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ABSTRACT

This technical guide is part of a packet of tools designed to assist state or local government practitioners in organizing and managing an energy conservation program. It gives information on adapting energy conservation methods to existing public buildings and on designing new public buildings with energy conservation in mind. It also discusses public vehicle fleet management related to energy conservation. Energy conservation in the private sector is covered with material on residential and commercial buildings, public transportation, and electric utilities. Alternate energy sources, such as pyrolysis and methane production from solid waste, are presented, in addition to some case studies in energy conservation. Finally, a management report, written for department heads and mid-level managers, lays out basic steps in administering an energy conservation program. (Author/BB)

ENERGY CONSERVATION

A Management Report for State and Local Governments

Public Technology, Inc.

National Science Foundation
RANN-Research Applied to National Needs

Public Technology, Inc., is a non-profit, tax-exempt public interest organization established in December 1971 as an institutional mechanism for applying available technologies to the problems of state and local governments. Sources of such technologies include federal agencies, private industries, universities, and state and local jurisdictions themselves. PTI works in both the hardware and software fields.

PTI works on specific problems that have been defined and given a high priority by state and local government officials. A problem also must be common to many units of government throughout the nation and one that is susceptible to technological solution. In this way two major organizational goals are realized: (1) Costs and benefits of large-scale undertakings are shared, and (2) private investment in the solution of public sector problems is encouraged by the aggregation of specific markets at the state and local levels of government.

The technology application process consists of these steps: problem definition, location of applicable technology, appropriate packaging of the technology for state and local governments, and help in adapting and implementing the technology at the operating level. Emphasis is placed on transfer and subsequent utilization of the technology by the largest possible number of jurisdictions. On-site assistance is provided, upon request, to make certain that state and local jurisdictions fully utilize the technology.

PTI was organized and is governed by the executive officers of the Council of State Governments, International City Management Association, National Association of Counties, National Governors' Conference, National League of Cities, and U.S. Conference of Mayors. Its work is supported financially by the Ford Foundation, by the annual subscription fees of participating jurisdictions, and by federal agency grants and contracts.

The National Science Foundation's (NSF) Research Applications Directorate works to encourage the systematic application of science and technology to State and local government problems. Working within the Research Applications Program, the Office of Intergovernmental Science and Research Utilization seeks ways of focusing on practical solutions to selected problems of national importance. ISRU works directly with agencies of State and local governments in experimental efforts to determine and test how best to bring RANN and other scientific and technological advice to bear on legislative, management and operating decisions. This handbook is one significant element in working toward this goal. ISRU was provided with technical support in this instance by the Office of Systems Integration and Analysis, another component under NSF's Research Applications Directorate, which administers both the ISRU and RANN programs.

The Research Applied to National Needs (RANN) program is administered by the Foundation's Research Applications Directorate. RANN supports research in energy, environment, productivity and resources. RANN's energy research activities are focused in four areas:

1. Energy systems research, including projections of future energy supply and demand, ways of conserving energy resources, and assessments of the environmental impacts of alternate energy sources.
2. Energy resource research, which addresses problems related to the utilization of geothermal energy, coal gasification technologies, and waste heat recovery.
3. Energy conversion studies, which focus on improving the overall efficiency of power generation, testing of new technologies for energy storage, and development of advanced solar energy technologies.
4. Energy and fuel transmission research, including low-temperature and high-voltage direct current transmissions and power network monitoring and control.

NSF, through the RANN program, is deeply committed to developing new energy conservation techniques and analytical tools for assessing energy policies and options at the federal, state, and local levels.

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A MANAGEMENT REPORT

Prepared by

Public Technology, Inc.

With the Support of the

National Science Foundation
Research Applied to National Needs
Office of Intergovernmental Science and Research Utilization
and Office of Systems Integration and Analysis

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ENERGY CONSERVATION

A MANAGEMENT REPORT FOR STATE AND LOCAL GOVERNMENTS

Energy costs are the biggest rising costs in every public budget. Short of conservation, the only alternative for state and local governments has been to pass on these increases to the taxpayers—either as increased taxes or decreased services. Both politics and common sense dictate that conservation is the best approach, both within government operations themselves and throughout the private sector. This Management Report provides guidelines to assist state and local government officials in effectively managing an energy conservation program.

The energy problem stems from the fact that the United States depends almost completely on three nonrenewable fossil fuels—oil, natural gas, and coal. Prices of these fuels have shot dramatically upward as a result of the oil embargo and continuing shortages.

In Washington, D.C., gasoline which cost a typical public agency about 17¢ per gallon in 1972 now costs about 31¢ per gallon or more. Heating oil which cost about 17¢ per gallon in that same year now costs about 34¢ per gallon. These increases average out at about 85 or 90 percent for most public jurisdictions. Electric power rates have climbed proportionately in those areas where fuel oil is used to generate electricity. Tomorrow, we will very likely face increased prices for all types of energy.

The obvious need now is to implement and enforce belt-tightening measures on energy use that will help save both energy and money. From a cost-benefit point of view, "benefits" are achieved as energy is conserved. Consider these examples of possible benefits to be achieved through conservation, as documented by the Energy Conservation Technical Guide that accompanies this Management Report:

The heating, ventilating, cooling, and lighting costs for a typical public building generally range from $1 to $2 per square foot per year, or more than $100,000, for a 100,000-square-foot building. State, county, and city governments own and operate several hundred thousand buildings including legislative, executive, and administrative offices, schools, fire stations, police stations, libraries, hospitals, garages, auditoriums, and public housing. A reasonable target for an energy conservation program might be a 25 percent savings in existing public buildings. That is

$25,000 per year on a 100,000-square-foot building. Future public buildings, designed for energy conservation, might save 50 percent.

State and local governments operate about 440,000 automobiles, 194,000 buses, and 842,000 trucks, trailers, and miscellaneous rolling stock. These public vehicles consume something like 1.5 billion gallons of gasoline and diesel fuel per year. A public vehicle fleet with 1,000 automobiles, each vehicle being driven about 20,000 miles per year and each getting about 10 miles per gallon at 31¢ per gallon, consumes over $600,000 in gasoline each year. A reasonable target for an energy conservation program might be a 20 percent savings or as much as $120 per vehicle per year—or $125,000 annually for the 1,000-car motor fleet.

In addition to these savings in internal government operations, government inducements to local builders to use high-performance equipment in new construction could save an individual homeowner hundreds of dollars per year in fuel costs. Information provided by governments to homeowners on such matters as proper insulation and best-performing heating and cooling techniques can also bring significant savings.

Obviously, you must determine which energy-conserving measures are most important to your jurisdiction and on which to focus your efforts. Basically, you have three options for reducing consumption of the major fossil fuels:

- Consume less by reducing the use of energy-demanding equipment or practices.
- Consume less by increasing the efficiency of energy-demanding equipment.
- Consume less critical fuels by switching to alternative energy sources such as hydroelectric, geothermal, solar, etc.

Jurisdictions that have not instituted a formal energy conservation program are well-advised to begin one, in the light of expert predictions of even more severe future shortages. Those governments that already have a program should review its components and expand or alter its scope and emphasis, as appropriate. This Management Report is written for the public official who must determine how to go about getting a comprehensive energy conservation program started. The report discusses how to plan, organize, implement, and evaluate energy conservation programs. Also, it overviews the guidance provided by the Technical Guide.

Planning Conservation Programs

An energy conservation program should begin with a brief look at the current situation faced by your jurisdiction. Four questions are suggested below. The answers to these questions should help you to assess your present program.

- Does your jurisdiction maintain records on fuel consumption that provide the basic information you require to manage fuel supplies?
- Does your jurisdiction maintain a fuel allocation plan for each department, agency, or service, as appropriate? Does your fuel allocation plan provide for a phased response to fuel shortages? Does it establish relative priorities?
- Does your jurisdiction have a way to audit energy consumption in public buildings or vehicles? How do you know whether your consumption patterns are good or bad?

- Does your jurisdiction have someone who is clearly responsible for energy conservation? Does this person have a detailed program plan against which you can measure results?

A comprehensive energy conservation program could have two thrusts—one directed inward toward governmental operations, and the other directed outward toward the private sector and the community. The program itself could be divided into five action areas—existing public buildings, future public buildings, public vehicle fleet management, the private sector, and public power utilities.

As noted at the outset, public buildings are a prime target for an energy conservation program, since state and local governments own and operate well over 100,000 buildings. These buildings require energy for heating, ventilating, cooling, and lighting—all areas in which energy savings are possible. A building energy conservation program might best begin by auditing energy use in existing buildings. Construction of future public buildings can benefit from ongoing research, particularly that related to use of solar energy.

Next to the operation and maintenance of public buildings, the biggest potential for energy conservation in state and local government activities lies in vehicle fleet management. This is an appropriate activity for emphasis because it was public fleet operations that were most affected by the recent fuel shortages. Critical matters to investigate include vehicle operations, vehicle maintenance, equipment modifications, and vehicle replacement.

Efforts of state and local governments to control private-sector use of energy should consider actions to affect energy use in residential and commercial buildings, transportation services, and industry. The fundamental government role in promoting energy conservation should be to influence certain individual choices which affect energy demand. Voluntary actions are designed to inform or enlist cooperation. Two examples are programs to make consumers aware of the energy used by various appliances, or to promote home improvements that cut down on energy consumption. Regulatory actions compel compliance based on governmental responsibility for public health, safety, and convenience. Examples are building code provisions mandating minimum home insulation standards or ordinances requiring builders to file energy impact statements for new developments.

A conservation program directed toward the residential and commercial building sector should focus on three or four priority areas—space heating, water heating, air conditioning, and refrigeration. State and local governments have three options to pursue regarding transportation services—reduce the demand for transportation, increase the energy efficiency of existing and future equipment, and increase the number of people in each vehicle. Industrial energy use can be influenced through such government actions as information dissemination and long-range planning for combined power-steam generating systems.

State and local governments should include electric utilities in their community energy conservation program. State governments regulate utility rate structures, thereby influencing both energy supply and demand. County and city governments occasionally find themselves arguing before a state utilities commission as either an advocate for or opponent to proposed changes in utility rate structures. This provides an opportunity to promote a utility rate structure that rewards conservation of energy. State and local governments influence electric consumption patterns with various policies that relate to tax incentives, tax disincentives, building codes, promotional activities, and consumer education. County and city governments are responsible for street lighting. In addition, about 2,000 jurisdictions operate their own electric utilities. A conservation program might address electric power consumer demand, utility regulation, joint purchasing and distribution, plant equipment, street lighting, conservation measures, and research and development.

For each of these program areas, which are covered in detail in the Technical Guide, short-term, intermediate, and long-term objectives can be established. Short-term energy conservation measures might be those implementable within 60 days, or in an even shorter time in the event of a curtailment in fuel deliveries. Intermediate objectives might be achievable in from 60 days to a year, and long-term objectives might be those taking up to three years or more for implementation. Regardless of the measures undertaken by different jurisdictions, the purposes of a formal energy conservation program are the same—to economize in government operations, to maintain essential services, and to minimize hardships to citizens.

Organizing Local Resources

An energy conservation program affects virtually every department, agency, or service in state or local government. Major fuel-consuming departments such as police, fire, public works, inspections, and public transportation will be affected most directly by fuel supplies and costs. Purchasing, budget, public relations, planning, and the city attorney will also be affected in their various capacities. Since so many activities are involved, it is best to organize the energy conservation program as a staff activity responsible to the executive. Also, governments should explore regional or areawide approaches to energy conservation. Councils of government have been particularly successful in assessing the severity of fuel shortages in metropolitan areas and in coordinating the efforts of local officials to obtain higher allotments.

There are several ways to go about organizing an energy conservation program. Probably the most common approach is for the executive to appoint an assistant to act as energy coordinator. The coordinator is responsible to the executive for assuring that department heads are acquainted with conservation measures that apply to their operations and that they are actively implementing these measures. He may also serve as the liaison with citizen groups planning energy conservation programs. Another common strategy is for the executive to appoint a task force consisting of representatives of each department. The task force meets periodically to develop and review measures for conserving energy in each department. Interdepartmental policy recommendations are then presented to the executive for a final decision.

Some jurisdictions have established energy advisory committees comprised of such persons as county, city, and school officials and the presidents of Chambers of Commerce, Parent-Teacher Associations, consumer groups, public utilities commissions, and citizens associations. Such committees have been useful to governing bodies in providing advice and perspective on energy-related problems. The use of local industry representatives to provide technical expertise in the identification of energy conservation opportunities and the development of conservation technology should not be overlooked. The important point is to involve as many counties, cities, school districts, special districts, and quasigovernmental agencies as required.

The major organizational options appear to be these:

- Assign energy responsibility to each department head and coordinate conservation activities through the executive's office.
- Create a temporary or permanent staff agency to coordinate all energy conservation activities.
- Establish an ad hoc task force comprised of selected line and staff persons.
- Designate a staff assistant to act as energy coordinator with all the department heads and bureau chiefs.
- Assign responsibility to an existing department or bureau such as budget, purchasing, or general services.

A comprehensive energy conservation program requires knowledge or experience in several areas such as public administration, architecture, planning, mechanical engineering, electrical engineering, automotive engineering, purchasing, public relations, and law. Obviously, the person who is selected to be responsible for your jurisdiction's energy program should be able to bring an interdisciplinary perspective to the problem. Someone with a public administration and engineering background would be ideal. Access to people with specialized expertise in the disciplines listed above would be most helpful. An energy coordinator might be responsible for the functions listed below.

- Monitor fuel supplies in the jurisdiction or metropolitan area.
- Monitor the jurisdiction's fuel purchases and supplier agreements.
- Monitor fuel allocation and consumption for each department, agency, service building, or vehicle.
- Stay informed about what is going on in the area of energy conservation.
- Evaluate energy conservation research and development, and practical measures.
- Encourage adoption of cost-beneficial energy conservation techniques.
- Communicate energy conservation information to the public and the media.
- Report energy conservation program results to the executive.

Implementing Conservation Measures

Once the organizational mechanism has been set up, the jurisdiction can begin to implement its energy conservation program. It is useful to bear in mind that energy conservation can be an expensive program. Nevertheless, the expenditure of as much as two dollars to conserve one dollar in energy may be justified in the long run. The PTI Energy Conservation Technical Guide offers a number of practical measures for reducing energy consumption in existing public buildings, future public buildings, public and private transportation, residential and commercial buildings, and public power generation. The Guide presents the basic information needed to get a program started and provides explicit directions for finding more detailed information in any particular problem area. In addition, the Guide includes an annotated bibliography describing basic reference materials for the energy coordinator or task force. The recommended implementation process is outlined below.

1. Establish a formal energy conservation program. Assign someone the responsibility for staying informed about energy conservation trends, developments, and experiences. Tap existing information sources listed in the Technical Guide.

2. Collect data on energy consumption by department, agency, or service. Conduct an energy audit on public buildings and vehicles to establish baseline consumption patterns. Collect data on energy consumption regularly in order to determine the savings that result from various conservation measures.
3. Establish a fuel allocation plan in case future shortages force a cutback in services and operations. Plan a phased response to various fuel "crisis" levels. Create priorities, as appropriate. Prepare estimates for fuel consumption by department, agency, or service at 30-day, 6-month, and 12-month intervals.
4. Determine your critical energy-related problems, establish specific objectives, and translate them into measurable work assignments. The Guide should help you to focus on the really important problems. It should help you to determine what alternative conservation measures to consider. Also, the Guide should help you to locate sources for additional information.
5. Determine whether each specific energy conservation measure is appropriate for your jurisdiction and cost-effective. Common sense should be used to determine the relative merits for some measures. Others could require a more detailed analysis to include such factors as building or vehicle condition, climate, labor costs, equipment costs, operating lifetimes, and fuel savings. Each jurisdiction is advised to consult a professional engineer, architect, or lawyer as appropriate.
6. Commit the manpower, dollar, and time resources required to implement the selected measures. Encourage feedback. At regular intervals, go back to assess the effectiveness of the measures implemented. Share your experiences with other jurisdictions.
7. Alert the public to the measures being taken and the rationale for them, and disseminate information on ways in which private citizens can conserve energy. The jurisdiction's public information office will play a crucial role in this process. The cooperation of the media and citizens groups should also be enlisted in this effort.

Assessing Program Results

In order to manage the energy conservation program, a jurisdiction must be able to determine the effectiveness of each energy conservation measure. This requires that a means be developed for measuring energy consumption in major activities before and after conservation measures are implemented. This is also necessary in order to determine how much energy can be saved through alternative actions. The measurement procedure used to do this is called an energy audit.

In general, an energy audit entails developing an accounting system for energy consumption by end use. Data on fuel types, costs, and availability are also obtained. Fuel consumption should be measured in some common unit such as British Thermal Units (BTUs). The principle behind energy audits makes them quite flexible to use. They can be used to compare the energy efficiency of different buildings or to determine the effective energy savings which would result from adoption of a particular energy conservation measure. The procedure used, which is detailed in the Technical Guide, is adaptable to any type of building and is thus of particular value to units of government.

An energy audit of a public service using motor vehicles, such as sanitation, would entail collecting fuel consumption data for each vehicle and mileage traveled over a specific period of time. If several vehicles are considered for use in performing the same service, having the gas mileage of each enables a simple comparison. However, if the two vehicles differ significantly in some other characteristic, such as the capacity of refuse collection vehicles, then a common basis for comparison must be established. Such a measure of service units could be tons collected per gallon, in the case of refuse collection, assuming the same route for all vehicles. Maintaining records of gas mileage for each vehicle permits an assessment of the effectiveness of such measures as revised maintenance schedules or use of radial ply tires.

Sponsoring Organizations

The PTI Energy Conservation Package was prepared under the sponsorship of the Office of Intergovernmental Science and Research Utilization and the Office of Systems Integration and Analysis of the National Science Foundation (NSF). The package makes use of research conducted for the NSF Research Applied to National Needs program.

Public Technology, Inc., is a non-profit public service organization which works to define state and local government problems, locate promising technologies, and provide assistance in implementation at the operational level. PTI is sponsored by the six national public interest groups representing state and local governments—the Council of State Governments, International City Management Association, National Association of Counties, National Governors' Conference, National League of Cities, and U.S. Conference of Mayors.

