450 12/28/79

Dr. 513

ENERGY CONSERVATION

DOE/TIC-10117(Vol.2)

PHASE I. INTEGRATED COMMUNITY ENERGY PLAN FOR RIVERSIDE, CALIFORNIA

Volume 2. Final Report

January 1979

Work Performed Under Contract No. W-7405-ENG-92-100

Battelle Columbus Laboratories
Columbus, Ohio

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

U. S. DEPARTMENT OF ENERGY

Division of Buildings and Community Systems

DOE/TIC-10117(Vol.2)
Distribution Categories UC-95c,
UC-95d, UC-95e, and UC-95f

Final Report

on

PHASE I. INTEGRATED COMMUNITY ENERGY PLAN FOR RIVERSIDE, CALIFORNIA

Contract W-7405-ENG-92, Task 100

Volume 2

to

U.S. Department of Energy
Office of Assistant Secretary for Environment
Office of Technology Impacts
Division of Regional Assessments
Office of Assistant Secretary for Conservation and Solar Applications
Division of Buildings and Community Systems

January 1979

BATTELLE
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

APPENDIX A

OVERALL METHODOLOGY FOR DEVELOPING AN INTEGRATED COMMUNITY ENERGY PLAN FOR RIVERSIDE, CALIFORNIA

TABLE OF CONTENTS

LIST OF FIGURES

APPENDIX A

OVERALL METHODOLOGY FOR DEVELOPING AN INTEGRATED COMMUNITY ENERGY PLAN FOR RIVERSIDE, CALIFORNIA

Methodology Background

Many technical aspects must interact closely and be integrated with pertinent socio-economic, institutional, and legal factors in the development of an integrated community energy plan. Figure A-1 shows schematically the key elements in this development. Phase 1 was accomplished by Battelle staff members who worked individually on a series of specific technical tasks, and who later worked together as a team in screening, evaluating, and selecting the recommended alternative energy strategies and in developing the specific action plans.

Although Phase 1 was heavily oriented toward technical analyses, before any analysis could be performed, a large amount of site-specific data were needed. Throughout the program, in order to discuss ideas and obtain data, numerous individual meetings and telephone contacts were established with City, County, State, and Federal officials, along with planners, architects, builders, utility representatives, private citizens, and others representing industry, business, and universities. Discussions were also held with many other individuals outside Riverside covering the state-of-the-art of technology in conservation and alternative energy resources. Much of this information came from researchers working in special technical fields at Battelle who were not directly assigned to the Riverside project. Battelle staff members also worked closely with the Director of the Riverside Public Utilities Department, Mr. Everett Ross, and his project coordinator appointed to interface with Battelle, Mr. David Sparks.

An Advisory Committee met at selected times throughout the Program to provide guidance and information pertinent to the program's operation and final results. Members were expected to make contributions in such areas as calling attention to relevant research or other demonstration programs,

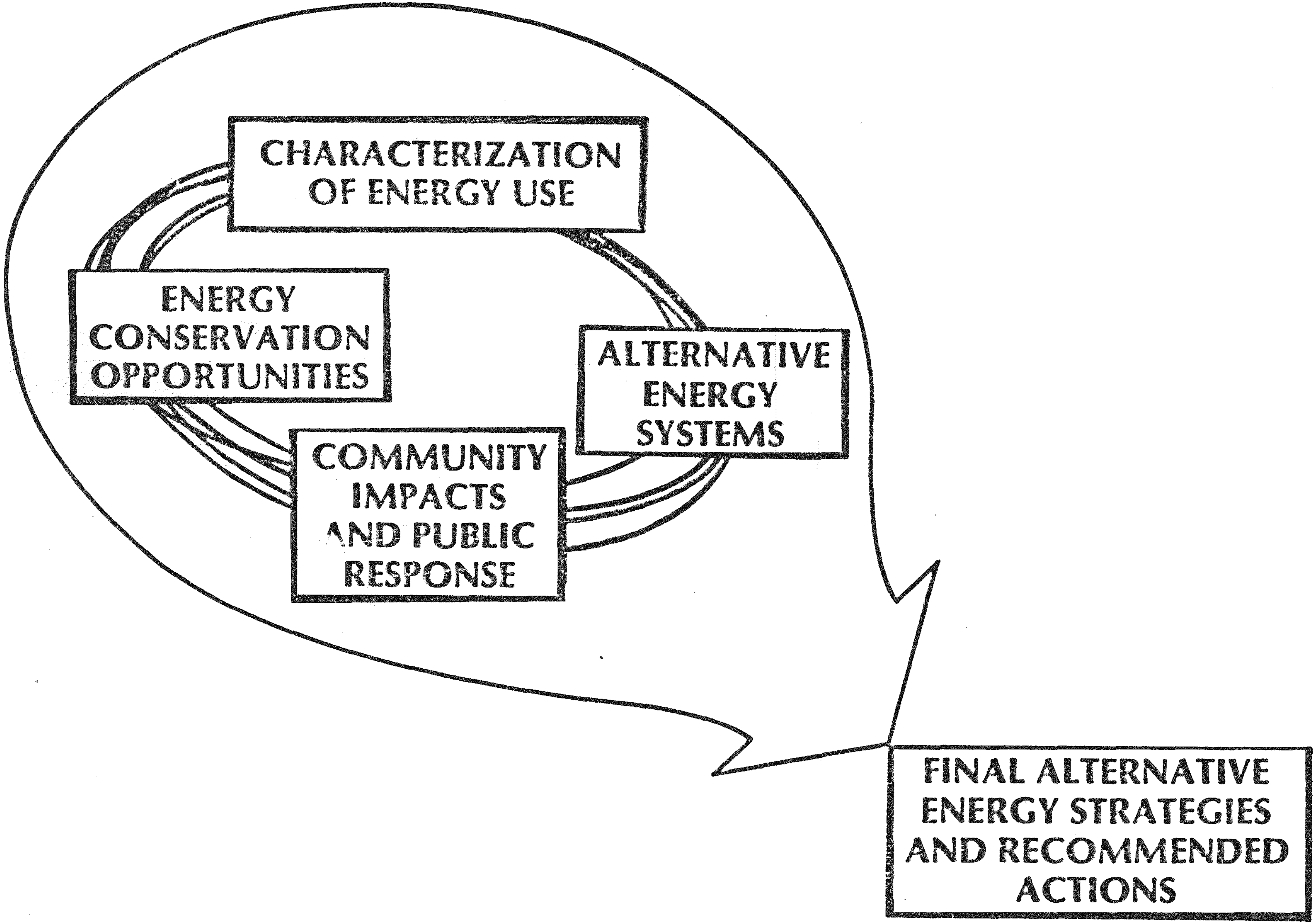


FIGURE A-1. KEY ELEMENTS IN DEVELOPING AN INTEGRATED COMMUNITY ENERGY PLAN suggesting and/or helping with contacts and public acceptance programs, identifying possible regulatory or institutional constraints, and providing technical inputs.

Initially, Advisory Committee members were:

Chairman: Dr. Paul Cho, Project Officer, Department of Energy, Washington, D. C.

Mr. I. O. Sewell, Department of Energy, Washington, D. C.

Mr. Paul Dickinson, Department of Energy, San Francisco, California

Dr. Meir Carasso, Energy Resources Conservation and Development Commission, Sacramento, California

Mr. Everett Ross, Public Utilities Director, City of Riverside, California

Mr. Robert H. Poirier, Environment and Technology Department, Battelle-Columbus

Mr. Kenneth E. Cochran, Project Manager, Riverside Program, Battelle-Columbus.

In January, 1978, it was decided by DOE, Battelle, and the Riverside representative that the representation was too limited and that the Advisory Committee should be expanded to include more citizens. The Committee was restructured and, with Battelle's concurrence, the two Battelle members were removed while the following were added:

Mr. Eric Haley
1435 Everton Place
Riverside, California 92507

Dr. Robert Zweig
Director, Pollution Control Research Institute
3875 Jackson Street
Riverside, California 92503

Ms. Rosanna Scott
5716 Abilene Road
Riverside, California 92506

Dr. [illegible] C. Taylor
[illegible] Statewide Air Pollution
Research [illegible]
Univ[illegible] Riverside
[illegible]

Mr. Herb Rogers
Riverside and Imperial County District Manager
Southern California Gas Company
P. O. Box 2200
(3700 Central Avenue)
Riverside, California 92506

In August, 1978, Mayor Ab Brown requested that three persons be added to the Committee. Those added were:

Mr. Lester G. Heustis
6815 DeAnza Avenue
Riverside, California 92506

Mr. Arden Anderson
3696 San Simeon Avenue
Riverside, California 92506

Mrs. Donald L. Morrow
6109 Enfield Place
Riverside, California 92506

Thus, at the conclusion of Phase 1, the Advisory Committee consisted of the following:

Mr. Eric Haley, Chairman, Riverside
Dr. Robert Zweig, Vice Chairman, Riverside
Mr. Arden Anderson, Riverside
Dr. Meir Carasso, Sacramento
Dr. Paul Cho, Washington, D. C.
Mr. Paul Dickinson, Oakland
Mr. Lester G. Heustis, Riverside
Mrs. Donald L. Morrow, Riverside
Mr. Herb Rogers, Riverside
Mr. Everett Ross, Riverside
Mr. I. O. Sewell, Washington, D. C.

In the latter part of the Phase 1 Program, the Advisory Committee recommended infrared aerial photographs be taken of Riverside. Since this activity was not within the scope of this program, DOE funded and contracted with a specialized firm for the work. These photos are to be used by Riverside's Public Utilities Department, the Riverside Chamber of Commerce, and the Southern California Gas Company in Riverside for a public energy awareness program.

The excellent cooperation received from all the Riverside contacts demonstrated the high degree of local interest in this Program and should contribute significantly to assuring the ability of the community to carry out the recommendations of this report.

DESCRIPTION OF DETAILED METHODOLOGY

Figure A-2 shows the elements in the methodology developed specifically for the Riverside Phase 1 Program.

Baseline Information

Baseline information was developed on the Riverside Community in relation to the current energy situation, existing supply systems, and conservation programs. This information was necessary so that in subsequent analyses, as energy conservation and alternative energy supplies were considered, appropriate technologies, programs, and incentives might be properly integrated with existing supply systems and programs to provide balanced site-specific alternative energy strategies. Specifically, baseline information was developed for the following categories:

- Geographic Location, Subdivisions, and Development Patterns
- Weather Conditions - local climate
- Historical and Current Energy Use - by fuel type and end uses, segregated by city census tracts
- Stationary Energy Consumers - residential, commerical, and industrial
- Current Energy Conservation Activities - buildings, community design, and industry
- Indigenous Alternative Energy Resources
- Transportation - characterization of vehicle population and available options
- Legal/Institutional Environment - a description of public sector institutions which most directly impact energy development in Riverside
- Environmental Quality - historical, current, and future trends
- Energy Conservation Education.

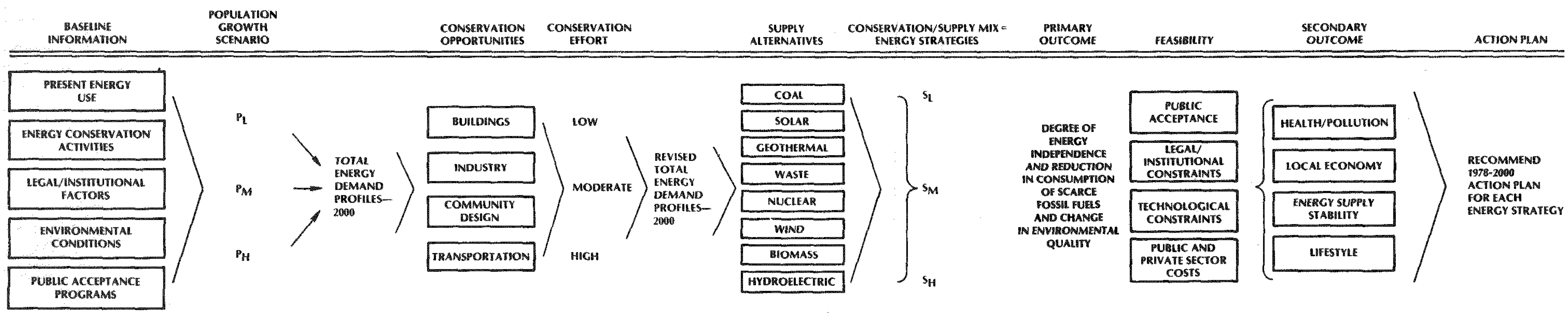


FIGURE A-2. INTEGRATION PROCESS IN THE DEVELOPMENT OF AN INTEGRATED COMMUNITY ENERGY PLAN

All of the site-specific information was obtained through a series of individual task directives to the assigned Battelle research staff. They, in turn, met with selected representatives of the City, business, and industry, as well as planners, architects, builders, and educators, to obtain the information.

Details of each of these reports are given in Appendices B, C, D, E, F, and G.

PROJECTION OF TOTAL ENERGY DEMAND

Three population growth scenarios (low, moderate, high) were developed for Riverside. These forecasts were derived from historical trends in birth, death, and migration rates, modified by estimates of the growth management planning and policies of Riverside.

Total energy demand was then projected to the year 2000 assuming a business-as-usual environment in Riverside for the various population growth rates. These demand projections were based on current per capita energy consumption; the distribution of energy consumption between residential, commercial, and industrial consumers and other end uses of energy; and building inventory projections. The projection also assumed that fuel availability would remain essentially unchanged, that the current spatial patterns of energy usage would remain constant, and that there would be no significant changes in lifestyle. 1976 consumption data were used as the base.

Candidate Conservation and Supply Options

Candidate conservation and alternative energy supply options applicable to Riverside were identified based upon a review of current technical literature and interviews and discussions with appropriate individuals. Conservation options were identified in the categories of buildings, community design, industry, and transportation.

The options listed included only those over which the City of Riverside could have direct control. For instance, development of a large-scale oil industry or large coal gasification/liquefaction plant at the nationwide level was not considered a part of this study. Larger global issues (i.e., an oil embargo imposed by Middle Eastern countries, nationwide gasoline rationing, war, a national regional four-day work week) were not considered in any detail in this study because they were outside the control of the City of Riverside. Also, in identifying these options, it was assumed that the City would continue to be in the utilities business although it was recognized that it is capable of managing or participating in the management of either centralized or decentralized energy production systems. In addition, this study did not include a detailed investigation of various options available to Riverside for purchasing options with utilities nor does it include analysis of energy supply options for the utilities themselves. For instance, this study did not address whether Southern California Edison should build nuclear, coal-fired, or other types of nonscarce fuel-based power plants or whether Southern California Gas Company should construct large coal-based synthetic gas plants.

Screening of Options

To initiate screening of the candidate options, all of the options were listed in a matrix with the evaluation criteria. Each option was then judged in relation to each evaluation factor and a set of inputs/effects scaled to range from 0 to 10--with 0 being the worst and 10, the best.

Candidate Options	Selected Evaluation Factors			Total Score	Rank	Category
	XXXX	XXXX	XXX	X	X	X
A						
B						
C						
.						
.						
.						

In conducting the analysis, scores, relative rankings, and categories were developed for each option.

It should be emphasized that the options were ranked and selected based upon a set of criteria and not upon whether one option was more energy conserving than another or whether one option was more cost effective than another. Also, only the relative ranking of the option was important (i.e., whether it was in the top, middle, or lower third) and not whether one option immediately preceded or followed another.

EVALUATION OF SELECTED OPTIONS

The conservation and alternative energy supply options are evaluated in terms of primary and secondary outcomes as well as feasibility of implementation.

Primary Outcomes

Primary outcomes cover the effect of conservation and alternative energy options on both total energy demand and environmental quality and are defined in this report, respectively, as:

(a) The amount of reduction in energy consumption and the amount of independence achieved through displacement of natural gas and oil

(b) The amount of reduction or increase in emissions for hydrocarbons (HC), carbon monoxide (CO), nitrogen oxides (NOx), sulfur dioxide (SO_2), and particulates.

Effect on Total Energy Demand

Estimates of energy savings were calculated for the surviving conservation options (Volume 2, Appendix C1, Attachment C1-1; Appendix C2, Attachment C2-2; Appendix C3, Attachment C3-1; Appendix C4, Attachment C4-1). Estimates of displacement of natural gas, purchased electricity, and fuel oil were also calculated for the surviving alternative supply options (Appendix D). Each of these estimates are prepared for the year 2000 based upon a low, moderate, and high impact for various population growth rates. The difference between low, moderate, and high impact varies and is the degree to which the

City might go to achieve certain savings. The savings and displacement estimates for each impact and each population growth rate were then compared with the business-as-usual projection to show the reduction in fuels used in Riverside in the year 2000. The reduced energy demand for natural gas and oil is made up from various alternative energy resources.

Effect on Environmental Quality

In this evaluation emission factors were selected for hydrocarbons, carbon monoxide, nitrogen oxides, sulfur dioxide, and particulates, by fuel type and end use. Estimates of decrease or increase in emissions were then calculated for the surviving conservation and alternative energy supply options by multiplying the emission factors times the energy savings. Each of these estimates are prepared for the year 2000 based upon a low, moderate, and high impact energy savings and for the low, moderate, and high population growth rates.

Secondary Outcomes

The implementation of an alternative energy strategy will generate numerous secondary outcomes, or impacts, which must be incorporated into the decision-making process. These, such as the impact on residential privacy or lifestyle, are subtle and must be evaluated at a qualitative level only. The secondary outcomes evaluated in this study included the local economy, energy supply stability, and lifestyle.

Modification of the Riverside energy demand profile and supply system will have numerous economic repercussions throughout the local economy. These were defined to include among others:

- Increased activity in the construction industry and demand for construction workers
- Attraction of new industries that seek stable, environmentally acceptable energy supplies
- Adjustment in the City's General Plan to provide for more energy-efficient neighborhoods, housing, and transportation, and the associated fiscal impacts of implementing such recommendations
- Local budgetary impacts associated with investments in, or management of, alternative fuel systems.

An important secondary outcome of switching to alternative energy resources is the impact on energy supply stability. Energy supply stability can be defined in numerous ways; in the present context, it refers to the ability of energy resources and their associated systems to dependably supply the energy needs of the end-use sector both in the long and short run. In the long run, the stability of alternative resources such as solar, geothermal, wind, coal, and wastes is well established. These resources will be available for our use in the foreseeable future, whereas natural gas and petroleum reserves are much more limited. However, short term stability, i.e., dependably supplying energy on a day-to-day basis, is a different concept. Because many alternative energy resources would be implemented and operated at the community level, the community will assume more responsibility and exercise more direct control in satisfying its own energy needs on a day-to-day basis. System backup and redundancy become important considerations in determining how the community relies on its own resources and what kind of relationship the community maintains with outside utilities. Addressed were the issues involved in both the long- and short-term energy supply stability picture relative to alternative energy resources.

Departures from the existing pattern of energy supply and demand within Riverside will result in some alteration of existing lifestyles. A solar-based zoning ordinance might place restrictions on the orientation of structures, which, in turn may impact the traditional concepts of privacy. Similarly, other new design requirements such as thermal efficiency standards may affect the range of options available to the local builder and home buyer. On the other hand there may be benefits such as increased comfort due to the building retrofit program or a more leisurely environment in the case of the planned neighborhood development program. Other lifestyle adjustments may be necessary as a result of modifications in the energy supply system. To be cost effective, for example, the implementation of a waste-to-energy system may require shifts in the location and/or frequency of solid waste collection and disposal. Energy generated from such a system will require a physical plant and distribution system to which some Riverside residents may object on aesthetic grounds. These are a few of the many types of lifestyle impacts associated with the various energy strategies that were considered in the analyses of alternative strategies.

Feasibility

Also, to arrive at a realistic alternative energy strategy, the feasibility of implementing each option was evaluated in terms of public acceptance, legal/institutional constraints, technological availability, and public and private sector costs.

Public acceptance and human behavioral aspects are a crucial consideration in the development of an integrated community energy plan. Without due attention to the human element in the process of planning and implementing strategies, technological and economic analyses are incomplete. Thus, in evaluating the feasibility of various energy options, the research team incorporated existing levels of public awareness and probable acceptance of energy-related policy changes and, furthermore, the potential of new public education programs for disseminating information and modifying attitudes toward supply and conservation innovations developed in earlier sections of this study. Findings were borrowed from previous research pursuits, including among others, that public receptiveness is maximized with (1) energy policies that reward conservation rather than penalize consumption and (2) policies that are developed as remotely as possible, or "upstream" from the consuming public.

Alternative energy strategies invariably require innovative and frequently untested legal/institutional arrangements for successful implementation. This is particularly true in the case of Riverside because of its committment to diversification of its energy supply system and to the implementation of a variety of innovative conservation activities. Some of the many legal/institutional issues which were raised and examined included.

- Feasible financing, ownership and operational arrangements for developing a small-scale waste-to-energy system
- Legal/political constraints on contractual arrangements between Riverside and neighboring municipalities in financing alternative energy systems
- The legal constraints at the municipal level to the adoption of tax incentives for the installation of solar systems in r sidences

- Legal uncertainties concerning the infringement of individual property rights associated with a solar-based zoning ordinance
- Conformance of proposed building and/or zoning regulations with existing state legislation.

Each consideration and alternate energy supply option was evaluated in view of these criteria in order to narrow the set of recommended options to those most feasible for implementation.

The objective of investigating technological constraints was to identify those options where significant additional research and development are required and to estimate the time and technological improvements necessary before implementation. The state of technology of the various conservation and supply options will have direct bearing on their feasibility of implementation. For instance, some options, such as photovoltaics and fuel cells, will require some research and development before commercialization. However, other portions, such as flat-plate solar collectors or passive solar design techniques, are commercially available and, therefore, do not require additional research prior to implementation although some further cost and feasibility analysis may be required.

The public and private sector costs of the various conservation and supply options identified were evaluated to estimate their impact on the feasibility of implementation. For instance, California has recently enacted a 55 percent tax rebate on solar heating systems to stimulate their use. Despite the benefits of solar energy, e.g., nonpolluting and nonreliance on scarce fuels, a subsidy or other type of incentive is required to overcome the high capital outlay required of the homeowner in the installation of an active solar system and the dubious cost effectiveness of active solar heating systems compared to conventional natural gas heating systems. The need for such a stimulus impedes the feasibility of implementation. However, active solar heating systems can be implemented on a small scale, in piecemeal fashion, which enhances the feasibility of implementation. On the other hand, large projects, e.g., mass transit systems and central conversion facilities making synthetic fuels from refuse and coal, require substantial blocks of investment capital which may not be readily obtainable.

Selection of Alternative Energy Strategies

Because quantitative analyses had already been performed on each selected option to estimate the primary outcome (energy savings or displacement) and their impact on environmental quality, the initial effort was to compare the options with those evaluation factors for which only qualitative information were available. As a result the evaluation factors considered at this time included local economic impact, energy supply stability, lifestyle, public acceptance, legal/institutional, technology availability, and public/private sector costs. This qualitative comparison was performed using a methodology similar to that used in the screening analysis. All of the building, community design, industry and transportation conservation options, as well as the alternative energy supply options, were listed in a matrix with the evaluation criteria. Each option was then judged in relation to each evaluation factor and a set of evaluation impacts/effects scaled to range from 10 to 0.

A total value considering all the criteria was developed for each option. These values were then compared with the estimated energy savings and the estimated impact on the quality of the environment determined for a low, moderate, and high population growth rate. As a part of this comparative analysis, conservation and supply options having the same relative ranking were then clustered and became the basis for the recommended alternate energy strategies.

Action Plan

Finally, the study methodology involved the development of an action plan. The plan consisted of a time schedule for implementation of a mix of conservation and supply initiatives for the years 1978-2000 for three alternative energy strategies--A (minimum), B (moderate), and C (maximum). The plan is intended to provide Riverside policymakers with guidance that may be used to select among the alternative energy strategies presented.

In some cases, many initiatives may be undertaken by the City in the immediate future. In other cases, technological, economic, and other constraints may delay implementation of some recommendations for at least a decade. The latter may be due to the need for further technological development or feasibility analyses, demonstration, planning, and construction.

APPENDIX B

CHARACTERIZATION OF ENERGY CONSUMPTION AND NEEDS OF THE COMMUNITY OF RIVERSIDE, CALIFORNIA

TABLE OF CONTENTS

LIST OF TABLES

TABLE OF CONTENTS (Continued)

LIST OF TABLES (Continued)

LIST OF FIGURES

APPENDIX B

CHARACTERIZATION OF ENERGY CONSUMPTION AND NEEDS OF THE COMMUNITY OF RIVERSIDE, CALIFORNIA

INTRODUCTION

The primary purpose of this task was to establish, by means of figures and tabulations, the energy consumption patterns of the Riverside community in detail sufficient to provide the information required by the other tasks of this project. The secondary purpose was the development of a general methodology for establishing the energy consumption patterns of any given community.

The results section which follows deals strictly with the information regarding the characterization of energy consumption in Riverside. Each figure and table presented in the results section is discussed in regard to its informational content and with reference to the need for such information in the subsequent tasks.

Throughout the results section, the numbers in parenthesis (e.g., (7)) refer the reader to a series of notes at the end of this appendix where the sources of data used in developing the results are cited, and where the methods of analysis are discussed when appropriate.

The sources of data used in characterizing the energy consumption in Riverside were extensive. The generic types of data that established these patterns are tabulated below.

Community Energy Characterization Data Requirements

Energy Related	Nonenergy Related
Annual Consumptions	Census Bureau Data
Consumer Categories	Community Demographics
Daily Profiles	Consumer Locations
Monthly Consumptions	Population Projections
Utility Projections	Weather Data

These types of data, in conjunction with the methodology discussed in the notes, allowed for the development of the results presented below.

RESULTS

For the sake of clarity, the results presented herein were kept separate from the methodology, which is discussed in notes at the end of this appendix. The results are presented in the following order:

1. Background information orienting the reader to the physical aspects of Riverside--location, population, and weather conditions

2. A review of the historical consumption patterns of the community to provide a perspective on the growth that Riverside has experienced in its energy consumption

3. An analysis of the current trends in the energy consumption patterns of the community to establish the energy characteristics within the designated subcommunities of Riverside

4. Projections of what the future energy needs of the community are expected to be, in order to assess the required performance characteristics of the selected alternative energy systems.

1. Background Information

Geographic Location

Figure B-1 shows the location of Riverside in Southern California. The City is located 53 miles east of Los Angeles and covers an area of 72.4 square miles, an area greater than that of either San Francisco or Manhattan Island.(1)

Figure B-2 is a close-up of the city itself. The heavy lines delineate the subcommunity boundaries, the names of which appear on the map. The finer lines within the subcommunities outline the census tracts within the City (2). Some subcommunities contain many census tracts, such as Arlanza-La Sierra, while others constitute a single census tract, such as Mountain View. It was found that the census tract subdivisions within the community of Riverside provided for a reasonable distribution of the energy analysis to subsections of the community. The census tracts, therefore, were convenient building blocks with which to establish the energy consumption patterns of Riverside as a whole, as well as establishing the distribution of the energy consumption patterns within the community. Additional subdivisions of the energy consumption were obtained by separating each census tract into the three consuming sectors: residential, commercial, and industrial.

Population

The current population of Riverside is approximately 165,000. The exact figure is not available, although each of the interested parties within Riverside and the State of California have made their own projections.

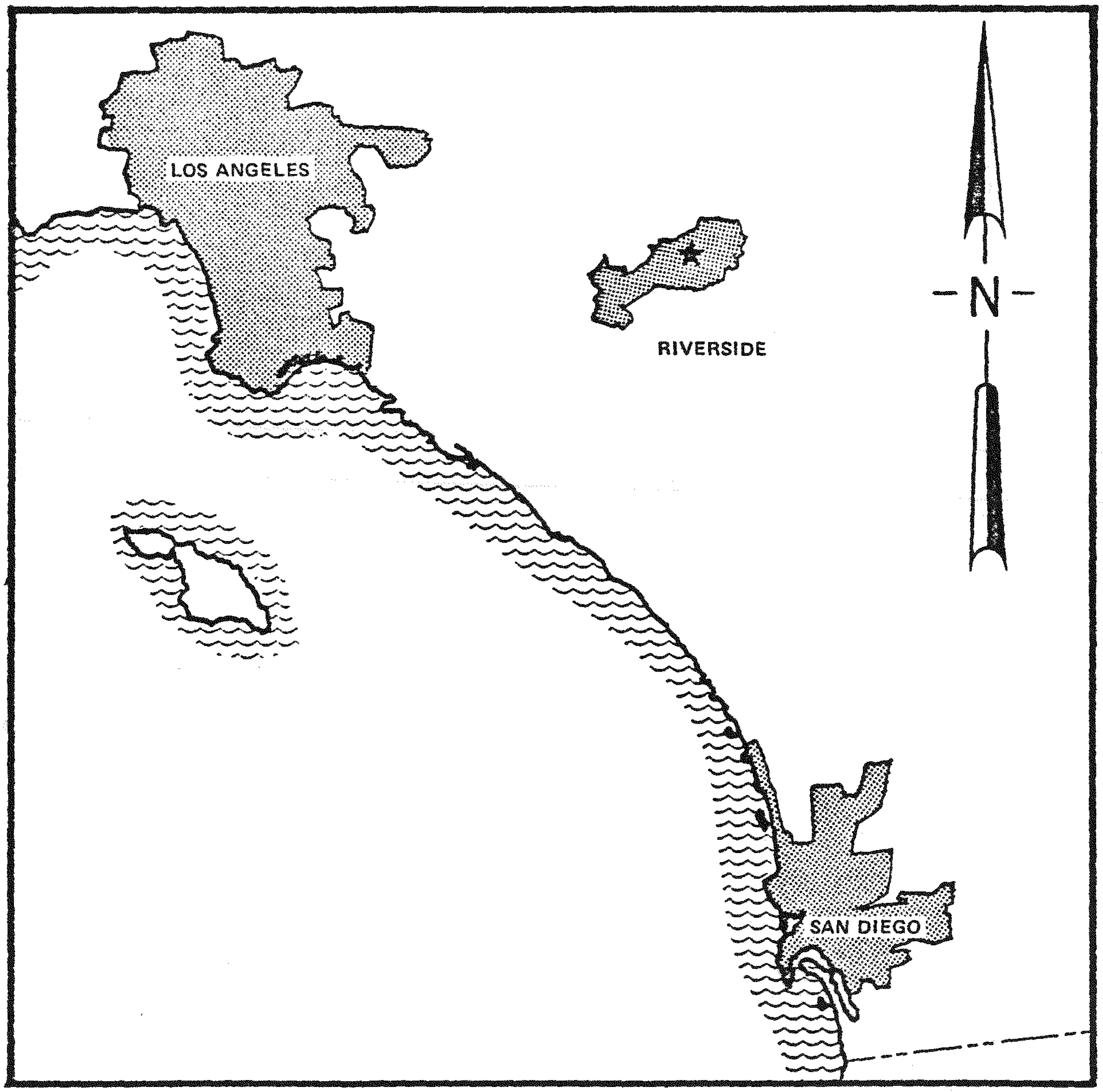


FIGURE B-1. MAP OF SOUTHERN CALIFORNIA

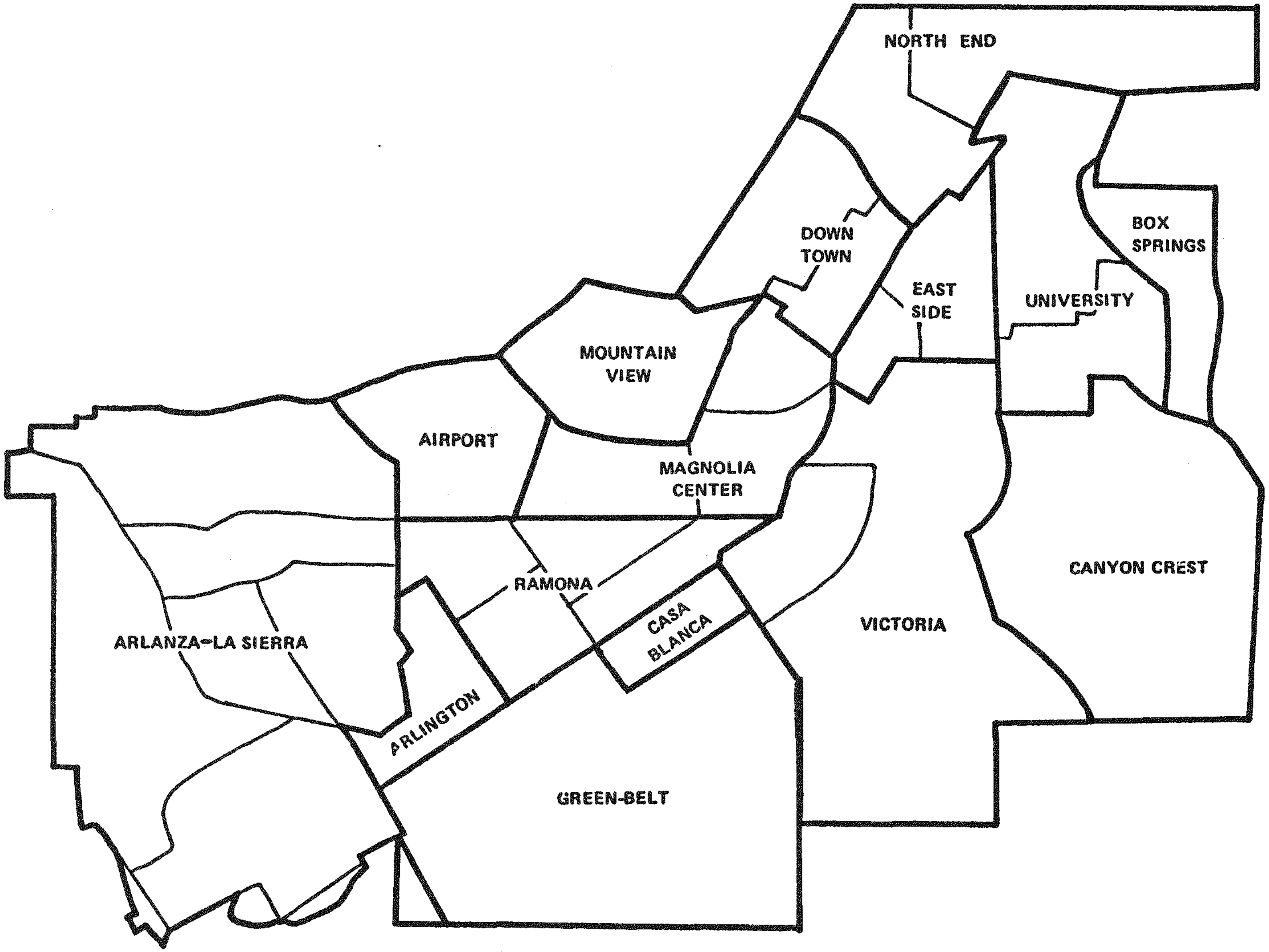


FIGURE B-2. RIVERSIDE CALIFORNIA--SUBCOMMUNITIES

Figure B-3 presents six population estimates and two projections to the year 1990. (3,4,5,6,7) The energy projections that are presented in a later part of this section are based on such future population projections.

Weather Conditions

The local climate of a region is one of the major contributing factors to the patterns of energy consumption. Space conditioning requirements, heating and cooling, are normally the largest contributing factors to energy consumption in each of the consuming sectors: residential, commercial, and industrial.

There are two National Oceanic and Atmospheric Administration (NOAA) reporting stations in Riverside:

WEATHER STATION	INDEX NUMBER	DIV.	LAT.	LONG.	ELEV.
Riverside Fire Sta. #3	7470	06	33°57'	117°23'	840
Riverside Cit. Exp. Sta. Ra.	7473	06	33°58'	117°21'	986

Both of these are cooperative reporting stations working in conjunction with NOAA. The reports from these stations, together with the ASHRAE design values (8) for Riverside, establish the pertinent weather design conditions.

Table B-1 presents the energy-related weather parameters for Riverside. (8,9,10,11) The Design Temperatures were established by the American Society of Heating, Refrigeration and Air Conditioning Engineers according to the long-term climatic conditions that have been experienced in Riverside. These are the extremes over which any heating and cooling system should be designed to operate. Degree Days are a measure of the amount of heating or cooling which is required; they are defined as the difference between the average daily temperature (TAVE) and a base temperature of 65 F:

Heating Degree Days = (65 - Tave) if Tave < 65

Cooling Degree Days = (Tave - 65) if Tave > 65.

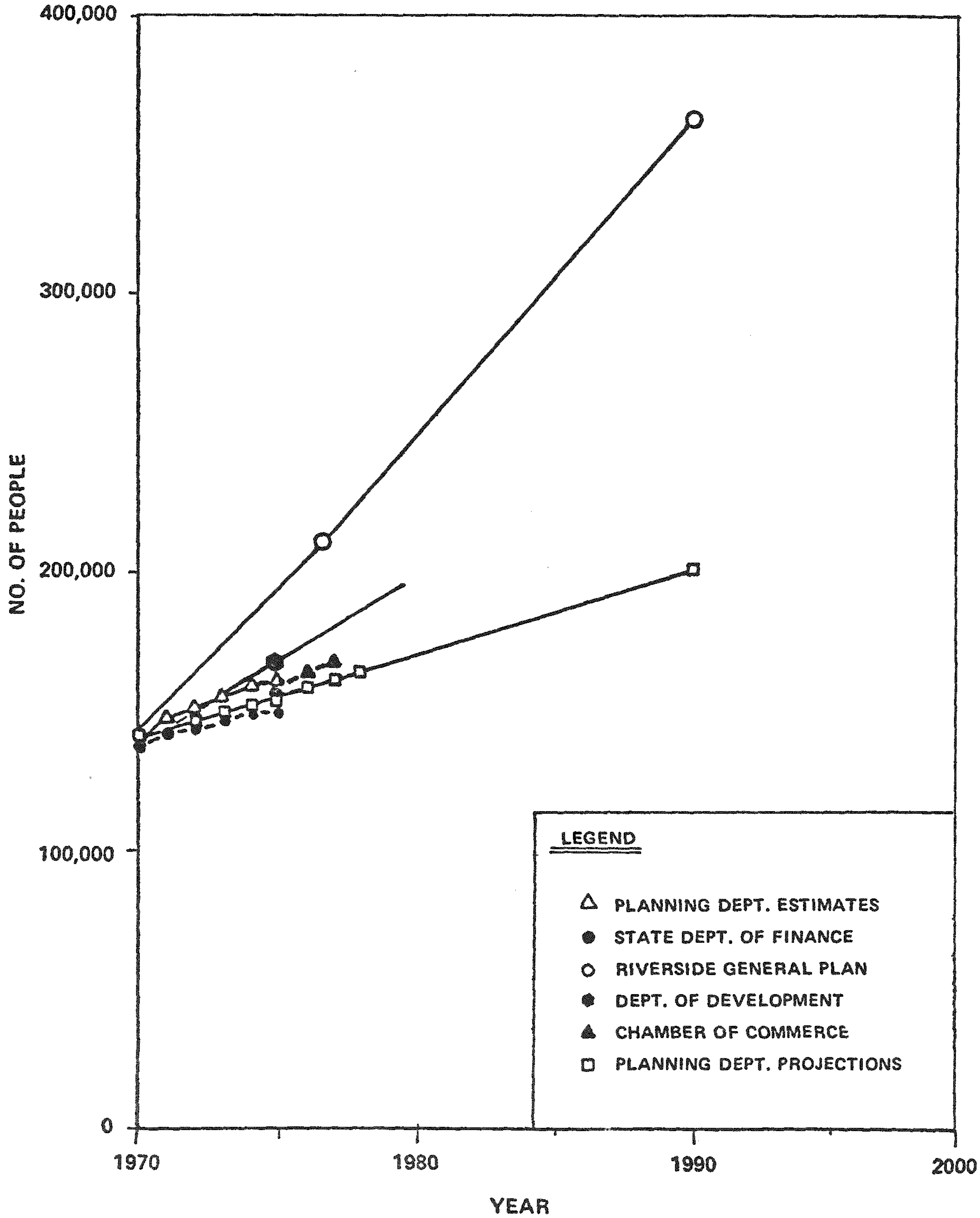


FIGURE B-3. ANNUAL POPULATION GROWTH AND PROJECTIONS

TABLE B-1. WEATHER CONDITIONS--RIVERSIDE, CALIFORNIA

Winter Design Temperature	34 F
Summer Design Temperatures	
Dry Bulb	96 F
Wet Bulb	71 F
Annual Heating Degree Days	1920 F-Day
Annual Cooling Degree Days	1590 F-Day

Month	Percentage of Annual Degree Days: Heating	Percentage of Annual Degree Days: Cooling
January	28	0
February	25	0
March	22	0
April	0	0
May	0	5
June	0	13
July	0	27
August	0	27
September	0	20
October	0	8
November	0	0
December	25	0

Table B-2 lists a representative sample of the monthly conditions in Riverside.(7)

TABLE B-2. CLIMATE--RIVERSIDE, CALIFORNIA

	AVERAGE TEMPERATURE, F			RAIN	HUMIDITY		
Period	Min.	Mean	Max.	Inches	4 A.M.	Noon	4 P.M.
January	37.0	51.0	65.2	1.70	55	40	55
April	45.7	60.5	75.2	.91	60	30	50
July	57.0	75.5	93.9	.01	45	40	35
October	48.4	65.8	83.1	.60	50	30	40
Year	46.8	62.9	79.0	11.96	52	37	45

PREVAILING WINDS
NW
Mean Hourly Speed:
10-12 m.p.h.
SOURCE:
National Weather Service

2. Historical Consumption Patterns

In order to establish the energy consumption pattern of Riverside, analyses were made of the historical energy consumption in the community in regard to: annual consumption, monthly and seasonal consumption, and peak hourly demands for energy.

Sources of Energy

The census data (12) indicated that over 98 percent of the major energy-consuming appliances in the residential sector (exclusive of transportation) use electricity or natural gas. The remaining two percent use sources such as bottled gas, heating oil, and wood. The commercial and industrial sectors likewise use the same two energy sources as their primary fuels. The natural gas customers who are on an interruptible contract will switch to alternative fuels (LPG or oil) when service is curtailed, but the primary fuel is natural gas. Of those industrial customers who responded to an energy survey conducted as part of this task (13) there was not any one customer whose propane or fuel oil consumption exceeded 1 percent of their natural gas consumption, on a Btu basis.

Table B-3 reports the distribution of energy sources within each of the following residential consumption categories: space heating, water heating, and cooling.

No electric generation takes place within the City limits of Riverside. The City's Public Utility's Department (PUD) purchases electricity from Southern California Edison Company (SCEC) and resells it to the customers in the City. Therefore, no attempt was made in this Appendix to convert the electricity consumed in Riverside to the primary energy units consumed by SCEC in converting oil, natural gas, hydropower, or nuclear energy to electricity. Each kilowatt-hour of electrical energy consumed in Riverside amounts to 3,413 BTU's of energy.

TABLE B-3. RESIDENTIAL FUELS FOR RIVERSIDE (1970 CENSUS)

	Percentage of Dwelling Units		
Fuel	Space Heating	Water Heating	Cooling
Natural Gas	92.8	94.8	71.7
Electricity	5.2	3.9	27.2
Bottled Gas	1.0	1.0	0.7
Oil	0.5	0.1	0.1
Wood	0.3	0.0	0.1
None	0.2	0.2	0.2
TOTAL	100.0	100.0	100.0

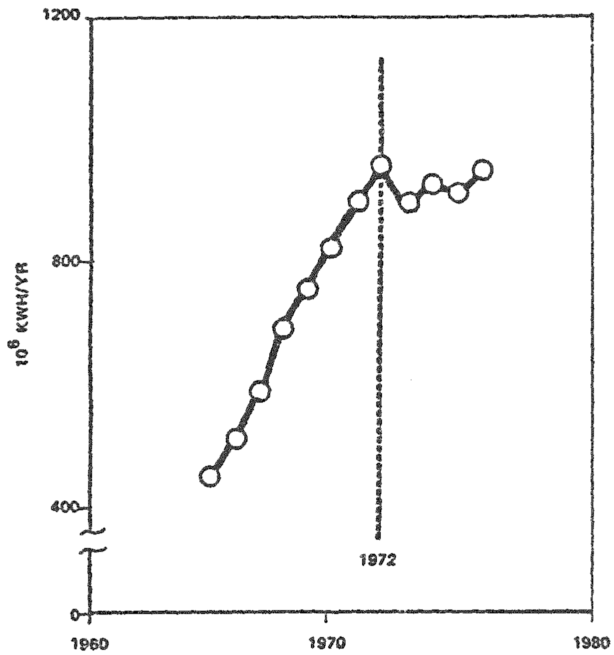
Electricity and natural gas comprise such an overwhelming percentage of Riverside's total energy consumption (exclusive of transportation) that the results presented below for the energy consumption patterns of the two main sources of energy provide a great deal of information regarding the energy consumption characteristics of this community.

Annual Consumption

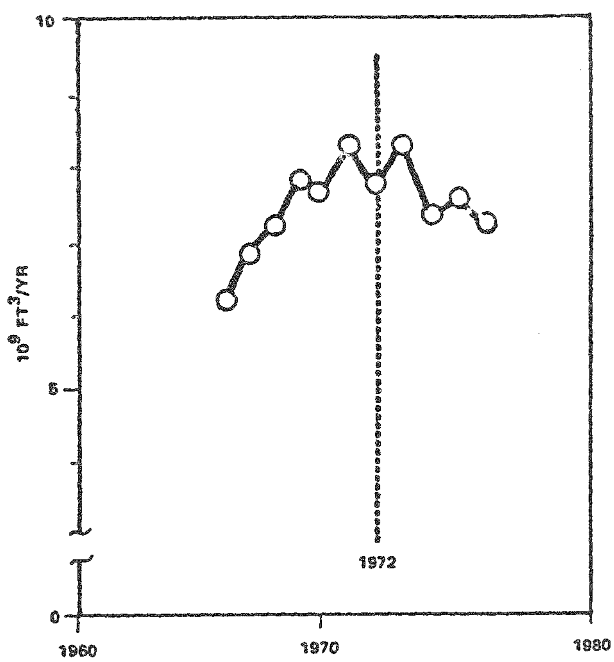
Figure B-4 presents the annual growth in energy consumption in Riverside for both electricity and natural gas. (14,15,16)

During the period from 1968 to 1972, electrical energy consumption was growing at a rate of 8.2 percent per year. After 1972, growth in electrical consumption was drastically altered, so much so that the consumption through 1976 has yet to surpass the record 1972 consumption of 936×10^6 kwhr.

Growth in natural gas consumption, although not as dramatic as the electrical consumption growth prior to 1972, was more drastically altered during the years following 1972. During the years from 1968 to 1971,



A. ELECTRICITY



B. NATURAL GAS

FIGURE B-4. ANNUAL GROWTH IN ENERGY CONSUMPTION natural gas consumption was growing at a rate of 4 percent per year. The tabulation below shows the effects of weather on the annual consumption of natural gas. The dip that occurred in 1972 was primarily due to the abnormally warm winter that occurred during that year as tabulated below.

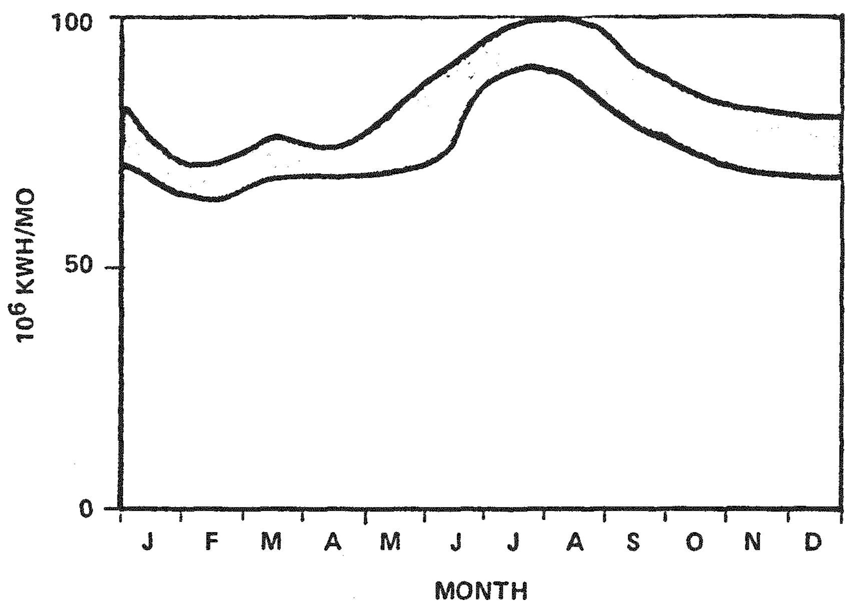
	1972	1973	Normal
Heating Degree Days, F-Day	1,685	2,003	1,920
Natural Gas Consumption, 10^6 cu ft	7.7	8.2	----

In 1972, the number of heating degree days was 16 percent less than that in 1973, while consumption was 6 percent less. Space heating requirements constitute roughly 40 percent of all natural gas consumption. Therefore, adjusting the 1972 space heating consumption to 1973 heating degree day levels results in an adjusted 1972 consumption of $.6(7.7) + .4(7.7) \times (2003/1685) = 8.3 \times 10^6$ cu ft. Thus the dip that occurred in 1972 may be attributable primarily to the warm winter during that year. The consumption patterns following 1972 however, cannot be attributed to the weather since near normal conditions existed through 1975.

The relative impact of the energy crisis, in conjunction with the economic recession in the years following 1972, on energy consumption in Riverside is impressive. However, more detailed information was required since annual consumption was too gross a measure of energy consumption for the alternative energy system analysis.

Monthly Consumption

Figure B-5 represents the monthly variations in electrical and natural gas consumption for all of the consuming sectors within Riverside: residential, commercial, industrial, and other. The band in each figure bounds all of the data points that were plotted. These represent all of the years following 1972. As observed from the annual consumption figures, this was the time period over which energy consumption remained relatively constant on an annual basis. Variations.



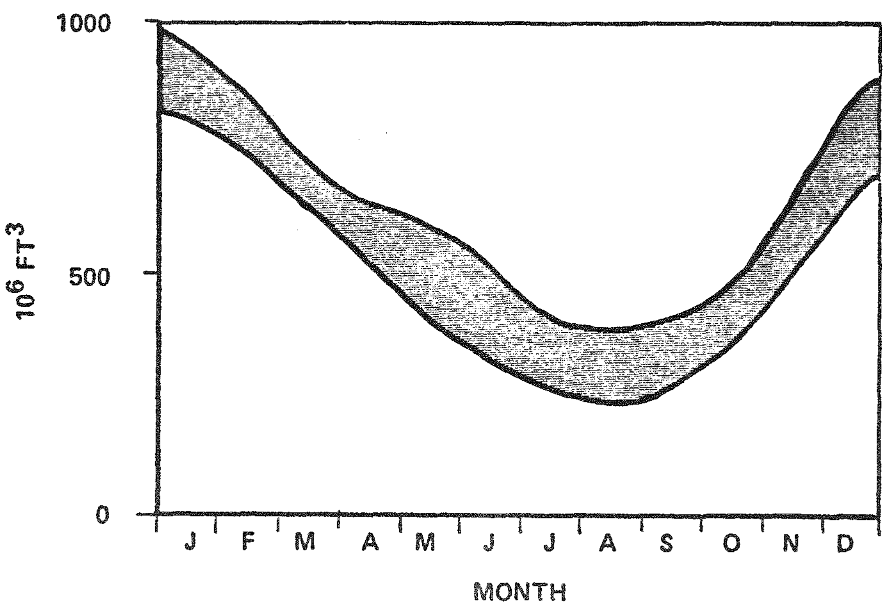


FIGURE B-5. MONTHLY VARIATIONS IN ENERGY CONSUMPTION between individual months due to the weather, billing schedules, production schedules and other factors are responsible for the width of the bands that appear on these figures. The variation over the course of the year is primarily a weather-dependent phenomena.

Figure B-6 resents an analytic representation of the relationship between energy consumption and the weather. This figure represents a least squares linear regression analysis applied to residential natural gas consumption, where consumption is assumed to be a linear function of the number of heating degree days per month. The Y-axis intercept (at zero degree days) represents the component of consumption, the base consumption, that is independent of the weather parameter; the slope of the line represents space heating, the weather-sensitive component of gas consumption. Such an analysis has been found to provide excellent correlations for communities where the billing periods, for which consumption is known, correspond exactly with the calendar months, for which degree day data are known. The resulting equations were used to normalize energy consumption for a standard weather year.

The Riverside consumption data were reported on a City-wide basis, and the schedules of the billing periods were not available. This is the primary reason for the scatter in the data points in the least-square analysis.

Tables B-4 and B-5 present the correlation coefficients that resulted from applying the least-squares, degree-day analysis to the 1976 electric power and natural gas consumption of each of the consuming sectors in Riverside. Cooling degree days were used to correlate electric power consumption, whereas heating degree days were used to correlate natural gas consumption. The standard deviation of each coefficient is also provided in order to establish the accuracy of these correlations. The residential correlations are the strongest, and the industrial correlations are the weakest. Reference (9) provides the degree-day data that the correlation equations required. The regression equations provide the means for calculating the normalized 1976 energy consumption. That is, the consumption per month that would have been observed in 1976 had the month contained the average number of degree days. The normalized energy

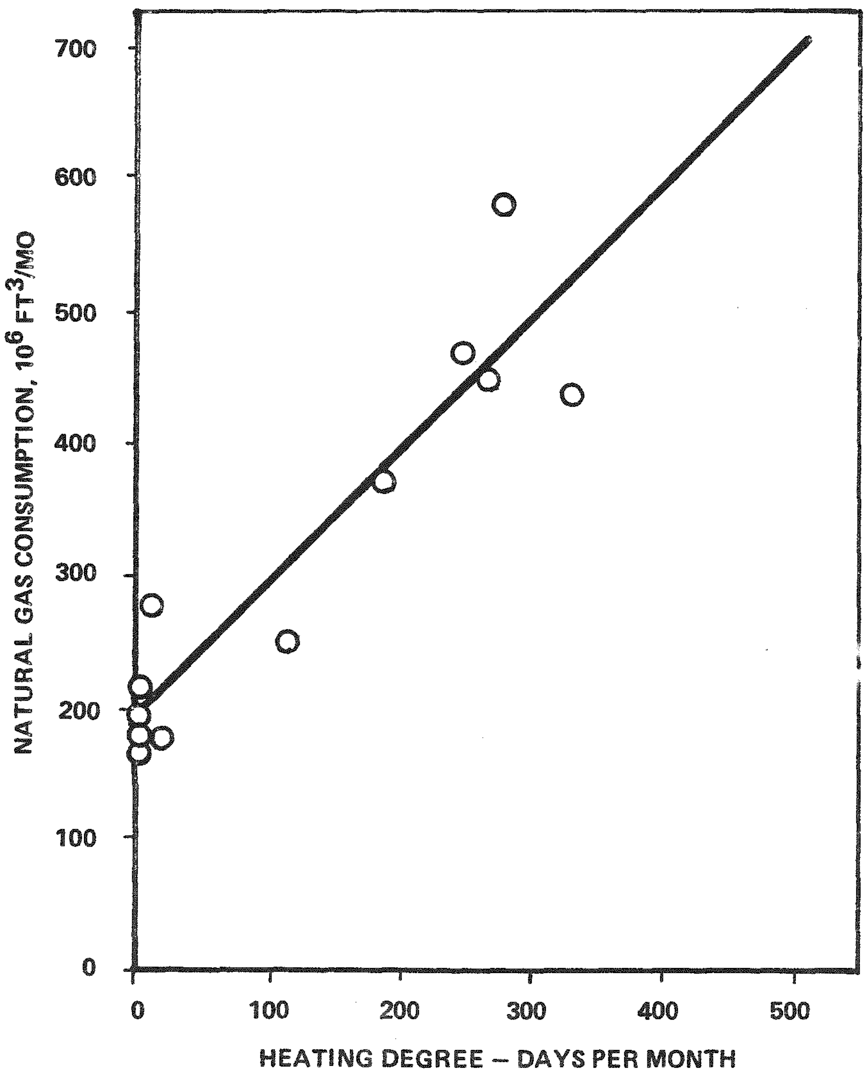


FIGURE B-6. RESIDENTIAL NATURAL GAS CONSUMPTION

TABLE B-4. LEAST-SQUARES CORRELATION COEFFICIENTS FOR ELECTRICAL ENERGY CONSUMPTION IN RIVERSIDE

Consumer	A ± σ		B ± σ	
Residential	19.0	1.5	0.054	0.009
Commercial	29.9	0.9	0.020	0.005
Industrial	8.3	0.3	0.002	0.001

$$\left\{\begin{array}{l}\text{Monthly}\\ \text{Electrical}\\ \text{Consumption}\\ \dfrac{10^6\ \text{kwh}}{\text{mo}}\end{array}\right\} = A + B \times \left\{\begin{array}{l}\text{Number of COOLING}\\ \text{Degree Days per}\\ \text{Month}\\ \text{(F-day)}\end{array}\right\}$$

TABLE B-5. LEAST-SQUARES CORRELATION COEFFICIENTS FOR NATURAL GAS CONSUMPTION IN RIVERSIDE

Consumer	A ± σ		B ± σ	
Residential	174.0	20.1	1.00	0.13
Commercial	95.3	9.7	0.33	0.06
Industrial	95.1	6.1	0.13	0.03

$$\left\{\begin{array}{l}\text{Monthly}\\ \text{Natural Gas}\\ \text{Consumption}\\ \dfrac{10^9\ \text{Btu}}{\text{mo}}\end{array}\right\} = A + B \times \left\{\begin{array}{l}\text{Number of HEATING}\\ \text{Degree Days per}\\ \text{month}\\ \text{(F-day)}\end{array}\right\}$$

σ = The standard deviation of the associated regression coefficient.

consumption is necessary for the evaluation of alternative energy systems, since the energy consumption patterns that are indicated by this analysis, establish those patterns according to the climate of the region. The unique aspects of the weather patterns of a particular year are eliminated in favor of the long-term expected climatic conditions.

Having established the seasonal, or monthly, energy requirements above, the design aspects of peak energy demand requirements are discussed below.

Peak Demands

Table B-6 presents the peak demands for energy in each of the three consuming sectors in Riverside.(17) These demands represent diversified demands. Not every consumer within a consuming sector demands energy at the exact same instant; thus the observed demands are not the simple sum of each individual customer's demand.

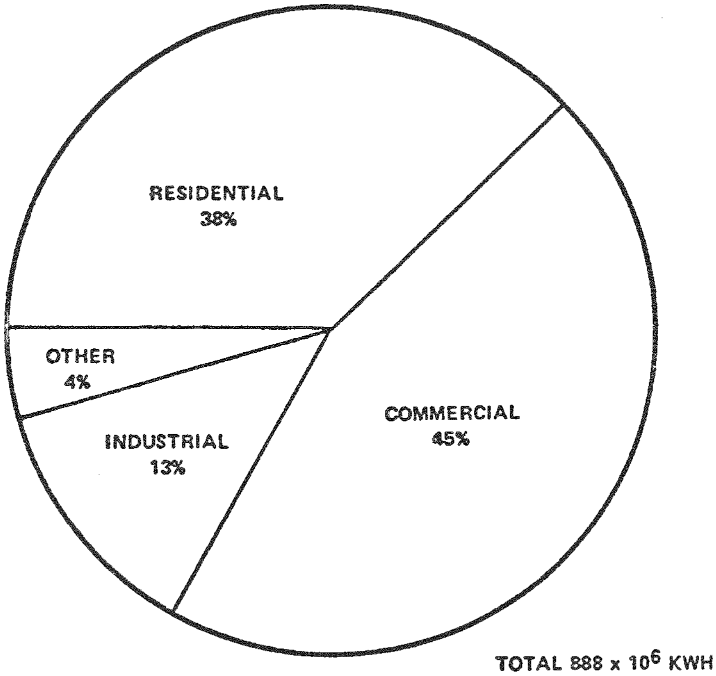
TABLE B-6. PEAK ENERGY DEMANDS (1976)

	Peak Thermal Demand, 10^6 Btuh	Peak Electrical Demand, MW
Residential Component	1320	121
Commercial Component	380	85
Industrial Component	290	44
TOTAL OBSERVED DEMAND	1990	250

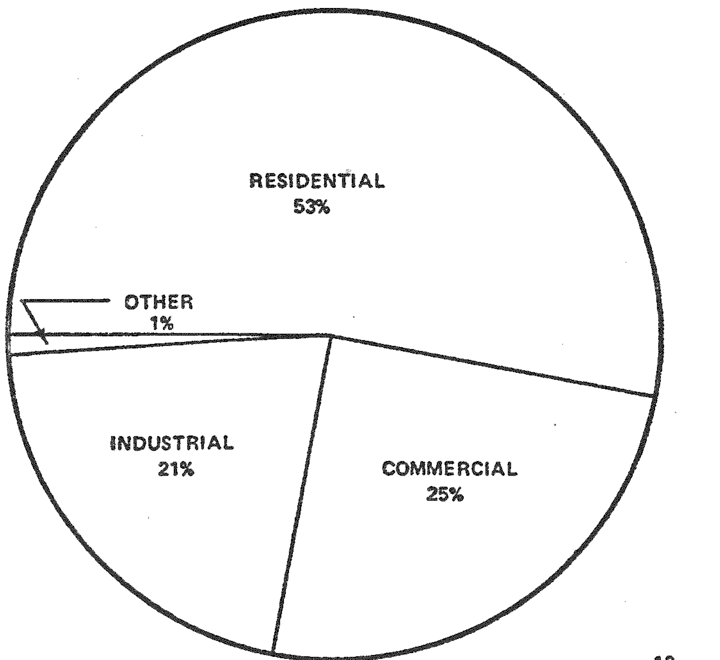
The peak demands play an important part in the sizing of alternative energy systems for a community. The system must not only be able to match the performance necessary or meet the requirements of annual and monthly consumption, but it must also be able to handle the instantaneous demands placed on it by the community. The peak demands thus aid in this aspect of sizing the alternative energy systems.

Energy Distribution

Figure B-7 presents the distribution of 1976 normalized energy consumption to each of the four consuming sectors: residential, commercial, industrial, and other.(15,16) These pie charts aid in establishing where the greatest impact of conservation measures may be felt.



A. ELECTRICITY



B. NATURAL GAS

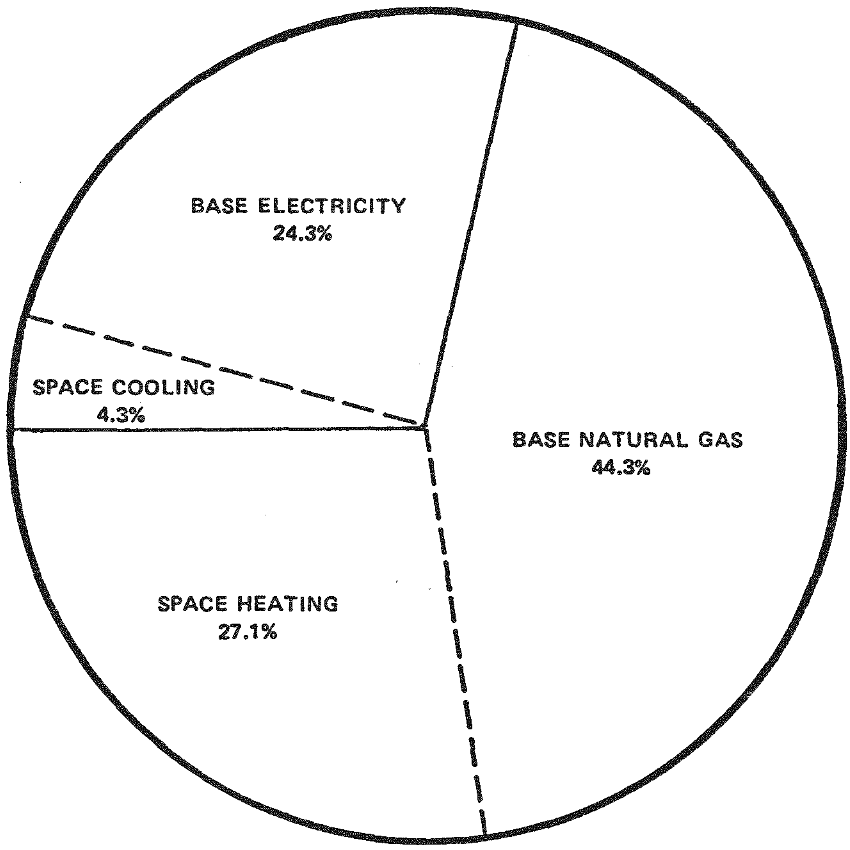
FIGURE B-7. DISTRIBUTION OF ENERGY BY CONSUMER
(1976 Normalized Consumption)

Table B-7 .further subdivides the energy consumed in each sector into its two important components: the space conditioning component that is dependent on the weather parameters as discussed under Monthly Consumption and the base load component that consists of such diverse elements as process heat, water heating, cooking, lighting, and power. Note that the space cooling load amounts to only 15 percent of the total electric power consumption. This seemingly low value is due to the fact that three-quarters of all the cooling degree days are concentrated in just three months: July, August and September. Although cooling amounts to about 40 percent of the electric power consumption in each of these three months, over the course of a year the base load in the noncooling months works to reduce the percentage of energy used for space cooling on an annual basis. Space heating, on the other hand, amounts to 38 percent of the annual consumption of natural gas and 65 percent of the natural gas consumption in each of the four heating months: December, January, February, and March.

TABLE B-7. DISTRIBUTION OF ENERGY BY END-USE
PERCENTAGE OF ANNUAL CONSUMPTION

	Electricity			Natural Gas		
Consumer Category	Space Cooling	Base	Total	Space Heating	Base	Total
Residential	9	29	38	24	29	53
Commercial	5	40	45	9	16	25
Industrial	1	12	13	5	16	21
Other	0	4	4	0	1	1
TOTAL	15	85	100	38	62	100

Figure B-8 presents a perspective on the total energy consumption in Riverside for stationary purposes (i.e., consumption exclusive of transportation). For every Btu of electrical energy that is consumed (1 kwh = 3413 Btu), 2.5 Btu of natural gas is consumed. Of the total energy consumed, 31.4 percent is consumed by space conditioning requirements, and 68.6 percent is consumed to satisfy the base load requirements.



1 ft^3 Natural Gas = 1050 Btu
1 kwh Electricity = 3413 Btu

TOTAL = 10.6 x 10^{12} Btu/yr

FIGURE B-8. TOTAL STATIONARY ENERGY CONSUMPTION (Normalized 1976)

3. Current Trends in Energy Consumption

As indicated in the preceding section, the basic sources of energy in Riverside are electricity and natural gas. However, in order to accommodate the needs of the subsequent tasks in this alternative energy study, it was necessary to take the preceding data concerning the sources of energy in Riverside and evaluate demands for the total energy requirements within the community. As such, two categories of energy demands were established:

(1) Thermal Demands, including
- Space heating
- Hot water
- Process heat
- Cooking heat

(2) Electrical Demands, including
- Space cooling
- Power
- Lighting.

