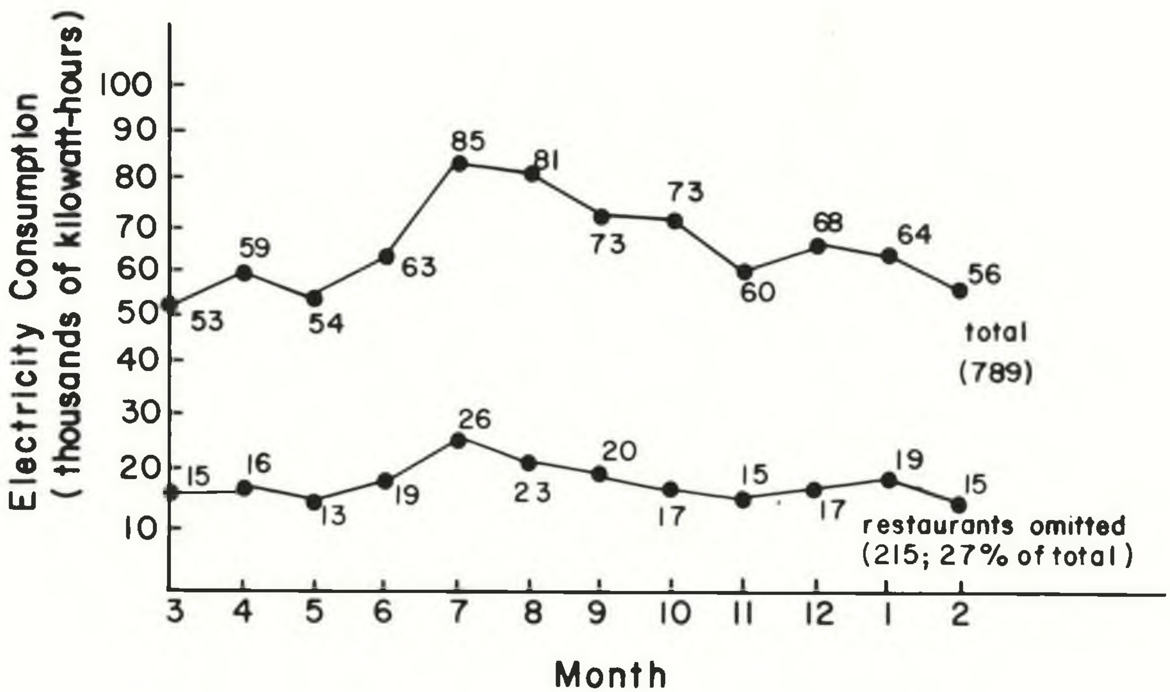


Fig. D-10. Electricity consumption from March 1980 to March 1981 for the entire block.

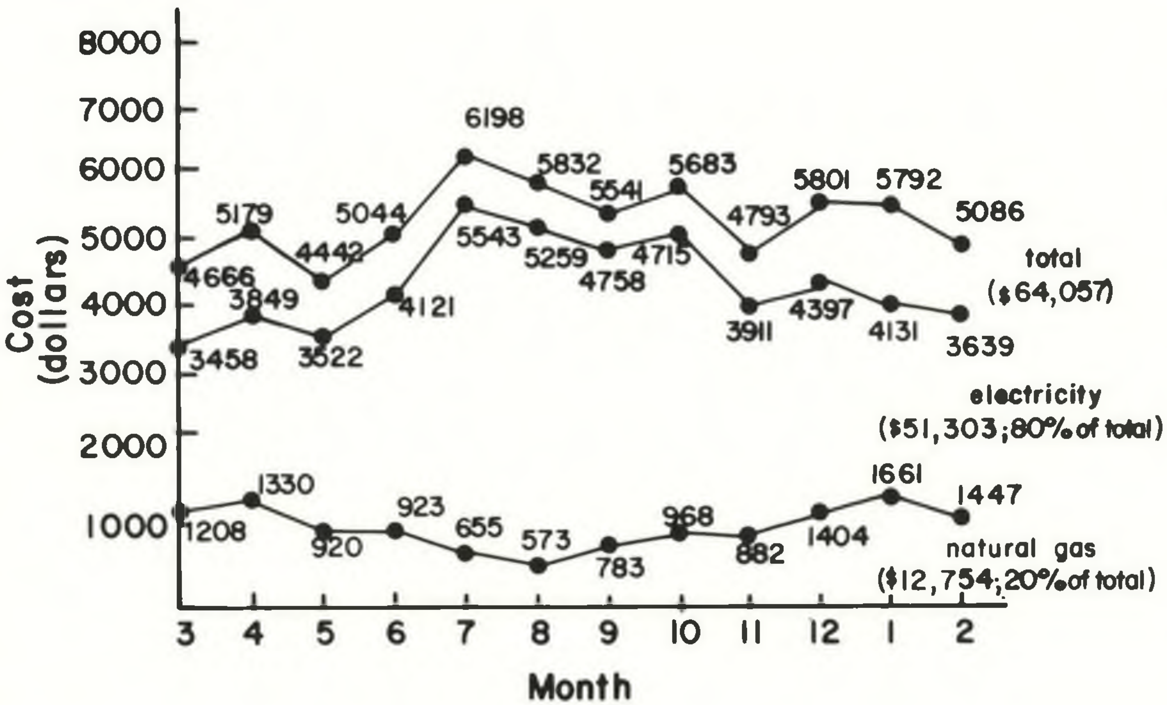


Fig. D-11. Energy costs from March 1980 to March 1981 for the entire block.

Lighting is also an energy consumer, particularly in retail stores and office buildings (as evidenced by the relatively flat lower plot in Fig. D-10). Because most of the buildings studied are single story, skylights and clerestories (especially those that provide solar gain during the winter) are retrofits that should be considered.

The information obtained during case studies of this kind is not a final result, but rather a tool to be used in the continuing process of promoting energy conservation and the use of renewable energy resources. These studies reveal the scope of the energy problem at hand and identify the large energy users. Armed with this information and information about various solutions, the planner can develop strategies to reduce energy usage in the block and thus produce economic benefits for local business owners. In addition, the results may well become a model for the rest of the community.

LOS ALAMOS SCIENTIFIC LABORATORY

Group S-2, MS-605
Modeling and Economic Analysis
P. O. Box 1663
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Utility Information Authorization

I, ______________________________ do hereby give my permission and consent to Virginia Parsons and/or Richard Mathews to secure utility information regarding my building located at ____

____

______________________________ ______________

Signature of Owner *Date*

____

PNM Account Number (if known)

____

Gas Company Account Number (if known)

Conclusions

The preceding case studies of single-family residential homes, mobile homes, multifamily units, and nonresidential buildings demonstrate the application of the methodologies discussed in Chap. 2. Each approach suggests some of the unique issues relating to retrofit potential analysis, such as employment impacts, retrofit cost considerations in a low-cost energy area, economic impacts of implementing mandatory programs, and the complexity of energy issues in nonresidential buildings. We hope these discussions have suggested analytical procedures that may be helpful in your local efforts to devise a retrofit program or address other policy questions.

The current low cost of natural gas in Albuquerque extends the discounted payback period of most all retrofit measures beyond the desired 7-year holding period. The exceptions are owner-installed measures on mobile homes, which appear to be very economic.* As the price of natural gas rises, retrofit measures should become more economic to Albuquerque residents. We emphasize that the contractor-installed retrofits appear to be uneconomic based on the assumptions of our analysis. The conservatism of our approach probably understates energy consumption in single-family homes and mobile homes. This conservatism reduces the magnitude of savings from retrofit measures. The basic intention of our methodological approaches is to determine total energy-savings potential for the city, not for individual homes. The energy savings in real-life situations will be higher or lower than our "average projected savings" based on individual circumstances.

The economic attraction of investment on a community scale in single-family and mobile-home retrofits is implicitly considered in our analyses. Based on economic criteria that are thought to respond to homeowner investment requirements, an assessment of the attraction of retrofits is suggested to the City. Both the single-family and mobile-home programs are economic given the stated criteria. Single-family home measures do require holding periods for the investments that go beyond the desired investment horizon for homeowners, however. The assessments of retrofit feasibility for single-family and mobile homes could be used to demonstrate the current economic viability of an overall retrofit program to the community.

This information might be used to garner support from local decisionmakers for organized efforts of encouraging residents to undertake such measures. The local government's involvement in such an effort might be related to information transfer, financing, or a combination of both. The single-family analysis would suggest that the local government consider a subsidy or low-interest loan program of some sort to improve the current economic attraction of contractor-installed retrofit measures. The approach discussed in the mobile-home section would suggest the possibility of the city capitalizing a cooperative or providing personnel to assist mobile-home occupants in installing various measures.

Although the basic economics of programs can be suggested by the approaches subject to the limitations of the analysis (for example, we only examine property-owner motivations), it is impossible to state that a local government's resources should be invested in a retrofit program. The decision of a local government to invest in the program will be related to complex considerations regarding the social needs of residents and/or possible benefits to the community (for example, more jobs and increased tax revenues). These types of considerations suggest a much more complex analysis than we are prepared to give in this sourcebook. For example, it might be useful to determine the economic impacts that additional dollars from energy savings might have on the local economy. In any event, even though it may be a good idea for the local government to support a retrofit program, local political and economic (budgetary) constraints will inevitably intervene.