State or local government officials requiring additional information on the subject of energy conservation may write to:

Technology Exchange Program
Public Technology, Inc.
1140 Connecticut Avenue, N.W.
Washington, D.C. 20036
(202)223-8240

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PREFACE

During the winter of 1973-74, state and local government officials were confronted with an energy "crisis" as fuel supplies declined drastically, fuel costs rose sharply, and some services had to be curtailed or suspended. At present, it is mainly higher prices that remain as reminders of this crisis. However, since the basic causes have not disappeared and continual forecasts are offered of future energy problems, Public Technology, Inc. (PTI), and the National Science Foundation (NSF) have joined to develop this Guide on energy conservation for the state or local government practitioner.

NSF, which conducts a broad-based energy research effort through its Research Applied to National Needs (RANN) program, provided financial support to PTI to prepare the Guide under PTI's Technology Information Exchange (TIE) program. Sponsored by the NSF Office of Intergovernmental Science and Research Utilization, TIE engages in four basic activities that serve to describe the methodology for preparing and implementing the Guide:

- *Problem Description.* The Exchange program actively encourages the participation of city, county, and state government representatives in the description of high-priority common problems.
- *Information Collection.* The Exchange program works systematically to acquire information about innovative technologies applicable to the problems defined by state and local practitioners.
- *Communications Product Assembly.* The Exchange program synthesizes new ideas, concepts, methods, and procedures into user-oriented communications tools.
- *Information Dissemination and Technical Assistance.* The Exchange program actively stimulates awareness, interest, evaluation, and adoption of these innovative technologies.

The Technology Information Exchange program does not engage in research and development, but rather works to pull together available information about existing technologies and to place this information in the hands of the state or local practitioner in an easy-to-use form. Thus, this Guide does not purport to present new research; it is a synthesis of existing technologies, a guide to what is now known about energy conservation.

Following the TIE methodology, the Guide draws upon the energy research sponsored by the National Science Foundation, other federal agencies, private enterprise, and state and local governments. The primary focus is on practical measures for energy conservation in public institutions and the community. Energy conservation problems faced by state and local government practitioners and addressed by the National Science Foundation research programs include heating, ventilating, air conditioning, lighting equipment and practices, thermal insulation standards, solar energy systems, building design and construction, motor vehicle gasoline consumption, electricity demand and supply, and waste heat utilization. Practical energy conservation measures dealing with these matters are divided into major chapters on new and existing public buildings, public vehicle fleet management, energy conservation in the private sector, electric utilities, alternative energy sources, and case studies in energy conservation.

This Technical Guide is part of a package of tools designed to assist the state or local government practitioner in organizing and managing an energy conservation program. The Management Report, written for department heads and mid-level managers, lays out basic steps in administering an energy conservation program. Training seminars conducted by staff personnel are also available to facilitate implementation. In addition, Public Technology, Inc., provides on-site technical assistance to subscribers upon request. State and local government officials may address inquiries concerning any of the above to:

Technology Exchange Program
Public Technology, Inc.
1140 Connecticut Avenue, N.W.
Washington, D.C. 20036
(202) 223-8240

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This Energy Conservation Guide was prepared with financial assistance from the Research Applied to National Needs (RANN) program, administered by the Research Applications Directorate of the National Science Foundation. As focal point for federal energy research, the RANN program provided the primary resource for assembling the technologies documented in this Guide. Other federal sources of information include the Department of Commerce, Department of Housing and Urban Development, Department of Transportation, General Services Administration, Federal Energy Administration, Environmental Protection Agency, and National Bureau of Standards.

Numerous other sources provided input to the documentation contained in the Guide. These are cited in Appendix A, and many additional sources are noted at appropriate points throughout the Guide. Such references usually provide names, addresses, and phone numbers for specific individuals who contributed to the Guide. Grateful appreciation is expressed to all such contributors.

Policy, technical, and editorial guidance were provided by an Energy Advisory Committee comprising the following members:

Richard Anderson, Deputy City Manager,
Ft. Lauderdale, Florida

Joseph Baker, City Manager,
Burbank, California

Kirk Drumheller, Program Manager, Energy Technology
Department, Battelle Pacific Northwest Laboratories

Larry Hobart, Assistant Director,
American Public Power Association

Dean Hunter, Chief Administrative Officer,
Lexington-Fayette County, Kentucky

Philip Hyatt, Chief of Program Planning, Office of Tributary
Area Development, Tennessee Valley Authority

Norbert Musial, Management Analyst,
Sarasota County, Florida

Edmund Rovner, Director of Energy Project,
National Governors' Conference

Alan Siegel, Director, Community Development Research,
Office of Policy Development and Research,
U.S. Department of Housing and Urban Development

Joseph Stein, Vice President,
Tishman Research Corporation

Robert Tanenhaus, Energy Planner, New York City
Planning Department

Hall Tennis, Assistant to the Manager,
Dade County, Florida

Robert Youkey, City Manager,
Lakeland, Florida

The Guide was reviewed by the following persons whose helpful comments and endorsement of the Guide's recommendations are particularly appreciated:

Richard E. Rowberg, Assistant to the Chief Engineer,
Federal Power Commission

William F. Sherman, Director, Engineering
Division, Motor Vehicle Manufacturers Association

Lawrence G. Spielvogel, Consulting Engineer and
member of Coordinating Committee on Design and
Evaluation Criteria for Energy Conservation in
New Buildings of the American Society of Heating,
Refrigerating and Air-Conditioning Engineers

William L. Slayton, Executive Vice President,
American Institute of Architects

Thomas J. Anderson, State Representative,
28th District, State of Michigan

Larry P. O'Keefe, Office of the County Manager,
Henrico County, Virginia

Robert B. Bugher, Executive Director,
American Public Works Association

I.

INTRODUCTION

I.

INTRODUCTION

Energy conservation is important to state and local government officials for several reasons. The basic energy problem has not disappeared—there are likely to be additional supply shortages and further increases in costs. Citizens still look to their government officials to deal with these problems that affect private transportation, buildings and residences, and the livelihoods of many people such as truck drivers and service station owners. Furthermore, state and local governments are major energy consumers themselves. While alternative energy sources are now under development, energy conservation—particularly the judicious use of existing supplies of petroleum products—is the only way to meet the nation's continuing energy needs in the short term. For the long term, energy conservation provides an alternative to large-scale expansion of our energy supply and the associated economic, environmental, and resource problems.

The United States energy problem, whatever the contributing causes, is basically a matter of demand and supply. Energy supply is determined by available fuel resources and production capacity. Over the past 25 years, per capita energy consumption increased 50 percent.[1] Since there has been a positive correlation between per capita energy consumption and increases in per capita income, some experts forecast that per capita energy consumption will increase another 50 percent over the next 15 years if no effort is made to utilize our energy resources more efficiently.[2] Unfortunately, the United States is dependent almost entirely on three fossil fuels—petroleum, coal, and gas—to meet its present energy supply needs. Figures 1 and 2 show energy consumption and the current sources and uses of energy in the U.S.

Electricity is a secondary energy form, since it is generated from primary sources such as coal, petroleum, gas, or nuclear materials. Demand for electric power has been increasing at the rate of 3 to 5 percent per year.[3] Historically, the rate of increase has been even higher. Electricity usage has doubled every ten years for the past four decades. While about 25 percent of all fossil fuel supplies are used to generate electricity at present, this is expected to increase to 40 percent by the year 2000.[4] However, the capacity to generate electricity has increased only about 3 percent per year because of delays in constructing new power plants. In some metropolitan areas, peak demand already exceeds capacity during hot spells, when air conditioning places a large burden on the electric power system.

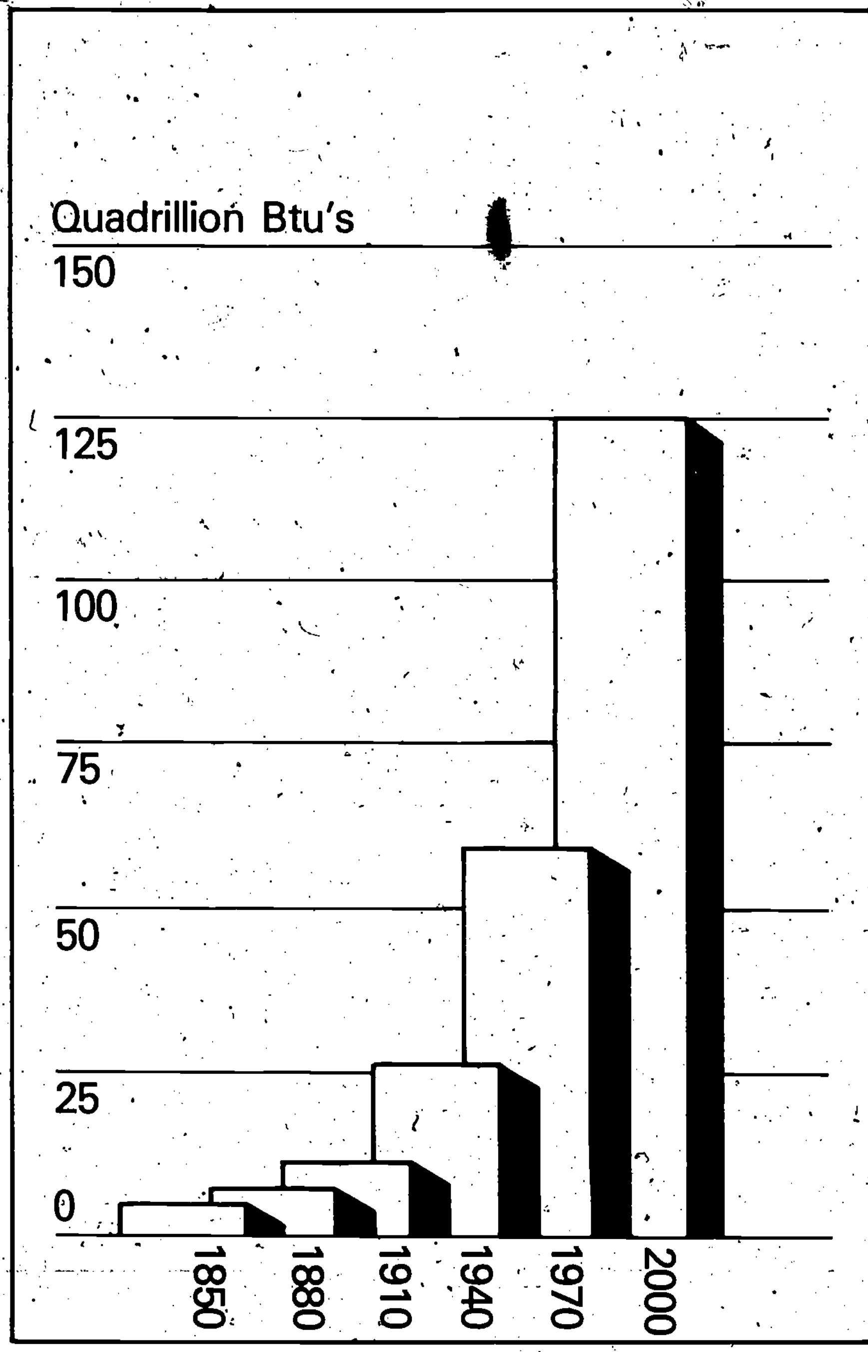


Figure 1. TOTAL U. S. ENERGY CONSUMPTION. Our total energy consumption more than doubled between 1940 and 1970. At current consumption levels it is projected to more than double again by the year 2000. (Courtesy of American Institute of Architects)

Petroleum now supplies 45 percent of our energy needs.[5] It is the one fuel upon which nearly all transportation depends. Petroleum consumption exceeded domestic production in 1971 by 4 million barrels per day, or about 34 percent. This difference was made up by imports. This consumption-production gap is expected to grow by 1980 to 11 million barrels per day. One reason for this gap is that domestic production has increased very little over the past 20 years; in fact, overall drilling declined 63 percent in the same period.[6]

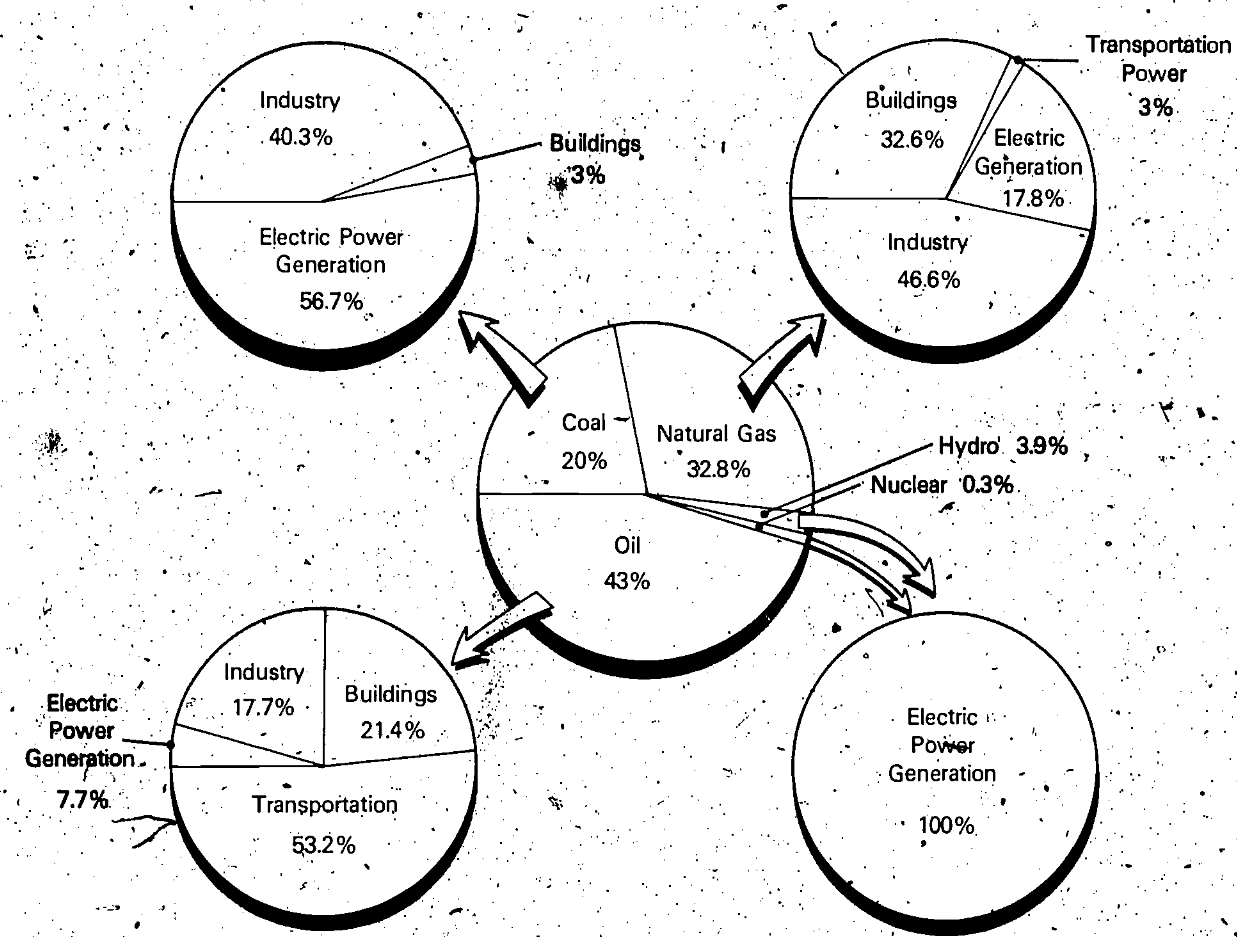


Figure 2. U. S. ENERGY SOURCES AND USES. This chart illustrates both our primary energy sources and their uses in each of the four energy-consuming sectors—buildings, industry, transportation, and electricity generation. About 95 per cent of our energy is supplied by nonrenewable fossil fuels. The other 5 per cent, nuclear and hydroelectric energy, is used entirely for electric power generation.

Coal is our most abundant fossil fuel, accounting for about 75 percent of the known domestic fossil fuel resources. Although coal is plentiful, its extraction and combustion have undesirable environmental consequences. The Clean Air Act of 1970 prohibited the use of coal with a high sulfur content and, as a result, many electric power plants, the primary users of this fuel, switched from burning coal to oil.[7] (Some, however, have switched back to coal because of the oil shortage.) Today, coal satisfies only 18 percent of our energy requirements.[8]

Natural gas supplies nearly one-third of the nation's energy requirements. However, we have consumed more gas each year since 1968 than we have found in new reserves. Total drilling has dropped 38 percent since 1959. Furthermore, proven reserves of natural gas (1972) will last only for another 11 years at current consumption rates.[9]

The Arab oil embargo during the winter of 1973-1974 served to call attention to these basic energy problems by causing a dramatic decrease in petroleum fuel supply and an equally dramatic increase in prices. State and local governments were forced to curtail or suspend some services and to respond to the many inconveniences experienced by citizens. These governments faced cutbacks in gasoline, diesel fuel, and fuel oil.

Gasoline and diesel fuel are used by state and local governments to operate nearly 1.5 million motor vehicles—police cars, fire trucks, snowplows, road graders, garbage trucks, etc. Fuel oil is used by these governments for heating, cooling, ventilating, and lighting several hundred thousand public buildings—offices, schools, garages, fire houses, libraries, hospitals, etc. Also, many of the municipalities which operate their own electric power plants burn oil.[10]

Alternative energy sources are now being studied by the National Science Foundation, Atomic Energy Commission, Battelle Memorial Institute, and the major petroleum companies and electric utilities, to name just a few. Most experts agree that such developments as magnetohydrodynamics and fast-breeder reactors for producing electric power will not be in commercial operation for at least two decades, and large-scale coal gasification is at least one decade away.[11] Solar and solid waste energy technologies are closer to commercial operation. Therefore, it appears that reducing energy consumption is the only practical means available in the near future to help balance the demand for energy with the supply. There are only three ways to reduce consumption of the major fossil fuels:

- Consume less by reducing the use of energy-demanding equipment or practices.
- Consume less by increasing the efficiency of energy-demanding equipment.
- Consume less critical fuels by switching to alternative energy sources such as hydroelectric, geothermal, solar, etc.

This Energy Conservation Technical Guide is written for state, county, or city government personnel who are faced with the difficult task of establishing a comprehensive energy conservation program or reviewing current energy conservation practices. It is organized into six major chapters:

1. *Existing Public Buildings*, which deals with methods of conserving energy through retrofit equipment, improved maintenance, more efficient operating procedures, and other methods.
2. *New Public Buildings*, which discusses the energy conservation aspects of design, comfort conditioning systems, and lighting.
3. *Public Vehicle Fleet Management*, which lays out fuel-saving techniques for vehicle fleet operations of state and local governments.
4. *Energy Conservation in the Private Sector*, which deals with how government measures can control energy use in residential and commercial buildings, transportation services, and industry.
5. *Electric Utilities*, which is concerned with the control of energy demand through utility rate structure regulation.
6. *Alternative Energy Sources*, which discusses the major alternate energy sources on the horizon.