Note that the electricity consumed for heating requirements is included under thermal demands, while that for space cooling requirements is included as part of the electrical demands.

The current consumption patterns in Riverside closely correspond to this classification: natural gas for most thermal requirements; electricity for lighting and power requirements. The aim of this study, however, is not only the potential reduction of energy demands through conservation, but also the displacement of scarce fuels, such as natural gas by other sources of energy. Thus, the establishment of thermal and electrical demand categories provided a rational approach to the evaluation of energy demand in Riverside, independent of limitations on the current supplies of energy. In this way, the projection of energy demands in the next section was established according to the expected growth patterns in Riverside. Subsequent tasks have then evaluated the effect of conservation measures on these projections, as well as the feasibility of displacing the scarce resources currently meeting these demands with alternative energy forms.

Energy Density Maps

It was mentioned earlier that census tracts were selected as the basic building blocks of the Riverside community. Maps of the City, subdivided into the component census tracts, were used to graphically portray the magnitude and distribution of thermal and electrical demands in Riverside. These maps were constructed by utilizing the demand information contained in the tables discussed in the Energy Matrix section below, along with measurements of the land area (square mile) of each census tract (20), resulting in energy per square mile figures, representative of the density of energy demands in a community (Btu/yr/sq mile).

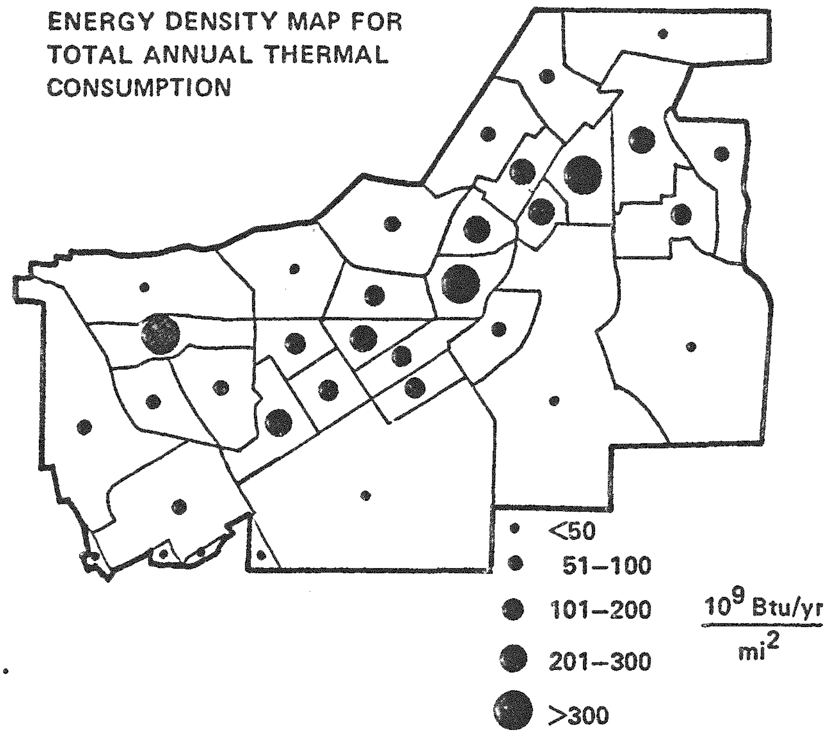
Figure B-9 presents representative energy density maps for the energy consumed by all sectors in Riverside.

Figure B-9a displays the total annual demands for thermal energy: space heating plus the base load. Such a map illustrates where the potential for applying district heating schemes to various sections of the community would be the greatest.

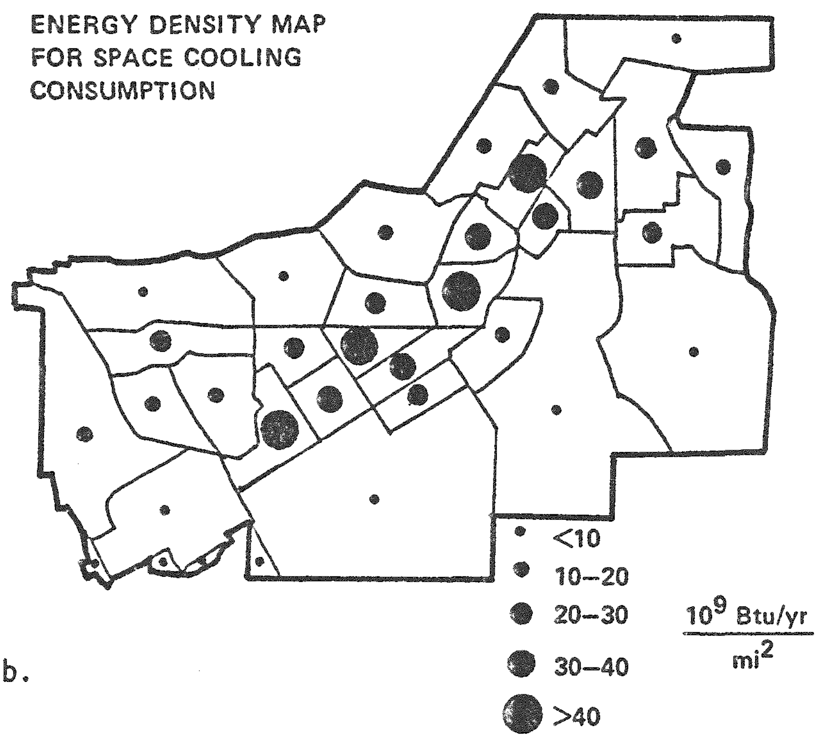
Figure B-9b displays the space cooling requirements of the community. Such a map is useful when considering district cooling in conjunction with the district heating system discussed above.

Energy Matrix

Figure B-10 presents the concept of an energy matrix. Each box within the matrix contains the consumption patterns of each consumer category in each region. The general consumer categories are:



a.



b.

FIGURE B-9. ENERGY DENSITY MAPS

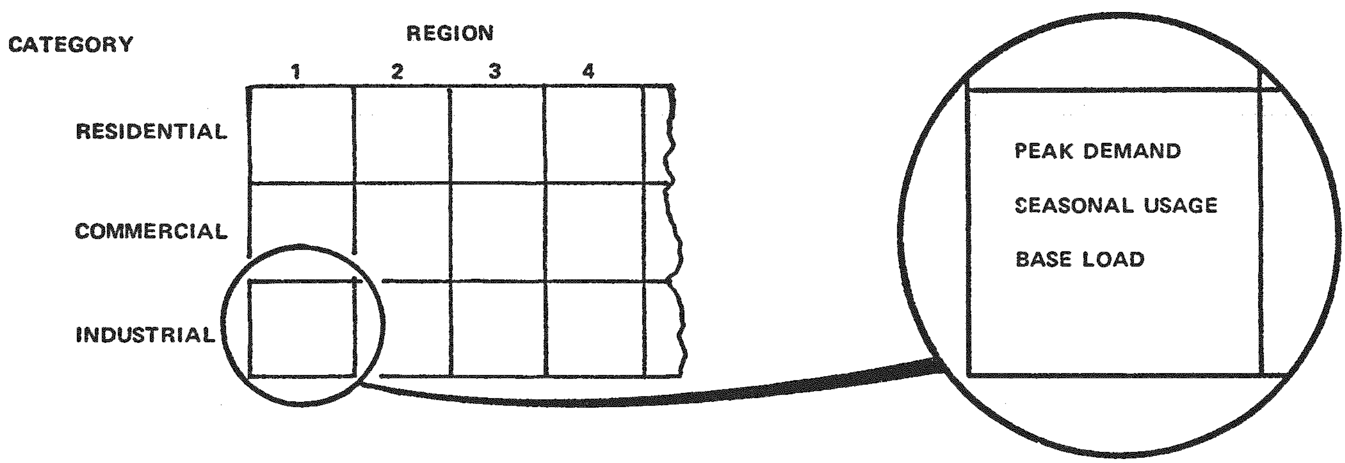


FIGURE B-10. ENERGY MATRIX CONCEPT

- Residential - dwelling units for the purpose of human habitation
- Commercial - those nonresidential customers who do not produce products as discussed under Industrial
- Industrial - those nonresidential customers who produce a salable manufactured or processed product.

The regions selected for Riverside were the 31 census tracts within the City limits.

The energy consumption patterns are established by three generic categories:

- Peak Demand - The largest instantaneous diversified demand for energy that is expected to occur
- Seasonal Usage - That component of energy consumption identified with the average space conditioning requirements, either space heating or space cooling
- Base Load - That component of energy consumption that is not directly dependent on weather parameters, such as water heating, process heat, lighting, and power.

The energy matrix establishes the required design and performance characteristics for an alternative energy system: peak demands to size the system, and seasonal and base load consumption requirements placed on the system to establish the required performance of the system.

Figure B-11 indicates the organization of the Riverside Energy Matrix. Each subcommunity is listed as a centered heading. Then the number of each census tract within the subcommunity is listed, along with the energy characteristics of the three major consuming sectors. Both the thermal and electrical energy consumption characteristics are presented. The census tract characteristics are then summed for the subcommunity, and listed under an abbreviation for the name of the subcommunity.

Figure B-12 indicates the location of the subcommunities and census tracts within Riverside.

Table B-8 is the Riverside Energy Matrix. The energy consumption characteristics of each of the three major consumer categories are presented for each census tract within Riverside. (21,22,23) The census tract listings are grouped according to the subcommunities that they comprise. Both the thermal and electrical energy consumption characteristics are presented in this matrix.

The thermal energy category represents the energy required by consumers within the city limits of Riverside to satisfy their thermal needs. It was derived from raw energy consumption data assuming the conversion efficiencies listed in Note 28. It directly represents the thermal requirements that need to be satisfied. Thermal energy only indirectly represents the natural gas and electricity consumed for thermal needs, due to the assumed efficiencies of conversion.

The electrical energy category represents the energy required by consumers within the city limits of Riverside to satisfy their electrical needs, exclusive of the electricity used to satisfy the thermal requirements which was included in the thermal category. It was derived directly from electrical energy consumption data. This category represents the electrical energy consumption characteristics as would be seen by an electrical generating station. The great preponderance of electric air conditioning equipment in the community was the rationale behind including space cooling under the electrical energy category.

Subcommunity Heading

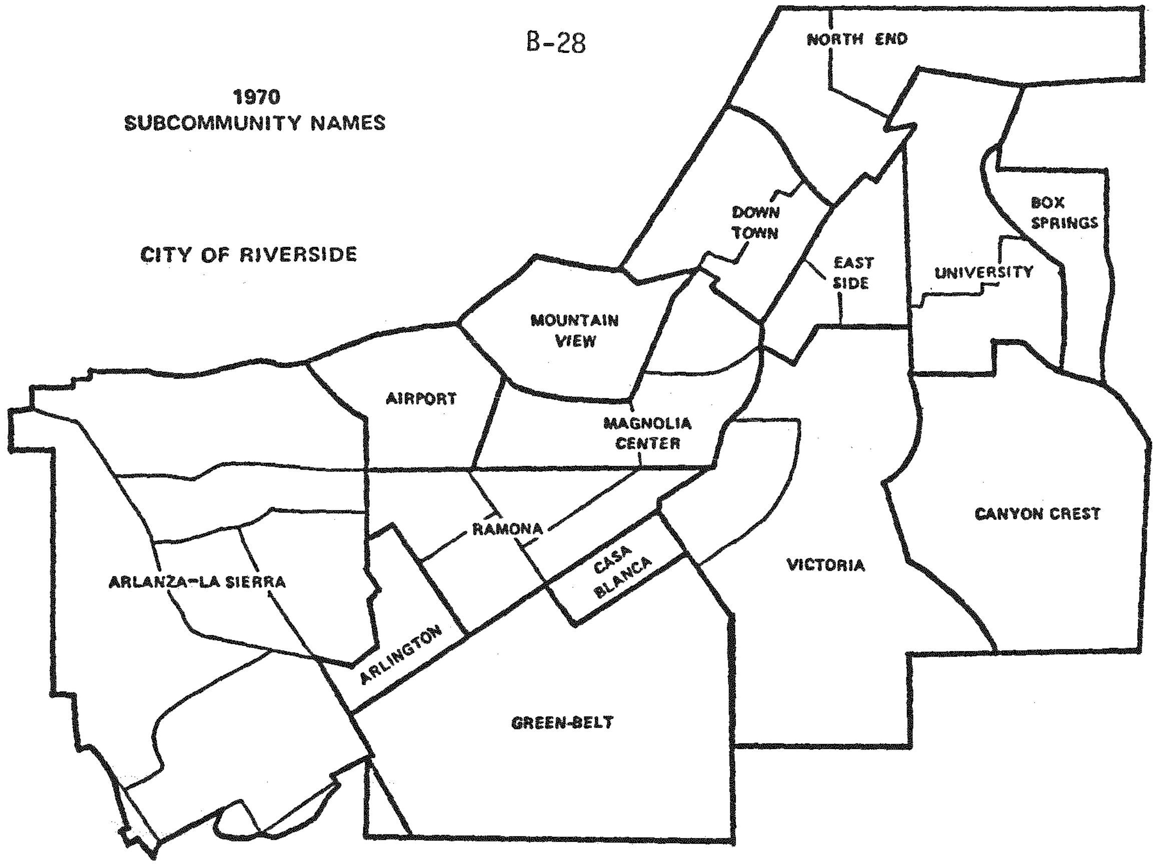
Census Tract No.	Consumer Classification	Thermal Characteristics: Peak Demand, 10^6 Btuh	Thermal Characteristics: Average Usage, 10^6 Btuh	Thermal Characteristics: Base Load, 10^6 Btuh	Electrical Characteristics: Peak Demand, MW	Electrical Characteristics: Average Usage, kW	Electrical Characteristics: Base Load, kW
			Ramona				
314.01	Residential	55.0	15.0	12.0	5.1	690	1,235
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	3.7	1.3	1.4	1.0	110	460
	TOTAL	58.7	16.3	13.4	6.1	800	1,695
314.02	Residential	48.0	13.0	9.9	4.4	610	1,055
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	19.0	6.5	7.6	4.9	570	2,390
	TOTAL	67.0	19.5	17.5	9.3	1,180	3,445
315.01	Residential	36.0	9.7	7.2	3.2	450	780
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	20.0	6.9	8.1	5.1	605	2,535
	TOTAL	56.0	16.6	15.3	8.3	1,055	3,315
315.02	Residential	47.0	13.0	9.1	3.8	590	670
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	4.8	1.7	1.9	1.2	145	610
	TOTAL	51.8	14.7	11.0	5.0	735	1,280
R.	Residential	186.0	50.7	38.2	16.5	2,340	3,740
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	47.5	16.4	19.0	12.2	1,430	5,995
	TOTAL	233.5	67.1	57.2	28.7	3,770	9,735
			Casa Blanca				
313	Residential	20.0	5.4	3.9	1.8	250	420
	Industrial	5.6	0.9	2.9	1.2	65	310
	Commercial	11.0	3.6	4.2	2.7	320	1,340
	TOTAL	36.6	9.9	11.0	5.7	635	2,070
C.B.	Residential	20.0	5.4	3.9	1.8	250	410
	Industrial	5.6	0.9	2.9	1.2	65	310
	Commercial	11.0	3.6	4.2	2.7	320	1,340
	TOTAL	36.6	9.9	11.0	5.7	635	2,070

Itemized Census Tracts Within Subcommunities

Totals for Ramona

Casa Blanca Has Only One Census Tract

FIGURE B-11. ORGANIZATION OF THE RIVERSIDE ENERGY MATRIX



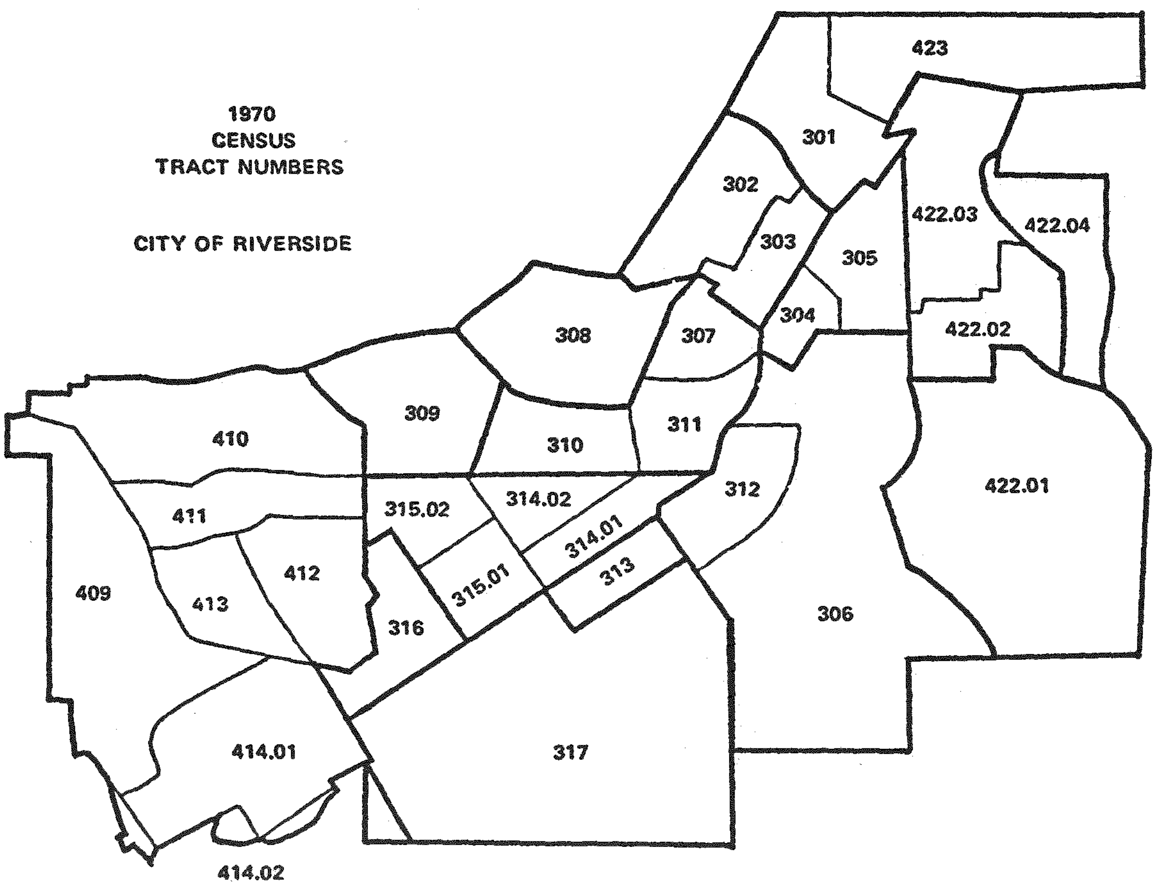


FIGURE B-12. SUBCOMMUNITIES AND CENSUS TRACTS WITHIN RIVERSIDE

TABLE B-8. THE RIVERSIDE ENERGY MATRIX

		Thermal Characteristics			Electrical Characteristics		
Census Tract No.	Consumer Classification	Peak Demand, 10^6 Btuh	Average Usage, 10^6 Btuh	Base Load, 10^6 Btuh	Peak Demand, MW	Average Usage, kW	Base Load, kW
		North End					
301	Residential	44.0	12.0	8.9	4.0	555	950
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	1.3	0.5	0.5	0.3	40	170
	TOTAL	45.3	12.5	9.4	4.3	595	1,120
423	Residential	2.8	0.7	0.7	0.3	35	80
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	3.7	1.3	1.4	1.0	110	460
	TOTAL	6.5	2.0	2.1	1.3	145	540
N.E.	Residential	46.8	12.7	9.6	4.3	590	1,030
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	5.0	1.8	1.9	1.3	150	630
	TOTAL	51.8	14.5	11.5	5.6	740	1,660
		Downtown					
302	Residential	52.0	14.0	11.0	4.9	645	1,220
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	1.3	0.5	0.5	0.3	40	170
	TOTAL	53.3	14.5	11.5	5.2	685	1,390
303	Residential	58.0	16.0	14.0	5.6	725	1,495
	Industrial	3.2	0.5	1.7	1.5	85	410
	Commercial	27.0	9.2	11.0	4.8	560	2,330
	TOTAL	88.2	25.7	26.7	11.9	1,370	4,235
D.T.	Residential	110.0	30.0	25.0	10.5	1,370	2,715
	Industrial	3.2	0.5	1.7	1.5	85	410
	Commercial	28.3	9.7	11.5	5.1	600	2,500
	TOTAL	141.5	40.2	38.2	17.1	2,055	5,625
		Mountain View					
308	Residential	56.0	16.0	11.0	5.0	700	1,180
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	8.4	0.5	0.5	2.2	250	1,045
	TOTAL	64.4	16.5	11.5	7.2	950	2,225

TABLE B-8. (Continued)

Census Tract No.	Consumer Classification	Thermal Characteristics Peak Demand, 10^6 Btuh	Thermal Characteristics Average Usage, 10^6 Btuh	Thermal Characteristics Base Load, 10^6 Btuh	Electrical Characteristics Peak Demand, MW	Electrical Characteristics Average Usage, kW	Electrical Characteristics Base Load, kW
		Mountain View (Continued)					
M.V.	Residential	56.0	16.0	11.0	5.0	700	1,180
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	8.4	0.5	0.5	2.2	250	1,045
	TOTAL	64.4	16.5	11.5	7.2	950	2,225
		East Side					
304	Residential	41.0	11.0	8.5	3.7	510	905
	Industrial	19.7	3.1	10.0	4.0	225	1,070
	Commercial	1.3	0.5	0.5	0.3	40	170
	TOTAL	62.0	14.6	19.0	8.0	775	2,145
305	Residential	64.0	17.0	15.0	6.0	805	1,530
	Industrial	43.0	6.7	22.0	7.3	410	1,960
	Commerical	11.0	3.6	4.2	2.7	320	1,340
	TOTAL	118.0	27.3	41.2	16.0	1,535	4,830
E.S.	Residential	105.0	28.0	23.5	9.7	1,315	2,435
	Industrial	62.7	9.8	32.0	11.3	635	3,030
	Commercial	12.3	4.1	4.7	3.0	360	1,510
	TOTAL	180.0	31.9	60.2	24.0	2,310	6,975
		University					
422.02	Residential	7.2	1.9	1.6	0.7	90	175
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	66.0	23.0	26.0	9.4	1,150	4,840
	TOTAL	73.2	24.9	27.6	10.1	1,240	5,015
422.03	Residential	26.0	7.0	6.7	2.6	325	730
	Industrial	90.0	14.0	47.0	18.8	1,060	5,130
	Commercial	8.4	2.9	3.3	2.0	250	1,045
	TOTAL	124.4	23.9	57.0	23.4	1,635	6,905
Univ.	Residential	33.2	8.9	8.3	3.3	415	905
	Industrial	90.0	14.0	47.0	18.8	1,060	5,130
	Commercial	74.4	25.9	29.3	11.4	1,400	5,885
	TOTAL	197.6	48.8	84.6	33.5	2,875	11,920

TABLE B-8. (Continued)

Census Tract No.	Consumer Classification	Thermal Characteristics: Peak Demand, 10^6 Btuh	Thermal Characteristics: Average Usage, 10^6 Btuh	Thermal Characteristics: Base Load, 10^6 Btuh	Electrical Characteristics: Peak Demand, MW	Electrical Characteristics: Average Usage, kW	Electrical Characteristics: Base Load, kW
	Box Springs						
422.04	Residential	49.0	13.0	9.9	4.6	615	1,060
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	6.0	2.1	2.4	1.5	180	755
	TOTAL	55.0	15.1	12.3	6.1	795	1,815
B.S.	Residential	49.0	13.0	9.9	4.6	615	1,060
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	6.0	2.1	2.4	1.5	180	755
	TOTAL	55.0	15.1	12.3	6.1	795	1,815
	Airport						
309	Residential	21.0	5.6	4.0	1.8	250	435
	Industrial	6.7	1.0	3.5	0.7	40	180
	Commercial	1.3	0.5	0.5	0.3	40	170
	TOTAL	29.0	7.1	8.0	2.8	330	785
A.P.	Residential	21.0	5.6	4.0	1.8	250	435
	Industrial	6.7	1.0	3.5	0.5	40	180
	Commercial	1.3	0.5	0.5	0.3	40	170
	TOTAL	29.0	7.1	8.0	2.8	330	785
	Magnolia Center						
307	Residential	61.0	17.0	13.0	5.6	770	1,330
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	6.0	2.1	2.4	1.5	180	755
	TOTAL	67.0	19.1	15.4	7.1	950	2,085
310	Residential	72.0	20.0	14.0	6.3	910	1,630
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	4.8	1.7	1.9	1.2	145	610
	TOTAL	76.8	21.7	15.9	7.5	1,055	2,240
311	Residential	50.0	14.0	10.0	4.5	630	1,085
	Industrial	1.5	0.2	0.8	0.3	20	80
	Commercial	80.0	27.0	32.0	20.0	2,340	9,815
	TOTAL	131.5	41.2	42.8	24.8	2,990	10,970

TABLE B-8. (Continued)

Census Tract No.	Consumer Classification	Thermal Characteristics: Peak Demand, 10^6 Btuh	Thermal Characteristics: Average Usage, 10^6 Btuh	Thermal Characteristics: Base Load, 10^6 Btuh	Electrical Characteristics: Peak Demand, MW	Electrical Characteristics: Average Usage, kW	Electrical Characteristics: Base Load, kW
			Magnolia Center (Continued)				
M.C.	Residential	183.0	51.0	37.0	16.4	2,310	4,045
	Industrial	1.5	0.2	0.8	0.3	20	80
	Commercial	90.8	30.8	36.3	22.7	2,665	11,180
	TOTAL	275.3	82.0	74.1	39.4	4,995	15,305
			Canyon Crest				
422.01	Residential	33.0	9.0	6.7	3.1	420	730
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	1.3	0.5	0.5	0.3	40	140
	TOTAL	34.3	9.5	7.2	3.4	460	870
C.C.	Residential	33.0	9.0	6.7	3.1	420	730
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	1.3	0.5	0.5	0.3	40	140
	TOTAL	34.3	9.5	7.2	3.4	460	870
			Victoria				
306	Residential	53.0	14.0	10.0	4.7	670	1,095
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	1.3	0.5	0.5	0.3	40	170
	TOTAL	54.3	14.5	10.5	5.0	710	1,265
312	Residential	45.0	12.0	8.8	4.0	570	940
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	3.7	1.3	1.4	1.0	110	460
	TOTAL	48.7	13.3	10.2	5.0	680	1,400
Vic.	Residential	98.0	26.0	18.8	8.7	1,240	2,035
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	5.0	1.8	1.9	1.3	150	630
	TOTAL	103.0	27.8	20.7	10.0	1,390	2,665

TABLE B-8. (Continued)

Census Tract No.	Consumer Classification	Thermal Characteristics: Peak Demand, 10^6 Btuh	Thermal Characteristics: Average Usage, 10^6 Btuh	Thermal Characteristics: Base Load, 10^6 Btuh	Electrical Characteristics: Peak Demand, MW	Electrical Characteristics: Average Usage, kW	Electrical Characteristics: Base Load, kW
			Ramona				
314.01	Residential	55.0	15.0	12.0	5.1	690	1,235
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	3.7	1.3	1.4	1.0	110	460
	TOTAL	58.7	16.3	13.4	6.1	800	1,695
314.02	Residential	48.0	13.0	9.9	4.4	610	1,055
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	19.0	6.5	7.6	4.9	570	2,390
	TOTAL	67.0	19.5	17.5	9.3	1,180	3,445
315.01	Residential	36.0	9.7	7.2	3.2	450	780
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	20.0	6.9	8.1	5.1	605	2,535
	TOTAL	56.0	16.6	15.3	8.3	1,055	3,315
315.02	Residential	47.0	13.0	9.1	3.8	590	670
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	4.8	1.7	1.9	1.2	145	610
	TOTAL	51.8	14.7	11.0	5.0	735	1,280
R.	Residential	186.0	50.7	38.2	16.5	2,340	3,740
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	47.5	16.4	19.0	12.2	1,430	5,995
	TOTAL	233.5	67.1	57.2	28.7	3,770	9,735
			Casa Blanca				
313	Residential	20.0	5.4	3.9	1.8	250	420
	Industrial	5.6	0.9	2.9	1.2	65	310
	Commercial	11.0	3.6	4.2	2.7	320	1,340
	TOTAL	36.6	9.9	11.0	5.7	635	2,070
C.B.	Residential	20.0	5.4	3.9	1.8	250	410
	Industrial	5.6	0.9	2.9	1.2	65	310
	Commercial	11.0	3.6	4.2	2.7	320	1,340
	TOTAL	36.6	9.9	11.0	5.7	635	2,070

TABLE B-8. (Continued)

Census Tract No.	Consumer Classification	Thermal Characteristics: Peak Demand, 10^6 Btuh	Thermal Characteristics: Average Usage, 10^6 Btuh	Thermal Characteristics: Base Load, 10^6 Btuh	Electrical Characteristics: Peak Demand, MW	Electrical Characteristics: Average Usage, kW	Electrical Characteristics: Base Load, kW
	Arlington						
316	Residential	58.0	16.0	12.0	5.4	735	1,305
	Industrial	1.5	0.2	0.8	0.1	10	35
	Commercial	44.0	15.0	18.0	11.0	1,295	5,430
	TOTAL	103.5	31.2	30.8	16.5	2,040	6,770
Arl.	Residential	58.0	16.0	12.0	5.4	735	1,305
	Industrial	1.5	0.2	0.8	0.1	10	35
	Commercial	44.0	15.0	18.0	11.0	1,295	5,430
	TOTAL	103.5	31.2	30.8	16.5	2,040	6,770
	Green Belt						
317	Residential	44.0	12.0	9.0	4.1	560	960
	Industrial	6.1	0.9	3.2	2.2	120	575
	Commercial	1.3	0.5	0.5	0.3	40	170
	TOTAL	51.4	13.4	12.7	6.6	720	1,705
.B.	Residential	44.0	12.0	9.0	4.1	560	960
	Industrial	6.1	0.9	3.2	2.2	120	575
	Commercial	1.3	0.5	0.5	0.3	40	170
	TOTAL	51.4	13.4	12.7	6.6	720	1,705
	Arlanza-La Sierra						
09	Residential	59.0	16.0	12.0	5.3	745	1,280
	Industrial	9.0	1.4	4.7	0.6	30	145
	Commercial	22.0	7.5	8.7	4.4	515	2,155
	TOTAL	90.0	24.9	25.4	10.3	1,290	3,580
.0	Residential	31.0	8.5	6.1	2.8	395	660
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	1.3	0.5	0.5	0.3	40	140
	TOTAL	32.3	9.0	6.6	3.1	435	800
.1	Residential	41.0	11.0	8.5	3.8	520	905
	Industrial	97.0	15.0	50.0	6.9	390	1,850
	Commercial	4.8	1.7	1.9	1.2	145	610
	TOTAL	142.8	27.7	60.4	11.9	1,055	3,365

TABLE B-8. (Continued)

Census Tract No.	Consumer Classification	Thermal Characteristics: Peak Demand, 10^6 Btuh	Thermal Characteristics: Average Usage, 10^6 Btuh	Thermal Characteristics: Base Load, 10^6 Btuh	Electrical Characteristics: Peak Demand, MW	Electrical Characteristics: Average Usage, kW	Electrical Characteristics: Base Load, kW
	Arlanza-La Sierra (Continued)						
412	Residential	48.0	13.0	9.4	9.1	610	1,005
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	11.0	3.9	4.4	1.4	165	700
	TOTAL	59.0	16.9	13.8	10.5	775	1,705
413	Residential	34.0	9.2	6.8	3.1	430	740
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	1.3	0.5	0.5	0.3	40	170
	TOTAL	35.3	9.7	7.3	3.4	470	910
414.01	Residential	67.0	18.0	17.0	6.3	845	1,690
	Industrial	6.4	1.0	3.3	3.1	45	215
	Commercial	1.3	0.5	0.5	0.3	40	170
	TOTAL	74.7	19.5	20.8	9.7	930	2,075
414.02	Residential	0.6	0.2	0.1	0.1	10	15
	Industrial	0.0	0.0	0.0	0.0	0	0
	Commercial	1.3	0.5	0.5	0.3	40	170
	TOTAL	1.9	0.7	0.6	0.4	50	185
A.L.S.	Residential	280.6	75.9	59.9	30.5	3,555	6,295
	Industrial	112.4	17.4	58.0	10.6	465	2,210
	Commercial	43.0	15.1	17.0	8.2	985	4,115
	TOTAL	436.0	108.4	134.9	49.3	5,005	12,620

The entries under each energy category in the matrix are discussed below.

Peak Demand for Thermal Energy. (Btuh = Btu per hour). This is the hourly demand for thermal energy on the winter design day discussed previously under Weather Conditions. This is the peak demand placed on the energy supply system. It is the amount of energy required at the point of use on a winter design day.

Average Seasonal Usage for Space Heating. (Btuh = Btu per hour). This entry represents the average hourly space heating consumption of energy during the heating season, December through March inclusive (2904 hours). It was arrived at by dividing the thermal consumption attributable to space heating by the number of hours in the heating season. This is the component of consumption that is dependent on the weather. Thus, the annual average usage for space heating may be obtained by the following equation:

$$\left\{\begin{matrix}\text{Annual space heating}\\ \text{consumption}\\ \text{Btu/yr}\end{matrix}\right\} = 2904\ \frac{\text{hr}}{\text{yr}} \times \left\{\begin{matrix}\text{Average usage}\\ \text{for space heating}\\ \text{Btu/hr}\end{matrix}\right\}$$

The average seasonal usage is the thermal consumption for space heating at the point of use, averaged over the entire heating season, and does not include the base load component discussed below.

Base Thermal Load. (Btuh = Btu per hour). This entry represents the mean hourly thermal consumption throughout the year, exclusive of that attributable to space heating. This is the component of thermal consumption that is independent of the weather. It was arrived at by dividing the total annual base consumption by the number of hours in the year (8760 hours/year). Thus, the following equation may be used to arrive at the annual base thermal consumption:

$$\left\{\begin{matrix}\text{Annual base}\\ \text{consumption}\\ \text{Btu/yr}\end{matrix}\right\} = 8760\ \frac{\text{hr}}{\text{yr}} \times \left\{\begin{matrix}\text{Base thermal}\\ \text{load}\\ \text{Btu/hr}\end{matrix}\right\}$$

The base load is the thermal consumption exclusive of that for space heating at the point of use, averaged over the entire year.

The examples below illustrate the above descriptions. In all cases the first census tract entry, 301, in the energy matrix will be used.

Thermal Example 1. The mean hourly residential thermal demand for energy during a typical day in the heating season is equal to the average usage plus the base load. For census tract 301:

$$12 + 8.9 = 20.9 \times 10^6 \text{ Btuh.}$$

Thermal Example 2. The annual requirements of all the consuming sectors for thermal energy in census tract 301 are:

$$\left[12.5 \times 10^6 \frac{\text{Btu}}{\text{hr}} \times \frac{2904 \text{ hr}}{\text{heating season}}\right] + \left[9.4 \times 10^6 \frac{\text{Btu}}{\text{hr}} \times \frac{8760 \text{ hr}}{\text{year}}\right] = 119 \times 10^9 \frac{\text{Btu}}{\text{year}}$$

(Space Heating) (Base Load) = (Annual Consumption)

Thermal Example 3. The base thermal consumption during the nonheating months in all of census tract 301:

$$\left[8760 \text{ hr} - 2904 \text{ hr}\right] \times \left[9.4 \times 10^6 \text{ Btu/hr}\right] = 55 \times 10^9 \text{ Btu}$$

(hours in the nonheating months) (base load)

Peak Demand for Electricity (MW = megawatts). This entry represents the greatest instantaneous demand for electric power in Riverside. This demand traditionally occurs on a summer design day as discussed previously under Weather Condtions. On a city-wide basis, the peak demand in 1976 was 250 MW, with 50 percent of the peak being attributable to space cooling requirements on the design day. This is the peak demand as would be seen by an electric generating station suppling the needs of the community.

Average Seasonal Usage for Space Cooling (KW = kilowatts). This entry represents the average hourly space cooling consumption of energy during the cooling season, May through October inclusive (4416 hours). It was arrived at by dividing the thermal consumption for space cooling by the number of hours in the cooling season. This is the component of consumption which is dependent on the weather. Thus, the annual average usage for space cooling may be obtained by the following equation:

$$\left\{\begin{matrix}\text{Annual space cooling}\\ \text{consumption}\\ \text{KWH/yr}\end{matrix}\right\} = 4416\ \frac{\text{hr}}{\text{yr}} \times \left\{\begin{matrix}\text{Average usage for}\\ \text{space cooling}\\ \text{KW}\end{matrix}\right\}$$

The average seasonal usage represents the electrical energy demand for space cooling that must be supplied during the cooling season.

Base Electrical Load (KW = kilowatts). This entry represents the mean hourly electrical consumption throughout the year, exclusive of that attributable to space cooling. This is the component of electrical consumption that is independent of the weather. It was arrived at by dividing the total annual base consumption by the number of hours in the year (8760 hours/year). Thus, the following equation may be used to arrive at annual base electrical consumption:

$$\left\{\begin{matrix}\text{Annual base}\\ \text{consumption}\\ \text{KWH/yr}\end{matrix}\right\} = 8760\ \frac{\text{hr}}{\text{yr}} \times \left\{\begin{matrix}\text{Base electrical}\\ \text{load}\\ \text{KW}\end{matrix}\right\}$$

This base load is the electrical energy requirements, exclusive of space cooling, that need to be supplied, averaged over the entire year.

The examples below illustrate the above descriptions for electrical energy consumption. In all cases the first census tract entry, 301, will be used.

Electrical Example 1. The mean hourly commercial consumption of electricity during a typical day in the cooling season in census tract 301 is: 40 + 170 = 210 KW.

Electrical Example 2. The annual electrical energy requirement for the residential sector in census tract 301 is:

$$\left[(555\ \text{KW}) \times \left(\frac{4416\ \text{hr}}{\text{cooling season}}\right)\right] + \left[(950\ \text{KW}) \times \left(\frac{8760\ \text{hr}}{\text{year}}\right)\right] = 10.8 \times 10^{6}\ \frac{\text{kWh}}{\text{year}}$$

(space cooling) (base load) = (annual consumption)

4. Projected Energy Requirements

One purpose of this project was to establish which alternative energy systems could meet the future energy requirements of the community. However, until the project was completed, there was no way to estimate what the future energy consumption would be. But before the subsequent tasks could proceed, estimates of the two energy requirements of the community had to be made available: electrical and thermal requirements. Once these requirements were estimated, the other tasks could then proceed to establish:

- The effects of conservation programs to reduce these requirements
- The potential of displacing scarce fuels, which currently satisfy these requirements, with alternative resources.

The projections presented here represent paths into the future following recent trends in the energy consumption pattern of the Riverside community. The future that is predicted represents a future without surprises, a future that incorporates the projected community growth patterns developed elsewhere in this report.

The primary assumption that was used to derive the energy projections is that the energy requirements of the community will grow in direct proportion to the population growth in the community. The projections are made assuming that no drastic changes in life-style occur. The final results of the Alternative Energy Study might indicate that sufficient alternatives are available and life-styles need not change, or the conclusions might include suggested alternative life-styles in the community.

The conclusions of this study, however, were not available to the first effort in the study, the energy characterization task. As such, projections of energy requirements were made so that they can subsequently be examined, analyzed, and satisfied or altered by the viable alternatives.[24]

Electrical Energy Projections

Figure B-13 presents the historical growth and projections of electrical energy requirements for three population scenarios. Electrical energy encompasses all of that energy used for: lighting, power, and space cooling. The projections represent the total requirements of all of the consuming sectors in Riverside. The distribution of the required energy to each of the consuming sectors is presented below.

Table B-9 shows the percentage of total annual electrical energy that will be required by each sector, for each of the two end uses: space cooling, the weather sensitive component of electrical energy, and base load, the weather-independent component of electrical energy. The line losses listed in the table account for the energy lost in transporting electricity to the consumers within Riverside; these losses have been considered separately from the actual requirements of the consumers. The relative percentage of energy centage of energy distributed to each consuming sector is expected to remain fixed throughout the entire projection time frame.

TABLE B-9. ELECTRICAL ENERGY DISTRIBUTION
Percentage of Annual Requirements

	Space Cooling	Base Load	Total for Sector
Residential	7.8	26.2	34.0
Industrial	1.2	11.1	12.3
Commercial	4.7	38.9	43.6
Total for End Use	13.7	76.2	89.9
Line Losses	--	--	5.5
Other	--	--	4.6
			100.0

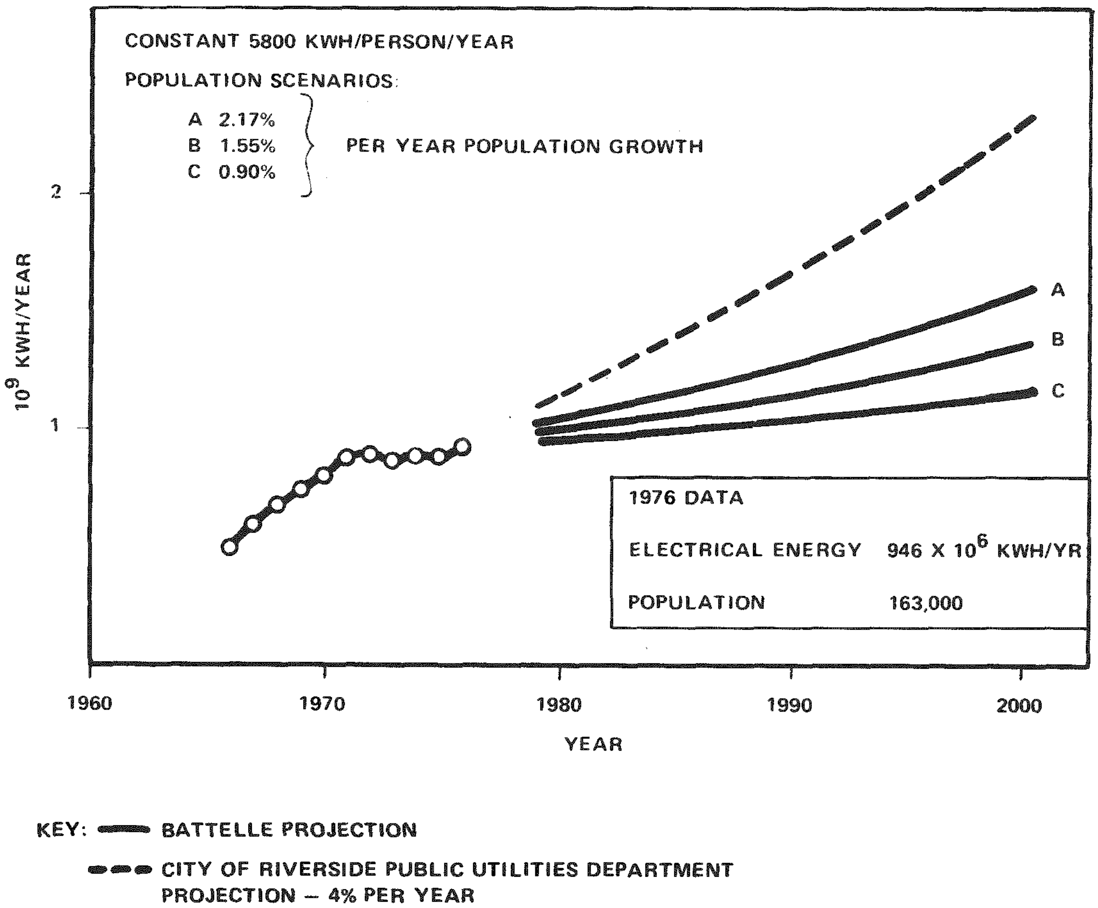


FIGURE B-13. GROWTH AND PROJECTIONS FOR ELECTRICAL ENERGY

Figure B-14 presents the growth and projections of peak summer electrical energy demand.

Thermal Projections

Figure B-15 presents the historical growth and projections of thermal energy requirements for three population scenarios. Thermal energy encompasses all of that energy used for: space heating, water heating, process heat, cooking, etc. Uses requiring temperatures above ambient conditions. The projections represent the total requirements of all of the consuming sectors in Riverside. The distribution of the required energy to each of the consuming sectors is presented below.

Table B-10 contains the percent of total annual thermal energy that will be required by each sector, for each of the two end uses: space heating, the weather sensitive component of thermal energy; base load, the weather independent component of thermal energy consumption. The relative percentage of energy distributed to each consuming sector is expected to remain fixed throughout the entire projection time frame.

TABLE B-10. THERMAL ENERGY DISTRIBUTION
Percentage of Annual Requirements

	Space Heating	Base Load	Total for Sector
Residential	15.7	36.2	51.9
Industrial	2.0	19.7	21.7
Commercial	5.7	19.7	25.4
Total for End Use	23.4	75.6	99.0
Other	--	--	1.0
			100.0

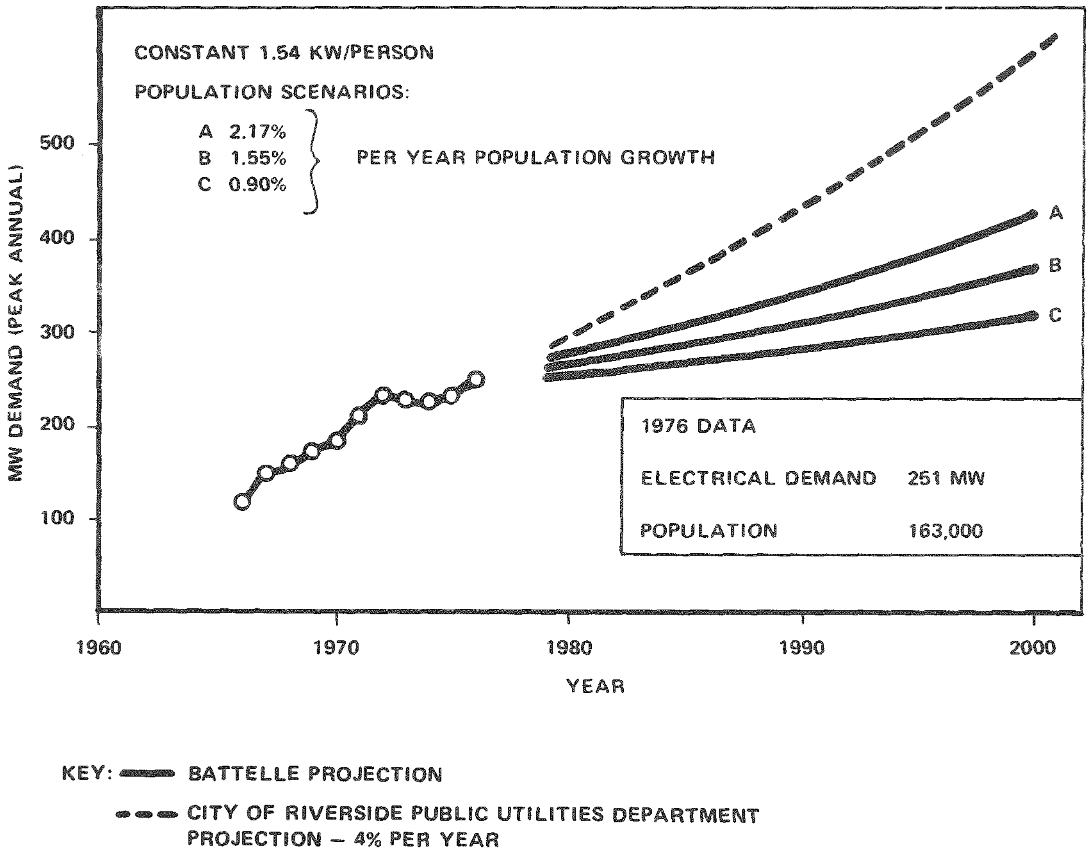


FIGURE B-14. HISTORICAL GROWTH AND PROJECTIONS FOR PEAK ELECTRICAL ENERGY DEMAND

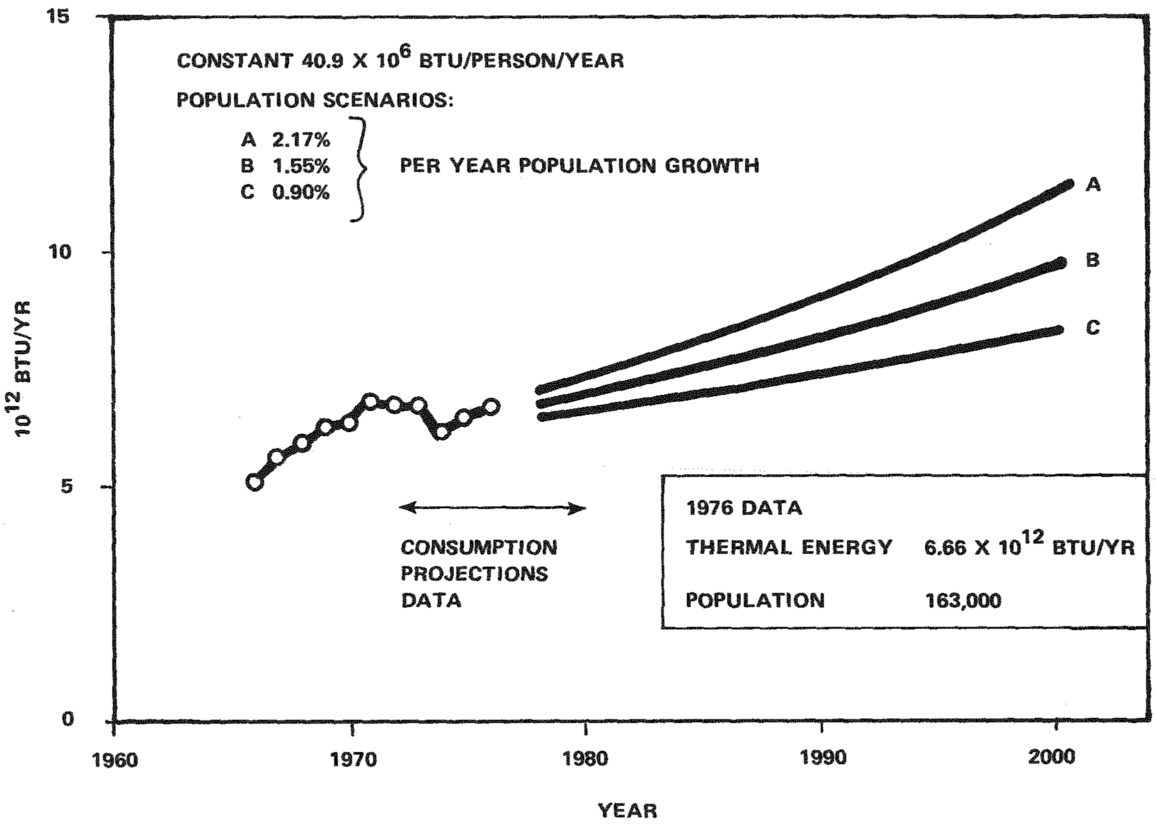


FIGURE B-15. GROWTH AND PROJECTIONS FOR THERMAL ENERGY

REFERENCES & NOTES TO APPENDIX A

[1] Riverside Chamber of Commerce booklet, "Why did Captain Juan Bantista de Anza Return to Riverside, California?", containing:

- A map of Southern California
- The history of Riverside
- A roster of Chamber members
- Aerial photographs of the Industrial Parks in the city.

[2] Riverside Planning Department, "Summary of the 1970 Census Data for Riverside, California", including:

- Statistics for the city
- A census tract/community map.

[3] Riverside City Planning Department, "City of Riverside General Plan: 1990", Livingstone and Blayney--City and Regional Planners, CIAES 7700040.

[4] Planning Department--City Hall, "Population Projections, City of Riverside--1975", CIAES 7700039.

[5] Riverside Chamber of Commerce, "General Statistics--Economic Indicators--Riverside, CA", Economic Development Division.

[6] Planning and Building Department, "Total Population and Dwelling Unit Estimates, and Annual Rates of Increase Since January 1, 1970", M. G. Gardner, Letter dated June, 1975, CIAES 7700039.

- Planning Department Population Estimates
- State Department of Finance Population Estimates.

[7] Riverside County Department of Development, "Community Economic Profile for Riverside, Riverside County, California", April, 1977.

[8] <u>ASHRAE Handbook of Fundamentals, 1972</u>, American Society of Heating, Refrigeration and Airconditioning Engineers.

[9] National Oceanic and Atmospheric Administration, <u>Climatological Data--California</u>, Vol. 76, No. 1, January, 1972, through Vol. 80, No. 12, December, 1976, CIAES 7700054.

[10] W. A. Beckman, S. A. Klein, J. A. Duffie, <u>Solar Heating Design by the F-Chart Method</u>, John Wiley & Sons (1977).

[11] Phone call to University of California at Riverside Weather Service, Mr. Willis Huxman, November 15, 1977.

[12] 1970 Census Data--California, Detailed Housing Characteristics: Fuels and Appliances for Areas and Places.

[13] Letter requests for energy consumption data were sent to 61 of the industrial customers in Riverside. A list of the largest electrical energy

consumers was obtained from C. E. Dole, Jr., Executive Director of the Economic Development Division of the Chamber of Commerce. Additional industries were selected from a County Department of Development publicaton entitled "Directory of Manufacturers--1978". This directory included product listings, the number of employees, and the total square footage.

The initial meager response to the first letter, September 30, 1977, prompted a second letter on December 12, 1977. A total of 14 responses, to the 61 letters sent, were received.

[14] Southern California Edison Company, "Electrical Energy and Demand Data for the City of Riverside--January, 1950 through May, 1977", CIAES 7700042.

[15] Riverside Public Utilities Department, "Electrical Consumption by Sector--1971 through 1976", J. Westmorland, letter dated November 3, 1977.

[16] Southern California Gas Company, "Natural Gas Consumption for the City of Riverside--1966 through 1976", CIAES 770044.

[17] Electric peak demand data were available through the Riverside Public Utilities Department. Comparisons of summer and winter peak demand charts established the component of peak demand attributable to electric space cooling applications. The following assumptions aided in distributing the peak demand among the consuming sectors:

(a) Weekday afternoon peaks were attriburable to residential, commercial, and industrial consumption.

(b) Sunday afternoon peaks were attributable to residential and commercial consumption.

(c) Sunday evening peaks were attributable to residential consumption.

The term "Thermal Energy" is fully explained in the text under "Current Trends in Energy Consumption--Energy Matrix". Estimates of the peak thermal demand were arrived at by:

- Extrapolation of the least-squares linear correlations of natural gas consumption versus heating degree days to an ASHRAE design day [8].
- Assuming a peak furnace and boiler conversion efficiency of 80 percent for the space heating component of natural gas consumption.
- Assuming the following saturation levels:
  --93 percent of homes have gas space heating[12]
  --95 percent of all homes are occupied [18].
- Assuming natural gas contains 1050 Btu/cu ft [19].

[18] Department of Housing and Urban Development, "Postal Vacancy Survey Riverside--San Bernardino--Ontario, California", June, 1975, CIAES 7700038.

[19] Southern California Gas Company, "Natural Gas Consumption in the City of Riverside", CIAES 7700038.

[20] Census Tract Areas, obtained by planimetering map [29]:

Census Tract	Area (sq mi)	Census Tract	Area (sq mi)
301	1.7	315.01	1.0
302	1.7	315.02	1.0
303	1.1	316	1.4
304	0.7	317	9.4
305	1.3	409	4.2
306	8.3	410	3.2
307	0.8	411	1.5
308	2.0	412	1.8
309	2.4	413	1.4
310	1.2	414.01	3.3
311	1.1	414.02	0.8
312	1.5	422.01	8.4
313	0.9	422.02	1.6
314.01	0.8	422.03	2.6
314.02	0.8	422.04	1.7
		423	2.8
Total			72.4

[21] The residential distribution of energy characteristics to each census tract was achieved by: (1) calculating from the consumption data [14, 15,16] the energy characteristics of individual dwelling units; (2) using the available dwelling unit estimtes [2,18] to establish the number of dwelling units per census tract. The final energy characteristics for the individual types of dwelling units are:

Residential Unit Demands

	Thermal (Btuh/unit)			Electrical (kW)unit)		
	Peak Demand	Average Usage	Base Load	Peak Demand	Average Usage	Base Load
Single Family	23,800	6500	4600	2.2	0.43	0.50
Multifamily	16,900	4600	4600	1.6	0.30	0.50
Mobile Home	15,200	4000	4600	1.4	0.27	0.50

[22] Since the industrial distribution of energy to the census tracts could not be obtained through individual letter requests [13], another approach was taken. From Reference [1], the Riverside telephone directory and a street map of the city [29], the 61 industries were collected into their respective census tracts. Requests were then made to Southern California Gas Company and the Riverside Public Utilities Department to tabulate the total monthly energy consumption of each census tract grouping for 12 months. In this way, the industrial consumption distribution by census tract was obtained without revealing any privileged information, such as the energy consumption of any one industry.

[23] A "Map of Shopping Centers and Retail Areas in Riverside" compiled by the Chamber of Commerce provided the location of the 26 large commercial areas in the city. A letter from the energy coordinator for this project, dated 12/19/77, ranked the size of these areas on a scale from 1 to 5. From this, a percentage distribution of the total commercial consumption to each census tract was derived. These percentages were altered to include:

(a) A blanket 15 percent distribution of the total commercial consumption to the entire city to account for the numerous small shops scattered throughout the city;

(b) The largest known commercial consumers, which were not included on the Chamber map: City Hall, La Sierra College, Riverside County Hospital, Riverside Community Hospital, and the University of California at Riverside.

[24] Projections of natural gas consumption, electrical energy consumption, and electrical energy demand were obtained from the utilities serving [25,26] and the published literature[27]. These, however, were projections in consumption of a particular form of energy and not projections of future energy requirements. The assumptions as to the extent of the impact of conservation, fuel displacement, etc., inplicit in these projections, were not made available.

[25] Letter from R. L. Gauslin, Corona Local Manager, Southern California Gas Company, January 19, 1978. Projected growth in natural gas consumption was 1.5 percent per year increase through 1990, in Southern California.

[26] "Riverside Public Utilities Department Energy Projections", CIAES 7700113, August 8, 1977. Effective electrical energy consumption is expected to grow at 4.8 percent per year while demand will grow at 4.9 percent per year through 1995, in the City of Riverside.

[27] The State Energy Commission expected statewide energy consumption to grow at 3.8 percent annually through 1995. "Energy Users Report", 1975.

[28] Assumed conversion efficiencies (percent):

	Residential	Commercial	Industrial
Peak	80	80	80
Average	60	75	75

[29] Riverside Chamber of Commerce "1977 Map & Street Guide: Riverside, California, March AFB".

APPENDIX C

ENERGY CONSERVATION OPTIONS

C1. ENERGY CONSERVATION OPTIONS IN BUILDINGS

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

C1. ENERGY CONSERVATION OPTIONS IN BUILDINGS

PURPOSE

The purpose of this analysis Task is:

(1) to identify and describe energy conservation opportunities for the buildings of Riverside

(2) to assess the value of these energy conservation opportunities by estimating potential energy savings, by examining potential constraints to implementation, and by identifying other positive or negative aspects of each opportunity

(3) to recommend energy conservation actions for immediate implementation

(4) to recommend further study and research on some energy conservation measures before a decision to implement or to reject is made.

The results are therefore expected to yield some recommendations for immediate implementation. Such recommendations will consist of those items which, in the opinion of Battelle, require no further study or research to justify implementation.

Other results will, however, consist of recommendations for further evaluation and research. Such recommendations are expected to be considered further in Phase II of the Riverside Integrated Community Energy System Study.

APPROACH

The investigative approach or procedure used in the completion of this task consists primarily of the following:

(1) Extensive discussions were held with a number of people in the Riverside Community.[1] These discussions concerned the extent of present building energy conservation in Riverside, the public acceptance of other energy conservation measures, and the various roles and postures of different interest groups in Riverside with respect to the issues of energy conservation.

(2) Data on the size, configuration and energy use of Riverside's building inventory were collected and examined. Most of these data were collected primarily for energy use characterization purposes (See Appendix A), and were augmented by additional studies and information.[2]

(3) Guidelines for the systematic implementation of building energy conservation programs were developed. The information used for their development came primarily from literature describing the features and problems of a variety of energy conservation programs which have been implemented in various communities in California and elsewhere in the United States.[3]

---

(1) A listing of persons contacted and interviewed in connection with this and other tasks is provided in Appendix H.

(2) Data sources used are identified in footnotes throughout the text.

(3) One primary resource was "Energy Policies and Programs of California Cities and Counties: A Survey", authored by Phillip A. Greenberg, Co-Director of Marin Citizens for Energy Planning, published in 1977.

In addition, results of Battelle-conducted in-house research were used extensively to develop these guidelines.[4]

(4) Finally, various possible energy conservation programs for buildings were identified as a result of the discussions and data collection described above. These energy conservation programs were examined under the implementation guidelines, and recommendations were made for the initiation.

The results of this research procedure are presented in this Appendix.

CURRENT ENERGY CONSERVATION EFFORTS AFFECTING BUILDINGS IN RIVERSIDE

Local Efforts

On the basis of conversations held with local officials in City Hall, County Government, and the Chamber of Commerce, it appears that building energy conservation efforts in Riverside need to be expanded and intensified significantly.

City and County Government Efforts

The City as well as the County Government are presently engaged in active programs to conserve the energy used by the buildings they own. However, this action is generally limited to energy conservation measures that are operational in nature (e.g., lowering the heating temperature, raising the cooling temperature, switching off lights) and does not include major retrofit programs. Moreover, the amount of interior space owned by the City and the County is only a small fraction of Riverside's

---

(4) See "Energy Conservation in Buildings--General Principles and Possible Results", in Integrated Community Energy Systems Planning, Battelle's Columbus Laboratories, Columbus, Ohio, 1977.

entire building inventory. As a result, these programs serve more as an example of prudent action to the city's residents than as major contributors to energy savings.

Although the City of Riverside owns its electrical distribution system, it has no generating capacity and relies on the Southern California Edison Company for almost all of its power. In an effort to reduce its peak demand, the City's Public Utilities Department has instituted a consulting service for business and industry, providing advice on proper load management. This consulting service is patterned after the one offered by Southern California Edison Company (described on p. 12 under "Load Management").

Currently, the City has four full-time staff members involved in energy conservation. The City's emphasis on energy conservation, initiated in 1973 among customers with loads above 200 KW, has resulted in significant reductions in electrical usage based upon field audits conducted by the City. Some of these results are as follows:

Riverside General Hospital - Energy conservation control system in planning

Park View Hospital - Lighting changed to energy saving fluorescent lamps. Energy system planned and 20 percent reduction guaranteed by the supplier

J. C. Penney Company - Delamping program, 250,000 KWH annual savings

K-Mart - 30 percent reduction in lighting

University of California-Riverside - Computer demand control installed. In-house energy conservation committees.

Another smaller load management program has been conducted by Riverside, involving an appeal to swimming pool owners to install an extra set of on/off trippers on existing time switches.

Chamber of Commerce Actions

The Riverside Chamber of Commerce, in response to the 1973 Arab oil embargo, embarked on a program to "de-escalate" outdoor sign illumination. This action was, however, short-lived, and is no longer being promoted by the Chamber of Commerce. More recently, the Chamber's Conservation Committee has inaugurated a series of seminars and workshops aimed at local business and industry to promote conservation in all types of energy use.

March Air Force Base Programs

A major local building-related energy conservation program is the one at March Air Force Base at the southern edge of Riverside. This program emphasizes operational conservation actions, maintenance to sustain equipment efficiency, and a certain amount of retrofit. Although March Air Force Base is not within the corporate boundaries of Riverside, its (over) 5,000 military and over 1,200 civilians are a major influence on the local economy.

Regional Efforts

Locally-based and advocated energy conservation programs are often difficult to implement effectively because of fear that large factions of the business and industrial communities may move to areas with less stringent requirements. Energy conservation programs that are advocated and implemented on a regional basis create a more uniform operational climate, and may therefore not only be more effective but may permit additional local programs to flourish under their umbrella of uniformity. For example, a regional energy conservation plan that includes certain tax penalties for non-compliance may induce some communities in that region to step up their conservation efforts by offering incentives for compliance. This example shows that it may be advantageous to consider punitive/disincentive programs at the regional level, and to permit individual communities to offer rewards for compliance at their own discretion. If this were done, communities could compete in an environment that offers uniform punishment for noncompliance, yet permits each community to allocate its own, unique rewards for compliance.

The mechanisms to permit such a symbiosis between local and regional programs do not yet exist in the Riverside region. Few, if any, regional entities of government in Southern California carry the legal powers necessary to enforce disincentive programs, and local communities generally do not have the flexible capital or other resources needed to offer significant incentives. As a result, the prominent regional energy conservation programs for buildings are conducted by regional public utility companies - not by regional government units - and they are incentive programs - not punitive ones.

Programs by Southern California Gas Company

Both the Southern California Gas Company and the Southern California Edison Company are now operating under a mandate from their Public Utilities Commission which is causing them to advocate energy conservation on the part of their customers. This mandate essentially states that future rate increase justifications must be accompanied by evidence that the public utilities have actively conducted programs to urge all of their customers to conserve energy.[5]

The resultant energy conservation programs conducted by the Southern California Gas Company have had the most impact on the City of Riverside. This is because Southern California Gas sells to individual customers in Riverside, whereas Southern California Edison sells its electrical power to the City's Public Utilities Department in bulk, who then resells it to individual customers. (For a detailed discussion of Southern California Edison's programs, see the next section of this report.)

---

(5) Public Utilities Commission, State of California: Case No. 9581 for electrical utilities. The Commission stated its intention. . ."to take into account the vigor, imagination and effectiveness of a utility's conservation efforts in deciding upon a fair rate of return and in authorizing new supply . . ." The Public Utilities Commission mandate to the Gas Company emanated from Case No. 9642, issued December 18, 1973, although the Gas Company initiated some conservation programs before that date.

A number of innovative incentive programs are offered by the Southern California Gas Company to its individual customers. A selected number of these programs is described below:[6]

(1) A 10 percent discount on labor and materials for residential customers who contract to have attic insulation installed. This discount is offered periodically in different market areas of the Gas Company.

(2) Consulting services by the Gas Company for industrial customers. Free advice is given on ways and means to conserve gas use, and free adjustments to equipment are made.