Determination of conservation and passive solar retrofit potential at the community level is useful in determining a preliminary estimate of the possible energy savings for a community. A true indication of the community potential is better accomplished through microlevel analyses in the various neighborhoods of the community. Aggregation of these data, recognizing solar access potential and unique building characteristics, can present a more accurate picture to the community leadership of the real level of possible savings. A "bottom up" planning approach, starting with the block, then the neighborhood, on up to the community level, can better provide the individualized building-specific data that are crucial to more exact estimates of community potential. We suggest that retrofit potential considerations could easily be incorporated into other ongoing planning efforts that your community might be taking at the neighborhood level. The elements involved in undertaking a neighborhood analysis are detailed in Appendix E.

*We would assume that owner-installed measures on single-family homes would also be economic in Albuquerque as well (we discussed only contractor-installed measures so that we could assess their employment impacts).

E Albuquerque Case Study in Evaluating Economic Impacts

Measuring Economic Benefits

Benefit-Cost Analysis

Economic Base Study


HOUSING

This appendix examines the economic ramifications of a retrofit program in detail. The techniques, which have already been discussed in Chap. 3, are relatively straightforward and can be applied without significant technical knowledge by a planner or community organizer. Two areas of concern are covered in the following pages. First, the economic attraction of a retrofit program at the neighborhood level is covered in depth. Here, we determine the economic viability of the conservation and passive solar retrofits using benefit-cost analysis. Second, the employment impacts of a conservation and passive solar retrofit program are estimated for single-family homes at the city level using the economic base multiplier. We also briefly discuss the possible neighborhood-level employment impacts of a retrofit program. We hope that both of these discussions provide a simple and effective means of assessing the economic ramifications of a retrofit program and a means of choosing among alternative programs.

A fundamental consideration in planning efforts at either a city-wide or neighborhood level is to assess the effectiveness of a given program based on the benefits that it provides for the money invested. Benefit-cost analysis does this by relating the initial investment to expected benefits over a specified period, discounted at the community's or individual's required rate of return. We will now apply this technique in a specific neighborhood to discern the practicality of a retrofit program. A preliminary discussion gives the unique socioeconomic characteristics of the study neighborhood, the policy objectives of the local economic development corporation, and the approach we used to determine the economic benefits in the form of reduced energy bills for a low- and moderate-income Albuquerque neighborhood.

The South Broadway Neighborhoods

Our interest in applying a typological approach (see Chap. 2) and assessing the economic attraction of a neighborhood retrofit program led to the establishment of contacts with the South Broadway Economic Development Corporation (SBEDC). SBEDC was established in 1980 by the City of Albuquerque with a $100,000 CDBG appropriation. The Corporation operates as an umbrella planning organization for five low- and moderate-income neighborhoods located in central Albuquerque. Housing rehabilitation and economic development strategies are being developed by the City and SBEDC. The Corporation serves as a conduit for Albuquerque CDBG funds to the community. Current plans call for a $1 million annual allocation for the next 10 years. Corporation organizers have identified an energy conservation retrofit program, and possibly a passive solar retrofit program, as a key element in their planning efforts. To further that goal, they have applied to DOE under the Appropriate Energy Technology Small Grants Program for funding to develop an energy plan for the South Broadway neighborhoods. This plan will focus on incorporating energy efficiency into four main areas: housing rehabilitation and new construction, commercial revitalization, venture development, and transportation. The Corporation also wants to operate a Community Energy Resource Center to provide direct assistance to residents and businesses through energy education, workshops, audits, development of a tool bank, and direct technical assistance.

The South Broadway neighborhoods have an ethnic racial population composition that is 70% Hispanic and 16% Black (South Broadway grant application 1981). The population estimate for 1980 was around 7,700. The emphasis that has been placed on developing community energy efficiency is understandable in view of the rising costs of energy and the economic characteristics of the neighborhood residents. In 1976, the average household income was approximately $7,300 compared with an average of $15,300 for Bernalillo County. The South Broadway area has a substandard housing rate of 70% according to records kept in the Albuquerque Urban Rehabilitation Department. The community also has a relatively high vacancy rate (10.3% in Census Tract 13 and 11.1% in Census Tract 15) according to R. L. Polk and Company's 1976 edition of *Profiles of Change* (South Broadway Economic Development Corporation 1981). This may be compared with the City's overall vacancy rate of 2.2% for the same year. Approximately 51% of the housing units in the community are owner occupied according to the Polk Study. The City value for 1970, by way of contrast, was 64.5% according to census data. Because of the overall condition of the neighborhoods, the City of Albuquerque plans to rehabilitate 600 units of housing over the next 6 years.

The Study Approach

The need for residents of the South Broadway neighborhoods to reduce present energy-consumption levels and in the process gain some measure of control over their future energy bills is obvious. Consequently, consideration of the potential impacts of a conservation and passive solar retrofit program, either alone or in the context of a property rehabilitation program, is of interest at this time.

The retrofit approach adopted for South Broadway will be based on contractor-installed measures. This was done because of the interest of the SBEDC in developing a community-controlled weatherization business to retrofit homes in the South Broadway neighborhoods and to provide employment opportunities to community residents. They hope that this business could eventually be expanded to undertake retrofits in other parts of the City. The business might also be structured at some later time to install passive solar retrofits. The Corporation's interest in developing a contractor-related business would mean somewhat higher costs to residents than if a do-it-yourself approach were emphasized. The higher cost of the retrofit measures to neighborhood residents would have to be made affordable. In our analysis, we assume that low-interest, long-term loans could be obtained by homeowners and landlords.

Because of time considerations, our analysis was limited to determining retrofit potential in only three of the five South Broadway neighborhoods: John Marshall, San Jose, and South Broadway. These neighborhoods were identified as priority areas for a community-scale retrofit plan.

Number of Residences. The number of residential structures in the neighborhoods were determined by a field survey conducted in June 1981. The housing type is overwhelmingly single-family and mostly single-story (90%). A number of multifamily units exist in the neighborhood, mainly from the partitioning of what were once single-family homes. We did not specifically determine whether a building was single- or multifamily, however.*

Our field survey allowed us to evaluate the condition of the neighborhood residential structures. This was done with the idea of accounting more fully for the potential magnitude of heat loss. We assumed that units in more deteriorated condition tend to have higher heating-fuel bills.** The evaluative criteria for the buildings were:

- good—high level of exterior maintenance; fresh paint; roof, windows, doors, and wall siding all in presentable condition.
- fair—evidence of deferred maintenance; peeling paint; some structural deficiencies evident, such as loose boards, missing shingles on roof, and cracks in plaster or walls.
- poor—deterioration obvious; roof sagging; missing plaster on walls; broken windows; and doors off hinges.

The breakdown of units by construction type and condition we obtained is given in Table E-I. We caution you that our evaluation was highly subjective and not made on the basis of a high level of expertise in analyzing structural soundness. Our results differ from those of the City and SBEDC, but this was due to the cursory nature of our assessment of physical conditions. Still, our field study suggests that at least 50% of the buildings are in need of substantial repairs. This strongly suggests the need for a comprehensive neighborhood housing rehabilitation program.

Construction Characteristics. Based on a review of the City of Albuquerque Department of Urban Rehabilitation files (126 rehabilitations), we estimate the average size of a home in the South Broadway neighborhood to be approximately 955 ft^2.† For the sake of simplicity, we have increased this number to 1,000 ft^2.

Most of the structures surveyed (59%) are of masonry construction. The predominant forms are adobe (particularly in San Jose) and concrete block. Frame buildings, mainly with brick, wood, or stucco siding, made up the rest of the buildings sampled. There are pitched roofs on 90% of the structures. Flat roofs are most prevalent in the San Jose neighborhood.

We estimate that most of the buildings in the neighborhoods are built on concrete slabs (85%), whereas the rest are built over crawl spaces. In general, all masonry structures are built on slabs except for some of the older homes (pre-1920) located in the South Broadway neighborhood.

Window area was estimated at 10% of the floor area. We felt this percentage was reasonable based

TABLE E-I. Distribution of Homes by Construction Type and Condition in Three South Broadway Neighborhoods

	Frame		Masonry		Totals	
Condition	Number	Per Cent	Number	Per Cent	Number	Per Cent
Good	296	46.7	480	52.9	776	50
Fair	162	25.5	250	27.6	412	27
Poor	176	27.8	177	19.5	353	23
	634	100.0	907	100.0	1,541	100

*The applicable percentages for the entire South Broadway neighborhoods are 78.6% single-family, 15.4% multifamily, and 6% mobile homes, based on a total of 3,081 housing units according to the 1976 edition of R. L. Polk's *Profiles of Change*.

**This approach was adopted as a result of conversations with Charles Burnette, Director of the Philadelphia Solar Planning Project. The Project pioneered this approach in their building studies of neighborhoods in Philadelphia.

†File reviewed by R. Mathews, July 22, 1981.

on the field survey and after conversations with persons involved in the rehabilitation of neighborhood homes.

The presence of insulation in South Broadway structures is rare.* This is due in part to the age of the structures (94% were built before 1960). Most of the housing also was built to appeal to low- and moderate-income households initially. Cost considerations at the time of construction and low energy prices worked to discourage the inclusion of insulation in most houses. Consequently, our analysis assumes no insulation in the roof, walls, or floor.

*Conversation with P. Wilkes of the Albuquerque Urban Rehabilitation Department, May 1981.