The practitioner should find that this Guide provides, in one place, the essential information about energy conservation for both public institutions and the private sector. Throughout the Guide, the names, addresses, and phone numbers of information sources are provided to give the reader a lead for further inquiry.* These include equipment manufacturers, federal, state, and local government officials, trade associations, and research and development institutions. In addition, Appendix A contains a list of federal agencies, as well as institutions and associations, which can provide additional information on subjects discussed in the text. These listings are not intended to be comprehensive but rather to provide the state or local government practitioner with some initial contacts.

*Although the citations were checked for accuracy just prior to publication, in some instances those whose names are cited may no longer be in the position noted. Use of individual names was felt advisable as a means of initiating contact with a specific source, even though the name of the contact listed may now be inaccurate.

II.

EXISTING PUBLIC BUILDINGS

Public buildings are a prime target for an energy conservation program. State, county, and city governments own and operate several hundred thousand buildings, including legislative, executive, and administrative offices, schools, fire stations, police stations, libraries, hospitals, garages, auditoriums, and public housing. These buildings require energy for heating, ventilating, cooling, and lighting.

The heating and electricity costs for a typical public office building of 100,000 square feet in a moderate climate range from $75,000 to $100,000 per year. Similarly, the utility bills for a typical 100,000-square-foot school building are about $50,000 to $100,000 per year. The National Bureau of Standards estimates that energy conservation practices can reduce energy consumption in existing buildings by 15 to 25 percent.[12] This chapter discusses a variety of practices and equipment that can be utilized to achieve this goal.

State and local governments should establish energy conservation programs for existing public buildings. A conservation program for existing buildings should focus on at least four key areas—heating, ventilating, cooling, and lighting. Energy consumption varies widely depending on building design, age, use, and location. Thus, there are no universal answers. In order to determine the specific energy consumption pattern for an individual building, it is desirable to begin by conducting a building energy audit.

Energy Audits

A building energy audit is simply a procedure for monitoring, on a continuing basis, the energy consumed in a certain structure. Thus, an energy audit is a management planning and control tool.

The functional areas of energy consumption in buildings are heating, cooling, ventilating, hot water, and lighting. One of the purposes of the energy audit is to obtain a breakdown, if possible, of the amount consumed in each functional area. The General Services Administration (GSA) performed an audit on a typical six-story government office building in a New England state with these results: heating—54 percent of annual energy use; lighting—18 percent; ventilating—14 percent; cooling—9 percent; and hot water—5 percent.[13] Of course, these figures would vary considerably from region to region. Audits also allow public officials to assess the effects of various conservation measures by providing data on consumption before and after a change is made.

Naturally, an audit should include all sources of energy used in a building.

Several computer programs have been developed to analyze energy consumption in buildings and to evaluate the feasibility of alternative energy-saving ideas for both new and existing buildings. Two such programs are:

- ECUBE (Energy Conservation Using Better Engineering) developed by the American Gas Association, and
- TRACE (Trane Air Conditioning Economics) developed by the Trane Company.

Both programs perform a comprehensive study of air conditioning-heating system alternatives to answer the basic question, how much less does it cost to operate one system versus another, and what is the saving worth in economic terms?

A dynamic analysis accounts for the complex interaction among building energy systems. One example of the interaction between energy systems is the effect of lighting on cooling. Another example is the changes which occur in a building over the course of a day as a result of the flow of people, the weather, and the operating schedule of building equipment.

ECUBE, which is commercially available to anyone, provides information on energy requirements, equipment selection, and economic comparisons of different building modifications. The program is not as comprehensive as TRACE, but the cost is only $50 to $100 per run. For additional information on the use of ECUBE for analyzing building energy requirements, contact the source below:

The American Gas Association
1515 Wilson Boulevard
Arlington, Virginia 22209
(703) 524-2000

The TRACE program calculates building loads (heat gains and losses), simulates both system and equipment operation, and prepares a detailed economic analysis comparing alternative designs with existing systems. Table 1 illustrates energy savings for a 20-story office building

Table 1 COMPUTER EVALUATION OF EFFECTS OF ENERGY-SAVING CHANGES ON 20-STORY OFFICE BUILDING*

Change	Annual energy savings[1]	
Change from electric to gas energy for heating	$10,700	(8.7%)
Change from absorption to centrifugal refrigeration	$ 4,880	(3.9%)
Change from dual duct to variable air volume	$24,190	(19.7%)
Reduce glass from 50 to 20 per cent	$26,680	(21.7)
Change from clear glass to insulated reflective glass	$26,170	(21.3%)
Reduce lighting intensity from 4 to 3 watts per sq. ft.	$13,040	(10.6%)
Cumulative annual energy savings	$63,354	(51.7% of base energy cost of $122,541)

*Based on TRACE computer program analysis for office building in Los Angeles.

[1] Except for final cumulative figure; savings shown would occur if each change were made independently, not cumulatively.

as computed by the TRACE program. The program is available to architects or design engineers through the Trane Company's local sales offices. The cost of running the program varies with the size of the building, ranging from $400 to $3,000. For more information on TRACE, contact:

Mr. Dennis Bridges
Manager of Market Development
The Trane Company
3600 Pammel Creek Road
LaCrosse, Wisconsin 54601
(608) 782-8000

Jurisdictions may conduct their own building energy audits manually by collecting and analyzing certain data. The information gathered should include:

- The floor space area of each building.
- Electric utility bills for several months.
- Heating fuel records for the same period.
- Degree days for the same period (available from the local weather station or heating oil supplier).

Such information can be used to construct a "Building Energy Index" to assess the approximate magnitude of potential energy savings. The index is computed by converting all fuel use data to British Thermal Units (BTUs) and weighting each factor for source energy. For example, since it takes about three BTUs of fuel at the source (the power plant) to deliver one BTU of energy in a building, electrical energy BTUs should be multiplied by three. Sum the BTUs from all energy sources and determine the ratio of BTUs per square foot of heated building space. Divide by the number of degree days. The energy content in BTUs per unit of heating fuel can be obtained from the supplier. The measure of BTUs per square foot per degree day is a good relative indicator of comparative energy use in most buildings.

A detailed step-by-step procedure for conducting a building energy audit, as developed by the New York Board of Trade, is shown in Figure 3. The procedure computes a Building Energy Ratio (BER) that can be compared with those of similar buildings. The Board's survey of energy consumption in four classes of buildings—hotels, banks, apartments, and offices—yielded the findings shown in the bar graphs. Such a manual energy audit is a wise first step before deciding on whether to invest in a computer energy consumption analysis.

Energy audits are also useful for maintaining an energy "quota" for each public building. A jurisdiction may wish to reduce arbitrarily the energy consumption of each building by a certain percentage and allocate the energy supply among all its buildings on this basis. Using preallocation records as a measure, the energy audit permits officials to determine how closely each building is conforming to its designated energy conservation program.

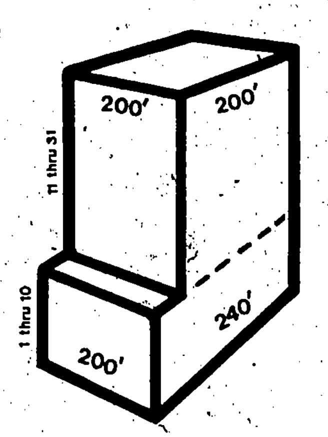
It is recommended that the energy audit be initiated first to establish a baseline against which to formulate a realistic program. After the program is started, officials can turn their attention to specific operating changes and equipment modifications for achieving energy savings. For further information on how to conduct and interpret the results of energy audits, contact:

DETERMINING EFFICIENCY

To determine how efficiently you are using energy in a building it is necessary to change all units of energy consumed to a common unit—BTU's (British thermal units). Total all BTU's, divide by the square footage and you will arrive at BTU's used annually per square foot. This ratio will be referred to as the building's BER—BUILDING ENERGY RATIO.

By comparing your BER with the BER of a building of like operation and category, you will be able to determine how you are doing on energy conservation. Please refer to a recent energy survey on back cover.

The formula for calculating your building's BER is described, step by step, and an example is given for each step.



EXAMPLE

Here we have a commercial office building. For demonstration purposes, the building in our example has all four commonly used energies. (Most buildings use only two or three.)

The building is 31 stories tall and has a setback. The dimensions are:

floors 1 thru 10: 240' x 200'
floors 11 thru 31: 200' x 200'

The energy consumed for 12 consecutive months is:

Electricity:	13,479,200 KWH
Natural Gas:	8,091 CCF
Steam:	54,872 M#
#2 Oil:	15,000 Gals.

NOW WE ARE READY TO START COMPUTING

1 Gather (from utility bills, etc.) the annual usage of energy units—kilowatt hours of electricity (KWH), hundreds of cubic feet of natural gas (CCF), thousands of pounds of steam* (M#), and gallons of oil. Enter the figures from your bills on lines 1, 3, 5 and 7 in COLUMN A. Be *sure* to include all forms of energy used in your operation. THEN:

(a) Calculate as shown by multiplying the units of energy by the factor given in COLUMN B.

(b) Add the products (lines 2, 4, 6 and 8) of COLUMN C — enter on line 9.

(c) Carry the figures on line 9 to line 12.

* Steam as purchased and billed from a utility. (On-site generated steam not to be calculated.)

COLUMN A *Units of Energy*	COLUMN B *Factor*	COLUMN C *BTU's (in thousands)*
Electricity: 1. 13,479,200 KWH (Kilowatt hours)	X 3.4 =	2. 45,829,280
Natural Gas: 3. 8,091 CCF (100's of cu. ft.)	X 100 =	4. 809,100
Steam: 5. 54,872 M# (1,000s of pounds)	X 1200 =	6. 65,846,400
Oil: 7. 15,000 Gallons	X *138 **146 =	8. 2,070,000
TOTAL (Add lines 2, 4, 6, 8)		9. 114,554,780 ENTER ON LINE 12 BTU's/yr. (in 1,000s)

* Use for #2 oil.
** Use for #6 oil.

2 Determine gross square footage or "rentable" square footage and enter on line 13.
Hotels use gross square footage — all others use "Rentable" square footage.
If you already have this figure, enter on line 13, if not, calculate as follows:

To calculate gross square footage: Determine square footage of each floor and multiply by the number of similar floors (if more than 1 floor). Total—the result is the gross square footage.
To calculate "rentable" square footage: "Rentable" square footage is gross square footage minus closets, halls, stairways, etc. If it is not practical to measure from plans, 85% of gross square footage may be used.

EXAMPLE: Our commercial office building has 31 stories:
Floors 1 thru 10: 240' x 200'
CALCULATION: 11 thru 31: 200' x 200'

240' x 200' — 48,000 sq. ft.
x 10 stories — 480,000 sq. ft.
200' x 200' — 40,000 sq. ft.
x 21 stories — 840,000 sq. ft.
(10.) 1,320,000 gross sq. ft.
x 85%
(11.) 1,122,000 "rentable" sq. ft.
ENTER ON LINE 13

3 Now calculate the Building Energy Ratio (BER) by dividing the total annual BTU's (line 12) by the square footage (line 13). Carry one decimal point, and enter on line 14.

12. 114,554,780 — Total BTU's/yr. (in thousands) —from line 9
÷
13. 1,122,000 — Hotels—Gross Sq. Ft. Others—Rentable Sq. Ft. —from line 10 or 11

14. 102.1
BUILDING ENERGY RATIO (BER)

Figure 3a. BUILDING ENERGY RATIO. The New York (City) Board of Trade has developed this procedure for computing an index to compare the efficiency of energy use in different buildings. This index is called the Building Energy Ratio (B.E.R.). The above illustration shows how the B.E.R. was computed for one commercial office building in New York City. You may wish to use a similar procedure to identify which buildings in your jurisdiction use energy in the least efficient manner. This procedure can assist the jurisdiction in setting relative priorities among existing office buildings in order to schedule corrective action as part of an overall energy conservation program.

NOW YOU ARE READY TO CALCULATE YOUR BER

COLUMN A *Units of Energy*		COLUMN B *Factor*		COLUMN C *BTU's (in thousands)*
Electricity:				
1. ______ KWH (Kilowatt hours)	X	3.4	=	2. ______
Natural Gas:				
3. ______ CCF (100s of cu. ft.)	X	100	=	4. ______
Steam:				
5. ______ M# (1,000s of pounds)	X	1200	=	6. ______
Oil:				
7. ______ Gallons	X	*138 **146	=	8. ______
TOTAL (Add lines 2, 4, 6, 8)				9. ______ ENTER ON LINE 12 BTU's/yr. (in 1,000s)

* Use for #2 oil.
** Use for #6 oil.

FLOORS		No. of Floors		Sq. Ft. Per Floor		Square Feet
____ To ____		____	X	____	=	____
____ To ____		____	X	____	=	____
____ To ____		____	X	____	=	____
____ To ____		____	X	____	=	____

Gross Sq. Ft. (10) ______

X 85%

Rentable Sq. Ft. (11) ______ Enter Line 13

12. Total BTU's/yr. (in thousands) from line 9 ÷ 13. Hotels—Gross Sq. Ft. Others—Rentable Sq. Ft.

14. BUILDING ENERGY RATIO (BER)

YOU NOW HAVE *YOUR* BUILDING ENERGY RATIO

ENERGY SURVEY

Alongside are the results of a recent energy survey conducted by the New York Board of Trade which reflects information supplied on returned questionnaires.

The figures on the left indicate the range of BER's and the bar graphs indicate how many respondents fell into that range. For instance, the chart headed "BANKS" indicates 40% of the 105 respondents had a BER of between 51 and 100.

Comparison between categories should not be made as varying energy inputs are involved.

NEW YORK BOARD OF TRADE INC.
330 MADISON AVENUE
NEW YORK, N.Y. 10017

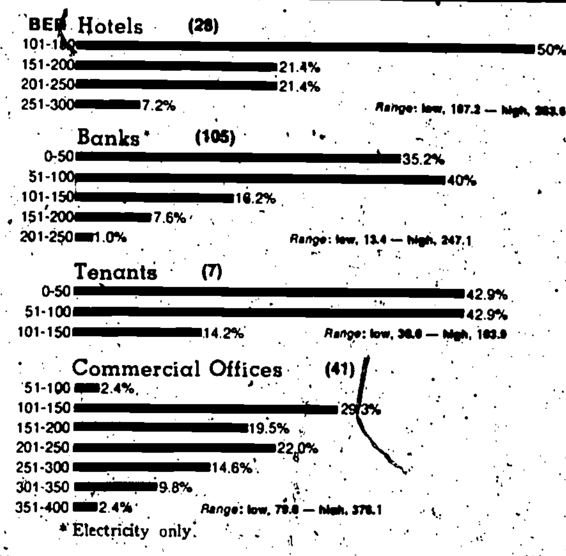


Figure 3b. BUILDING ENERGY RATIO. This section of Figure 3 may be used to compute your Building Energy Ratio. The bar graphs show the results of a survey of BERs for various types of buildings in New York City. The BERs shown apply only to the New York City survey and might vary significantly for similar surveys in other cities. (Courtesy of New York City Office of Energy Conservation and New York Board of Trade)

Mr. Cliff Cabellero
Chief Administrative Office—Energy Section
Room 344—Hall of Records
320 West Temple Street
Los Angeles, California 90012
(213) 974-1461

The following sections show how the three ways to conserve the major fossil fuels—consume less, increase efficiency, and use alternate sources—relate to existing building systems. Energy conservation features discussed include heat recovery, windows, lighting, air conditioning, and ventilation. At the end of the chapter is a comprehensive checklist of building energy conservation tips.

Heating and Cooling

Comfort conditioning is undoubtedly the greatest energy consuming function of a building. Comfort conditioning involves three interrelated building systems—heating, ventilating, and air conditioning (HVAC). In turn, there are four approaches that can be used together to conserve the energy needed to provide comfort conditioning:

- Operating HVAC systems at lower levels,
- Reducing heat gains and losses,
- Installing new equipment to reclaim waste heat, and
- Instituting more effective maintenance procedures.

The first approach includes turning off heating and cooling systems in unoccupied areas or during periods when the building is unoccupied. This requires sectioning the building into zones and regulating the heating and cooling system independently for each zone.

Building managers have heard a great deal recently about energy savings achieved by turning down thermostats in the winter and up in the summer. Raising thermostat settings in the summer to 80° F and humidistat settings to 60 percent relative humidity can reduce energy demand by 15 percent compared with operation at 75° F and 50 percent relative humidity.[14] Recent studies have shown that with suitable clothing, the higher temperature is acceptable. In the winter, comfort can be maintained at temperatures below 70° F if the relative humidity can be increased above 45 percent.[15] In the heating season, the average energy consumption for heating increases from 3 to 5 percent for every degree Fahrenheit a building is maintained above 70° F. Care must be taken in lowering thermostats to 68° F in the winter if different sectors of the building are not independently conditioned. Since the interior or core of a building is often warmer than 68° F even in the winter, this may cause the air conditioning system to go on in order to cool the core sector.

Setting controls back on the HVAC systems should be phased in gradually in the morning over several hours to avoid a sudden electric power demand. Electric motors generally require about six times as much power during the first few seconds of start-up as during operation. Phased start-up will also reduce utility bills, since electric power charges are based on both energy consumption and power demand.

Minor modifications of the control logic of some HVAC systems can have a dramatic impact on the energy consumption of these systems. One type, the reheat system, commonly installed in commercial and institutional buildings because of its low first cost, is particularly energy-wasteful. This system actually runs both the boiler and chiller simultaneously in order to control humidity when the system is on the cooling cycle. This means that heating oil is being burned in the summer in order to reheat the air which was overcooled by the chiller. It is possible to modify the controls of many dew-point reheat HVAC systems and achieve significant energy savings. The Grumman Aerospace Corporation provides architectural-engineering services to make these changes. For additional information, contact:

Mr. Timothy J. Murphy, P.E.
Energy Systems Division
Grumman Aerospace Corporation
Plant #30
Bethpage, New York 11714
(516) 575-9630

The second approach involves reducing heat gains and losses. Ventilation places a significant demand on heating and cooling systems because the outside air it brings into a building is usually a different temperature from that inside. Some experts feel that the present code standards regarding ventilation are excessive for the purposes of health and comfort and that significant energy savings could be realized by reducing these requirements. Most current ventilation standards are set arbitrarily because there has been little scientific study of the relationship between ventilation rate and human response. The General Services Administration is currently studying this relationship and results will be forthcoming.