(3) The Gas Company offers water flow restrictors and water heater insulation kits for sale at significant discounts to its customers. This discount is offered periodically in different market areas of the Gas Company.

(4) An "800" Area Code Hot Line with a 24-hour answering service for personal advice on energy conservation matters.

(5) A consumer information program with Gas Company representatives who talk to different groups and organizations, or who man "conversation centers" in high-traffic areas of the city.

(6) A "Concern Award" to encourage builders and architects to include energy-saving features exceeding those required by building standards for new homes and apartments. New housing developments qualifying for this award are featured as energy-conserving projects featured in Gas Company-paid advertising in local newspapers, and Gas Company representatives are present in model homes to help market the energy-saving features.

(7) Similar "Concern Award" programs exist for manufactured housing and for commercial and industrial customers.

---

(6) Based on notes of an interview held between T. Martineau and Mr. Vic Sterling, Area Services Manager of Southern California Gas Company, Riverside, on October 4, 1977.

(8) A Real Estate Retrofit Pilot Program to encourage the retrofitting of older homes. The Program, now discontinued, encouraged home sellers to have their homes weatherized before the sale, thus making the homes more valuable and more saleworthy.

At the present time, the Gas Company continues actively to promote such programs among its customers in Riverside.

Programs by Southern California Edison Company

Southern California Edison Company has an equally intensive and multifaceted energy conservation program; however, its impact on the City of Riverside has not been as direct as that of the Gas Company's. This difference stems from the fact that, while the Gas Company sells to individual customers in Riverside, Southern California Edison sells its power in bulk to Riverside's Public Utilities Department, who in turn, resells it to individual customers in Riverside via its own power grid. This resale relationship causes the impact of Southern California Edison's conservation programs to be once removed from the customers. Southern California Edison can therefore only promote energy conservation through the mass media in Riverside rather than mandate or directly influence such action. Because the City of Riverside would have to bear the cost of implementing any direct programs, few have been initiated. In addition, since revenues to the City partly consist of net earnings from the resale of Southern California Edison's power, successful efforts to obtain significant conservation would reduce Riverside's revenues. In fact, to maintain the level of income to the City's General Revenue Fund; Riverside would need to increase utility rates in direct proportion to the amounts conserved, thus nullifying any financial advantages of energy conservation. Coupling this condition with the fact that Riverside--not Southern California Edison--must pay for implementing its own conservation programs, it is clearly evident that

Riverside may have little incentive to initiate bold and comprehensive programs to conserve electricity. In spite of this situation, the record indicates a significant leveling in the rate of electrical consumption beginning in 1973. (See Figure A-4, A-11 of Appendix A.) This leveling can be attributed largely to a combination of (1) the closing of the local Alcan plant, (2) leveling of new construction, (3) higher energy costs, (4) voluntary actions on the part of large industry, and (5) appeals through the mass media as well as the programs promoted by the City, the Chamber of Commerce, and the Southern California Gas Company.

Because of the potential future applicability of many of the Southern California Edison programs to Riverside, a brief synopsis is presented herewith. This synopsis is taken verbatim from Southern California Edison's 1977 Conservation Report.(7)

---

(7) For a full description of these programs, consult "Conservation Report for the California Public Utilities Commission", submitted by Southern California Edison Company, Rosemead, California, March 31, 1977. (Presumably, an annual update is provided to the PUCO by SCE.)

Discussion of Conservation Programs and Activities

In 1976, Edison was involved in eleven specific conservation programs, as well as various load management and waste heat projects. Some of the programs evolved from energy management programs implemented in 1973; others were put into effect during 1976 to strengthen conservation efforts.

Following is a brief recap of the 1976 programs.

Home Insulation

Edison acted as a primary contractor for a home insulation service and subcontracted installations to qualified, licensed contractors. Provision was made for customer installment payment of charges for insulation materials and services.

In order not to duplicate efforts of the Southern California Gas Company, the program was implemented only in Barstow/ Victorville and Long Beach since these areas were not served by that utility.

The success of this program was rather limited. Low customer response resulted in only 13 sales per month as compared to the 33 per month anticipated. The program was not considered as cost effective in comparison with other programs ($4.67 per kwh saved) due to the low kilowatthour savings. The savings were low due to all of the homes having gas heat and a smaller proportion than expected having air conditioning.

The decision as to whether Edison will continue the program in its present form will be dependent upon the decision reached by the Commission as a result of the Insulation OII (Order Instituting Investigation), Case No. 10032, now being investigated.

Electric Water Heating Conservation Program

The goal of this program was to reduce the electric energy used in providing hot water for showers in addition to other energy reductions due to water savings. Through a mailer, electric water heating customers were offered a free shower-flow control device to reduce the amount of water being used.

Twenty-six percent of the customers receiving the mailer requested the device. A survey showed that 32 percent of those requesting the device installed it, resulting in a total of 20,182 devices installed. The cost to Edison to distribute the device was $2.13 each.

Advertising

Bill stuffers and media advertising were used to convey messages to residential customers. Several brochures were also distributed giving specific suggestions for saving energy.

The Advertising Department in cooperation with the Educational Services Department also developed a teachers kit and supportive materials to encourage conservation among elementary school children.

Consumer Education Program

Consumer Services Consultants continued with group meetings stressing the need for conservation. The thrust of the program was to contact a wide range (ethnic, income, age, etc.) of residential customers in group meetings to discuss ways to conserve energy in the home. The efficient use of all residential appliances was emphasized with the 116,889 customers who were contacted in these meetings.

Energy Conservation Kit for New Customers

In 1976, 489,000 residential customers requesting electric services received a conservation kit containing information on understanding the electric bill, how to read the meter, and appliance usage and operation cost.

The customers receiving the kit were surveyed; of those who remembered receiving the kit, 47 percent used the information and 31 percent took action.

Sure Actions for Valuable Energy Savings (S.A.V.E.S.)

To personalize residential energy conservation techniques a computer program called S.A.V.E.S. was developed. This conservation program was not implemented during 1976, but the questionnaire and computer output were completed. The program was implemented in April 1977.

Expanded Information/Publicity

Activities which were supportive of the conservation ethic and of specific conservation programs were intensified during 1976. A syndicated column was provided to newspapers under the title of "Conservation Corner" and several brochures were prepared to help residential customers evaluate appliance purchase and use by cost of operation.

Commercial/Industrial/Public Authority Energy Audit

By direct contact with commercial/industrial customers, Edison Energy Services Representatives conducted energy audits seeking where and when electricity was being used. These contacts included customers with demands over 200 kw. When specific actions were taken by a customer these were noted along with kilowatt demand and kilowatthour reductions, as well as improvements in power factor. Results for 1976 showed that energy used by these customers was reduced by an annualized 395,000,000 kwh.

Commercial Customer Contact Program

During 1976, an accelerated effort was made to extend the successful Energy Audits Program to small commercial and industrial customers to effectively reduce kilowatthours used by this customer class. These contacts included customers with demands ranging from 20 to 200 kw. To make the contacts, it was estimated that twenty additional personnel would be required.

The program was implemented in January with existing manpower. Throughout the year, new personnel were hired, but by year-end, the target of twenty new people had not been reached. As a consequence, the results for the program were not as high as anticipated.

Solar Water Heating Demonstration/Publicity Program

To stimulate public interest and acceptance of solar energy as a viable method of providing hot water, a solar demonstration program was implemented. The program was not readily received by the construction industry due to housing market conditions; however, three projects involving 649 units were under negotiation at the end of 1976.

Load Management

Edison continued to investigate and test cost-effective load management techniques during 1976. Load management programs included time-of-use rate experiments, domestic water heater tests, and air conditioning demand-limiting investigations.

To promote the shift of load from on-peak to off-peak periods, rate design was one alternative tested. Contacts were made with all Edison's very large power (5MW and above) customer group through the Energy Services Representative and a time-of-use pricing schedule was filed with the Commission for review and consideration.

Other load management alternatives involved the installation of demand limiting equipment. One program was a test of radio-controlled water heating to determine the impact on the Edison system from the control of electric water heaters and the customer's reaction to the system.

An air conditioning demand limiting device on residential air conditioning was also tested. This device cycled air conditioning compressors whenever the outside temperature reached a certain point. The objective was to determine the diversity of the operation of air conditioning compressors and any resulting reduction in peak demand.

Waste Heat/Cogeneration

As part of Edison's efforts to investigate all alternatives for load management and energy conservation, work continued on proposals involving utilization of waste energy and cogeneration. Serious negotiations were opened with four of eight industrial customers identified as having cogeneration potential. In addition, Edison's Very Large Customer Class was analyzed for other cogeneration possibilities.

Other Conservation-Related Activities

Other departments at Edison were not directly linked to a specific conservation program but were related to conservation. These were the Load Research staff who implement and monitor load management activities; the supportive activities of Corporate Communications including public inquiries, speakers bureau, and training; projects of the Research and Development Department mainly relating to building applications involving solar and thermal storage; and industrial and hydraulic tests conducted by Customer Service on a customers equipment indicating operating characteristics and efficiency.

Additionally, other activities supporting conservation were performed by the Corporate Communications Department. These activities included publications and prepared statements for employee and general media distribution. These publications included information related to specific conservation programs as well as to the overall reinforcement of the conservation ethic. The activities were as follows: publication of the employee newspaper, The Edison News; publication of a retired employee newsletter, The SCE Scene an external newsletter, The Energy Scene, and the issuance of media news releases.

Notes on conservations held with Southern California Edison's Conservation Planners[8] show that the "Commercial/Industrial Public Authority Energy Audit" for users over 200   is considered to be the most successful program, yielding an annual reduction of nearly 400 million kwh, and exceeding program goals by over 40 percent. It is significant to point out that this program was available to the large users in Riverside. The actual rate of application of this program with industrial, commercial and public users in Riverside has been low, since Southern California Edison does not extend its programs directly to the electricity users in Riverside, and Riverside must rely on its own funding and manpower to conduct them.

Statewide Programs

California's programs to develop building codes which encourage the construction of energy-efficient buildings are among the most far-reaching in the United States. These programs, effective July, 1978, are described in three documents available from the State of California's Energy Resources Conservation and Development Commission.[9]

Residential Codes

The standards for new residential buildings indicate design guidelines for minimum levels of insulation, for the placement of vapor barriors, for passive solar energy design for glazing areas and minimum thermal resistance of glazing, and for minimum levels of infiltration.

---

(8) Interview between T. Martineau and L. Welling of Battelle with Joan Fill, Southern California Edison Company, Rosemead, California, October 5, 1977.

(9) "Conservation Division Regulations Establishing Energy Conservation Standards for New Residential Buildings and New Nonresidential Buildings" as amended December 14, 1977, describes the basic governing regulations. Two design manuals, "Energy Design Manual for Residential Buildings", dated April 1976, and "Energy Conservation Design Manual for New Nonresidential Buildings", dated October, 1977, provide detailed guidance for compliance to architects and engineers.

With respect to climate control systems and equipment, the standards provide a methodology for the selection of systems by life cycle cost calculation, and they set parameters for equipment efficiencies, equipment sizing, (50 percent over design heat load now, 30 percent after January 1, 1979)and for the workmanship quality of hot and cold air circulation ducts. Water heating systems are the third and final area for which parameters are given. Electric resistance water heating is generally discouraged, unless life cycle cost calculations show it to be equivalent to that of natural gas or solar installations. Swimming pool heating systems are similarly governed, and insulation is required for steam or condensate piping and for hot water piping in unheated areas. Enforcement of this residential code is delegated to local code enforcement authorities. In areas without such enforcement capabilities, the State will review plans and specifications. The State is the final authority on the interpretation of this code, and a dispute procedure is established to resolve differences in code interpretation between applicants and building departments. Locally promulgated codes are acceptable substitutes only if they are more stringent than the State's code. Procedures to hear claims for exemption from this code are provided to accommodate situations where substantial design occurred prior to code inception, but where construction is expected after inception.

The residential building code requirements for energy conservation are, in their major provisions, generally equal to those set forth in ASHRAE Standard 90-75, entitled "Energy Conservation in New Building Design", and released by ASHRAE's Committee on Standards in August, 1975. However, two additional provisions in the California Code go beyond ASHRAE 90-75 and may thus make it more effective than the 7.5 percent energy savings for single-family homes or the 45.4 percent savings for low-rise multifamily apartments (as forecast for ASHRAE 90-75 in the western United States).[10]

---

(10) "An Impact Assessment of ASHRAE 90-75" Conservation Paper Number 43B, prepared for the Federal Energy Administration, Office of Conservation and Environment, by D. Little, Inc., 1975, pp 40-47.

These two provisions are:

(1) the requirement of life cycle cost analysis for the selection of climate control systems, and

(2) the encouraged use of passive solar design by permitting certain glazing areas of southern orientation to be exempt from the maximum glazing rules.

However, no data have been discovered to date to substantiate any claims that the California residential energy conservation standard is more effective than ASHRAE 90-75. As a result, it should be conservatively assumed that the impact of the California standard will be similar to that of ASHRAE 90-75, especially since actual results will depend heavily on the vigor and accuracy of code enforcement and code interpretation.

Nonresidential Codes

The provisions of the nonresidential energy conservation building code differ significantly from those of the residential code just described. Essentially, compliance with the nonresidential code may be obtained in one of three ways.

(1) New designs may be developed to fall within certain energy budgets (Btu/sq.ft./yr) for given building types to satisfy code requirements;

(2) New designs that obtain 40 percent of their thermal energy needs or 20 percent of all energy needs from nondepletable sources will be in compliance with the code,

(3) New designs may be developed in compliance with the code if they fall within the restrictions placed on the design of the building envelope, the HVAC systems and equipment, the service water heating systems, and electrical and the lighting system. Enforcement procedures, procedures for the hearing of exemption claims, and other administrative regulations are similar to those described for the residential code.

It is difficult to determine whether the California nonresidential code is equal in its potential impact to that estimated for ASHRAE 90-75. A cursory and preliminary comparison between the California code and ASHRAE 90-75 reveals some aspects to be equal, others to be more stringent in one code, and yet others to be more stringent in the other. In an attempt to estimate the possible savings from the California code, it has been projected that average annual savings for the City of Riverside will be 1.95×10^6 kwh from 1977 to 1995.(11) Based on Riverside's annual consumption of roughly 1×10^9 kwh at the present time, this savings would appear to be negligible, e.g. on the order of .2 percent of electrical use per year through 1995.

This illustration demonstrates that building codes governing the energy efficiency of new buildings have a negligible effect on overall energy savings. This is the case because:

(1) New buildings generally make up only a small part of most communities' building inventories.

(2) New buildings always add to a community's total energy use, unless they are totally reliant on renewable fuels, or unless an existing building of equal size is demolished and thus removed from the inventory. Only after many years will the cumulative savings from new construction become substantial, and only after the existing building inventory has either been retrofitted or removed will maximum savings be realized.

---

(11) Data from "Prepared Testimony of Bill F. Roberts, dated June 15, 1977, for the State Energy Resources Conservation and Development Commission of the State of California, Docket No. 76-NOI-2", pp b-27 to b-34, Section entitled "Conservation Savings from Title 24 Building Standards".

Summary Statement Concerning Current Energy Conservation Efforts Affecting Building in Riverside

The foregoing description of current energy conservation efforts shows that a number of forces are already influencing energy conservation in the buildings at Riverside. The characteristics of these forces are as follows:

(1) On the local scene, no official government efforts affect the entire building inventory at the present time. The buildings owned and operated by local (city, county) government are, however, being operated with energy consciousness.

(2) Programs by the two major public utility companies in the Riverside area have made an impact on the energy consumed in the residential, commercial and industrial sectors of Riverside. This is especially true of Southern California Gas Company programs. Programs by the Southern Claifornia Edison Company have been less effective because Edison sells its power to Riverside in bulk, and the City resells the power to individual customers, meaning that Edison's programs can only be offered indirectly, via the City to Riverside customers, and the City must pay for the cost of implementing such programs.

(3) Statewide building codes for energy conservation in new residential and nonresidential facilities are just now being implemented.[12] Since Riverside has had no such building codes of its own, the implementation of these new statewide codes constitutes the first enforcement of energy efficient design and construction in Riverside, but savings are generally expected to be negligible overall.

It is clear from the above description that energy conservation in the buildings of Riverside since 1973 has largely resulted from individual initiative on the part of building owners, with guidance and support from programs originated by the major gas and electric utilities serving the City. In addition, it is evident that the future application of the new statewide building codes will increase the energy efficiency of newly constructed buildings but will not have an immediate, significant effect. Two significant shortcomings exist in this present thrust to conserve energy in the Riverside buildings. These are:

- The absence of a concerted, locally controlled and systematic program to conserve the energy used by the buildings in Riverside
- The lack of programs directed at upgrading the energy efficiency of the largest and most significant component of Riverside's building inventory -- the existing building stock. Although building codes governing new construction do result in "savings" by reducing the <u>increase</u> in energy demand, codes requiring retrofit will result in actual <u>reductions</u> of present energy use.

---

(12) A less stringent version of the current residential code has been in effect since 1974.

Possible programs and mechanisms to deal with these shortcomings are explored on subsequent pages.

CONSIDERATIONS FOR THE DEVELOPMENT OF A LOCALLY CONTROLLED, COMPREHENSIVE PROGRAM FOR ENERGY CONSERVATION IN THE BUILDINGS IN RIVERSIDE

The City of Riverside presently has no active or official plan or program directed at reducing the amount of energy consumed by all buildings within its boundaries. The possible structure and components of such a program are considered below.

Program Structure

The City of Riverside has, within its governmental structure, a Public Utilities Department, a Public Works Department and a City Planning Department. The major functions of these and other departments are succinctly explained in a Riverside Chamber of Commerce Publication entitled "Builders and Developers Handbook for Commercial and Industrial Development."(14)

It is within these existing departments that the control and operation of an energy conservation program for buildings is most appropriately based. The most prominent role, and perhaps primary, program responsibility, should be given to the Planning Department, since building plans are reviewed and approved in its Current Planning Division. Moreover, the development of utilities, especially electrical service and public works, plays a major role and is therefore closely linked with current and future planning activities. Based on this

---

(14) Published by the Riverside Chambers of Commerce, Riverside-Arlington-La Sierra, 4261 Main Street, Riverside, 1975.

reasoning, a Coordinator of Energy Conservation could be established within Riverside's Planning Department. This Coordinator would be responsible for development and carrythrough of an energy conservation program for buildings in Riverside. The components of such a program are multifaceted and require that the activities of many program participants be coordinated and guided in accordance with designated goals.

Program Inputs

Several major inputs to the program must be sought, dealt with and coordinated by the Coordinator of Energy Conservation. These inputs for the Riverside community are derived both internally as well as externally.

External Inputs

Inputs from outside the community come primarily from:

- the Federal Government
- the State of California Government
- the major utilities serving Riverside
- the private research and development community in the U.S.

The Federal Government's Inputs. Probably the most significant input consists of financial assistance with the development of energy conservation programs. The newly created cabinet-level Department of Energy is at this time just beginning to formulate various national programs to assist localities with energy conservation efforts. One of the most developed of these programs is a weatherization grants program that has, during the past four years, been administered by the Community Services Administration. This program will, in 1978, be transferred to the Department of Energy, and be significantly expanded. The weatherization grants program provides financial grants to local communities for the purchase of weatherization materials for homes owned by low-income families. The communities must pay for the labor or use available manpower covered under the CETA (Comprehensive Employment Training Act) provisions. Frequently, this program is carried out by local community action agencies (CAA's) who obtain the grants, purchase the materials for weatherization, hire the manpower, and qualify families who are low-income homeowners. The City of Riverside's Division of Energy Conservation could act in a fashion similar to the CAA's, and administer this as well as any other Federally sponsored program.

Another significant input from the Federal Government is in the form of research data, advice and other guidance to help communities develop energy conservation programs. The Department of Energy's Community Systems Branch is the major source of such information.

Finally, the Federal Government influences local communities by energy legislation and executive mandates. For example, possible legislation permitting homeowners to deduct the cost of energy conservation measures from their Federal Income Tax will influence the policies that need to be followed at the local level.

Inputs from the California State Government. The State's most prominent input to Riverside's local energy programs consists of the statewide residential and nonresidential building codes for energy conservation already described. In addition, some Federal Programs may provide financial assistance to the States for statewide energy programs. Finally, the State of California itself will be spending $500 million on energy conservation and energy development, and some of these funds may become available to Riverside.[15]

---

(15) "Governor Jerry Brown Launches $500 Million Energy Program" in The Energy Daily, January 12, 1978. This article points out that $200 million will be earmarked to retrofit State buildings and State-run schools and universities.

Inputs from the Major Utilities. As previously described, programs by the Southern California Gas Company to encourage energy conservation have already made some impact on Riverside. If the City of Riverside were to work together with the Gas Company and increase consumer response to these programs, it would be possible for even greater conservation to result. Since Southern California Gas can already reach its customers directly, the above effort may not be as important as an effort by the City to work with Southern California Edison, who cannot reach any consumers directly.

Inputs from the Private Research and Development Community in the United States. In addition to the external inputs already mentioned, the City of Riverside may wish to consider contracting private consultants and experts to conduct special energy-conservation studies. Such studies can often be funded with assistance from the State of California or the Federal Government.

Internal Inputs

A most important series of inputs to a Riverside Coordinator of Energy Conservation comes from within the Riverside Community. The originators of such inputs are :

- industry and business
- interest groups and individuals

Industry and Business Inputs. The role of industry and business in an energy conservation program for Riverside can be significant because the buildings and facilities of industry and business are generally energy-intensive in character. In addition, the rapid rise of energy costs has increased the costs of doing business in Riverside, while the anticipated shortages of natural gas have made industries concerned about alternative fuels. As a result, businesses and especially industry in Riverside have realized that it is imperative to reduce energy use and switch to less costly fuels in order to remain competitive.

Using perhaps the Riverside Chamber of Commerce as a liason with a Riverside Coordinator of Energy Conservation, businesses and industry could develop procedures and programs which would seek a systematic energy conservation effort across all business and industry, large and small.

Inputs from Interest Groups and Individuals. Specific inputs from interest groups and individuals cannot be identified at this time. However, it must be stressed that such organizations and their members should be sought as allies in the energy conservation effort by Riverside's government. In general, the roles of such community interest groups should be that of educator and catalyst: to spread the word that energy conservation in buildings is both necessary and in the interest of Riverside. Individual citizens should also be recruited by Riverside as volunteers to work within neighborhoods and to support energy conservation efforts by their own example.

The external and internal inputs described above are summarized in the table below.

TABLE C1-1. EXTERNAL AND INTERNAL INPUTS TO RIVERSIDE'S BUILDING ENERGY CONSERVATION PROGRAM

DIVISION OF ENERGY CONSERVATION OF THE DEPARTMENT OF PLANNING, REVERSIDE	
Federal Government Financial assistance, research data, advice and guidance legislation, directives	Research & Development Funding of external research & development for energy conservation
California Government Energy conservation building codes, financial assistance	Business and Industry Program to enable all businesses and industry to conserve energy
Major Utilities Cooperation with City in energy conservation programs	Interest Groups/Individuals Educators or catalysts in the community

Program Components

Considering the external and internal inputs, a series of program components can be examined to determine where and how such inputs might be used.

Program Intensity Levels

Three levels of intensity can be defined for the conduct of an energy conservation program for buildings. Riverside's program will most likely operate on the first two levels.

Level One: Educational Programs. This level is characterized by appeals to conserve energy in buildings, and also consists of programs that teach people how to conserve this energy. Several of the programs already developed by the Southern Claifornia Gas Company and by the Southern California Edison Company are conducted at this level. These programs should be examined and incorporated as much as possible into the Riverside program in cooperation with the utilities. Furthermore, Riverside could study ways in which guidebooks or seminars for homeowners could be developed and how small businesses and industry could be given useful information. In this case, the energy audit programs for small businesses and industries, as developed by the utility companies, may be worth further study.

Level Two: Regulatory Programs. With the impending implementation of the State Energy Conservation Building Codes for residential and nonresidential buildings, the City of Riverside, as an agent of the State Government, will be required to perform an energy conservation program for buildings. As a result, Riverside will be operating on this second level, even if no other programs are instituted. For the best possible administration of these codes, careful study should be given to the possible needs within Riverside's government staff for additional training and personnel. Also, the possibility of retrofitting existing buildings for energy conservation should be examined as a possible Level-Two Program. Thereafter, other regulatory measures, such as a code that is more stringent than the State Code, may be considered.

Level Three: Mandatory Programs. With the exception of mandatory code compliance, no programs of a mandatory nature presently impact or directly effect Riverside. A possible mandatory program that may be considered by Riverside is the escalation of retrofit programs from Level Two to Level Three. Under Level Two, such programs would regulate rehabilitation or renovation of buildings to include retrofit for energy conservation. Under Level Three, the retrofit of existing buildings would be made mandatory by a certain date (e.g., by December 31, 1984) or penalties would be imposed. Other mandatory programs would most likely arise because of extreme energy emergencies and should not be expected to be commomplace in Riverside's energy conservation program for cuildings.

Various Program Scopes

An energy conservation program for buildings in Riverside may, in addition to the above levels, cover various scopes. Riverside will most likely be served best by considering all of the possible scopes first, and later on by subtracting or eliminating any program elements no longer considered necessary.

Building Types. At the present time energy conservation programs for all building types -- residential, commercial, industrial and institutional -- should be considered.

Existing or New Construction: Programs at Level One address education about energy and conservation in existing buildings on a largely operational level (e.g., setting back thermostats, reducing lighting levels, putting up storm windows). This does not accomplish as much as could be done to make existing buildings more energy efficient. New construction will soon be dealt with on a more comprehensive basis by means of the State Energy Conservation Codes. Measures to make all buildings more energy efficient should be considered.

Energy Conservation Measures. Educational (Level One) programs frequently deal only with operational measures that require no special construction or retrofit. Some programs add maintenance measures, such as the periodic servicing of energy systems to assure proper operation at top, specified performance levels. Finally, some programs at the regulatory level consider energy conservation measures that require substantial retrofit or new design that differs significantly from conventional design practice. Riverside's energy conservation program should cover all such measures.

The foregoing description outlines some of the basic considerations for the development of an energy conservation program for the buildings of Riverside. Such a program would fill one of the two shortcomings previously identified. The second shortcoming -- a lack of programs dealing effectively with the existing building stock -- can be filled by developing a special component of Riverside's overall building energy conservation program: a code for retrofit and rehabilitation of existing facilities.

CONSIDERATIONS FOR THE DEVELOPMENT OF MEASURES TO UPGRADE THE ENERGY EFFICIENCY OF EXISTING BUILDINGS IN RIVERSIDE

Riverside has a substantial inventory of existing residential, commercial, industrial and institutional structures. A vast majority of this inventory was constructed prior to 1970. As a result, few of these buildings approach the insulation levels or other energy-efficient measures presently required under the State's building code. Ways and means to bring these existing buildings to a higher level of energy efficiency would therefore yield significant reductions in the energy consumed by Riverside's buildings.

Level-One Program Considerations

Appeals via the media, aimed especially at homeowners, have in the past been made and may have had a response from this target market group. A continuation of such appeals should be considered, and the scope of such appeals should include other building owners, such as those of apartments, businesses and industry. The appeals should stress the need for retrofit, in addition to operational and maintenance measures.

Level-Two Program Considerations

Riverside should consider the development of a building code for retrofit. This code should, to the extent possible, have requirements that equal those containted in the State's Energy Conservation Codes for new residential and nonresidential buildings. At Level Two, a requirement could be instituted by which plans for renovations, additons or alterations to existing buildings must comply with this retrofit code.

Level-Three Program Considerations

On this mandatory level, consideration may be given to the establishment of a deadline by which all existing buildings must comply with the retrofit code.

RECOMMENDATIONS FOR THE IMPLEMENTATION OF AN ENERGY CONSERVATION PROGRAM FOR THE BUILDINGS OF RIVERSIDE

On the basis of the foregoing discussion of program considerations, it is now possible to examine various individual recommended programs or actions that will lead to the implementation of a comprehensive energy conservation program for the buildings in Riverside. These recommended programs will be studied under the following eight topics:

(1) When the program should be implemented
(2) Who should have primary responsibility for the program
(3) Who should provide inputs to the program
(4) The level or levels at which the program should operate
(5) The scope to be covered by the program
(6) Possible constraints to program implementation
(7) Possible incentives to encourage cooperation with the program
(8) Potential energy savings that may result from program implementation.

A description of recommended programs follows, in the order in which they should be implemented:

RECOMMENDED OPTION NO 1.
ESTABLISH THE POSITION OF ENERGY COORDINATOR IN THE CITY PLANNING DEPARTMENT

Recommended Time of Implementation

Appointment of an Energy Coordinator to oversee all energy-related activities of the City is an essential component of a concerted conservation effort. Duties of the Energy Coordinator are discussed in some detail in this section as regards building activities, however his duties should be wider and include industrial processing and transportation energy conservation. This individual (optionally, with one assistant) would serve as a liaison between the Public Utilities, Public Service and Planning Departments in developing and implementing the City's energy programs. The creation of this position should occur on or before January 1, 1979.

Inputs

External inputs should be explored in three ways: first, in the form of possible funding from State or Federal Sources; second, advice from other local governments on energy programs already established by them; third, ongoing inputs from Federal and State Governments, from public utilities, and from private research and development organizations.

Internal inputs should also be explored in a similar manner: first, in the form of advice and support from Departments and Divisions in City Hall; second, in the form of advice and support from leadership in the community (business, industry and citizens' groups); third, ongoing liaison with working units in City Hall and with interest groups in the community.

Levels of Operation

The Energy Coordinator should advocate, develop and administer programs at all levels. Level one effort should include education programs as a resource for the community. These programs may include:

- development of and distribution of pamphlets and handbooks for homeowners and apartment building owners on operational and maintenance and retrofit measures for energy conservation
- seminars for homeowners and apartment building owners on the same topics
- energy audit programs and free advice for business and industry on operational, maintenance and retrofit measures for energy conservation
- the periodic discussion in the local media of the current energy position of Riverside, of future programs to improve that position, and of appeals for cooperation from all interest groups in Riverside.

Programs of a similar nature are already being conducted by the local utility companies and by the City's Public Utilities Department. Consideration should therefore be given to the direct use of these programs, or to the possible coordination of such ongoing efforts.

At Level Two, the establishment of a liaison with the State for the Administration of the State Energy Conservation Building Codes will be a primary function. While the actual enforcement and on-line examination of plans, specifications and construction projects will remain with the City's Building Division, the Energy Coordinator would be concerned with:

- implementation of new amendments to the Code and new related regulations as these are handed down by the State
- programs arising in Code enforcement that should be brought to the attention of the State
- the development of alternative code provisions that would improve upon the provisions in the State's energy Code
- the development of special regulations that would provide incentives to owners of existing buildings to upgrade their facilities' energy efficiency.

Once again, some incentive programs are already being used by the public utilities, and these may be integrated by the City with the cooperation of these utility companies.

At Level Three, the Energy Coordinator should be concerned with the mandatory provisions already in existence in the State's Energy Code, but only to the extent already described under Level Two: as a liaison with the State to obtain new amendments and regulations or to call enforcement problems to the attention of the State.

Other Level Three considerations may consist of:

- development of a code and program which mandates that all Riverside buildings must meet such a code's energy conservation requirements by a certain future date
- development of preparedness programs in the event of an energy emergency.

Scope

The Energy Coordinator should seek to develop and implement a complement of programs that span a broad scope including:

- all building types should be covered
- new as well as existing construction should be dealt with
- energy conservation efforts should include the operation, maintenance as well as the design and construction of buildings for energy efficiency.

Possible Constraints to Implementation

Adequate funding and additional staffing for this new Coordinator is perhaps the major constraint to implementation. Another important constraint to the proper implementation will be potential lack of community support for municipal energy activities.

Possible Incentives

State and/or Federal financial support is likely to be an important incentive for the successful implementation of this program. Once the program is established, effective and factual educational campaigns pointing out the benefits to be derived from energy conservation will provide possible impetus for support from the community.

Potential Energy Savings

This option would represent all energy conservation activities in all Building Programs for the City of Riverside. As a result, energy savings realized from the option would contribute to the sum of the savings realized from all of these activities.

RECOMMENDED OPTION NO. 2: PREPARE FOR OPTIMUM ADMINISTRATION OF NEW RESIDENTIAL AND NONRESIDENTIAL STATE ENERGY CODES

Recommended Time of Implementation

Inasmuch as the new State codes take effect in March of 1978, preparations should be made immediately to develop all needed services and capabilities for their best possible administration.

Primary Responsibility

Because the Division of Buildings in the City's Planning Department has a major review and approval function over building plans and specifications, the primary responsibility should rest with this Division. Actions that should be taken immediately are:

- to assess whether or not the present manpower can sufficiently handle the additional workload created by the administration of these new code requirements
- to assess whether or not the Building Division's staff has the understanding and knowledge required for exact and fair administration of the new code
- to prepare staff increase requests and to hire new staff if additional inspectors and code administrators are needed.
- to prepare or seek training programs for staff if better understanding and knowledge of the new codes are needed.
- to inform the local construction industry (architects, builders, developers, etc.) of the existence and nature of the new code requirements

Inputs

Major inputs will be needed externally from California's Energy Resources Conservation and Development Commission. Among these inputs are:

- possible financial assistance for payment of salaries of additional code administrators and inspectors (with possible direct assistance form the Federal Government)
- materials for training and orientation of administrators and inspectors, or for seminars conducted directly by the State's Commission
- materials that present the code provisions in condensed form for use in the preparation of publicity statements informing the construction industry about the new code.

Other external inputs may be needed from the Gas and Electric Companies. These inputs may consist of information and design guidelines developed by the utilities to aid with code compliance. Coordination of review and approval procedures should be established with the utility companies.

Internally, Riverside should seek advice from developers in business and industry on the best logistics and procedures for code approvals, and establish a liaison with the Chamber of Commerce for the purpose of obtaining business and industry feedback on possible improvements to the code or its administration. Similar liaisons should be established with interest groups in the residential sector.

Levels of Operation

At Level One, the program should perform two important educational functions: to inform the construction industry about the new code, and to train Building Division staff in the particulars of the code's provisions.

At Level Two, the program operates as a mechanism to regulate the design and construction of new residential and nonresidential buildings.

At Level Three, the program makes code compliance mandatory -- compliance is necessary before construction permits can be issued. (The code provides for exemptions under some limited, unusual circumstances.)

Scope

All residential and nonresidential building types are covered, with a few minor exceptions. The program only deals with new construction and is limited to energy conservation measures achieved through design and construction.

Possible Constraints to Implementation

Although the administration of these codes is mandated by the State of California, local jurisdictions will be responsible to use their own resources for such administration. As a result, the quality of code interpretation and enforcement will depend upon the ability of Riverside's building and construction inspectors to perform this function. Inadequate staff with insufficient training will therefore prevent an optimum administration of these new codes. If Riverside cannot apply its own resources to provide sufficient staff with proper training, or if the City cannot obtain assistance from other sources to make such provisions, the implementation of the program will suffer.

Possible Incentives

The local gas and electric companies have, as previously described, developed and implemented a variety of programs offering incentives to conserve energy in Buildings. The "Concern Award" program, for example, offers publicity and assistance with sales to home-builders who build energy-conserving homes. Riverside should explore possible incentive programs that the utilities could offer to architects or builders if they develop and use low-cost methods to comply with the codes, or if they develop innovative ways to use nondepletable energy sources to obtain partial or complete exemption from the codes.

Potential Energy Savings

It must be pointed out that, in a strict sense, little energy savings will result from this program. Attachment C1-1 shows that the effect of this program will instead be a reduction demand of about $.187 \times 10^9$ Btu to 904×10^9 Btu of the amount of the total stationary energy consumption in Riverside by the year 2000 from buildings that will be added to Riverside's building inventory. The minimum figure is for the low population growth, low impact effort and the maximum is for the high population growth, high impact effort. This 0.9 to 3.5 percent reduction will only be achieved if the new codes are vigorously and eruditely enforced. Based on analyses of the impacts of similar standards,(16) possible reductions in individual building types over new buildings not designed with the code may be:

- single family residents, approximately 7 percent
- low-rise multi-family, approximately 40 percent
- office buildings, approximately 50 percent
- retail stores, approximately 35 percent
- schools, approximately 50 percent.

RECOMMENDED OPTION NO. 3:
DEVELOP PROGRAMS TO INCREASE THE ENERGY EFFICIENCY OF RIVERSIDE'S EXISTING BUILDINGS

Recommended Time of Implementation

No immediate urgency exists. However, as soon as the Coordinator of Energy Conservation is established, as recommended earlier, it should be one of the foremost goals of this activity to upgrade Riverside's existing building stock.

Primary Responsibility

Riverside's Energy Coordinator should have primary responsibility for this program. The Coordinator should develop an energy building code applicable to renovations, alternations and retrofit of existing buildings. This code should be as closely equivalent to the energy codes for new construction as possible. No building permits for rehabilitation projects should be issued unless plans meet this energy code.

Inputs

The Energy Coordinator needs input and advice from the City Building Department on the proper requirements and procedures for the issuance of permits for renovations, alternations and retrofits. External inputs may consist of information on similar programs implemented or under study elsewhere.

Levels of Operation

If the regulations require that construction permits for work on existing buildings will only be issued if the construction meets prescribed codes, then the operation occurs on the regulatory Level Two. However, mandatory Level-Three requirements may also be considered. Such mandatory measures could be:

- that no property may be resold until it meets the code, or
- that all property must be upgraded to meet the code by a certain date (e.g., December 31, 1984).

Scope

The energy-efficient design and construction aspects of all existing buildings are covered.

Possible Constraints to Implementation

Opposition from building owners, especially organized opposition from business and industry, is the major possible constraint.

Possible Incentives

Property tax credits, tax reductions or other variations of tax incentives are possible. Since the City owns its own utility company, temporary rate reductions could be offered as incentives.

Potential Energy Savings

The percent reduction in energy demand for individual building types can be expected to be the same as those shown for Option No. 1, except that these reductions are true savings, not merely reductions in the increase of energy use, and will thus have a greater impact on total energy comsumption. Assuming 50, 75, or 100 percent compliance for low-, moderate- and high-impact efforts, respectively, the total annual reduction of energy demand in the year 2000 is estimated to range from 660 x 10^9 Btu to 1186 x 10^9 Btu. (See Attachment C1-1).

Reductions in Riverside's total stationary energy demand from retrofitting existing buildings for energy conservation range from 2.5 to 6 percent. It should be remembered that these reductions are for existing buildings and are additional to energy savings realized from new buildings.

If it were assumed that Riverside had no growth and retrofitted existing buildings to the same schedule suggested in this program, percent savings of present total stationary energy demand would be 4, 6, and 8 percent for low-, moderate- and high-impact efforts, respectively.

RECOMMENDED OPTION NO. 4: SEEK CONTINUED IMPROVEMENT OF THE ENERGY BUILDING CODES FOR NEW AND EXISTING RESIDENTIAL AND NONRESIDENTIAL BUILDINGS

Recommended Time of Implementation

This option has no immediate urgency; instead, this should be an ongoing program by the Energy Coordinator to seek better standards and criteria for energy-efficient design and construction. With the next 12 months, a program plan should be fully developed.

Primary Responsibility

Riverside's Coordinator of Energy Conservation will be responsible for the identification and recommendation of new standards for improving the existing codes.

Inputs

Major inputs come from municipalities that have already developed significant codes or performance standards.[18] Other inputs may come from private research and development sources and from organizations that advocate new standards and criteria.

Levels of Operation

New codes or amendments to codes generally operate at the regulatory Level Two.

Scope

New codes or amendments to codes will most likely affect new construction, assuming existing construction will have been largely upgraded by their time of implementation. The design and construction of all building types, or of only residential or nonresidential, may be affected.

Possible Constraints to Implementation

Constraints will most likely result from insufficient funding and manpower for the Coordination of Energy Conservation.

Possible Incentives

No program incentives can be identified.

Potential Energy Savings

Until the nature of possible improvements to the present codes is known, no energy savings can be postulated.

(18) For example: "An Ordinance Establishing Energy Conservation Performance Standards for Residential Construction Within the City of Davis", Oct. 15, 1975.

SUMMARY OF RECOMMENDATIONS

Although the five recommended options may, on the surface, appear to be a small number of activities to deal effectively with building energy conservation in Riverside's buildings, the following table points out that they provide broad coverage across all levels, building types and energy conservation actions.

	Operational Level			Building Categories				Energy Conserving Activities		
	(1) Educational	(2) Regulatory	(3) Mandatory	(1) Residential	(2) Nonresidential	(3) New	(4) Existing	(1) Operational	(2) Maintenance	(3) Design/Const.
Option No. 1: Optimum Code Enforcement	X	X	X	X	X	X				X
Option No. 2: Existing Bldg. Retrofit		X	X	X	X		X			X
Option No. 3: Improvement of Present Codes		X		X	X	X	X			X

While it is recommended that all of the options described be implemented in Riverside, the manner of their presentation in the report allows each program to be studied separately and implemented individually.

Options No. 2 and 3 are admittedly sources of possible dissention and argument among interest groups in Riverside, particularly if mandatory requirements are established. As a result, it is suggested that the moods of the public be studied before attempts are made to implement these programs.

The suggestion to appoint an Energy Coordinator in the Planning Department may be a potential cause for arguments within City Government and for a voicing of opinion by the public. All possible options should therefore be identified and debated before a decision is reached, particularly in view of recent developments associated with Proposition 13.

Option No. 1 is not generally controversial, and should be implemented as soon as possible.

ATTACHMENT C1-1

ESTIMATE OF ENERGY SAVINGS FROM RECOMMENDED OPTIONS FOR ENERGY CONSERVATION FOR BUILDINGS IN RIVERSIDE

RECOMMENDED OPTION NO. 1, ADMINISTRATION OF NEW STATE ENERGY CODES FOR RESIDENTIAL AND NONRESIDENTIAL BUILDINGS

a.1 Energy Demand Per Unit Per Year

- Baseline data based on 1976 statistics
- Explanation of calculations in Appendix A
- Residential on dwelling unit basis; commercial and industrial on square foot basis.
- Space heating and space cooling considered for all calculations, plus 10 percent of base demands for thermal and electrical added for total estimated energy effected by building code.

a.2 Residential (Annual Energy Demand Per Unit)

Single Family

Space Heating 6500 Btuh x 2904 =	18.88×10^6 Btu
Total Thermal (18.88×10^6) + (4600 x 8760 x 0.10) =	22.9×10^6 Btu
Space Cooling 0.43 kw x 4416 =	1899 kwh
Total Electric (1899) + (0.50 x 8760 x 0.10) =	2337 kwh

Multi-family

Space Heating 4600 Btuh x 2904 =	13.36×10^6 Btu
Total Thermal (13.36×10^6) + (4600 x 8760 x 0.10) =	17.39×10^6 Btu
Space Cooling 0.30 kw x 4416 =	1325 kwh
Total Electric (1325) + (0.5 x 8760 x 0.10) =	1763 kwh

Mobile Home

Space Heating 4000 Btuh x 2904 =	11.62×10^6 Btu
Total Thermal (11.62×10^6) + (4600 x 8760 x 0.10) =	15.65×10^6 Btu
Space Cooling 0.27 kw x 4416 =	11.92 kwh
Total Electric (1192) + (4600 x 8760 x 0.10) =	1630 kwh

a.3 Commercial (Annual Energy Demand Per Sq. Ft.

Total Space Heating $(130 \times 10^6) \times 2904$	=	377.5×10^9 Btu
$(377.5 \times 10^9$ Btu$) \div (8.6 \times 10^6$ sq. ft.$)$	=	43.9×10^3 Btu/sq. ft.
Total Thermal $(43.9 \times 10^3) + [(150 \times 10^6)$ $(8760)\ (0.10) \div (8.6 \times 10^6)]$	=	59.2×10^3 Btu/sq. ft.
Total Space Cooling $(10{,}000 \times 4416)$	=	44×10^6 kwh
$(44 \times 10^6$ kwh$) \div (8.6 \times 10^6$ s.f.$)$	=	5.1 kwh/sq. ft.
Total Electric $(5.1) + [(42 \times 10^3)$ $(8760)\ (0.10) \div (8.6 \times 10^6)]$	=	9.4 kwh/sq. ft.

a.4 Industrial (Annual Energy Demand Per Sq. Ft.)

Total Space Heating $(45 \times 10^6) \times 2904$	=	130.7×10^9 Btu
$(130.7 \times 10^9$ Btu $\div (5.0 \times 10^6$ s.f.$)$	=	26.1×10^3 Btu/sq. ft.
Total Thermal $(26.1 \times 10^3) + [(150 \times 10^6)$ $(8760)\ (0.10 \div (5.0 \times 10^6)]$	=	52.4×10^3 Btu/sq. ft.
Total Space Cooling (2500×4416)	=	11×10^6 kwh
$(11 \times 10^6$ kwh$) \div (5 \times 10^6$ s.f.$)$	=	2.2 kwh/sq. ft.
Total Electric $(2.2) + [(12 \times 10^3)$ $(8760)\ (0.10) \div (5.0 \times 10^6)]$	=	4.3 kwh/sq. ft.

b. Projected Number Of Residential Units For Calculation Of Demand Savings - Corrected For Community Design, Passive Design And Shading Measures.* (See Appendix C-4)

	Low Impact		Moderate Impact		High Impact	
	Thermal	Electric	Thermal	Electric	Thermal	Electric
Single Family (Detached)						
Low Growth	7635	4772	4554	3711	5121	2651
Moderate Growth	13610	8506	7939	6615	3780	4725
High Growth	21379	13362	12471	10392	5945	7423
Multifamily						
Low Growth:						
Duplex	834	463	6901	826	10839	1298
Low Rise	2597	1298	4630	2315	7271	3635
High Rise	440	440	783	783	1232	1232
Moderate Growth:						
Duplex	1488	826	10233	1535	16073	2411
Low Rise	4630	12315	6047	3023	9498	4749
High Rise	783	783	1730	1730	2717	2717
High Growth:						
Duplex	7514	1153	13394	2055	21040	3228
Low Rise	3976	1988	7087	3543	6456	5565
High Rise	1924	1924	3430	3430	5390	5390
Mobile Home						
Low Growth	519	519	519	519	519	519
Moderate Growth	925	925	925	925	925	925
High Growth	1453	1453	1453	1453	1453	1453

* Shading assumed to save 50 percent of electrical requirements for cooling.

c. Calculation Of Decrease In Energy Demand In 2000 By Category And Level Of Conservation Effort

Sample. (# New Housing Units) Energy Demand/Unit 1-b) (Percent Savings for Category)

c.1 Residential -

1.1 Single Family - (Estimate 7 Percent Savings)

	Low Impact		Moderate Impact		High Impact	
	Thermal	Electric	Thermal	Electric	Thermal	Electric
Low Growth	12.2×10^9 Btu	0.8×10^6 kwh	7.1×10^9 Btu	0.5×10^6 kwh	8.2×10^9 Btu	0.4×10^6 kwh
Moderate Growth	21.8 "	1.4 "	12.7 "	1.1 "	6.1 "	0.8 "
High Growth	34.3 "	2.2 "	20.0 "	1.7 "	9.5 "	1.2 "

1.2 Multifamily (Est. Savings Duplex 25%; Low Rise 45%; High Rise 55%

	Low Impact		Moderate Impact		High Impact	
	Thermal	Electric	Thermal	Electric	Thermal	Electric
Low Growth: Duplex	3.6×10^9 Btu	0.2×10^6 kwh	30.0×10^9 Btu	0.4×10^6 kwh	47.1×10^9 Btu	0.6×10^6 kwh
Low Rise	20.3 "	1.0 "	36.2 "	1.8 "	56.9 "	2.9 "
High Rise	4.2 "	0.4 "	7.5 "	0.8 "	11.8 "	1.2 "
Moderate Growth:						
Duplex	6.5 "	0.4 "	44.5 "	0.7 "	69.9 "	1.1 "
Low Rise	36.2 "	1.8 "	47.3 "	2.4 "	74.3 "	3.8 "
High Rise	7.5 "	0.8 "	16.5 "	1.7 "	25.9 "	2.6 "
High Growth:						
Duplex	32.7 "	0.5 "	58.2 "	0.9 "	91.5 "	1.4 "
Low Rise	31.1 "	1.6 "	55.5 "	2.8 "	50.5 "	4.4 "
High Rise	18.4 "	1.9 "	32.8 "	3.3 "	51.6 "	5.2 "

1.3 Mobile Homes (Estimated 7 Percent Savings)

	Low Impact		Moderate Impact		High Impact	
	Thermal	Electric	Thermal	Electric	Thermal	Electric
Low Growth	0.6×10^9 Btu	0.06×10^6 kwh	0.6×10^9 Btu	0.6×10^6 kwh	0.6×10^9 Btu	0.6×10^6 kwh
Moderate Growth	1.0 "	0.1 "	1.0 "	0.1 "	1.0 "	0.1 "
High Growth	1.6 "	0.2 "	1.6 "	0.2 "	1.6 "	0.2 "

1.4 Residential Summary - 2000 Demand Decreases

	Low Impact		Moderate Impact		High Impact	
	10^9 Btu Thermal	10^6 kwh Electric	10^9 Btu Thermal	10^6 kwh Electric	10^9 Btu Thermal	10^6 kwh Electric
Low Growth						
Single Family	12.2	0.8	7.1	0.6	8.2	0.4
Multifamily	28.1	1.6	73.7	3.0	115.8	4.7
Mobile Home	0.6	0.06	0.6	0.06	0.6	0.06
TOTAL	40.9	2.5	81.4	3.7	124.6	5.2
Moderate Growth						
Single Family	21.8	1.4	12.7	1.1	6.1	0.8
Multifamily	50.2	3.0	108.3	4.8	170.1	7.5
Mobile Home	1.0	0.1	1.0	0.1	1.0	0.1
TOTAL	73.0	4.5	122.0	6.0	177.2	8.4
High Growth						
Single Family	34.3	2.2	20.0	1.7	9.5	1.2
Multifamily	82.2	4.0	146.5	7.0	193.6	11.0
Mobile Home	1.6	0.2	1.6	0.2	1.6	0.2
TOTAL	118.1	6.4	168.1	8.9	204.7	12.4

c.2 Commercial

2.1 Projection of Commercial* Floor Space To 2000

	1976 Commercial Space Sq. Ft. x 10^6	Commercial Sq. Ft. Added by 2000 Sq. Ft. x 10^6	Total Commercial Space in 2000 Sq. Ft. x 10^6
Low Growth	8.6	2.1	10.7
Moderate Growth	8.6	3.7	12.3
High Growth	8.6	5.7	14.3

2.2 Estimated Commercial Savings Are:

Low Impact	30 percent
Moderate Impact	40 percent
High Impact	50 percent

* Commercial floor space in future estimated to be in ratio of 1.7:1 to industrial space. Total Commercial and Industrial space in 1976 estimated to be 13.6 x 10^6 sq. ft. Growth in space at same ratio as population growth.

2.3 Decrease In Space Heating And Cooling Demand By 2000 For Commercial

	Low Impact		Moderate Impact		High Impact	
	Thermal $x10^9$ Btu	Electric $x10^6$ kwh	Thermal $x10^9$ Btu	Electric $x10^6$ kwh	Thermal $x10^9$ Btu	Electric $x10^6$ kwh
Low Growth	37.3	5.9	65.7	10.4	101.2	16.1
Moderate Growth	49.7	7.9	87.6	13.9	134.9	21.4
High Growth	62.2	9.9	109.5	17.4	168.7	26.8

c.3 Industrial

3.1 Projection Of Industrial* Floor Space To 2000

	1976 Industrial Space Sq. Ft. x 10^6	Industrial Space Added by 2000 Sq. Ft. x 10^6	Total Industrial Space in 2000 Sq. Ft. x 10^6
Low	5.0	1.2	6.2
Moderate	5.0	2.2	7.2
High	5.0	3.4	8.4

3.2 Estimated Industrial Savings Are:

Low Impact	20 percent
Moderate Impact	30 percent
High Impact	40 percent

* Total Commercial and Industrial space in 1976 estimated to be 13.6 x 10^6 sq. ft. Industrial space in 1976 is remainder after subtracting commercial space at ratio of 1.7:1 to industrial space.

3.3 Decrease In Thermal And Electrical Demand By 2000 For Riverside

	Low Impact		Moderate Impact		High Impact	
	Thermal x10^9 Btu	Electric x10^6 kwh	Thermal x10^9 Btu	Electric x10^6 kwh	Thermal x10^9 Btu	Electric x10^6 kwh
Low Growth	12.6	1.0	23.1	1.9	35.6	2.9
Moderate Growth	18.9	1.5	34.6	2.8	53.4	4.4
High Growth	25.2	2.1	46.1	3.8	71.3	5.8

d. Total Overall Reduction In Energy Demand In 2000 By End Use Sector, Level Of Impact And Population Growth

	Low Impact		Moderate Impact		High Impact	
	Thermal x10^9 Btu	Electric x10^6 kwh	Thermal x10^9 Btu	Electric x10^6 kwh	Thermal x10^9 Btu	Electric x10^6 kwh
Low Growth:						
Residential	40.9	2.5	81.4	3.7	124.6	5.2
Commerical	37.3	5.9	65.7	10.4	101.2	16.1
Industrial	12.6	1.0	23.1	1.9	35.6	2.9
TOTAL	90.8	9.4	170.2	16.0	261.4	24.2
Moderate Growth:						
Residential	73.0	4.5	122.0	6.0	177.2	8.4
Commercial	49.7	7.9	87.6	13.9	134.9	21.4
Industrial	18.9	1.5	34.6	2.8	53.4	4.4
TOTAL	141.1	13.9	244.2	22.7	365.5	34.2
High Growth:						
Residential	118.1	6.4	168.1	8.9	204.7	12.4
Commercial	62.2	9.9	109.5	17.4	168.7	26.8
Industrial	25.2	2.1	46.1	3.8	71.3	5.8
TOTAL	205.5	18.4	323.7	30.1	444.7	45.0

e. Percent Reduction In Total Riverside Stationary Energy Demand For Low, Moderate And High Population Growth And Low, Moderate And High Energy Conservation Efforts

	Low Impact	Moderate Impact	High Impact
Low Growth	0.9%	2.0%	3.0%
Moderate Growth	1.0%	2.0%	3.0%
High Growth	1.5%	2.5%	3.5%

Recommended Option No. 2. Develop Programs To Increase The Energy Efficiency Of Riverside's Existing Buildings

a. Basis Of Calculations

- Energy per unit the same as for Program No. 1
- Retrofit will be according to same conditions as the new state energy code i.e., level of savings will be the same as in Reference 1.

b. Existing Number Of Residential Units For Calculation Of Demand Savings--Corrected For Number To Be Shaded By 2000

	Low Impact*		Moderate Impact*		High Impact*		Total Units in 1977
	Thermal	Electric	Thermal	Electric	Thermal	Electric	
Single Family (Detached)	22600	20800	33900	31200	45200	41600	45200
Multifamily							12400
(15.5%) Duplex	961	906	1442	1360	1922	1812	1922
(73%) Low Rise	4526	4031	6789	6047	9052	8062	9052
(11.5%) High Rise	713	713	1070	1070	1426	1426	1426
Mobile Homes	1100	950	1650	1425	2200	1900	2200

* Estimate Impacts To Be Based On Percentage Of Units Retrofitted By 2000 As Follows:

Low	50 percent
Moderate	75 percent
High	100 percent

- Units shaded by 2000 effect cooling (electric)- for number of units see Appendix C-4.
- Assume shading decreases cooling electric needs 50 percent.

c. Calculation Of Decrease In Energy Demand In 2000 By Category And Level Of Conservation Effort

c.1 Residential - Decrease In Thermal And Electrical Demand In 2000 From Retrofit Of Buildings

	Low Impact		Moderate Impact		High Impact	
	Thermal $\times 10^9$ Btu	Electric $\times 10^6$ kwh	Thermal $\times 10^9$ Btu	Electric $\times 10^6$ kwh	Thermal $\times 10^9$ Btu	Electric $\times 10^6$ kwh
Single Family (7%)	36.2	3.4	54.3	5.1	72.5	6.8
Multifamily						
Duplex (25%)	4.2	0.4	6.3	0.6	8.4	0.8
Low Rise (45%)	35.4	3.2	53.1	4.8	70.8	6.4
High Rise (55%)	6.8	0.7	10.2	1.0	13.6	1.4
Mobile Homes (7%)	1.2	0.1	1.8	0.2	2.4	0.2
TOTAL	83.8	7.8	125.7	11.7	167.7	15.6

c.2 Commercial

- Commercial space in 1976 estimated to be 8.6 million sq. ft.
- Estimate commercial savings is as follows:

  Low Impact 30 percent
  Moderate Impact 40 percent
  High Impact 50 percent

	Low Impact		Moderate Impact		High Impact	
	Thermal $x10^9$ Btu	Electric $x10^6$ kwh	Thermal $x10^9$ Btu	Electric $x10^6$ kwh	Thermal $x10^9$ Btu	Electric $x10^6$ kwh
Commercial	152.7	24.3	203.6	32.3	254.6	40.4

c.3 Industrial

- Industrial space in 1976 estimated to be 5.0 million sq. ft.
- Estimated industrial savings is as follows:

Low Impact	20 percent
Moderate Impact	30 percent
High Impact	40 percent

Decrease In Thermal And Electrical Demand In 2000 From Retrofit Of Industrial Buildings

	Low Impact		Moderate Impact		High Impact	
	Thermal $x10^9$ Btu	Electric $x10^6$ kwh	Thermal $x10^9$ Btu	Electric $x10^6$ kwh	Thermal $x10^9$ Btu	Electric $x10^6$ kwh
Industrial	52.4	4.3	78.6	6.5	104.8	8.6

d. Total Overall Reduction In Energy Demand In 2000 By End Use Sector And Level Of Impact Due To Retrofit Of Existing Buildings

	Low Impact		Moderate Impact		High Impact	
	Thermal $x10^9$ Btu	Electric $x10^6$ kwh	Thermal $x10^9$ Btu	Electric $x10^6$ kwh	Thermal $x10^9$ Btu	Electric $x10^6$ kwh
Residential	83.8	7.8	125.7	11.7	167.7	15.6
Commercial	152.7	24.3	203.6	32.3	254.6	40.4
Industrial	52.4	4.3	78.6	6.5	104.8	8.6
TOTAL	288.9	36.4	407.9	50.5	527.1	64.6

e. Percent Reduction In Total Riverside Stationary Energy Demand In 2000 By Low, Moderate And High Energy Conservation Efforts In Retrofitting Existing Buildings

	Low Impact	Moderate Impact	High Impact
Low Population Growth	3.5%	5%	6%
Moderate Population Growth	3%	4%	5%
High Population Growth	2.5%	3.5%	4.5%

ATTACHMENT C1-2

HISTORIC, CURRENT AND PROJECTED
RESIDENTIAL BUILDING INVENTORY

HISTORIC, CURRENT AND PROJECTED NUMBERS OF RESIDENTIAL UNITS IN RIVERSIDE

Historical Data

Among the statistical data available on the number of residential units in Riverside, the years 1966 through 1974 are represented in information from the 1970 U.S. Census and from a Riverside Area Postal Vacancy Survey. This information is displayed as follows:

TABLE I. NUMBER OF RESIDENTIAL UNITS BY TYPE AND YEAR IN RIVERSIDE

	Number of Single-Family Homes	Number of Multifamily Units	Number of Mobile Homes	Total Units
1-1-66	34,987(b)	7,866(b)	350(c)	43,203(c)
1-1-67	35,187(b)	8,023(b)	400(c)	43,610(c)
1-1-68	35,462(b)	8,256(b)	450(c)	44,168(c)
1-1-69	35,812(b)	8,652(b)	500(c)	44,964(c)
4-1-70	36,213(a)	9,174(a)	541(a)	45,928(a)
1-1-71	36,421(d)	10,400(d)	718(c)	47,539(d)
1-1-72	36,791(d)	11,606(d)	782(c)	49,179(d)
1-1-73	37,255(d)	12,851(d)	1,005(c)	51,111(d)
1-1-74	37,886(d)	13,929(d)	1,176(c)	52,991(d)
1-1-75	38,105(d)	14,583(d)	1,212(c)	53,900(d)

Sources of Data:

(a) 1970 Census Data.
(b) Planning Department, City of Riverside - "Population and Housing".
(c) Battelle estimate based on available data sources (a), (b), and (d).
(d) Riverside Planning Department - "Riverside Area Postal and Vacancy Survey".

Of the figures shown in the above table, the ones as of 4-1-70 are the most reliable and accurate because they reflect the official 1970 Census. These census data are also available in greater detail, reflecting a finer breakdown of residential building types.

TABLE II. DETAILED BREAKDOWN OF 1970 CENSUS DATA
FOR THE NUMBER OF RESIDENTIAL UNITS IN RIVERSIDE ON 4-1-70

Number of Single-Family Homes	36,213	(78.8 percent)	
Number of Units Built as Duplexes	1,726	(3.75 percent)	(20 percent)
Number of Units Built in 3- or 4-Plexes	1,993	(4.34 percent)	
Number of Units in Buildings Housing 5-49 Units	4,724	(10.30 percent)	
Number of Units in Buildings Housing 50+ Units	731	(1.61 percent)	
Number of Mobile Homes	541	(1.20 percent)	
Total	45,928	(100.0 percent)	

Thus, the 1970 ratio of single family to multifamily to mobile home units is approximately 78.8 percent : 20 percent : 1.2 percent, or 65-2/3 : 16-2/3 : 1. A more detailed examination of this ratio in a historical context reveals the following trend.

TABLE III. HISTORIC RATIO OF SINGLE-FAMILY DWELLINGS TO MULTIFAMILY DWELLINGS TO MOBILE HOME UNITS

Year	Single Family :	Multifamily : (Percent)	Mobile Home
1966	81.0	18.2	0.8
1967	80.7	18.4	0.9
1968	80.3	18.7	1.0
1969	79.6	19.2	1.2
1970	78.8	20.0	1.2
1971	76.7	21.8	1.5
1972	74.8	23.6	1.6
1973	72.9	25.1	2.0
1974	71.5	26.3	2.2
1975	70.7	27.1	2.2

This trend shows that during the 10 year period 1966-1975, the proportion of single-family homes has decreased in favor of a marked increase in the share of multifamily units, and a slight increase in mobile homes. Other data show evidence that in the multifamily category, the duplex category has experienced a drop in its share while the types of multifamily units housing more than five dwellings have increased their share of all multifamily dwellings. However, the available data are not sufficient to permit this to be substantiated by numbers.

Estimate Of Current Number Of Residential Units in Riverside

Using the historical data and indicated trends as a basis, the current number and mix of residential units in Riverside can be estimated with some reliability.

The current housing stock in Riverside (mid-1977) is estimated to to be 56,700, distributed as follows:

Single-Family Homes	39,000	(68.8 percent)
Multifamily Units	16,100	(28.4 percent)
Mobile Homes	1,600	(2.8 percent)

The current distribution of multifamily residential building types may be estimated on the basis of the detailed 1970 Census information displayed previously in Table II. By strict transfer of the ratios displayed in that Table to the 16,100 multifamily units estimated for mid-1977, the following breakdown results:

Duplexes	3,019	(18.75 percent)
Triplex, Quadriplex	3,494	(21.70 percent)
5-49	8,291	(51.50 percent)
50+	1,296	(8.05 percent)
Total	16,100	

However, the 1970 Census already noted a trend of a lessening in duplex construction and of an increase in multiple units, especially in the 50+ category. As a result, the mix of multifamily units was modified to reduce the proportion of duplexes and to increase the proportions of the 5-49 and 50+ categories:

Duplexes	2,500	(15.5 percent)
Triplex, Quadriplex	3,200	(20.0 percent)
5-49	8,600	(53.0 percent)
50+	1,800	(11.5 percent)
Total	16,100	

Based on the above discussion, the current number of residential units (as of mid-1977) in Riverside is estimated as follows:

Single-Family Homes			39,000	(68.8 percent)
Multifamily Units			16,100	(28.4 percent)
Duplexes	2,500	(15.5 percent)		
Triplex, Quadriplex	3,200	(20.0 percent)		
5-49	8,600	(53.0 percent)		
50+	1,800	(11.5 percent)		
Mobile Homes			1,600	(2.8 percent)
Total			56,700	(100.0 percent)

Projected Number Of
Residential Units In Riverside To 2000

(For details of this projection see Appendix C-4).

ATTACHMENT C1-3

ESTIMATE OF ANNUAL ENERGY SAVINGS, ADDED COST, SAVINGS IN FUEL COST, AND PAYBACK PERIOD FOR RECOMMENDED CONSERVATION OPTIONS IN SINGLE- AND MULTIFAMILY RESIDENTIAL, OFFICE, RETAIL STORE AND EDUCATIONAL STRUCTURES

INTRODUCTION

Paybacks were calculated for ten different conditions:

- 5 separate prototype buildings (single family, multifamily, office building, retail store, school)
- 2 different assumptions for each building: first, each is a building yet to be constructed; second, each is an existing structure to be retrofitted.

Major influences can be drawn from the payback calculations as follows:

(1) It is likely that new buildings designed to meet the California Energy Standard will have a slightly lower initial cost than if they had been conventionally designed. Thus, the payback periods in most such instances would be zero. The most likely buildings to have such a lower initial cost are office buildings; the ones least likely to have a lower initial cost are single family homes.

(2) Existing buildings which are significantly below the present California Energy Standard in their thermal performance (e.g., by a factor of 3 or more) make the best retrofit candidates from a payback standpoint.

Buildings whose performance is nearly equal to but somewhat below the California Energy Standard (e.g., by a factor of 1.5 or less) are not likely to show acceptable payback periods for retrofit.

I. Estimated Payback Periods Resulting From A Modification of Conventional Buildings In Order to Make Them Conform to California's New Energy Standard for New Residential and Commercial Buildings

This section examines five prototypical, "conventionally designed" buildings, and estimates the extra installation costs and the costs of energy savings in order to make these buildings conform to California's new energy standard for new residential and commercial buildings.

The Prototypical Buildings

The five prototypical buildings used for this purpose are the same ones developed by A. D. Little and Co. in their 1975 "Impact Assessment of ASHRAE 90-75" for the Federal Energy Administration. These buildings are described by A. D. Little on p. 19 of their report as "... a reasonable representation of current construction practices regarding thermal integrity, and (are) neither indicative of the lower insulation standards common in the not too distant past (e.g., 1970), nor of the higher standards attainable if alternate energy conservation practices are followed".

ASHRAE 90-75 Versus the California Energy Standard

In earlier studies of Riverside's energy situation, it was found that the present California Energy Standard for New Residential Buildings is toughly equivalent to the provisions of ASHRAE 90-75. However, the differences between ASHRAE 90-75 and California's Energy Standard for Nonresidential construction were to unclear to discern any equivalency at that time. At this point, however, the details of the California Nonresidential Standard have become available,and once again show themselves to be basically equivalent to ASHRAE 90-75.