Infiltration levels were adjusted to account for the condition of the home. This was done on an intuitive basis with 1.4 air changes/hour constituting the lower limit, 1.75 the middle, and 2.4 the upper. The 1.4 number was based on the average obtained for typical homes in the City. The other figures were estimated based on a consideration of what might be reasonable given the condition of a structure. This is a subjective consideration and is done basically for purposes of illustration, not as an indication of actual level of infiltration for South Broadway homes. Such a number could be estimated through conversations with utility officials or from actual studies of neighborhood structures in varying states of physical repair.

Estimating Heating Loads for Neighborhood Homes

Heating loads for the neighborhoods' homes were estimated using the same modeling techniques that were applied to single-family residences and mobile homes. These estimates are presented in Table E-II. The average energy consumption level (bill) for homes in the neighborhoods according to the Albuquerque Urban Rehabilitation Department is $380. This implies actual consumption of 1,086 therms (108.6 million Btu). Assuming a 55% furnace efficiency, the heating load would be 59.7 million Btu with a heat-loss factor of 13.9 Btu/degree day $\cdot$ ft^2. Conversations with staff members of Albuquerque Economic Opportunity Board's Weatherization Program, who are in charge of weatherization programs, and examination of a number of completed weatherization job files suggest that this value is fairly typical of homes in the South Broadway area.**

**Telephone conversation with Ray Caire of the Weatherization Program, Albuquerque Economic Opportunity Board, August 1981.

Applying Retrofit Measures

Provision of both conservation and passive solar retrofit measures are to be done through a community corporation that employs residents of the neighborhood. Conservation measures include ceiling insulation, storm windows, caulking, and weather stripping. We assume that caulking and weather stripping are installed by the building occupant and that the insulation is sold at current contractor prices. The storm windows are manufactured in the community and sold at an installed cost of $4.00/ft^2. The glazing in these windows may be glass or low-cost plastic. Estimated costs for the measures are presented in Table E-III for a typical 1,000-ft^2 home. The dollar amount for caulking and weather stripping is adjusted according to the condition of the home.

Conservation savings that are attributable to the measures are shown in Table E-II. All measures were adopted based on a 10-year holding period, 12% discount rate, 16% rate of price escalation for natural gas, and a 10% underlying inflation rate. The longer holding period was adopted assuming that people in the neighborhood, because of economic circumstances, will not move as often. It also is feasible that they may obtain a 10-year, low-interest rehabilitation loan.

Estimating Solar Savings

The results of a field study to assess solar retrofit potential is presented in Table E-IV.

The assessment of neighborhood solar potential was done simultaneously with the unit count and determination of structural conditions. The same approach described in the single-family section of Appendix D was used in the neighborhood study. The criteria were applied conservatively, and it is estimated that the overall retrofit potential for the three South Broadway neighborhoods is 38.3%. Potential by neighborhood varies, however. We estimate that 24.6%(168) of the homes in the John Marshall neighborhood can be retrofitted, 23.5%(94) in South Broadway, and 71%(329) in San Jose. The greater potential in San Jose is attributable to a more sparse pattern of settlement, which reflects its semirural character in some areas.

Setbacks of buildings and side yards vary markedly in portions of the neighborhoods, presenting a high level of solar potential. John Marshall and South Broadway, in general, are laid out on a more conventional urban pattern with uniform setbacks and side yards. Most of the homes are on north-south streets, and they typically have small side-yard dimensions of 7 to 20 ft. The proximity of other structures on the south side of buildings poses major difficulties for solar access. This problem is further complicated in the South Broadway neighborhood by a number of two-story structures that,

TABLE E-II. Estimated Energy and Dollar Savings Attributable to Conservation Retrofits[a]

Home Type and Condition	Initial Heating Load [million Btu ($)]	Heat-Loss Factor (Btu/degree day · ft^2)	Conservation Savings [million Btu ($)]	Conservation Savings (%)	New Heating Load (million Btu)	New Heat-Loss Factor (Btu/degree day · ft^2)
Masonry						
Good	61.8(393)	14.4	23.7(151)	38	38.1(242)	8.9
Fair	64.5(410)	15.0	26.4(168)	41	38.1(242)	8.9
Poor	69.6(443)	16.2	31.5(200)	45	38.1(242)	8.9
Frame						
Good	58.4(371)	13.6	23.7(151)	41	34.7(221)	8.1
Fair	61.1(389)	14.2	26.4(168)	43	34.7(221)	8.1
Poor	66.2(421)	15.4	31.5(200)	48	34.7(221)	8.1

[a]Before combustion losses.

TABLE E-III. Cost of Conservation Measures

Retrofit	Cost ($)
Ceiling insulation (R-30 at $0.37/ft^2)	400
Storm windows (at $4.00/ft^2)	400
Caulking and weather stripping[a]	100-200
	900-1,000

[a]Cost according to condition of home: good—$100, fair—$150, poor—$200.

together with narrow side yards, end up blocking out the major portion of the sun's rays to the south walls of adjacent buildings. The breakdown by neighborhood suggests the variation in retrofit potential that may exist even between neighborhoods near each other.

The greenhouse and Trombe wall described in the single-family section of Appendix D are once again used for the retrofit applications. The cost for these systems, though done on a contractor basis, is estimated to be lower for residents of the South Broadway neighborhoods. Costs must be kept down because of the economic needs of the resident population. Systems are assumed to be fairly simple in design and construction, thus keeping material and labor costs down. We also assume that a community-controlled conservation and passive solar retrofit corporation would be willing to reduce its profit margin somewhat so as to make the systems more affordable to community residents. Costs for a greenhouse can be anywhere from $9/ft^2 for an owner-built unit to $18/ft^2 and up for a contractor-installed unit. Costs for a Trombe wall can go from $4/ft^2 for an owner-built unit to $16/ft^2 for a deluxe contractor-installed unit.* *For purposes of our analysis*, we estimate that a greenhouse could be built for around $14/ft^2 and that a Trombe wall could be constructed at a cost of about $6/ft^2. This results in an approximate greenhouse cost of $1,800 and a Trombe wall cost of about $1,100.

Apportioning the Systems. An arbitrary apportionment of systems is adopted here. Both Trombe walls and greenhouses can be used to retrofit masonry homes. We assume that 70% of the masonry homes with solar access are retrofitted with Trombe walls because of their lower cost and that the remaining 30% are retrofitted with greenhouses. All the frame homes are assumed to be retrofitted with greenhouses because such homes do not have a significant heat-storage capacity. This apportionment assumes the construction of 318 Trombe walls and 272 greenhouses. The greenhouses are divided almost evenly between frame (134) and masonry homes (138).

All homes are assumed to have been weatherized before the installation of the solar retrofits. Homes in good, fair, and poor condition have been brought up

TABLE E-IV. The Distribution of Homes with Solar Potential in the South Broadway Neighborhoods

	Construction Type					
	Frame		Masonry		Total	
Condition	Number	Per Cent of Total	Number	Per Cent of Total	Number	Per Cent of Total
Good	78	58.2	266	58.3	344	58
Fair	25	18.7	97	21.3	122	21
Poor	31	23.1	93	20.4	124	21
	134	100.0	456	100.0	590	100.0

TABLE E-V. Estimated Solar Savings for South Broadway Homes

Home Type and Passive Retrofit	Heating Load after Conservation (million Btu)	Building Load Coefficient (Btu/degree day)	Load Collector Ratio	Solar-Savings Fraction[a] (%)	Solar Savings [million Btu ($)]
Masonry					
Greenhouse	38.1	8,877	61.6	55	21.0 (134)
Trombe wall	38.1	8,877	59.3	35	13.3 (85)
Frame					
Greenhouse	34.7	8,085	56.1	60	20.8 (132)

[a]Approximate

*Cost figures supplied by the New Mexico Solar Energy Association (letter from M. Wells to R. Mathews, June 30, 1981).

to an equivalent standard of 8.1 Btu/degree day · ft^2 for frame homes and 8.9 Btu/degree day · ft^2 for masonry homes. This weatherization standard is an important consideration and implies that many of the homes have to be rehabilitated substantially in order to achieve those values. The passive systems will not operate at an optimal level unless the integrity of the building shell is ensured first. Thus, there may be additional expenses when a retrofit program is proposed for areas where the physical soundness of many of the buildings is poor to start with. We assume that night insulation will be used by residents to boost system performance and maximize the economic returns. Our estimated solar savings are given in Table E-V.

Total Estimated Conservation and Solar Savings

Table E-VI details total estimated conservation and solar savings that are attributable to the combined retrofits.

TABLE E-VI. Total Estimated Savings for Conservation and Solar Retrofits

Home Type and Condition	Initial Load [million Btu ($)]	Conservation Savings [million Btu ($)]	Conservation Savings (%)	New Load [million Btu ($)]	Passive Retrofit[a]	Solar Savings [million Btu ($)]	Solar Savings (%)[b]	Total Savings [million Btu ($)]	Total Savings (%)	Final Load [million Btu ($)]
Masonry										
Good	61.8 (393)	23.7 (151)	38	38.1 (242)	GH	21 (134)	34	44.7 (284)	72	17.1 (109)
					TW	13.3 (85)	22	37.0 (235)	60	24.8 (158)
Fair	64.5 (410)	26.4 (168)	41	38.1 (242)	GH	21 (134)	33	47.4 (301)	74	17.1 (109)
					TW	13.3 (85)	21	39.7 (252)	62	24.8 (158)
Poor	69.6 (443)	31.5 (201)	45	38.1 (242)	GH	21 (134)	30	52.5 (334)	75	17.1 (109)
					TW	13.3 (85)	19	44.8 (285)	64	24.8 (158)
Frame										
Good	58.4 (371)	23.7 (150)	41	34.7 (221)	GH	20.8 (132)	36	44.5 (283)	76	13.9 (88)
Fair	61.1 (389)	26.4 (168)	43	34.7 (221)	GH	20.8 (132)	34	47.2 (301)	77	13.9 (88)
Poor	66.2 (421)	31.5 (200)	45	34.7 (221)	GH	20.8 (132)	31	52.3 (333)	79	13.9 (88)

[a]Retrofit type: GH = greenhouse; TW = Trombe wall.