In the absence of better data, the National Bureau of Standards has issued the following ventilation guidelines:[16]

Oxygen Supply	3 CFM/person
Cafeterias	10-12 CFM/person
Smoking Areas	25-40 CFM/person
Odor Control	5 CFM/person
Toilet Exhaust	10-15 air changes per hour
Corridors	2 air changes per hour

The National Bureau of Standards estimates that a reduction up to 30-50 percent of the energy required for heating and 15-20 percent of that required for air conditioning can be achieved by adjusting the ventilation level to occupancy.[17] This means varying independently the ventilation air flow in different sectors of the building. Of course, when outdoor air temperatures are mild, energy use can be reduced by relying more on outdoor air and less on mechanical cooling and heating. Other factors, such as solar penetration through windows, also affect the load on heating and cooling systems.

In many commercial and institutional buildings, a large percentage of the exterior surface area is glass. Solar transmission through conventional windows accounts for a significant portion of the cooling load in the summer. Over 80 percent of the solar heat striking a 1/4th-inch clear plate window penetrates into the building.[18] Because the capacity of ordinary plate glass to conduct heat is five to ten times that of well-insulated walls, windows also become a source of heat loss in cold weather.

Several design measures can minimize these disadvantages. Shading can reduce solar gain during the cooling season, but should be removed during the heating season. For more advice on windows and other glass surfaces, contact one of the information sources below:

Dr. Jack Snell
Chief, Office of Energy Conservation
Center for Building Technology
National Bureau of Standards
U.S. Department of Commerce
Washington, D.C. 20234
(301) 921-3637

Mr. John T. Malarky
Market Manager—Residential Construction
PPG Industries, Inc.
1 Gateway Center
Pittsburgh, Pennsylvania 15222

The third approach to optimizing energy use in building heating and cooling systems is to reclaim heat energy that would otherwise be wasted. All building systems generate heat from equipment in addition to that for warming the building. In most cases this heat is exhausted to the outside and dissipated. There are methods, however, of capturing this heat and using it for supplementing the basic heating system or for the terminal reheat portion of the air conditioning system.

The major commercially available heat recovery system is the heat wheel (see Figure 4). A heat wheel is packed with aluminum or steel mesh or a corrugated asbestos-type material for absorbing hot or cold air. It is installed directly in the ventilation system. As the motor-driven wheel turns, it continuously transfers heat from the warmer ventilating duct to the cooler one. In addition to heating, the heat wheel can be used for cooling and dehumidifying air in the summer. The cost of these devices is determined by the building design, although the key factor is the ventilation rate in terms of cubic feet of air moved per minute. Installation costs are between 30 and 50 cents per cubic foot per minute capacity.[19] Heat wheels cannot be used at all, however, unless exhaust and intake ducts are close together. Thus, they are most suitable in buildings which have central exhaust systems. Another heat recovery system, the runaround system, can accomplish much the same effect as the heat wheel in buildings where the exhaust and intake ducts are far apart.

Careful consideration should be given to installing heat wheels in buildings which are being enlarged or renovated, because heat wheels increase the effectiveness of existing heating and cooling plants. Their use may eliminate the necessity of adding new heating and cooling equipment, thus saving both energy and money. For additional information on heat wheels and other heat recovery devices, write or phone the following corporations:

Wing Corporation
Division Aero-Flow Dynamics, Inc.
2300 North Stiles Street
Linden, New Jersey 07036
(201) 486-7400

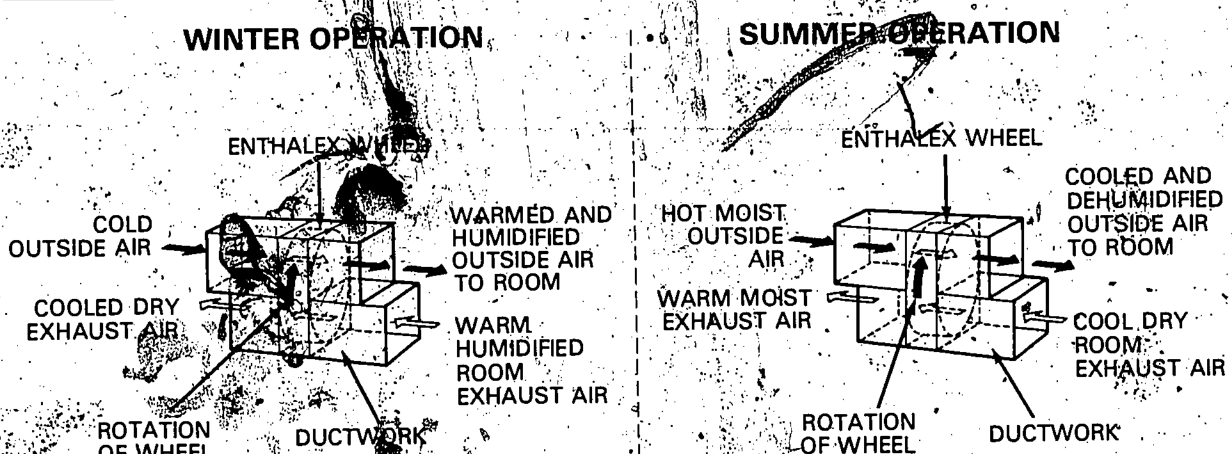


Figure 4. HOW A HEAT WHEEL WORKS. Heat wheels can be placed in many existing ventilation systems when the exhaust and intake ducts are close together. During summer operation, the wheel surface is cooled and dehumidified as it rotates through the cool, dry exhaust airstream. The surface then rotates across the hot, moist fresh air supply airstream and absorbs heat and moisture. Up to 90 per cent of the normally wasted cooling energy in the exhaust airstream is recovered to cool the fresh air supply. In winter the heat wheel absorbs heat and moisture from the exhaust airstream and transfers it to the fresh air supply. Up to 90 per cent of the normally wasted exhaust energy is [illegible] heat and humidify the fresh air supply. (Courtesy of Wing Corporation)

Mr. John McGuinness, Sales Manager
Cargo Caire Engineering Corporation
6 Chestnut Street
Amesbury, Massachusetts 01913
(617) 388-0600

Mr. Dennis Bridges
Manager of Market Development
The Trane Company
3600 Pammel Creek Road
LaCrosse, Wisconsin 54601
(608) 782-8000

Another example of waste heat recovery is the utilization of heat from the lighting system for space heating.[20] This can be accomplished by using a lighting fixture provided with slots through which return air is drawn into the ceiling plenum. The air picks up heat dissipated from the lamp, raising the temperature of the ceiling plenum. This plenum air then can be used for heating the perimeter zones of the building, or in the summer it can be vented to the outside, thus reducing the cooling load. This is a particularly important feature since in some commercial buildings up to 50 percent of the cooling load is due to lighting.[21] The warm plenum air can be used effectively also in the terminal reheat portion of air conditioning systems. Another advantage is that fluorescent lights operate more efficiently at lower temperatures. Fluorescent light fixtures with pumps for recovering light-generated heat are commercially available and can be installed in new or in existing buildings. Decisions regarding installation of equipment for recovering the heat of light must be made for a particular building by an architectural and engineering firm.

The costs of purchasing and installing these energy conservation devices will vary from building to building depending on the components and modifications required to make the equipment compatible with the existing HVAC system. The heat recovery equipment discussed above can be added to existing buildings, as well as installed in new buildings. The economic feasibility of installing heat recovery systems depends on individual building characteristics, local fuel costs, and local climatic conditions. Computer analysis can forecast the economic advantage of such installations.

The fourth method of conserving energy in public buildings is to institute more effective equipment maintenance procedures. A coordinated program of preventive maintenance for HVAC systems can have a significant impact on the energy requirements of office buildings. Some measures to be included are:

- Check automatic combustion control systems.
- Clean heat transfer surfaces and backflush pipes periodically.
- Change air filters periodically.
- Check excess air in boiler operations.
- Minimize the level of terminal reheat.
- Check steam traps for leaks.

Many office buildings consume far more energy than necessary because operating personnel are not acquainted with the design capabilities of their buildings. Consulting engineers who design HVAC systems often do not transmit necessary information to the operators.

Sometimes, as a building changes hands, it passes from one set of operators to another. Designers should be required to provide an operating guide with each building system. For more information on the energy conservation aspects of building heating and cooling systems, call or write the General Services Administration, an agency of the federal government, at the address below:

Mr. M.S. Blackistone
Public Buildings Service
General Services Administration
18th and F Streets, N.W.
Washington, D.C. 20405
(202) 343-6117

For additional information on energy conservation in heating, ventilating, and air conditioning systems in general, please refer to the AIA Research Corporation's *Energy Conservation in Building Design* (see bibliography reference 29), the ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) *Handbook of Fundamentals*, and other handbooks. Copies of these and other materials on this topic can be obtained by contacting the following sources:

American Society of Heating, Refrigerating
and Air-Conditioning Engineers, Inc.
345 E. 47th Street
New York, New York 10017
(212) 752-6800

AIA Research Corporation
1735 New York Avenue, N.W.
Washington, D.C. 20006
(202) 785-8778

Lighting With the exception of heating, ventilation, and air conditioning, lighting systems use more energy in buildings than any other feature. Also, in a typical office building, lighting systems account for one-fourth to two-thirds of the cooling load in hot weather. The National Bureau of Standards suggests that the demand for lighting could be cut by at least 15 percent in most buildings by implementing some basic recommendations developed by the Illuminating Engineering Society.[22] These recommendations apply to the design of lighting for new construction, the selection of lighting equipment, and renovation, operation, and maintenance of existing lighting systems.

1. *Design lighting for the expected activity.* Lighting levels should be adjusted for specific tasks. There should be a capability to relocate or alter lighting equipment when and where changes in the use of space are anticipated.
2. *Provide flexibility in the control of lighting.* Use separate and convenient switching or dimming devices for areas that have different use patterns. It is always more economical to turn off incandescent lighting when a working space is unoccupied. Where off-time is more than a few minutes, fluorescent and other high-intensity lighting should be turned off too. In areas where adequate daylighting is available, photoelectric systems can be used to control electric lighting and take advantage of natural lighting. In buildings that do not provide for separate switching, it may be desirable to install switches.

3. *Use the most efficient light source appropriate to each application.* The efficiency of different sources of light is measured in light output (lumens) per unit of electrical input (watts). Table 2 shows the relative efficiencies of various light sources. Note, in general, that with higher wattage, energy efficiency increases, even among light sources of the same type. Table 3 illustrates the annual energy and computed cost savings for specific relamping opportunities in offices, industrial plants, and stores.
4. *Use lighter finishes on ceilings, walls, floors, and furnishings.* Lighter finishes reflect a greater proportion of available light, which reduces the drain on electricity used for lighting.
5. *Keep lighting equipment clean and in good working condition.* With good maintenance you can get up to 50 percent additional illumination at no increase in cost or energy consumption. Here are the simple rules of a good lighting maintenance program:

Table 2 COMPARATIVE LIGHT SOURCE EFFICIENCIES

Light type	Description	Lumens to watts ratio
Incandescent	40-watt general service	11 to 1
Incandescent	1000-watt general service	22 to 1
Fluorescent	2 24-inch cool white	50 to 1
Mercury vapor	400-watt phosphor-coated mercury	50 to 1
Mercury vapor	1000-watt phosphor-coated mercury	55 to 1
Fluorescent	2 48-inch cool white	70 to 1
Metal halide	400-watt metal halide	75 to 1
Metal halide	1000-watt metal halide	85 to 1
Sodium vapor	400-watt high-pressure sodium	100 to 1

SOURCE: Illuminating Engineering Society, *Recommendations for Better Utilization of Energy Expended for Lighting* (New York: The Society, 1973), p. 4.

Table 3 RELAMPING OPPORTUNITIES*

Previous lamping	Changed to	Annual savings	
Office lamps (2700 hrs. per yr.)			
1 300-watt incandescent	1 100-watt mercury vapor	$14.58	(486 kwh)
2 100-watt incandescent	1 40-watt fluorescent	$12.00	(400 kwh)
7 150-watt incandescent	1 150-watt sodium vapor	$70.80	(2360 kwh)
Industrial lamps (3000 hrs. per yr.)			
1 300-watt incandescent	2 40-watt fluorescent	$18.69	(623 kwh)
1 10000-watt incandescent	2 215-watt fluorescent	$48.51	(1617 kwh)
3 300-watt incandescent	1 250-watt sodium vapor	$54.18	(1806 kwh)
Store lamps (3300 hrs. per yr.)			
1 300-watt incandescent	2 40-watt fluorescent	$20.55	(685 kwh)
1 200-watt incandescent	1 100-watt mercury vapor	$ 7.92	(264 kwh)
2 200-watt incandescent	1 175-watt mercury vapor	$20.10	(670 kwh)

SOURCE: Office of Conservation and Environment, *Lighting and Thermal Operations* (Washington, D.C.: Federal Energy Administration, 1974), p. 8.

*All costs are figured at 3 cents per kwh. The annual savings include normal ballast loss.

(a) Replace burned out lamps immediately.
(b) Use lamps that are rated for the voltage in use.
(c) Be sure fluorescent lamps operate at a cool ambient temperature.
(d) Keep lamps and luminaires clean. Repaint them when reflectances fall below their recommended values.
(e) When you remove fluorescent lamps from fixtures to reduce light level, disconnect the power to the ballast or you will have done only 80 percent of what you thought you did.

Post instructions covering operation and maintenance. You may have the greatest system in the world, but unless you communicate its features to the users, your efficiency will suffer.

According to the American Institute of Architects Research Corporation, reducing footcandle levels by one-third can reduce the energy consumption of lighting systems by as much as 90 percent. (This is based on an engineering study by Dubin-Mindell-Bloome Associates in New York.) Lighting in the United States is usually measured in footcandles with a standard light meter. However, the Illuminating Engineering Society (IES), which recommends lighting standards, has recently introduced Equivalent Sphere Illumination (ESI) as a new measure of effective lighting. The ESI is essentially a glare-free footcandle.

There are no nationally accepted standards for lighting levels in buildings. The minimum standard suggested by the IES, 140-125 footcandles (FC), has been criticized for being unnecessarily high. Therefore, several sets of recommendations are cited to provide guidance in adjusting lighting levels. Table 4 shows Federal Energy Administration guidelines for illumination levels in offices and institutional buildings.

These recommended levels are based on a year-long study by the General Services Administration in federal office buildings. Tests conducted since the 1950s have shown that reading does not improve above 30 FC, and a recent NSF(RANN)-sponsored study of New York City public schools has reported that there is no correlation between higher light levels and educational achievement.

The Grumman Aerospace Corporation reduced lighting levels in its offices from the range of 140-160 FC to 70-110 FC; secretaries were able

Table 4 RECOMMENDED MAXIMUM LIGHTING LEVELS

Task or area	Footcandle levels	How measured
Hallways or corridors	10 ± 5	Measured average, minimum 1 footcandle
Work and circulation areas surrounding work stations	30 ± 5	Measured average
Normal office work, such as reading and writing (on task only), store shelves, and general display areas	50 ± 10	Measured at work station
Prolonged office work which is somewhat difficult visually (on task only)	75 ± 15	Measured at work station
Prolonged office work which is visually difficult and critical in nature (on task only)	100 ± 20	Measured at work station

SOURCE: Office of Conservation and Environment, *Lighting and Thermal Operations* (Washington, D.C.: Federal Energy Administration, 1974), p. 6.

to read and type at the lower illumination without trouble. The electricity consumption for lighting was consequently reduced from 5 watts per square foot to 2.5 watts per square foot.

For more information on energy conservation opportunities in building lighting systems, refer to *Lighting and Thermal Operations* (bibliography reference 18). The following contacts are also suggested:

Mr. Frank Coda
Illuminating Engineering Society
345 East 47th Street
New York, New York 10017
(212) 752-6800

Mr. Willard S. Cahill
Lamp Division
General Electric Corporation
Nela Park—No. 4452
Cleveland, Ohio 44112
(216) 266-2207

Mr. B. T. Gilmore
Westinghouse Electric Corporation
Lamp Division
1 Westinghouse Plaza
Bloomfield, New Jersey 07003

Checklist

A comprehensive energy conservation checklist for existing public buildings is presented below. Each jurisdiction must determine for itself the appropriateness and potential effectiveness of each measure. Some measures vary according to geographic area or climate. Others vary with respect to building design and condition. Some cause secondary effects or interact with each other. Some of the measures are new, while others may already be covered by local building and health codes. Each jurisdiction should always seek the opinion of a professional engineer or architect.

Operations

- Heat buildings to no more than 68° F in the winter when occupied.
- Heat buildings to no more than 60° F when unoccupied.
- Cool buildings to no less than 78° F in the summer when occupied.
- Do not cool buildings in the summer when they are unoccupied.
- Schedule morning start-up in the winter so that buildings are at 63° F when occupants arrive and warm up to 68° over the first hour.
- Limit precooling start-up in the morning to give buildings a temperature of 5° F less than the outdoor temperature, or 80° F, whichever is higher.
- Close outdoor air dampers for the first hour of occupancy whenever outdoor air has to be either heated or cooled.
- Close outdoor air dampers for the last hour of occupancy whenever outdoor air has to be either heated or cooled.
- Turn off heating or cooling 30 minutes before the end of the work day.

- Close outdoor air dampers for 10 minutes in every hour. This, however, may be impractical if the task must be performed manually.
- Allow relative humidity to vary naturally between 20 percent and 65 percent.
- Use cool night air to flush buildings in the summer.
- Light buildings only when they are occupied.
- Turn off unneeded lights if consistent with safety considerations.
- Schedule cleaning and maintenance for normal working hours or when daylight is available and sufficient for this task.
- Draw drapes over windows, or close thermal shutters when daylight is not available and when the building is unoccupied.
- Use economizer cycle whenever waste heat cannot be used or stored.
- Do not start the building's ventilation fans until mid-morning.
- Shut off toilet exhaust systems where natural ventilation is adequate for odor control.
- Reduce fresh air intake to building ventilation systems.
- Run air conditioning equipment only on really hot days; open windows for necessary cooling on other days, if possible.
- Ventilate storage and utility spaces with exhaust air from other areas requiring a higher load of air freshness.
- Do not attempt to maintain the same comfort conditions in corridors as in offices.
- Ban smoking in public areas so that the amount of fresh air intake can be reduced.
- Turn off lights, heat, and air conditioning in storerooms and closets.
- Remove every third fluorescent lamp (and ballast) from ceiling fixtures and diminish light in hallways to a minimum footcandle level, if consistent with safety and codes.
- Close off unoccupied spaces and turn off the heat.