Generally, the application of ASHRAE 90-75 is estimated to bring about the following physical differences in the conventional versus ASHRAE 90-75 modified buildings:

Exterior Glass - Glass area (percent fenestration) was reduced in approximately two-thirds of the buildings. Reductions were as much as 30 percent, but most were less than 20 percent. One region--the North Central--required reductions in glass area for all buildings.

Exterior Wall - Decreases in glass area were balanced by increased in net wall area; virtually all increases were less than 8 percent.

Insulation - Additional insulation requirements for residential construction varied from 80 to 300 pounds per unit. Increased requirements for insulation in commercial construction were even greater than those needed in residential construction.

Lighting - Reductions in lamps and lamp fixtures varied by building type, and averaged 24 percent and 22 percent, respectively, for nonresidential construction.

HVA/C System Capacities - Reductions in heating system capacities were significant, averaging 42 percent, while reductions in cooling systems were generally less, averaging 31 percent. The greatest reductions were found in the school building. Auxiliary HVA/C equipment, including pumps, towers, fans, supply fans, etc., also showed a significant reduction, averaging 44 percent in rated kilowatt capacity.

As a result, the figures developed by A. D. Little and Company in their impact assessment of ASHRAE 90-75 will be used to represent the likely payback periods to be obtained from the use of the California Energy Standards for New Residential and Nonresidential Buildings.

Payback Estimate:
New Single Family Residence

The Prototypical Building:

Total area and configuration: 1700 Sq. ft. (34 x 50)

Number of floors: 1 over crawlspace

Total height: 10 ft.

Ext. walls: 3/4 in. stucco; 8 in. concrete block; 3-1/2 in. fiberglass insulation; light framing; 1/2 in. gypsum wallboard

Fenestration: Single strength glass; 15 percent all walls

Roof construction: Asphalt shingles; 1/2 in. plywood sheathing; 3-1/2 in. fiberglass insulation; 1/2 in. gypsum wallboard; vented attic; roof slope: 3 in 12.

Computations:

Annual energy use/conventional design: 100,400 Btu/ft^2

Annual energy use/ASHRAE 90-75: 92,900 Btu/ft^2

Annual savings: 7,500 Btu/ft^2

Total annual energy savings: 7,500 x 1700 = 12,750,000 Btu

Added cost per ft^2 for ASHRAE 90-75: $0.01/ft^2

Total added cost: $75

Savings in gas heat @ cost of $2/million Btu: $25.50

Payback period for gas heat $17/$25.50 = .67 years (no inflation adjustment needed due to short time period)

Comment:

These favorable figures are due primarily to the additional costs of insulation, weather-stripping and other thermal considerations being offset by smaller sizes of HVA/C equipment being required.

Payback Estimate:
New Multifamily Building

The Prototypical Building:

Total area and configuration: 18,000 sq ft (50 x 180)

Number of floors: 2 over slab on grade

Total height: 24 ft

Ext. walls: 4 in. commbon brick; 1/2 in. plywood sheathing, light framing; no insulation; 1/2 in. gypsum wallboard.

Fenestration: Single strength sheet; 30 percent sidewalls; 0 percent end walls

Roof construction: asphalt shingles; 1/2 in. plywood sheathing; 3 in. fiberglass insulation; 1/2 in. gypsum wallboard; ventilated attic; roof slope 3 in 12.

Computations:

Annual energy use/conventional design: 297,600 Btu/ft^2

Annual energy use/ASHRAE 90-75: 162,600 Btu/ft^2

Annual savings 135,000 Btu/ft^2

Total annual energy savings: 135,000 x 18,000 = 2,430,000,000 Btu

Reduced cost per ft^2 for ASHRAE 90-75 = $-.36

Total reduced initial cost: $6,480

Total cost of annual gas savings @ $2/million Btu: $4,860

Payback period: Zero

Comment:

Initial construction cost is anticipated to be less than conventional construction primarily because of savings in fenestration and HVA/C (equipment and distribution), which more than offset increases in exterior walls, roof, floor insulation, water heating, and distribution. Similar patterns also are in evidence for the remaining prototypical buildings.

Payback Estimate:
New Office Building

The Prototypical Building:

Total area and configuration: 40,000 ft^2 (90 x 150)

Number of floors: 3

Total height: 36 ft

Ext. walls: 1 in. insulated sandwich panel with aluminum mullions; structural steel frame

Fenestration: 1/4 in. plate; 50 percent all walls

Roof: metal deck; 4 in. poured concrete; structural steel frame; 1/2 in. softwood hung ceiling.

<u>Computations</u>:

Annual energy use/conventional design: 248,600 Btu/ft^2

Annual energy use/ASHRAE 90-75: 107,300 Btu/ft^2

Annual savings: 141,300 Btu/ft^2

Total annual energy savings: 141,000 x 40,000 = 5,640,000,000 Btu

Reduced construction cost per ft^2: $-.93

Total <u>reduced</u> initial cost: $37,200

Total cost of annual gas savings @ $2/million Btu: $11,280

Payback period: Zero.

<u>Payback Estimate</u>:
<u>Retail Store</u>

<u>The Prototypical Building</u>:

Total area and configuration: 32,400 ft^2 (180 x 180)

Number of floors: 1 (slab on grade)

Total height: 15 ft

Ext. walls: 12 in. concrete block, painted both sides

Fenestration: 1/4 in. plate; 60 percent south wall, all other walls 0 percent

Roof construction: 4 ply built-up roofing with gravel, 2 in. rigid insulation; steel decking; open web joists; 1/2 in. softboard.

<u>Computations</u>:

Annual energy use/conventional design: 274,000 Btu/ft^2

Annual energy use/ASHRAE 90-75: 169,000 Btu/ft^2

Annual savings 105,000 Btu/ft^2

Total annual energy savings: 105,000 x 32,400 = 3,402,000,000 Btu

Reduced construction cost per ft^2: $-.33

Total <u>reduced</u> initial cost: $10,692

Total cost of annual gas savings @ $2/million Btu: $6,804

Payback period: Zero

Payback Estimate: School Building

The Prototypical Building:

Total area and configuration: 40,000 ft^2 (100 x 400)

Number of floors: 1

Total height: 14 ft

Ext. walls: 4 in. common brick; no insulation; 4 in. concrete block

Fenestration: single strength glass; 20 percent all walls

Roof construction: 4 ply built-up roofing with gravel; 1 in. rigid insulation; 4 in. concrete plank; structural steel framing; 1/2 in. softboard.

Computations:

Annual energy use/conventional design: 153,300 Btu/ft^2

Annual energy use/ASHRAE 90-75: 75,000 Btu/ft^2

Annual savings: 78,300 Btu/ft^2

Total annual energy savings: 78,300 x 40,000 = 3,132,000,000 Btu

Reduced construction cost per ft^2: $-.33

Total reduced initial cost: $13,200

Total cost of annual gas savings @ $2/million Btu: $6,264

Payback period: Zero

II. Estimated Payback Periods Resulting From Retrofit of Existing Structures Built Before the Era of Energy Consciousness (Retrofit to Present Standards for Walls, Ceilings, and Floors)

In this section, the five prototypical buildings are modified to be more typical of structures built between 1955 and 1965. Subsequently, the costs of retrofit and the potential energy savings are estimated, as if the buildings were retrofitted to present California standards.

Payback Estimate: Single Family Home Retrofit

Modifications to Prototype:

1200 ft^2 instead of 1700 ft^2 (30 x 40)

Exterior walls: no insulation

Roof: no insulation

Retrofit Actions:

3-1/2 in. blown insulation for walls

6 in. balten insulation for ceiling

Cost of Retrofit Actions:

- 1,400 ft^2 of cellulose insulation, 3-1/2 in. thick = 410 ft^3
  cost per ft^3 = \$1.40 x 410 = \$574
  Deduct 15 percent for window area: \$488
- 1,200 ft^2 of glass fiber batt, 6 in. thick
  cost per ft^2 = .51 x 1200 = \$612
- Total cost of retrofit actions: \$1,100

Amount of Energy Savings:

- Heat loss through uninsulated wall: U = .41
  " " " insulated wall: U = .08
  ΔU for wall = .33

  $$\text{Saved Btu} = \frac{.33 \times 24 \text{ hrs} \times 2000 \text{ DD} \times 1190 \text{ ft}^2}{.67 \text{ gas efficiency}} = 28{,}133{,}730$$

- Heat loss through uninsulated attic: U = .71
  " " " insulated attic: U = .05
  ΔU for attic = .66

  $$\text{Saved Btu} = \frac{.66 \times 24 \times 2000 \times 1200}{.67} = 56{,}740{,}300$$

Total heat loss saved: 84,874,030 Btu

Value at $2/million Btu for gas: $169.75

- Heat gain saved through wall

  $$\text{Saved Btu} = \frac{.33 \times 31(\Delta t) \times 1000(\text{hr}) \times 1190(\text{ft}^2)}{2 \text{ (AC efficiency)}} = 6{,}086{,}850$$

- Heat gain saved through ceiling

  $$\text{Saved Btu} = \frac{.66 \times 31 \times 1000 \times 1200}{2} = 12{,}276{,}000$$

Total heat gain saved: 18,362,850 Btu

Value at $11.39/million Btu for electricity: $209.14

Payback Calculation:

Total initial cost of retrofit: $1,100

Total annual savings in fuel: $379.00

$$\frac{1{,}100}{379} = 2.9 \text{ years simple payback}$$

Adjustment factor for inflation: .87*

Adjusted payback: 2.9 x .87 = 2.53 years

* Taken from "Selection of Cost-Effective Energy Conserving Features for New Homes" by R. J. Johnson, NAHB Research Foundation, P. O. Box 1627, Rockville, Md. 20850. Assumes 6 percent inflation plus 5 percent fuel cost increase for total of 11 percent.

Payback Estimate:
Multifamily Building Retrofit

Modifications to Prototype:

No modifications. However, it will be assumed that the prototype has been built and, thus, all retrofit actions will constitute an added cost.

Retrofit Actions:

- 3 in. blown insulation in attic above 3 in. already existing
- apply tint to south-facing windows (assume 1/2 of all windows face south)

Cost of Retrofit Actions:

- 9,000 ft^2 of 3 in. thick glass fiber blown insulation
  2,250 ft^3 of insulation @ $1.44/$ft^3$ = $3,240
- 1,296 ft^2 of glass area to be tinted @ .33/ft^2
  = $428
- Total cost of retrofit actions = $3,668

Amount of Energy Savings:

- Heat loss through 3 in. insulated attic: U = .08
- Heat loss through 6 in. insulated attic: U = .05

  ΔU for attic = .03

  $$\text{Saved Btu} = \frac{.03 \times 24 \times 2000 \times 9000}{.67} = 19{,}343{,}283$$

  Value of total heat loss saved @ $2/million Btu = $38.69

- Heat gain through untinted windows: U = 1.06
- Heat gain through tinted windows: U = .64

  ΔU = .42

  $$\text{Saved Btu} = \frac{.42 \times 31 \times 1000 \times 1296}{2} = 8{,}436{,}960$$

  Value at $11.39/million Btu for electricity: $96.10

Payback Calculation:

Total initial cost of retrofit: $ 3,668
Total annual savings in fuel: $134.79

$\frac{3668}{135}$ = 27.17 years simple payback

Adjustment factors for inflation: .38

Adjusted payback: 27.17 x .38 = 10.32 yrs

Comment:

In apartment buildings without insulation in the attic, this payback period could be considerably shortened. In addition, if it were practical to insulate the walls, this should also be done.

Payback Estimate:
Office Building Retrofit

Modifications to Prototype:

No modifications to prototype.

Retrofit Actions:

Tint east, west, south walls fenestration

Add 3 in. of rigid board insulation above metal roof deck

Cost of Retrofit Actions:

5940 ft^2 of glass area to be tinted @ $.33/$ft^2$ = $1,960

13,500 ft^2 of rigid board insulation, with 4 ply built-up roofing and gravel on top $1.98/$ft^2$ = $26,730

Total cost of retrofit actions: $28,690

Amount of Energy Savings:

- Heat gain saved through glass: $\Delta U = .42$

  $$\text{Saved Btu} = \frac{.42 \times 31 \times 1000 \times 5940}{2} = 38{,}669{,}400$$

  Value at $11.39/million Btu for electricity = $440.44

- Heat loss saved through roof
  Heat loss without insulation: U = .37
  Heat loss with insulation: U = .04
  $\Delta U = .33$

  $$\text{Saved Btu} = \frac{.33 \times 24 \times 2000 \times 13{,}500}{.67} = 319{,}164{,}170$$

  Value at $2/million Btu for gas = $638.33

- Heat gain saved through roof

  $$\text{Saved Btu} = \frac{.33 \times 31 \times 1000 \times 13{,}500}{2} = 69{,}052{,}500$$

  Value at $11.39/million Btu: $786.00

  Total amount of annual savings: $1,864

Payback Calculation:

Total initial cost of retrofit: $28,690

Total annual savings in fuel: $ 1,864

$$\frac{38{,}690}{1{,}864} = 15.39 \text{ years simple payback}$$

Adjustment factor for inflation: .59

Adjusted payback: 9.08 years

Payback Estimate:
Retail Store Retrofit

Modifications to Prototype:

No insulation in roof.

Retrofit Actions:

Add 4 in. of roof insulation with built-up roofing and gravel

Add 2 in. of rigid insulation to wall interiors, with finish paneling.

Cost of Retrofit Actions:

32,400 ft^2 @ $1.98/$ft^2$ = $64,152 roof insulation
8,100 ft^2 @ $ .43/ft^2 = $ 3,483 rigid wall insulation
8,100 ft^2 @ $ .84/ft^2 = $ 6,804 paneling
$10,287 total walls

Total cost of retrofit $74,439

Amount of Energy Savings:

Heat loss saved through roof
Heat loss without insulation: U = .49
Heat loss with insulation: U = .04
$\Delta U = .45$

$$\text{Saved Btu} = \frac{.45 \times 24 \times 2000 \times 32{,}400}{.67} = 1{,}044{,}537{,}300$$

Value at $2/million Btu for gas = $2,089

Heat gain saved through roof

$$\text{Saved Btu} = \frac{.45 \times 31 \times 1000 \times 32{,}400}{2} = 225{,}990{,}000$$

Value at $11.39/million Btu for electricity = $2,574

Heat loss saved through walls
Heat loss without insulation: U = .39
Heat loss with insulation: U = .08
$\Delta U = .31$

$$\text{Saved Btu} = \frac{.31 \times 24 \times 2000 \times 8100}{.67} = 179{,}892{,}530$$

Value at $2/million Btu for gas = $360

Heat gain saved through walls

$$\text{Saved Btu} = \frac{.31 \times 31 \times 1000 \times 8100}{2} = 3w,920,500$$

Value at $11.39/million Btu for electricity = $443

Total amount of annual savings: $5,466

Payback Calculation:

Total initial cost of retrofit: $74,439
Total annual fuel savings: $ 5,466

$$\frac{74,439}{5,466} = 13.62 \text{ years simple payback}$$

Adjustment factor for inflation: .62

Adjusted payback: 8.44 years

Payback Estimate: School Building Retrofit

Modifications to Prototype:

No modifications.

Retrofit Actions:

Few retrofit actions are feasible. Walls are different to insulate. 3 in. of rigid insulation can be added to roof.

Cost of Retrofit Actions:

40,000 ft^2 of 3 in. insulation plus 4 ply roofing @ $1.64/$ft^2$
= $65,600

<u>Amount of Energy Savings</u>:

Heat loss saved through roof
Heat loss without insulation: U = .11
Heat loss with insulation: U = .04
$\Delta U = .07$

$$\text{Saved Btu} = \frac{.07 \times 24 \times 2000 \times 40{,}000}{.67} = 200{,}597{,}010$$

Value at $2/million But for gas = $401

Heat gain saved through roof

$$\text{Saved Btu} = \frac{.07 \times 31 \times 1000 \times 40{,}000}{2} = 43{,}400{,}000$$

Value at $11.39/million Btu = $494

Total amount of annual savings: $895

<u>Payback Calculation</u>:

Total initial cost of retrofit: $65,600

Total annual fuel savings: $ 895

$$\frac{65{,}600}{895} = \underline{73.3 \text{ years simple payback}}$$

<u>Comment</u>:

Even if this payback were adjusted for inflation, or if electricity were used as the fuel for heating, this payback would remain unattractive. This points out that the most feasible retrofit situations are with buildings that are significantly underinsulated. When buildings nearly meet the current standards, it becomes very costly to retrofit them for complete compliance with the standards.

C2. ENERGY CONSERVATION OPTIONS IN INDUSTRY

APPENDIX C2

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES
(Continued)

LIST OF FIGURES

C2. ENERGY CONSERVATION OPTIONS IN INDUSTRY

Background

The most commonly employed indicators of energy use in the United States were computed by the Stanford Research Institute, using 1968 data.[1] These estimates, which are still applicable show that industrial energy use is about 41 percent of the total energy consumed; of this 41 percent, about 17 percent is for process steam, 11 percent for direct heat, 8 percent for electric drives, and 5 percent for other purposes. Over three-fourths of the total industrial energy use is concentrated in six key industry groups: primary metals; chemicals; petroleum and coal; stone, clay, and glass; paper; and food.

Industry, particularly large industry, has been conserving energy on its own initiative for some time. Since World War II there has been a rapid decline in energy use per unit of product. From 1954 to 1967 this decline averaged 1.6 percent for all industries and 1.4 percent for the key industries listed above, despite the fact that energy prices were declining during this period.[2] This reduction does not even begin to approach industry's potential for energy conservation. Industry has the alternative of: (1) decreasing the use of energy and (2) increasing the efficiency of energy utilization.

Since 1974, a result of the new energy awareness, many industries have instituted energy conservation and management programs with dramatic results--improvements in energy efficiency ranging from 25 to 50 percent[3], (primarily in large companies and in the most energy-intensive sectors). In 1975, the Environmental Protection and Conservation Act become law (Public Law 94-163), which led to setting energy efficiency improvement targets for the 10 most energy intensive industries.[4] These industries, and their performance to date, as reported through the Department of Commerce's Voluntary Reporting Program,[5] are shown in Table C2-1.

TABLE C2-1. PERFORMANCE TO DATE BY TEN MOST ENERGY INTENSIVE INDUSTRIES IN MEETING EPCA GOALS[5]

Net Energy Efficiency Improvement (1972-1980)

	Target, Percent	Progress, Percent
Chemicals	14	9.1
Primary Metals	9	3.8
Petroleum and Coal	12	12.2
Stone, Clay and Glass	16	7.3
Paper	20	9.3
Food	12	11.4
Fabricated Metals	24	3.8
Transportation Equipment	16	12.3
Nonelectrical Machinery	15	16.8
Textiles	22	11.2

In contrast to the above results, thousands of small manufacturing companies in the U.S. have not, in most cases, become aware of energy problems or even been touched by the complexities of fuel availability, fuel price regulations, etc. With few exceptions, these companies have not experienced an energy crisis and are aware only of the increasing cost which they pay for needed energy supplies.

Obviously, the industry situation in Riverside is not similar to that of the national picture. Characteristics of Riverside's industry are discussed below.

Characterization of Riverside Industry

Almost all of Riverside's industry is located in 12 industrial parks and districts. The City has over 2300 acres zoned for light, medium and heavy industry. About 50 percent is vacant and available in parcels ranging from 1/2 to 300 acres. Industrial properties in Riverside are excellent because they are (1) served by at least one railroad and, in some cases, two or three; (2) close to major freeways; and (3) on level, well-drained land with existing utilities and streets.

There are 96 manufacturing plants in the City of Riverside. Among the top 15 manufacturing employers in Riverside are those producing aerospace and aircraft products, electronic equipment, aluminum products, food processing equipment, food and food container products, and mobile homes and recreational vehicles. Riverside is considered to be a major center for mobile home manufacturers. Table C2-2 shows the top 15 manufacturing employers in Riverside.

Another view of industry in the Riverside area was obtained from the Riverside Chamber of Commerce Industrial Directory.[8] While this directory covers an area larger than the city limits, useful statistics on the general types and size of industry in the area can be obtained. The total of about 296 industrial firms which had coded information on the number of employees were analyzed to obtain the data in Table C2-3.

Companies with less than 100 employees represent 90 percent of the industry in the area. Most of these small companies (particularly the 80 percent with less than 50 employees) conduct service and/or supply activities and

TABLE C2-2. LARGEST MANUFACTURING EMPLOYERS, CITY OF RIVERSIDE, 1977(6)

Rank	Name of Firm	Approximate Employees	Products
1	Bourns, Inc.	1,325	Electric components
2	Fleetwood Homes, Inc.	1,325	Mobile homes
3	Alfred M. Lewis, Inc.	1,200	Food distributors
4	Rohr Industries	950	Aerospace and aircraft components
5	Riverside Daily Press	700	Newspaper and rotary press products
6	American Metal Climax-Amax	450	Aluminum sheet, foil, plate, rod, bar and fabricated products
7	Owens-Illinois - Lily-Tulip, Division	415	Paper and plastic cups, containers
8	Toro Company (Irrig. Div.)	400	Automatic irrigation systems
9	Hunter Engineering Co. Inc.	300	Aluminum rolling mills, stretch-levellers-line, print lines
10	Riverside Cement Co.	285	Cement products
11	Loma Linda Foods	250	Vegetable products, foods, cereals and gravies
12	Cal-Togs of California - BR and BR Sportswear	150	Ladies sportswear
13	E.T. Wall	150	Orange Packer/shipper
14	Broadmore Mobile Homes, Inc.	85	Mobile homes
15	FMC Corporation	75	Food processing equipment

Source: Riverside Chamber of Commerce.

TABLE C2-3. DISTRIBUTION OF INDUSTRIAL FIRMS IN THE RIVERSIDE, CALIFORNIA, AREA ACCORDING TO NUMBER OF EMPLOYEES

Number of Employees	Number of Firms in Each Category
Greater than 1000	2
501 - 1000	2
251 - 500	4
101 - 250	24
51 - 100	26
11 - 50	100
Less than 10	138

could be classified as commercial with regard to the type and amount of energy they use. It is common to look at companies with greater than 100 employees as (1) being large enough to use significant amounts of energy, and (2) having a special interest in energy conservation. About 10 percent (31 companies) fall into this category. Further analysis of these 31 companies resulted in the data shown in Table C2-4.

Although these statistics are based on a broader area than the city limits of Riverside, they are illustrative of the types and sizes of industry there. With reference to Table C2-4, the following observations are presented.

- The largest number of firms in any one category concerns those building mobile homes. This clearly supports the claim that Riverside is a center for this industry. Several of the mobile home companies are part of Fleetwood Industries, which represents one of Riverside's largest industries, as shown in Table C2-2.
- About two-thirds of the largest companies are in the category of energy intensive industries, i.e., cement, aluminum products, food processing, plastics, tranportation equipment, fabricated metals, etc. The Riverside Cement Company is not within the city limits and was not considered in this program, although it was visited because it is a large energy user and the only company in the area using coal as a fuel.
- All of the companies are performing a variety of manufacturing operations having relatively low energy use characteristics, as is discussed in later sections.

Characterization of Industrial Energy Use in Riverside

Characterization of industrial energy use was derived from several data sources. These were:

(1) Direct contacts with industry

(2) Characterization of Riverside Energy Consumption Patterns as described in Appendix A

(3) Energy Conservation Opportunities in Buildings as described in Appendix C-1

(4) Utility data giving electricity and natural gas use of large energy consumers, usually identified only by census tract but also for individual companies in some cases where permission was obtained

TABLE C2-4. TYPES OF INDUSTRIAL FIRMS IN THE RIVERSIDE, CALIFORNIA, AREA WITH MORE THAN 100 EMPLOYEES

Number of Employees	Number of Companies	Type of Business
Greater than 1000	1	Electronics
	1	Aerospace
501 to 1000	1	Newspaper and Rotary Press Products
	1	Cement Products
251 to 500	1	Aluminum Products
	1	Machinery
	1	Manufacturer -- Irrigation Systems
	1	Construction -- Asphalt Mixes
101 to 250	2	Plastics
	2	Transportation Equipment and Machinery
	2	Prefabricated Buildings
	1	Clothing
	4	Fruit Packing
	1	Electronics
	1	Cement Mixing-Pipe
	1	Food Equipment
	7	Mobile Homes -- Recreational Vehicles
	1	Food Processing
	1	Metal Fabrication
	1	Printing

(5) U.S. Environmental Protection Agency Point Source Listings for Riverside Companies, located for 16 companies out of the list of about 60 companies contacted. These Point Source Listings were not useful for determining total energy use, nor for characterizing energy use within the companies. In some cases boiler types and sizes could be obtained, as well as the types of some processing equipment which may contribute to environmental emissions.

Direct Contacts with Industry

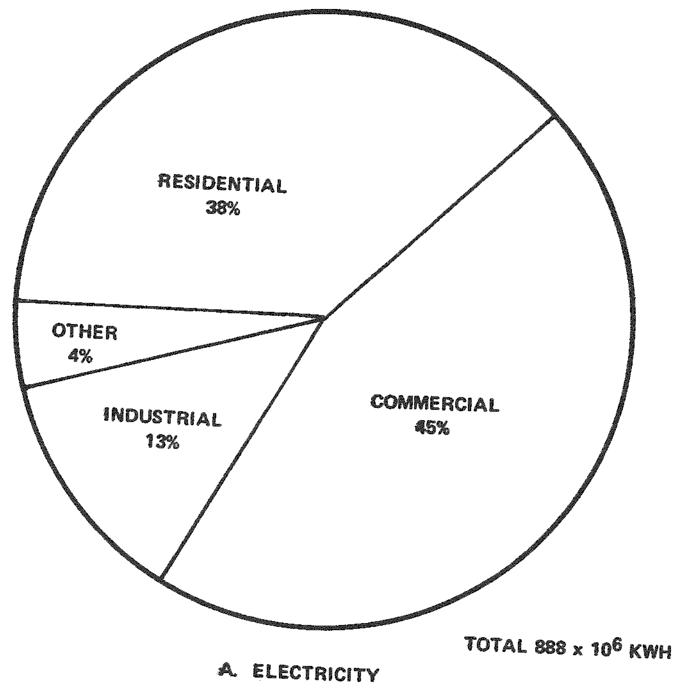
Direct contacts were either letter/questionnaires to a selected group of companies or personal/telephone discussions.

Letter/Questionnaire: Letters were sent to about 60 companies asking for their total energy use for the past 2 years on a monthly basis for all types of fuel/energy used (electricity, natural gas, fuel oil, propane, and gasoline). Companies were selected, indicating the largest energy users and obtaining a cross section of industry types distributed among the census tracts within the Riverside city limits. Very little response was received, and a follow-up letter was sent 2 months later, resulting in 16 responses.

Personal/Telephone: Several of the largest industries were visited one or more times, and numerous telephone discussions were held with companies to which letters had been sent.

Industrial Energy Use Patterns

Distribution of electricity and natural gas use by type of consumer is shown in Figure C2-1. Electricity use is for lighting, power (electric motors, etc.), and space cooling. Natural gas use is for thermal requirements such as space heating, hot water heating, process heat, and cooking. The industrial use of electricity (13 percent total) and natural gas (21 percent total) are small portions of Riverside's total energy consumption, which supports the idea that Riverside is basically a residential community. It is obvious then that the major energy savings from energy conservation will come from the residential and commercial sectors.



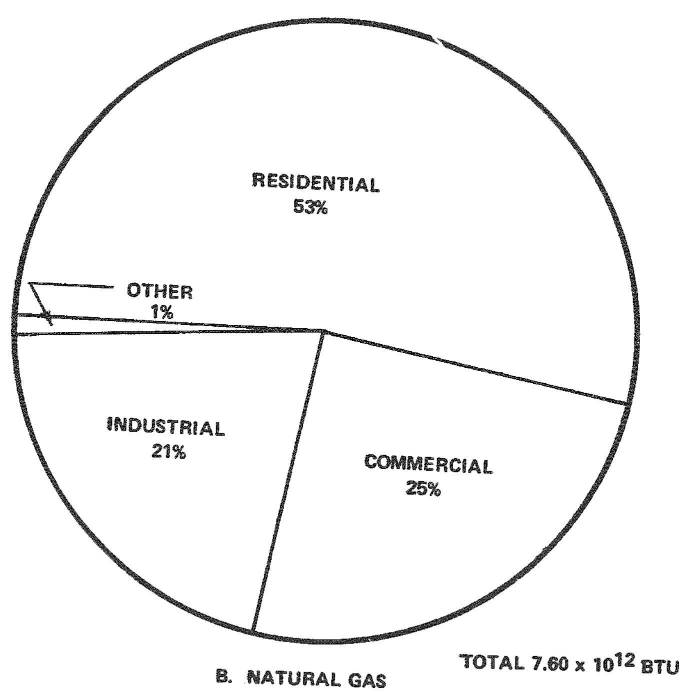


FIGURE C2-1. DISTRIBUTION OF ENERGY USE BY CONSUMER (1976 Normalized Consumption)

Source: Appendix B - Figure B-7.

Data from the Riverside Energy Matrix (Table B-7, Appendix B) were used to produce a Riverside Industrial Energy Use Matrix as shown in Table C2-5, showing subcommunity names and census tracts. It is apparent which communities are residential/commercial (no industrial energy use) and which are industrial. Those census tracts which show industrial energy use are those in which industrial parks are located. A more graphic picture of locations where industrial energy is used in Riverside is shown in Figure C2-2.

The 12 census tracts having industrial operations were ranked in decreasing order of the total energy used, as shown in Table C2-6. This clearly shows where the concentration of industrial energy use is located. Seventy-eight percent of the total industrial energy use is in three census tracts--411/Arlanza-La Sierra, 422.03/University and 305/East Side. The other 9 census tracts have nominal energy use ranging from 5 percent to less than 1 percent of total industrial energy use, and reflect the operations of many small firms each using relatively little energy.

Using data obtained directly from the industrial companies surveyed, further analysis was made which resulted in the following findings:

- Rohr, Inc. dominates energy use in Census Tract 411, using about 50 percent of the total energy amount in this area. Rohr is also the largest natural gas user in Riverside[9] and the third largest electricity consumer supplied by the Riverside Public Utilities Department.[6]
- The University of California at Riverside (UCR) dominates energy use in Census Tract 422.03, using about 50 percent of the total energy amount in this area. UCR is the largest electricity consumer in Riverside being supplied by the Riverside Public Utilities Department[6], and among the largest natural gas consumers.[10] UCR is classed as a commercial customer by the Riverside Public Utilities Department; however, for the purposes of this study it has been considered an industrial user.
- Other significant energy consumers in Census Tract 422.03 are the Lily Division of Owens-Illinois and AMAX. Adding these to UCR accounts for about 75 percent of the total energy used in this area.

TABLE C2-5. RIVERSIDE INDUSTRIAL ENERGY USE MATRIX[a]

Census Tract	Thermal Energy Annual Use, Btu x 10^9	Thermal Energy Percentage of Total	Electrical Energy Annual Use, kwh x 10^6	Electrical Energy Percentage of Total	Total Use[b] Btu x 10^9
			North End		
301	0	0	0	0	0
423	0	0	0	0	0
North End	0	0	0	0	0
			Down Town		
302	0	0	0	0	0
303	16.3	5.3	3.9	9.2	56.8
Downtown	16.3	3.6	3.9	6.7	56.8
			Mountain View		
308	0	0	0	0	0
Mountainview	0	0	0	0	0
			East Side		
304	96.6	46.3	10.4	46.8	106.1
305	212.2	48.2	18.9	38.5	404.9
East Side	308.8	49.8	29.3	41.1	511.0
			University		
422.02	0	0	0	0	0
422.03	452.4	79.5	49.6	73.3	505.9
University	452.4	51.2	49.6	42.4	505.9
			Box Springs		
422.04	0	0	0	0	0
Box Springs	0	0	0	0	0
			Airport		
309	33.6	37.1	1.8	21.6	18.4
Airport	33.6	37.1	1.8	21.6	18.4
			Magnolia Center		
307	0	0	0	0	0
310	0	0	0	0	0
311	7.5	3.7	0.79	3.3	15.6
Magnolia Center	7.5	0.9	0.79	0.5	15.6

TABLE C2-5. (Continued)

Census Tract	Thermal Energy Annual Use, Btu x 10^9	Thermal Energy Percentage of Total	Electrical Energy Annual Use, kwh x 10^6	Electrical Energy Percentage of Total	Total Use(b) Btu x 10^9
		Canyon Crest			
422.01	0	0	0	0	0
Canyon Crest	0	0	0	0	0
		Victoria			
306	0	0	0	0	0
312	0	0	0	0	0
Victoria	0	0	0	0	0
		Ramona			
314.01	0	0	0	0	0
314.02	0	0	0	0	0
315.01	0	0	0	0	0
315.02	0	0	0	0	0
Ramona	0	0	0	0	0
		Casa Blanca			
313	28.0	22.0	3.0	14.3	58.6
Casa Blanca	28.0	22.0	3.0	14.3	58.6
		Arlington			
316	7.6	2.1	0.35	0.5	11.2
Arlington	7.6	2.1	0.35	0.5	11.2
		Green Belt			
317	30.7	20.4	5.6	30.9	87.8
Greenbelt	30.7	20.4	5.6	30.9	87.8
		Arlanza-La Sierra			
409	45.2	15.3	1.4	3.8	59.5
410	0	0	0	0	0
411	481.6	79.0	17.9	52.5	664.2
412	0	0	0	0	0
413	0	0	0	0	0
414.01	31.8	13.3	2.1	9.4	53.2
414.02	0	0	0	0	0
Arlonza/ La Sierra	558.6	37.3	21.4	16.1	776.9
TOTALS	1443.5		115.7		2042.2

(a) Source - Table B-1, Appendix B: calculations of annual consumption made using formulas on pages B-36 to B-39.

(b) Kilowatt hour conversions to Btu made at 10,200 Btu/kwh.

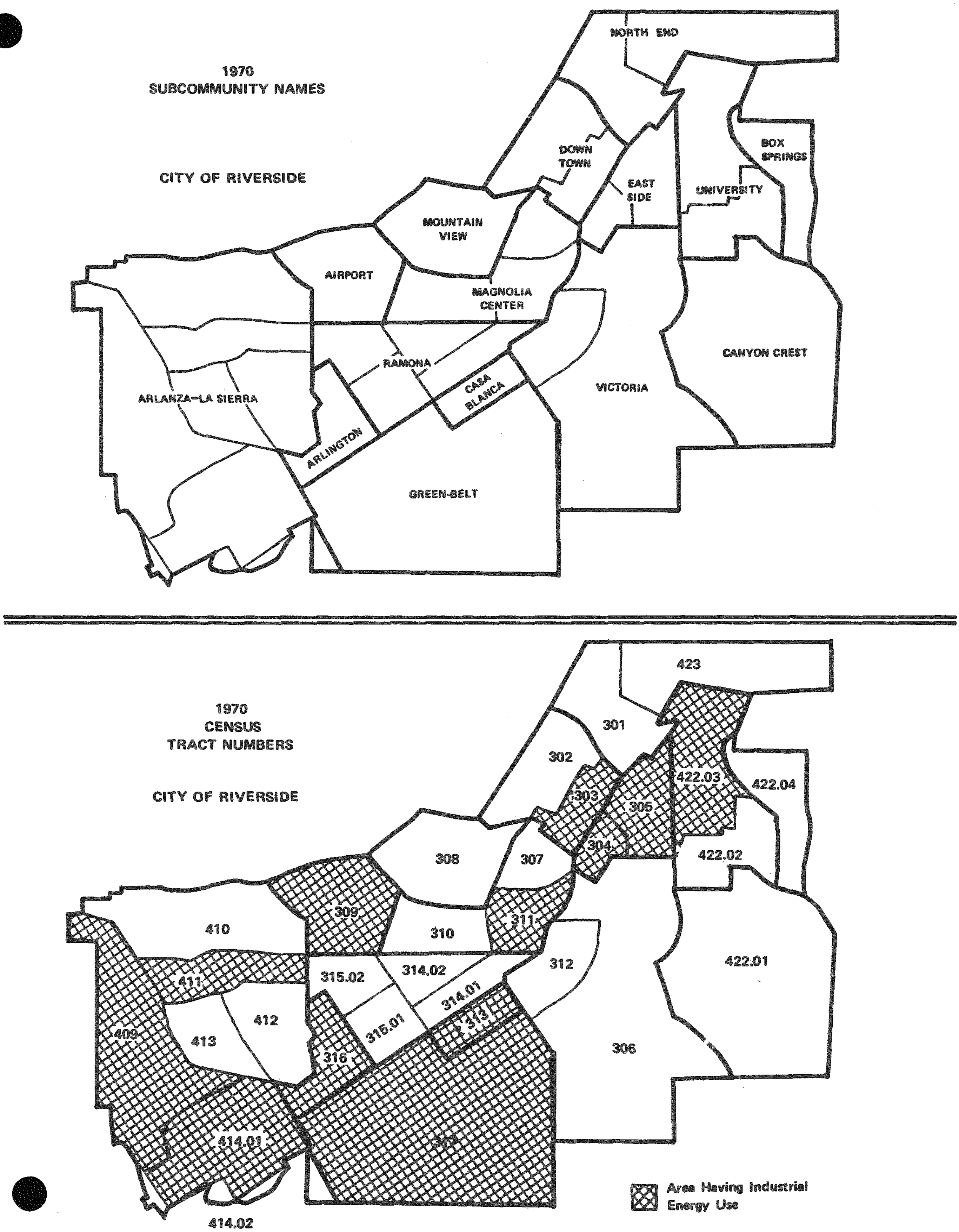


FIGURE C2-2. SUBCOMMUNITIES AND CENSUS TRACTS WITHIN RIVERSIDE

TABLE C2-6. RANKING OF CENSUS TRACTS HAVING INDUSTRIAL OPERATIONS IN DECREASING ORDER OF TOTAL ENERGY USED

Ranking	Census Tract	Community	Annual Thermal Energy Use, Btu x 10^9	Annual Electrical Energy Use, kwh x 10^6	Total Btu's Used,[a] Btu x 10^9	Total Btu's Used for Industrial, percent
1	411	Arlanza-La Sierra	481.6	17.9	664.2	33
2	422.03	University	452.4	49.6	505.9	25
3	305	East Side	212.2	18.9	404.9	20
4	304	East Side	96.6	10.4	106.1	5
5	317	Green Belt	30.7	5.6	87.8	4
6	409	Arlanza-La Sierra	45.2	1.4	59.5	3
7	313	Casa Blanca	28.0	3.0	58.6	2.8
8	303	Downtown	16.3	3.9	56.8	2.6
9	414.01	Arlanza-La Sierra	31.8	2.1	53.2	2.4
10	309	Airport	33.6	1.8	18.4	1
11	311	Magnolia Center	7.6	0.79	15.6	0.7
12	316	Arlington	7.6	0.35	11.2	0.5
		Totals	1443.5	115.7	2042.2	100

(a) Kilowatt Hour conversions to Btu made at 10,200 Btu/kwh.

- About one-fourth of the total energy used in Census Tract 305 is a combination of Alfred M. Lewis, Inc. and Toro, Irrigation Division.
- FMC Corporation uses about 15 percent of the total energy amount in Census Tract 304.
- The Press-Enterprise Company uses about 50 percent of the total energy amount in Census Tract 303. Their energy use is practically all electrical.

This analysis was designed within the limitations of the data available, (1) to point out the total amount of energy used by Riverside industry, (2) to indicate the areas of the City which have industrial operations, (3) to rank the industrial areas by amount of total industrial energy used, and (4) to identify large energy users that dominate or have a major impact on industrial energy use in some of the larger energy consumption areas. This information was then used to evaluate energy conservation opportunities for industry.

Present Energy Conservation Activities

Large Energy Users

As might be expected, the large energy users are usually larger companies that have effective energy management programs. Such companies characteristically have the technical staff and incentives to develop an energy management plan and follow through with its implementation and operation.

An example is Rohr Industries, Inc., one of the largest energy users in Riverside. An energy conservation program was initiated in mid-1975, and during 1976, electrical energy use decreased 25 percent and natural gas use 36 percent.[11] Water use management is also a part of the program. The overall program is comprehensive and includes:

- A committee of plant management and employees
- A plan for energy management with targets for reduced energy use with regular reporting
- Prominent displays of energy use/cost data on production/processing equipment
- An education program for all employees aimed at energy use in the plant and in the employee's home, transportation, etc.

Another example is the University of California at Riverside. Energy conservation guidelines were established early in 1974 in response to the energy crisis of 1973-1974, and from that time through 1975-1976, use of electrical energy has decreased about 14 percent and use of natural gas has decreased about 32 percent. Water management is also a part of the program. Early savings resulted from modifications to operating procedures, while present and future savings will accrue from improvements to existing systems and new energy saving facilities. In the latter category, a computerized energy management system is being installed and will be operational in late 1978. New guidelines for conservation and management of energy and water were issued in June 1977, with the goal of saving 30 percent per annum (related to 1972/1973) of electricity, natural gas, and liquid fuels (oil is available as a standby fuel).

It was apparent from the data received from other large industrial energy users that several were monitoring energy use closely. Thus, while the larger industrial energy users are good candidates for achieving the greatest energy savings, they may already be realizing an appreciable part of possible energy savings from energy conservation. They are, of course, highly interested in the stability of supply and costs which might be achieved by the implementation of alternative energy systems.

Small Energy Users

Some of the "smaller" companies are divisions of larger companies, such as the Lily Division of Owens-Illinois and Safeway Stores. These companies participate in the energy conservation programs of their parent corporations, and have generally achieved significant energy savings even though they do not have in-house energy conservation organizations. In general the energy conservation responsibility in these divisions and other small companies lies with the plant manager. Cost benefits are considered closely when looking at energy conservation options.

Some of the typical energy conservation measures implemented by smaller companies in Riverside include:

- Sizing electrical motors and staging operations to lower electrical demand.
- Installing air or plastic-strip curtains at freezer-cooler doors.
- Turning off as many incandescent lights as possible, and removing 30 to 50 percent of the fluorescent lamps.
- Setting thermostats at 68 to 70 degrees in Winter and 74-75 degrees in Summer.
- Changing air-conditioning systems to enable use of outside air to a greater extent with less humidity control.
- Correcting power factors to 95 to 98 percent.
- Cleaning and adjusting boilers (usually with Gas Company help).
- Using the telephone more and cutting down mileage on company vehicles.
- Better planning of deliveries and other vehicle trips.

Recommended Energy Conservation Opportunities

Most of the industrial companies in Riverside are small and are engaged in a variety of manufacturing and large commercial operations. Individually each uses relatively small amounts of energy. As a group, when the few large industries are accounted for, industrial energy use is still a relatively small part of total energy consumed in Riverside. Nevertheless, it is important that all industry be educated and encouraged to practive energy conservation (or energy management, which may be a better term). The following energy conservation discussion is applicable to all company sizes.

Management of energy in a given company requires close scrutiny and documentation of the energy forms in use, availability, quantities used, cost, how this usage is divided according to process and other requirements, and what is done with all heat that may be generated for, or is a part of, a given manufacturing operation.

The implementation of energy management programs requires the full commitment of management, employees, and union leadership if the program is to succeed. The abundance of confusing facts concerning the energy picture and the continuing uninterrupted supply of most fuel forms makes the implementation of energy management programs difficult to achieve. Thus, if an expanded effort to implement an energy management program is to be realized, it must come through an increasing awareness of the economic advantages of such a program. The facts are that the cost per unit of output of all types of manufactured products can be reduced through energy management, thereby resulting in increased profits.

The initiation of an energy management program need not be costly, nor require the use of outside organizations, consultants, etc. The wealth of government publications,[12-16] energy conservation seminars sponsored by trade associations and technical societies, energy information offices operated by the government, etc., can all provide straightforward, systematic approaches for initiation and follow through of an energy management program. Attachment C2-1 is a section from the EPIC Handbook[12] which lists energy conservation opportunities and illustrates the type of information available. Another useful example is given in Attachment C2-2[2,17].

Improved energy efficiencies of 10 to 15 percent can be achieved with minimal or no investment cost. Where some investments are required, the payback period is commonly less than 1 year. The implementation of alternative processes or installation of controls and/or different equipment requires more effort and investment than housekeeping-type improvements. The basis for implementing an energy conservation actions is to reduce manufacturing costs through a more efficient use of energy. Many companies have achieved savings in energy of 25 percent or more over a 2 to 3-year period with minimal investment. These savings are directly added to company profits.

There are three basic types of energy conservation strategies: (1) product substitution and demand-reduction strategies--those methods that reduce demand for energy-intensive products or that change the product mix to a less energy-intensive blend; (2) housekeeping strategies--those strategies that imporve the operation and maintenance of existing facilities; and (3) capital investment strategies--those approaches that involve the retrofitting of existing plants or the installation of new equipment. These are generally illustrated in Attachments C2-1 and C2-2.

Given the diversity of industry types and sizes, it is impossible, as part of this Program, to tailor energy conservation options to individual companies. The same energy conservation options would be listed for low, moderate, and high energy conservation efforts, the only difference being the intensity of promotion and implementation of the options. Thus the recommendations below are to cover all areas of the energy conservation effort, and to apply to all Riverside industry.

- Implement a continuing education program with special emphasis on helping the many small companies understand and adopt energy conservation measures. The EPIC Program (Reference 12 and Attachment C2-1) could be the basis, as could be from the electric and gas utilities, the University, and state federal sources.
- Publish on a regular basis, in the newspaper, a Chamber of Commerce or City Newsletter, or else where case histories of the large and small Riverside companies techniques and achievements in energy conservation. It is important for credibility that local sources be used.
- Provide a mechanism in the City Offices to record and track overall trends in industrial energy use in Riverside. These statistics could be periodically published in the above. This logically would be part of the Riverside Energy Coordinator's responsibilities as suggested in Appendix C-1. Efforts should be made to relate the overall picture of industrial engergy strategy being followed by the City of Riverside, thus obtaining the understanding and cooperation of the public, governmental, industrial, commercial and academic sectors.

Estimate of Energy Conservation Savings

Industry in Riverside is quite varied and it is not possible to estimate energy savings on an industry type basis within the scope of this study. It has been noted that large industry in Riverside is already achieving significant energy savings from energy conservation. Referring to the energy efficiency targets shown in Table C2-1, and realizing that Riverside industry is heavy in the fabricated metals area because of mobile home and similar metal fabrication industries, a realistic overall energy saving target for 1986 is estimated to be 25 percent. It is estimated that this could be increased to 40 percent by the year 2000.

These energy saving percentages would also be affected by the level of energy conservation effort, although industry is cost conscious and will probably achieve a major part of these targets because of economic pressures. Because of this it is assumed that the percentage decrease in energy demand for a low, moderate, and high energy conservation impact would be 20, 30, and 40 percent, respectively. Increase in industrial space was projected on the basis of low, moderate, and high population growth scenarios. Table C2-7 was constructed using these criteria, and Attachment C2-3 shows details of the calculations. Minimum savings from low population growth and a low energy conservation effort in the year 2000 would be about 3 percent of total stationary (nonvehicular) energy use in Riverside. The maximum savings in the year 2000 from high population growth and maximum energy conservation effort would be about 5 percent.

The above analysis assumes that the distribution of industrial energy use in Riverside will remain the same from present to the year 2000, and that industry will grow at the same rate as that of population. The estimated savings will probably bracket that which will likely occur in Riverside. This analysis further emphasizes that Riverside is basically a residential community, and that industry will play a relatively small role in the overall energy picture. However, these savings are significant, and in addition, industry may be more likely than other sectors to change their thermal and electrical energy supplies to stable alternative energy systems implemented in Riverside. Energy conservation savings as well as alternative energy use by industry can have a relatively large impact on saving scarce fuels--natural gas and petroleum.

TABLE C2-7. ESTIMATED PERCENT OF INDUSTRIAL REDUCTION IN ENERGY DEMAND OF TOTAL RIVERSIDE STATIONARY ENERGY USE, RELATED TO LOW, MODERATE AND HIGH POPULATION GROWTH STRATEGIES AND LOW, MODERATE AND HIGH ENERGY CONSERVATION EFFORTS.

	Low Impact	Moderate Impact	High Impact
Low Population Growth	3%	4%	5%
Moderate Population Growth	3%	4%	5%
High Population Growth	3%	4%	5%

References

(1) U.S. Office of Science and Technology, Executive office of the President, Patterns of Energy Consumption in the United States, January, 1972.

(2) Dean, N.L.(Environmental Law Institute), "A Checklist of Potential State Strategies for Reductions of Energy Use by Manufacturing and Processing Industries", Paper No. 9 presented at the Energy Conservation Training Institute, Chicago, Illinois, March 17-20, 1976.

(3) "Energy Management in Manufacturing - Key to Increased Profits and Preparation of Government Reporting", Byrer, T.G., and Billhardt, C.F., Battelle's Columbus Laboratories, Paper presented at the Fifth Annual Conference on Energy and Environment, Cincinnati, Ohio, November 1, 1977.

(4) Industrial Energy Conservation Program, Federal Register (June 9, 1977), Part II.

(5) "Voluntary Industrial Energy Conservation", U.S. Department of Commerce and Federal Energy Administration Progress Report #5 (July, 1977).

(6) Official Statement by the City of Riverside for the sale of $2,500,000 of Electric Revenue Bonds, March 22, 1977.

(7) Community Economics Profile for Riverside, Riverside County, California, published by the Riverside County Department of Development, April 1977.

(8) Industrial Directory, Riverside, California-Business Information, prepared by the Riverside Chambers of Commerce, January, 1977.

(9) Statistical data supplied by the Southern California Gas Company.

(10) Data supplied by Mr. H.D. Boen, Physical Plant Adminstrator, University of California, Riverside.

(11) Data supplied by Mr. R.N. Nordstrom, Senior Plant Electrical Engineer/Energy Coordinator, Rohr Industries, Inc., Riverside, California.

(12) "Energy Conservation Program Guide for Industry and Commerce", NBS Handbook #115, U.S. Government Printing Office, Washington, D.C. 20402 (September, 1974), and Supplement 1 (December, 1975).

(13) "Economic Thickness for Industrial Insulation", Stock #041-018-00115-8, U.S. Government Printing Office, Washington, D.C. 20402 (August, 1976).

(14) McElroy, N. N., and Shore, D. E., "Guidelines for Industrial Boiler Performance Improvement", Report No. EPA-600/8-77-003a (January, 1977).

(15) Kreider, K. G., and McNeil, M. B., "Waste Heat Management Guidebook", NBS Handbook #121, S.D. C13.11:121, U.S. Government Printing Office, Washington, D.C. 20402 (February, 1977).

(16) Kelnhofer, W. J., and Wood, L. A., "Energy Management Guide for Light Industry and Commerce", NBS Handbook #120, S.D. C13.11:120, U.S. Government Printing Office, Washington, D.C. 20402 (December, 1976).

(17) Michigan Department of Commerce, Industrial Processes - Energy Management Handbook for Small and Medium Sized Industry, April, 1975.

ATTACHMENT C2-1

C2-25

Energy Conservation Program Guide for Industry and Commerce (EPIC)

SUPPLEMENT 1

Robert G. Massey, Editor

Office of Energy Conservation
Center for Building Technology
Institute for Applied Technology
National Bureau of Standards
Washington, D.C. 20234

Sponsored by:

Conservation and Environment
Federal Energy Administration

Issued December 1975

U.S. DEPARTMENT OF COMMERCE
Rogers C. B. Morton, *Secretary*

NATIONAL BUREAU OF STANDARDS
Ernest Ambler, *Acting Director*

FEDERAL ENERGY ADMINISTRATION
Frank G. Zarb, *Administrator*

CONSERVATION AND ENVIRONMENT
Roger W. Sant, *Assistant Administrator*

ENERGY CONSERVATION OPPORTUNITIES (ECO's)

TABLE OF CONTENTS

3. ENERGY CONSERVATION

3.0 INTRODUCTION

Energy Conservation Opportunities (ECOs) are reported in this section. Section 3.1 is a checklist of such opportunities and Sections 3.2 through 3.13 contain case descriptions of specific applications of ECOs. When a case report is included in EPIC, the checklist item to which it pertains is followed by a subsection number identifying the case report. The checklist and the case reports are categorized in the same manner. One case report may be shown as an example of more than one checklist item.

All of the ECO cases reported are either based on a specific industrial and commercial experience or representative of several experiences. The reports include graphs, tables and sample calculations, as well as a brief description of the circumstances and the action. The calculations are intended to illustrate key steps in estimating energy savings potential and associated cost savings. They are not complete engineering analyses of the application. The cases have been checked for internal consistency but do not contain all of the factors which will affect your decision to implement an ECO.

3.0.1 ENERGY COSTS

It will be noted that costs of fuel, steam, and electric power vary from case to case. In some instances, low energy costs were reported because the projects were actually implemented two or three years ago. The energy costs in hypothetical examples were chosen arbitrarily to reflect current trends. Even so, it is recognized that energy costs vary widely from region to region. When applying a particular ECO appropriate local unit costs must be used to revise the cost calculation. Recent increases in the price of energy indicate that consideration should be given to including energy escalation costs. This will result in a shorter payback period.

3.0.2 ECO SELECTION

The ECOs have been reported from many different sources and where appropriate both the contributor and the company which supplied the case are listed. Even though all ECOs won't apply to your industry, the ideas may help you formulate ECOs applicable to your particular business. The Checklist (Section 3.1.4) may also be used to find ideas for ECOs applicable to your circumstances.

Some of the most profitable areas to check for energy conservation are reported to be waste water, stack gas and exhaust ventilation air containing energy that may be recoverable with heat exchangers. The higher the temperature of the water or the gas, the more energy available for recovery. However, temperature measurement and flow rate surveys must be made (see Section 9) followed by analysis to determine exactly how much energy is available and the practicality of recovering the energy.

3.0.3 SUPPLEMENTS

It is planned that this section of EPIC, the Checklist and case studies, will be expanded in future supplements. You will be notified of the availability of these supplements if you will return the form located in the back of the Handbook or the supplements.

PLEASE NOTE THAT ALL ECO'S USE THE FOLLOWING SYMBOLS:

k = thousand or kilo
M = million or mega

3.1 ENERGY CONSERVATION OPPORTUNITY CHECKLIST

3.1.1 FACTORS TO CONSIDER IN EVALUATING ECO's

The ECO's in the checklist are suggested possibilities for conserving energy. However, any ECO requires careful evaluation for a specific application. For instance, the possibility that under certain circumstances an ECO could be counterproductive needs to be determined for the application.

In some cases existing equipment will have operating limits which must be considered. For example, excessive insulation on a furnace roof can confine too much heat, overheat the refractory, and cause failure of the roof.

Other factors to be considered are listed in the form, ""Energy Conservation Project Evaluation Summary" in Section 2.7.3. Information on financial analysis and safety and pollution considerations appears in Section 5 and Section 7 respectively.

3.1.2 BUILDINGS AND GROUNDS

Suggestions for Immediate Action

	REFERENCE RELATED ECO
Reduce Ventilation Air	3.2.1
Increase Light Reflectance of Walls and Ceilings	
Shut Off Air Conditioning in Winter Heating Season	
Eliminate Unused Roof Openings or Abandoned Stacks	
Reduce Building Exhausts and Thus Make-Up Air	
Reduce Glazed Areas in Buildings	
Reduce Temperature of Service Hot Water	
Shut Down Air Conditioning During Non-Working Hours	3.2.2
Reduce Heating Level When Building Is Not in Use	3.2.5
Install Timers on Light Switches in Little Used Areas	
Close Holes and Openings in Buildings Such as Broken Windows, Unnecessary Louvers and Dampers, Cracks Around Doors and Windows	
Repair Faulty Louvers and Dampers	
Conserve Energy by Efficient Use of Water Coolers and Vending Machines	3.2.3
Schedule Use of Elevators to Conserve Energy	3.2.4
Use Cold Water for Clean Up Whenever Possible	
Analyze Pipe and Duct Insulation—Use Amount Necessary to Accomplish Task	
Clean or Replace Air Filters Regularly	
Centralize Control of Exhaust Fans to Ensure Their Shutdown	
Mix Hot Air Near the Ceiling with Outside Air, Then Recirculate	
Plant Trees or Shrubs Near Windows to Shield From Sunlight	
Change Zone Reheat Coils to Low Pressure Variable Air Volume Boxes	
Replace High Resistance Ducts, Pipes, and Fittings	
Close Outdoor Air Dampers During Warm-up or Cool-down Periods Each Day	

Other Suggested Actions

	REFERENCE RELATED ECO
Reduce Air Conditioning Load by Evaporating Water from Roof	
Convert to Fluorescent, Mercury, Sodium, or High Intensity Direct Lighting	
Insulate Walls, Ceilings, and Roofs	
Install Timers on Air Conditioning for Summer Operation	
Periodically Calibrate the Sensors Controlling Louvers and Dampers on Buildings	
Eliminate Inefficient Electric Lamps from Plant Stocks and Catalogs	3.3.2
Clean Air Conditioning Refrigerant Condensers to Reduce Compressor Horsepower — Check Cooling Water Treatment	
Use "Heat Wheel" or Other Heat Exchanger to Cross-Exchange Building Exhaust Air with Make-up Air	
Use Photocell Control on Outdoor Lights	
Use Building Materials Which Require Less Energy to Produce	
Size Air Handling Grills, Ducts, and Coils to Minimize Air Resistance	
Recover Heat in Waste Service Hot Water	
Avoid Introducing High Moisture Exhaust Air Into Air Conditioning System	
Air Condition Only Space in Use	
Shade Windows from Summer Sun	
Use Direct Air Supply to Exhaust Hoods	
Use Exhaust Heat from Buildings for Snow and Ice Removal from Walks, Driveways, Parkways, Parking Lots, etc.	
Use Separate Switches on Perimeter Lighting Which May be Turned Off When Natural Light is Available	

	REFERENCE RELATED ECO
Use Double or Triple Glazed Windows to Maintain Higher Relative Humidity and to Reduce Heat Losses	
Heat Water During Off-Peak Periods and Store for Later Use	
Use Heat Pump for Space Conditioning	
Heat Service Hot Water with Air Conditioning Compressor Exhaust	
Use Radiant Heater for Spot Heating Rather than Heating Entire Area	
Reduce or Eliminate General Lighting Where Natural Light Provides Sufficient Illumination. Limit Higher Lighting Levels to Task Areas Only	
Reduce Exterior Buildings and Grounds Illumination to Minimum Safe Level	3.13.1

	REFERENCE RELATED ECO
Interlock Heating and Air Conditioning Systems to Prevent Simultaneous Operation	
Recycle Air for Heating, Ventilation and Air Conditioning to Maximum Extent	
Minimize Use of Outside Make-Up Air for Ventilation Except When Used for Economizer Cycle	
Lower Light Fixtures in High Ceiling Areas	
Reduce General Illumination to Minimum Necessary for Safety	3.2.6
Replace Air Curtain Doors with Solid Doors	
Reduce Heat Gain by Window Tinting	3.2.8
Minimize Water Use in Lavatories by Choosing Appropriate Fixtures and Valves	
Recover Heat in Domestic Hot Water Going to Drain	
Install Storm Windows and Doors	

3.1.3 ELECTRICAL POWER

Other Suggested Actions

	REFERENCE RELATED ECO
Use Combined Cycle Gas Turbine Generator Sets with Waste Heat Boilers Connected to Turbine Exhaust	
Replace Steam Jets on Vacuum Systems with Electric Motor Driven Vacuum Pumps	
Size Electric Motors for Peak Operating Efficiency—Use Most Efficient Type of Electric Motors	
Use Power During Off-Peak Periods —Store Heated/Cooled Water for Use During Peak Demand Periods	
Use Steam Pressure Reduction to Generate Power	
Use Immersion Heating in Tanks, Melting Pots, etc.	
Reduce Load on Electric Conductors to Reduce Heating Losses	
Increase Electrical Conductor Size to Reduce Distribution Losses	
Optimize Plant Power Factors	
Use By-Product Heat from Transformers for Service Water Heating	3.3.3
De-energize Excess Transformer Capacity	
Provide Proper Maintenance and Lubrication of Motor Driven Equipment	
Consider Energy Efficiency When Purchasing New Equipment	
Consider Power Loss as Well as Initial Loads and Load Growth in Sizing Transformers	
Schedule to Minimize Electrical Demand Charge	3.3.1
Use Multiple Speed Motors or Variable Speed Drives for Variable Pump, Blower and Compressor Loads.	
Check for Accuracy of Power Meter	
Optimize Motor Size with Load to Improve Power Factor and Efficiency	

3.1.4 STEAM

	REFERENCE RELATED ECO
Suggestions for Immediate Action	
Turn Off Steam Tracing During Mild Weather	
Maintain Steam Jets Used for Vacuum System	
Repair Leaks in Lines and Valves	3.4.5
Repair Insulation on Condensate Lines	
Repair Faulty Insulation on Steam Lines	
Repair or Replace Steam Traps	3.4.6
Eliminate Leaks in High Pressure Reducing Stations	
Cover Condensate Storage Tanks	
Other Suggested Actions	
Consider Replacing Electric Motors with Back Pressure Steam Turbines and Use Exhaust Steam for Process Heat	
Operate Distillation Columns at Minimum Quality Requirements	
Operate Distillation Columns at Near Flooding Conditions for Maximum Separation Efficiency	
Determine Correct Feed Plate Location on Distillation Columns to Increase Efficiency and Minimize Steam Consumption	
Consider Switching Selected Steam Stripping Distillation Units from Direct (Live) Steam to Indirect (Dry) Stripping	
Use Heat Exchange Fluids Instead of Steam in Pipeline Tracing Systems	3.12.2
Clean Steam Coils in Processing Tanks	
Use Correct Size Steam Traps	
Flash Condensate to Produce Lower Pressure Steam	3.4.4
Evaluate Replacing Condensing Steam Turbine Rotating Equipment Drives with Electric Motors, If Your Plant Has a Power Generating Capability	
Add Traps to a Distillation Column to Reduce the Reflux Ratio	
Insulate Condensate Lines	
Minimize Boiler Blowdown with Better Feedwater Treatment	
Insulate Steam Lines	3.4.1
Install Steam Traps	3.4.2
Return Steam Condensate to Boiler Plant	3.4.3
Use Minimum Steam Operating Pressure	
Use Waste Heat Low Pressure Steam for Absorption Refrigeration	
Replace Barometric Condensers with Surface Condensers	
Shut Off Steam Traps on Superheated Steam Lines When Not in Use	
Optimize Operation of Multi-Stage Vacuum Steam Jets	
Use Optimum Thickness Insulation	
Use Reflux Ratio Control or Similar Control Instead of Flow Control on Distillation Towers	
Substitute Hot Process Fluids for Steam	
Use Steam Sparging or Injections in Place of Indirect Heating	3.12.3
Use Steam Condensate for Hot Water Supply (Non Potable)	

3.1.5 OTHER UTILITIES

	REFERENCE RELATED ECO
Suggestions for Immediate Action	
Clean Fouling from Water Lines Regularly	
Shut Off Cooling Water When Not Required	
Reduce Business Travel By Using Telephone When Possible	
Conduct Monthly Audit of Water Meters for Early Leak Detection	
Clean or Replace Air Filters Regularly	
Remove Unneeded Service Lines to Eliminate Potential Leaks	
Eliminate Leaks in Combustible Gas Lines	3.5.1
Eliminate Leaks in Inert Gas and Compressed Air Lines and Valves	3.5.3
Eliminate Leaks in Water Lines and Valves	
Shut Off All Laboratory Fume Hoods When Not In Use	
Other Suggested Actions	
Install Adequate Dryers on Air Lines to Eliminate Blowdown	
Install Compressor Air Intakes in Coolest Locations	3.5.4
Recover and Reuse Cooling Water	
Do Not Use Compressed Air for Personal Cooling	3.5.5
Use Flow Control Valves on Equipment to Optimize Water Use	
Evaluate Water Cooling vs. Air Cooling for Specific Situations	
Check for Accuracy of Utility Meters	
Eliminate or Reduce Compressed Air Used for Cooling Product, Equipment, or for Agitating Liquids	

	REFERENCE RELATED ECO
Replace Water Cooling on Processes with Air Cooling Where Possible	
Recover Heat from Compressed Air Dryers	
Eliminate Cooling of Process Streams Which Subsequently Must Be Heated and Vice Versa	
Shut Off Cooling If Cold Outside Air Will Cool Process	
Use Cascade System of Recirculating During Cold Weather to Avoid Sub-Cooling	
Operate Cooling Towers at Constant Outlet Temperature to Avoid Sub-Cooling	
Use Minimum Cooling Water to Bearings	
Increase the Level of the Water in a Drainage Ditch To Reduce the Pumping Head and Horsepower Required Where Drainage Water Must be Pumped Over a Levee for Disposal	
Reduce Sewer Liquid Volume Which Reduces Treatment Energy by Returning Steam Condensate to Boilers	
Replace Over-Size Motors and Pumps with Optimum Size	
Reduce the Pressure of Compressed Air to the Minimum Required	3.5.2
Reduce Hot Water Temperature to the Minimum Required	
Recycle Treated Water	
Eliminate Compressed Air Drives from Permanent Installations	

3.1.6 HEAT RECOVERY

Other Suggested Actions

	REFERENCE RELATED ECO
Use the Overhead Condenser to Generate Steam From Condensates in a Distillation Process	
Use Hot Flue Gases in Radiant Heater for Space Heating, Ovens, Dryers, etc.	
Use Heat in Flue Gases to Preheat Products or Material Going into Ovens, Dryers, etc.	
Use Hot Process Fluids to Preheat Incoming Process Fluids	
Use Hot Flue Gases to Preheat Wastes for Incinerator Boiler	
Use Waste Heat from Hot Flue Gases to Generate Steam for Processes or Consider Selling Excess Steam	3.6.3
Use Waste Heat from Hot Flue Gases to Heat Space Conditioning Air	3.6.1
Use Waste Heat from Hot Flue Gases to Preheat Combustion Air	3.6.7
Use Engine Exhaust Heat to Make Steam	3.6.2

	REFERENCE RELATED ECO
Recover Heat from Hot Waste Water	3.6.9
Use Oven Exhaust to Preheat Air	3.6.10
Recover Fuel Value in Polluted Exhaust Air	3.6.11
Recover Fuel Value in Waste By-Product	3.6.4, 3.6.5
Use Flue Gases to Heat Process or Service Water	3.6.6
Use Oven Exhaust for Space Heating	3.6.8
Recover Heating or Cooling Effect from Ventilation Exhaust Air to Precondition Incoming Ventilation Air	
Use Recovered Heat from Lighting Fixtures for Useful Purpose, i.e., to Operate Absorption Cooling Equipment	3.2.5
Use Flue Gas Heat to Preheat Boiler Feedwater	3.6.1
Use Cooling Air Which Cools Hot Work Pieces for Space Heating or Make-Up Air in Cold Weather	

3.1.7 HEAT CONFINEMENT

	REFERENCE RELATED ECO
Suggestions for Immediate Action	
Repair Faulty Insulation in Furnaces, Boilers, etc.	
Other Suggested Actions	
Use Economic Thickness of Insulation for Low Temperatures	
Increase Insulation Thickness	
Cover Open Tanks with Floating Insulation to Minimize Energy Losses	3.7.1
Use Soft Insulation in Cycling Furnaces to Facilitate Heating Up and Cooling Down	
Use Minimum Safe Oven Ventilation	
Upgrade Insulation and Linings in Furnaces, Boilers, etc.	
Repair Furnaces and Oven Doors So That They Seal Efficiently	

3.1.8 COMBUSTION	REFERENCE RELATED ECO
Suggestions for Immediate Action	
Calculate and Plot Boiler Efficiency Daily	3.8.4
Establish Burner Maintenance Schedule	
Adjust Burners for Efficient Operation	
Other Suggested Actions	
Improve Combustion Control Capability	3.8.1; 3.8.2
Heat Oil to Proper Temperature for Good Atomization	3.8.3
Keep Boiler Tubes Clean (Fireside)	3.8.7
Keep Boiler Tubes Clean (Waterside)	3.4.7
Analyze Flue Gas for Proper Air/Fuel Ratio	
Eliminate Combustible Gas in Flue Gas	3.8.5
Reduce Combustion Air Flow to Optimum	3.8.6
Convert Combustion to More Efficient Fuel	
Replace Obsolete Burners with More Efficient Ones	
Use Waste and By-Products as Fuel	
Limit and Control Secondary Combustion Air in Furnace Operations to the Amount Required for Proper Furnace Operation	

3.1.9 SCHEDULING	REFERENCE RELATED ECO
Suggestions for Immediate Action	
Shut Down Process Heating Equipment When Not in Use	3.9.2
Other Suggested Actions	
Locate Causes of Electrical Power Demand Charges, and Reschedule Plant Operations to Avoid Peaks	3.3.1
Reduce Temperature of Process Heating Equipment When on Standby	3.9.1
Use Most Efficient Equipment at It's Maximum Capacity and Less Efficient Equipment Only When Necessary	
Use Drying Oven (Batch Type) on Alternate Days or Other Optimum Schedule to Run Equipment with Full Loads	

	REFERENCE RELATED ECO
Heat Treat Parts Only to Required Specifications or Standards	3.9.3
Schedule Routine Maintenance During Non-Operating Periods	
Consider Three or Four Days Around-the-Clock Operation Rather Than One or Two Shifts Per Day	
Minimize Operation of Equipment Required to be Maintained in Standby Condition	
Reduce Operating Time of Equipment to That Actually Required	3.9.4
Optimize Production Lot Sizes and Inventories	

3.1.10 MATERIALS HANDLING	REFERENCE RELATED ECO
Suggestions for Immediate Action	
Turn Off Conveyors, Lift Trucks, etc. When Not In Use	
Recharge Batteries on Materials Handling Equipment During Off-Peak Demand Periods	
Adjust and Maintain Fork Lift Trucks for Most Efficient Operation	
Shut Down Diesel Construction Equipment When Not Needed	
Other Suggested Actions	
Use Optimum Size and Capacity Equipment	
Upgrade Conveyors	
Use Gravity Feeds Wherever Possible	
Improve Lubrication Practices	3.10.1

3.1.11 SHIPPING, DISTRIBUTION, AND TRANSPORTATION

Suggestions for Immediate Action	REFERENCE RELATED ECO
Schedule Regular Maintenance to Maintain Efficiency of Truck Engines	
Shut Down Truck Engines While Loading, Unloading, or Waiting	
Keep Loading Dock Doors Closed When Not In Use	
Turn Off Equipment During Lunch Breaks	
Consider Intermediate or Economy Size Autos and Trucks for Company Sales and Plant Fleets	
Change to Lower Energy Content Packaging	
Use Only Amount of Packaging Material Necessary	
Consider Use of Bulk Materials Where Possible	
Add Air Shields to Long Distance Trucks to Increase Fuel Mileage	

Other Suggested Actions	REFERENCE RELATED ECO
Size Trucks to Job	
Reduce Delivery Schedules	
Consolidate Deliveries	
Eliminate Lighting on Top of Stacked Material	
Install Air Seals Around Truck Loading Dock Doors	
Optimize Routing of Delivery Trucks to Minimize Mileage	3.11.1
Evaluate Energy Use in Packaging	3.11.2

3.1.12 PROCESS CHANGES

Other Suggested Actions

	REFERENCE RELATED ECO
Schedule Baking Times of Small and Large Components to Minimize Use of Energy	3.9.3
Use Vapor Recompression Design in Distillation Processes	
Use "Side Draw" Principle in Distillation Column Design	
Use Continuous Equipment Which Retains Process Heating Conveyors Within the Heated Chamber	
Use Direct Flame Impingement or Infrared Processing for Chamber Type Heating	
Convert from Indirect to Direct Firing	
Use Batch Firing with Kiln "Furniture" Designed Specifically for the Job	
Salvage and Re-Use Process Waste	
To Drive Off Combustible Solvents, Use Only Amount of Air Necessary to Prevent Explosion Hazard and to Protect Personnel	

	REFERENCE RELATED ECO
Increase Use of Re-Cycled Material	
Use Small Number of High Output Units Instead of Many Small Inefficient Units	
Avoid Cooling of Process Streams or Materials That Must Subsequently be Heated	
Reschedule Plant Operation to Minimize Electric Power Demand Peaks	
Convert from Batch to Continuous Operation	
Use Shaft Type Furnaces for Preheating Incoming Material	
Convert Liquid Heaters from Underfiring to Immersion or Submersion Heating	
Minimize Unessential Material in Heat Treatment Process	3.12.1
Change Product Design to Reduce Processing Energy Requirements	
Reduce Scrap Production	
Upgrade Obsolete or Little Used Equipment	

3.1.13 COMMERCIAL PRACTICES

	REFERENCE RELATED ECO
Suggestions for Immediate Action	
Shut-Down Air Conditioning During Non-Working Hours	3.2.2
Reduce Heating Level When Building is Not in Use	3.2.5
Air Condition Only Space in Use	
Reduce Business Travel by Using Telephone When Possible	
Turn Off Lights, Electric Typewriters and Other Such Equipment When Not in Use	3.2.6, 3.2.7
Replace Broken Windows and/or Window Sash	
Maintain Space Temperature Lower During the Winter Season and Higher During the Summer Season	
Reduce Interior Lighting to Minimum Necessary Level	
Reduce Hot Water Temperature in Washrooms to 120F	
Avoid Electrically-Powered Animated Displays	
Urge Customers to Take Merchandise with Them	
Reduce Lighting of Used-Car Lots After Midnight	
Eliminate or Reduce Lighting of Outdoor Displays and Signs	
Utilize Daylight Whenever Possible in Lieu of Artificial Light	
Add Area Lighting Switches to Allow Smaller Areas to be Darkened When Not in Use	
Use Computer Programs, for Example, an Enthalpy Optimization Program to Reduce Heating and Mechanical Cooling Requirements of HVAC Equipment	
Delay Turning on Heating and Air Conditioning Equipment Until Necessary	
Revise Conference Room Ventilation System to Shut Off When Room is Not in Use	
Install Timers on Light Switches in Little Use Areas	
Keep Doors and Windows Shut to Retain Heated or Air Conditioned Air	
Overlap the Work Hours of Custodial Services with Normal Day Hours	
Turn On Display Merchandise, Such as Radios, TV Sets, Washers, Dryers, Power Tools, etc., for Demonstration Only When Requested by Customer	
Consolidate Freight Shipments and/or Deliveries	
Other Suggested Actions	
Shade Windows From Summer Sun	
Reduce Exterior Buildings and Grounds Illumination to Minimum Safe Level	3.13.1
Clean or Replace Air Filters Regularly	
Use More Efficient Light Sources, i.e. Fluorescent Lamps for Incandescent Bulbs	
Use Light Color Finishes on Ceilings, Walls, Floors and Furnishings	
Keep Lamps and Reflectors Clean	
Reduce Illumination to Minimum Necessary Level Except Where Custodial Work is Actually Being Performed	

REDUCE WAREHOUSE VENTILATION

Energy savings may be realized by reducing forced ventilation in buildings to a lesser but still adequate amount required to provide safe conditions.