[b]Per cent of initial load.

This section examines the economics of the neighborhood program through the use of benefit-cost analysis. The methodology that is presented may be used at the community level as well. This approach has already been used to assess the community-level economic attraction of single-family and mobile-home retrofit programs. In this section we discuss the nature of the underlying economic criteria and demonstrate the mechanics of the benefit-cost technique.

Determining Economic Criteria for the Analysis

Selection of the economic criteria by which a given program(s) will be judged is an important aspect of any analysis. There will also be a good deal of subjectivity in the selection of the criteria based on assumptions about the National economy and the particular requirements of the investor. For our neighborhood analysis (and the City analysis), we use a discount rate of 12%, an annual inflation rate of 10%, and an escalation rate in the price of natural gas of 16%. The selection of these criteria is now discussed briefly.

Discount Rate

Selection of the discount rate is based on the return that an investor might obtain on an alternative investment, on the cost of borrowing capital, or in the case of public organizations, on legislative or executive requirements* (Marshall and Ruegg, 1980).

The discount rate should exceed the inflation rate (for private investors) to ensure that money invested is in fact growing faster than the implied reduction in purchasing power. Until recent years, the difference between a discount rate and inflation has ranged from 2% to 4%. The advent of double-digit inflation has worked to shorten individual time perspectives (the time horizon for investment), and discount rates for investors will now exceed the traditional spread over the inflation rate, in many cases.

For purposes of our analysis, we have selected a 12% discount rate, which is reasonable based on current rates of return on alternative investments for individuals and expected economic conditions. Although the Nation has seen double-digit inflation occur in the past several years, there are some expectations that this rate should moderate over the next 3 to 5 years. Our analysis assumes a 10% annual rate. Comparative estimates from private econometric forecasting services and the Federal government bracket this rate.

Escalation Rate in the Cost of Energy

Fuel costs have taken a dramatic jump over the past several years. Although there is no general consensus on the exact magnitude of future increases in fuel prices, there is little disagreement about their continuing upwards. Our analysis in Albuquerque only looks at natural gas because it is the predominant heating fuel. We use a 16% annual rate of increase for natural-gas prices, which implies that prices will double in just under 5 years. This seems likely given current trends and mounting political pressure at the National level for the complete deregulation of natural-gas prices. We suggest that an assumed rate of increase for the price of energy for heating (oil, natural gas, or electricity) be included in any economic analysis to account more fully for expected trends in the economy that will obviously have an impact on the investor.

Time Horizon

A time horizon reflects the period of time over which the individual must recover his or her investment. Selection of the time horizon can be based on some concept of investment life or on the personal time perspective of the investor. No rule-of-thumb time horizon can be used for all projects. Many investment periods are based on the expected life of the building or the useful life of the improvement. For purposes of retrofit analysis, the individual's time horizon will often be linked to the period of time that he or she lives in the building. Any investment will have to provide its full return in that period. Renters, for example, may require an investment to pay for itself in 1 to 2 years.** The time horizon for homeowners will be longer; the average homeowner will move once every 7 years or so (Andreassi 1977).

*A 7% to 10% discount rate is used by Federal agencies in evaluating most government investments, including conservation investments in buildings. This is a real discount rate; that is, it does not include the effect of inflation.

**Landlords will often have similarly short investment perspectives (possibly 1 to 3 years).

We use varying holding periods in this sourcebook because natural-gas prices in Albuquerque are so low. According to our calculations, only the investment of a mobile homeowner in conservation and passive solar improvements can be recovered in less than 7 years, and only if the retrofits are self-installed and the cost of materials is reduced by a cooperative purchasing arrangement. Present prices make the use of a 7-year time horizon impossible for single-family homes where retrofit measures are installed by a contractor.* A 15-year period was used to evaluate a greater number of retrofit measures and consequently a greater level of City-wide savings. Fifteen years also is the maximum term of a home-improvements loan (FHA Title I terms) that a homeowner could expect to obtain. We use a 10-year time horizon for the South Broadway neighborhoods, assuming the economic characteristics of households there will make them somewhat less mobile than average homeowners. It is also assumed that any investment in energy efficiency should be recovered by the time of payoff on a 10-year low-interest loan.

The economic criteria used in an analysis have a major impact on the results. For example, if the escalation rate for the price of energy is greater than the inflation rate, the dollar benefits are greater and the payback period for the investment is shorter. Where the projected price increase is below the inflation rate, the opposite situation can be expected. A longer holding period also improves the economics of an investment. In this instance, annual cash benefits can be smaller and still meet the requirements of the investor.

*Only owner-installed caulking and weather stripping were economic, based on a 7-year holding period.

Neighborhood Energy Savings from a Retrofit Program

The following section discusses how benefit-cost analysis is applied at the neighborhood level (or a city level). The dollar savings (benefits) and costs of conservation and solar retrofits are developed initially and then are followed by the actual benefit-cost calculations.

Benefit-cost analysis provides the community leadership and residents with an overall perspective on the value of a given program and also can enable them to choose among alternatives. The value of the program to residents is implicitly considered by the economic criteria, which reflect individual investment considerations. We should point out that these criteria are oriented toward homeowners, not landlords and renters. A more finely tuned analysis would account for these considerations. However, our purpose here is only to demonstrate the application of benefit-cost analysis in a general sense.

Conservation Retrofits

Table E-VII gives the estimated community savings attributable to conservation retrofits. Measures considered are R-30 ceiling insulation, storm windows, caulking, and weather stripping.

Total energy consumption for space heating in the three South Broadway neighborhoods is estimated at 176.2 billion Btu (approximately $620,000). Our calculations show that 73.5 billion Btu or about 42%

of total consumption can be saved through a comprehensive conservation retrofit program. Annual dollar energy savings are estimated at around $260,000 based on a price of $0.35/therm at 55% furnace efficiency (a delivered cost of gas of $6.36/million Btu). Estimated costs of the retrofits would be $1,450,000.

Passive Solar Retrofits

Energy savings and costs from the passive solar retrofits are shown in Table E-VIII. Frame and masonry homes are assumed to have been improved to attain heat-loss factors of 8.1 and 8.9 Btu/degree day · ft^2, respectively, before the solar measures are installed.

Approximate energy savings from the passive solar retrofits would be 18.1 billion Btu, which would mean a savings of about $63,000 at a natural-gas cost of $0.35/therm. The cost of the program is estimated at $840,000.

Combined Conservation and Passive Solar Retrofit Program

A conservation and passive solar retrofit program could produce approximate energy savings of 91.6 billion Btu, which represents 52% of the neighborhoods' estimated total consumption level of 176.2 billion Btu. Conservation actions would generate around 80% of this savings while solar would provide the remaining 20%. The estimated energy bill for space heating in the community would be reduced from around $620,000 annually to about $297,000, a savings of around $323,000. The cost of the total program is estimated at $2,300,000.

Performing the Analysis

We now have all of the relevant costs and benefits (fuel savings) to perform benefit-cost analysis. The costs we have not considered yet are those incurred for the operation and maintenance of the greenhouses and Trombe walls. Operation and maintenance include painting, periodic sealing and caulking, and replacement of glazing. For our example, we assume operation and maintenance costs to be 1% of the system cost annually. Thus, for a greenhouse, the yearly figure would be $18.00, whereas for a Trombe wall it would be $11.00. Total annual operation and maintenance costs for the solar retrofits in the South Broadway neighborhoods would be approximately $8,400. Referring to the present value equations in Chap. 3, we can begin our benefit-cost analysis.

TABLE E-VII. Annual Community Energy Savings from Conservation Retrofits[a]

Home Type and Condition	Number of Homes	Initial Load (million Btu)	Community Consumption (billion Btu)	Conservation Savings[b] (million Btu)	Community Savings (billion Btu)	Cost of Retrofit[b] ($)	Total Cost ($)
Frame							
Good	296	106.2	31.4	43.1	12.8	900	266,400
Fair	162	111.1	18.0	48.0	7.8	950	153,900
Poor	176	120.4	21.2	57.3	10.1	1,000	176,000
Masonry							
Good	480	112.4	53.9	43.1	20.7	900	432,000
Fair	250	117.3	29.3	48.0	12.0	950	237,500
Poor	177	126.6	22.4	57.3	10.1	1,000	177,000
			176.2		73.5		1,442,800

[a]After combustion losses, assuming 55% furnace efficiency.
[b]Per retrofit.