Maintenance Measures

- Maintain equipment properly to retain "as new" efficiency.
- Clean air filters on a regular maintenance schedule.
- Clean light fixtures and change lamps on a regular maintenance schedule to maintain desired lighting levels.
- Improve maintenance practices to prevent energy loss due to leaks of steam and hot water, scale formation and corrosion, etc.
- Inspect, clean, and adjust boilers and heating furnaces at least once a year to insure that they are operating at maximum efficiency.

Educational Measures

- Improve the operation of buildings through an operator education program.
- Educate personnel to keep windows closed when the heating or air conditioning equipment is in service.
- Educate personnel to draw draperies and blinds in unoccupied rooms and offices.

Low-Cost Measures (Payback within 2 Years)

- Install automatic door closers where appropriate.
- Install permanent or temporary storm windows in all existing buildings. In some cases storm windows of glass (or plastic) may be installed on the inside of the existing glass panels. This is practical for colder climates, primarily.
- Weatherstrip and caulk all buildings.
- Install exterior solar shading devices.
- Cover steam and hot water pipes with insulating material.

Higher-Cost Measures

- Convert large buildings to district heating. The energy savings are particularly impressive when the steam is derived from power plant turbine generators.
- Construct vestibules at main entrances so there will be a double set of doors to prevent hot and cold air loss.

The measures in this checklist were compiled by the Federal Energy Administration, and all inquiries pertaining to them should be directed to that agency:

Dr. Maxine Savitz
Federal Energy Administration
Office of Energy Conservation and Environment
Ben Franklin Station
Washington, D.C. 20461
(202) 961-8665

III.

NEW PUBLIC BUILDINGS

The latest analysis of the use of federal revenue sharing monies shows that state and local governments have channeled much of these funds into capital expenditures such as new buildings. The large number of new public buildings now in the planning stage presents a great opportunity for incorporating energy conservation features into the designs of these structures. Many of these features must be included as design components since they would be difficult or impossible to retrofit into existing buildings. New buildings also offer opportunities to apply new energy technologies such as solar energy equipment and total energy systems. The potential payoffs are much higher for new construction than for existing buildings. The American Institute of Architects Research Corporation estimates that the potential energy savings in specially designed new buildings may be as high as 50 percent over comparable conventional buildings.[23]

Federal Office Buildings Design

The General Services Administration has selected two federal office buildings currently being designed for construction in Manchester, New Hampshire, and Saginaw, Michigan, as energy conservation demonstration buildings. These two buildings are being designed to incorporate various innovative energy conservation features. In addition, the buildings are being equipped with the instrumentation needed to measure energy consumption performance. Also, employee reaction to the various energy saving features will be evaluated. These demonstrations offer state and local governments a chance to see how specific energy conservation measures work in practice before spending their limited dollars on similar ventures. Both buildings are expected to be completed by late 1975. Figure 5 shows an artist's conception for the Saginaw building.

These federal buildings are expected to consume at least 40 percent less energy than other buildings of comparable size, type, and location.[24] Three general conservation principles were employed in the designs:

- One large building is more energy efficient than a number of smaller buildings.
- Buildings should be as nearly square as possible in order to minimize exterior wall exposure.

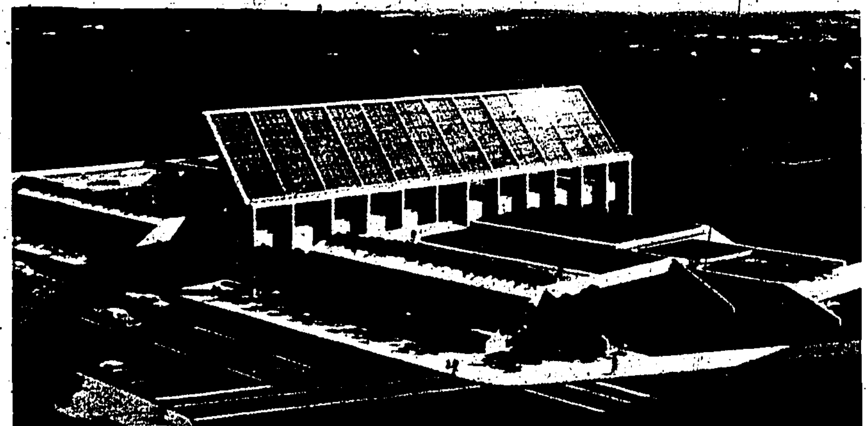


Figure 5. FEDERAL OFFICE BUILDING, SAGINAW, MICHIGAN. The large solar collectors will provide all the domestic hot water heating and up to 70 per cent of the space heating requirements of this building. (Courtesy of U. S. General Services Administration)

- Buildings should be so situated with respect to sun, wind, and topography that the effects of heat and cold will be minimized.

General features were adopted to reduce heat loss. The lowest office floors are directly over the basement to avoid floor exposure to outside weather extremes. The thermal conductivity of the walls, roofs, and first floors of these buildings is 0.06 BTUs per hour per square foot per degree Fahrenheit as opposed to the normal 0.24 - 0.12. In addition, the exterior wall mass is designed to be 100 pounds per square foot instead of the normal 10 to 30 pounds per square foot for curtain wall construction, in order to obtain optimum thermal performance.

The outside air ventilating systems employ two innovations. Both demonstration buildings will use economizers (except when heat recovery is employed) to regulate ventilation when the outside air temperature falls within a specified range. Economizers are ventilating devices that use cool outdoor air to offset heat gains inside buildings. Also, variable volume boxes will be used to regulate air flow in branches from the main distribution supply ducts. Variable volume systems operate at a constant temperature and regulate the amount of air supplied to any room or space in accordance with its cooling requirements.

The heating and cooling systems are designed to demonstrate several features. In one building, closed-loop water-to-air heat pumps (described in Chapter V) will transfer warmth or coolness from one building zone to another, as required. In both buildings waste heat generated during the day will be stored in a large insulated hot water tank and used later at night for heating. Still another innovation is the use of central chillers at night, when the electric demand is relatively low, to generate chilled water and store it in an insulated tank for cooling the building during its next occupied period.

Domestic hot water and most of the space heating requirements are expected to be met by utilizing solar energy. Both the Saginaw and Manchester office buildings will employ flat-plate solar collector systems.

The principal window design features of these two buildings work to minimize the solar load during the summer and to maximize it during the winter. The basic strategy is to keep the number of windows at a minimum and to utilize double glazing to minimize heat loss and infiltration. There will be no windows in the north walls of either building, and windows on the other three sides will be limited to no more than 15 percent of the wall areas.

In addition to the use of conventional window shades, the buildings feature two kinds of architectural features for screening out direct summer sunlight—side fins (vertical projections between windows) and overhangs (horizontal projections between windows). Figure 6 illustrates a building which uses overhangs and side fins.

Another method of reducing undesired solar transmission through windows is the use of heat-absorbing or reflecting glass and sunscreens, or a more recent innovation, reflective metallic coating. This kind of glass can block out any desired amount of solar light and heat. Combined with double glazing, reflective metallic windows keep heat outside when cooling is desired. Reflective glass can reduce interior heat gain by as much as 50 percent compared with clear glass. Although the initial cost is somewhat higher than for regular glass, the reduction in cooling costs

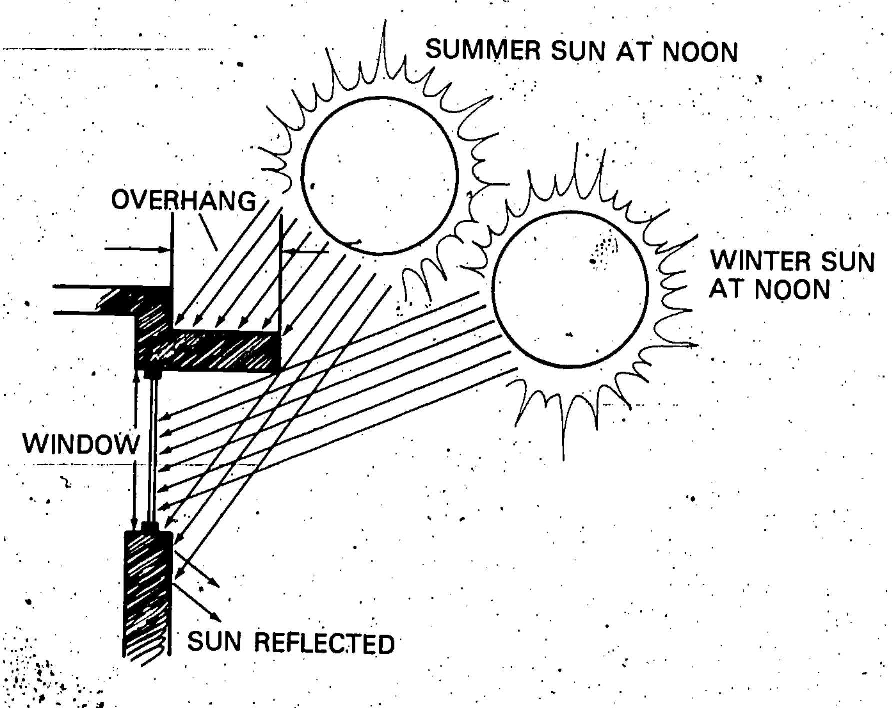


Figure 6. SHADE-PROJECTION OVERHANG. Properly-sized overhangs above south-facing windows can provide shading from direct sunlight in the summer because the sun is then high in the sky. In winter, however, when the heat from direct sunlight is desired inside the building, the sun's rays are not blocked by the overhang because the sun is then lower in the sky. (Courtesy of Living Systems, Inc., Winters, Cal.)

can more than offset this outlay. For example, the designers of the Toledo Edison Building found that use of chromium-coated dual-wall insulating glass, which cost $122,000 more than plate glass, permitted installation of a smaller heating-cooling system. Installation of the smaller unit saved $123,000 in investment and resulted in yearly operating cost savings of $40,000.[25] Additional information regarding these buildings can be found in *Energy Conservation Design Guidelines for Office Buildings* (see bibliography reference 3). Also, contact:

Mr. M. S. Blackistone
Public Buildings Service
General Services Administration
Eighteenth and F Streets, N.W.
Washington, D.C. 20405
(202)343-6117

For more information concerning architects and consulting engineers in your area, contact:

American Consulting Engineers Council
1155 Fifteenth St., N.W.
Washington, D.C. 20005
(202)296-1780

One reason that so many buildings constructed by state and local jurisdictions have not utilized available energy-conserving technologies is the emphasis on minimizing first costs implicit in government budgeting systems. Very often the building having lower construction cost uses significantly more energy and consequently has a higher total cost over its economic life (called life-cycle cost) than a comparable building which is more expensive initially. To correct this situation and assure that energy costs are taken into account when government buildings are first designed, several states (e.g., California, Florida, New York, and Washington) have passed legislation requiring life-cycle cost analysis of all state-owned and assisted facilities (see Appendix B for sample legislation). The U.S. Postal Service, Veterans Administration, and General Services Administration already require life-cycle costing of their buildings.

Solar Energy Applications

The largest energy-consuming function in buildings is heating and cooling for comfort conditioning. Solar energy is the source that has the most immediate potential for cutting down on the amount of petroleum needed to provide comfort-conditioning. While existing buildings can be modified to utilize solar energy, most experts agree that the required hardware can be best integrated into new construction. Solar energy is no longer a faraway dream but an idea whose time has come. The severe shortage of fuels has created renewed public interest in this energy form and has greatly accelerated the development of solar energy technologies and production of solar energy equipment. State and local governments are advised to consider incorporating solar energy equipment into the design of new buildings for the following reasons:

- Solar energy systems can significantly reduce the fossil fuel requirements for water heating and space heating.
- Solar energy is the earth's most abundant energy source, and it is inexhaustible.
- Solar heating can provide up to 80 percent of the energy for heating a building in a city such as Washington, D.C.[26]

- Solar energy utilization is non-polluting.
- Solar energy can be utilized in most sections of the country—the more severe the heating requirements, the more economical its use becomes.
- Solar systems are becoming cost effective—the initial cost of the equipment will soon be more than repaid in fuel savings over the life of the building.
- Utilization of solar energy in public buildings can demonstrate the practicality of this source and result in a multiplier effect in the private sector.

This type of energy system collects and stores radiant heat from the sun for use in providing three building services—water heating, space heating, and eventually space cooling. All three applications employ a flat-plate solar collector, a heat storage, and an auxiliary heat supply capability.

The collector intercepts and absorbs solar radiation which raises the temperature of a fluid—usually air, water, or some other heat transfer liquid. The collector is fabricated from black metal or glass, usually insulated underneath, and covered on top with one or more sheets of window glass or plastic to reduce radiation. The solar energy trapped on the black surface causes the temperature of the collector to rise. This heat is removed by the circulating fluid which is then piped into a hot water system to provide heat or into an absorption chiller to provide cooling. (Solar-powered cooling is not yet sufficiently developed for commercial application. However, some experts believe that the obstacles to widespread use of solar refrigeration will be overcome within five years.)

Even on winter days, up to 50 percent of the sun's energy can be recovered at temperatures between 90° and 130° F. However, overall efficiencies of 10 to 20 percent are more common when transport losses are accounted for. Since solar radiation is greater when the receiving surface is more nearly perpendicular to the sun's rays, the flat-plate collector is usually faced toward the equator and tilted. It has been determined that tilting the collector plate at an angle equal to the latitude plus 10 degrees provides optimal solar absorption. Deviations of as much as 15° from the south-facing orientation have little effect on performance.

The heat storage system works by raising the temperature of inert substances such as water or rocks, or by reversible chemical reactions. Most systems use water stored in a tank, usually in the basement. A pump returns the water to the collector. When air is the heat transfer medium, storage is provided by bins of small rocks. Since the heat capacity of rocks is less than that of water, the volume of rocks required to store an equivalent amount of heat is about three times as great as that of water. Heated air from the solar collector is circulated through the rocks by means of a blower, which returns the air to the collector for reheating. The major problems of heat storage by hot water or rocks are the large volume and weight and the cost of tanks and thermal insulation. The maximum temperature achieved is about 150° F.

Several types of flat-plate solar collectors are being tested in residential, commercial, and public buildings. The National Science Foundation, which has been responsible for coordinating federal solar research and development, is now sponsoring several research projects to evaluate the economics, feasibility, and effectiveness of various solar collector systems. Unfortunately, there is not yet sufficient experience with these technologies to permit a clear choice of one over another. Nevertheless, solar energy technology appears to be coming into its own. PPG Industries recently became the first major U.S. company to manufacture and market solar collector systems on a nationwide basis. The state of Indiana already offers real estate tax deductions to encourage citizens to use solar energy systems,[27] and Virginia, California, and Arizona are considering similar tax incentives.[28] Three solar energy demonstration projects with significant implications for state and local governments are discussed below.

The General Services Administration federal office building project in Saginaw, Michigan, incorporated into the building design the latest state-of-the-art solar energy technologies. As mentioned in the previous section, domestic hot water heating and up to 70 percent of the space heating requirements will be provided by solar energy utilization. The reader is again referred for additional information to:

Mr. M. S. Blackistone
Public Buildings Service
General Services Administration
Eighteenth and F Streets, N.W.
Washington, D.C. 20405
(202)343-6117

The National Science Foundation is sponsoring a very interesting solar energy demonstration in four public schools located in Warrenton, Virginia; Boston, Massachusetts; Osseo, Minnesota; and Baltimore County, Maryland. These solar energy applications handle both heating and cooling. The Maryland site was visited to obtain information for this Technical Guide.

The Timonium Elementary School in Baltimore County provides a good case study of the application of solar energy to public building construction. Like many schools in the United States, it is basically a one-story construction with window walls on one side of each room. The central classroom wing of the three-wing building was selected for the demonstration (see Figure 7). The central wing is heated by a conventional oil-fired boiler. Since the solar energy heating system uses hot water as a heat transfer medium, a special hot water distribution system, as well as special forced-air convection heaters, had to be installed in the central wing. Buildings which already have hot water space conditioning systems can be more easily adapted to solar space conditioning. The major system components are 180 solar collector panels, a 15,000-gallon hot water storage tank, the hot water room heating system, and automatic controls. An absorption chiller is being considered by the designer to provide solar-assisted air conditioning during the summer.

The solar collector panels are arranged in ten rows running east-west across the roof, which runs north-south. Each panel has a 28-square-foot surface which is tilted at a 45° angle facing south. A steel support structure resting on the present steel "I" beams on the east and west sides of the school takes all wind and snow loads without putting any additional load on the present roof. The panels consist of a blackened aluminum base covered with two layers of high-strength glass. The glass layers are separated by an aluminum honeycomb structure. Since the panels for this demonstration were constructed by hand, they are

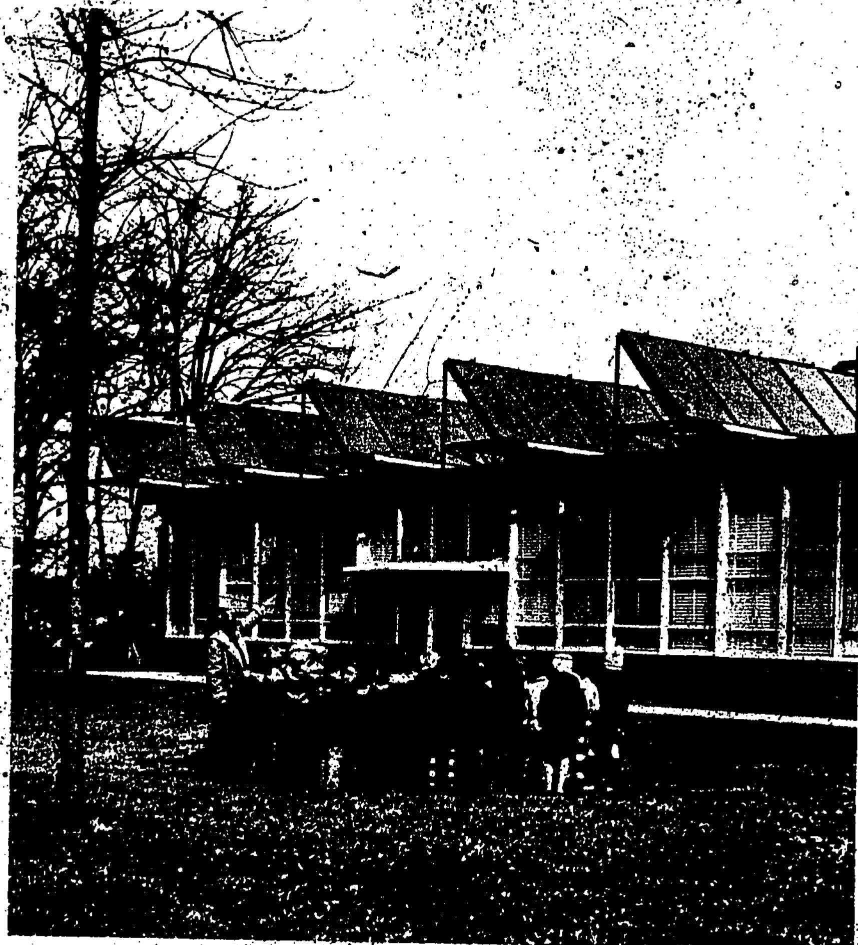


Figure 7. SOLAR COLLECTORS. These solar collector panels were installed on the Timonium Elementary School in Baltimore County, Maryland, as part of a demonstration project sponsored by the NSF Research Applied to National Needs (RANN) program. Panels are constructed from blackened aluminum and glass. (Courtesy of AAI Corporation, Baltimore, Maryland)

naturally far more expensive than had they been mass-produced. The cost of materials alone used for the panels was $18 per square foot. If materials were ordered in sufficient quantities and mass production techniques used, some experts estimate that producing panels may be reduced to as little as $4 per square foot.[29] The solar collector panels are the major expense in this system. (PPG Industries is about to market solar collector panels in the price range of $6 to $7.20 per square foot.)