The air flow from a centrifugal fan varies directly as its rotational speed. Thus, the amount of ventilation can be reduced by decreasing fan speed. Figure 1 shows the air flow from a centrifugal fan versus the power required to drive it, both as percent of full rating.

EXAMPLE

A new 150,000 cubic foot warehouse was constructed with provision for five air changes per hour. This required a 10 hp motor (with a fan load of 9.83 hp) driving a 24 inch centrifugal fan at 915 rpm to deliver air at the rate of 12,500 cfm. Later information showed that only four changes per hour would be adequate, or 80% of the original design. Pulley changes were made, therefore, to reduce the fan speed to 915 × 0.80, or 732 rpm.

Reference to Figure 1 shows that with the fan speed reduced to 80% of full rating, the power required to drive it is only 50% of full load. Assuming a motor efficiency of 80% at full load,

Power at full load = 9.83 hp × 0.746 kW/hp × 1/0.80
= 9.166 kW

Assuming a drop in motor efficiency to 77%,

Power at 50% load = 9.83 hp × 0.50 × 0.746 kW/hp × 1/0.77
= 4.762 kw

Elec. Power saving = (9.166 − 4.762)kW × 8760 h/yr
= 38,600 kWh/yr

If the utility consumes 10,000 Btu of fuel/kWh generated,

Annual energy savings = 38,600 kWh/yr × 10,000 Btu/kWh
= 386 MBtu per year

If the cost of electric power is $0.02 per kWh,

Annual cost saving = 38,600 kWh/yr × 0.02 $k/Wh
= $770 per year

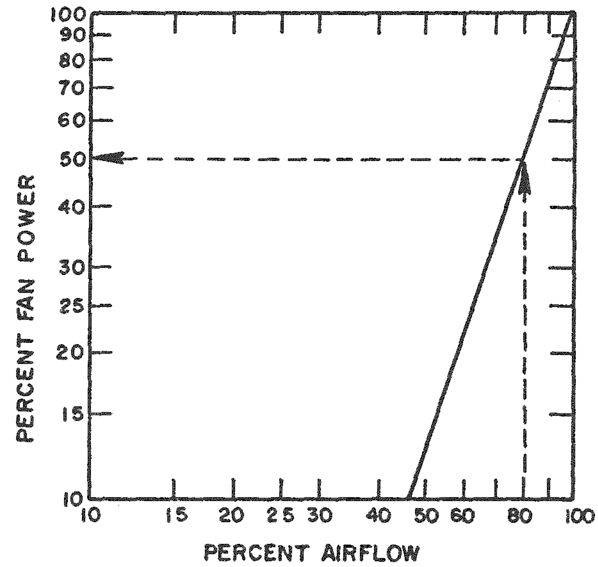


FIGURE 1. *Decrease in horsepower accomplished by reducing fan speed (based on laws of fan performance).*

SUGGESTED ACTION

Determine whether the number of air changes provided by your ventilation system can be reduced and still maintain safe conditions.

Fan speed can be reduced, and energy saved, merely by changing pulleys. If the motor operates at less than 50% of its rated load, however, its efficiency may be very poor and its power factor unduly high. In such cases, consult the motor manufacturer to determine electric efficiencies and power factors at low loads. In some cases a smaller motor rated for the job will produce greater savings.

(Note: Reducing ventilation may also reduce the energy requirements for heating and cooling.)

REFERENCE

Heating, Refrigerating, Ventilating and Air Conditioning Guide and Data Book—Equipment—1972
American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
345 E. 47th Street
New York, New York 10017

SOURCE Based on J. R. Kernan—"Examples of Energy Conservation," Energy Conservation Through Effective Energy Utilization, National Bureau of Standards Special Publication No. 403, Vol. II

ATTACHMENT C2-2

1. Calculation Of Industrial Thermal And Electrical Demand Savings In 2000 Due To Energy Conservation

(a) Industrial Energy Use In 1976 (Basis Appendix A)

(1) Space Heating $(45 \times 10^6)(2904) = 130.7 \times 10^9$ Btu

(2) Base Thermal $(150 \times 10^6)(8760) = 1314 \times 10^9$ Btu

(3) Space Cooling $(2500)(4416) = 11 \times 10^6$ kwh

$(11 \times 10^6)(10.2 \times 10^3) = 112.2 \times 10^9$ Btu

(4) Base Electrical $(12000)(8760) = 105.1 \times 10^6$ kwh

$(105.1 \times 10^6)(10.2 \times 10^3) = 1072 \times 10^9$ Btu

(5) 1976 Industrial Totals

Thermal 1443.5×10^9 Btu

Electrical 115.7×10^6 kwh

Total Btu 2628.9×10^9 Btu

(b) Calculation Of Unit (per square foot) Energy Use

(1) Estimated total of 5×10^6 sq. ft. Industrial Space in 1976 (Appendix

(2) Thermal $(1444.7 \times 10^9) \div (5 \times 10^6) = 288.9 \times 10^3$ Btu/sq.ft.

Electrical $(116.1 \times 10^6) \div (5 \times 10^6) = 23.2$ kwh/sq.ft.

(c) Projection Of Industrial Floor Space Additions To The Year 2000 Based On Low, Moderate And High Population Growth Scenarios

Population	1976 Estimated Space Sq. Ft. $\times 10^6$	Space Added to 2000 Sq. Ft. $\times 10^6$	Total Industrial Space in 2000 Sq. Ft. $\times 10^6$
Low Growth	5.0	1.2	6.2
Moderate Growth	5.0	2.2	7.2
High Growth	5.0	3.4	8.4

(d) From Appendix C1

- Decreases in industrial thermal and electrical demand from applying new energy code to new buildings and from retrofitting existing buildings subtracted from overall energy conservation savings.

- Estimated industrial savings are:

Low Impact	20%
Moderate Impact	30%
High Impact	40%

(e) Total Overall Reduction In Industrial Energy Demand in The Year 2000*

	Low Impact		Moderate Impact		High Impact	
	Thermal $\times 10^9$ Btu	Electric $\times 10^6$ kwh	Thermal $\times 10^9$ Btu	Electric $\times 10^6$ kwh	Thermal $\times 10^9$ Btu	Electric $\times 10^6$ kwh
Low Growth	293.2	23.5	435.7	34.8	576.1	46.0
Moderate Growth	344.7	27.6	510.8	40.8	673.8	53.8
High Growth	407.7	32.5	603.3	48.2	794.6	63.5

* Reductions in thermal and electric demand shown do not include space heating, space cooling and 10 percent of base thermal and electric use which were associated with building energy savings.

ATTACHMENT C2-2*

*Excerpt from Michigan Department of Commerce Publication - Industrial Processes - Energy Management Handbook, for Small and Medium Sized Industry, April, 1975.

COMPRESSED AIR

Compressed air is a production tool very extensively used in industry and naturally represents a major use of energy, usually electric. In many plants its share of the electric load is such that inefficiencies or large losses are significant in the total plant energy cost.

Energy Savings:

Savings of 5% or more in compressed air energy use are entirely possible.

Suggested Actions:

Operation:

1. Shut down the extra air compressor when not needed. The remaining unit or units will operate most efficiently at or near full load.

2. Make sure that all air compressors are shut down when not needed.

3. Determine lowest air pressure at which the system can operate satisfactorily and adjust compressor controls to that level. Excessive pressure wastes pumping energy. 80 PSI vs 100 PSI reduces power requirements by 12%.

4. Make sure that compressed air is not being used for personal cooling at work stations. It is costly and dangerous.

Expense:

5. Modify air intakes as required so that the compressors draw air from cool locations. For every 5°F reduction in intake air temperature the power required to compress the same quantity will be reduced 1%.

6. Investigate the possibility of installing some type of recovery system so that the waste heat at the after cooler can be used for building or process heating.

7. Install automatic controls to insure shutdown of unneeded compressors.

Maintenance:

8. Repair all leaks in the air lines, fittings, and attachments. Make a survey during non-operating time when leaks may be heard.

PROCESS MANAGEMENT

In this area the plant management team has a wide scope of control of energy utilization. A plant survey should be undertaken with every operation scrutinized. The question "why" should be asked and answered - whenever an obvious loss or waste of energy is observed.

New more efficient methods, processes, or techniques should be investigated and used if feasible. Cost analyses should use best possible projections of cost of money and cost of energy.

Energy Savings:

The energy saved by a serious plant-wide effort can total 10% or more of total plant consumption. Often, no major expenditures are involved to realize these benefits.

Suggested Actions:

Operation:

9. Shut down production equipment whenever it is not in use. Usually savings result when equipment is shut down and restarted as needed. An exception might be frequent starts of a large inertia, slow accelerating machine.

10. Reduce standby or idle time of heat process equipment, also temperature during idle time, if practical.

11. Check all processes involving temperature and time to determine if either could be minmized without affecting product quality of production costs.

12. Use most efficient equipment at its maximum capacity. Use less efficient equipment only when it is needed.

13. Reschedule process or batch sizes to make the flow as continuous and uniform as possible.

14. Develop the process flow to take full advantage of retained heat to minimize reheating.

15. Eliminate sub-cooling in process flow if the process must later be reheated. Adjust water flow or recirculate to prevent over cooling.

Expense

16. Insulate all heat process and heat transfer equipment.

17. Install automatic process controls. Generally they are more efficient than manual control systems, and afford a "bonus" by freeing manhours for more productive use.

18. Minimize length of conveyor and pipe runs for heated materials.

19. Convert large batch type process to continuous flow operation.

20. Investigate the use of an electronic accelerator in conjunction with bread-baking ovens. The electronic accelerator gives marked reduction in baking time and is very effective in time and energy savings.

Maintenance:

21. Establish a log of temperatures on each side of heat exchangers. An increase in temperature differences may signal the need for attention. Inspection should be made as soon as possible to prevent further energy loss.

22. Be sure that maintenance is being performed at specified intervals on controls, and accessories as well as on the major equipment. If proper preventive maintenance is allowed to lag, costly inefficiencies and breakdowns are bound to happen.

23. Check whether cooling towers or evaporative coolers are pulling plant air during the heating season. Outside air only should be used at the cooling tower evaporator intake.

24. Schedule routine maintenance for non-operating periods to assure minimum disturbance to the normal flow of work.

25. Schedule routine adjustments of all burners for maximum combustion efficiency.

Remarks:

Once new procedures or process changes are established, good follow-up is essential.

Take a fresh look at every phase of your operation strictly from the standpoint of saving energy. Make a conservative estimate of benefits expected from each proposed change. total all of these potential advantages. It may be surprising.

OVENS AND PROCESS TANKS

This is an area of manufacturing and processing using energy in very large quantities. The potential savings here are very substantial and in some instances relatively easy to realize.

Energy Savings:

Reduction in energy use will depend on the type, number and degree of changes made. Due to the high level of energy used in processes involving ovens and heated tanks, the potential for energy savings is great. It is well worth our best effort.

Suggested Actions:

Operation:

26. Minimize open time of oven doors and tank covers.

27. Reduce holding temperature during idle time.

28. Schedule work to reduce heat up and cool down periods.

29. Heat full loads on batch type ovens.

Expense:

30. Insulate all heat process and heat transfer equipment.

31. Install covers over vats or tanks for heat containment. Plastic balls have been used as a floating insulating cover over liquid in tanks or troughs.

32. Convert from batch type process to continuous process.

33. Consider use of infra-red heaters in paint drying ovens.

34. Consider alternative energy application for optimum utilization.

35. Convert from chamber type to direct or infra-red heating whenever feasible.

36. Convert from indirect to direct heating wherever feasible.

37. Convert to direct flame impingement wherever feasible.

38. Install automatic control on radiant heat ovens.

39. Use controlled flame geometry for brazing or soldering tasks.

40. Burning fuel in air and forcing the heated gas under surface of a fluid patch is very effective. 75% to 85% efficient.

41. Convert liquid heaters from underfiring to submersion type.

42. Use explosive gas detector in paint drying ovens. This will eliminate need for using large amount of excess air to prevent an explosive mixture.

43. Use pre-heaters on any wet material entering a process oven. This is a good use for recovered heat.

44. Install continuous conveyor arrangement so that process heating conveyors return within the heated chambers.

45. Convert paddle type or "nu-tating" type mixing methods in flocculation or mixing tanks to high efficiency, flow inducing impellers. They will give improved maintenance and require up to 50% less power.

Maintenance:

46. Maintenance of high temperature equipment should be performed at regular intervals and scheduled for minimum interference.

ELECTRIC POWER AND MOTORS

The one type of energy most taken for granted in U.S. industry is electric power. Traditionally, utilities have been ready and willing to supply it in any quantity, when and where needed and at low cost. All of these conditions are rapidly changing, as with other energy sources.

Energy Savings:

The process heating applications offer opportunities of 10% or more energy savings.

Suggested Actions:

Operation:

47. Shut off all electric motors or electric ovens whenever practical to do so. It is generally cheaper to restart than to operate at no load.

48. Operate all process equipment at or near full load as much as possible for maximum efficiency.

49. Schedule processes, including start up, to have as even a flow as possible to avoid higher than necessary demand charges on the electric billing and to utilize all equipment to best advantage.

50. Size furnaces and heating equipment to the load requirements for maximum efficiency.

51. Size all electric motors to the actual power needed.

52. Size transformers to the load. Oversized transformers waste energy in excessive no-load losses.

53. Unused transformers should be de-energized.

Expense:

54. Peak demand monitoring systems can automatically shut off pre-selected loads so as to avoid setting peak demands that will result in higher billing. Such systems may be worth considering, especially with power-intensive operations.

55. Increase electrical conductor size to reduce distribution system losses.

56. Change to immersion heating in tanks, melting pots, etc.

57. Improve power factor by installation of capacitors. Have services of a specialist on this.

Maintenance:

58. Provide proper maintenance and lubrication of motors and motor-driven equipment.

ELECTRIC DEMAND CONTROL

Large commercial and practically all industrial films are billed for their electric energy requirements by using a two-part rate schedule. There is a per unit charge for the kilowatthours (KWh) of energy used, and another per unit charge for the highest demand, measured in kilowatts (KW), established during each monthly billing period. Good energy management will keep both of these charges to a minimum.

The desired kilowatt demand limit is the lowest practical KW maximum demand that can be maintained without hampering production requirements. Any demand charge for kilowatts in excess of this established maximum demand can be considered an unnecessary cost. Side benefits of limiting the maximum demand will be more efficient utilization of equipment and deferring the need for additional manufacturing equipment.

Energy Savings:

Savings in cost of electric power of up to 10% may be achieved depending on type of load.

Suggested Actions:

Operation:

59. Establish a predetermined maximum electric demand limit.

60. Establish a priority listing of interruptible loads and assign responsibility and authority to proper production people to follow the load interruption plan as required to limit maximum demand to predetermined amount.

61. Keep production supervisory people informed of the predetermined maximum demand and of the current demands being set.

62. Schedule processes to avoid coincidental operation of large power using units.

63. Schedule large power using units to operate during second and third shifts if practical or whenever power demand is lowest.

64. Investigate energy management procedures in the building operation (heating, ventilating, air conditioning and illumination) to reduce demand as well as energy used.

65. Use small sized equipment over a longer period if practical to do so.

Expense:

66. Install an alarm or some indication so production supervisor or designated person can be warned of load approaching the predetermined maximum demand and of the need to initiate load reduction.

67. An alternative is to install an automatic load monitoring equipment which will shut down pre-selected loads when a predetermined demand is reached

68. Another alternative is to install a more sophisticated automatic load monitoring system which monitors load trend and actuates load reduction at the last possible moment in a given demand interval to prevent exceeding the predetermined demand limit.

Maintenance:

69. Keep high energy using equipment as efficient as possible to reduce power requirements.

Remarks:

Consideration is now being given to use of new type of rates where demand charges for demands established during the hours of utility peak load will be substantially higher than demand charges in the past, and the charges for demands established during the utilities light load periods will be less. This situation may dictate serious consideration of electric load demand management.

WASTE MATERIALS

In this area, energy management begins with a maximum effort to minimize wastes at the point of generation. All processes should be continually under review to achieve zero waste production.

Many materials that were once disposal problems are now new products or are now considered as courses of heat energy.

Energy Savings:

There is a good potential for energy saving in waste recovery. It is estimated that solid wastes collected for waste disposal incinerators contain about 5000 BTU per pound or nearly half the heat value of coal. The waste oil contains nearly the same BTU content as fuel oil. Process waste heat recovery may save 10% or more of its energy use.

Suggested Actions:

Expense:

70. Examine the possibility of a heat recovery unit in the incinerator. The recovered heat might be used for process or space heating.

71. Check all processes for waste materials that may be useable for drying ovens which might be burnable in the oven or in some other process, or in the incinerator where the heat could be recovered.

72. Investigate a collecting system of all waste oil (cutting, lubricating, cleaning, heat treat, etc.) for use as a fuel.

Maintenance:

73. Practice good maintenance of oil lines, fittings and valves.

WASTE HEAT:

A complete survey of the plant directed toward uncovering any and all places and processes where heat is being wasted will reveal a surprising number of instances.

A review of these observations with production and maintenance personnel will, in many cases, result in a simple and economical elimination of an energy waste.

Energy Savings:

This will depend on the correction or improvement. If a heat recovery system is installed, savings of 10% to 25% may be realized in a given process.

Insulation of process lines or conveyors can save 10% of heat input.

Suggested Actions:

74. Check all processes to see if the flow of work and temperature differentials warrant installation of a heat exchanger and reintroduction of the recovered heat.

Expense:

75. Insulate hot process lines and storage tanks.

76. Insulate hot water and chilled water lines.

77. Check all processes for possible improvement in insulation. This might be additional furnace roof insulation, pipe or duct insulation, conveyor insulation and enclosure. (Plastic balls floating on a liquid filled conveying trough or tank.)

78. Process furnace stacks are a prime waste of heat. Consider carefully a heat recovery installation there, for the use of this waste heat elsewhere. Install if feasible.

79. If heated make-up air must be used for dilution purposes, consider the use of a heat recovery device to obtain theheated make-up air.

80. Investigate any large internal combustion engine used in the plant for possible use of a heat exchanger or waste-heat boiler. Consider replacement

of the engine with an alternate source.

81. Replace or cover water cooled work rails with refractory materials.

Maintenance:

82. Check and repair or replace any missing or damaged insulation on all furnaces, steam lines, water lines, process fluid lines, air or gas ducts and other process equipment.

83. Check to see that all heat exchanger surfaces are clean. Temperatures on each side of the exchanger indicate the efficiency. A high temperature differential indicates poor heat transfer.

Remarks:

Good follow-up is necessary to insure that improvements authorized in equipment and methods are implemented and followed.

PROCESS STEAM LINES AND TRAPS:

A routine program designed to maintain process steam system components including steam traps will improve the plant efficiency. Even small steam leaks are costly and wasteful.

Energy Savings:

Savings of 5 to 10% of fuel consumption may be realized by a complete plant-wide steam line and trap maintenance program.

Suggested Action:

Operation:

84. Survey condensate return system to see that all possible is being gathered and returned to the boiler. In some cases, you may find condensate being used as process water make up when the heat it contains is not needed in the process. Condensate may be dumped because of possible contamination. It may be possible to eliminate the contamination.

85. Use lowest steam pressure possible within operating limits.

Expense:

86. Install insulation on any uninsulated steam lines. Upgrade insulation if more is needed.

87. Install steam traps wherever steam is being exhausted into the atmosphere.

88. Install a complete condensate gathering, cleaning, and return system if justified by study. Help should be obtained for this study.

Maintenance:

89. Carry out a weekly inspection of all steam traps. Proper operation may be checked with a mechanic's stethoscope or by temperature measurements on each side of the trap. If steam is blowing through to the condensate side, temperature will be high. Replace or repair any defective steam traps. Replace any grossly oversided steam traps.

90. Repair all steam leaks in lines, valves or fittings.

91. Repair or replace any defective or missing pipe insulation.

C3. ENERGY CONSERVATION OPTIONS IN TRANSPORTATION

APPENDIX C3

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

C3. ENERGY CONSERVATION OPTIONS IN TRANSPORTATION

Transportation in Riverside and the Need for Energy Conservation

The people of Riverside are nearly 100 percent oriented toward and dependent on the automobile as the means of transportation (as is the case for the majority of the people in the United States). Although there are some bus services, these alternatives are simply not feasible or convenient for most people. The bus systems are primarily used by people in Riverside who do not have access to an automobile. While Riverside does have a modest degree of locally based employment, there are large numbers of people who have choosen to live in Riverside and commute to employment located outside Riverside and outside Riverside County. This situation results in a high usage of gasoline. Gasoline is a fuel which must be used less, and, ultimately, it is a fuel upon which our people can no longer be as dependent.

We must keep in mind that Americans use one-quarter of all the energy consumed in the United States in automobile passenger travel. To put it in another way, American cars are now using about 1 out of every 10 barrels of oil produced in the world. Thus, ultimately we will need an alternative fuel for most of our transportation needs. Until that time, however, we must reduce our usage through conservation measures. Even though there is much oil on the market and gasoline is flowing at the pumps, our large purchases of foreign oil are causing problems with our economy and our political posture. Thus, the need to conserve is not based on a lack of oil, but rather to protect our political status, our own economy, and the value of our dollar. As science editor Philip Abelson puts it, "This economic weakness attests to a loss of confidence in the dollar occasioned by a huge trade deficit arising out of soaring oil imports. As foreigners continue to convert their holdings into stronger currencies, they place further pressure on the dollar. ... weakness of the dollar is likely to persist while the value of oil reserves is likely to increase".[1] The people of Riverside (as well as everyone else) must be made aware and educated to the fact that conservation of fuel is necessary, not because of a current lack of fuel, but because our increasing use of fuel is severely affecting our economy. Of equal importance, our dependence on foreign oil also puts us in a position of being politically influenced (or blackmailed) by our suppliers. Consequently, conservation measures are necessary.

Transportation Alternatives Available in Riverside

The best method of reducing fuel usage is to use transportation other than the personal automobile. The alternatives that are available to the people of Riverside are briefly discussed below.

Car Pool/Van Pool Programs

The car pool program is a five-county-wide, state-supported program. A commuter who wishes to "car pool" can be helped through this program. A van pool program is also available, but it has had problems getting enough riders and drivers with similar transportation needs. The car/van pool programs have been available to the people in Riverside and surrounding counties for some time now. A detailed description of these programs will not be given here since complete descriptions are available at the program offices. These programs are not popular, and it is debatable whether they can be called a success in Riverside.

Car and van pooling, especially to and from work, or shopping with a neighbor, is one of the best ways that the people of Riverside can reduce fuel. However, these fuel savings are far from being realized. People are simply not willing to put up with the inconvenience of pooling (this is generally true across the United States). A means to compel the American people into pooling without being forced by a crisis situation has eluded and frustrated pooling proponents for years. A variety of incentives have been tried in this country, and in a few cases these incentives have met with some success, such as the car/van pool express lanes into

Washington, D.C. from Northern Virginia. However, no incentive has really been universally successful. Consequently, widespread pooling has not occurred in Riverside nor in the rest of the United States. However, car pools and van pools are viable and important transportation alternatives.

Public Transit

The Riverside Transit Agency provides a bus service within the City of Riverside which primarily caters to those people who do not have access to the automobile, such as students and the elderly. This service is probably also a source of transportation for some people to get to work, shopping, etc., but this is only a supposition. Most likely the service could be used by more people for trips within the City, but available information suggests that a survey study would be required to determine the extent to which this service could potentially be used.

The City of Riverside is included in the Rapid Transit District (RTD), and there is some bus service from the city to the surrounding cities and counties. This service is limited and the routes are not convenient for most people in Riverside who work in and commute to the surrounding cities and counties. Consequently, this service, in its present form, is a limited transportation alternative for most people.

There is also a Dial-a-Ride program for the elderly and handicapped, but this service is not a transportation alternative for the people of Riverside. The hydrogen bus experiment* is a part of this program. As stated previously, an alternative fuel is the ultimate answer to our transportation needs. The hydrogen bus is the beginning of experiments with alternative fuels. It remains to be seen whether the bus will demonstrate that hydrogen can be used in a cost-effective manner.

Bicycles, Mopeds, Motorcycles, and Walking

These alternative methods of transportation are available to the people of Riverside, but are not practical for most transportation

* Presently, as discussed later, the City of Riverside is conducting an experiment using a hydride-storage hydrogen-powered bus. This experimental vehicle has suffered problems and has not been subjected to prolonged use.

needs. Certainly those people who can use these alternatives for getting to work and shopping near to their homes should do so. It is cheaper and can be healthier than using the personal car. But for most people, the personal car is the only practical means of transportation due to distances from home to work and to shopping, and the need to transport goods.

Alternative Fuels

The people of the South Coast Air Basin are unlikely to effect a voluntary change in driving habits since such a change could occur only in combination with a total change in life-style. In the past, California--and especially Southern California--has led the evolutionary trend to more appropriate vehicles (smaller automobiles) in response to increasing costs of motor fuel. Because of the near-absolute dependence of the region on automobile transport, it is there that derived fuels would have the most likelihood of early adoption.

The use of such alternative fuels would not be without problems, setbacks, and, possibly, accidents. (The use of conventional fuels is, of course, also continually subject to problems and accidents.) The orderly development and introduction of technology involving nonpetroleum fuels will start with small demonstration projects. Because the major difficulty associated with alternative fuels is the logistics of the distribution system, the demonstration can be applied best to fleet vehicles. For this reason, the vehicle fleets of the City of Riverside are examined below.

Characterization of Riverside Vehicle Population [2]

As of 1977 there were 89,166 automobiles and 16,165 trucks registered in the City of Riverside. Based on national averages, approximately 6,500 of the automobiles and approximately 5,200 of the trucks were fleet vehicles. (The corresponding numbers for large fleets, i.e., greater than 24 vehicles, are 2,700 and 500.) The city fleet is composed of approximately 770 vehicles (excluding police and fire) and meters some 3.8 million miles per year. The County fleet of approximately 650 vehicles logs somewhat more than 17,000 miles per vehicle per year. Most of these miles are driven outside the city limits, however. The U.S. Government maintains a fleet of 418 vehicles in Riverside (excluding Post Office and Forest Service vehicles); each of these vehicles is driven an average of approximately 14,000 miles per year, of which approximately 2,800 are logged within the city limits. The Riverside Bus System maintains 24 diesel buses which average approximately 4,000 miles per month. No information was available on school buses, but, based on national statistics, Riverside should have approximately 200 public school buses, each logging approximately 7,000 miles per year. In addition, there should be approximately another 100 school buses associated with private facilities. The University of California, Riverside, maintains a fleet of approximately 250 vehicles. No information was obtained on Post Office or police vehicles. Despite the unavailability of this information, all major fleets are assumed to have been identified. Based on national statistics, there should be approximately 800 more fleet vehicles in large fleets in Riverside than were identified. Major industry in Riverside was questioned but no other large fleets were identified. The "missing"fleets are assumed to have been: (1) fire, police, and postal vehicles, and (2) a result of the character of Riverside, i.e., as a bedroom and soft-industry community (as opposed to a heavy manufacturing community). Information obtained on large fleets in Riverside is summarized in Table C3-1.

TABLE C3-1. VEHICLE FLEETS IN RIVERSIDE

Type	Number of Vehicles	Approximate Average Mileage (Annual)	Total Annual Mileage, million
City	770	5,000	3.85
County	650	17,000 [a]	11.05
Federal	418	14,000 [a]	5.85
Univ. of Calif.	250	22,000 [b]	5.5
Riverside Bus	24	42,000	1.01
School Buses	300 [b]	7,000 [b]	2.10

(a) Most of this mileage is driven outside the City.

(b) Estimated on the basis of national averages.

Data were obtained on 543 of the vehicles in Riverside's city fleet. The results of calculations on these data are summarized in Table C2-2. These results are used in later sections. The raw data consisted of 12-month average monthly usage for each vehicle and monthly usage for each vehicle for 3 months. These data were plotted for several classes of vehicles according to number of vehicles (in each mileage interval) vs. monthly mileage. No particularly striking pattern was observed. The data were then assumed to be samples from a normal distribution and the means and standard deviations were calculated. As can be seen from Table C3-2, the results from the 12-month average and those from the 3 one-month averages are not particularly different. The standard deviations are smaller for the 12-month averages, but this is a natural result of working with numbers already averages. Operating on the premise that each vehicle of a given type is identical, on a given day, with every other such vehicle and, therefore, equally likely to be used, an average daily usage was calculated for each class of vehicle. It should be noted that, in some cases, these are quite small and that, in every case, the deviation exceeds the "average" usage. In some cases, this is obviously a result of the day being too small an interval for averaging; for instance, the road roller may sit idle for several days and then be driven many times its average daily mileage on a given day. This is simply a warning that, in designing for an alternative fuel, the fuel capacity should allow for a range of several standard deviations.

Data were provided by the City of Riverside relative to the fuel consumption of city vehicles for the month of October, 1977. When averaged over vehicle type, however, the average fuel consumption per month and the average mileage traveled per month did not relate in any meaningful fashion. Thus, estimated fuel mileages were used, based on the estimated weight of the particular vehicle.

Conversion Alternatives

A demonstration of derived fuels within the Riverside automotive fleets appears to be an appropriate introduction of these technologies to the Southern Coast Basin. Therefore, a description of the

TABLE C3-2. CHARACTERISTICS OF RIVERSIDE CITY FLEET VEHICLE USAGE[a]

Vehicle Type	Number	12 Month Average Monthly Use	12 Month Standard Deviation	1 Month Average Monthly Use	1 Month Standard Deviation	Estimated (b) Daily Use	Estimated (b) Standard Deviation
Pickup	145	733	446	818	744	35	36
Scooters	54	227	121	197	205	10	35
Automobile	81	669	308	669	484	30	84
Special Equipment (winch, compressor)	82	376	333	437	433	18	82
Cement Mixers (Roller Grader)	16	40	21	46	38	2	6
Special Equipment (Flatbed, sign trk)	10	349	299	410	408	17	75
Water tankers	13	269	201	305	282	13	51
Dump trucks	42	562	382	542	463	25	90
Packers	34	451	142	526	431	22	61
Vans	23	1,037	854	1,171	1,152	50	213
Sweepers	9	694	169	577	309	29	51
Bus	24	4,100	1,073 (c)	-----	-----	187	229

(a) Excludes; tractors (7), cranes (5), compressors (1), high range, boom, compacters, loaders, D8(10).

(b) Assumes 22-day month

(c) At 4.70 mpg ± .25 mpg (diesel).

rationale behind the choice of the technologies recommended is needed. In addition to gasoline derived from nonpetroleum feedstocks, three derived fuels have received much attention in recent years; these are electricity, hydrogen, and methyl fuel. Nonpetrochemical gasoline is the most attractive from the point of view of distribution; a system already exists for the marketing of gasoline and few changes would have to be effected in order to introduce nonpetroleum gasoline. The other derived fuels, however, provide environmental and efficiency advantages relative to gasoline.

The purpose of demonstration projects suggested by this work was interpreted as being to demonstrate the feasibility and problems associated with general implementation of the advanced technologies and to pave the way for possible wide-scale adoption of these technologies. The adoption of these technologies, it was interpreted, would follow a path of:

Large Riverside Fleets → Other Southeastern Fleets → South Coast General → National

Large Riverside Fleets → Small Riverside Fleets → Riverside General Use → National

It was further assumed that massive relocations of people will not occur. Within this pattern of assumptions; an electrically powered automobile is unlikely to be suitable for residents of the South Coast Air Basin in the foreseeable future. Traditionally, the modal Southern California resident drives his primary vehicle in excess of 40 km[3] (25 Miles) on a given day and about 25 percent of the vehicles are driven in excess of 80 km (50 miles) per day.[3] Some advanced electric passenger cars are capable of this range but cannot perform at freeway speeds; DOE near-term goals of a four-passenger vehicle capable of a top speed of 50 mph, a 0 to 30 mph acceleration of 9 seconds, and a range of 75 miles (in SAEJ227a driving cycle D corresponding to a top speed of 45 mph) would be marginally acceptable to the Southern California driver.* Furthermore, at the present time, marginal

---

* This goal vehicle would consume oil (at the power plant) at the rate of approximately 22 mpg for driving cycle D. Existing electric vehicles consume approximately 1 to 2 kwh/mi traveled. Assuming a heat rate of 12,500 Btu, this is an equivalent mileage of 5 to 10 mpg.

electricity in California is generated at oil-fired power plants at a price of approximately 5¢/kwh. Because of the inefficiencies associated with generating electricity, the electric car will consume more petroleum than the petroleum-fueled car powered by an internal combustion engine. Until, and unless, nuclear or coal-fired power plants become more dominant in California, electric vehicles do not appear to be an attractive option.

In some cases, the conversion of the vehicle to an alternative fuel would involve the addition of weight. In this case, the structural strength of the vehicle would have to be increased to support the modification; this increase in structural strength itself adds yet more weight to the vehicle. Figures for the mass-compounding factor which relates the increase in total weight to an increase in dead weight have been published, but these vary; instead of using these published figures, a mass compounding factor was derived by examining the variation with gross vehicle weight of published values of curb weight for a family of otherwise identical pickup trucks. Based on these figures, a mass-compounding factor of 1.2 appeared to be reasonable and was, therefore, used in this work.

In a previous Battelle study [4], a relationship between fuel consumption and weight was derived. This is shown in Figure C3-1 and was used in this work.

Other required assumptions are discussed in the individual sections. The calculations involved in the various sections are assumption-independent so that the reader may perform similar calculations based on alternative assumptions.

Hydrogen Alternative Fuel

Many researchers [5] have studied the application of hydrogen as a fuel for internal combustion engines under various possible fuel storage conditions. At the present time, two possible storage mechanisms are popular candidates: storage of hydrogen as a cryogenic liquid and storage of the hydrogen weakly bound in another chemical.

The advantages of hydrogen as a fuel are severalfold. Hydrogen burns cleanly; no pollution control devices are needed on the hydrogen-fueled

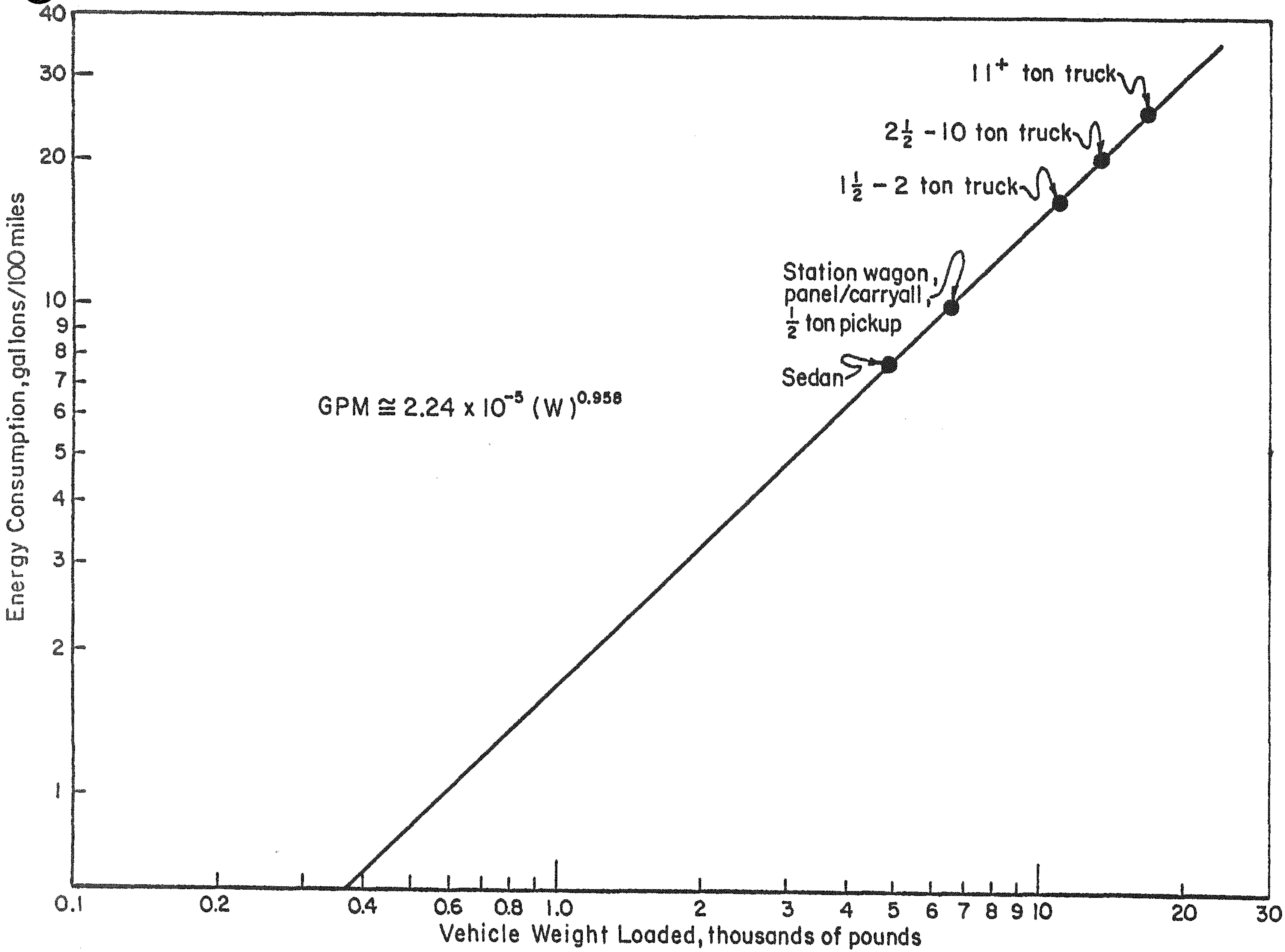


FIGURE C3-1. AVERAGE FUEL CONSUMPTION AS A FUNCTION OF WEIGHT

(Based on Data From Reference (1))

automobile. Hydrogen is an efficient fuel; it has a thermal efficiency at least 50 percent greater than that of gasoline. Additionally, hydrogen is a derived fuel--possible feedstocks for fuel hydrogen include any carbon-containing material. Prices estimated for fuel hydrogen vary from $1.60 to $10/10^6 Btu.[6] This study projects a value of $7.50 for a community the size of Riverside. Because larger-scale plants would be able to produce hydrogen more cheaply, for the purposes of this report, both $2.00 and $7.50/10^6 Btu were costed. This is to be compared to a value of $3.85/10^6 Btu as used for gasoline ($.48/gallon). All prices are less taxes.

The use of hydrogen fuel in internal combustion engines has some disadvantages. Hydrogen has an extremely small ignition energy and an extremely small quench distance. As a result, hydrogen-fueled engines are prone to backfiring. This can be ameliorated by careful shielding of ignition wires and through water injection. Also, normally aspirated internal combustion engines suffer a reduction in performance of approximately 25 percent when converted to hydrogen fuel. This loss in performance is a result of the smaller fuel value of hydrogen on a volumetric basis relative to that of gasoline fuel. If full power and torque are needed in a particular application, this can be obtained by direct injection of the fuel into the combustion chamber or by injection at reduced temperature.

Hydrogen has a reputation for being unsafe. (This reaction has been dubbed the "Hindenberg syndrome" by some people.) Opponents of the use of hydrogen have pointed to the dangers of 2×10^6 Btu of hydrogen fuel igniting in a crash situation; of course, an equivalent quantity of gasoline is carried in a gasoline-powered vehicle. Hydrogen gas has a wider flammability range and lower ignition energy than those of gas-line vapors. If a tank is ruptured and an ignition source is encountered, a fire is more likely to result than in the case of gasoline. On the other hand, hydrogen gas is much lighter than air and therefore tends to rise above ground-level ignition sources; this is in distinct contrast to gasoline vapors which follow the ground for large distances. Overall, the use of hydrogen as a fuel does not appear to present a significantly greater hazard than the use of gasoline.

The hydrogen fuel can be stored onboard the vehicle as a compressed gas, a cryogenic liquid, or a weakly bound chemical compound.

Storage as a compressed gas would not give adequate range for the vehicles under consideration and was, therefore, given no further consideration.

Storage as a cryogenic liquid (LH_2) requires a vessel capable of maintaining a temperature of approximately 20 K. It also entails the additional cost of liquefying the hydrogen fuel. A cryogenic storage vessel that is capable of storing liquid hydrogen for a period of up to 4 days before pressure builds up (and therefore must be vented) can be mass-produced for a cost of $395 (18 gallons) to $455 (39 gallons).* Venting does not constitute a safety hazard as the hydrogen gas is passed over a catalyst which oxidizes the gas harmlessly to water. The cost of liquefaction of hydrogen was estimated to be $\$1.80/10^6$ Btu. The cost of converting a vehicle to operate on hydrogen fuel has been estimated as up to $300, depending upon the extent of engine retrofitting required. Thus, the total cost of conversion to cryogenically stored hydrogen is about $700 to $800. In the case of heavy vehicles and special-purpose equipment used only intermittently, it is assumed that the tanks would be kept at the vehicle control facility and installed in the equipment as needed. Since one cryogenic storage tank could thus serve several pieces of equipment, fewer tanks than pieces of equipment would be required. The cost of conversion for this equipment would then be in the vicinity of $300. This adjustment has <u>not</u> been made in cost calculations shown here.

Hydrogen might also be stored chemically bound as a metal hydride or as a hydrogenated organic liquid. The volume density of hydrogen stored in this way can exceed that of LH_2. Cost estimates for hydrogen storage as hydrogenated organic liquid are similar to those for hydride storage and are discussed no further here. Two metal alloys have been considered for the storage of fuel hydrogen as hydrides: these are Mg_2Ni and FeTi. The magnesium alloy is lighter and can store approximately twice the hydrogen (by weight) as the iron alloy; it is also more expensive and requires an above-ambient temperature to release the hydrogen. Containers for the hydrides can be constructed either from aluminum alloy or stainless steel.

---

* 1974 dollars. Note that this price is for lots of 30,000. Individual tanks would be expected to cost $40-$45,000. Other sources, designing tanks to less stringent boil-off specifications have arrived at slightly lower tank cost estimates.

Stainless steel containers would have a known lifetime exceeding that of the vehicle; the lifetime of aluminum alloy containers is uncertain. The assumptions for the properties and costs of these materials and containers are given in Table C3-3. The cost calculations for hydride storage are summarized in Table C3-4. As can be seen, the LH_2 option has enormous cost and weight advantages relative to the metal hydride system.

Under the assumption that demonstration of hydrogen vehicles in Riverside fleets would lead to incorporation of this technology for other fleets in the South Coast area and then to private vehicles, the storage and distribution problems associated with wide-scale adoption of LH_2 are ameliorated. Thus, the weight and cost advantages of LH_2 relative to metal hydride storage led to the recommendation of the former.

For a hydrogen-powered automobile, the power plant can be either an internal combustion engine or a fuel cell driving an electric motor. The fuel cell power plant can legitimately be viewed as a second-generation system and is not discussed further here. As the hydrogen-fueled internal-combustion automotive system becomes widely utilized, the fuel cell system should be explored as it presents both economic and environmental advantages.

The early hydrogen-fueled vehicle envisaged here has a normally aspirated engine with water injection to control backfire. Such an engine would naturally have to be derated from its power with gasoline. The hydrogen would be stored as LH_2 with a small hydride buffer to take up boil off and to provide a small reservoir of quickly available hydrogen for starting. The safety of such a system has already been demonstrated in an accident in which a fully fueled LH_2-powered vehicle overturned while being towed; in this accident, no untoward effects were noted. The potential hazards associated with the use of hydrogen as a fuel were also demonstrated when a hydrogen-powered vehicle belonging to one prominent promoter of this fuel burned in his driveway.* (The latter incident illustrates possible public-relations problems associated with a conversion to hydrogen fuel. This accident must be anticipated as inevitable.)

---

* It has been said that the owner of the vehicle is question was aware that there was a leak in the hydrogen system but failed to have the needed repairs made.

TABLE C3-3. PROPERTIES AND COSTS OF MATERIALS AND CONTAINERS FOR HYDRIDE STORAGE

	Mg_2Ni	FeTi
Hydrogen Storage Capacity, percent by weight	3.3	0.9 - 1.7
Specific Gravity	1.45	5.9
Cost, $ per pound	3.00	0.50
Hydrogen Storage Capacity, pounds of alloy needed per pound of hydrogen storage	30	59 - 110 (assume 60)
Volume of Alloy Needed per Pound of Hydrogen Storage, ft^3	0.332	0.163
Cost of Alloy per Pound of Hydrogen Storage, $	90	29 - 56 (assume 30)
Tank Weight, lb[a]		
Stainless	990	990
Aluminum	340	340
Tank Cost, $[a]		
Stainless	4730	4730
Aluminum	480	480

(a) Based on storage capacity of 24.2 pounds of hydrogen.

Note: Data from Reference (10). 1975 prices.

TABLE C3-4. COST CALCULATION FOR HYDRIDE STORAGE

Hydride Type	Capacity of Hydrogen pounds	Tank Weight Empty, pounds		Tank Volume, ft^3	Hydride Weight, pounds	Skin Cost $		Hydride Cost $	Total Cost $		Total Weight lb	
		Al	Stainless			Al	Stainless		Al	Stainess	Al	Stainless
FeTi	10	190	550	4.9	600	270	2600	300	570	2900	790	1150
	12	210	620	5.9	720	300	3000	360	660	3360	930	1340
	33	420	1200	16.1	1980	590	5800	990	1580	6790	2400	3180
	50	550	1600	24.5	3000	780	7700	1500	2280	9200	3550	4600
Mg_2Ni	10	190	550	10.0	300	270	2600	900	1170	3500	490	850
	12	210	620	12.0	360	300	3000	1080	1380	4080	570	1080
	33	420	1200	32.9	990	590	5800	2970	3560	8770	1410	2190
	50	550	1600	49.8	1500	780	7700	4500	5280	12,200	2050	3100

Note: 1975 figures; add $100 to tank costs for controls.

The next version of the hydrogen-powered vehicle is viewed as having been specifically designed for the use of that fuel. The work of expansion of the hydrogen from the liquid to ambient state will be used either to provide accessory support, turbocharging, or the work to inject the fuel directly into the cylinder (approximately 10 percent of the total possible recoverable energy content of the fuel is the work of expansion). Other more novel approaches would also be possible.

For the purposes of estimating the effects of the transition to hydrogen fuel, only the earliest generation was considered. The results of such estimates are shown in Table C3-5. Cost estimates are shown for the two extreme cases of $\$2.00/10^6$ Btu and $\$7.50/10^6$ Btu (plus $\$1.80/10^6$ Btu for liquefaction). As can be seen, at the higher cost the hydrogen fuel is more expensive than petroleum-based fuel at $\$3.85/10^6$ Btu ($.46/gallon). However, if the price of petroleum-derived fuel rises marginally relative to coal-derived hydrogen, then hydrogen would be the fuel of economic choice, even at this high figure. If, however, the high volume cost of $\$2.00/10^6$ Btu were to prevail, then hydrogen would be the fuel of economic choice at this time, if the distribution system existed.

In the above calculations, hydrogen was assumed to be 50 percent more energy efficient than petroleum-based fuel. Numerous experiments in prototype engines have been extrapolated to predict 25 to 100 percent increased efficiency. The figure chosen to be used here was based on a projected driving cycle efficiency for a 16,000-pound bus using both gasoline and hydrogen fuels.(11)

Emissions estimates presumed new vehicles. Most likely, the hydrogen-fueled vehicles would be replacing conventional vehicles, thus this is a reasonable assumption. In addition, in this case, the reduction in pollution control equipment will largely offset the capital investment required to convert to hydrogen.

As can be seen from Table C3-5, the use of LH_2 fuel would result in considerably reduced emissions. The most dramatic reduction would occur in the area of carbon monoxide and hydrocarbons, as the hydrogen-fueled engine should emit little CO or HC (all these will come from the lubricating oils). The amount of NO_x emitted by the hydrogen-fueled vehicle is uncertain and can vary widely depending upon the mode of operation.

TABLE C3-5. RESULTS OF CONVERSION TO HYDROGEN FUEL

TABLE C3-5. RESULTS OF CONVERSION TO HYDROGEN FUEL

Vehicle	Assumed mpg (Petroleum)	Fuel Cost/Yr (per vehicle), $		Fleet Cost/Yr thousands of $		Emissions annual pounds/vehicle)					
						HC		CO		NO_x[f]	
		Petroleum	Hydrogen	Petroleum	Hydrogen	Petroleum	Hydrogen	Petroleum	Hydrogen	Petroleum	Hydrogen
Riverside City Fleet											
Pickup	9.9	428	688 (281)	62.0	99.8 (40.9)	11.6	neg	104.4	neg	29.0	10.2
Automobile	12.75	303	488 (200)	24.5	39.6 (16.2)	10.6	neg	95.4	neg	26.4	9.28
Vans	10.0	597	961 (393)	20.3	32.7 (13.4)	16.4	neg	1,489.0	neg	41.0	14.4
Dump Trucks	6.6	496	799 (327)	20.8	33.6 (13.7)	8.9	neg	1,740.0	neg	169.0	16.2
Sweepers[a]	4.0	1,113	1,792 (728)	10.0	16.1 (6.7)	11.0	neg	2,140.0	neg	208.0	15.6
Packers[a]	4.0	719	1,158 (473)	24.4	39.3 (16.2)	7.14	neg	1,390.0	neg	136.0	10.1
Winch, Compressor Trucks	6.0	362	583 (238)	29.7	47.7 (19.6)	5.96	neg	1,160.0	neg	113.0	8.44
Riverside Bus[a]	4.7[b]	5,562	8,956 (3,659)	133.5	215.0 (87.8)	6.50	neg	12,700.0	neg	1,230.0	92.0
School Buses	4.5	749	1,206 (493)	224.6	361.7 (147.7)	9.24	neg	1,800.0	neg	176.0	13.1
All Riverside Automobiles and Trucks	12.3[c]	391	630 (257)	41,212	66,367.0 (27,118.0)	3,170.0[g]	neg	40,385.0[g]	neg	6,529.0[g]	608.0[g]

Assumption: Petroleum fuel at $\$3.85/10^6$ Btu, LH_2 at $\$9.30/10^6$ Btu with $\$3.80/10^6$ Btu in parentheses, petroleum-based fuel at $\$3.85/10^6$ Btu. All less taxes. Price of LH_2 includes $\$1.80/10^6$ Btu for liquefaction.

(a) Assumed to be diesel.
(b) Known mileage.
(c) Assumed to drive 10,000 miles/year.
(d) Assuming new vehicle standards.
(e) For all University city automobile
(f) NO_x data based on 100 ppm NO_x for H_2-powered engines.(12)
(g) In annual tons.

Methanol Fuel

The use of methanol or methyl fuel (methanol plus higher alcohols) as an automobile fuel is not a new idea; racing cars have used methanol for many years to take advantage of an improvement in performance. Additionally, the City of Santa Clara, California has operated two city vehicles on methanol for several years.(13) Since methanol has approximately half the heat value of gasoline per unit volume, methyl fuel-powered vehicles would have reduced range or require enlarged fuel tanks. Methyl fuel has a much higher latent heat than gasoline, so, on vaporizing, more heat must be added.

Conversion to methyl fuel of an engine designed to operate on gasoline involves enrichening the mixture, recycling an increased fraction of the exhaust heat, and providing for cold starts. The conversion cost has been estimated at approximately $100 per vehicle.

Methyl fuel can be made from synthesis gas (H_2+CO) by passing the gas over a catalyst. Cost estimates for methyl fuel range from 8.5¢/gallon (for fuel manufactured from coal at a 10,000 ton/day facility) to 59¢/gallon.(14) This study projected a cost for methanol of $8.50/$10^6$ Btu (for Riverside scale) or approximately 55¢/gallon. For costing purposes, values of 10¢/gallon and 55¢/gallon were utilized.

In the calculations, it was assumed that, although methyl fuel has only about 50 percent of the energy content of gasoline, the increased efficiency of approximately 15 percent led to an overall thermal efficiency of 57 percent of that of gasoline (on a volume basis). For the purpose of demonstrating the use of methyl fuel, the motorcycle fleet would, perhaps, be the most satisfactory. An average uncontrolled motorcycle emits twice the carbon monoxide (CO) and six times the NO_x of the 1977 controlled (U.S. standards) automobile (per mile). This amounts to approximately nine times the CO and 15 times the HC for the national standards for 1980. New regulations will impose standards for motorcycles. The cost of implementation of these regulations is comparable to that for conversion to methyl fuel (as the modifications are quite similar) and the U.S. EPA projects these modifications to result in improved operating efficiencies comparable to those obtained by going to methyl fuel. However, the use of methyl fuel permits an improvement in drivability as opposed to lean operation as for gasoline. Table 6 shows the results of some calculations comparing alternatives. It is seen that the use of methyl fuel at 55¢/gallon results in a somewhat higher cost of operation (relative to that using gasoline) but significantly lower emissions of carbon monoxide and NO_x; the hydrocarbons emitted are mainly not photochemically reactive. The latter are also reduced if a single function catalyst is used. If the 10¢/gallon price for synthetic methanol figure prevails, the cost of operation drops significantly.

For comparison purposes, also shown in Table 6 are the results in reduction of emissions if all Riverside automobiles converted to the use of methyl fuel, assuming the use of a single function exhaust catalyst. The present case refers to the California mean emission factors as calculated for 1977 from U.S. EPA data.[15] The methyl fuel emissions factors were obtained by using the predicted reduction in emissions for a Ford Pinto engine based on gasoline and methanol operation.

Specific Recommendations

Conservation

Many of the following recommendations will not be new to the people of Riverside. They have been stated before, by many different sources, to the citizens of our nation. Since these recommendations require voluntary actions, and because there is no current crisis, it is anticipated that they will not be followed by the majority of people. If these recommendations are followed, fuel savings can be realized. But, these take a concerted and conscious effort, and some changes in life-style and reductions in convenience to achieve.

TABLE C3-6. RESULTS OF CONVERSION OF MOTORCYCLE FLEET TO METHYL FUEL

	Monthly Fuel, Cost, $[a,b]		Emissions, Pounds/year Each Motorcycle[c]			Fleet, tons/year		
	Each	Fleet	H/C[d]	CO	NO_x	H/C	CO	NO_x
Present Case	2.69	145	494	180	135	13.3	4.9	3.6
Methyl Fuel	5.41 (.98)	292 (53)	983 (150)[e]	21	12.6	20.5 (4.0)	.57	.34
Controlled (1978 Standards)	2.24	120	135	164	630	3.7	4.4	143
If all City Automobiles Converted								
Present Case (1977 Mix)[f]						43,000	3,750	2,040
Methyl Fuel[g]						1,130	2,770	190

(a) Assumed 1,500-pound motorcycle including rider and equipment.
(b) Gasoline at $.48/gallon; methyl fuel at $.55/gallon with $.10/gallon figure in parentheses.
(c) Based on experiments with modified Pinto engine.[7a]
(d) In the case of methyl fuel, these are methanol and formaldehyde; these can be removed (80-90 percent) with a single-function catalyst.
(e) The value in parentheses assures an 80 percent reduction in unburned hydrocarbons using a single-function catalyst.
(f) Based on California mean emission factors as calculated from "Compiliation of Air Pollutant Emission Factors", CO, 43.8 g/mile; NO_x, 2.8 g/mile; H/C, 3.82 g/mile.
(g) Assuming simple catalyst to remove unburned fuel.

Car Pools/Van Pools. Car pools and van pools do provide excellent methods for saving fuel and money and for reducing the number of vehicles on the road. Although these "pools" are not popular, because they are so effective in saving fuel, they must be recommended. It is also recommended that the Car Pool and Van Pool Programs in and around Riverside be continued on, at least, a low program-cost basis. These programs could be very useful if another fuel crisis results in shortages, higher costs, gasoline rationing, etc. In the event of another crisis, these programs could be expanded quickly to help people form car and van pools.

Car pooling and van pooling are the most immediate and effective means of saving fuel available to the people of Riverside. Often there are two or three people who live near one another and work near each other. These people could form a car or van pool. It is highly recommended that each resident of Riverside who uses a personal automobile to get to work should consider pooling and should attempt to identify interested partners. Also, companies have been successful in providing information to employees concerning those people residing near to one another and in generally organizing can/van pools. Companies should be encouraged to provide special privileges to car/van pools.

There is no doubt that inconveniences occur. But, there may come a time when these inconveniences may become commonplace in an effort just to get to work.

Riverside Transit Agency (RTA). The intra-Riverside bus system should certainly be continued and the people of Riverside should be encouraged to use the system not only for getting to work (if possible), but also for light shopping and trips to services. Although the current riders are primarily people without access to an automobile, in the future, if a crisis occurs, the transit may become more widely used for commuting to work. This would create the need for additional buses and new routes. The transit agency should make plans for what it would do to help people with their transportation needs in the event of a crisis. A survey study is recommended to determine whether people would-or could-take the bus to work in Riverside and would be willing to use it for other purposes in the event of a crisis situation. The results of a survey study would be very useful in determining the full potential of the RTA.

Mass Transit. As it now stands, additional mass transit (commuter trains and buses) may not be a viable transportation alternative in Riverside. Mass transit is normally workable when a group of people live in one general area and work in another general area (such as "downtown"). Because of the dispersed commuting pattern from Riverside to the surrounding areas, it is doubtful that mass transit could be effective. However, it is recommended that the City of Riverside perform a survey study to obtain a clearer picture of the patterns of commuting practices. It is conceivable that there are sufficient numbers of people in Riverside who work in the same general area who could be serviced by mass transit, such as RTA.

Purchasing Fuel-Efficient Vehicles. It is recommended that when a new or a replacement vehicle is purchased, one of the most important criteria for selecting the vehicle be its fuel efficiency. By continually increasing the gas mileage of vehicles owned, fuel savings can be realized, and a demand will be placed on auto manufacturers to continue to improve vehicle fuel efficiency. By adopting this policy, the people of Riverside could have an important impact on the local vehicle dealers and the types of vehicles they stock. The dealers, in turn, would have an important impact on the manufacturers. The City of Riverside should promote the purchase of fuel-efficient vehicles.

Efficient Driving Behaviors. Most cars get about 20 percent more miles per gallon on the highway at 55 miles per hour than they do at 70 miles per hour. By keeping within the speed limit and supporting enforcement of the speed limit, fuel is conserved.