The present value of the stream of benefits of the total program is

$$PV_B = 323{,}000 + \frac{323{,}000(1.16)}{(1.12)} + \frac{323{,}000(1.16)^2}{(1.12)^2} + \dots + \frac{323{,}000(1.16)^9}{(1.12)^9}$$

$$= \$3{,}802{,}000.$$

The present value of the stream of costs associated with the total program is

$$PV_C = 2{,}300{,}000 + \frac{8{,}400(1.10)}{(1.10)} + \frac{8{,}400(1.10)^2}{(1.10)^2} + \dots + \frac{8{,}400(1.10)^9}{(1.10)^9}$$

$$= 2{,}300{,}000 + 77{,}541$$

$$= \$2{,}377{,}541.$$

Our analysis indicates that benefits will exceed costs by a large margin of $1,424,459, which produces a benefit-cost ratio of around 1.6. This ratio tells us that the program is economic given the specified discount rate, holding period, and escalation rate in the price of natural gas and in fact exceeds the typical homeowner's required rate of return.

Individual analysis of the conservation and passive solar elements of the retrofit program provides an interesting glimpse of the program's underlying economic attraction. Application of benefit-cost analysis to the conservation program produces a very favorable ratio of 2.1 ($3,059,000/$1,450,000). The passive solar program on the other hand has a benefit-cost ratio of 0.88 ($740,000/$840,000), which suggests that investments in passive systems are not really economic at this time. The individual benefit-cost ratios of the conservation and passive solar retrofits point out that the economic attraction of the overall retrofit program is being supported by the conservation measures. Program organizers may wish to defer on the installation of the passive solar energy systems at present and invest in other needs that may provide a higher return to the community. As energy prices rise, it will soon become economic to advocate the installation of passive solar measures.

Alternatively, it is clear that the overall retrofit program is economic at this time and, in fact, provides a return to residents that is well above the specified economic requirements. A comprehensive program could economically be advocated now. In addition, as energy costs rise, the returns will increase as the value of the conservation improvements increase and as the benefit-cost ratios for the passive greenhouses and Trombe walls move past 1.0. Starting a comprehensive program may be a desirable approach because steps can be taken now to protect community residents more fully against the increases in natural-gas prices that can be expected to occur in the future.

The energy and dollar savings from a retrofit program may be expected to vary from the projections of an analysis because of a number of influences. These may include the energy consumption habits of the building occupants, weather conditions, and possible overestimations of savings because of the inclusion of previously weatherized homes. It is suggested that a range of savings be developed to inject some flexibility into an analysis and to provide figures that can be better assessed for their reasonability. We do this by calculating a lower bound for savings that will just make the proposed retrofit program economic to the community. This lower level of savings is calculated by determining the minimum level of annual dollar savings that would result in a benefit-cost ratio of 1.0, which indicates an acceptable investment based on specified economic criteria. This lower level of

TABLE E-VIII. Annual Community Energy Savings from Passive Solar Retrofits[a]

Home Type and Passive Retrofit	Number of Retrofits	Solar Savings[b] (million Btu)	Community Savings (billion Btu)	Cost of Retrofit[b] ($)	Total Cost ($)
Frame					
Greenhouse	134	37.8	5.1	1,800	241,200
Masonry					
Greenhouse	138	38.2	5.3	1,800	248,400
Trombe wall	318	24.2	7.7	1,100	349,800
			18.1		839,400

[a]After combustion losses, assuming 55% furnace efficiency.
[b]Per retrofit.

savings could be compared against the reported savings in actual buildings in the community (with similar retrofit measures installed) or perhaps the level of savings that was achieved in other community retrofit programs. Establishment of a required minimum level of savings may give you a better feel for the likelihood that a program will generate the desired savings. The calculation can also make your figures more credible to the decisionmakers who may be evaluating the merits of a retrofit program.

In the South Broadway neighborhoods, estimated annual savings from the total retrofit program could be just below $196,000, and a benefit-cost ratio of 1.0 would still be achieved. This represents a 39% reduction of the estimated savings of $323,000. The lower bound suggests estimated savings of 56.0 billion Btu or 32% of the total consumption as opposed to 52% originally estimated.

This relatively large spread between the predicted savings of 52% and the level of savings that would just make the program economic (32%) indicates that the economic attraction of the measures, given the stated criteria, is very strong now. The spread would be even larger if only the conservation measures were implemented because of their greater cost effectiveness at this time. The spread that exists between the predicted level of savings and the lower bound represents a margin of safety for the economic attraction of the program. In South Broadway, a fairly significant variation of 39% from the predicted level of energy savings could occur and the program would still be economically viable.

In addition to evaluating a particular program, benefit-cost analysis can compare alternative retrofit approaches for the community. Assumptions regarding system costs, the mix of retrofits, and the required economic returns can be manipulated by the planner or community organizer, and an assessment can be made as to which is the most effective in meeting community needs. The program with the highest benefit-cost ratio disregarding other criteria (capital constraints, other social objectives, workforce shortages) would be the one selected for implementation.

Another way to examine the economic feasibility of the neighborhood program is to compute the discounted payback period of the retrofit measures. This technique measures the time that it takes the accumulated benefits minus other accumulated costs (for example, operation and maintenance) to offset the amount of the initial investment. The benefits are discounted at a desired rate of return to reflect the time value of money. For the investor who requires a quick turnover of invested funds, a short payback period means a more desirable investment. This intuitively is an important consideration to homeowners who may be on tight budgets and need to recover their investments quickly. It is also important in that a homeowner will want to recover his or her investment before moving to another home. Renters and landlords will require short paybacks because of their unique investment perspectives.

The modeling of the overall retrofit program for the South Broadway neighborhoods indicates a discounted payback period of 6.5 years. This meets the traditional 7-year investment criterion of most homeowners and suggests that the overall program will address their typical time horizon perspectives. We should point out that the discounted payback represents a benefit-cost ratio of 1.0. The allowable reduction in savings that was developed for the South Broadway neighborhoods simply reflects that potential benefits could be about 39% less than the initial estimate and a discounted payback period of 10 years would still be attained.

Comments

This section of the appendix has attempted to demonstrate how benefit-cost analysis can be used to evaluate a neighborhood retrofit program. The analysis also could be applied at the city level. Such an attempt has been made in both the single-family residential and mobile-home sections of Appendix D. Benefit-cost analysis is a useful technique for analyzing a local energy program because it can be used to determine the economic viability of a program(s) and/or be used to rank alternative programs that the community may be considering. Evaluation of discounted payback periods can also be a useful analytical technique, suggesting the amount of time needed to recoup the initial investment.

Estimating Employment Impacts of a Conservation and Passive Solar Retrofit Program for Single-Family Homes

A basic objective in considering only contractor-installed retrofits on single-family homes in Albuquerque was to assess the employment impacts of a community-scale retrofit program.

Calculation of the estimated employment impacts of a retrofit program relies on the use of an economic base multiplier. Chapter 3 discusses methods that can be used to identify basic industries.* Our analysis will be based on the use of the location quotient (LQ).

Employment data for Albuquerque and the US are presented in Table E-IX.

The formula for the LQ presented in Chap. 3 was used to estimate the basic employment by sector. Our computations indicate that there are 23,840 basic jobs in Albuquerque. The ratio of total employment to basic employment, 5.19 (or 123,727 ÷ 23,840), is the base multiplier. It says that for every job created in a basic industry, 4.19 jobs will be created in other sectors (5.19 includes the original job). This is a relatively high multiplier. The accuracy of the multiplier can be improved when the LQs are determined using more disaggregated sectors and your own judgment as to which sectors are basic and which are not.

Initially, it is necessary to determine the number of homes that will receive retrofit measures. Referring back to the single-family section in Appendix D, we determine that the conservation retrofit measures in Table E-X will be required. Conservation and passive solar retrofits are examined separately in this analysis. Labor requirements for the conservation retrofits per home are estimated in Table E-XI.

If we assume that the average work year consists of 250 days, we can derive an estimate of the number of jobs that would be created in Albuquerque to undertake the conservation retrofits. Based on our estimates of hours required to do a particular retrofit, we conclude that one person could install insulation in 1,000 ceilings, in the walls of 167 homes, or under 167 floors or could install storm windows in 333 homes in an average year. The estimated number of jobs created can now be determined.

*Employment arising in certain industries from government "sponsored" programs may be considered basic; whereas in the overall economy, the industries may be more nonbasic in nature. A good example is the construction sector, which in general relies on business opportunities created by other economic activity. If the government "induces" increased activity in the local construction sector through a conservation and solar retrofit program, then the resulting increase in employment should be considered basic for your analysis purposes. Thus, in the following discussion, increases in contract labor are assumed to be basic to the local economy with subsequent effects on all other employment activity.

TABLE E-IX. 1972 Employment by Major Sector

Sector	Albuquerque	US
Mining	252	755,871
Construction	11,260	3,816,716
Manufacturing	12,302	19,405,252
Transportation, communications, and utilities	7,593	4,853,574
Wholesale trade	7,593	4,642,629
Retail trade	20,793	11,295,517
Finance, insurance, and real estate	7,143	4,262,318
Services	26,657	12,039,838
Government	30,337	10,608,778
	123,727	71,680,493

TABLE E-X. Estimated Conservation Retrofit Measures

Retrofit	Number of Homes
Ceiling insulation	72,807
Wall insulation	10,406
Floor insulation	10,406
Storm windows	72,807
Caulking and weather stripping	[a]

[a]Assumed to be owner installed.