Figure 8 illustrates the basic operation of the Timonium solar energy system. Cold water from the bottom of the storage tank is pumped to the collector panels. This water is heated by absorbing solar energy as it flows between the aluminum and glass. The water then drains into the storage tank, which is located outside the wing. Hot water from the top of the tank is pumped to the interior forced-air convection heating system and returns to the bottom of the tank. This flow is controlled by separate room thermostats. When the storage tank temperature falls below a required heating level, the main steam heating system is turned on automatically to supplement the solar heating system. The automatic controls also start up the pump when the temperature of the collector panels is 10° F higher than the water at the top of the tank.

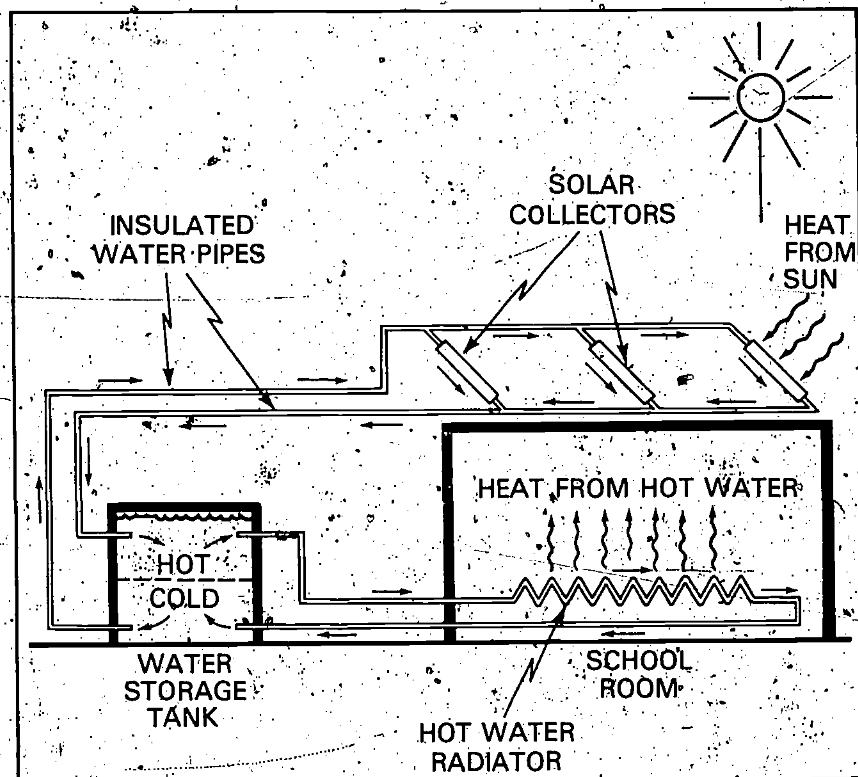


Figure 8. HOW A SOLAR HEATING SYSTEM WORKS. This schematic drawing shows how solar energy is used to heat the Timonium School shown in Figure 7. Water is pumped from the bottom of the insulated water storage tank to the top of the collector panels. After passing through the panels and absorbing their heat, it runs into the top of the tank. The schoolroom is heated by conventional radiators through which hot water is circulated. (Courtesy of AAI Corporation, Baltimore, Maryland)

The 15,000-gallon storage tank has sufficient capacity to heat the school for four days and nights when the sun is not shining. Most of the heating load is at night when the lights are turned off and the building is unoccupied. At night and on weekends, the temperature is allowed to drop to 65° F. Heat comes on early enough each school day to bring the temperature to 68° F by the time the students and teachers arrive.

The overall energy efficiency of this solar heating system is about 40 percent. This means that 40 percent of the solar energy striking the collectors can be delivered as heat to the classrooms. This efficiency can be improved by using glass with better transmission-emission characteristics. Still, the system satisfies more than half of the heating requirements even in winter months, as shown below:[30]

November	105%
December	50%
January	42%
February	94%
March	160%

The Timonium school demonstration is significant to state and local governments because it shows the technical feasibility of retrofitting an existing public building for solar energy utilization in a relatively short time—two months from design to operation.

Another innovative project is a municipally endorsed demonstration in Colorado Springs, Colorado. This demonstration is intended to promote solar energy use in private homes. Colorado Springs began to search for an alternate energy source when the natural gas supply used for heating homes in the region became severely restricted. Because the gas consumption rate began to exceed the capacity of known gas reserves, the gas utility, which is owned by the city, declared a moratorium on new gas connections.

To enable the community to continue building homes, the local government, the mayor, the Colorado Home Builders Association, the American Institute of Architects, and interested citizens from a variety of organizations agreed to promote a solar energy demonstration. The city of Colorado Springs helped to organize the nonprofit Phoenix Corporation to sponsor the construction of a solar-heated home (see Figure 9). This is the first instance of direct municipal involvement in the sponsorship of a solar energy demonstration.

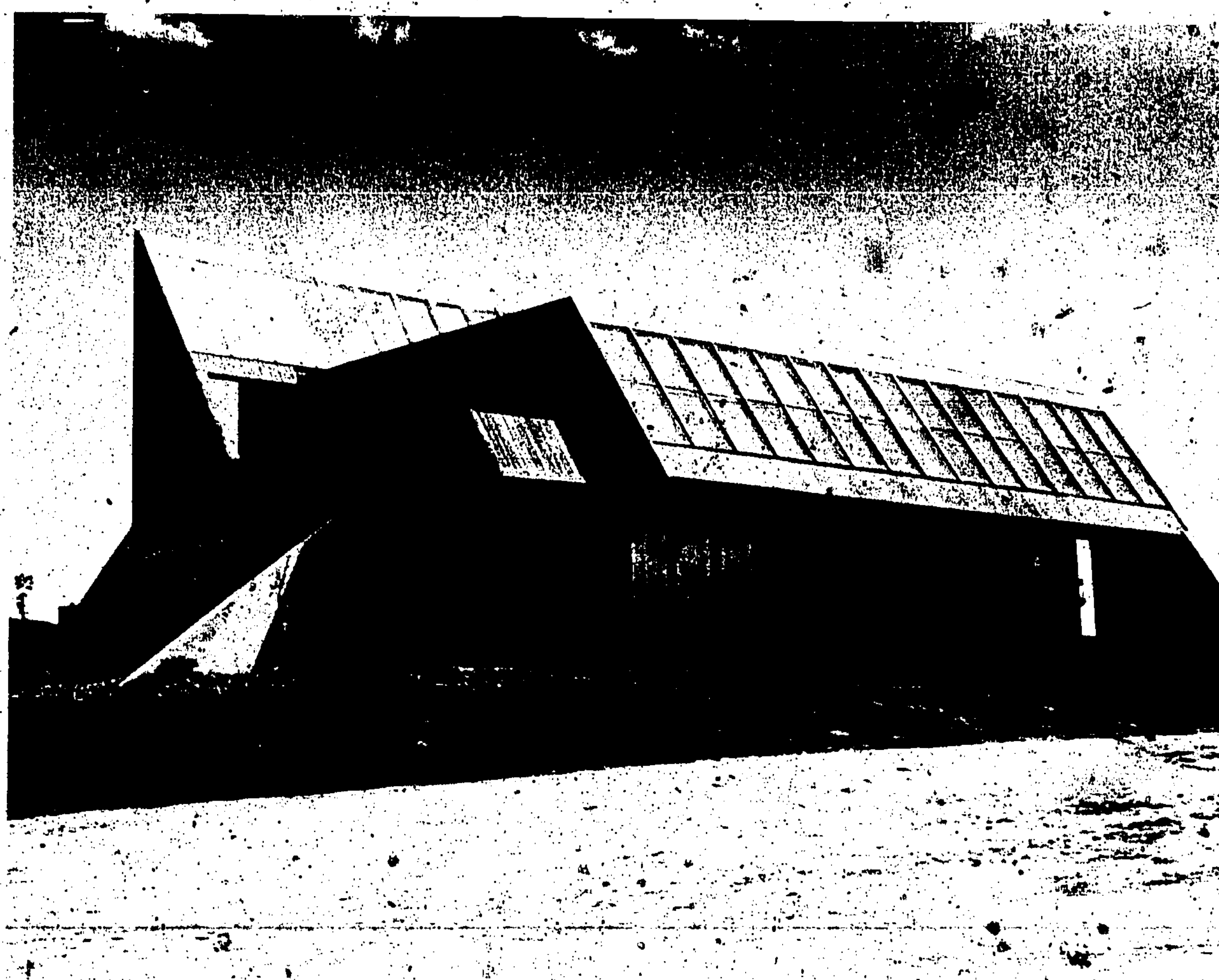


Figure 9. SOLAR HOUSE. This solar house, which has solar collector panels in the roof, was built by the Phoenix Corporation. The Corporation is a nonprofit entity established in Colorado Springs, Colorado, by a group of interested citizens with the encouragement and support of the city government. Financial support for the instrumentation of the solar system and data analysis is being provided through NSF's Research Applied to National Needs (RANN) program. (Courtesy of Phoenix of Colorado Springs, Inc.)

The demonstration house is a two-story structure with 2,200 square feet of floor space. The solar heating system consists of a flat-plate collector which is integrated into the roof structure and a hot water storage tank. It uses a heat-transfer medium called Dowtherm J in distilled water to transfer heat from the collectors to the storage tank. Dowtherm J is a noncorrosive heat transfer fluid with excellent stability from 100° F to 575° F. An air-to-air heat pump supplements the solar heating system and provides cooling in the summer.

The commercially fabricated aluminum collector plates, which make up one side of the roof, are covered with two sheets of tempered glass. Glazing frames for the collectors are built locally. The aluminum plates are separated from the interior of the roof by three inches of fiberglass insulation. The collectors cost $3.88 per square foot to build, which is less expensive than self-contained collectors.

Phoenix of Colorado Springs, Inc., has the cooperation of local banks, home builders' associations, the American Institute of Architects, and the National Society of Professional Engineers. It is sponsoring programs to foster consumer acceptance of solar homes as well as to examine the legal implications and economics of solar heating. Insurance companies and mortgage institutions are being educated in order to gain their acceptance of solar-heated homes.

The Colorado Springs demonstration is significant for two reasons. First, it is an outstanding example of local governmental action to ease a public hardship caused by the energy shortage, and second, it shows the extent to which the private sector must become involved in order to make solar energy a reality.

The National Science Foundation's RANN program is sponsoring a demonstration of a combined solar heating and cooling system in Santa Clara, California. This demonstration involves the design of a solar collector system which is to provide 75 percent of the heating and cooling requirements of the newly designed 27,000-square-foot Santa Clara Community Center. Auxiliary energy will be supplied by a gas-fired boiler.

The solar collector area is 6,500 square feet. The cooling system consists of three 25-ton absorption water chillers which are operated directly by using heated water (at 230° F) from the collectors. In the summer the chilled water is stored in a 50,000-gallon insulated tank and circulated through fan-coil heat exchanger units throughout the building when cooling is desired. During the heating season, hot water is stored in a 10,000-gallon thermal reservoir and pumped through the fan-coil units as required. The Santa Clara Center is to have automatically controlled pumps and flow dividing valves so that the system can provide heating and cooling to different parts of the building simultaneously. Solar energy supplied by the collector will furnish 65 percent of the energy demand at "maximum" summer conditions and 84 percent of the annual heating and hot water needs of the community center.

For more specific information on the applications of solar energy to public buildings as well as to residences, contact:

Mr. Raymond H. Fields
Director, Public Technology Projects
National Science Foundation
1800 G Street, N.W.
Washington, D.C. 20550

Mr. R. R. Lewchuk, Project Manager
Glass Division, New Project Development
PPG Industries, Incorporated
1 Gateway Center
Pittsburgh, Pennsylvania 15222
(412)434-2645

A. A. I. Corporation
P.O. Box 6767
Baltimore, Maryland 21204
(301)666-1400

Mr. John Mockovciak, Jr., P.E.
Deputy Director, Energy Programs
Energy Systems Division
Grumman Aerospace Corporation
Plant #30
Bethpage, New York 11714
(516)575-3785

Solar Heating and Cooling Demonstration Project
U.S. Department of Housing and Urban Development
Room 8158
Washington, D.C. 20410

Phoenix of Colorado Springs, Inc. (The Phoenix Corporation)
3020 N. El Paso
P.O. Box 7240
Colorado Springs, Colorado 80933
(303)633-2633

The Solar Heating and Cooling Demonstration Act of 1974 (Public Law 93-409) appropriated $50 million over the next five years to provide for the development and demonstration of solar heating systems for use in residential dwellings and commercial buildings. The provisions of this act, which is to expedite the widespread commercial application of solar heating and cooling technologies, will be administered by the National Aeronautics and Space Administration, the Department of Housing and Urban Development, the Department of Defense, and the National Bureau of Standards.

Solar energy seems to offer promise as an alternative energy source available in the near term. Nevertheless, the potential user is well-advised to weigh both the advantages and disadvantages. There are several disadvantages. First, the initial costs are higher than for conventional heating and cooling systems. These "extra" costs include the solar collectors, storage tank, plumbing, pumps, and installation. Second, an alternative energy source such as gas, oil, or electricity is required to back up the solar conditioning system when an extended period of cloudy weather exhausts the storage capacity. This alternate system involves additional equipment, material, and installation costs. Third, solar energy systems could possibly require building code and land use zoning changes. Zoning changes would be required, for instance, to protect the sun space of a building from shading by other buildings. This could present a difficult problem for central business districts. Fourth, solar energy hardware represents relatively new technologies and, consequently, component service lifetimes are not yet known. Also, servicing could be a problem. Fifth, solar collectors may cause structural design and aesthetic problems. Professional architectural or engineering services are required.

Additional research and development is now being sponsored by the National Science Foundation and the U.S. Department of Housing and Urban Development to overcome some of these obstacles to the widespread use of solar heating systems.

Localized Power Generation

Installing solar energy devices is one way of supplementing the use of fossil fuels for hot water and space heating and cooling, but utilization of the most efficient sources of electrical power must also be a major planning consideration. State, county, and city governments should look into the economics of localized power generation for meeting the electricity needs of large public and institutional buildings, particularly those that may be located some distance from a central power station. Localized generation simply means on-site electric power generation for a particular building or cluster of buildings. One method of providing localized power generation that is more energy-efficient than conventional fossil-fuel plants is through utilization of a total energy system (see Figure 10).

A total energy system provides electrical power, hot water heating, and air conditioning by recovering waste heat from the electric generating plant. In a gas-turbine generator plant, the exhaust gases pass through a waste heat boiler which extracts their energy to heat water or to produce steam at low or medium pressures. In a gasoline or diesel-engine generating plant, both the engine-jacket cooling water and hot exhaust gases pass through a heat exchanger which heats water or produces low-pressure steam. In this way, total energy systems are capable of extracting over 60 percent of the potentially available energy from fuel, whereas standard electric generation plants extract only 40 percent at best.[31]

Total energy plants are best suited for meeting energy needs at locations relatively far removed from a central power station where the energy demand is relatively constant. The heating, cooling, and electricity requirements of the buildings served by total energy systems must be well-balanced, both in quantity and time. Maintenance costs per kilowatt hour are generally higher for this type of plant, but if the choice is between expanding central plant capacity or constructing a total energy plant, the latter usually represents a smaller capital investment.

Southern California Edison has successfully integrated total energy systems into its regional power network. The electric utility company installs, operates, and maintains total energy plants for selected customers. These customers use the hot water and steam produced by the total energy power plant for domestic hot water, space heating, and space cooling. (For cooling, the steam or hot water is used to power chillers.) Electric power deficiencies or excesses are balanced by the regional power network. This arrangement solves maintenance problems for the customer.