There are other driving techniques that a careful driver can use to get 20 percent more miles per gallon than the average driver and 50 percent more than a wasteful one. These techniques include accelerating smoothly and moderately, driving at a steady pace, avoiding stop-and-go traffic, minimizing braking, not letting the motor idle for more than a minute, not overfilling the gasoline tank, planning trips carefully, having the car tuned (3-9 percent savings), keeping the engine air filter clean, checking tire pressure regularly (2 percent waste per pound of under-inflation), using radial tires (3-10 percent savings), and removing unnecessary weight from the car.[16]

Efficient Route Planning. Another important method for saving fuel is to plan trips and routes in an efficient manner. The trip to work and back should be planned for maximum fuel efficiency and most people have probably--if unconsciously-- already done so. However, inefficient use of the car for shopping, errands, etc., can easily occur. All trips should be planned, perhaps on a weekly basis, so that trips can be combined and efficient routes identified and used.

The telephone can also be very useful. In many cases, trips are made uselessly because the store did not have the item wanted or the store was not open. Calling ahead can save time and fuel. Also, catalog shopping can help reduce the use of the car.

Conclusion. Conserving fuel takes a conscious and concerted effort on the part of everyone. Each person in Riverside who is dependent upon the automobile for personal transportation should make contingency plans in case of gasoline shortages, a soar in price, gasoline rationing, etc. A variety of ways have been recommended here.

Alternative Fuels

Two synthetic fuels not dependent upon petroleum appear to be feasible as substitutes for petroleum-based fuels. These are hydrogen in liquid form and methyl fuel. A satisfactory large-scale demonstration of the feasibility and problems associated with the use of these alternative fuels could be conducted with the City of Riverside fleet vehicles. The City fleet is particularly appropriate for a start because, as a governmental unit, California State fuel taxes, which are levied per gallon (and not on an equivalent Btu basis), would not apply. Thus, these taxes would be irrelevant for the start of the demonstration. As the demonstration progressed, and if the feasibility of the alternative fuel is demonstrated, a fair tax based on an equivalent Btu basis (or perhaps on an emissions basis) would need to be negotiated with the State to permit expansion of the alternative fuel to private vehicles.

It is recommended that the methyl fuel application be demonstrated using motorcycles. The timing for such a demonstration is particularly appropriate as new motorcycles will be incorporating changes made in response to emission regulations. These changes will probably adversely affect drivability; the comparison with similar motorcycles without controls but operating on methyl fuel should be important in assessing the true applicability of this substitute fuel. If successful, the demonstration should be extended to other vehicles in the fleet.

The recommended demonstration of liquid hydrogen vehicles* might logically start with the bus fleet for two reasons:

- These buses operate fixed routes with reasonably well-known demands for fuel.
- A hydride storage hydrogen-powered bus is presently undergoing testing in Riverside.

A comparison of the benefits and difficulties of operation of the hydride-storage bus and one operating on LH_2 would be useful in assessing the better approach for on-board hydrogen storage.

* The Linde facility near Fontana, California has a 30 ton/day LH_2 plant, which might serve as an interim source of LH_2.

A demonstration bus should have water injection to suppress backfiring. Preferably, the hydrogen should be introduced into the cylinder cold so as to avoid derating of the engine.

The demonstration should plan expansion in such a way as to incorporate more advanced concepts (this applies to methyl fuel as well) as the LH_2 fleet expands. It is important that each demonstration be planned to include several vehicles with a planned expansion to include the entire city fleet.* The demonstration should also incorporate plans for a local supply system for the alternative fuels as (and if) other local fleets (or even private vehicles) adopt these fuels.

The public relations part of such a demonstration is extremely important. The public should be prepared for problems associated with the use of these alternative fuels. There will be breakdowns, fires, and accidents. All these, of course, are in common with petroleum-fueled vehicles. Because of the nature of a demonstration fleet, each of these will receive immensely more public exposure than would a similar happening with a conventional vehicle.

Estimated Fuel Savings

The recommendations for transportation energy conservation actions accept the fact that most drivers have no real alternative to the automobile in their trips to work. For this reason, the aggregate energy savings in the transportation sector due to voluntary energy conservation will not be as great as in the other sectors. Furthermore, federal programs (most notably the requirement that new car fleets average 20 miles per gallon in 1980, and 27.5 miles per gallon in 1985) have to an extent preempted state and local efforts and will result in substantial fuel savings over the next several years. Even with more efficient vehicles, the recommended energy conservation actions will provide additional energy savings and should be promoted. Table C3-7 gives a summary of the maximum reduction in total

* Some vehicles must be available to use conventional fuels for special purposes outside the Riverside area.

TABLE C3-7. SUMMARY, EFFECTIVENESS OF POLICIES DESIGNED TO REDUCE TRANSPORTATION FUEL CONSUMPTION

Type of Travel and Policy	Maximum Percent Reduction In Total Transportation Fuel Consumption	Dates Associated With Policies		Governmental Unit Primarily Responsible For Policy Promotion
		Implementation	Maximum Effectiveness Attained	
Person Movement				
Urban				
Improved Vehicle Efficiency	17.4	1975	1992	Federal
Mass Transit Improvements	1.7	1975	1985	Federal, State, Local
Other Conservation Measures	4.0	1975	1980	Local
Combined Impact*	20.2	1975	1992	---
Intercity				
Improved Vehicle Efficiency	7.7	1975	1992	Federal
Increased Airline Load Factors	1.1	1975	1980	Federal, State
Modal Shifts	0.6	1975	1980	Federal
Combined Impact*	9	1975	1992	---
Total Potential Savings	29.2	1975	1992	---
Goods Movement				
Urban				
Incentives to Increase Load Factors	0.8	1975	1980	Local
Intercity				
Improved Diesel Efficiency	1.0	1975	1980	Federal
Alterations in Regulation	2.0	1975	1980	Federal, State
Modal Shift	0.2	1975	1980	Federal, State
Combined Impact*	3	1975	1980	---
Total Potential Savings	3.8	1975	1980	---
All Transportation	33.0	1975	1992	---

* All conservation measures are not compatible. Thus, the potential savings associated with the individual measures are not additive in determining total savings.

transportation fuel consumption as a result of various energy conservation actions and/or policies.[17]

For purposes of estimated transportation energy savings in Riverside, it was assumed that the maximum likely savings would be 20 percent for a high impact conservation strategy. This was scaled back to 15 percent and 10 percent for moderate and low strategies, respectively. It was further assumed that 60 percent of the passenger car driving and selected percentages of fleet vehicle driving was within the city limits. Using these assumptions, Attachment C3-1 gives the details of transportation energy savings and emissions in Riverside for low, moderate and high impact conservation strategies and population growth scenarios.

The question of alternative fuels for vehicles has been approached on the basis that the first steps will be the suggested demonstration programs using hydrogen for the Riverside City Fleet Vehicles and methanol in motorcycles. Technology is still being developed for these applications, and changeover of a significant portion of Riverside's vehicles by the year 2000 is not expected to occur. Some replacement of petroleum by hydrogen for vehicle use has been assumed in the integration methodology (see Volume I).

REFERENCE

1. "Policy for Energy", Science, March 10, 1978, 199 (4333).

2. Most of the data relating to vehicle numbers and use were obtained from City officials and provided to the project through the good offices of Mr. David Sparks.

3. Shonka. D. B., et al, "Transportation Energy Conservation Data Book: Edition 2", Prepared for U.S. ERDA by Oak Ridge National Laboratory, October 1977, ORNL-5320.

4. "The Development of The Basis for an Integrated Alternative Energy Plan for the Sewells Point Naval Complex, Norfolk, Virginia", Battelle Report to U.S. ERDA, November 1977.

5. de Boer, P.C.T., McLean, W. J., Homan, H.S., "Performance and Emissions of H_2 Fueled Internal Combustion Engines", Int. J. Hydrogen Energy, 1,153 (1976).

   VanVorst, W.D., and Finegold, J.G., "Automobile Hydrogen Engines and On-Board Storage Methods", 1975 Miami Hydrogen Theme Conference.

   Mackay, D.B., "Economy of Hydrogen-Fueled Automotive Engines", unpublished.

   Billings, R. E., "Hydrogen Storage in Automobiles Using Cryogenics and Metal Hydrides", 1974 Miami Hydrogen Theme Conference.

   Eschen. W.J.D., "Hydrogen-Fueled Internal Combustion Engine, A Technical Survey of Contemporary U.S. Projects", U.S. ERDA, Publication TEC-75/005, September, 1975.

   Reilly, J.J., Wiswall, R. H., and Waide, C. H., "Motor Vehicle Storage of Hydrogen Using Metal Hydrides", U.S. ERDA Report, TEC-75/001, October, 1974.

   Sultan, O., and Shaw, H., "Study of Automotive Storage of Hydrogen Using Recyclable Liquid Chemical Carriers", U.S. ERDA Report, TEC-75/003.

   Rohy, D. A., Nachman, J. F., and Duffy, T. E., "Automotive Storage of Hydrogen Using Modified Magnesium Hydrides", U.S. ERDA Report, TEC 75/002, July, 1975.

6. Parrish, W. R., et al.,"Selected Topics on Hydrogen Fuel", NBS Special Publication 419, May, 1975.

   Finegold, J. G., "Hydrogen: Primary or Supplementary Fuel for Automotive Engines", Int. J. of Hydrogen Energy, 3,83 (1978).

   Boer, P.C.T., et al "Performance and Emissions of Hydrogen Fueled Internal Combustion Engines", Int. J. of Hydrogen Energy 1,153,(1976).

   Korycinski, P.F., "The Liquid Hydrogen Option For The Subsonic Transport--A Status Report", Proc. 12th Intersociety Energy Conversion Eng'g Conference, September, 1977, p 964.

   Allen, C. M., et al.,"An Assessment of the Economic Feasibility of Hydrogen Fueling Ground Vehicles", Battelle Report, April, 1975.

7. J. J. Hibl, Beech Aircraft, Personal Communication.

8. Roger Billings, Personal Communication.

9. Finegold, J.G., and VanVorst, W. D., "Crash Test of a Liquid Hydrogen Vehicle", First World Hydrogen Energy Conference, Miami, Florida, 1976.

10. Allen, C.M., Brooman, E. W., Creswick, F.A., and Broehl, J.H., "An Assessment of the Economic Feasibility of Hydrogen--Fueling Ground Vehicles", Battelle Report, April, 1975.

11. Woolley, R. L., and Germane, G. J., "Dynamic Tests of Hydrogen-Powered IC Engines", First World Hydrogen Energy Conference, Miami, Florida, 1976.

12. deBoer, P.C.T., McLean, W. J., and Homan, H.S., "Performance and Emissions of Hydrogen Fueled Internal Combustion Engines", Int. J. of Hydrogen Energy, 1,153 (1976).

13. Pefley, R. K., et al., "Characterization and Research Investigation of Methanol and Methyl Fuel", Final Report to U.S. EPA and Progress Report to U.S. ERDA (Division of Transportation--Energy Conservation), Report CONS/1258.

14. Burke, D. P., "Methanol", Chemical Week, September 24, 1975, p 33.

Reed, T. B., and Lerner, R. M., "Methanol: A Versatile Fuel for Immediate Use", Science, 182, 1299 (December 28, 1973).

Baratz, B., Ouellette, R., Park, W., and Stokes, B., "Survey of Alcohol Fuel Technology", Office of R&D Policy NSF M74-61, November 1975.

Anon, "New Doubts About Coal-Based Chemicals, C&E News, November 21, 1977, p 17.

Mills, G. A., and Harvey, B. W., "Methanol--The "New Fuel" From Coal", Chem. Tech., January 1974, p 26.

15. "Compiliation of Air Pollutant Emission Factors", U.S. EPA.

16. "Tips for Energy Savers", FEA, 1977.

17. "Fuel Conservation Measures: The Transportation Sector - Volume II", The State of Texas Governor's Energy Advisory Council, January 1975.

ATTACHMENT C3.1

TRANSPORTATION CALCULATIONS

ATTACHMENT C3.1

TRANSPORTATION CALCULATIONS

a. Number Of Private Vehicles In Riverside

89,166 - 6,500 = 82,666 private autos

16,165 - 5,200 = 10,965 private trucks

93,631 Total private vehicles in Riverside - 1976 .

b. Number Of Vehicles Per Person

$$\frac{\text{93,631 total private autos}}{\text{163,000 population}} = \text{0.57 vehicles/person}.$$

c. Population Scenarios - Year 2000 Population

Low growth	202,276
Moderate growth	233,009
High growth	272,973 .

d. Total Private Vehicles - Year 2000

Low	202,276 x 0.57 = 115,297
Moderate	233,009 x 0.57 = 132,815
High	272,973 x 0.57 = 155,595 .

e. Assumed Overall MPG = 12.3 mpg (Table C3-5).

f. Assume 10,000 Mile/Year/Vehicle .

g. Gallons Gasoline/Vehicle/Year

$$\frac{\text{10,000 miles/yr/vehicle}}{\text{12.3 mpg}} = \text{813 gallons fuel/vehicle/yr}.$$

h. Total Gallons And Btu For Low, Moderate And High Population Scenarios For Private Vehicles (120,000 Btu/Gallon Of Gasoline)

Growth		Total Gallons	Btu
Low	(115,297) x (813) =	93.7×10^6	$11,244 \times 10^9$
Moderate	(132,815) x (813) =	107.9×10^6	$12,948 \times 10^9$
High	(115,595) x (813) =	126.5×10^6	$15,180 \times 10^9$

i. Total Gallons And Btu Used In City Of Riverside Assuming 60 Percent Of Driving In City-Private Vehicles

Growth	Total Gallons	Btu
Low	56.2×10^6	$6,746.4 \times 10^9$
Moderate	64.7×10^6	$7,768.8 \times 10^9$
High	75.9×10^6	$9,108.0 \times 10^9$

j. Riverside Fleet And Public Vehicle Use - 1976

Type	Annual Mileage	Assumed % in Driving in City	Total Mileage in City
City	3.85×10^6	90	3.5×10^6
County	1.1×10^6	10	0.1×10^6
Federal	5.9×10^6	10	0.6×10^6
Univ. of California	5.5×10^6	50	2.8×10^6
Riverside Bus	1.0×10^6	100	1.0×10^6
School Buses	2.1×10^6	100	2.1×10^6
		Total	10.1×10^6

k. Total Gallons And Btu Used By Vehicle Fleets in Riverside in 1976

From Table C3-5 average assumed mpg for overall fleets = 7 mpg.

$$\frac{10.1 \times 10^6 \text{ miles}}{7 \text{ mpg}} = 1.4 \times 10^6 \text{ gallons fuel/yr for fleet use in city.}$$

$$= 168.0 \times 10^9 \text{ Btu/yr for fleet use in city in 1976.}$$

l. Projection Of Fleet Fuel Use In 2000 For 3 Population Scenarios

Population	Btu Used By Fleets in 1976	Population Growth Rate	Total Btu
Low growth	168.0×10^9	1.24 =	208.3×10^9 Btu
Moderate growth	168.0×10^9	1.45 =	243.6×10^9 Btu
High growth	168.0×10^9	1.67 =	280.6×10^9 Btu

m. Total Gallons And Btu For Existing Vehicles In Riverside - 1976

		Gallons	Btu
Autos	93,631 x 813 gal/vehicle/yr x 60% (assume 60% of driving in City)	45.7×10^6	$5{,}480.8 \times 10^9$
Fleets,	(mileage in City already calculated) =	1.4×10^6	168.0×10^9
	Totals	47.1×10^6	$5{,}648.8 \times 10^9$

n. Projection Of Total Transportation Btu Use In 2000 For Low, Moderate And High Population Growths

Low growth

Autos		$6{,}746.4 \times 10^9$ Btu
Fleets		208.3×10^9 Btu
	Total	$6{,}954.7 \times 10^9$ Btu

Moderate growth

Autos		$7{,}768.8 \times 10^9$ Btu
Fleets		243.6×10^9 Btu
	Total	$8{,}012.4 \times 10^9$ Btu

High growth

Autos		$9{,}108.0 \times 10^9$ Btu
Fleets		280.6×10^9 Btu
	Total	$9{,}388.6 \times 10^9$ Btu

o. Transportation Energy Reductions in 2000 For Low, Moderate And High Population Growth, And Low, Moderate And High Energy Conservation Impacts

Assumptions:

- Maximum percent reduction in total transportation fuel demand = 20 percent*
- About one-half, or 10 percent reduction is due to increased vehicle efficiency to be fully effective around 1995, i.e., smaller, more efficient autos per federal specifications*
- Assumptions used for energy savings for low, moderate and high impact energy conservation efforts are:

low	10%
moderate	15%
high	20%

p. Transportation Energy Savings in 2000 For Low, Moderate And High Population Growths and Low, Moderate And High Energy Conservation Impact Strategies

Population Growth	Strategy Low Btu x 10^9	Moderate Btu x 10^9	High Btu x 10^9
Low	695.5	1043.2	1390.9
Moderate	801.2	1201.9	1602.5
High	938.9	1408.3	1877.7

q. Emissions Factors For Transportation in City of Riverside (Calculated From Table C3-5)

Hydrocarbon	0.6×10^{-6} lb/Btu
CO	7.9×10^{-6} lb/Btu
NO_x	1.3×10^{-6} lb/Btu
SO_2	0.050×10^{-6} lb/Btu
Particulates	0.13×10^{-6} lb/Btu

* State of Texas Governor's Energy Advisory Council Report, Project S/D-9, "Fuel Conservation Measures: The Transportation Sector", Volume II, January 1975, Table S-2.

r. Estimate Of Total Decreased Emissions in Riverside In 2000 Due To Transportation Energy Savings

Population Growth and Type of Emission	Strategy Low lb x 10^3	Strategy Moderate lb x 10^3	Strategy High lb x 10^3
Low			
HC	417.3	625.9	834.5
CO	5494.5	8241.3	10988.1
NO_x	904.2	1356.2	1808.2
Moderate			
HC	480.7	721.1	961.5
CO	6329.5	9495.0	12659.8
NO_x	1041.6	1562.5	2083.3
High			
HC	563.3	845.0	1126.6
CO	7413.3	11125.6	14833.8
NO_x	1220.6	1830.8	2441.0

C4. ENERGY CONSERVATION OPTIONS IN COMMUNITY DESIGN

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

TABLE OF CONTENTS (Cont.)

TABLES

FIGURES

TABLE OF CONTENTS (Cont.)

Page

FIGURES (Cont.)

C4. ENERGY CONSERVATION OPTIONS IN COMMUNITY DESIGN

Background

Integrated community energy systems planning strives to provide effective conservation as well as efficient and cost-effective use of alternative energy sources. One area in which energy usage can be more efficiently programmed is community design which this section of the report addresses.

Most communities evolve over time and their form and relationship of functional areas are in most cases lacking in energy efficiency One reason is that the cost of energy has, until recently, been low, and the cost benefits have not been great enough to encourage energy-efficient design or retrofit of communities. Esplosive growth rates have also created many functional problems as related activities become widely scattered. As a result, many operations are not as productive as they could be and much could be accomplished through the restructuring of planning activities within a community.

One area of energy conservation that has not received significant attention is "passive" solar design of both buildings and the community itself. Thermal burdens, being a result of direct or indirect solar radiation, are often imposed on building air-conditioning systems or on the occupants of buildings themselves. For example, south-facing building walls adjacent to a street will receive solar reflection and glare from a light-colored street surface or radiation from a black, heat-absorbing street surface. The latter will continue to radiate at night, directing unwanted thermal energy at the building walls and windows, thereby adding to the air-conditioning load or the discomfort of the occupants.

The location and positioning of a building in relation to other surrounding buildings and landscaping are also important factors, particularly in regard to solar-based energy considerations. The idea here is to avoid improper building location in terms of solar access.

Thus, one of the purposes of this task is to establish the potential for conserving energy and improving habitability through energy conservation in community design and to provide a basis for determining whether savings derived from these opportunities warrant further in-depth study.

Objectives and Scope

The objective of this task is to investigate energy conservation options in community design and recommend those opportunities applicable to new and retrofit community development.

The scope of this activity relates to an investigation of alternative energy conservation options in community development patterns; the relationship of land uses and buildings; passive solar design of both buildings and the community; the microclimate, including landscaping and building shielding; and street lighting.

Approach

The approach Battelle used to conduct this task was divided into six parts: (1) collection of available information on current efforts relating to energy conservation in Riverside's community design; (2) identification and screening of energy conservation options in community design; (3) preparation of an estimate of energy savings for each recommended conservation option; (4) an analysis of the impact these options will have on pollution/health, the local economy, energy stability, and lifestyles; (5) the feasibility of these options in terms of public acceptance, legal/institutional constraints, technological constraints, and public/private sector costs; and (6) the chronological integration of the recommended options into an implementation plan for Riverside.

Only parts (1) through (3) are included in this section of the report. Parts (4) through (6) are discussed in Volume I of this report.

CURRENT ENERGY CONSERVATION EFFORTS AFFECTING COMMUNITY DESIGN IN RIVERSIDE

Based on discussions held in Riverside with City officials, local architects, planners, and builders, very little effort has been implemented relative to energy conservation in community design. Areas relevant to energy conservation that were found to be under way were: community development patterns, redevelopment, transportation (bicycle master plan), and street lighting.

Community Development Patterns

Growth in the City of Riverside has been a major issue in the Community and is the major concern of the City Planning Commission and the City's Planning Department. A controversy--ongoing since the mid-1950's--involves the conversion of agricultural land (orange groves) to residential land use. The geographic area involved is Arlington Heights in the south-east part of the City. This area includes 12,300 acres, about two-thirds of which is in Riverside with the remainder in the unincorporated Woodcrest Community. Its boundaries are Victoria Avenue and the Alessandro Arroyo on the north, Alessandro Boulevard and Wood Road on the east, La Sierra Avenue on the west, and a line on the south generally coinciding with the east-west portion of Van Buren Boulevard (Figure C4-0). According to a 1977 study, about 2,560 acres in this area are developed and contain 6,500 residents.

With developers preparing for even more building, the City undertook a massive revision of its Arlington Heights master plan in 1977. The present plan permits an almost complete conversion of the area into a suburban community, with a potential population of 110,000, having about 66,000 in the city limits. Since calling for the general plan changes in January, 1977, the City Council has refused to rezone land in Arlington Heights for housing projects.

Before planning for the revision began, the City voted on and turned down an initiative ordinance that would have retained existing agricultural lands and restricted new housing throughout the City. The initiative was narrowly defeated by a 51 to 49 percent vote.

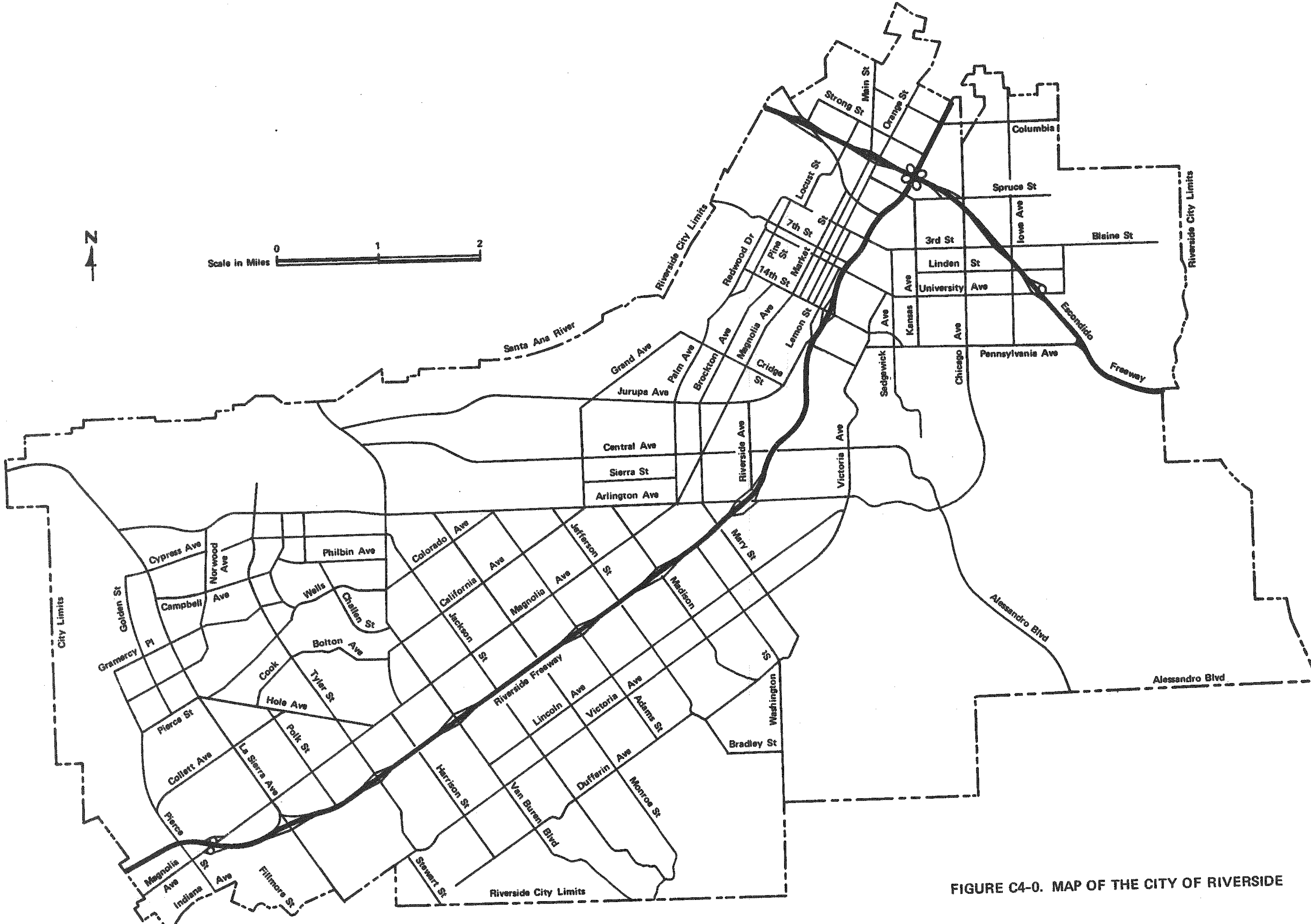


FIGURE C4-0. MAP OF THE CITY OF RIVERSIDE

Currently, there is a moratorium on new housing permits and the acceptance of new rezoning and subdivision maps until October 1, 1978. Also, work is under way to revise the Arlington Heights Plan. Initially, planning consultants looked at what they considered to be the two extremes--maximum preservation and maximum development. The maximum preservation, which is closest to the goals of the initiative, allowed for the construction of most developments now awaiting City approval and for the preservation of the remainder in citrus and open space. Maximum development[1] would permit the entire area to be developed, containing an estimated 110,000 residents, as shown below.

LAND USES, BY ACRES

	Residential	Mockingbird Park	Open Space	Citrus	Residents
Maximum Preservation	4,750-8,662	0	3,383-3,646	0-4,176	28,650-52,869
General Plan	10,265	1,000	200	0	111,795

Source: Press-Enterprise, Sunday, February 19, 1978, pg. B-3.

Planning consultants have since decided that neither of these extremes are very likely to satisfy City residents. As a result, they have prepared nine alternatives, each with the possibility of an even split between housing tracts and preservation of citrus groves and open space.

Recognizing the need for further action, the City is also developing a points system plan. The points system is designed to control residential growth by requiring new housing projects that meet standards for the availability of fire protection, schools, parks, sewers, water, electricity, streets, and storm drains. The intent of the system is to encourage the developers to use existing service capacity rather than to expand so far out that the City is forced to extend services at additional cost before actually necessary.

To date, little effort has been placed in Riverside on energy conservation in terms of community development. Obviously, the final decision on the revised master plan for Arlington Heights will have a major impact on how energy efficient the community is in the long term. Energy consumption in any community is affected largely by residential heating and air-conditioning requirements and by automobile use. Because heating and air-conditioning requirements are related primarily to the type of dwelling unit, multifamily residential developments have lower energy demands than do single-family ones. Transportation demands are affected both by the degree of clustering and community planning, as well as by density. Recent research has shown that "planning" alone can save nearly 14 percent of the total energy consumed, but "planning" combined with increased multifamily residential development can save up to 44 percent.

Recognizing both the potential for savings through increased multifamily residential development and the strong desire in Riverside to control residential growth and retain a low density development strategy, Battelle has carefully considered the subsequent recommendations resulting from this task.

Redevelopment

There are currently five major redevelopment project areas in the City. The purpose of redeveloping these areas is to stimulate economic and physical development as well as to eliminate blight. The redevelopment project areas are:

(1) Downtown Mall (includes Mission Inn)
(2) East Side
(3) Casa Blanca
(4) Airport
(5) Central Industrial.

The only areas that are expected to incorporate any energy conservation measures will be the East Side and Casa Blanca areas in which a small number (<100 units) of dwellings will be reconstructed or renovated using higher insulation and weatherization standards[2]. These are not expected to reflect any significant reductions in either total energy consumption (per capita) or in consumption of scarce fossil fuels.

Transportation

In terms of total energy consumption, transportation in Riverside represents a significant share. Comparatively, in the U.S., transportation accounts for more than 40 percent of all energy used. The inefficiency of a private, automobile-oriented transportation system is obvious to anyone, particularly early in the morning or late in the afternoon as hundreds of automotive vehicles crowd together on the freeway, frequently carrying only one person.

In recognition of the role bicycling can play in a transportation system, the City of Riverside has developed a Master Plan of Bikeways. In 1973, the City commissioned a study to define and recommend a bicycle system designed to increase the safety of bicyclists and to encourage the use of the bicycle as a mode of transportation, as well as a form of recreation. This study was completed in April, 1975.

The objectives, as stated in the Master Plan, were:

(1) to provide and encourage safe conditions for bicycle travel on public streets and other public rights-of-way

(2) to encourage and provide for maximum security against bicycle theft

(3) to educate the motorist and the bicyclist, thus insuring that they are fully aware of their rights and responsibilities toward one another as users of public rights-of way

(4) to fully integrate bicycling as a recreational activity into the City's planned open-space system.

The proposed Master Plan of Bikeways consists of (1) commuter and general-purpose bike routes, and (2) recreational routes. Commuter bicycle routes are proposed to be developed as Class II facilities and recreational routes are proposed to be developed primarily as Class I with a limited number of Class II facilities. These classes are defined as follows[3]:

Class I: A graded and surfaced pathway on a completely separate right-of-way designated for the exclusive use of bicycles. This type of facility is usually most appropriate for recreational cycling, as it does not function well along streets in urban areas.

Class II: An approximately 8-foot-wide restricted land on the surfaced roadway of an existing public street designated for the exclusive or semi-exclusive use of bicycles. This type of facility is much less expensive than a Class I facility, since the existing street surface is utilized. The route is marked with appropriate signs and pavement markings to define the type of use. In many instances this facility requires the removal of curb parking. This type of facility is generally most suitable in urban areas, as it is designed to safely integrate bicycling into the street structure by providing necessary room and a defined area for bicycle operations.

The proposed commuter and recreational bicycle routes are shown in Figure C4-1.

Since 1973, the City has taken a number of steps to implement the proposed Master Plan of Bikeways. Commuter bike routes have been established on (1) Magnolia Avenue, between Jurupa Avenue and Riverside City College; (2) California Avenue, generally between Jefferson Street and MacArthur Road; (3) Linden Street, between Chicago Avenue and Canyon Crest Drive; Canyon Crest Drive, between Blaine Street and University

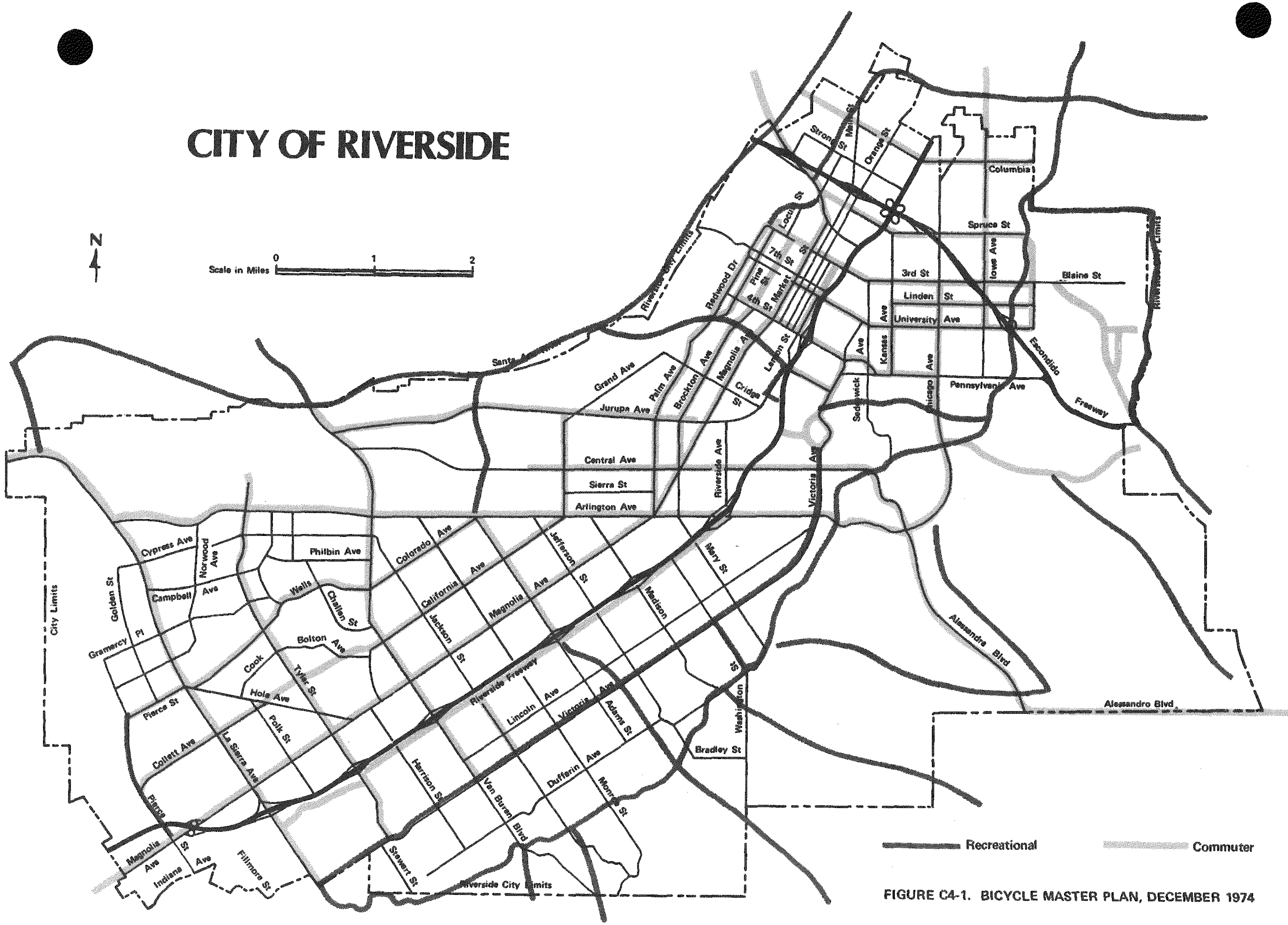


FIGURE C4-1. BICYCLE MASTER PLAN, DECEMBER 1974

Avenue; (5) Big Springs Road, between UCR and Mt. Vernon Avenue; (6) Watkins Drive, between Blaine Street and Valencia Hill Drive, and between Picacho Drive and the Escondido Freeway; and (7) La Sierra Avenue, generally between Five Points and the Riverside Freeway. All of these routes have been established as Class II facilities with the exception of the Linden Street bike route, which consists of both Class I and Class II facilities. A Class I bikeway is also proposed in the near future along Victoria Avenue, between Van Buren Boulevard and Myrtle Street, a distance of 5-1/2 miles. When this is completed, the total bicycle system implemented to date in Riverside will total approximately 12 miles.

To help determine public reaction to the existing bicycle lanes, the City commissioned a survey on the Magnolia Avenue, Canyon Crest Drive, and Linden Street bicycle lanes. The most extensive survey was conducted on the Magnolia Avenue lanes. Bicycle counts taken on four different occasions on the Magnolia Avenue route showed an increase in bicycle usage of 6 to 14 percent (during weekdays) after land installation. Bicycle-automobile accidents decreased from an average of three to six per year along this route, prior to the installation of the lanes, to none during the 8-month survey after installation. Eighty-five percent of the bicyclists surveyed expressed that the lanes made bicycle operations safer; 5 percent had no opinion, and 10 percent felt that there was no difference. Eighty-six percent of the motorists surveyed felt that the bicycle lane did not change their normal driving routine; 5 percent were not aware of the provisions; and 9 percent felt favorably toward the lane's elimination of bicycle-car conflicts.

To date, the implementation of this plan has had negligible impact on the reduction of automobile travel in Riverside, or on the reduction of energy consumed by these vehicles.

Street Lighting

Between 1969 and 1973, the City of Riverside upgraded their street lighting system. At present, the City has approximately 21,946[4]. street lights. Of this amount, 18,196 are mercury vapor lamps, 3,550 are incandescent, and 200 are high-pressure sodium vapor. Another 650 new mercury vapor lights are expected to be added during the time period July, 1978 to June, 1979.

Currently, the City has turned off street lignting on one side of the street in the downtown area in an effort to save energy. In other commercial areas every other street light has been turned off. Of the 18,196 street lights in Riverside, 1,317 have been turned off--1,289 mercury vapor and 28 incandescent. Since all of Riverside's street lighting system only constitutes 2-1/2 percent of the City's total electric consumption, these energy conservation efforts have had a minimal impact.

The Public Utilities Department has investigated and tested photo controls that turn off lights at midnight or some preset number of hours after they have turned on. However, performance was not considered to be satisfactory. The Department is currently investigating a new type of cell that will reduce total energy consumption by the street lighting system by about 20 percent. This new solid state unit is expected to achieve significant savings by turning on 15 to 30 minutes later and off 90 to 105 minutes earlier than existing units.

Following the Arab oil embargo in 1973, the Riverside Chamber of Commerce initiated a program to encourage the reduced use of illuminated outdoor signs. However, this program did not continue for long.

ENERGY CONSERVATION OPPORTUNITIES IN COMMUNITY DESIGN

This section identifies and discusses energy conservation opportunities in community design. The characteristics of the opportunities are discussed as well as various considerations and potential energy savings. In some cases information is presented on experiences other communities have had with the opportunities. Generally, in this study the energy conservation opportunities presented include only those over which the City of Riverside could have direct control.

On one hand, certain planning activities that may be controlled by the City are presented. On the other hand, for instance, the State of California has responsibility for the freeway lighting system and the City has no direct control over its operation; therefore, cases such as these are not covered here.

The major areas covered in this study are: (1) community development patterns; (2) passive solar building and community design; (3) building microenvironment; and (4) the City street lighting system.

Community Development Patterns

In considering an energy conservation program relating to community development patterns, the elements that most greatly affect energy demand are (1) the type of dwelling unit and (2) the relationship and distance between dwelling units and frequently used facilities such as places of work, convenience shopping, schools, and recreation. These elements can also be significant contributors to energy savings.

Until recently, the impact of new community development on energy demand and the potential for energy conservation in community design has been ignored. In fact, community planning has been wasteful in terms of energy requirements for the heating and cooling of buildings and transportation. One of the major factors contributing to energy waste as well as to major increases in energy demand has been urban sprawl. Business, industry, and small municipal governments have encouraged urban sprawl. Shopping centers built in outlying areas have helped to encourage the growth of new communities. Industry has supported sprawl because it promotes placing a high value on items such as the single-family home and the automobile as well as all of the goods and services required to support them. Municipalities, outlying the larger urban areas, have benefited from this growth because additional residents increase the tax base.

With buildings spreading over larger land areas, more energy is used to heat and cool buildings and the necessity for using the automobile increases. Additional freeways are needed as people move from the inner city but still want to return to the inner city for business or family purposes. More cars and trucks are needed to move people and goods from one point to another.

People move from one area to escape air pollution, then contribute to it daily when they commute to their jobs. In Riverside, where low density housing is predominant, there is a nearly exclusive reliance upon the automobile for commuting to work, shopping, and recreation. The resulting high ratio of automobiles to people contributes significantly to the deterioration of air quality.

In the United States, few cities discourage the use of automobiles in the city. In contrast, many European cities have encouraged pedestrian and bicycle traffic by closing off inner city areas to automobile traffic.

Land area within the City of Riverside is currently about 50 percent developed, with the remaining portions either vacant or devoted to agricultural production. Residential use occupies the major portion of developed land. Figure C4-2 shows that in 1975 residential use occupied approximately 60 percent of the developed land area within the City, or about 30 percent of the total area. The second largest land uses are public and institutional, which occupied approximately 13 percent of the developed area, or 6 percent of the total City area. Commercial and industrial occupied approximately 12 percent of the developed area.

A comparison of Riverside's present land use pattern with that of 1966 indicates the most dramatic increase has been in residential acreage. In 1966, residential use comprised about 47 percent of the developed area. Public and institutional comprised 16 percent of the developed land area while commercial and industrial covered about 6 percent (Figure C4-3)[(5)].

Thus, it is clear that Riverside a low-density community.

Typically, energy usage is lower on a per unit basis in more densely populated areas than in less densely populated areas such as in the suburbs. This was borne out in our analysis of energy in Riverside as shown in the following distribution.

Distribution of Energy Demand
1976

	Thermal Demand		Electric Demand	
	Space Heating ($\times 10^6$)	Base Load ($\times 10^6$)	Cooling Load ($\times 10^6$)	Base Load ($\times 10^6$)
Single-family	18.88	40.3	19.37	44.68
Multifamily	13.36	40.3	13.51	44.68
Mobile Homes	11.62	40.3	12.16	44.68

Source: Battelle Survey.

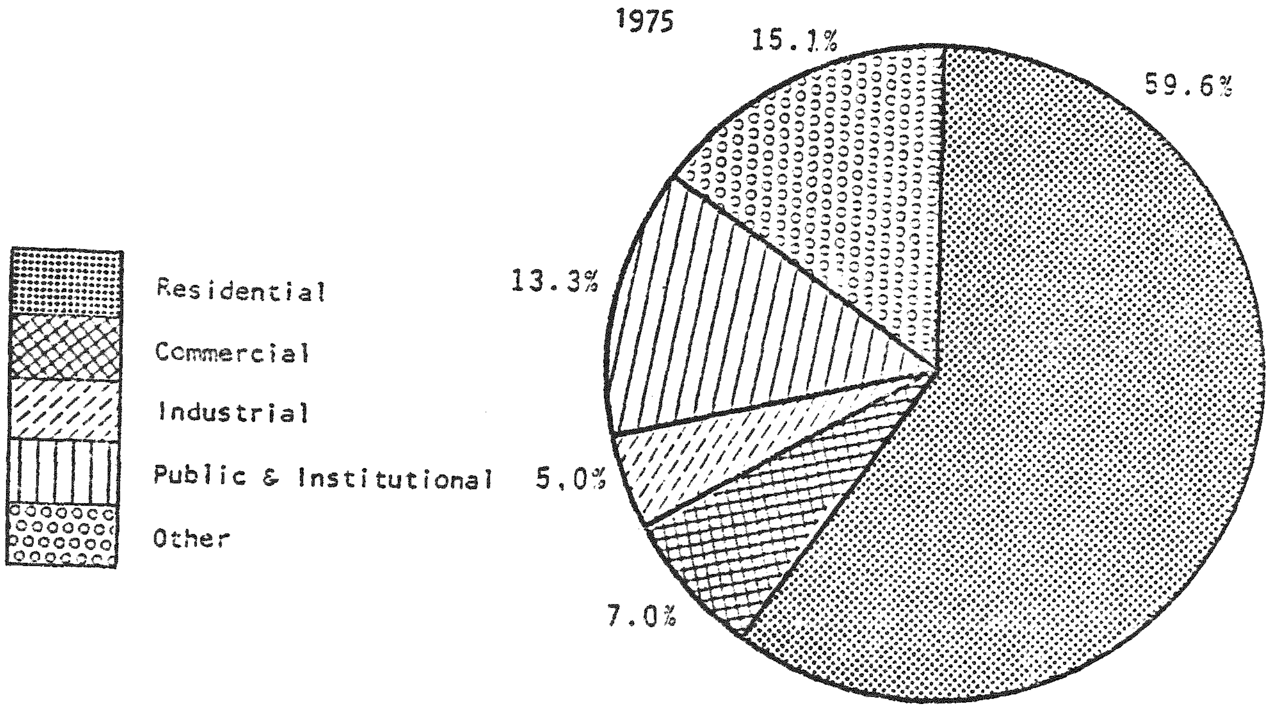


FIGURE C4-2. RIVERSIDE DEVELOPMENT PATTERN 1975

Source: Economic Basic Report, City of Riverside, July, 1977, Wilsey and Ham.

The housing mix in Riverside as of 1976 is estimated as follows:

	No. of Units	% of Total
Single-family detached	45,200	75.6
Multifamily	12,400	20.7
duplex	1,922	3.2
low rise	9,052	15.1
high rise	1,426	2.4
Mobile homes	2,200	3.7
	59,800	100.0

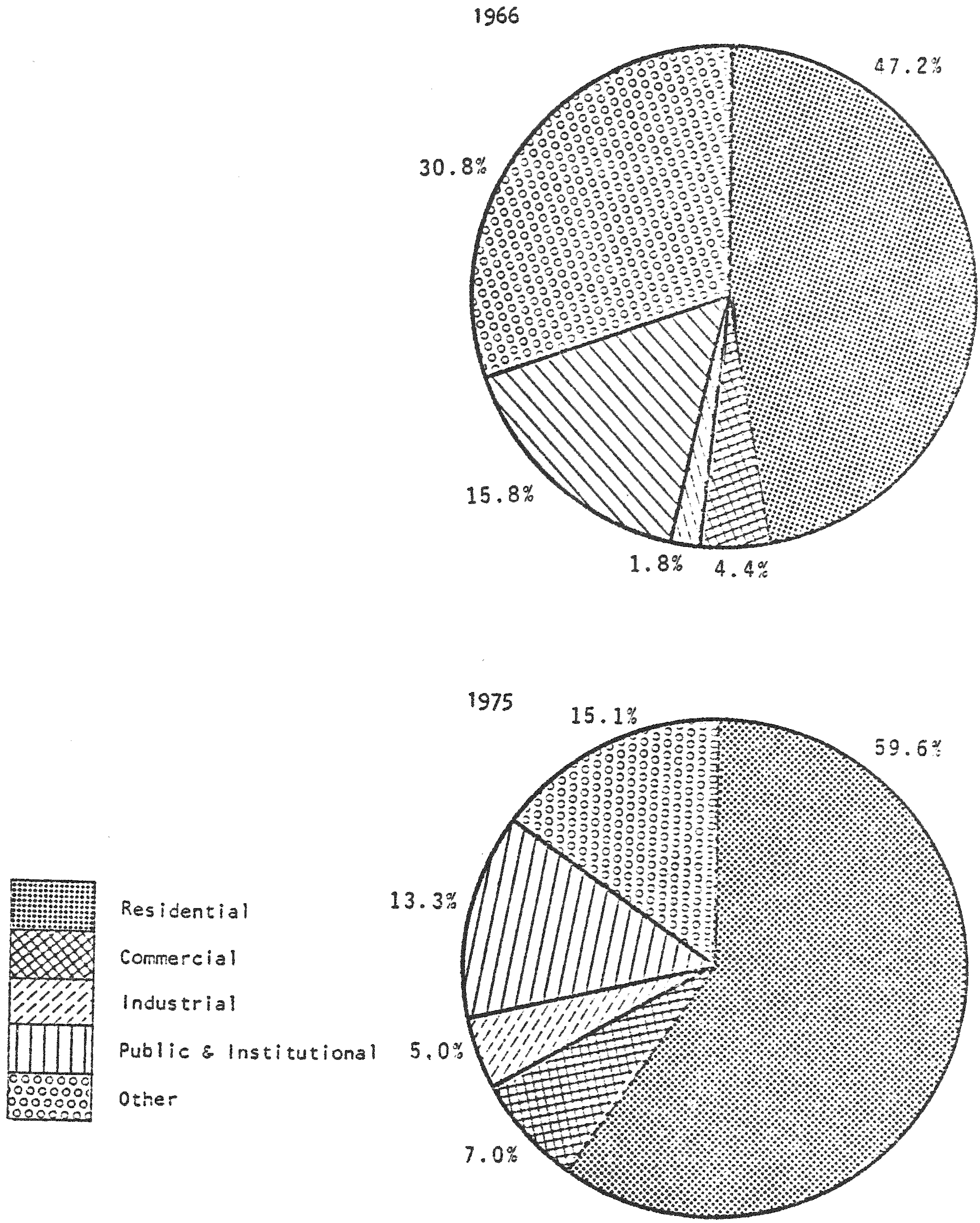
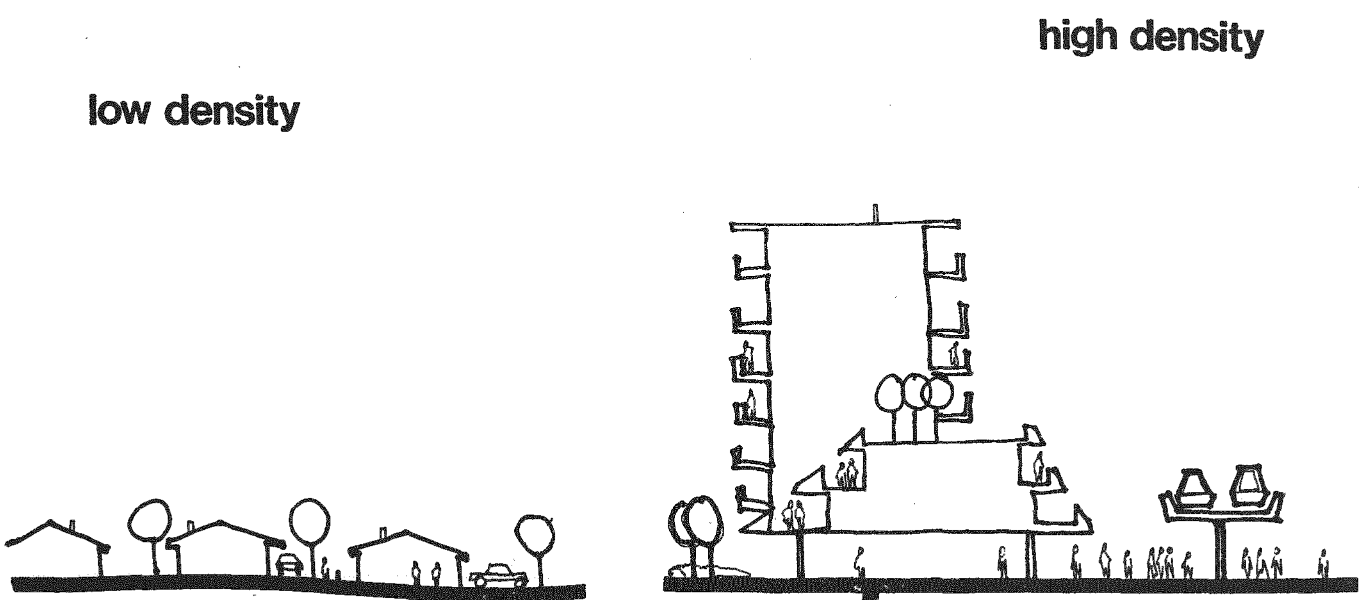


FIGURE C4-3. RIVERSIDE DEVELOPMENT PATTERN 1966-1975

Source: Economic Base Report, City of Riverside, July, 1977, Wilsey and Ham.

Based upon this analysis, space heating demand in multifamily dwelling units in Riverside was found to be approximately 30 percent less than that required in single-family detached units. Space cooling is also 30 percent less than that required in single-family detached units.

Research by Richard Crowther further substantiates that energy usage is lower in more densely populated areas than in less densely populated areas[6]. Figure C4-4 compares the usage of energy and water as well as the amount of certain pollutants produced by a low-density community and a high-density community. Each community is assumed to have 10,000 occupants.



Low density	Unit	Item	High density	Unit
1,168,000,000	gallons	annual consumption–water	762,850,000	gallons
4,060	billion BTU	annual consumption–energy	2,257	billion BTU
		air pollution–auto		
4,040	pounds/day	CO	2,031	pounds/day
487		HC	244	
475		NO_x	238	
		air pollution – residential		
142	pounds/day	particulate	81	pounds/day
4.7		SO_x	2.1	
3.1		CO	1.6	
317.2		HC	181	
951		NO_x	543	

FIGURE C4-4. ENERGY AND WATER USAGE AND POLLUTANTS PRODUCED

Source: "Sun/Earth--How to Use Solar and Climatic Energies Today", Richard Crowther, February, 1977, p 127.

By consolidating a number of dwelling units in one building envelope, the wall area exposed to the outside air is also reduced. Heat transmitted through interior walls can be used in adjoining units and not lost to the exterior. As a result, temperature differences across adjoining walls will be so small that best transmission will be kept to a minimum, stabilizing interior temperatures and decreasing energy demand (Figure C4-5).

For even further energy conservation, residential buildings may be arranged in clusters and incorporate multi-use space and individual living units as well as common spaces to accommodate activities for which the living units are not adequate (Figure C4-6).

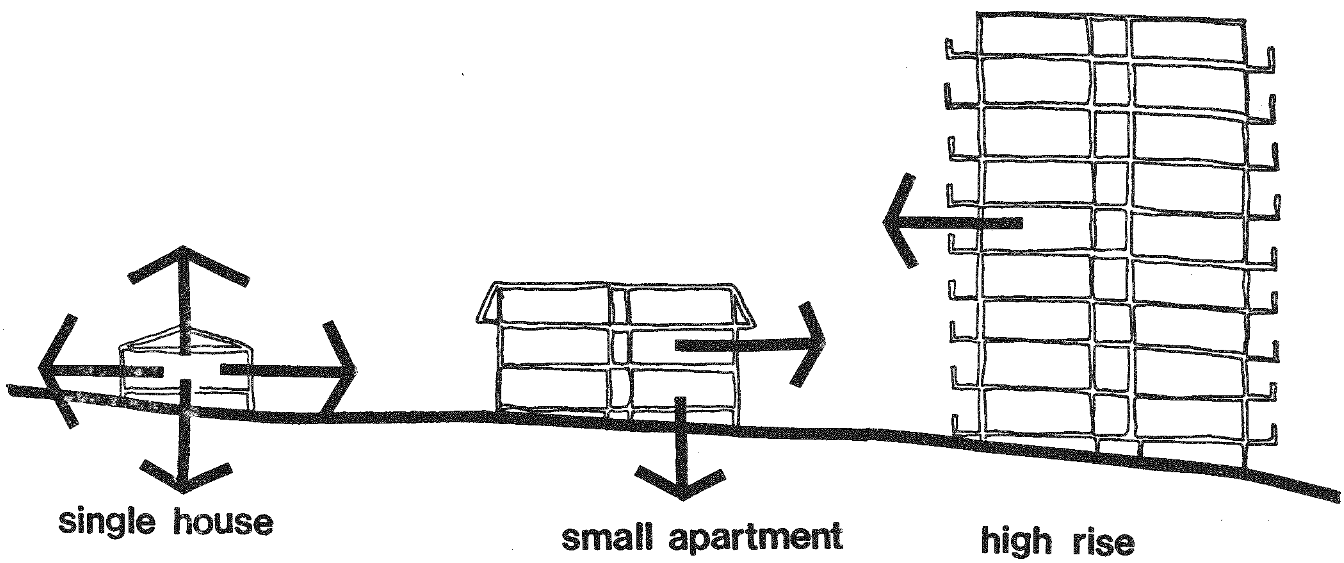


FIGURE C4-5. PROPORTIONAL HEAT LOSS FOR VARIOUS RESIDENTIAL UNITS*

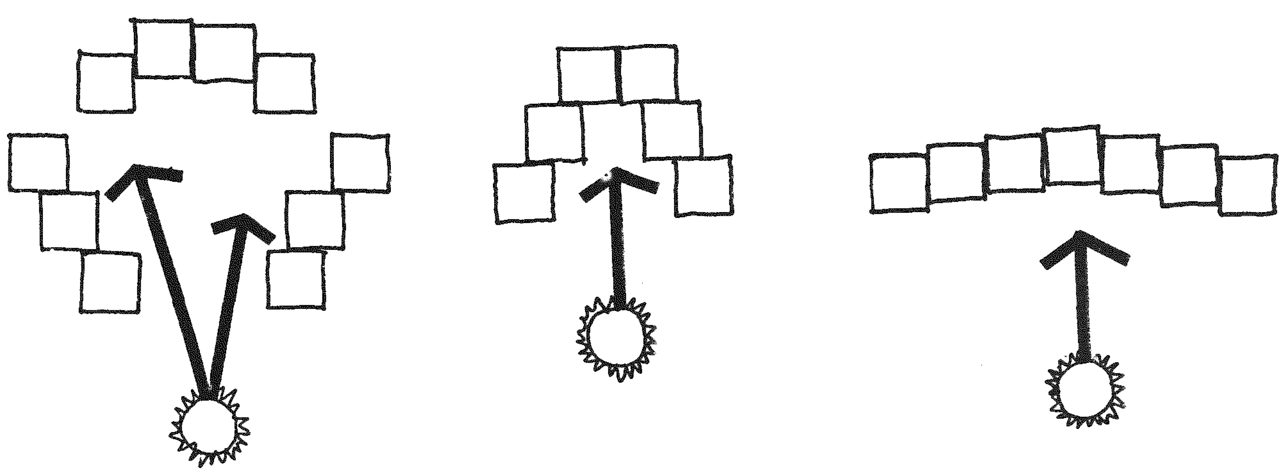


FIGURE C4-6. CLUSTERS AND TOWNHOUSES CAN BE ARRANGED TO MINIMIZE HEAT LOSS AND MAXIMIZE WINTER SOLAR COLLECTION*

* Source: "Sun/Earth--How to Use Solar and Climate Energies Today", Richard Crowther, February, 1977, p 128.

Research recently completed by the Real Estate Research Corporation(7) further reinforces the finding that increased residential density will have lower overall energy demands than low-density development such as in Riverside. In their study, six prototype communities were devised (see Figure C4-7 to C4-12) reflecting various communities were assumed to contain 10,000 dwelling units. The prototype communities are:

a. Type 1 -- Planned Mix Community. Consists of a housing mix of 20 percent of each type (single-family conventional, single-family clustered, townhouses, walk-up apartments, and high-rise apartments). Thus, there are 2,000 housing units of each type in this community. Neighborhoods are contiguous and large areas of open space are preserved.

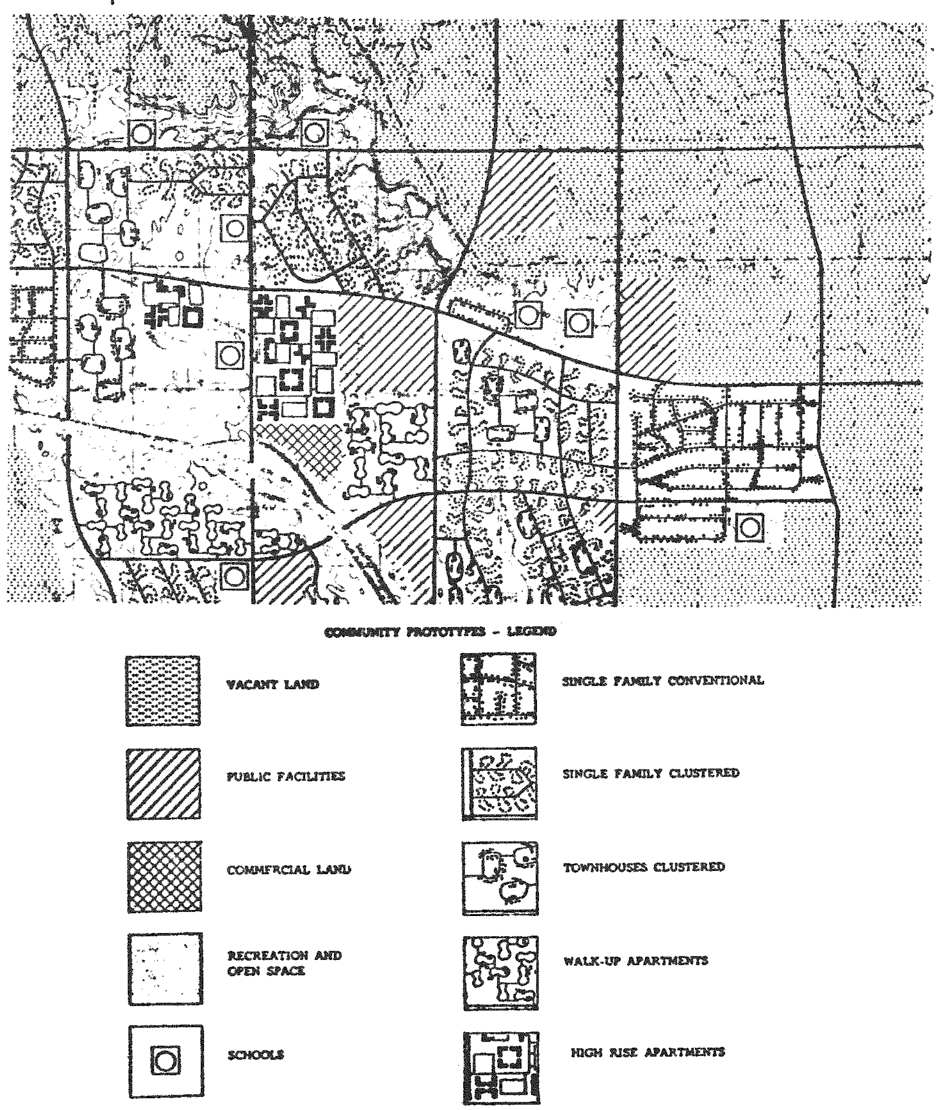


FIGURE C4-7. COMMUNITY PROTOTYPE 1, PLANNED MIX

Source: "The Costs of Sprawl, Detailed Cost Analysis", Real Estate Research Corporation (RERC) April, 1974, pp 94.

b. Type II -- Combination Mix Community. Assumes that 50 percent of the community is constructed as planned unit developments (PUD), with contiguous and related land uses, while 50 percent is built in the typical "sprawl" suburban pattern. The housing mix is the same as for Type 1.

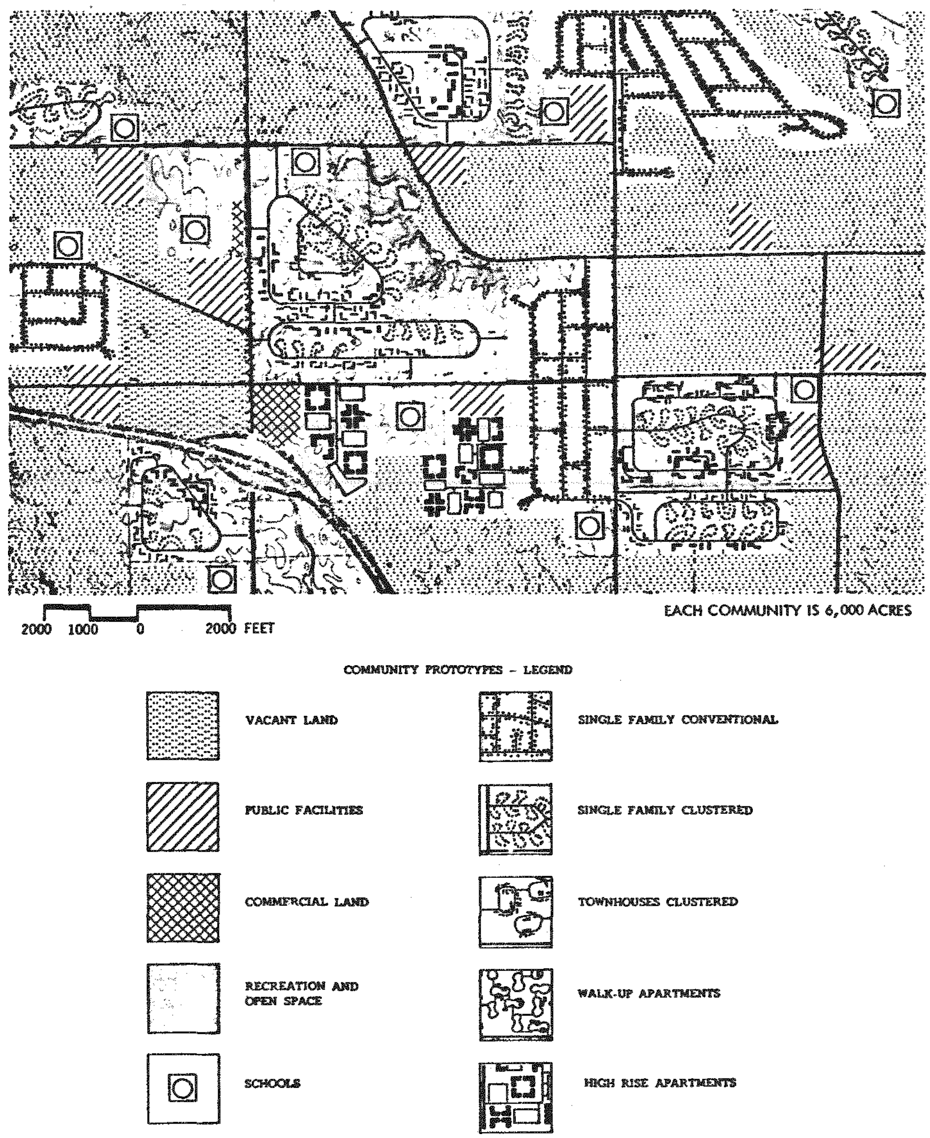


FIGURE C4-8. COMMUNITY PROTOTYPE II, COMBINATION MIX (50% PUD, 50% SPRAWL)

Source: "The Costs of Sprawl, Detailed Cost Analysis", Real Estate Research Corporation, April, 1974, pp 94.

c. Type III -- Sprawl Mix Community. Development occurs somewhat randomly in a "leapfrog" manner, with many small parcels of passed-over, vacant land remaining. The housing mix is the same as in Types I and II, with 20 percent of each type of housing.