The total number of basic jobs* created is determined by dividing the number of retrofits that will be undertaken annually by the number that can be handled by one person. For example, at a 5% implementation rate, 3,640 roofs would have ceiling insulation installed annually. This number would be divided by the number of jobs that one person could handle in a year (1,000) to determine that about 4 workers will be required to handle the volume.

We used 5%, 10%, and 20% annual implementation rates, implying retrofitting of existing housing in 20, 10, and 5 years, respectively (Table E-XII). The table indicates that a conservation program is not a major generator of basic jobs. If we include secondary employment impacts by using the multiplier of 5.19, total jobs created at the 5%, 10%, and 20% levels would be around 109, 219, and 442, respectively.

Estimation of the employment impacts from the passive solar retrofits constitute our next concern. We assume that it takes 10 work days of labor to build a greenhouse and 2 work days for a Trombe wall. We thus estimate that one person can build 25 greenhouses a year or 125 Trombe walls, based on 250 working days annually.

Estimates from the Albuquerque single-family section in Apendix D reveal that there is a total City potential for 36,324 passive systems. Of this total, 27,547 are assumed to be greenhouses and 8,777 Trombe walls. The 5%, 10%, and 20% implementation rates are used once again. We assume that the greenhouses and Trombe walls will be built in the same proportions as reflected by the total City potential. This would indicate that approximately 76% of the retrofits would be greenhouses and that the remaining 24% would be Trombe walls on an annual basis (Table E-XIII). The employment that these retrofits would generate is shown in Table E-XIV.

The table indicates that passive solar retrofits will generate a higher level of employment because the time it takes to build them is longer than the installation time for conservation retrofits. Total jobs created by the passive program including secondary employment impacts would be 306 jobs at the 5% rate, 607 at the 10% rate, and 1,214 at the 20% rate.

Total employment impacts of the conservation and passive solar retrofit program can now be estimated for Albuquerque (Table E-XV). Employment created by the conservation retrofits is arbitrarily reduced by 25% to account for homes that may have already received weatherization measures. This may be a high adjustment factor because many of those homes could still use some additional improvement.

*We again note that all direct increases in employment levels by the local construction industry that are attributable to a government initiative should be and are considered increases in the basic employment of the community.

TABLE E-XI. Estimated Labor Requirements[a]

Retrofit	Time (work days)
Ceiling insulation (blown cellulose)	0.25
Wall insulation (blown cellulose)	1.5
Floor insulation (fiber-glass batts)	1.5
Storm windows	0.75

[a]Insulation installation estimate, Duke Insulation and Triple A Insulation; storm window installation estimate, Madrid Manufacturing, Albuquerque.

Comments

The employment impacts of the retrofit program can be predicted only with extreme caution. In addition to the points discussed in the footnote on

TABLE E-XII. Estimated Basic Employment Impacts of Conservation Retrofits

	Implementation Rate		
Retrofit	5%	10%	20%
Ceiling insulation	4	8	15
Wall insulation	3	7	13
Floor insulation	3	7	13
Storm windows	11	22	44
	21	44	85

TABLE E-XIII. Estimated Annual Passive Solar Retrofits

	Implementation Rate		
Retrofit	5%	10%	20%
Greenhouses	1,371	2,754	5,510
Trombe walls	439	878	1,755
	1,816	3,632	7,265

TABLE E-XIV. Estimated Basic Employment Impacts of Passive Solar Retrofits

Retrofit	Implementation Rate 5%	10%	20%
Greenhouses	55	110	220
Trombe walls	4	7	14
	59	117	234

TABLE E-XV. Total Estimated Employment Impacts of a City-Wide Conservation and Passive Solar Retrofit Program for Single-Family Homes

Employment	Implementation Rate 5%	10%	20%
Basic			
Conservation	16	33	64
Passive solar	59	117	234
Subtotal	75	150	298
Nonbasic			
Conservation	67	138	268
Passive solar	247	490	980
Subtotal	314	628	1,248
TOTAL	389	778	1,546

p. 267, the estimated jobs may not all be new jobs. Many of the employment opportunities may be absorbed by existing contracting firms or perhaps by moonlighting workers. In addition, we treat the installation of insulation measures as if they were done separately. Contractors often install ceiling, wall, and floor insulation at one time. This permits some economies of scale to be achieved, reducing the labor requirement.

Determination of employment impacts is an important objective for this sourcebook, however. Perhaps the best way to demonstrate the employment impact of the program is to compare the estimates with actual employment figures for the Albuquerque metropolitan area. The annualized number of available workers was estimated at 202,187 for Bernalillo and Sandoval Counties in 1980. The annualized unemployment rate was 7.7%, implying that 15,568 persons were unemployed.* Assuming that all the jobs predicted by the multiplier are realized, employment would be increased by 389, 778, or 1,546 under the 5%, 10%, or 20% implementation rates. The unemployment rate would fall to 7.5%, 7.3%, or 6.9% under the assumed implementation rates. These reductions represent percentage reductions in the County unemployment rate of approximately 3%, 5%, and 10%, respectively.

Employment impacts generated by a single-family residential retrofit program do not consider the employment increases that might be generated through the promotion of energy efficiency in other building sectors. We may consequently infer that the employment impacts would be somewhat greater under a comprehensive retrofit program. Still, it cannot be guaranteed that all the jobs predicted will actually be realized by the community. Also remember that the jobs created will only be for the duration of the retrofit program and will largely disappear after it has been completed. Finally, the quality of the jobs (pay and working conditions) may not be particularly attractive to many workers in a community. Installing ceiling insulation in a hot attic in July doesn't appeal to many. A high rate of job turnover may be expected.

In conclusion, we foresee employment impacts from a retrofit program, but they are difficult to predict and are probably not that large. The employment-generating possibilities of a program, although a positive side effect, are obviously of secondary importance to the ability of a program to help a community reduce capital outflows and in the process develop the basis for a stable and growing economy in the future.

Estimating Neighborhood Employment Impacts

As noted in Chap. 3, determining the employment impacts of a retrofit program at the neighborhood level applying economic base analysis techniques is not recommended because employment multipliers are developed at the city, county, or perhaps the SMSA level. They are designed to measure impacts based on a consideration of the unique aspects of the overall local economy. Relating these multipliers to the neighborhood level would be an inappropriate application because it is unlikely that the economic

*Telephone conversation with the New Mexico Department of Employment Security (Albuquerque Office), September 10, 1981. Information specific to Albuquerque alone was not available.

considerations that the multipliers have been formulated on will all exist in the same manner in one neighborhood.

Based on our estimates for Albuquerque, we would estimate that employment opportunities generated from a neighborhood-oriented retrofit program would be very small. This is because of the small number of retrofits that probably would be installed each year and the low labor requirement for conservation measures. In any event, even if a 20% annual retrofit level were achieved, this would imply that the community would be weatherized and outfitted with all of the feasible passive solar energy systems within 5 years. After that, the employment opportunities in a neighborhood retrofit business would cease to exist.

We feel that a successful neighborhood business must seek retrofit jobs in other neighborhoods of the city. This can ensure more employment opportunities for local residents. Consideration also should be given to including retrofit services as but one aspect of a community business that conducts other activities. The most logical business would be a contracting business that also handles property rehabilitation and new construction. A business based on neighborhood retrofits alone most likely will not survive or at best just limp along.

We should state that our analysis has focused on three small neighborhoods in Albuquerque. There may be situations in other cities where employment opportunities in a retrofit program will be greater. Still, a neighborhood retrofit program probably is not a panacea for local unemployment. It should constitute but one element of an overall community development strategy.

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Yanda, Bill, and Rick Fisher, *The Food and Heat Producing Solar Greenhouse* (John Muir Publications, Inc., Santa Fe, New Mexico, 1980).

Alliance to Save Energy
1925 K St. NW
Washington, DC 20006
(202)857-0666
(Nonprofit organization; public policy analysis for the promotion of energy efficiency)

Alternative Energy Collective
5829 Adeline St.
Oakland, CA 94608
(415)849-3816
Conservation and solar technologies; training and education, consultation and design, building assistance, sales)

American Planning Association
Energy Planning Division
Box 172
Vienna, VA 22180
(703)827-7040

Anacostia Energy Alliance
2027 Martin Luther King Ave. SE
Washington, DC 20020
(202)889-7932
(Conservation and solar technologies; installation, energy audits, training and education)

Anne Arundel County
Office of Finance, Filling and Collection Division
P.O. Box 427
Annapolis, MD 21404
(301)224-1511
Contact: William Paull
(Property tax credits)

Boston Building Materials Cooperative
52 Plympton St.
Boston, MA 02118
(617)542-5842
Contact: John Rowse
(Weatherization services for low- and moderate-income households)

Campaign for Human Development (CHD)
1312 Massachusetts Ave. NW
Washington, DC 20005
(202)659-6650
(Funded by Catholic parishes around the Nation; assists lower income communities by providing grants, loans, and technical advice)

Cape Cod and Islands Self-Reliance Cooperative
Box 954
Hyannis, MA 02601
(617)771-1727
Contact: Peter Olotka
(Energy auditing, weatherization)

Center for Community Technology
1121 University Ave.
Madison, WI 53715
(Information on insulating shades and shutters)

Center for Maximum Potential Building Systems
Max's Pot
8604 FM 969
Austin, TX 78724
(512)928-4786
Contact: Pling Fisk III
(Assessment and application of alternative energy building technologies in existing buildings)

Center for Renewable Resources
1001 Connecticut Ave. NW, 5th Floor
Washington, DC 20036
(202)466-6350