Jersey City, New Jersey, is operating a large-scale total energy facility with funding from the U.S. Department of Housing and Urban Development. This plant serves a complex of five apartment buildings, an office building, and an elementary school. Electric power, space heating, air conditioning, and domestic hot water are provided by the plant. The complex is connected to the utility network of the Public Service Electric and Gas Company only for emergency power. Supplementary boilers

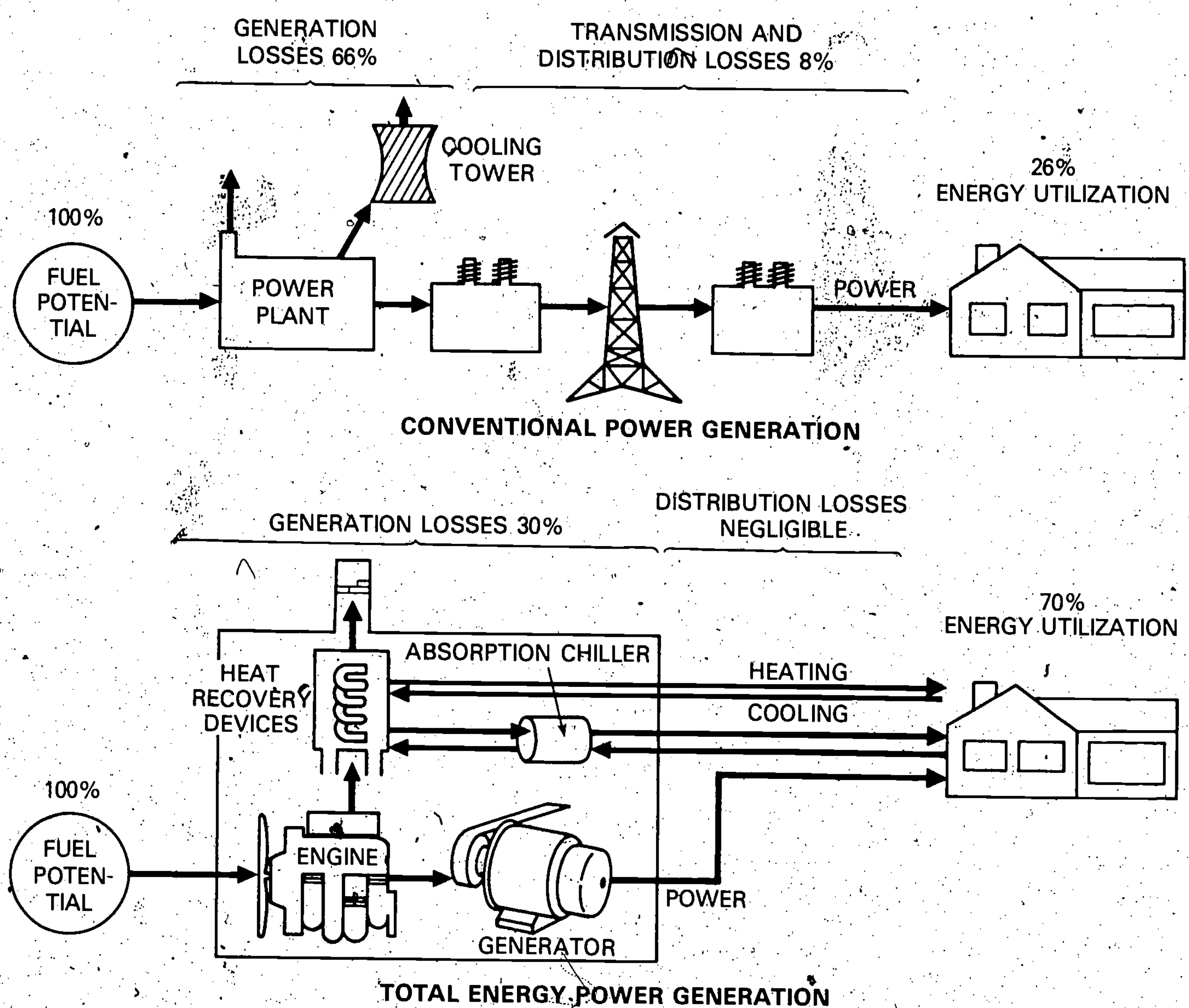


Figure 10. CONVENTIONAL VS. TOTAL ENERGY POWER GENERATION. This illustration compares two ways of delivering electric power to a building—by a conventional central power station with transmission lines and by a total energy system. The total energy system has over twice the energy utilization efficiency because most of the "waste heat" from the engine generators is recovered for use in heating and cooling the building. In central station power systems, generation losses as well as transmission and distribution losses are not recovered. (Courtesy of U.S. Department of Housing and Urban Development)

provide hot water when the electric power demand is so low that too little waste heat is generated.

The major components of the total energy plant are five diesel engine-driven generators, each with heat recovery mufflers and heat exchangers, two supplementary boilers, and two absorption chillers. The diesel engines burn #2 low-sulfur oil so there is no need for pollution control equipment. The five generators together have a peak capacity of three megawatts. One of the generators is intended as a standby.

A total energy plant compares favorably with conventional power and heating plants. As stated above, in a total energy plant, over 60 percent of the energy input can be utilized as either electricity, heat, or cooling. The electric power output of a conventional power plant is at best 40 percent of the energy input. Conventional heating plants generally have peak efficiencies of about 70 to 80 percent. Cost comparisons are difficult to make between total energy plants and conventional electric power or heating plants. However, in the Jersey City plant it is believed that the cost of electricity, heating, and cooling is considerably less than would have been the case if these energy needs had been met through the electric utility and a separate heating plant.[32]

Total energy systems become viable alternatives when four conditions are present: first, when a single developer or public agency constructs, owns, and operates a large high-density housing development or office building complex; second, when difficulties are encountered in siting large new central power stations or in expanding existing stations; third, when a relatively stable balance exists among demands for electricity, heating, and cooling; fourth, when air conditioning places a heavy demand load on electric energy facilities during peak hours. The primary drawback to the use of total energy systems is that they generally burn oil, although some do burn coal. For more specific information on total energy systems contact:

Mr. Jerry Leighton
Division of Community Development Research
U.S. Department of Housing and Urban Development
451 - 7th Street, S.W.
Washington, D.C. 20410
(202) 755-6878

Gamze-Korobkin-Caloger, Inc.
205 West Wacker Drive
Chicago, Illinois 60606
(312) 641-5988

Checklist Most of the energy conservation measures presented below were compiled by the Office of Energy Conservation of the Federal Energy Administration and published in the *Congressional Record* on October 30, 1973. Others are recommendations contained in *Energy Conservation Design Guidelines for Office Buildings* issued by the General Services Administration. Again, the effectiveness of any one measure will depend on the building type, size, intended use, climatic region, and other factors. Architects and consulting engineers must assess the appropriateness of each measure in the process of planning and designing new buildings.

Initial Design Considerations

- Orient buildings so as to minimize solar heat load in the summer and exposure to cold winds in the winter.
- Orient rectangular buildings so as to optimize the window area exposed to solar radiation (maximize or minimize depending on regional climate).
- Build partially below grade and employ earth berms to reduce solar loads and transmission losses.
- Orient new buildings to take advantage of existing buildings and trees as shields against excessive solar heat gain in the summer and cold wind in the winter.

- Design solar shades, side fins, balconies, overhangs, vertical louvers, or awnings over windows facing south or west to provide summertime shading.
- Plant deciduous trees and vines on the south and west sides of buildings to provide protective shade against summer sun.
- Design buildings for multiple uses. For example, one structure could serve as a school during the day, a community recreational center at night, a synagogue on Saturday, and a church on Sunday.
- Establish maximum energy consumption values in BTUs per square foot of floor space.
- Design heating and cooling systems to maintain desired conditions for all but the 5 percent of the time during which the weather exceeds design conditions. (2.5 percent has been the common design limit. This has resulted in designing systems of excessive size and lower efficiency.)
- Have the building architect help select the site before purchasing it.
- Design new buildings with operable windows or some other means so that natural ventilation can be used to maintain comfortable conditions in moderate weather.
- In the North, minimize the number of windows installed in the north wall where no solar heating gain can be achieved in winter. In the South, put the fewest number of windows in the south and west walls to reduce the summer solar heat load.
- Orient roof surfaces to the south so that solar collectors may be added to the building.
- Do not install electric resistance heating or separate heating furnaces or boilers in new buildings if district heating systems with sufficient capacity pass within 600 feet.
- Bill organizational units for the electricity, gas, space heat, hot water, and air conditioning they use. This will require separate utility metering.
- Install heating-ventilating-air conditioning systems that utilize heat recovery technology. These include heat wheels, electro-hydronic (closed-loop, water-circuit) systems, and heat pumps.
- Use modular boilers instead of a single large boiler. By working at full load more of the time, modular boilers are more efficient than a single large boiler operating at partial load.
- Reduce piping friction and pumping power requirements by using generously sized lines.
- Reduce duct losses and fan power requirements through use of large duct work and variable air flow heating and cooling.
- Exhaust the heat and moisture released in cafeteria kitchens and laundries directly to the outside. This is best accomplished by using double-duct systems that use outside air to remove moisture generated rather than inside conditioned air.
- Situate buildings so that natural screens shield doorways from the wind on the north or west face of the building.
- Require central heating and cooling in designs for new buildings, since central systems are more efficient than individual units.
- Avoid terminal reheat systems unless waste heat is used in the reheat loop. While they provide good humidity control in air

conditioned buildings, they consume fossil fuels during the cooling cycle.

- Select hot water heaters with high efficiency and insulation having high thermal resistance (R value).
- Design buildings to make maximum use of natural light year-round, consistent with efforts to reduce heat flow through windows.
- Design fixtures for one large bulb rather than several smaller ones.
- Choose fluorescent rather than incandescent lamps.
- Use fluorescent fixtures with long bulbs since these are more efficient than those with short bulbs.
- Avoid the use of energy-inefficient "long-life" incandescent lamps. Check the "lumens per watt" rating.
- Use lighter colors for walls, rugs, draperies, and furniture to reduce the amount of artificial lighting required.
- Cut down the lighting in garages and parking lots to an extent compatible with security.

Low-Cost Measures (2-Year Payback)

- Make use of special window glass having desired heat-reflecting or heat-absorbing characteristics as appropriate.
- Weatherstrip and caulk where air infiltration is contributing to heat loss (or adding to the cooling load in the summer).
- Install demand limiters to reduce the peak electric load. If this were done by all large power users, the electric utility could reduce the use of inefficient peaking units.
- Install power-factor correction equipment. This is particularly important when electric motors consume a significant portion of the electric energy in a building.
- Install controls to start up the heating plant automatically each morning and shut it down at night, with timers adjusted automatically in response to outside air temperature.

Moderate-Cost Measures (5-Year Payback)

- Provide a separate temperature control zone for each office if the building is electrically heated.
- Employ heating and cooling energy storage systems to reduce peak demands and improve overall efficiency.
- Install solar hot water heaters to lighten the load on electric or gas-fired hot water heaters.
- Design buildings with a vestibule or second set of doors at lobby entrances to reduce loss of heated or cooled air.
- Use natural draft cooling towers in lieu of mechanical draft towers.

IV.

PUBLIC VEHICLE FLEET MANAGEMENT

Next to the operation and maintenance of public buildings, the biggest potential for energy conservation in state and local government lies in fleet management. State and local governments operate approximately half a million automobiles, a million trucks, and 200,000 buses, plus a large number of miscellaneous other rolling stock.[33] These vehicles consume approximately 1.5 billion gallons of gasoline and diesel fuel per year. This is an appropriate activity for emphasis because it was public fleet operations that were most affected by the recent fuel shortages. This section on public fleet management is divided into four subsections—vehicle operations, vehicle maintenance, vehicle modification and replacement, and a comprehensive fuel conservation checklist.

Vehicle Operations

Many common-sense measures can be taken to conserve fuel in public fleet operations. Several matters to investigate are operator training, servicing, vehicle routing, vehicle job assignments, and fuel allocation.

The vehicle operator should be trained to be conscious of fuel economy. Minor eccentricities such as tapping the gas pedal can reduce fuel economy. Driving with a steady foot is one of the best ways to conserve fuel. The driver should maintain a steady speed for as long as traffic conditions permit because varying speed by five miles per hour can reduce fuel economy by as much as 9 percent.[34] Also, operators should never gun a vehicle's engine to warm it up, since the automatic choke feeds an extra-rich fuel mixture to the carburetor if the engine is cold. Running a cold engine at too high a speed is also extremely damaging to the engine.

It is important to accelerate gradually from a stop, since "jackrabbit" starts can increase gasoline consumption by as much as 18 percent. High speeds should also be avoided; driving 70 miles per hour can use about 22 percent more gasoline per mile than driving at 50 miles per hour.[35] The driver should not leave the engine idling when the vehicle is parked, except for diesel engines which should be idled for several minutes. In fact, engines should be turned off whenever the vehicle will be motionless for one minute or longer. One minute of idling uses more fuel than it takes to restart the engine. Air conditioners should not be used unless absolutely needed. A car air conditioner drains enough engine power to use almost one-and-a-half gallons of gasoline in each tankful.

The vehicle operator should also be trained to follow certain conservation measures along with regular servicing. The operator should assure that tires are kept fully inflated because the drag caused by underinflated tires can result in a decline in fuel economy of 6 percent.[36] Some tire manufacturers recommend inflating tires by about four pounds over the normal inflation level (not to exceed the inflation limit, which is usually 32 psi for passenger vehicles). The operator should assure that the vehicle is filled with the octane-rated fuel recommended by the manufacturer for optimal gasoline economy. Also, the operator should be sure that the tank is not filled to the point of overflowing. Finally, the operator can save some fuel by removing extra weight—each 100 pounds of weight reduces gasoline mileage by about 0.2 miles per gallon.[37]

The vehicle dispatcher should assure that the correct vehicle is used for each job assignment. Also, jobs should be combined where possible. A small, lightweight vehicle should be used for inspections and errands. Motor scooters and even bicycles are appropriate for some short trips. Transfer trailers should be considered for long-haul refuse disposal runs provided that a system of transfer stations and trailers is determined to be more economical than direct haul by a refuse collection truck. Short trips generally consume more fuel per mile than longer trips because a cold engine gets poorer fuel economy. In a test conducted by the Motor Vehicle Manufacturers Association, a vehicle started cold and driven four miles averaged eight miles per gallon. The same vehicle started cold and driven 15 miles averaged 11 miles per gallon.[38] Thus, local governments should consider combining inspection functions such as building code and fire prevention inspections. Finally, local governments should consider the use of vehicle routing programs to eliminate unnecessary distance traveled for jobs such as refuse collection, street sweeping, library bookmobile services, and school bus services.

Public Technology, Inc., is developing a Refuse Vehicle Districting Program and Routing Procedure designed to minimize the total distance traveled by refuse collection vehicles. The user determines the total number of collection districts into which he desires to divide the jurisdiction. Using information obtained from a road map and population distribution data, the Refuse Vehicle Districting Program (a computer program) determines the configuration of the most compact set of collection districts. Assigning one truck to each district will equalize the work load among all collection trucks. Once collection districts are determined, the routing procedure is used for selecting the best route to cover all the streets within each district. Routes are constructed by using a simple manual procedure that eliminates unnecessary retracing. Thus, the length of each collection route is minimized. A training program is being developed to assist local government personnel in using the Districting Program and Routing technique. Figure 11 illustrates one type of vehicle routing pattern.

International Business Machines Corporation has developed a vehicle scheduling program that can be used to determine routes and schedules for school buses. The program analyzes a network, representing the potential calling points, by computing either actual or approximate distances between all points. It then produces schedules that meet various restrictions, such as route time, speed, and vehicle capacity. The program then combines service points into routes that minimize total

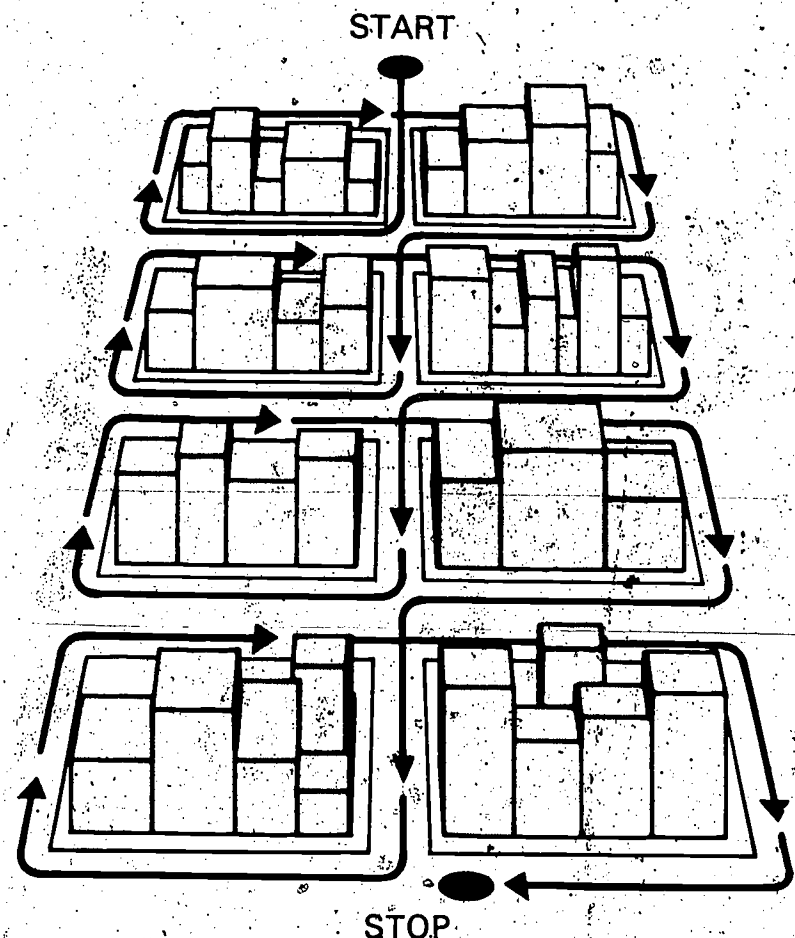


Figure 11. COLLECTION VEHICLE ROUTING. The objective of improved vehicle routing is to minimize travel distance and delay times for a "collection" vehicle such as a school bus or refuse truck, thus using less gasoline or diesel fuel. In the routing pattern illustrated above, collection is made from both sides of a one-way street during the pass. For wide or busy one-way streets, it is necessary to loop back to the upper end and make a straight pass down the other side. (Courtesy of U.S. Environmental Protection Agency)

travel distance. For more information about the Vehicle Scheduling Program Extended, contact:

Mr. Robert Kennedy
International Business Machines Corporation
Cross Industry Support Center
1133 Westchester Ave.
White Plains, N.Y. 10604
(914)696-3700

State and local governments should prepare contingency allocation plans for both gasoline and diesel fuels. In addition, several jurisdictions have found it desirable to centralize all fuel purchasing and distribution under one department such as finance, purchasing, or general services. Fuel consumption records should be maintained for each vehicle and by each department or function (see Figure 12). The information required for calculating fuel economy for each vehicle can easily be obtained at the pump. Well-maintained fuel management records can aid in the

Gas Truck or Pump No. ______
Sheet No. ______

GAS AND OIL RECORD
BUREAU OF MUNICIPAL EQUIPMENT
City of Milwaukee

Location ______
Date ______

Form ME-5

PLEASE WRITE LEGIBLY	STICK	MOTOR FUEL	STICK		OIL				AUTO. TRANS FLUID	ANTI FREEZE	
	GASOLINE		DIESEL FUEL		MOTOR OIL		HOIST OIL				
STARTING INVENTORY,		METER READING		METER READING		METER READING		METER READING			TIME ISSUED
Equip. No.	Gals.		Gals.		Qts.		Qts.		Qts.	Qts.	
RECEIPTS											
Ending Meter											
Beginning Meter											
Total Disbursed											

METROPOLITAN DADE COUNTY
MOBILE EQUIPMENT
SERVICE STATION ISSUES
THIS TICKET WILL BE DATA PROCESSED!
ALL INFO. MUST BE COMPLETE: CORRECT & LEGIBLE.