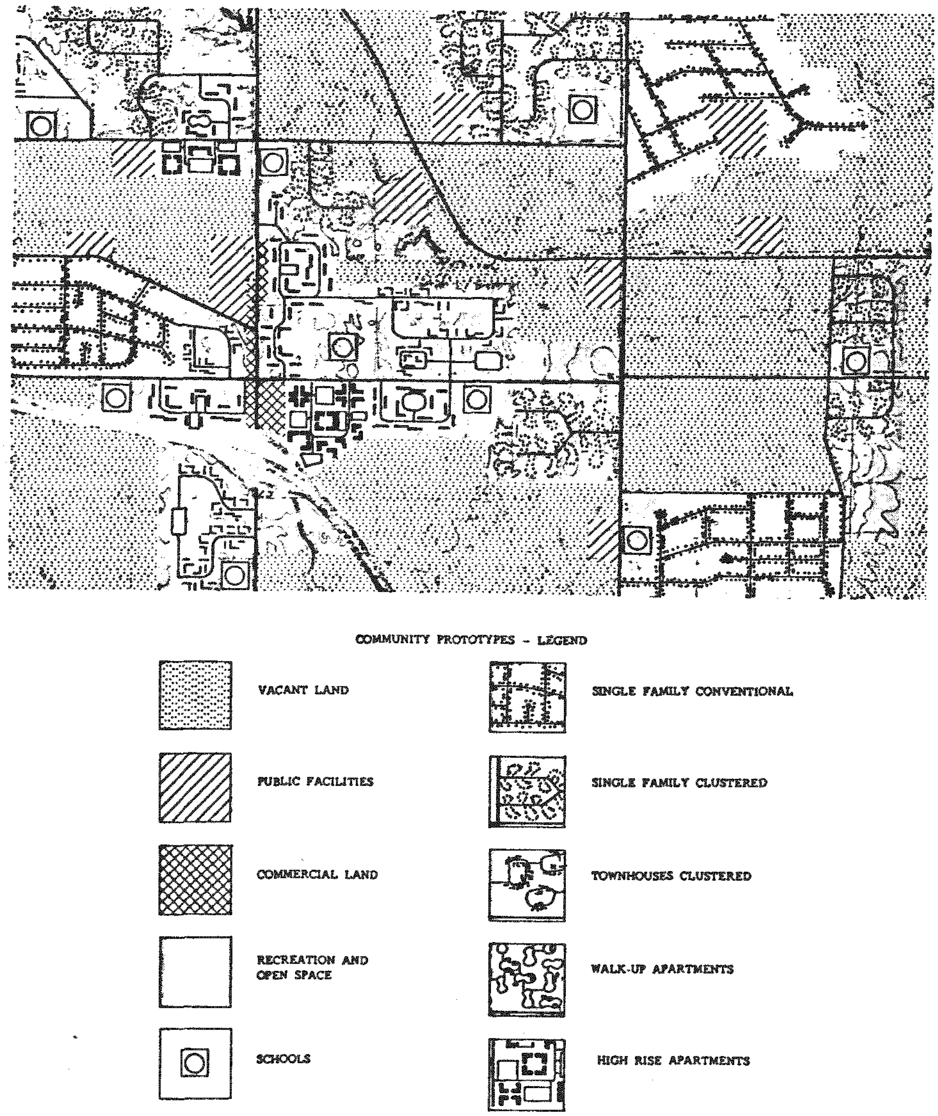


FIGURE C4-9. COMMUNITY PROTOTYPE III, SPRAWL MIX

Source: "The Costs of Sprawl, Detailed Cost Analysis", Real Estate Research Corporation, April 1974, pp 95.

d. Type IV -- Low Density Planned Community. 75 percent of dwelling units are single-family homes clustered around cul-de-sacs; 25 percent are conventional single-family dwellings. Neighborhoods are contiguous, as in Type I, but densities are lower, resulting in less undeveloped, vacant land. Open spaces are preserved and land uses are comprehensively designed and interrelated.

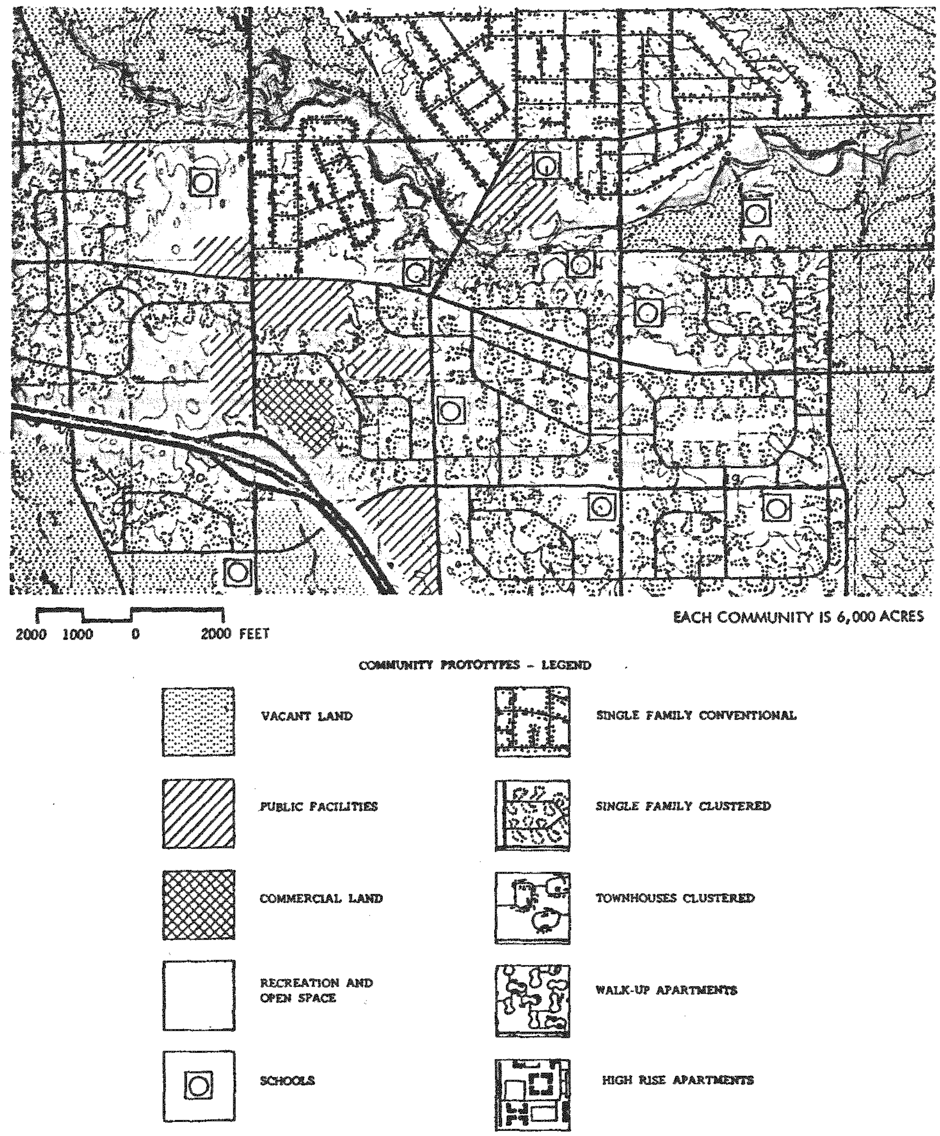


FIGURE C4-10. COMMUNITY PROTOTYPE IV, LOW-DENSITY PLANNED

Source: "The Costs of Sprawl, Detailed Cost Analysis", Real Estate Research Corporation, April 1974, pp 95.

e. Type V -- Low Density Sprawl Community. 75 percent of dwelling units are conventional single-family homes; 25 percent are clustered single-family units. There are small parcels of passed-over land separating neighborhoods, but no land is left vacant and undeveloped. This represents the most prevalent form of development currently practiced in suburban fringe areas.

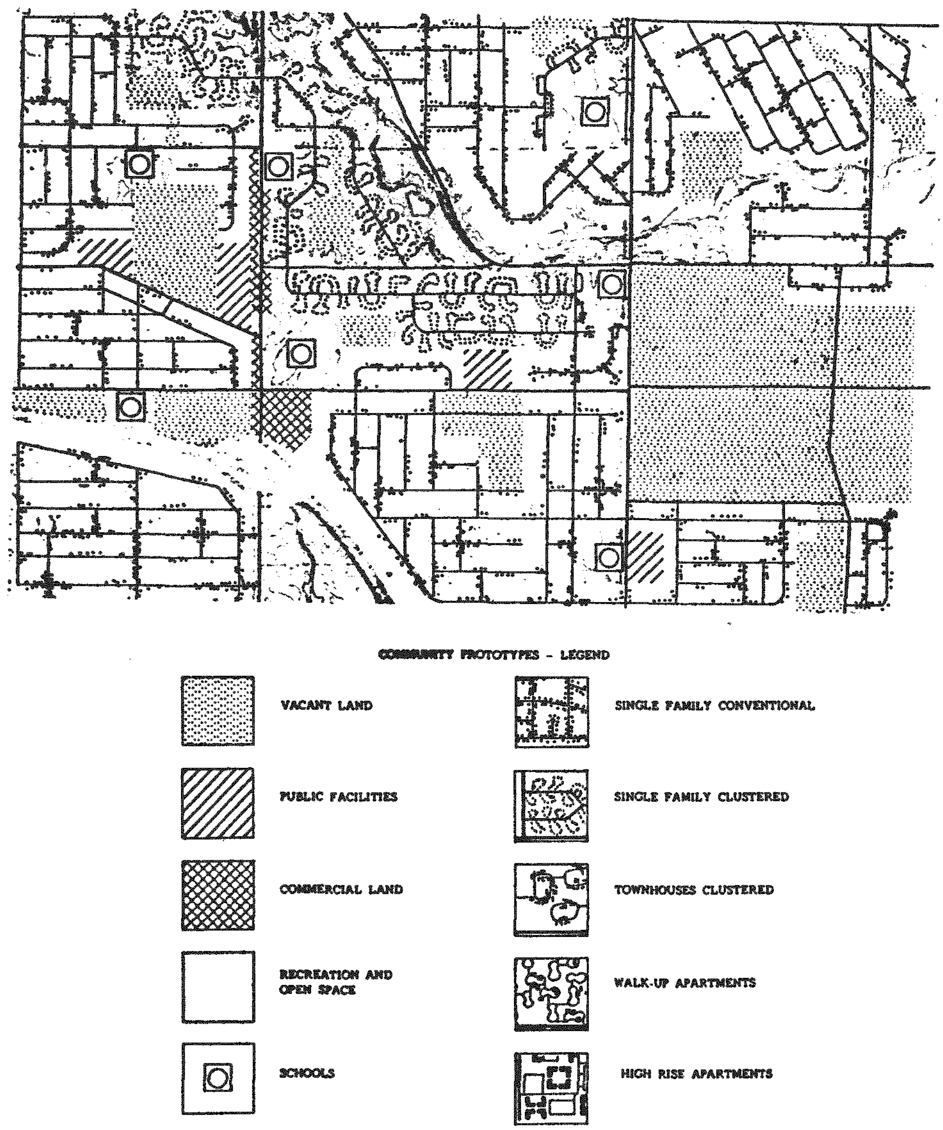


FIGURE C4-11. COMMUNITY PROTOTYPE V, LOW-DENSITY SPRAWL

Source: "The Costs of Sprawl, Detailed Cost Analysis", Real Estate Research Corporation, April 1974, pp 96.

f. Type VI -- High Density Planned Community. 10 percent of dwelling units are clustered single-family homes, 20 percent are townhouses, 30 percent are walk-up apartments, and 40 percent are high-rise apartments. Housing types are mixed in contiguous neighborhoods. Much vacant land remains. Considerable proportions of open space are planned and land uses are related.

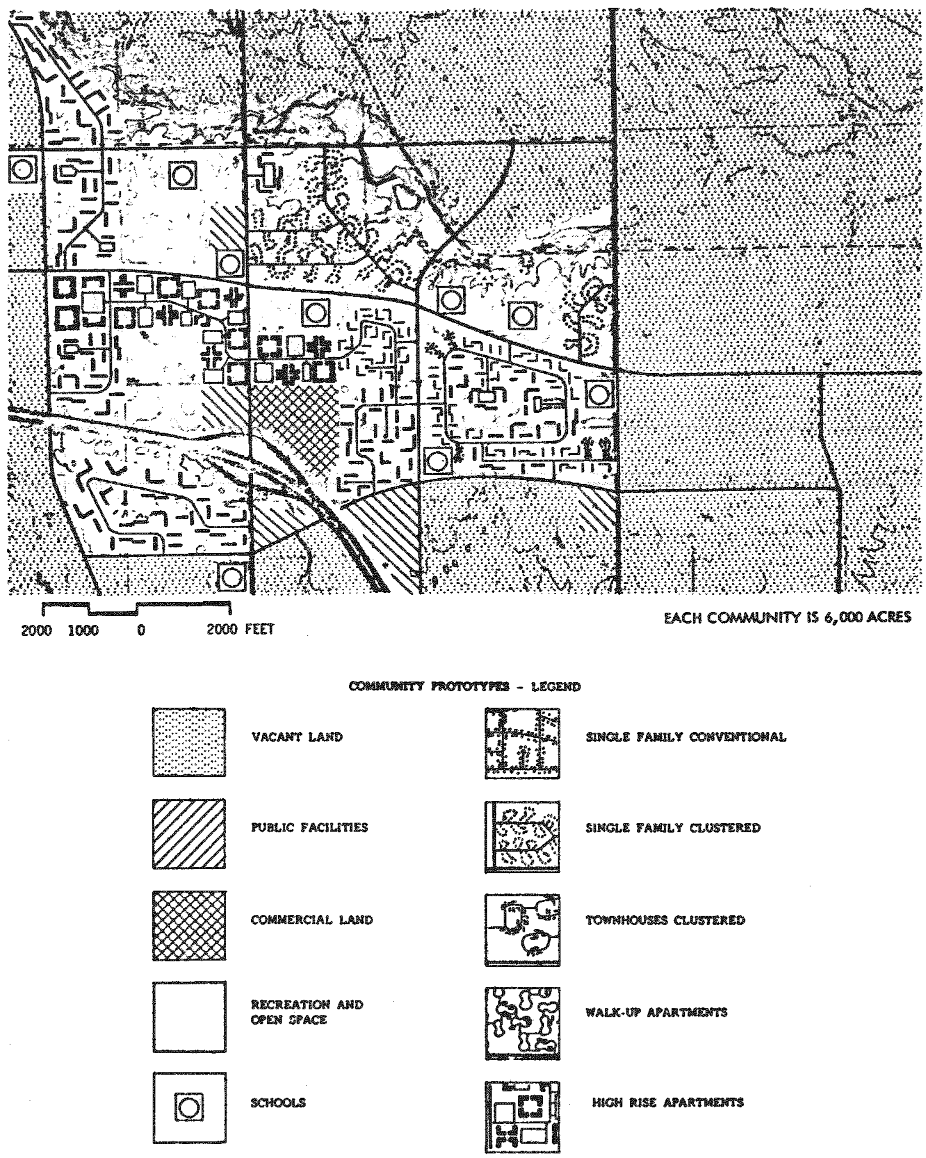


FIGURE C4-12. COMMUNITY PROTOTYPE VI, HIGH DENSITY PLANNED

Source: "The Costs of Sprawl, Detailed Cost Analysis", Real Estate Research Corporation, April 1974, pp 96.

The prototype communities have energy consumption variations because of the following factors:

(a) differences in housing mix and residential density

(b) differences in the degree of planning, reflected in differences in land budget

(c) differences in time of development. In planned communities, housing constructed each year consists of a mix of types, while in sprawl communities, lower density housing is constructed initially and higher density housing is built later in the development period to fill in passed-over sites. In planned communities, other facilities are constructed earlier in time, staged in larger increments, and phased according to housing construction; in sprawl communities, other facilities are built later, in smaller increments, and not necessarily in phase with housing construction.

Based on an analysis of energy consumption for the various prototype community development patterns (Table C4-1), the following energy savings were estimated.

Community Development Pattern	Total Energy Consumption-Gas and Electric 1% of (1)	Total Energy Savings Due To Density Changes % of (1)
(1) Low-density sprawl	100	0
(2) Low-density planned	100	0
(3) Sprawl mix	74	26
(4) Combination mix	74	26
(5) Planned mix	74	26
(6) High density planned	60	40

Thus, in terms of residential density, the greatest energy savings can be achieved with a greater emphasis on high-rise dwelling units than on single-family detached units. And yet, considerable energy savings are possible just by modifying the mix of single-family detached, single-family attached (duplexes, quadriplexes, townhouses for sale, condominiums), and multifamily units (walk-up and high-rise apartments).

TABLE C4-1. COMMUNITY ANALYSIS OF ENERGY CONSUMPTION

	Community Development Pattern (10,000 Units)					
	I	II	III	IV	V	VI
	Planned Mix	Combination Mix, 50 Percent PUD, 50 Percent Sprawl	Sprawl Mix	Low Density Planned	Low Density Sprawl	High-Density Planned
Annual Consumption of Energy (1)						
Natural gas, billion Btu's per year	999.418	999.418	999.418	1,347.090	1,347.090	795.177
Electricity, billion Btu's per year	751.020	751.020	751.020	1,007.610	1,007.610	604.960
Total Billion Btu's per year	1,750.438	1,750.438	1,750.438	2,354.700	2,354.700	1,400.137

Notes:

(1) Consumption of energy as follows:

	I	II	III	IV	V	VI
Natural gas - therms per year	9,994,180	9,994,180	9,994,180	13,470,900	13,470,900	7,951,770
Electricity - kwh per year	220,046,750	220,046,750	220,046,750	295,227,080	295,227,080	177,251,577

(2) 1 therm = 100,000 Btu's.

(3) 1 kilowatt-hour = 3,413 Btu's.

Source: Excerpted from "The Costs of Sprawl, Detailed Cost Analysis", Real Estate Research Corporation, April 1974, p 147.

Improved land use planning techniques in neighborhood development also offer a major opportunity for energy savings. Given a fixed number of households, "sprawl" is the most expensive form of residential development not only in terms of economic costs but in terms of energy as well. There are specific land use actions that will reduce energy consumption. These include clustering of dwelling units and providing centers of mixed activity to allow people to live near their place of employment, shopping and recreation. All of these actions fall within the domain of local government planning and land use regulation. As a result, the success of reducing energy consumption through development and land use controls depends on the commitment and involvement of local government.

When employment, residential, and shopping areas are separated by long distances, people are forced to use automobiles. In addition, other development decisions discourage the use of alternative forms of transportation such as mass transit, bicycles, or walking. As a result, to conserve energy land use patterns must involve clustered neighborhood centers of mixed uses which encourage the use of mass transit, electric cars, bicycles and walking and thus reduce the distance and frequency of vehicular travel.

RERC estimated that energy consumption can be reduced up to 14 percent in planned communities, largely because of reduced automobile travel. Table C4-1a illustrates annual gasoline energy consumption due to various community development patterns as defined in the RERC study. Automobile travel outside the local community for work, shopping, or recreation was not considered.

As a result, the following energy savings are possible due to various community land use planning techniques and the resultant reduction in automobile travel.

TABLE C4-1a. COMMUNITY ANALYSIS ENERGY CONSUMPTION

	Community Development Pattern (10,000 Units)					
	I	II	III	IV	V	VI
	Planned Mix	Combination Mix 50 Percent PUD, 50 Percent Sprawl	Sprawl Mix	Low Density Planned	Low Density Sprawl	Low Density Planned
Annual Consumption of Energy(1)						
Gasoline, billion BTUs per yr(2)	1,066.043	1,284.313	1,531.053	1,385.540	1,705.037	2,857.263

Notes:

(1) Consumption of energy as follows:

	I	II	III	IV	V	VI
Gasoline - Gallons per yr	8,200,333	9,879,333	11,777,333	10,658,000	13,115,667	6,594,333

(2) 1 gallon of gasoline=130,000 BTUs.

Source: "Excerpted from "The Costs of Sprawl, Detailed Cost Analysis", Real Estate Research Corporation, April, 1974, pp 147.

TABLE C4-2. GASOLINE CONSUMPTION IN VARIOUS COMMUNITY DEVELOPMENT PATTERNS

Community Development Patterns	Total Energy Consumption-Gasoline % of (1)*	Total Energy Savings (Gasoline) Due to to Land Use Planning Changes(%)
(1) Low-density sprawl	100	0
(2) Low-density planned	81	19
(3) Sprawl mix	90	10
(4) Combination mix	75	25
(5) Planned mix	63	27
(6) High density planned	50	50

See Table C4-1.

Passive Solar Building and Community Design

As the result of government and private research efforts, the so-called"passive solar building" is beginning to be understood and is proving to be a practical and cost effective method for lowering the energy demand of buildings. It is a significant alternative to scarce fossil fuels. Passive design concepts rely on natural energy, such as the sun, contain few mechanical parts or complex hardware, require little or no energy themselves, and tend to be low in cost. A passive approach to solar heating and cooling may be a window, of the correct size and type, with the proper orientation to the sun and wind, and with an insulated operable shutter. An active approach to solar heating and cooling, for example, may involve a complex roof-mounted collector with fans, pumps, storage or heat exchange units and highly sophisticated controls.

The primary requirements for properly designed passive systems entail providing mass within the structure, and controlling heat flow into and out of the building. Over a period of days the temperature of a building can be driven up or down by allowing heat in and by using insulation to trap it within the mass of the structure. By manipulating heat flow and storage, it is possible to take advantage of those parts of the daily and weekly temperature fluctuations that drive the temperature of the building above or below the average outdoor temperature.

Buildings constructed with stone or adobe have good mass characteristics. The sun shining on a thick stone wall slowly heat the wall and by evening the heat will reach the inside surface of the wall. Adobe buildings, for example, work well where there is a reliable daily temperature cycle; each night the walls are cooled and it takes all day for the heat to penetrate the structure. In the winter the adobe does not work nearly so well, especially in cold cloudy weather when there is no heat input from the outside and a steady flow of heat out of the structure occurs. Contemporary light weight structures with proper insulation solve the problem of outward heat flow, but provide no mass within the structure to moderate the surges of energy that can be brought into a structure on clear winter days. Buildings with many south-facing windows and little mass often overheat on such days. More mass within the structure would soak up this heat so that it could be utilized in underheated periods. The contemporary passively designed structure brings together insulation systems and the historical use of mass in structures to create a building with superior energy performance characteristics.

The various generic approaches to passive solar energy utilization may be categorized into four basic groups.[8]

The first and simplest type of passive system is the direct gain approach in which one simply has an expanse of glass (usually double glass) facing south. The building should have considerable thermal mass, either a poured concrete floor or a massive masonry construction with insulation on the outside. The characteristic sun angles result in a favorable situation, since the south face is exposed to a maximum amount of solar energy in the cold winter months when the sun angles are low.

The second type of system is the thermal storage wall, in which the thermal storage is in a wall that absorbs the solar energy after it comes through the glazing and that stores the heat energy. The wall is usually painted black to enhance absorption qualities and may consist either of water in containers or a heavy masonry (Trombe) wall.

A third type of passive system is a solar greenhouse, which combines the features of direct gain and thermal storage wall techniques For this type of system, one builds a greenhouse onto the south side of the building with some kind of thermal storage wall between the greenhouse and the house. The temperature in the greenhouse does not require very much control (as long as the plants do not freeze), and solar energy normally provides all of the heat required for the greenhouse as well as providing a substantial amount of energy for heating the house.

The fourth type of design is the roof pond in which the thermal storage is in the ceiling of the building. In this case, movable insulation is needed because sun angles cause large solar inputs in the summer and small inputs in the winter. The system provides good natural cooling since the movable insulation allows one to take advantage of nighttime radiation.

Passive design is based upon energy optimization. To optimize energy use, it is desirable for a building to have the greatest amount of area with southern exposure during the winter (to maximize solar heat gaines when they are most needed), but the least amount during the summer (to minimize solar heat gains when they are not needed).

The location of rooms within a building should be determined with consideration being given to the amount of heat which various activities within the room will generate and the amount of heat which will be lost because of the room's location.[9] Spaces which are not occupied a great deal of the time, such as corridors, closets, mechanical equipment rooms, laundries, and garages, can be kept at lower temperatures. They can be located on the north side of a building to provide a buffer zone between the occupied areas and the colder north wall.

Occupied rooms should be oriented to warmer climate conditions. During the day the north and east walls receive the least amount of radiation. As a result they remain the coolest. South walls receive radiation throughout the day, while west walls are exposed to intense late afternoon summer sun. Walls with these last two orientations will be the hottest and may significantly contribute to heat gains.

Areas in which heat is generated, such as laundry rooms or mechanical rooms, should be located on the north or east sides of a building so that heat can be vented to the outside in the summer or used to warm the inside in the winter. Consideration should be given to using hot air to preheat domestic water or to supplement other heating sources.

The north side is a good location for a kitchen, hall, stairway, closet, or other areas that are not continually occupied. Stoves, ovens, and other appliances generate internal heat that warms the kitchen in the winter and may be used to initiate cooling inductive ventilation in the summer.

The south side of a building is a good location for living, family, and dining room areas. Heat gains and illumination in these areas and greater than those in other areas, making them good for continuous-occupancy locations (Figure C4-13).

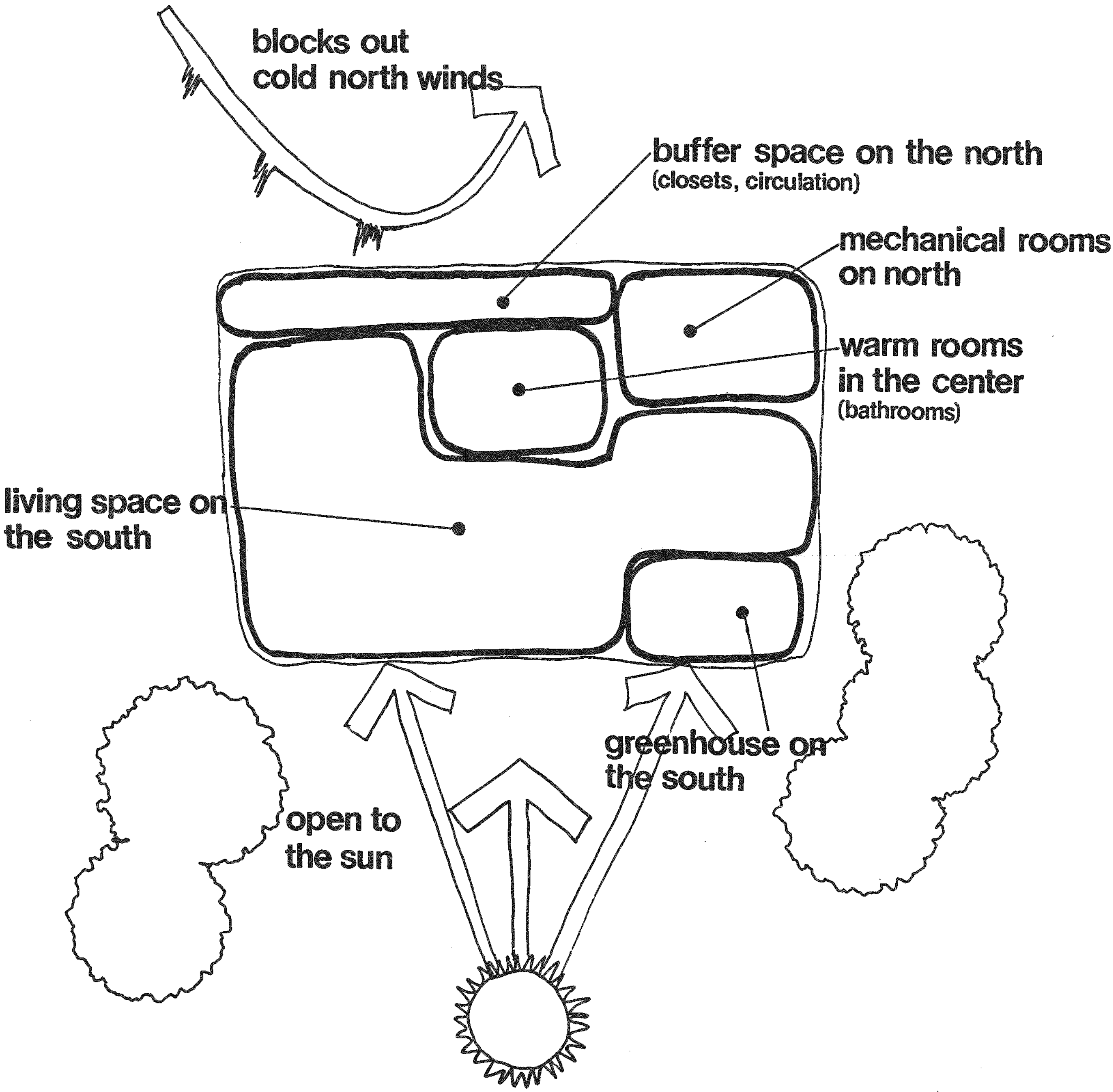


FIGURE C4-13. DESIGN REPRESENTING ENERGY OPTIMIZATION

Source: "Sun/Earth - How to Use Solar and Climatic Energies Today", Richard L. Crowther, A.I.A; February 1977, p 130.

As a result, in a climate like Riverside's, south-facing glazing is a major consideration in achieving energy efficiency. Some recent research has been performed in Davis, California to quantify the effectiveness of south-facing glazing (Figure C4-14). The purpose of this research was to monitor solar energy heating effects in a variety of types and houses in winter weather. The interior temperature was measured in six rooms of three new unoccupied duplex-houses in Davis in January 1976. The test units were all on the first floor, except number 6, which was on the second floor. All had single glazing. While not ideal, the units varied enough that significant temperature differences resulted.

The results confirmed the hypothesis that the best solar heating was obtained in rooms with large unobstructed south windows; however, the room with the best exposure cooled off at night because it had inadequate window insulation and very little thermal storage. West windows added very little heat to rooms.[10]

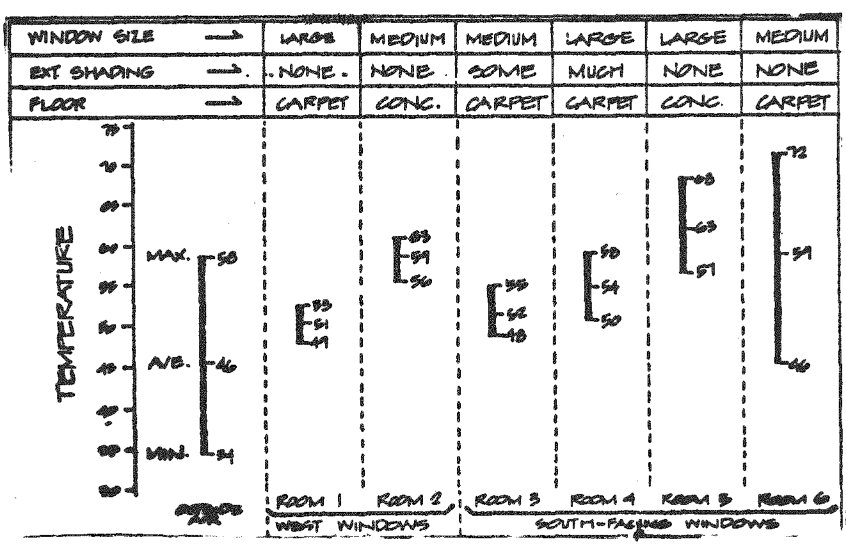


FIGURE C4-14. GRAPH OF ROOM TEMPERATURES, DAVIS, CALIFORNIA

Source: "Davis Energy Conservation Report", City of Davis (CA), May, 1977, p. 28.

Figure C4-15 shows various ratios of north-south building dimensions versus east-west building dimensions for different types of climates, with the optimum and acceptable ranges of building proportions for each[11]

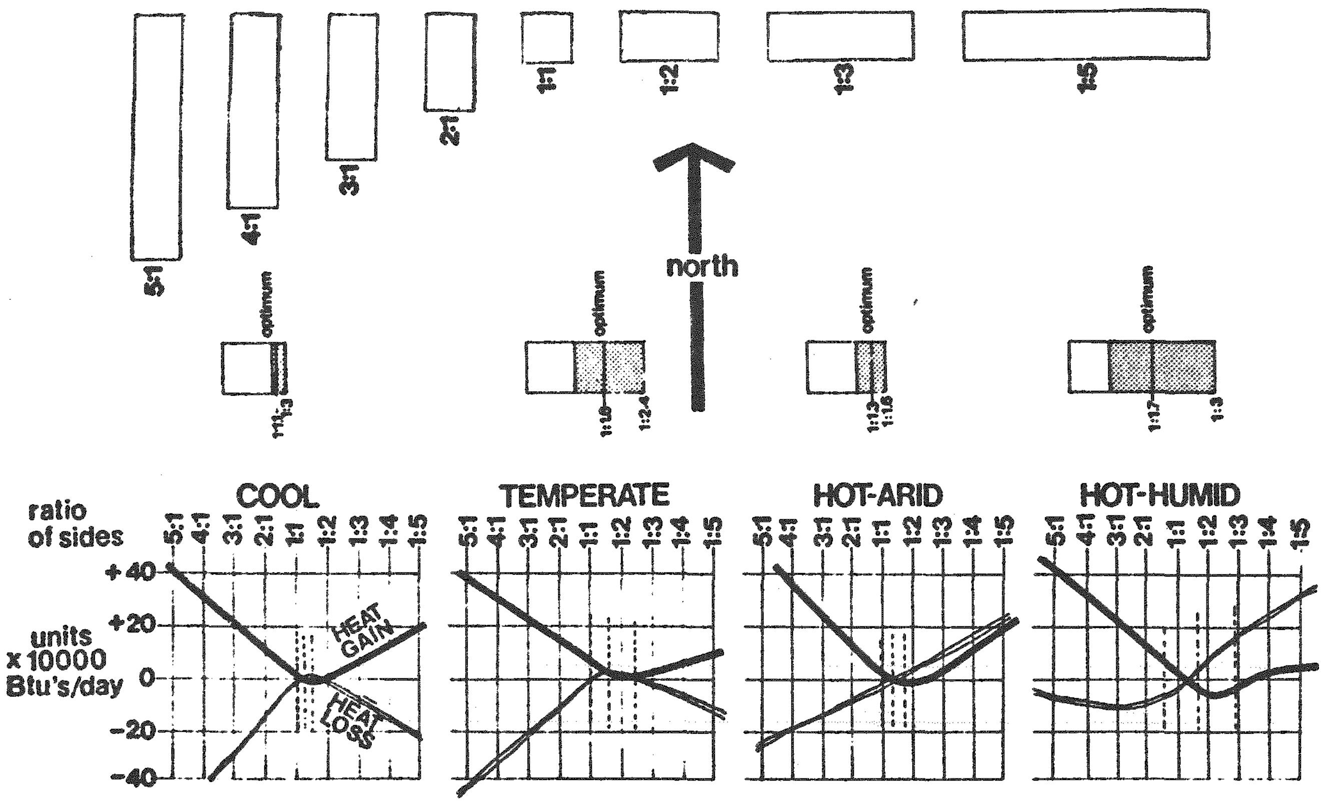


FIGURE C4-15. BUILDING DIMENSION RATIOS IN VARIOUS CLIMATES

Source: Olgyay, Victor, "Design with Climate: A Climatic Approach to Architecture", Princeton University, 1963, p 89, Figure 174.

According to research conducted by Dr. Douglas Balcomb at the Los Alamos Scientific Laboratory, it has been determined that with proper planning the solar heating fraction for the Los Angeles area is 99.9 percent.(12) Thus, virtually all of the space and hot water heating requirements of a dwelling unit in Riverside can be provided through passive design concepts.

Several actions may be implemented by the City, relative to orientation that are supportive of the passive solar design of buildings. For example, orientation of building in relation to the sun, wind patterns, topography, trees, and other off-site developments can greatly affect energy usage in buildings. Another factor is the intensity, direction, swing, and deviation of sunlight, and the ability of the building design to control or collect heat.

On the average, Riverside receives sun 70 percent of the time possible during the five winter months. However, the sun's position varies both seasonally and from day to day. The critical day is commonly December 21, and on that day in Riverside, the maximum elevation of 34^{o} occurs at noon and the sun moves through an arc of 120^{o} from the Southeast to the Southwest. Buildings and evergreen trees to the south may block this low-angle sun and prevent valuable heat gain. In Riverside where one-third of the nonautomotive energy consumed is for space heating. access to the sun will be required if a solar energy strategy is encouraged. As a result, careful consideration must be given to building relationships to avoid having these buildings adversely impacted by adjacent buildings or trees.

Topography also influences energy usage in buildings. For example, large temperature differentials occur at the foot of hills, and re-radiation of heat into buildings from parking lots and other dark areas can be much greater than radiation from landscape or earthen areas.

The most direct way to accomplish proper building orientation is to orient the building sites so that they face north-south. The city of Davis has implemented this planning procedure and more than 90 percent of all new lots in new developments are oriented to face south (Figure C4-16).[13]

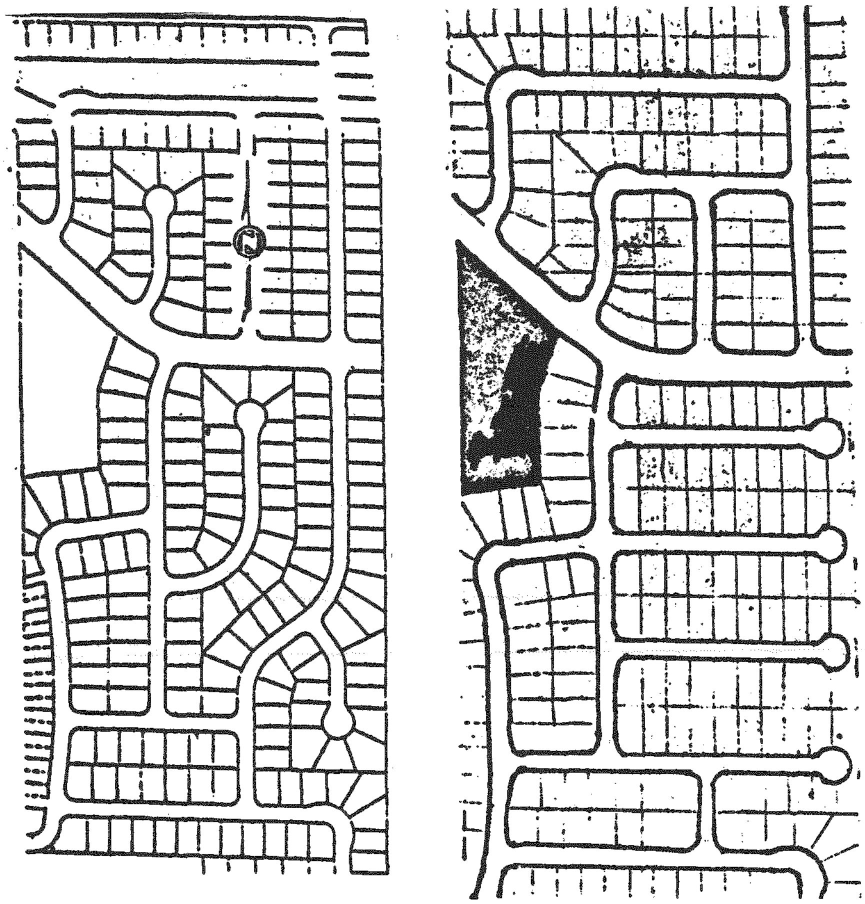


FIGURE C4-16. A STANLEY DAVIS SUBDIVISION THAT WAS REDESIGNED FROM AN EAST-WEST TO A NORTH-SOUTH ORIENTATION (DAVIS, CA)

Source: "Davis Energy Conservation Report", City of Davis, (CA), May 1, 1977, p. 35.

To facilitate planning for more efficient energy use in retrofit conditions new buildings may be oriented properly for maximum solar orientation if setback requirements are changed to allow greater flexibility in building placement. Proper orientation may in some cases require buildings be placed on the extreme edges of lots (Figure C4-17).

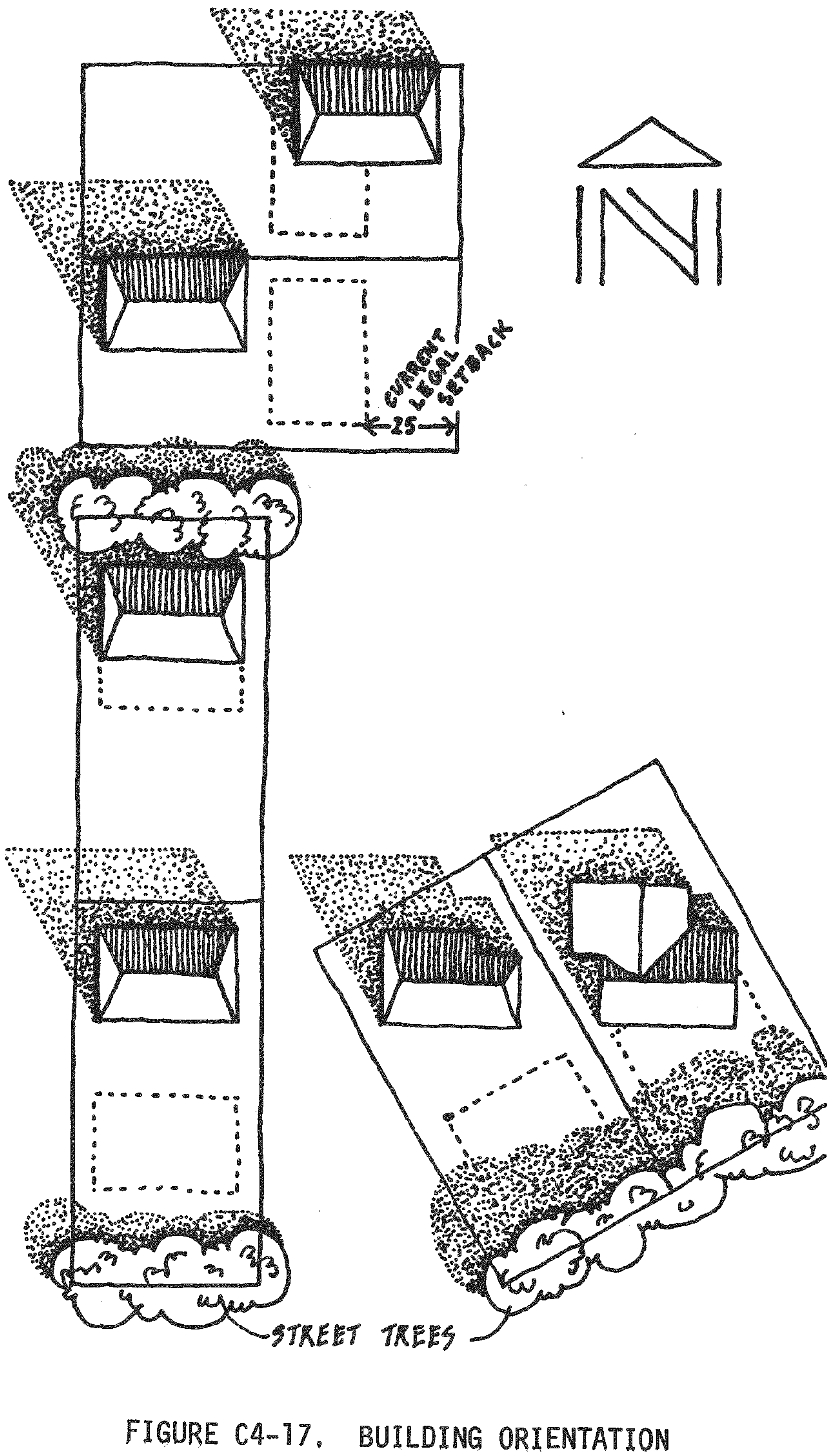


FIGURE C4-17. BUILDING ORIENTATION

Source: Davis Energy Conservation Report, City of Davis (CA), May 1977, p. 39.

It should be emphasized that these "zero yard setbacks" also encourage commonwall construction that will provide even more energy efficiency.

In southern California where privacy fences are frequently used, fence setbacks (distance required from the street) often causes permanent shading of south-facing windows. Required setback distances should be decreased to prevent permanent shading. Height restrictions on fences which preclude full privacy for southern windows should be changed to permit higher fences unless increased fence heights create traffic safety problems (Figure C4-18).

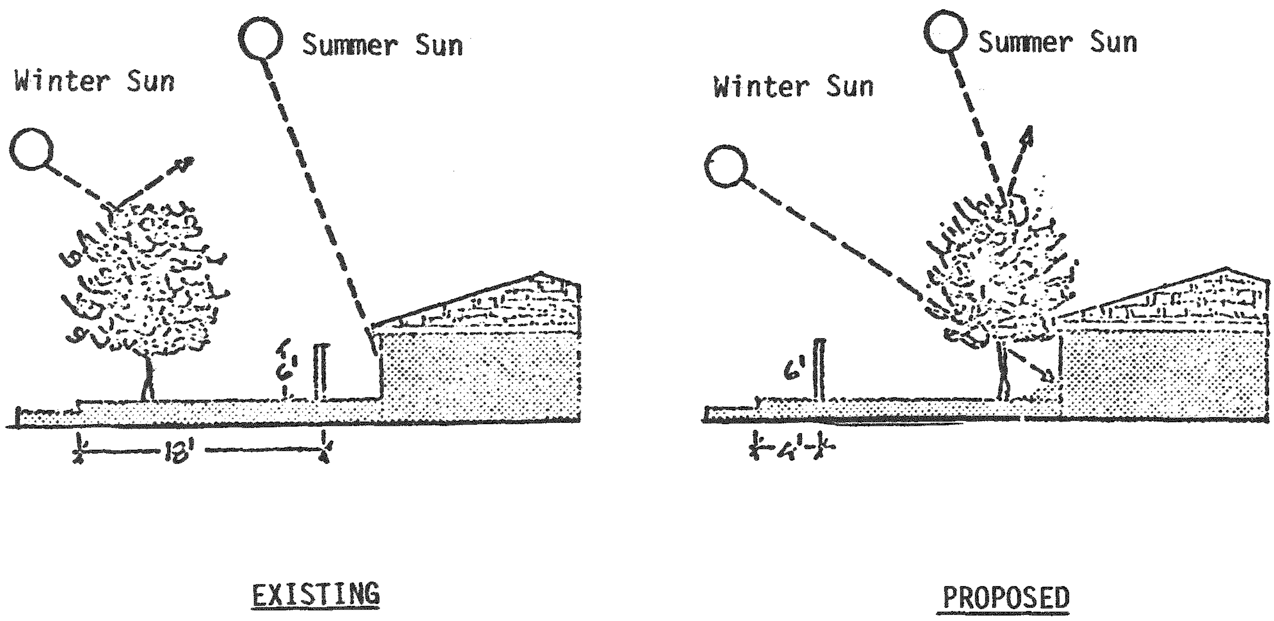


FIGURE C4-18. PLANS FOR MAXIMIZED SOLAR HEATING EFFECT

The proposed application representing the greatest optimization of natural solar heating effects is shown in Figure C4-19.

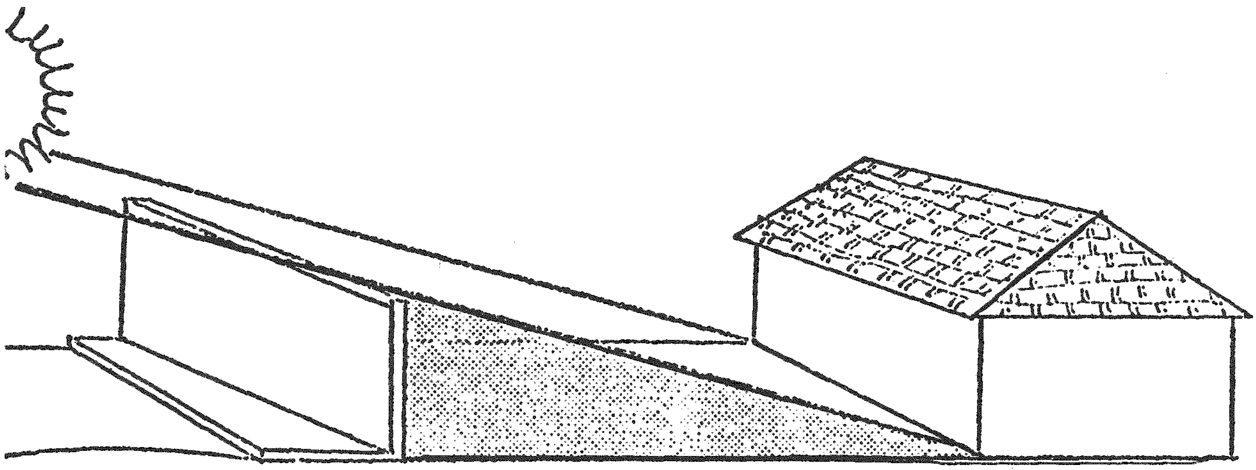


FIGURE C4-19. PROPOSED APPLICATION MAXIMIZING NATURAL SOLAR HEATING

Utilization of 0 to 4-foot side yards or back yards along with narrower front yards will allow sufficient flexibility to properly orient a building in relation to trees or adjacent buildings.

Solar Access

With an increasing emphasis on solar energy and the potential for it in Riverside, providing and protecting access to the sun is a major concern. Height restrictions can be effective in protecting access to the sun. One city that has adopted an ordinance based on height restrictions is Albuquerque, New Mexico. This ordinance requires that buildings not shade each other from the south. The ordinance is as follows:

> Height: Structure height up to 26 feet is permitted at any legal location. The height and width of the structure over 26 feet high shall fall within 45-degree angle planes drawn from the horizontal at the mean grade along each internal boundary of the premises and each adjacent public right-of-way centerline, or drainage right-of-way centerline. To protect solar access, a structure over 26 feet may not exceed the northern boundary of these 45-degree planes, but may not be sited in any other direction within planes drawn at a 60-degree angle from the same boundaries or centerline.

Height restrictions are usually accepted in zoning ordinances and have been upheld by the courts as a legitimate exercise of police power. As a result, they avoid the legal and institutional barriers which may accompany more comprehensive controls such as solar air-space easements or solar zoning. However, height restrictions may not be effective in protecting solar access in certain cases.

One of the most effective ways of protecting access to the sun is through the establishment of a comprehensive solar zoning ordinance. Most proposed model ordinances focus on protecting solar access in new developments. The most common approach is to establish easements that can then be recorded and transferred as property interests. The City of Colorado Springs has adopted a system of "airspace solar easements" which is:

> A specific volume of airspace defined by a plane sloping upward to the south at a specified angle from the horizontal (22° is recommended), and the plan is further defined in both plane view and

elevation with reference to the property lines over which it passes. The plane view description shall be in terms of the bearings and horizontal distances, and the elevation shall be with reference to mean sea level.

This regulation permits the creation of airspace easements across contiguous lots to establish solar access. The ordinance provides that the air-space solar easements may be purchased and recorded. Anyone seeking a building permit that involves a structure increasing the consumption of airspace is required to certify in writing that no air-space solar easement exists over the site. In cases where an easement does exist, the City Building Department will not issue a building permit unless it has been determined that the construction will not impose on the easement.

The City of Davis (California) and Sacramento County both have proposed ordinances aimed at passive solar systems. They require developers to include solar easements in each deed in new subdivisions. In this process, every development proposal would be required to include a description of the allowable height and shape of an "envelope zone" for all structures and vegetation designed to minimize shading of adjacent properties. Once the envelope is recorded no structure or vegetation would be permitted outside the envelope zone. If such were permitted the shading pattern may adversely impact an adjoining site. All proposals are to include a description and diagram of the envelope zone and a diagram of the shading pattern cast by the envelope on December 21 from 9 A.M. to 3 P.M. and must be written as an easement to be included with the property deeds.

Establishment of envelope zones for individual sites as well as establishment of a standard envelope zone for new development and retrofit should be considered in Riverside.

Building Microenvironment: Landscaping/Shading

The landscaping and shading of buildings can also reduce energy use for space heating and cooling and can improve the microclimate for pedestrians and bicyclists. Only a few measurements have been made of the direct effects of landscaping on energy conservation and buildings. However, these measurements indicate that a 25 to 35 percent reduction in the heating and cooling loads might be possible through careful use of landscape elements such as grass, paving, shrubs, and trees. To achieve these savings requires careful placement and selection of landscaped elements, based on an understanding of heat gain and heat loss in buildings, and the effects of landscaped elements on the building environment.

Heat gains and losses through the shell of a dwelling unit are due to radiation, air leakage, and conductive heat transfer. Landscaping can be beneficial in reducing these heat gains or losses in buildings in the following ways:

1. Reducing direct solar radiation, sky re-radiation, and reflected ground radiation at windows during the summer.
2. Reducing air leakage in all seasons through cracks and joints around windows and doors, at roof eaves, building corners, and at the foundation line by lowering the wind velocity at the building surfaces.
3. Reducing the heat transmission of windows and to a lesser degree of building shell elements, since modifying the amount of wind, sun, and rain that strikes the building surfaces can decrease the temperature difference between indoors and outdoors.

Ground Surfaces

Ground surfaces around houses effect the radiant and conductive heat gains and losses of windows and walls. They reflect solar radiation through windows and cause local changes in outdoor air temperatures by storing warmth and coldness in surrounding materials. Light-colored materials are usually reflective and will increase the heat load immediately by indirect radiation, while dark-colored materials will store large amounts of solar radiation and thus delay the heat load. Plant materials, on the other hand, because of their dark color, large surface area and evaporative cooling, neither reflect heat toward a building nor store heat for later re-radiation to the building.

Several measurements have been made of variations in air temperatures due to changes in surface materials. In his book, Climate And Architecture,(14) Jeffrey Aronin reported an experiment in Montreal under sunny conditions which measured the temperature of the grass at 89 F, asphalt at 106 F, and concrete at 111 F. Aronin also reported a case in which asphalt, overhung by the eave of a roof on the south side of the house, reached a temperature of 120 F while the lawn nearby was at 80 F. In his book, American Building,(15) James Fitch reported an observation made in August at 2:00 P.M. in Texas which showed a temperature of 125 F immediately above unshaded asphalt pavement and a temperature of 98 F above a shaded grass area 30 feet away.

Overhanging eaves may worsen the performance of a surface material by acting as a radiant heat trap while shade may improve its performance. Paving on the south side of a house in a warm climate can increase the air conditioning load significantly, whereas in a cold climate, this effect may be unimportant, and in a temperate climate paving may be an asset if exposed to the sun in the winter and shade in the summer.

Shrubs

Shrubs such as arborvitae, hemlock, or spruce, when planted close to a building, affect its outside surface temperature by blocking the wind, creating shade, and providing and insulating dead air-space between the shrub and building.

In his book, Design With Climate,(16) Victor Olgyay reported on an experiment conducted in Nebraska on two identical houses. One was exposed to the winds, and the other protected by dense shrubbery. Using the exact fuel required to maintain an indoor temperature of 70 F in each house, a savings of 23 percent was measured in the protected house. From this experiment it was extrapolated that with good protection on three sides of the experimental house the fuel savings could have run as high as 30 percent.

Low shrubs will have a limited benefit in conserving energy but consideration should be given to planting shrubs on the east, west, and north exposures as an energy saver.

Trees

Trees significantly reduce ambient air temperatures in the summer through shading. Buildings are generally 20 F cooler in the shade than in the direct sun. This reduces a building's needs, resulting in direct energy and cost savings. Free standing trees provide an effective shading device that can affect not only the walls of a building, but its roof. As the number of trees increase, their effect on the house will change. A grove of trees will not only provide shade and wind protection, but modify outside air temperature through evaporative cooling.

It has been reported that air conditioners in fully shaded dwelling units are required to operate only half as much as those in a dwelling unit with its walls and roof exposed to the sun. A difference in shaded and unshaded outdoor wall surfaces of 8 F were reported. This would be equivalent to increasing the insulating value of the shaded portion of the wall by 30 percent. Victor Olgyay has reported that shade trees will reduce solar heat gains by 40 to 80 percent, depending on their density, and that even a sparse shade tree may be a better energy saver than an interior venetian blind.

In his book, Design With Climate,(16) Victor Olgyay reports that the type of tree to be used in a given location is very important. Consideration must be given to the shape and character of the tree itself, both in winter and summer, and the shape of its shadow for a natural shading device.

It is desirable to transplant shade trees in as large a size as practical. For a tree to give results in a comparatively few years, it should be 15 to 20 feet high when planted. It does not, however, take some trees as long to mature to their full usefulness as is often assumed; generally, when a fast-growing five-year-old tree is planted in a new location it takes only five more years to grow to 80 percent of its full shading effect.

Deciduous trees let the sun in during the winter and provide shade during the summer, while evergreen trees provide constant shade. Among deciduous shade trees, the maple and ash produce more or less circular shadow effects during the summer, with an ascending branch pattern in the winter. The linden tree is spherical but is dense and twiggy without its leaves. The honey locust and tulip tree have oblong shapes. The white oak is horizontally oblong, with an open branched structure in winter. The lombardy poplar is columnar in appearance, while the American elm is base shaped.

Among the small flowering trees is a great variety of forms, such as the upright growing crabapple, the dogwood with its horizontal branches, the vase-shaped honeysuckle, the rounded spirea, the columnar enkiathus, or the broad-spreading dwarf Japanese quince. Each of these shapes has a definite implication in its shading effect. The exact location of trees and vegetation can be determined with their shading masks through the use of a protractor.

To achieve efficient shading, trees have to be placed strategically. As the sun passes in the morning and late afternoon at a low altitude, trees give their best performance on the east-south-east and on the west-south-west sides. Low sun rays cast long shadows, which can be utilized effectively on the sides otherwise difficult to protect from the sun's heat. At mid-day the sun's path is high and the rays can be intercepted easily with a roof overhang; at this time of day trees on the south side perform poorly, casting their shadows near themselves.

The section and plan of a house with planting shows an arrangement for temperate climates (Fig. C4-20). In this case the early morning sun may relieve the coolness of day break. After 8:00 a.m., the east side gets protection from the single tree at the southeast corner. At noon an overhang shields the building. In the early afternoon the tree on the southwest corner protects the west side. For complete shade coverage, there is another tree to the west. This is placed at a greater distance from the house, as the setting sun lengthens the shadows. The west hedge is intended to catch the last low angle evening sun rays.

Shading parking lots can substantially reduce the maximum temperatures. The lower air temperatures in parking lots will also lower the thermal stress on people and make it more enjoyable to be in the area. It will also reduce use of auto air conditioners, since autos will stay cooler while parked and will therefore increase energy efficiency of automobiles as well.

One of the most important considerations affecting bicycle use is the comfort of using bicycles in all weather for commuter or recreational purposes. The cyclist is more aware of weather than the driver of a "climate-controlled" vehicle. As a result, microclimatic improvement is desirable. Shading bicycle paths is one way to provide that improvement.

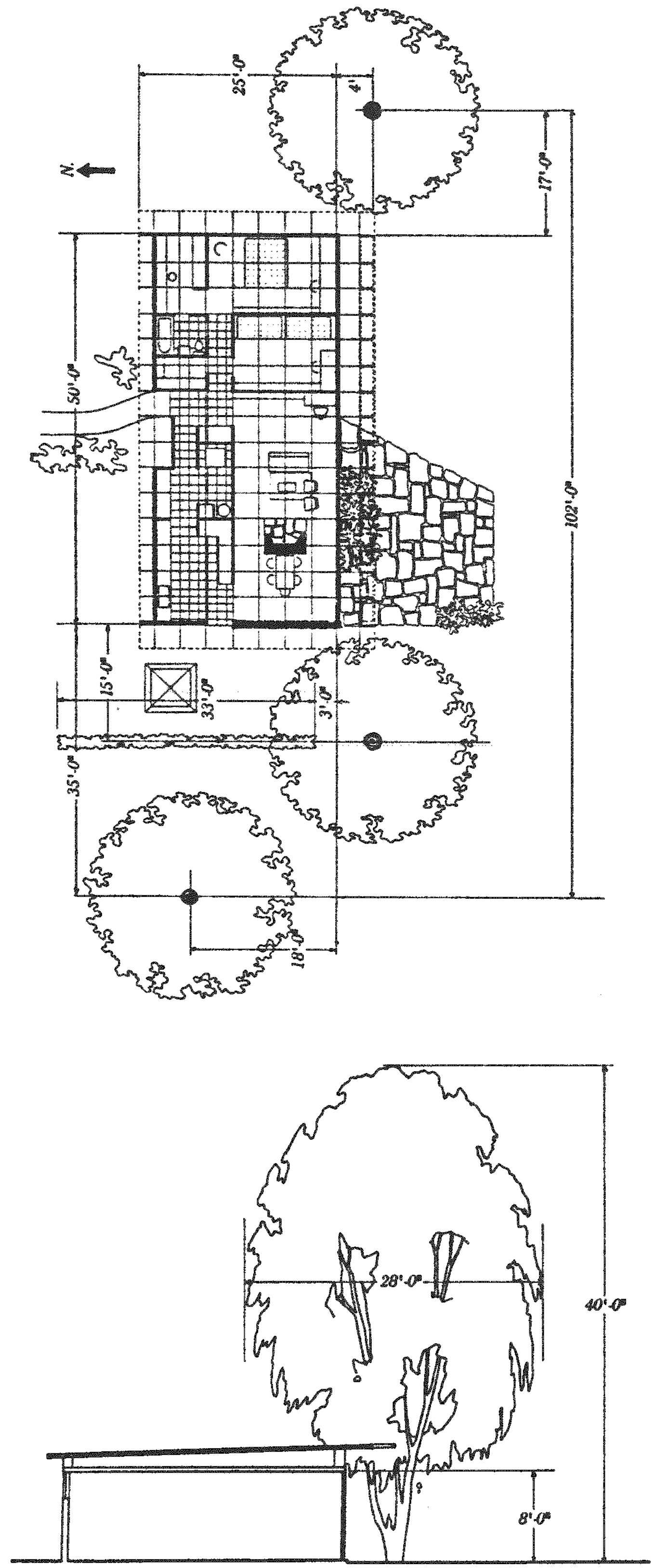


FIGURE C4-20. SECTION AND PLAN OF HOUSE SHOWING LANDSCAPING AND OVERHANG

Source: Olgyay, Victor, "Design with Climate", Princeton University Press, 1973, pp. 76.

Another method for reducing heat gain and heat loss in buildings is by special treatment of the glass areas. Windows are the largest single factor affecting overall heat loss and heat gain in buildings. On hot days, a quarter-inch clear glass window may conduct up to 80 percent of the solar energy striking its exterior surface. This amount of heat flow may be 10 times that of the heat flow through an adjacent insulated wall. On cold days, a clear glass window may conduct 5 to 10 times more energy from the interior to the exterior than adjacent insulated wall areas. Double pane windows and reflective tinting of windows can reduce heating losses and gains. Double-paned windows consist of two panes of glass with an insulating air space between them to add resistance to heat gain or loss. Selected types of these windows can reduce heat gains or losses by as much as 80 percent over conventional single-pane windows. Tinted glass is used to reduce light levels and glare, but also reduces solar heat transmissions. However, when compared to drapes, shades, and heating loads as alternative conservation methods, tinted glass can only realize net energy savings under specific design conditions. On the other hand, heat absorbing glass can absorb up to 45 percent of solar energy inputs, and can be used in conjunction with external shading devices to reduce solar heat loads up to 75 percent. Air movement between shades and glass surfaces can lead to even greater savings. Finally, traditional storm windows can reduce heat gains and losses by 10 to 15 percent, even without shading devices.

Alternative Parking Lot Paving Materials

Light-colored materials are usually reflective and will increase the heat load immediately by indirect radiation, while dark-colored materials will store large amounts of solar radiation and thus delay the heat load. For example, asphalt increases air temperature. Consideration should be given to alternative paving systems, such as turf block, brick, cobble stones, and gravel.

STREET LIGHTING

Energy purchased for street lighting by the City of Riverside amounts to approximately 2 to 2-1/2 percent of Riverside's total annual electric consumption.[17] Although given the relatively small amount of energy consumed by the street lighting system--some may say insignificant--conservation measures in the street lighting system should be an integral part of any comprehensive community energy plan. However, there are two reasons why reductions in street lighting energy consumption is necessary. Energy can be saved in terms of per capita consumption and as a result can contribute to a reduction in dependence on scarce fossil fuels. In addition, reduction in street lighting energy consumption is a highly visible action which can serve to encourage public support and participation in all other conservation activities.

Generally, there are three types of lamps used for lighting streets: incandescent, mercury vapor, and high-pressure sodium vapor. When viewed from a distance, each lamp produces a different colored light; incandescent appears yellow, mercury vapor appears blue, and high-pressure sodium appears gold. Light output is measured in lumens, and for a given wattage level, a mercury vapor lamp provides about twice as many lumens as an incandescent lamp. High-pressure sodium lamps provide about four times as many lumens per watt as an incandescent lamp.

Lumen per watt comparisons can be misleading if all factors are not considered. Mercury vapor (M.V.) and high pressure sodium (H.P.S.) lamp lumens per watt increase as the wattage of the lamp increases. However, ballast watts must also be included when comparing to incandescent.

Incandescent lumens per watt also increase as the wattage increases. However, large wattage incandescent lamps are not used for street lighting purposes in Riverside. The largest used in Riverside is 295 watts. 93 percent of Riverside's incandescent lamps are 200 watts or less. The following table indicates lumens per watt for various lamps:

TABLE C4-3 COMPARISON OF INCANDESCENT, MERCURY-VAPOR AND HIGH PRESSURE SODIUM LAMPS

INCANDESCENT			MERCURY VAPOR			HIGH PRESSURE SODIUM		
Lumens	Watts	L/M	Lumens	*Watts	L/M	Lumens	*Watts	L/M
2500	200	13	7500	205	36	3300	Δ70	47
4780	295	16	20,000	460	43	5800	95	61
			55,000	1,102	50	9500	144	66
						16,000	202	79
						22,000	254	86
						50,000	485	103

* Includes ballast Watts Δ Estimated

Source: RIVERSIDE PUBLIC UTILITIES DEPARTMENT

As the above table indicates, replacement of incandescent with M.V. or HPS, or M.V. with HPS cannot be accomplished on a matching lumen basis. In most instances incandescent and M.V. can be replaced with HPS and provide equal or higher light levels while still achieving substantial energy savings. Lighting designs also have to take into account uniformity ratio, lamp lumen depreciation and luminaire efficiency.

According to a study done in 1974 by the Law Enforcement Assistance Administration,[18] it was determined that on a national average, some 20 percent of all street lights are of the incandescent type, averaging some 300 watts each; 75 percent are of the mercury vapor type, averaging some 330 watts each; and 5 percent are of other types, including sodium vapor, averaging 350 watts each. The relatively inefficient incandescent lights, which use approximatley one-third of the electrical energy used nationally by street lights, are primary candidates for replacement with the significantly more efficient gaseous vapor lights.

Although the high-pressure sodium light delivers the most illumination per watt, there may be some problems with this type of lighting according to the LEAA study. High-pressure sodium lights have a gold hue that many people find unpleasant. In addition, law enforcement officers have found that it is difficult to identify the color of people's hair or clothing or to even discern certain colors of automobiles accurately. The reason is that the color rendition of high-pressure sodium is considerably less than mercury vapor. On the other hand, it is better than low-pressure sodium which has a color rendition factor of 0. Further, a number of communities have expressed concern over the environmental effects of sodium vapor lighting on trees and plants. These effects include delaying the dormancy of trees in the fall, changes in the blooming and growing characteristics of certain plants (e.g., poinsettias), and increased sensitivity of some types of woody trees to air pollution, particularly sulfur dioxide.