Chautaugua County Energy Office
Mayville, NY 14757
(716)753-4258
Contact: Tom Duro

Cheyenne Community Greenhouse
3714 Whitney Rd.
Cheyenne, WY 82001
(307)635-9340
Contact: Shane Smith

Citizen's Energy Project
1110 Sixth St. NW
Washington, DC 20001
(202)387-8998

City of Baltimore
418 N. Bond St.
Baltimore, MD 21231
Department of Housing and Community Development
Energy Conservation Education Office
(301)396-9303
Contact: Jim Cosgrove
Weatherization Loan Program
(301)396-4148
Contact: Nora McCarthy
(For details on Baltimore's $2 million general obligation bond issue for conservation retrofits)

City of Davis
Community Development Department
226 F St.
Davis, CA 95616
(Information on the City of Davis' community energy program)

City of Northampton Energy Department
City Hall
210 Main St.
Northampton, MA 01060
(413)586-6950

City of Wichita
Home Insulation Program
1601 S. McLean
Wichita, KS 67213
(316)268-4696
Contact: Joe Dermid
(Direct loans for weatherization)

Civic Action Institute
1010 16th St. NW
Washington, DC 20036
(202)293-1461
(Concerned with neighborhood issues related to housing, energy, and employment)

Clearinghouse for Training in Alternative Energy
Solar America Inc.
2025 San Pedro Dr. NE
Albuquerque, NM 87110
(800)545-6928

Conference on Alternative State and Local Policies
2000 Florida Ave. NW
Washington, DC 20009
(202)387-6030

(Information on cooperative formation and management as well as on the activities of the Consumer Cooperative Bank)

Community Energy Project
ACTION
Room M-204
806 Connecticut Ave. NW
Washington, DC 20525
(800)424-8867

Conservation and Renewable Energy Inquiry and Referral Service (CREIRS)
P.O. Box 1607
Rockville, MD 20850
(800)523-2929
(800)462-4983 (Pennsylvania)
(800)523-4700 (Alaska and Hawaii)

Consumer Action Now
355 Lexington Ave.
New York, NY 10017
(212)682-8915

Consumer Cooperative Alliance
40 Cooperative Services, Inc.
7404 Woodward Ave.
Detroit, MI 48202

Cooperative Assistance Fund (CAF)
1312 Massachusetts Ave. NW
Washington, DC 20005
(202)659-6650
(Provides a means by which large foundations and philanthropic organizations can make investments in programs that promote the economic development of lower income areas. Assets currently stand at $5,000,000.)

Cooperative League of the U.S.A.
1828 L St. NW
Suite 1100
Washington, DC 20036
(202)872-0550
(Information on starting and managing cooperatives)

Council on Economic Priorities
86 Fifth Ave.
New York, NY 10011
(212)691-8550

Crosby Gardens
5403 Elmer Dr.
Toledo, OH 43615
Contact: Mary Tucker

Energy Task Force
156 Fifth Ave.
New York, NY 10010
(212)675-1920

Federation of Southern Cooperatives
P.O. Box 95
Epes, AL 35460
(205)652-9676
(Information on management and organization of cooperatives)

Fitchburg Alliance to Conserve Energy (FACE)
120 Academy St.
Fitchburg, MA 01420
Contact: Larry Cassasa
(Weatherization program)

Foundation Center
888 Seventh Ave.
New York, NY 10019
(212)975-1120

or

1007 Connecticut Ave. NW
Washington, DC 20036
(202)331-1400
(Provides list of foundations with their interests and particular application procedures, which may be of interest to individuals organizing cooperatives)

Franklin County Energy Project
Box 548
Greenfield, MA 01302
(413)774-2306
Contact: Daria Fisk
(Comprehensive program assessing the potential of alternative technologies at the local level)

Grantsmanship Center (West)
1031 S. Grand Ave.
Los Angeles, CA 90015
(213)749-4721

or

Grantsmanship Center (East)
719 Eighth St.
Washington, DC 20003
(202)547-5005
(Information on various foundations, their funding interests, and application procedures, which may be of interest to individuals forming cooperatives)

Greater Roxbury Development Corporation
90 Warren St.
Roxbury, MA 02119
(617)445-4242
Contact: Curtis Davis
(Neighborhood energy planning)

Green Mountain Appropriate Technology Cooperative
100 N. Winooski Ave.
Burlington, VT 05401
(802)863-2939
(Weatherization program, tool and skills bank)

Greensboro-Guilford County Emergency Management Assistance Agency
Drawer W-2
Greensboro, NC 27402
(919)373-2000
Contact: Marilyn J. Braun
(Energy audits)

Harford County Assessor's Office
Director of Administration
45 S. Main
Bel Air, MD 21014
(301)879-2000
Contact: Mrs. B. Packard
(Property tax credits)

Home Maintenance Cooperative
Box 7215
New Haven, CT 06579
(203)865-0114
(Tool-lending program for low-income minority neighborhoods)

Housing Energy Alliance for Tenants Cooperative, Inc. (HEAT)
156 Fifth Ave.
New York, NY 10010
(212)675-1920
(Bulk purchase of heating oil, boiler repair and maintenance)

Hutchinson City Planning Department
P.O. Box 1567
Hutchinson, KS 67501
(316)663-6151
(Energy analysis using advanced technology)

Industrial Cooperatives Association
2161 Massachusetts Ave.
Cambridge, MA 02140

Institute for Ecological Policies
9208 Christopher St.
Fairfax, VA 22031
(703)691-1271
(Research on potential of alternative technologies in community planning strategies)

Institute for Local Self-Reliance
1717 18th St. NW
Washington, DC 20009
(202)232-4108
(Research and programs pertaining to the development of increased economic independence for communities and neighborhoods)

Jordon College
366 W. Pine St.
Cedar Springs, MI 49319
(Solar, wind, and biomass workshops and seminars)

Local or state solar energy associations

Local or state energy extension offices

Local US Department of Agriculture Extension Offices

Local utilities

Mid-American Solar Energy Center
8140 26th Ave. South
Bloomington, MN 55420
(612)853-0400
(Regional information resource on solar energy)

Mid-Atlantic Solar Energy Association
2233 Gray's Ferry Ave.
Philadelphia, PA 19146

Midland Financial Savings and Loan
606 Walnut
Des Moines, IA 50307
(515)283-2151
Contact: Richard Bryan, President
(Loans for energy conservation)

Minneapolis Community Development Agency
1400 Park Ave. South
Minneapolis, MN 55404
(612)348-4982
Contact: Steve Peterson
(Credit agreements with private lending institutions)

Minnesota Housing Finance Agency
Suite 200
333 Sibley
St. Paul, MN 55101
(612)297-3126
Contact: Mary Tingerthall
(FHA Title I bond financing for home improvements)

Montachusetts Opportunity Council
7 Fairmont Pl.
Fitchburg, MA 01420
Contact: Brian Angus

Monterey Energy Project
Box 125
Monterey, MA 01245
(413)528-9200
(Weatherization)

National Association of Counties
1735 New York Ave. NW
Washington, DC 20006
(202)785-9577

National Association of Home Builders
15th and M St. NW
Washington, DC 20005
(202)452-0200

National Bureau of Standards
Office of Energy Conservation
Building 226, Room B-114
Washington, DC 20234

National Bureau of Standards
Solar Technology Group
Building 225, Room B-150
Washington, DC 20234
(Technical information)

National Center for Appropriate Technology (NCAT)
Butte, MT 59701
(406)494-4572
(Research on and application of conservation and renewable energy technologies for low- and moderate-income households)

National Climatic Center
Federal Building
Asheville, NC 28801
(704)258-2850
(National weather data)

National Committee for Full Employment Energy Project
Environmentalists for Full Employment
1536 16th St. NW
Washington, DC 20036

National Congress for Community Economic Development
1828 L St. NW
Suite 401
Washington, DC 20036

National Consumer Cooperative Bank
2001 S St. NW
Washington, DC 20009
(800)424-2481
(Potential funding for community energy cooperatives)

National League of Cities
1301 Pennsylvania Ave. NW
Washington, DC 20004
(202)626-3000
(Research and publications on energy efficiency in urban environments)

Neighborhood Information Sharing Exchange
(800)424-2852
(202)293-2813 (Washington, DC)
(Ideas on neighborhood organizing and community development)

Neighborhood Technology Program
Metro Center YMCA
909 Fourth Ave.
Seattle, WA 98104
(206)447-3625

New Alchemy Institute
P.O. Box 47
Woods Hole, MA 02543
(617)563-2665
(Research on and practical application of alternative technologies in energy and food production)

New England Energy Congress
53 D St. SE
Washington, DC 20003
(202)543-8855

New Haven Community Energy Cooperative
770 Chapel St.
New Haven, CT 06510
(203)789-0378
(Bulk purchase of fuel oil, education, encouraging self-help conservation actions)

New Mexico Solar Energy Association
P.O. Box 2004
Santa Fe, NM 87501
(505)983-2861
(Technical assistance, research in renewables, workshops, demonstrations; publishes *Sunpaper)*

Northeast Solar Energy Center
70 Memorial Dr.
Cambridge, MA 02141
(617)661-3500
(Regional solar information center)

Northwest Energy Cooperative Association
559 Carpenter Ln.
Philadelphia, PA 19119
(215)844-2324
Contact: Vince Pieri
(Bulk fuel-oil purchase)