The City of Riverside has trial installations of High Pressure Sodium lighting in three residential areas in addition to two commercial areas and numerous traffic signal controlled intersections. Mail polls of two of the residential areas resulted in replies from 44 of the 77 residents. Listed below are the results of the poll:

QUESTIONS ASKED	YES	NO	UNDECIDED
1) Has the HPS street lighting improved lighting on your street?	28	12	4
2) Is the color of the HPS lighting objectionable to you?	9	35	
3) Do you think HPS lighting installations would be acceptable to residents City-wide?	34	5	5
4) Would you have preferred installation of Mercury Vapor (M.V.) lighting (blueish-white light) instead of HPS? The M.V. lights would have provided approximately the same light as HPS but require twice as much energy to operate	10	33	1

According to representatives of the Public Utilities Department the main objection to HPS from most people in Riverside is the color. However, it is felt this is an initial response. Some people still object to M.V. or any type of light source employed. It is also the City's experience that HPS color rendition is as good or better than M.V. Information available to the City indicates that HPS lighting will not environmentally effect trees and plants because of the City's climate.

Many communities are trying to determine whether there are areas in which outdoor lighting could be safely reduced--some in response to severe electricity shortages; others in response to a general conservation consciousness. In Portland, Oregon, for example, a 10 percent decrease in the total street lighting consumption was achieved by reductions primarily in commercial areas that were lit well above the levels required for safety in order to enhance commercial interests. This reduction was achieved by turning off every third or fourth light in these areas. After three months of monitoring, the City had not detected any increases in crime.

In Salem, Oregon, two hundred 1000-watt mercury lights were replaced by the more efficient 400 watt sodium vapor lights.

The City of Los Angeles has developed and implemented a plan to achieve a goal of reducing street lighting energy consumption by 25 percent. The deactivation of every fourth lamp was considered but rejected because of cost, degradation of the inoperative lights due to moisture accumulation, and property tax assessment inequities. Reducing the hours of active street lighting rather than the lighting level was also rejected because of the extent of physical modifications required and the anticipated loss of physical security during the hours when all street lights would be out of service. The initial implementation included:

(1) Reduction of lighting in areas that are essentially lit to enhance commercial interests

(2) Replacement of 6000 lumen incandescent lamps with 4000 lumen incandescent lamps, and 4000 lumen incandescent lamps with 2500 lumen incandescent lamps on selected mid-block residential streets

(3) Conversion of incandescent lights to mercury vapor lights on selected arterial and non-residential streets

(4) Removal of selected lights in cleared properties, on streets having unusually low traffic volumes, and in areas lit by decorative lights.

In Riverside, the approximate amount of energy consumed by the street lighting system is 21,095,196 KWH annually[19] which amounts to about 2-1/2 percent of the City's total electric consumption.

RECOMMENDATIONS FOR AN ENERGY CONSERVATION PROGRAM IN COMMUNITY DESIGN FOR RIVERSIDE

Based on further consideration of the information presented in the preceding sections, recommendations were prepared relative to an energy conservation program in community design for Riverside. In this section of the report, these recommendations are presented in a brief concise statement along with a discussion of their scope, physical impact, and the estimated energy savings attributed to the recommended energy conservation measure.

Recommendation No. 1
Develop and Implement a Land Use Policy to Modify the Housing Mix

Scope

A planning policy should be prepared, adopted, and implemented to gradually modify the current mix of housing in Riverside for the specific purpose of reducing building energy demand.

At present there are approximately 45,200 single-family detached dwelling units and 12,400 multifamily units in Riverside. Of the latter it is estimated that approximately 1400 units are high-rise units. Another 2,200 dwelling units in Riverside in mid-1977, 75.6 percent are single-family detached, 20.7 percent are multi-family, and 3.7 percent are mobile homes.

The proposed planning policy should focus on modifying the distribution of single-family and multifamily units. This does not mean to imply that a new development must consist primarily of multifamily dwelling units. New developments may include single-family units but clustered together more closely with common open spaces. Neither does this recommendation mean that the same percentage distribution should be applied to each new development or redevelopment, but rather the redistribution be applied to the total housing mix withing the City. As a result to achieve the modification both new development and redevelopment areas should be included.

Physical Impact

The projected inventory and the revised housing mix based upon the various growth rates and modification of the housing mix is shown in Table C4-4.

Estimated Energy Savings*

The estimated energy savings for this conservation option are:

	Low Impact	Moderate Impact	High Impact
Low Growth Rate	$.013 \times 10^{12}$	$.044 \times 10^{12}$	$.080 \times 10^{12}$
Moderate Growth Rate	$.025 \times 10^{12}$	$.079 \times 10^{12}$	$.142 \times 10^{12}$
High Growth Rate	$.039 \times 10^{12}$	$.124 \times 10^{12}$	$.222 \times 10^{12}$

These savings are based upon switching a given percentage of detached dwelling units to multifamily units as follows:

Low Impact	10%
Moderate Impact	30%
High Impact	50%

These units are then distributed as follows:

	Low Impact	Moderate Impact	High Impact
Duplex	45%	40%	35%
Low Rise	45%	40%	35%
High Rise	10%	20%	30%

*For detailed calculations, see Attachment C4-1.

TABLE C4-4. CHANGES IN THE HOUSING MIX BASED UPON VARIOUS ENERGY IMPACTS AND GROWTH RATES

LOW IMPACT

		Low Growth Rate						Moderate Growth Rate						High Growth Rate					
		Business as Usual			Change in Housing Mix			Business as Usual			Change in Housing Mix			Business as Usual			Change in Housing Mix		
	Existing	New Units	2000 Inventory	% of Total	New Units	2000 Inventory	% of Total	New Units	2000 Inventory	% of Total	New Units	2000 Inventory	% of Total	New Units	2000 Inventory	% of Total	New Units	2000 Inventory	% of Total
Single Family	45,200	10,604	55,804	75.6	9,544	54,744	74.2	18,902	64,102	75.6	17,012	62,212	73.4	29,693	74,893	75.6	26,724	71,924	72.6
Multifamily	12,400	2,904	15,304	20.7	3,964	16,364	22.2	5,176	17,576	20.7	7,066	19,466	22.9	8,130	20,530	20.7	11,099	23,499	23.7
Duplex	1,922	450	2,372	3.2	927	2,849	3.9	802	2,724	3.2	1,653	3,575	4.2	1,260	3,182	3.2	2,596	4,518	4.6
Low rise	9,052	2,120	11,172	15.1	2,597	11,649	15.8	3,778	12,830	15.1	4,630	13,682	16.1	5,935	14,987	15.1	7,271	16,323	16.5
High rise	1,426	334	1,760	2.4	440	1,866	2.5	595	2,021	2.4	783	2,209	2.6	935	2,361	2.4	1,232	2,658	2.7
Mobile Homes	2,200	519	2,719	3.7	519	2,719	3.7	925	3,125	3.7	925	3,125	3.7	1,453	3,653	3.7	1,453	3,653	3.7
Total	59,800	14,027	73,827	100.0	14,027	73,827	100.0	25,003	84,803	100.0	25,003	84,803	100.0	39,276	99,076	100.0	39,276	99,076	100.0

MODERATE IMPACT

	Existing	New Units	2000 Inventory	% of Total	New Units	2000 Inventory	% of Total	New Units	2000 Inventory	% of Total	New Units	2000 Inventory	% of Total	New Units	2000 Inventory	% of Total	New Units	2000 Inventory	% of Total
Single Family	45,200	10,604	55,804	75.6	7,423	52,623	71.3	18,902	64,102	75.6	13,231	58,431	68.9	29,693	74,893	75.6	20,785	65,985	66.6
Multifamily	12,400	2,904	15,304	20.7	6,085	18,485	25.0	5,176	17,576	20.7	10,847	23,247	27.4	8,130	20,530	20.7	17,038	29,438	29.7
Duplex	1,922	450	2,372	3.2	1,722	3,644	4.9	802	2,724	3.2	3,070	4,992	5.9	1,260	3,182	3.2	4,823	6,745	6.8
Low rise	9,052	2,120	11,172	15.1	3,392	12,444	16.9	3,778	12,830	15.1	6,047	15,099	17.8	5,935	14,987	15.1	9,498	18,550	18.7
High rise	1,426	334	1,760	2.4	971	2,397	3.2	595	2,021	2.4	1,730	3,156	3.7	935	2,361	2.4	2,717	4,143	4.2
Mobile Homes	2,200	519	2,719	3.7	519	2,719	3.7	925	3,125	3.7	925	3,125	3.7	1,453	3,653	3.7	1,453	3,653	3.7
Total	59,800	14,027	73,827	100.0	14,027	73,827	100.0	25,003	84,803	100.0	25,003	84,803	100.0	39,276	99,076	100.0	39,276	99,076	100.0

HIGH IMPACT

	Existing	New Units	2000 Inventory	% of Total	New Units	2000 Inventory	% of Total	New Units	2000 Inventory	% of Total	New Units	2000 Inventory	% of Total	New Units	2000 Inventory	% of Total	New Units	2000 Inventory	% of Total
Single Family	45,200	10,604	55,804	75.6	5,302	50,502	68.4	18,902	64,102	75.6	9,451	54,651	64.4	29,693	74,893	75.6	14,847	60,047	60.6
Multifamily	12,400	2,904	15,304	20.7	8,206	20,606	27.9	5,176	17,576	20.7	14,627	27,027	31.9	8,130	20,530	20.7	22,977	35,377	35.7
Duplex	1,922	450	2,372	3.2	2,306	4,228	5.7	802	2,724	3.2	4,110	6,032	7.1	1,260	3,182	3.2	6,456	8,378	8.4
Low rise	9,052	2,120	11,172	15.1	3,976	13,028	17.7	3,778	12,830	15.1	7,087	16,139	19.0	5,935	14,987	15.1	11,131	20,183	20.4
High rise	1,426	334	1,760	2.4	1,924	3,350	4.5	595	2,021	2.4	3,430	4,856	5.8	935	2,361	2.4	5,390	6,816	6.9
Mobile Homes	2,200	519	2,719	3.7	519	2,719	3.7	925	3,125	3.7	925	3,125	3.7	1,453	3,653	3.7	1,453	3,653	3.7
Total	59,800	14,027	73,827	100.0	14,027	73,827	100.0	25,003	84,803	100.0	25,003	84,803	100.0	39,276	99,076	100.0	39,276	99,076	100.0

Recommendation No. 2
Develop and Implement a Land Use Policy
Aimed at Emphasizing Concentrated Planned Development
With Mixed Uses

Scope

A planning policy should be prepared, adopted, and implemented emphasizing concentrated planned community development for the specific purpose of developing energy-efficient communities within the City. New developments and to some degree even existing developments can be concentrated to reduce distances between residences and other frequently used facilities such as places of work, shopping areas, schools, and recreational facilities.

Physical Impact

In this concept it is very important to consider the geometric pattern or spatial disposition of land use. Conceptually, one might imagine that new development within the City is arranged in a number of small concentrations such as villages. Up to three villages could be formed across the southern edge of the City. The villages are compact with all the functions efficiently concentrated providing easy access to work, convenience shopping, recreation, and educational facilities from homes. Although compactness may be gained by stacking commercial and industrial land uses near the core, actual density may vary depending upon the desired activity in the village. Village development would not be connected but rather would be interwoven with open green spaces that could be used for agricultural purposes, parks, or recreation. Villages would be interconnected with major arterial ways, incorporating mass transit. Because average distances between any two points within villages will be reduced in comparison to traditional sprawl development, horizontal travel could be by electric car, electric mopeds, bicycles, or walking. Freight traffic, the distribution of goods and the removal of garbage could be made more energy efficient because of the shorter distances and the opportunity for using conveyor belts or pneumatic tubes. Thermal and electric energy could be supplied by a district cogeneration plant.

Estimated Energy Savings *

Due to this recommendation, in estimating energy savings it was assumed that because of potential institutional constraints savings would only apply to the high impact strategy. The estimated energy savings for this recommendation are:

	High Impact
Low Growth	$.321 \times 10^{12}$ Btu's
Moderate Growth	$.573 \times 10^{12}$ Btu's
High Growth	$.900 \times 10^{12}$ Btu's

In preparing these estimates the following assumptions were made:

(1) All new dwelling units constructed between 1976 and 2000 will go into planned community development.

(2) The savings generated from this action apply only to transportation. Thus, these savings accrue to a reduction in gasoline consumption.

(3) Reduction in gasoline consumption was estimated at 12.5 percent in the year 2000. This is derived from a report prepared by the Real Estate Research Corporation entitled "Costs of Sprawl-Detailed Cost Analysis". RERC found that in a community with a combination mix of 50 percent planned unit development and 50 percent sprawl there would be transportation savings of 25 percent over traditional sprawl. It was estimated that only 25 percent of the units in Riverside will be in planned developments by the year 200; or, approximately one-half of those considered in the study.

(4) There are 1.5 drivers per dwelling unit **.

(5) Gasoline consumption is 12.14 miles per gallon ***.

(6) Seventy-five percent of Southern California residents drive in excess of 25 miles per day. Twenty-five percent drive 50 miles per day ****.

* For detailed calculations, see Attachment C4-1
** Appendix C-3, "Transportation"
*** U.S. Average for 1970, "State of Texas, Governor's Energy Advisory
**** Appendix C-3, "Transportation"

Recommendation No. 3
Develop and Implement a Planning Policy to Encourage the Use of Passive Solar Building Design

Scope

A planning policy should be prepared, adopted, and implemented to encourage the planning for and the use of passive solar building design for the purpose of reducing energy demand in buildings. The planning policy should include orienting a minimum of 90 percent of the building lots in new developments to face south. To further facilitate planning for more efficient energy use, and so that new and existing buildings may be oriented for maximum solar orientation, setback requirements should be changed to permit greater flexibility in building placement.

The policy should apply to all new developments. Further, the policy is intended to be accompanied by (1) an educational program informing building owners of the principles and benefits of passive building design and (2) an incentive program to encourage building owners, particularly homecwners, to incorporate passive design concepts in new buildings.

Recommendation No. 3A
Develop and Implement a Minimum Winter Performance Standard Relating to the Use of Passive Thermal Systems on New Single-Family Detached and Duplex Units

Scope

A minimum winter performance standard should be prepared, adopted, and implemented relating to the use of passive thermal storage systems on all new single-family detached and selected new single-family attached (primarily duplex) units. Further, this standard is intended to be accomplished by (1) an educational program informing building owners of the principles and benefits of passive thermal design and (2) an incentive program to encourage owners of existing single-family detached and duplex units to incorporate thermal storage in the design of their units.

Physical Impact

Because passive design principles are currently more readily adapted to new single-family detached and duplex units, it was assumed the greatest impact on reducing building thermal demand by such an approach would be made in these building types by the year 2000. Although it is anticipated that other buildings (e.g., low-rise multifamily, commercial) will utilize passive design concepts, these are not expected to be significant enough in number by the year 2000 to make an impact on energy savings. This is due largely to the fact that the state-of-the-art of passive technology is in its infancy.

Estimated Energy Savings *

In estimating energy savings for this recommendation it was assumed that in Riverside all of the space and hot water heating requirements in detached and duplex dwelling units could be provided through passive design. This assumption was based on research conducted at the Los Alamos Scientific Laboratory relating to the Los Angeles area in which it was determined that with proper planning the solar heating fraction is 99.9 percent.(12)

While cooling is an important element of any passive design system, it is specifically addressed in Recommendation No. 4 and not in this recommendation. Thus, this recommendation deals only with the effects of passive design on space and hot water heating. The recommendations were made separately so that the reader can see the impact that each has on energy demand. However, it was further assumed that if a building used passive design principles that both Recommendations 3 and 4 would be incorporated. To estimate the magnitude of any energy savings due to the use of passive design by the year 2000 given a low, moderate, or high impact strategy, the following distribution of new single-family detached and duplex units with a passive solar heating system was assumed:

	Low Impact	
	Detached	Duplex
Low Growth Rate	20%	10%
Moderate Growth Rate	20%	10%
High Growth Rate	20%	10%

	Moderate Impact	
	Detached	Duplex
Low Growth Rate	40%	20%
Moderate Growth Rate	40%	20%
High Growth Rate	40%	20%

	High Impact	
	Detached	Duplex
Low Growth Rate	60%	30%
Moderate Growth Rate	60%	30%
High Growth Rate	60%	30%

* For detailed calculations, see Attachment C4-1.

Thus, the energy savings estimated for this recommendation are:

	Low Impact
Low Growth Rate	$.141 \times 10^{12}$ Btu's
Moderate Growth Rate	$.252 \times 10^{12}$ Btu's
High Growth Rate	$.395 \times 10^{12}$ Btu's

	Moderate Impact
Low Growth Rate	$.231 \times 10^{12}$ Btu's
Moderate Growth Rate	$.412 \times 10^{12}$ Btu's
High Growth Rate	$.646 \times 10^{12}$ Btu's

	High Impact
Low Growth Rate	$.266 \times 10^{12}$ Btu's
Moderate Growth Rate	$.475 \times 10^{12}$ Btu's
High Growth Rate	$.745 \times 10^{12}$ Btu's

Recommendation No. 4
Develop and Implement a Minimum Summer Performance Standard Relating to the Use of Passive Shading and Sheilding Devices on New Single-Family and Low-Rise Residential Units and to Encourage the Use of Such Devices on Existing Units

Scope

A minimum summer performance standard should be prepared, adopted, and implemented relating to the use of shading and shielding devices on all new single-family detached and low-rise multifamily residential units for the specific purpose of reducing space cooling energy demands. Further, this standard is intended to be accompanied by (1) an educational program informing building owners of the principles and benefits of shading and shielding and (2) an incentive program to encourage owners of existing single-family and duplex units to incorporate shading and/or shielding devices in their units.

A shading and shielding device may include deciduous trees, shrubs, building overhangs, or special glass products sufficient in amount and size and properly arranged along the south wall or at the southeast or southwest corner of the building so as to significantly reduce the amount of direct heat gain during the summer, but not adversely effect direct heat gain during the winter.

Specific types of deciduous trees that are appropriate to the Riverside climate are:

Type	Maximum Height	Maximum Spread	Characteristics
Fruitless Mulberry	35'	25' - 30'	• large leaf
Eucalyptus	100' - 125'	50' - 60'	• rapid growing
Jacarunda	25' - 40'	15' - 30'	• fine textured foliage
Modesto Ash	50'	30'	• fine textured foliage • rapid growing
Sweet Gum	60'	20' - 25'	• moderate size foliage • moderate growth rate • excellent color

The policy should require approval of a shading plan and an elevation of the south wall showing shading at 8:00 AM, 1:00 PM, and 6:00 PM, based on the sun's path and resultant angles of direct sunlight on August 21, approximately 34° latitude North.

Physical Impact

It was assumed that the greatest impact of shading, particularly tree and shrub shading, relative to reducing space cooling energy demand would be made in new single-family detached, duplex, other low-rise multifamily units, and mobile homes, and to a limited degree in existing similar type units. The latter would be dependent upon the effectiveness of the proposed educational and incentive program.

Estimated Energy Savings*

To estimate the magnitude of energy savings by the year 2000 due to shading, based upon either a low- moderate- or high-impact strategy, the following distribution of new and existing single-family detached, duplex, other low-rise multifamily, and mobile home units was assumed:

Low Growth Rate	Low Impact
Single-Family Detached	- 100% of new units - 100% of 3600 existing units
Multifamily	
-duplex	- 100% of new units - 10% of 1100 existing units
- other low-rise	- 100% of new units - 90% of 1100 existing units
Mobile Homes	- 100% of new units - 100% of 300 existing units

* For detailed calculations, see Attachment C4-1.

Moderate Growth Rate

The same as for low growth rate except for the following:

	Low Impact
-duplex	- 7.5% of 1100 existing units
-other low-rise	- 92.5% of 1100 existing units

High Growth Rate

The same as for low growth rate except for the following:

- duplex	- 7% of 1100 existing units
- other low-rise	- 90% of 1100 existing units

	Moderate Impact
Low Growth Rate	
Single-Family Detached	- 100% of new units - 100% of 5400 existing units
Multifamily	
-duplex	- 100% of new units - 10% of 1650 existing buildings
-other low-rise	- 100% of new units - 90% of 1650 existing units
Mobile Homes	- 100% of new units - 100% of 450 existing units

Moderate Growth Rate

The same as for low growth rate above except for the following:

-duplex	- 7.5% of 1650 existing units
-other low-rise	- 92.5% of 1650 existing units

High Growth Rate

The same as for low growth rate except for the following:

-duplex	- 7% of 1650 existing units
-other low-rise	- 93% of 1650 existing units

Low Growth Rate	High Impact
Single-Family Detached	- 100% of new units - 100% of 7200 existing units
Multifamily	
-duplex	- 100% of new units - 10% of 2200 existing units
-other low-rise	- 100% of new units - 90% of 2200 existing units
Mobile Homes	- 100% of new units - 100% of 600 existing units

Moderate Growth Rate

The same as for low growth rate above except for the following:

-duplex	- 7.5% of 2200 existing units
-other low-rise	- 92.5% of 2200 existing units

High Growth Rate

The same as for low growth rate except for the following:

-duplex	- 7% of 2200 existing units
-other low-rise	- 93% of 2200 existing units

It was further assumed that in Riverside an individual unit's space cooling requirements could be reduced 40 to 80 percent due to shading. These reductions were based on research conducted by Victor Olgyay and reported in his book, Design with Climate.[11] Olgyay further reports that reduction in heat gain is dependent upon density, but even a sparse shade tree may be a better energy saver than an interior venetian blind. Based upon this assumption, the reduction in energy demand for space cooling was as follows:

Low Impact	40%
Moderate Impact	60%
High Impact	80%

Thus, the energy savings estimated for this option are:

	Low Impact
Low Growth Rate	$.1206 \times 10^{12}$ Btu's
Moderate Growth Rate	$.1865 \times 10^{12}$ Btu's
High Growth Rate	$.2764 \times 10^{12}$ Btu's

	Moderate Impact
Low Growth Rate	$.197 \times 10^{12}$ Btu's
Moderate Growth Rate	$.293 \times 10^{12}$ Btu's
High Growth Rate	$.416 \times 10^{12}$ Btu's

	High Impact
Low Growth Rate	$.280 \times 10^{12}$ Btu's
Moderate Growth Rate	$.393 \times 10^{12}$ Btu's
High Growth Rate	$.540 \times 10^{12}$ Btu's

Recommendation No. 5
Replace Existing Incandescent Street Lamps with High-Pressure Sodium

Scope

Action should be taken by the City to replace a majority of the existing incandescent street with high pressure sodium. Recent trial installations by the City indicates general acceptance of this type of lighting installation. Installation, maintenance and operating costs will approximate the cost of existing incandescent units; however, energy savings and improved lighting will benefit the City.

Physical Impact

There are currently 3550 incandescent street lights in Riverside. Approximately 3300 of these can be readily converted to 5800 lumen high pressure sodium units. Remaining units, primarily old style Raincross Standards, are not readily converted. The average maintained foot candles will be equal to or greater than the present incandescent systems. Although a smaller size HPS unit (3300 lumen) is now available, it is not felt that the lower lumen to watt ratio is attractive enough to justify its installation. Also it would result in much lower lighting levels when compared to existing lighting in the rest of the City.

Estimated Energy Savings*

The estimated annual energy savings for this option is .014666 x 10^{12} BTU's.

The estimated savings were assumed to be the same for all impact levels and growth rates. No variations in impact were assumed because the decision to replace is either "go or no go". Further, the degree of savings is not related to population growth.

Recommendation No. 6
Reduce Total Energy Consumed
By the Street Lighting System

Scope

Action should be taken by the City to reduce total energy consumed by the street lighting system by the year 2000. Currently, there are approximately 20,657 street lights operating in Riverside. These are distributed as follows:

Mercury vapor	- 18,196**
High Pressure Sodium	- 200
Incandescent	- 3,550
TOTAL	21,946
Turned off	- 1,289
	20,657

This equates to approximately 1 light per 8 persons in Riverside. As of February, 1978, the annual electric consumption for this street lighting system was 21,095, 196 KWH. This equates to approximately 2.8 KWH per day per light.

* For calculations, see Attachment C4-1
** 1289 mercury vapor lights have been turned off.

Physical Impact

This option may be implemented by:

(1) Replacing all street lamps with high pressure sodium except those lamps that have already been converted and the old style Raincross standards.

(2) Reducing lighting in locations essentially lit to enhance commercial areas

(3) Replacing street lamps with a lower level light output (lumens) on selected streets

(4) Removing selected lights in areas already lit by decorative lights

(5) Removal of lights on streets having a very low traffic volume.

Deactivation of alternate lamps was not recommended because of degradation of lights due to moisture accumulation and property tax inequities. Reduction of the hours of street lighting was not recommended either because of the cost of physical modification and the anticipated loss of security and safety during the time the lights are out of service.

Estimated Energy Savings*

The estimated energy savings for this option are:

	Low Impact
Low Growth Rate	$.066 \times 10^{12}$ Btu's
Moderate Growth Rate	$.038 \times 10^{12}$ Btu's
High Growth Rate	$.045 \times 10^{12}$ Btu's

	Moderate Impact
Low Growth Rate	$.066 \times 10^{12}$ Btu's
Moderate Growth Rate	$.076 \times 10^{12}$ Btu's
High Growth Rate	$.089 \times 10^{12}$ Btu's

* For detailed calculations, see Attachment C4-1.

	High Impact
Low Growth Rate	$.099 \times 10^{12}$ Btu's
Moderate Growth Rate	$.114 \times 10^{12}$ Btu's
High Growth Rate	$.134 \times 10^{12}$ Btu's

The above estimates are based on the following impacts:

Low impact - Reduce the energy usage of 25 percent of all street lights (except sodium lights) by one-half

Moderate impact - Reduce the energy usage of 50 percent of all street lights (except sodium lights) by one-half

High Impact - Reduce the energy usage of 75 percent of all street lights (except sodium lights) by one-half.

The level of savings is also based on continuing the ratio of 1 light per 8 persons, which indicates a need for the following additional lights based on different levels of population growth.

Low growth - 4910 new lights
Moderate growth - 8751 new lights
High growth - 13747 new lights

ATTACHMENT C4-1

PRIMARY OUTCOME (ENERGY SAVINGS) OF COMMUNITY DESIGN-RELATED ENERGY CONSERVATION OPTIONS

C4. PRIMARY OUTCOME (ENERGY SAVINGS) OF COMMUNITY DESIGN - RELATED ENERGY CONSERVATION OPTIONS

(1) 1976 Housing Inventory

Single-Family detached (SFD)	45,200 (75.6%)
Multifamily (MF)	12,400 (20.7%)
Mobile Homes (MH)	2,200 (3.7%)
	59,800 (100.0%)

(2) Population Change

Scenario	Year 2000 Population	Population	Change Δ
Low	202,276	163,000	+ 39,276
Moderate	233,009	163,000	+ 70,009
High	272,973	163,000	+109,973

(3) New Dwelling Units (DU's): 1976-2000, 2.8 Persons/Dewlling Unit

Low 39,276 ÷ 2.8 = 14,027 DU's
Moderate 70,009 ÷ 2.8 = 25,003 DU's
High 109,973 ÷ 2.8 = 39,276 DU's

(4) Distribution of New Dwelling Units

(a) Assumption: Year 2000 distribution same as for 1976
(b) Calculation of projected dwelling units, by type

Low	14,027	(75.6%) =	10,604 SFD
		(20.7%) =	2,904 MF
		(3.7%) =	519 MH
Moderate	25,003	(75.6%) =	18,902 SFD
		(20.7%) =	5,176 MF
		(3.7%) =	925 MH
High	39,276	(75.6%) =	29,693 SFD
		(20.7%) =	8,130 MF
		(3.7%) =	1,453 MH

(c) Projected Inventory (to Year 2000)

	SFD			MF			MH		
	.9	1.55	2.17	.9	1.55	2.17	.9	1.55	2.17
April 1, 1976 Inventory	45,200	45,200	45,200	12,400	12,400	12,400	2,200	2,200	2,200
New DU's Added	10,604	18,902	29,693	2,904	5,176	8,130	519	925	1,453
April 1, 2000 Inventory	55,804	64,102	74,893	15.304	17,576	20,530	2,719	3,125	3,653

<u>(5) Energy Demand/Per Dwelling Unit: 1976</u>

SFD Space heating 6,500 x 2,904 = 18.88 x 10^6 Btu's/yr
Other thermal 4,600 x 8,760 = 40.30x 10^6 Btu's/yr
Space cooling 0.43 x 4,416 = 1899 kwh/yr
1899 (10,200) = 19.37 x 10^6 Btu's/yr
Other electrical .50 x 8,760 = 4,380 kwh/yr
4,380 (10,200) = 44.68 x 10^6 Btu's/yr
TOTAL = 123.23 x 10^6 Btu's/yr

MF Space heating 4,600 x 2,904 = 13.36 x 10^6 Btu's/yr
Other thermal 4,600 x 8,760 = 40.30 x 10^6 Btu's/yr
Space cooling 0.30 x 4,416 = 1,325 kwh/yr
1,325 (10,200) = = 13.51 x 10^6 Btu's/yr
Other electrical 0.50 x 8,760 = 4,380 kwh/yr
4,380 (10,200) = = 44.68 x 10^6 Btu's/yr
TOTAL = 111.85 x 10^6 Btu's/yr

MH Space heating 4,000 x 2,904 = 11.62 x 10^6 Btu's/yr
Other thermal 4,600 x 8,760 = 40.30 x 10^6 Btu's/yr
Space cooling 0.27 x 4,416 = 1192 kwh/yr
1192 (10,200) = = 12.16 x 10^6 Btu's/yr
Other electrical 0.50 x 8,760 = 4,380 kwh/yr
4,380 (10,200) = = 44.68 x 10^6 Btu's/yr
TOTAL = 108.76 x 10^6 Btu's/yr

Recommendation No. 1: Develop and Implement a Land Use Policy to Modify the Existing Housing Mix

(a) Proposed Housing Mix, New Units Only: Year 2000

Low Impact

Low Growth Rate (.9)

	TOTAL	SFD	MF	MH
Business as usual	14,027	10,604	2,904	519
Low Impact (10% x SFD)	14,027	9,544	3,964	519
Change	0	1,060	1,060	0

Moderate Growth Rate (1.55)

	TOTAL	SFD	MF	MH
Business as usual	24,003	18,902	5,176	925
Low Impact (10% x SFD)	25,003	17,012	7,066	925
Change	0	1,890	1,890	0

High Growth Rate (2.17)

	TOTAL	SFD	MF	MH
Business as usual	39,276	29,693	8,130	1,453
Low Impact (10% x SFD)	39,276	26,724	11,099	1,453
Change	0	2,969	2,969	0

Moderate Impact

Low Growth Rate (.9)

	TOTAL	SFD	MF	MH
Business as usual	14,027	10,604	2,904	519
Moderate Impact (30% x SFD)	14,027	7,423	6,085	519
Change	0	3,181	3,181	0

Moderate Growth Rate (1.55)

	TOTAL	SFD	MF	MH
Business as usual	25,003	18,902	5,176	925
Moderate Impact (30% x SFD)	25,003	13,231	10,847	925
Change	0	5,671	5,671	0

High Growth Rate (2.17)

	TOTAL	SFD	MF	MH
Business as usual	39,276	29,693	8,130	1,453
Moderate Impact (30% x SFD)	39,276	20,785	17,038	1,453
Change	0	8,908	8,908	0

High Impact

Low Growth Rate (.9)

	TOTAL	SFD	MF	MH
Business as usual	14,027	10,604	2,904	519
High Impact (50% x SFD)	14,027	5,302	8,206	519
Change	0	5,302	5,302	0

Moderate Growth Rate (1.55)

	TOTAL	SFD	MF	MH
Business as usual	25,003	18,902	5,176	925
High Impact (50%)x SFD)	25,003	9,451	14,627	925
Change	0	9,451	9,451	0

High Growth Rate (2.17)

	TOTAL	SFD	MF	MH
Business as usual	39,276	29,693	8,130	1453
High Impact(50%xSFD)	39,276	14,847	22,976	1453
Change	0	14,846	14,846	0

(b) Energy Demand Production: By DU Type*

SFA reduction over SFD=18%***
MFLR reduction over SFD=30%**
MFHR reduction over SFD=45%***

Reduction in Space Heating & Cooling
Energy Consumption: By DU Type

SFA $(.123 \times 10^9)(.18)(.40) = .0089 \times 10^9$ Btu's
MFLR$(.123 \times 10^9)(.30)(.40) = .0148 \times 10^9$ Btu's
MFHR$(.123 \times 10^9)(.45)(.40) = .0221 \times 10^9$ Btu's

---

* Dwelling unit type: single-family attached (SFA), multifamily low-rise (MFLR), multifamily high-rise (MFHR).
** Determined from Battelle energy audit in Riverside
*** Battelle estimate derived from energy audit.

Estimated Energy Savings
(Year 2000)

Low Impact

Growth Rate	Total Units	Total Btu's
Low	1,060 (45%) = 477 (SFA) x (.0089 $\times 10^9$) =	.004 x 10^{12}
	(45%) = 477 (MFLR)x (.0148 $\times 10^9$) =	.007 x 10^{12}
	(10%) = 106 (MFHR)x (.0221 $\times 10^9$) =	.002 x 10^{12}
		.013 x 10^{12}
Moderate	1,890 (45%) = 851 (SFA) x (.0089 $\times 10^9$) =	.008 x 10^{12}
	(45%) = 851 (MFLR)x (.0148 $\times 10^9$) =	.013 x 10^{12}
	(10%) = 188 (MFHR)x (.0221 $\times 10^9$) =	.004 x 10^{12}
		.025 x 10^{12}
High	2,969 (45%) =1336 (SFA) x (.0089 $\times 10^9$) =	.012 x 10^{12}
	(45%) =1336 (MFLR)x (.0148 $\times 10^9$) =	.020 x 10^{12}
	(10%) = 297 (MFHR)x (.0221 $\times 10^9$) =	.007 x 10^{12}
		.039 x 10^{12}

Moderate Impact

Growth Rate	Total Units	
Low	3,181 (40%) = 1272 (SFA) x(.0089 x 10^9) =	.011 x 10^{12}
	(40%) = 1272 (MFLR)x(.0148 x 10^9) =	.019 x 10^{12}
	(20%) = 637 (MFHR)x(.0221 x 10^9) =	.014 x 10^{12}
		.044 x 10^{12}
Moderate	5,671 (40%) = 2268 (SFA) x(.0089 x 10^9) =	.020 x 10^{12}
	(40%) = 2268 (MFLR)x(.0148 x 10^9) =	.034 x 10^{12}
	(20%) = 1135 (MFHR)x(.0221 x 10^9) =	.025 x 10^{12}
		.079 x 10^{12}
High	8,908 (40%) = 3563 (SFA) x(.0089 x 10^9) =	.032 x 10^{12}
	(40%) = 3563(MFLR) x(.0148 x 10^9) =	.053 x 10^{12}
	(20%) = 1782(MFHR) x(.0221 x 10^9) =	.039 x 10^{12}
		.124 x 10^{12}

High Impact

Growth Rate	Total Units		
Low	5,302	(35%) = 1856 (SFA) x (.0089 x 10^9) =	.017 x 10^{12}
		(35%) = 1856(MFLR) x (.0148 x 10^9) =	.028 x 10^{12}
		(30%) = 1590(MFHR) x (.0221 x 10^9) =	.035 x 10^{12}
			.080 x 10^{12}
Moderate	9,451	(35%) = 3308 (SFA) x (.0089 x 10^9) =	.030 x 10^{12}
		(35%) = 3308(MFLR) x (.0148 x 10^9) =	.049 x 10^{12}
		(30%) = 2835(MFHR) x (.0221 x 10^9) =	.063 x 10^{12}
			.142 x 10^{12}
High	14,847	(35%) = 5196 (SFA) x (.0089 x 10^9) =	.046 x 10^{12}
		(35%) = 5196(MFLR) x (.0148 x 10^9) =	.077 x 10^{12}
		(30%) = 4455(MFHR) x (.0221 x 10^9) =	.099 x 10^{12}
			.222 x 10^{12}

Recommendation No. 2: Develop and Implement a Land Use Policy Requiring Energy-Efficient Neighborhood Development

(a) Assumptions

(1) All new dwelling units constructed between 1976 and 2000 go into planned neighborhood development.

(2) Referencing the "Costs of Sprawl" report, the estimated housing mix in Riverside in 2000 most closely represents Community Development Pattern 11 (combination mix 50 percent PUD, 50 percent sprawl). But by the year 2000 it is estimated that only 25 percent of the units in Riverside, or, approximately one-half those in the study, will be in PUD's. With the report showing 25 percent savings, the savings for Riverside are estimated to be 12.5 percent. These savings will be reduced in transportation

(3) There are 1.5 drivers per dwelling unit.*

(4) Gasoline consumption is 12.14 miles per gallon.[20]

---

* Based on data collected by Battelle for this study.

(5) A southern California resident drives a primary vehicle in excess of 25 miles/day. Twenty-five percent of vehicles are driven 50/ miles/day.*

(6) Because of potential institutional constraints, this option is expected to apply only to the high impact strategy.

---

* Appendix C3, Transportation

High Impact (only)

Low Growth Rate (.9)

- 14,027 total new dwelling units (year 2000)
- 1.5 drivers/DU
- 21,040 additional drivers
- 21,040 (.75)(25)(365) = 143.99 million miles
- 21,040 (.25)(50)(365) = 95.99 " "

  239.98 " "
- 239.98 x 10^6 ÷ 12.14 = 19.77 x 10^6 gal.
- 19.77 x 10^6 (130,000) = 2.57 x 10^{12} Btu's
- 2.57 x 10^{12} (.125) = .321 x 10^{12} Btu's saved

Moderate Growth Rate (1.55)

- 25,000 total new dwelling units (year 2000)
- 1.5 drivers/DU
- 25,003 (1.5) = 37,505 additional drivers
- 37,505 (.75)(25)(365) = 256.68 million miles
- 37,505 (.25)(50)(365) = 171.12 " "

  427.98 " "
- 427,8 x 10^6 ÷ 12.14 = 35.24 x 10^6 gal.
- 35.24 x 10^6 (130,000) = 4.58 x 10^{12} Btu's
- 4.58 x 10^{12} (.125) = .573 x 10^{12} Btu's saved

High Growth Rate (2.17)

- 39,276 total new dwelling units (year 2000)
- 1.5 drivers/DU
- 39,276 x 1.5 = 58,914 additional drivers
- 58,914 (.75)(25)(365) = 403.19 million miles
- 58,914 (.25)(50)(365) = 268.80 " "

  671.99 " "
- 671.99 x 10^6 ÷ 12.14 = 55.35 x 10^6 gal.
- 55.35 x 10^6 (130,000) = 7.20 x 10^{12} Btu's
- 7.2 x 10^{12} (.125) = .900 x 10^{12} Btu's saved

Recommendation No. 3: Passive Solar Residential Design

(a) 1976 Housing Inventory: See Recommendation No.1

(b) Projected Inventory: See Recommendation No.1

(c) 1976 Residential Energy Consumption(annual)
See Recommendation No.1

(d) Assumption: Passive design applies only to new single-family detached and duplex units

(e) Estimated Distribution of New Dwelling units: Year 2000

Impact	Growth Rate	Dwelling Unit Type	New Units
Low	Low		14,027
		Detached	9,544
		Multifamily	3,964
		Mobile Homes	519
	Moderate		25,003
		Detached	17,012
		Multifamily	7,066
		Mobile Homes	925
	High		39,276
		Detached	26,724
		Multifamily	11,099
		Mobile Homes	1,453
Moderate	Low		14,027
		Detached	7,423
		Multifamily	6,085
		Mobile Homes	519
	Moderate		25,003
		Detached	13,231
		Multifamily	10,847
		Mobile Homes	925
	High		39,276
		Detached	20,785
		Multifamily	17,038
		Mobile Homes	1,453

Impact	Growth Rate	Dwelling Unit Type	New Units
High	Low		14,027
		Detached	5,302
		Multifamily	8,206
		Mobile Homes	519
	Moderate		25,003
		Detached	9,451
		Multifamily	14,627
		Mobile Homes	925
	High		39,276
		Detached	14,847
		Multifamily	22,976
		Mobile Homes	1,453

(f) Distribution of New Multifamily Dwelling Units: Year 2000

	Due to Business as Usual*	Due to Housing Mix Change		
		Low	Moderate	High
Duplex	15.5%	45%	40%	35%
Low Rise	73.0%	45%	40%	35%
High Rise	11.5%	10%	20%	30%

Low Impact

Low Growth Rate	2904	1060	3964
Duplex	450	477	927
Low Rise	2120	477	2597
High Rise	334	106	440
Moderate Growth Rate	5176	1890	7066
Duplex	802	851	1653
Low Rise	3779	851	4630
High Rise	595	188	783
High Growth Rate	8130	2969	11,099
Duplex	1260	1336	2596
Low Rise	5935	1336	7271
High Rise	935	297	1232

* Same as 1976.

Moderate Impact

Low Growth Rate	2904	3181	6085
Duplex	450	1272	1722
Low Rise	2120	1272	3392
High Rise	334	637	971
Moderate Growth Rate	5156	5671	10,847
Duplex	802	2268	3070
Low Rise	3779	2268	6047
High Rise	595	1135	1730
High Growth Rate	8130	8908	17,038
Duplex	450	1856	2306
Low Rise	2120	1856	3976
High Rise	935	1782	2717

High Impact

Low Growth Rate	2904	5302	8206
Duplex	450	1856	2306
Low Rise	2120	1856	3976
High Rise	334	1590	1924
Moderate Growth Rate	5176	9451	14,627
Duplex	802	3308	4110
Low Rise	3779	3308	7087
High Rise	595	2835	3430
High Growth Rate	8130	14,847	22,977
Duplex	1260	5196	6456
Low Rise	5935	5196	11131
High Rise	935	4455	5390

(g) Estimated Distribution of Dwelling Units Available for Passive Design Application by Various Impacts and Growth Rates

	Low Impact	
	SFD	SFA
Low Growth Rate	9,544	927
Moderate Growth Rate	17,012	1,653
High Growth Rate	26,724	2,596

	Moderate Impact	
	SFD	SFA
Low Growth Rate	7,423	1,722
Moderate Growth Rate	13,231	3,070
High Growth Rate	20,785	4,823

	High Impact	
	SFD	SFA
Low Growth Rate	5,302	2,306
Moderate Growth Rate	9,451	4,110
High Growth Rate	14,846	6,456

(h) Estimated Distribution of Passively Designed Dwelling Units: Year 2000

Low Impact

Growth Rate	SFD	% Passive	# Passive Units	SFA	% Passive	# Passive Units
Low	9,544	20%	1,909	927	10%	93
Moderate	17,012	20%	3,402	1,653	10%	165
High	26,724	20%	5,345	2,596	10%	260

Moderate Impact

Growth Rate	SFD	% Passive	# Passive Units	SFA	% Passive	# Passive Units
Low	7,423	40%	2,969	1,722	20%	344
Moderate	13,231	40%	5,292	3,070	20%	614
High	20,785	40%	8,314	4,823	20%	965

High Impact

Growth Rate	SFD	%Passive	# Passive Units	SFA	%Passive	# Passive Units
Low	5,302	60%	3,181	2,306	30%	692
Moderate	9,451	60%	5,671	4,110	30%	1,233
High	14,846	60%	8,908	6,456	30%	1,937

Reduction in Space and Hot Water Energy Demand

SFD $(.123 \times 10^9)(.575) = .071 \times 10^9$ Btu's

SFA $(.123 \times 10^9)(.575) - [.123 \times 10^9(.575)(.18)] = .058 \times 10^9$

Estimated Energy Savings

Low Impact

Growth Rate	Dwelling Unit Type	No. of DU's	Savings Due to Passive Design	Energy Savings	Total Energy Savings
Low	SFD	1909	$(.071 \times 10^9) =$	$.136 \times 10^{12}$	$= .141 \times 10^{12}$ Btu's
	SFA	93	$(.058 \times 10^9) =$	$.005 \times 10^{12}$	
Moderate	SFD	3402	$(.071 \times 10^9) =$	$.242 \times 10^{12}$	$= .252 \times 10^{12}$ Btu's
	SFA	165	$(.058 \times 10^9) =$	$.010 \times 10^{12}$	
High	SFD	5345	$(.071 \times 10^9) =$	$.380 \times 10^{12}$	$= .395 \times 10^{12}$ Btu's
	SFA	260	$(.058 \times 10^9) =$	$.015 \times 10^{12}$	

Moderate Impact

Growth Rate	Dwelling Unit Type	No. of DU's	Savings Due to Passive Design	Energy Savings	Total Energy Savings
Low	SFD	2969	$(.071 \times 10^9) =$	$.211 \times 10^{12}$	$= .231 \times 10^{12}$ Btu's
	SFA	344	$(.058 \times 10^9) =$	$.020 \times 10^{12}$	
Moderate	SFD	5292	$(.071 \times 10^9) =$	$.376 \times 10^{12}$	$= .412 \times 10^{12}$ Btu's
	SFA	614	$(.058 \times 10^9) =$	$.036 \times 10^{12}$	
High	SFD	8314	$(.071 \times 10^9) =$	$.590 \times 10^{12}$	$= .646 \times 10^{12}$ Btu's
	SFA	965	$(.058 \times 10^9) =$	$.056 \times 10^{12}$	

High Impact

Growth Rate	Dwelling Unit Type	No. of DU's	Savings Due to Passive Design	Energy Savings	Total Energy Savings
Low	SFD	3181	$(.071 \times 10^9) =$	$.226 \times 10^{12}$	$= .266 \times 10^{12}$ Btu's
	SFA	692	$(.058 \times 10^9) =$	$.040 \times 10^{12}$	
Moderate	SFD	5671	$(.071 \times 10^9) =$	$.403 \times 10^{12}$	$= .475 \times 10^{12}$ Btu's
	SFA	1233	$(.072 \times 10^9) =$	$.072 \times 10^{12}$	
High	SFD	8908	$(.071 \times 10^9) =$	$.633 \times 10^{12}$	$= .745 \times 10^{12}$ Btu's
	SFA	1937	$(.058 \times 10^9) =$	$.112 \times 10^{12}$	

Recommendation No.4: Require Shading of South-Walls of New Dwelling Units and Encourage Shading of Existing Dwelling Units

(a) Assumptions

(1) Applies to new and existing dwelling units where shading can affect the entire south wall and a portion of the roof

(2) Energy consumption for cooling an individual DU (average)

SF = .019 x 10^9 Btu/year
MF = .014 x 10^9 Btu/year
MH = .012 x 10^9 Btu/year

(3) Tree shading reduces heat gain by 40 to 80 percent. Source: "Design With Climate": Victor Olgyay.

	SFD	MF
Low	40%	20%
Mod	60%	40%
High	80%	60%

---

* Annual cooling requirements
SF = .43 x 4416 = 1899 kwh** = .019 x 10^9 Btu/year
MF = .30 x 4416 = 1325 kwh** = .014 x 10^9 Btu/year
MH = .27 x 4416 = 1192 kwh** = .012 x 10^9 Btu/year

** One kwh = 10,200 Btu's

(4) Owners of existing dwelling units are to be encouraged to shade unshaded south walls through an educational program.

(b) Distribution of DU's and Estimated Energy Savings: Year 2000

Low Growth Rate (.9)

Low Impact

SFD	New	9,544	(100%) =	9,544	$(.019 \times 10^9)(.4)$	= $.073 \times 10^{12}$ Btu's
	Exist	3,600	(100%) =	3,600	$(.019 \times 10^9)(.4)$	= $.027 \times 10^{12}$ Btu's
MF	New	3,964*		927 SFA	$(.014 \times 10^9)(.4)$	= $.005 \times 10^{12}$ Btu's
				2,597 LR	$(.014 \times 10^9)(.2)$	= $.007 \times 10^{12}$ Btu's
	Exist.	1,100	(10%) =	110 SFA	$(.014 \times 10^9)(.4)$	= $.006 \times 10^{12}$ Btu's
			(90%) =	990 LR	$(.014 \times 10^9)(.2)$	= $.003 \times 10^{12}$ Btu's
MH	New	519	(100%) =	519	$(.012 \times 10^9)(.4)$	= $.003 \times 10^{12}$ Btu's
	Exist.	300	(100%) =	300	$(.012 \times 10^9)(.4)$	= $.002 \times 10^{12}$ Btu's

Moderate Growth Rate (1.55)

Low Impact

SFD	New	17,012	(100%)=	17,012	$(.019 \times 10^9)(.4)$	= $.129 \times 10^{12}$ Btu's
	Exist.	3,600	(100%)=	3,600	$(.019 \times 10^9)(.4)$	= $.027 \times 10^{12}$ Btu's
MF	New	7,066*		1,653	$(.014 \times 10^9)(.4)$	= $.009 \times 10^{12}$ Btu's
				4,630	$(.014 \times 10^9)(.2)$	= $.013 \times 10^{12}$ Btu's
	Exist.	1,100	(7.5%)=	83	$(.014 \times 10^9)(.4)$	=$.0005 \times 10^{12}$ Btu's
			(92.5%)=	1,017	$(.014 \times 10^9)(.2)$	= $.003 \times 10^{12}$ Btu's
MH	New	925	(100%)=	925	$(.012 \times 10^9)(.4)$	= $.004 \times 10^{12}$ Btu's
	Exist.	300	(100%)=	300	$(.012 \times 10^9)(.4)$	= $.001 \times 10^{12}$ Btu's
						$.1865 \times 10^{12}$ Btu's

* See Recommendation No. 3, paragraph (f).

High Growth Rate (2.17)

Low Impact

SFD	New	26,724 (100%)	= 26,724 (.019 x 10^9)(.4)	= .203 x 10^{12} Btu's
	Exist.	3,600 (100%)	= 3,600 (.019 x 10^9)(.4)	= .027 x 10^{12} Btu's
MF	New	11,099*	2,596 SFA(.014 x 10^9)(.4)	= .015 x 10^{12} Btu's
			7,271 LR(.014 x 10^9)(.2)	= .020 x 10^{12} Btu's
	Exist.	1,100 (7%)	= 77 SFA(.014 x 10^9)(.4)	=.0004 x 10^{12} Btu's
		(93%)	= 1,023 LR(.014 x 10^9)(.2)	= .003 x 10^{12} Btu's
MH	New	1,453 (100%)	= 1,453 (.012 x 10^9)(.4)	= .007 x 10^{12} Btu's
	Exist.	300 (100%)	= 300 (.012 x 10^9)(.4)	= .001 x 10^{12} Btu's
				.2764 x 10^{12} Btu's

Low Growth Rate (.9)

Moderate Impact

SFD	New	7,423 (100%)	= 7,423 (.019 x 10^9)(.6)	= .085 x 10^{12} Btu's
	Exist.	5,400 (100%)	= 5,400 (.019 x 10^9)(.6)	= .062 x 10^{12} Btu's
MF	New	6,085*	= 1,722 (.014 x 10^9)(.6)	= .015 x 10^{12} Btu's
			= 3,392 (.014 x 10^9)(.4)	= .019 x 10^{12} Btu's
	Exist.	1,650 (10%)	= 165 SFA(.014 x 10^9)(.6)	= .001 x 10^{12} Btu's
		(90%)	= 1485 LR(.014 x 10^9)(.4)	= .008 x 10^{12} Btu's
MH	New	519 (100%)	= 519 (.012 x 10^9)(.6)	= .004 x 10^{12} Btu's
	Exist.	450 (100%)	= 459 (.012 x 10^9)(.6)	= .003 x 10^{12} Btu's
				.197 x 10^{12} Btu's

* See Recommendation No. 3, paragraph (f).

Moderate Growth Rate (1.55)

Moderate Impact

SFD	New	13,231 (100%)	= 13,231	$(.019 \times 10^9)(.6)$	= .151	$\times 10^{12}$ Btu's
	Exist.	5,400 (100%)	= 5,400	$(.019 \times 10^9)(.6)$	= .062	$\times 10^{12}$ Btu's
MF	New	10,847*	= 3,070	$(.014 \times 10^9)(.6)$	= .026	$\times 10^{12}$ Btu's
			6,047	$(.014 \times 10^9)(.4)$	= .034	$\times 10^{12}$ Btu's
	Exist.	1,650 (7.5%)	= 124	$(.014 \times 10^9)(.6)$	= .001	$\times 10^{12}$ Btu's
		(92.5%)	= 1,526	$(.014 \times 10^9)(.4)$	= .009	$\times 10^{12}$ Btu's
MH	New	925 (100%)	= 925	$(.012 \times 10^9)(.6)$	= .007	$\times 10^{12}$ Btu's
	Exist.	450 (100%)	= 450	$(.012 \times 10^9)(.6)$	= .003	$\times 10^{12}$ Btu's
					.293	$\times 10^{12}$ Btu's

Low Growth Rate (.9)

High Impact(.8)

SFD	New	5,302 (100%)	= 5,302	$(.019 \times 10^9)(.8)$	= .081	$\times 10^{12}$ Btu's
	Exist.	7,200 (100%)	= 7,200	$(.019 \times 10^9)(.8)$	= .109	$\times 10^{12}$ Btu's
MF	New	8,206*	= 2,306 SFA	$(.014 \times 10^9)(.8)$	= .026	$\times 10^{12}$ Btu's
			= 3,976 LR	$(.014 \times 10^9)(.6)$	= .033	$\times 10^{12}$ Btu's
	Exist	2,200 (10%)	= 220 SFA	$(.014 \times 10^9)(.8)$	= .003	$\times 10^{12}$ Btu's
		(90%)	= 1,980 LR	$(.014 \times 10^9)(.6)$	= .017	$\times 10^{12}$ Btu's
MH	New	519 (100%)	= 519	$(.012 \times 10^9)(.8)$	= .005	$\times 10^{12}$ Btu's
	Exist.	600 (100%)	= 600	$(.012 \times 10^9)$ .8)	= .006	$\times 10^{12}$ Btu's
					.280	$\times 10^{12}$ Btu's

* See Recommendation No. 3, paragraph (f).

Moderate Growth Rate (1.55)

High Impact

SFD	New	9,451	(100%) = 9,451	$(.019 \times 10^9)(.8)$	=	$.144 \times 10^{12}$ Btu's
	Exist.	7,200	(100%) = 7,200	$(.019 \times 10^9)(.8)$	=	$.109 \times 10^{12}$ Btu's
MF	New	14,627*	4,110	$(.014 \times 10^9)(.8)$	=	$.046 \times 10^{12}$ Btu's
			7,087	$(.014 \times 10^9)(.6)$	=	$.060 \times 10^{12}$ Btu's
	Exist.	2,200	(7.5%) = 165 SFA	$(.014 \times 10^9)(.8)$	=	$.002 \times 10^{12}$ Btu's
			(92.5%) = 2,035 LR	$(.014 \times 10^9)(.6)$	=	$.017 \times 10^{12}$ Btu's
MH	New	925	(100%) = 925	$(.012 \times 10^9)(.8)$	=	$.009 \times 10^{12}$ Btu's
	Exist.	600	(100%) = 600	$(.012 \times 10^9)(.8)$	=	$.006 \times 10^{12}$ Btu's
						$.393 \times 10^{12}$ Btu's

High Growth Rate (2.17)

High Impact

SFD	New	14,847	(100%) = 14,847	$(.019 \times 10^9)(.8)$	=	$.226 \times 10^{12}$ Btu's
	Exist.	7,200	(100%) = 7,200	$(.019 \times 10^9)(.8)$	=	$.109 \times 10^{12}$ Btu's
MF	New	22,977*	6,456 SFA	$(.014 \times 10^9)(.8)$	=	$.072 \times 10^{12}$ Btu's
			11,131 LR	$(.014 \times 10^9)(.6)$	=	$.094 \times 10^{12}$ Btu's
	Exist.	2,200	(7%) =154 SFA	$(.014 \times 10^9)(.8)$	=	$.002 \times 10^{12}$ Btu's
			(93%) = 2,046 LR	$(.014 \times 10^9)(.6)$	=	$.017 \times 10^{12}$ Btu's
MH	New	1,453	(100%) = 1,453	$(.012 \times 10^9)(.8)$	=	$.014 \times 10^{12}$ Btu's
	Exist.	600	(100%) = 600	$(.012 \times 10^9)(.8)$	=	$.006 \times 10^{12}$ Btu's
						$.540 \times 10^{12}$ Btu's

---

* See Recommendation No. 3, paragraph (f).

Recommendation No. 5: Convert Majority of Remaining Incandescent Street Lamps to High-Pressure Sodium

(a) Current Status:
- 3,550 incandescent street lights
- 2.8 kwh/day/light*

(b) Assumption: Convert 3300, 2500 lumen, 200 watt incandescent street lights to 5800 lumen, 70 watt (95 watt including ballast) high pressure sodium luminaires.

(c) Energy Savings

$$\text{Annual Kilowatt Hours} = \frac{\text{No. units x watts/unit x burning hours per year}}{1000}$$

$$\text{Annual KWH year for 2500 lumin incandescent} = \frac{3300 \times 200 \times 4148}{1000} = 2,737,680$$

$$\text{Annual KWH year for 5800 lumen HPS} = \frac{3300 \times 95 \times 4148}{1000} = 1,300,398$$

Annual KWH Savings = 1,437,282

Annual BTU's/Year Savings =

$1,437,282 \times 10,200 = .014666 \times 10^{12}$

Recommendation No.6: Reduce Energy Consumption in Street Lighting System

(a) Current Status

- 20,657 operating street lights in Riverside(21)
  - 16,907 Mercury Vapor
  - 3,550 Incandescent
  - 200 High-Pressure Sodium
  - 1,289 Mercury Vapor Lights turned off
- 21,095, 196 kwh consumed by the street lighting system from February, 1977 to February, 1978, therefore, 2.8 kwh/day/light.
- With 163,000 and 20,667 street lights operating, there is one light per eight persons in Riverside.**

$$* \frac{\text{21,095,196 kwh/yr.}}{\text{365 days x 20,657 street lights}} = \text{2.8 kwh/day/light}$$

** Determined by dividing existing population (163,000) by the number of existing street lights. The US average is 1 light per 20 persons.

(b) Assumption

- Reduce energy usage as follows:

Low--reduce the energy usage of 25 percent of all street lights (except sodium lights) by one-half

Moderate--reduce the energy usage of 50 percent street lights (except sodium lights) by one-half

High--reduce the energy usage of 75 percent of all street lights (except sodium lights) by one-half.

(c) Estimation of the Number of New Lights Required by Year 2000

	Additional Population		Lights Per Person		New Lights Required
Low Growth	39,276	÷	8	=	4910
Moderate Growth	70,009	÷	8	=	8751
High Growth	109,973	÷	8	=	13747

(d) Determination of Total Number Lights by Year 2000

	Low Growth	Moderate Growth	High Growth
Mercury Vapor	16,907	16,907	16,907
Incandescent	3,550	3,550	3,550
High Pressure Sodium	200	200	200
New Lights	4,910	8,751	13,747
	25,567	29,408	34,404
Less Sodium Lights*	200	200	200
	25,367	29,208	34,204

* See (b) above

Estimate of Energy Savings: Year 2000

Low Impact

Low Growth

$25,367\ (.25)(2.8)(365) = 6.48 \times 10^6$ kwh/year

$6.48 \times 10^6\ (10,200) = .066 \times 10^{12}$ Btu'syear

$.066 \times 10^{12}(.5) = .033 \times 10^{12}$ Btu's/year

Moderate Growth

$29,208\ (.25)(2.8)(365) = 7.46 \times 10^6$ kwh/year

$7.46 \times 10^6(10,200) - .076 \times 10^{12}$ Btu's/year

$.076 \times 10^{12}(.5) = .038 \times 10^{12}$ Btu's/year

High Growth

$34,204(.25)(2.8)(365) = 8.74 \times 10^6$ kwh/year

$8.74 \times 10^6(10,200) = .089 \times 10^{12}$ Btu's/year

$.089 \times 10^{12}(.5) = 1045 \times 10^{12}$ Btu's/year

Moderate Impact

Low Growth

$25,367(.5)(2.8)(365) = 12.96 \times 10^6$ kwh/year

$12.96 \times 10^6(10,200) =.132 \times 10^{12}$ Btu's/year

$.132 \times 10^{12}(.5) = .066 \times 10^{12}$ Btu's/year

Moderate Growth

$29,208(.5)(2.8)(365) = 14.93 \times 10^6$ kwh/year

$14.93 \times 10^6(10,200) = .152 \times 10^{12}$ Btu's/year

$.152 \times 10^{12}(.5) = .076 \times 10^{12}$ Btu's/year

High Growth

$34,204(.5)(218)(365) = 17.48 \times 10^6$ kwh/year

$17.48 \times 10^6\ (10,200) = .178 \times 10^{12}$ Btu's/year

$.178 \times 10^{12}\ (.5) = .089 \times 10^{12}$ Btu's/year

High Impact

Low Growth

$25{,}367(.75)(2.8)(365) = 19.44 \times 10^{6}$ kwh/year

19.44×10^{6} (10,200) - $.198 \times 10^{12}$ Btu's/year

$.198 \times 10^{12}$ (.5) = $.99 \times 10^{12}$ Btu's/year

Moderate Growth

$29{,}208\ (.75)(2.8)(365) = 22.39 \times 10^{6}$ kwh/year

$22.39 \times 10^{6}(10{,}200) = .228 \times 10^{12}$ Btu's/year

$.228 \times 10^{12}(.5) = .114 \times 10^{12}$ Btu's/year

High Growth

$34{,}204\ (.75)(2.8)(365) = 26.22 \times 10^{6}$ kwh/year

$26.22 \times 10^{6}\ (10{,}200) = .267 \times 10^{12}$ Btu's/year

$.267 \times 10^{12}(.5) = .134 \times 10^{12}$ Btu's/year

Impact on Energy Savings	Population Growth Rate	(1) Modify Housing Mix (NEW DU's ONLY)	(2) Energy Efficient Neighborhood Development (NEW DU's ONLY)	(3) Passive Residential Design (NEW DU's ONLY)	(4) Shading South Walls Residential Units (NEW AND EXISTING	(5) Convert Incandescent Street Lamps to Mercury Vapor	(6) Reduce Energy Consumption of Street Lamps (NEW & EXIST)	Total Energy Savings
Low	Low	$.013 \times 10^{12}$	--	$.141 \times 10^{12}$	$.121 \times 10^{12}$	$.015 \times 10^{12}$	$.033 \times 10^{12}$	$.327 \times 10^{12}$
	Moderate	$.025 \times 10^{12}$	--	$.252 \times 10^{12}$	$.187 \times 10^{12}$	$.015 \times 10^{12}$	$.038 \times 10^{12}$	$.521 \times 10^{12}$
	High	$.039 \times 10^{12}$	--	$.395 \times 10^{12}$	$.276 \times 10^{12}$	$.015 \times 10^{12}$	$.045 \times 10^{12}$	$.774 \times 10^{12}$
Moderate	Low	$.044 \times 10^{12}$	--	$.231 \times 10^{12}$	$.197 \times 10^{12}$	$.015 \times 10^{12}$	$.066 \times 10^{12}$	$.557 \times 10^{12}$
	Moderate	$.079 \times 10^{12}$	--	$.412 \times 10^{12}$	$.293 \times 10^{12}$	$.015 \times 10^{12}$	$.076 \times 10^{12}$	$.879 \times 10^{12}$
	High	$.124 \times 10^{12}$	--	$.646 \times 10^{12}$	$.416 \times 10^{12}$	$.015 \times 10^{12}$	$.089 \times 10^{12}$	1.294×10^{12}
High	Low	$.080 \times 10^{12}$	$.321 \times 10^{12}$	$.266 \times 10^{12}$	$.280 \times 10^{12}$	$.015 \times 10^{12}$	$.099 \times 10^{12}$	1.065×10^{12}
	Moderate	$.142 \times 10^{12}$	$.573 \times 10^{12}$	$.475 \times 10^{12}$	$.393 \times 10^{12}$	$.015 \times 10^{12}$	$.114 \times 10^{12}$	1.716×10^{12}
	High	$.222 \times 10^{12}$	$.900 \times 10^{12}$	$.745 \times 10^{12}$	$.540 \times 10^{12}$	$.015 \times 10^{12}$	$.134 \times 10^{12}$	2.560×10^{12}

Year 2000: Energy Savings Resulting from Energy Conservation Options in Community Design Under Various Impact Strategies and Population Growth Rates.

1. Riverside Press - Enterprise, Sunday, February 19, 1978, p. B-3.

2. Discussion with Mr. Robert Hill, Assistant Director, Riverside Redevelopment Agency.

3. Provided by the City of Riverside, Planning Department.

4. Data provided by the City of Riverside, Public Utilities Department.

5. "Economic Base Report, City of Riverside," Wilsey and Ham, July, 1977.

6. "Sun/Earth - How to Use Solar and Climatic Eulagies Today", Richard L. Crowther, A.1.A., February, 1977.

7. The Costs of Sprawl, Detailed Cost Analyses", Real Estate Research Corporation, April, 1974.

8. "Passive Solar Buildings: A Compilation of Data and Results", Sandia Laboratories, August, 1977, p. 5.

9. "Sun/Earth - How to Use Solar and Climatic Energies Today", Richard L. Crowther, A.1.A., February, 1977.

10. "Davis Energy Conservation Report", City of Davis (CA), May, 1977.

11. Olgyay, Victor, "Design with Climate: A Climatic Approach to Architecture", Princeton, University, 1963.

12. "Passive Solar Buildings: A Compilation of Data and Results", Sandia Laboratories, August, 1977, p. 18.

13. "Davis Energy Conservation Report", City of Davis (CA), May, 1977.

14. Aronin, Jeffrey, "Climate and Architecture", Reinhold, New York, 1953.

15. Fitch, James, M., "American Building", Second Edition, Houghton Mifflin, New York, 1966-1972.

16. Olgyay, Victor, "Design with Climate: A Climatic Approach to Architecture", Princeton University, 1963.

17. Information provided by City of Riverside, Public Utilities Department.

18. "Street Lighting, Energy Conservation and Crime", LEAA Emergency Energy Committee, Energy Report No. 2, Law Enforcement Assistance Administration, U.S. Department of Justice, March 1, 1974.

19. Measured by the City of Riverside, Public Utilities Department, between March, 1977, and February, 1978.

20. U.S. average for 1970. State of Texas, Governor's Energy Advisory Council.

21. Associate Engineer, City of Riverside, Public Utilities Department, Electrical Division.

U.S. GOVERNMENT PRINTING OFFICE: 1979—640-258/ 1388