Passive Solar Industries Council
c/o Potomac Energy Group
125 S. Royal St.
Alexandria, VA 22314

People's Energy Resource Cooperative
36 Concord St.
Framingham, MA 01701
(617)527-5383
Contact: Brad Steele
(Bulk fuel-oil purchase, weatherization, energy audits)

Philadelphia Solar Planning Project
Charles Burnette and Associates
234 S. Third
Philadelphia, PA 19106
(215)925-0844
Contact: Charles Burnette
(Reports on a variety of subjects pertaining to the potential of solar technologies in urban environments)

Portland Development Commission
1500 S.W. First Ave., Seventh Floor
Portland, OR 97201
(503)248-4800
(Credit agreements with local lenders)

Portland Energy Office
1220 S.W. Fifth Ave.
Room 405
Portland, OR 97204
(503)248-4579
(Details on Portland's comprehensive energy plan)

Portland Wood Fuel Cooperative
155 Brackett St.
Portland, ME 04102
(207)775-0105
(Sells wood for heating)

Potrero Valley Project
Box 754
El Rito, NM 87530
(505)581-4598
Contact: Neil Withers

Project Sunshine
Milton Township Committee on Youth
Wheaton, IL 60187
Contact: Roy Grundy

Public Resource Center
1747 Connecticut Ave. NW
Washington, DC 20009
(202)483-3321

Riverside/Cambridgeport Community Development Corporation
217 Western Ave.
Cambridge, MA 02139
Contact: Henry Joseph

St. Louis County Department of Human Resources
555 S. Brentwood
Clayton, MO 63105
(314)889-3453
Contact: Patricia Sheehan

St. Paul Energy Office
365 City Hall
St. Paul, MN 55102
(612)292-6730
Contact: Janet Hanasin
(Details on St. Paul's energy program)

San Bernadino West-Side Community Development Corporation
1736 W. Highland Ave.
San Bernadino, CA 92411
(Job training)

San Diego Federal Savings and Loan
600 B St.
San Diego, CA 92183
(714)231-1885
Contact: Peter Hall
(Loans for solar hot-water systems)

Santa Fe Community Solar Cooperative Association
1050 Old Pecos Trail
Santa Fe, NM 87501
(505)982-3574
Contact: Judy Turley
(Worker cooperative providing solar design, energy audit, and weatherization services)

Seattle City Light
1015 Third Ave.
Seattle, WA 98104
(206)625-3200
Contact: Joe Richie, Superintendent
(Seattle Light has recently completed a solar access study for the City.)

Seattle Department of Community Development
400 Yesler
Seattle, WA 98104

Security Pacific National Bank
Community Development Center
P.O. Box 4330
Downey, CA 90241
(213)923-5551
Contact: Phil Long
(Linked deposits for housing rehabilitation)

SMILE
Community Action Agency
P.O. Box 3343
Lafayette, LA 70502
(318)234-3272
Contact: Frank Neelis
(Weatherization, passive solar retrofits)

Solar Access Alliance
P.O. Box 8210
Portland, OR 97207

Solar and Insulation Coop Inc.
511 E. Saginaw
Lansing, MI 48906
(517)371-1111
Contact: John Veenstra
(Worker cooperative; sell and install insulation materials, window quilts, and other conservation measures)

The Solar Center
1115 S. Indiana
San Francisco, CA 94107
(415)957-9660
(Design, sell, and install solar systems)

Solar Energy Industries Association
1001 Connecticut Ave. NW
Suite 800
Washington, DC 20036
(202)293-2981

Solar Energy Research Institute
1617 Cole Blvd.
Golden, CO 80401
(303)231-1000
(Solar Energy Information Data Bank; also ask for the address of your regional solar information center)

Southern Cooperative Development Fund (SCDF)
P.O. Box 3885
Lafayette, LA 70501
(318)232-9206
(Provides financial and technical assistance to qualified cooperatives or community-controlled organizations located in the District of Columbia, Maryland, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Louisiana, Mississippi, Texas, Arkansas, Oklahoma, Missouri, and Kentucky)

Southern Solar Energy Center
61 Perimeter Park
Atlanta, GA 30341
(Regional solar information center)

State and local energy offices
(Offer many publications that have regional information on conservation and solar)

State of Kansas
Division of Property Valuation
(913)296-7775

State of Maryland
Assessments and Taxation Department
(301)321-3750
(Property tax credits)

Tennessee Valley Authority
Power Service Center 4
Chattanooga, TN 37401
(615)755-3901
Contact: Lee R. Culpepper
(Utility conservation program)

The Urban Ark
2100 Ridge Ave.
Evanston, IL 60201
(312)328-1191

US Department of Commerce
National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161
(Government publications on various energy issues may be purchased through NTIS)

US Department of Commerce
Office of Energy Programs
14th and Constitution Ave.
Washington, DC 20236

US Department of Energy
Appropriate Technology Small Grants Program
Office of Small-Scale Technology
1000 Independence Ave. SW
Washington, DC 20585

US Department of Energy
Comprehensive Community Energy Management Program (CCEMP)
Office of Building and Community Systems
1000 Independence Ave. SW
Washington, DC 20585
(202)252-9395
Contact: Jerry Duanne
(Studies related to energy planning at the local level)

US Department of Energy
National Energy Information Center
EI-71, MS 240
1726 M St. NW
Washington, DC 20461
(202)634-5610
(Statistics of energy supply, demand, and policy)

US Department of Energy
Weatherization Assistance Program
Office of State Programs
1000 Independence Ave. SW
Washington, DC 20585

US Department of Housing and Urban Development
451 Seventh St. SW
Washington, DC 20410
[HUD will insure mortgages made by private lending institutions to build or rehabilitate multifamily housing under the following programs (conservation and solar energy systems may generally be included in both new construction and rehabilitation):
207 - Moderate-Income Housing
213 - Cooperative Housing
231 - Housing for the Elderly or the Handicapped
241 - Property Improvement Loans for Multifamily Housing. Conservation and solar retrofits (including passive) are eligible under program regulations.

Section 8 Rental Housing - HUD assists lower income households to meet their housing needs by providing a subsidy that makes up the difference between what the tenant can pay in rent and the market rate. A tenant is not allowed to pay more than 25% of his adjusted gross monthly income in rent.

A Section 8 financing commitment can be obtained by interested profit- and non-profit-oriented investors at the invitation of HUD. They may also apply to their state housing finance agency for funding. Passive solar and conservation retrofits could feasibly be financed in both new construction and during the rehabilitation of structures.]

US Department of Housing and Urban Development
Assistant Secretary for Community Planning and Development
Cities Division
Room 7284
451 Seventh St. SW
Washington, DC 20410
(202)755-9267
Contact: James Broughman
(Community Development Block Grants)

US Department of Housing and Urban Development
Community Planning and Development
Room 7231
451 Seventh St. SW
Washington, DC 20410
(202)472-3947
Contact: David Cordish
(Urban Development Action Grants)

US Department of Housing and Urban Development
Innovative Grants for Community Energy Conservation
Office of Community Planning and Development
451 Seventh St. SW
Washington, DC 20410

US Department of Housing and Urban Development
Neighborhoods Voluntary Associations and Consumer Protection
Room 4228
451 Seventh St. SW
Washington, DC 20410
(202)755-6920
Contact: Cal Wilson
(Programs on improving neighborhood economic self-reliance)

US Department of Housing and Urban Development
Office of Housing
Room 9220
451 Seventh St. SW
Washington, DC 20410
(202)755-6454
Contact: Michael C. Wells, Program Analyst
(FHA insurance on loans for energy improvements on FHA-insured multifamily housing)

US Department of Housing and Urban Development
Office of Policy Development and Research
HUD User Bibliography Service
P.O. Box 280
Germantown, MD 20767

US Department of Housing and Urban Development
Office of Policy Planning
Room 7134
451 Seventh St. SW
Washington, DC 20410
(Community Energy Conservation Competition)

US Department of Housing and Urban Development
Office of Urban Rehabilitation and Community Reinvestment
Room 7170
451 Seventh St. SW
Washington, DC 20410
(202)755-5685
Contact: Robert I. Dodge III, Director

US Department of Housing and Urban Development
Small Cities Program
451 Seventh St. SW
Washington, DC 20410
(202)755-6322
Contact: James Forsberg, Director
(Community Development Block Grants)

US Department of Housing and Urban Development
Title I Insured Loan Division
Room 9172
451 Seventh St. SW
Washington, DC 20410
Contact: John Brady
(Information on using FHA Title I insurance for property improvement)

US General Services Administration
Public Building Service
18th and F St. NW
Washington, DC 20405

Utility Clearinghouse
Environmental Action Foundation
724 Dupont Circle Bldg.
Washington, DC 20036
(202)659-1130

Western Solar Utilization Network (SUN)
Pioneer Park Bldg.
71 S.W. Morrison St.
Portland, OR 97205
(503)241-1222

Wintergreen Cooperative Solar Greenhouse, Inc.
58 Logan Ave.
Orange, MA 01364
(617)544-6416
Contact: Karen Idoine
(Food production and sale)

Wisconsin Department of Local Government Affairs and Development
Loraine Bldg.
P.O. Box 7970
123 W. Washington Ave.
Madison, WI 53707
Contact: Ron Krohn
(608)266-8923
(FHA Title I bond financing for home improvements)

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Los Alamos

Los Alamos National Laboratory
Los Alamos, New Mexico 87545