DATE ______ 19 ______ Equip. No. ______
ODOMETER READING ______ MILES ______ 10 TENTHS
DEPT. - DIVISION CODE NO.

Accounting Only - Do Not Use

AMOUNT	UNIT	DESCRIPTION		PRICE	AMOUNT
.	Gals.	Gasoline - Reg.	A		
.	Gals.	Gasoline - Prem.	B		
.	Gals.	Diesel Fuel	C		
	Qts.	Motor Oil - SAE ___	D		
	Lbs.	Trans. Grease	E		
	Qts.	Auto. Trans. Fluid	F		
.	Gals.	Kerosene	G		
.	Gals.	L. P. Gas	H		
	Qts.	Hydraulic Oil	J		
	Pts.	Molylube (Chassis)	K		

TICKET NO.
1- 153201
Issued By ______
Rec'd By ______
Signature
Uarco Business Forms

Figure 12. GAS AND OIL MONITORING. Recording forms and fuel tickets such as these are part of an equipment management system. By keeping track of how fuel and oil is consumed, vehicle fleet managers have essential information for evaluating energy conservation measures for vehicle fleets. (Courtesy of Dade County, Florida, and the City of Milwaukee, Wisconsin)

selection of new vehicles and can be used to provide an incentive to operators to be "energy conscious" in operating vehicles. Each department or function should establish service priorities so that less essential services can be cut back in the event of fuel shortages. For additional information on saving gasoline, a brochure entitled *GSA Tips for Conserving Gasoline* can be obtained by writing to:

Federal Supply Service
General Services Administration
18th and F Streets, N.W.
Washington, D.C. 20406

Vehicle Maintenance

A vehicle preventive maintenance program offers several opportunities to save gasoline and diesel fuel. A maintenance check with a tune-up should be performed on all vehicles every 10,000 miles and more frequently on those vehicles that operate at slow speeds or make frequent starts and stops, such as refuse collection vehicles. A spark plug misfiring half the time can reduce fuel economy by about 7 percent.[39] A vehicle in need of a tune-up (new points and spark plugs) may be wasting as much as 20 percent of its fuel consumption. Similarly, filters and pollution control devices should be checked regularly. A dirty air filter can cause as much as a 10 percent loss in fuel economy. Based on fuel consumption records, a motor vehicle fleet manager can easily determine the dollar cost of inadequate maintenance.

The Public Technology, Inc., Equipment Management System will provide a computer-based program for monitoring the fuel consumption of all motor vehicles in a jurisdiction's fleet. Gasoline or diesel fuel dispensed is recorded along with the vehicle identification number and mileage. The program analyzes these data so that average gas mileage by vehicle class can be compared. A master record for each vehicle is created which signals when maintenance is required to significantly improve fuel economy. By maintaining a continuous fuel consumption record, the program permits evaluation of gasoline conservation measures. Also, the information collected is used to help decide when is the best time to replace a particular vehicle.

State and local government fleet managers should collect used lubrication oil as a conservation measure. Many jurisdictions have, in the past, been paying private contractors to haul it away. With higher petroleum prices the picture has completely changed. For example, a contractor was charging Kansas City, Missouri, three cents per gallon in 1973 to haul away waste lubrication oil collected from city vehicles. The same contractor is now *paying the city* one cent per gallon for the same oil. The petroleum shortage has motivated Americans to search for new uses for a substance which was once considered "waste."

Industry is experimenting with the use of recovered lubrication oil in the manufacture of asphalt products. As asphalt prices have been climbing, this process should prove cost-effective. The use of recovered lubrication oil as a fuel supplement has been considered. However, the air pollution emissions which have resulted from waste oil combustion have proven to be a potential health hazard. Fairfax County, Virginia, for example, ran an experiment in which recovered lubrication oil was used as a fuel supplement in the boilers of school buildings. After measuring the lead emission levels, the experiment concluded that the lead represented a long-term health hazard. The experiment has been terminated.

Vehicle Modification and Replacement

State and local governments should be alert for any vehicle equipment modifications that promise to help conserve gasoline or diesel fuel. One fuel-conserving measure is to use trailers with small vehicles to handle an occasional big load. In this way the vehicle weight during normal operation is minimized. Although use of radial ply tires has been promoted as a gas-saving and safety measure, a recent study by the Law Enforcement Standards Laboratory of the National Bureau of Standards warns against their use for police patrol cars. The study found that such tires may blow out at high speeds, as the tire becomes overheated and the rubber tread lets go of the steel belts. The NBS study documents two deaths and another 20 nonfatal accidents caused by high-speed blowouts of radial ply tires.[40] Thus, while tire replacement may be a useful area to consider in vehicle modifications to conserve energy, the use of steel radials in high-speed vehicles is not advisable. Other areas to investigate include lubricants, air filters, carburetors, oil filters, exhaust manifolds, mufflers, spark plugs, and pollution control equipment.

State and local governments should begin to take energy conservation measures into account in preparing specifications for replacement equipment. A new vehicle with a lower gross weight than another will get better gasoline mileage, as a general rule. Also, a new vehicle with lower horsepower usually will get better mileage. Vehicles with lower axle-to-wheel ratios generally get greater gasoline mileage also, especially if the vehicles have automatic transmissions. A higher engine compression ratio gives improved fuel economy—a 10 percent increase saves somewhere between 0.3 and 0.5 miles per gallon. Similarly, a lower engine displacement promises better economy—a 10 percent decrease saves about 0.2 miles per gallon.[41] For more information about fuel economy in new vehicles, contact:

Mr. Harry Weaver
Motor Vehicle Manufacturers Association
320 New Center Building
Detroit, Michigan 48202
(313)872-4311

The U.S. Department of Transportation (DOT) is currently conducting research into methods of improving fuel economy in the design of new automobiles. DOT's Automobile Energy Efficiency Program is studying the feasibility of lean burning engines, catalytic burners, transmission improvements such as four-speed and continuously variable transmissions, and torque converter lockups which reduce fuel consumption during idling. The Aerospace Corporation is testing a number of retrofit devices that can be attached to carburetors to improve fuel economy. Two state-of-the-art evaluations by the Arthur D. Little Company and the Southwest Research Institute are scheduled for publication during 1975. For further information about the Department of Transportation automotive research program, contact:

Dr. Richard Strombotne
Office of Systems Engineering
Energy and Environmental Division
Department of Transportation
400 Seventh Street, S.W.
Washington, D.C. 20590

Checklist The Federal Energy Administration has prepared some suggestions for achieving greater fuel economy in vehicle fleet operations. State and local governments should evaluate each suggestion on its own merits.

These conservation tips appear to be technically and economically sound, but common sense should determine their application in a specific situation. Some measures could require a more detailed analysis to include such factors as labor and equipment costs, fuel savings, and operating lifetimes. Please consult with the manufacturer's automotive engineers.

- Conduct a maintenance check every 10,000 miles; more often for slow-moving vehicles or those making frequent starts and stops.
- Use the air conditioner only when necessary.
- Use the lightest vehicle appropriate for the job.
- Use subcompact vehicles when high acceleration is not required.
- Collect waste lubricating oil for sale or reuse if a market for it is nearby.
- Combine inspection teams to reduce the number of trips.
- Buy diesel rather than gasoline-powered vehicles, if appropriate.
- Check factors contributing to improved fuel economy such as gross weight, engine displacement, axle ratio, and transmission ratio before purchasing new vehicles.
- Centralize fuel purchasing and allocation.
- Plan the most efficient vehicle routing.
- Operate vehicles on the lowest octane fuel consistent with performance.
- Rank fuel-consuming services so priorities are established for periods when fuel is scarce or unavailable.
- Remove excess weight from vehicles.
- Use trailers to increase vehicle payloads when the vehicle is occasionally used to carry such a load but under normal operation would not need the carrying capacity.
- Use waste oil for fueling construction equipment and other "off-road" vehicles, provided this is consistent with the manufacturer's recommendation.
- Train drivers to go at a steady moderate speed, to turn off the engine when stopping for more than one minute (except for diesel engines), and to keep tires properly inflated.
- Train drivers to avoid gunning the engine to warm it up and to avoid "jackrabbit" starts.

V.

ENERGY CONSERVATION IN THE PRIVATE SECTOR

This Technical Guide has thus far focused on energy conservation measures that state and local governments may undertake on their own operations. In addition, however, governmental measures can significantly influence private-sector use of energy. Specifically, state and local governments should consider ways to control energy use in residential and commercial buildings, transportation services, and industry. This chapter discusses each of these private-sector energy users and suggests governmental actions to control their uses of energy. Figure 13 provides an overview of how energy is used in the United States within the private sector.

Residential and Commercial Buildings

State and local governments should be concerned with energy conservation in private residences and commercial buildings since these structures consume about one-third of the nation's energy. The primary role of state and local government in promoting energy conservation in privately owned buildings should be to influence certain individual choices that affect energy demand. These choices are made by builders, prospective home buyers, those who are contemplating home improvements, and companies which are considering buying or building new facilities.

A local jurisdiction's program for promoting energy conservation in privately owned buildings should be based on government's consumer education role. (See listing of sample educational literature in Appendix C.) As heating fuels and electricity become more costly, it is in the building owner's best interest to take actions which minimize utility and fuel bills. Examples of consumer education programs are:

- Providing information on the energy consumption of various household appliances and the relative energy efficiencies of different brands of the same appliance.
- Promoting home improvements which reduce heating and air conditioning energy costs.
- Helping prospective buyers select homes with energy-conserving features such as adequate insulation.

Another type of action that local governments should consider is the use of planning controls and incentives to assure that new residential and commercial construction is consistent with the community's energy conservation goals. One recent innovation, the energy impact statement,

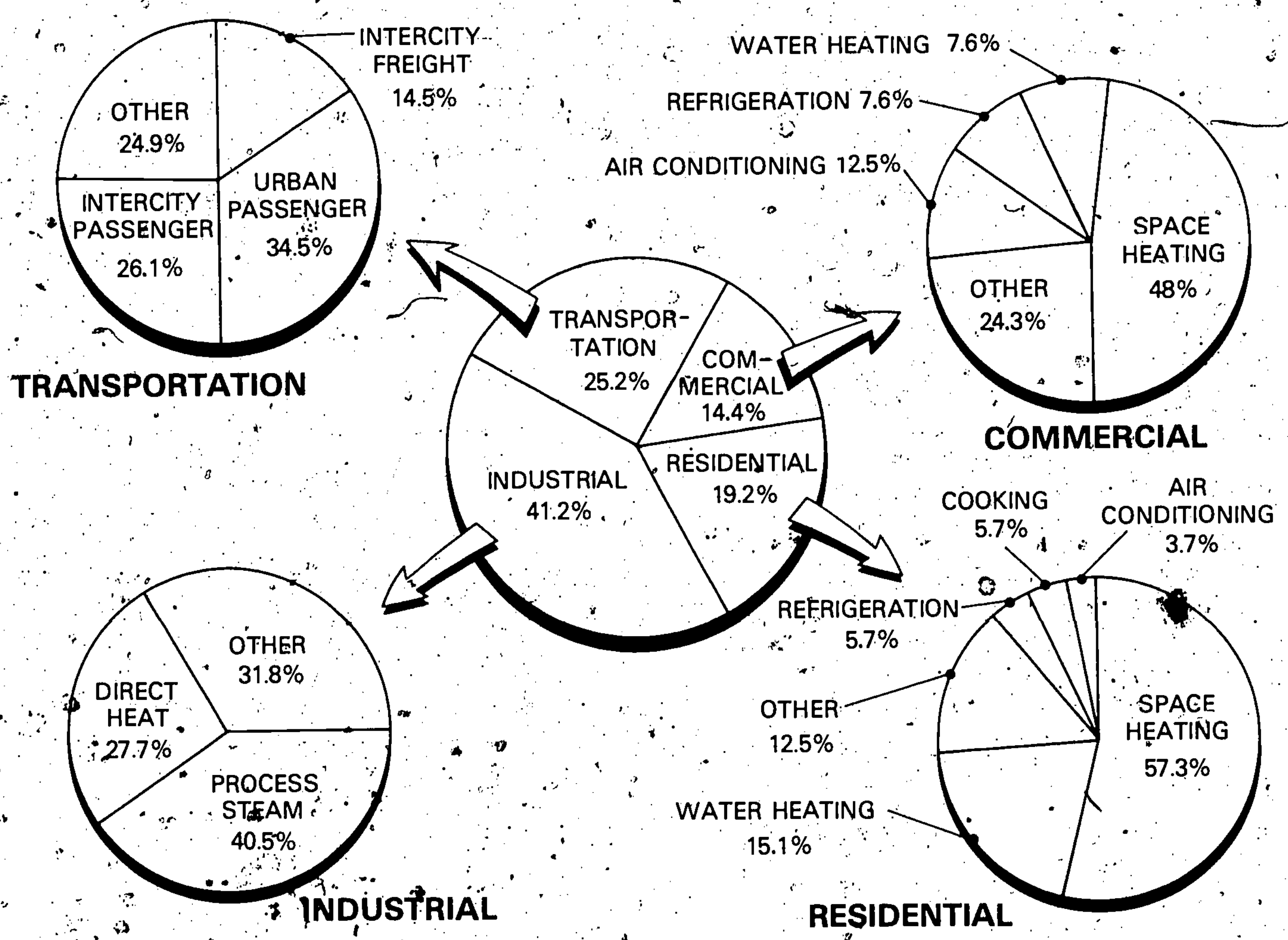


Figure 13. HOW ENERGY IS USED IN THE UNITED STATES. This figure illustrates the national energy consumption pattern in 1973 by sector and within each of the four sectors. Government consumption is not shown, as it is a very small percentage of total consumption. The transportation, residential, and commercial sectors together account for over 58 per cent of total national energy consumption. Energy use in these sectors is most responsive to state and local government policy. (Courtesy of U. S. Atomic Energy Commission)

may enable local jurisdictions to manage the growth in energy consumption brought about by new commercial and residential developments. A more stringent use of government regulation in this regard is the enactment of building code provisions which set standards for energy conservation in new construction.

This section on energy conservation in residential and commercial buildings addresses four action areas for local government programs—planning controls, home heating, air conditioning systems, and thermal insulation. Table 5 illustrates the national energy consumption pattern for residential and commercial buildings. These figures of course vary widely from one geographic region to another. However, they should aid governments in setting relative priorities for a residential and commercial energy conservation program.

Table 5 RESIDENTIAL AND COMMERCIAL ENERGY CONSUMPTION PATTERNS

Energy use	Percentage
Space heating	53%
Water heating	12
Air conditioning	8
Refrigeration	7
Lighting	5
Other electrical	5
Cooking	4
Clothes drying	1
Miscellaneous	5
Total	100%

SOURCE: National Bureau of Standards, *Technical Options for Energy Conservation in Buildings* (Washington, D.C.: U.S. Department of Commerce, 1973), p. xi.

Planning Controls

Most buildings, both commercial and residential, have been constructed with primarily initial cost in mind. Little consideration is generally given by architects, engineers, and builders to the energy costs for heating and air conditioning that will have to be paid over the lifetime of the structure, although the cumulative operating costs may equal or possibly exceed the first cost of the building. Because builders have an incentive to keep construction costs (and therefore purchase price) down, they usually have not installed energy conserving features when these features would have added to the cost of a home or office building. Unfortunately, prospective buyers generally do not possess the information necessary to distinguish between a building which has been well-designed from an energy conservation standpoint and one that has been poorly designed.

Local and state government consumer affairs departments can aid prospective home buyers in estimating the annual energy costs for heating and air conditioning. Builders could be required to supply the necessary information about heating and cooling equipment to the buyer. Standard procedures for calculating projected energy costs of a new house have not yet been developed, however, although energy efficiency ratings are available for some appliances such as room air conditioners.

Another way to encourage energy savings might be to require that a certain portion of new housing be in high-density planned developments. Multiple-family dwellings, in general, require less energy for space heating and cooling per dwelling than do single-family detached houses. Also, high-density planned residential development facilitates the use of less energy-intensive transportation modes. A recent study prepared by the Real Estate Research Corporation (sponsored jointly by the U.S. Department of Housing and Urban Development and the Environmental Protection Agency) estimates that a high-density, planned residential development uses approximately 44 percent less energy than a low-density sprawl community with the same number of dwelling units. The prototype high-density community used in the study consisted of 40 percent high-rises (six-story apartments), 30 percent walk-ups, 20 percent townhouses, and 10 percent clustered single-family homes.

To assure that proposed residential and commercial development does not overburden a community's energy resources, jurisdictions should consider requiring builders of large developments to submit an "energy impact statement" along with plans for a proposed project. Energy impact statements (analogous to environmental impact statements) would require the builder to calculate the projected energy demand for the entire development, justify his selection of heating and air conditioning systems, and consider several alternatives for supplying the energy needs of the buildings. (For example, the builder should provide evidence that he has considered on-site power generation and district heating and cooling systems.)

The energy impact statement is a very new concept, and its limited application has yet to be evaluated. The use of an energy impact statement has been explored by the Center for Environmental Studies at Princeton University under a grant from the NSF Research Applied to National Needs program. The Center has been studying how the planning and development process influences the energy consumption of dwelling units in a planned unit housing project at Twin Rivers, New Jersey.

The subject of energy conservation standards for new buildings has attracted much attention and controversy over the past year. First, there is not yet a consensus among state legislatures that local governments have the legal authority to legislate such conservation standards. The authority to establish building codes is founded on government's role in protecting the health and safety of the public. Requiring compliance with an energy conservation building standard must be shown to be based on this legal principle.

Second, there is danger in a local jurisdiction's unilaterally legislating energy conservation standards for buildings. If the standards differ from one jurisdiction to another, manufacturers will not be able to supply standard materials and equipment to builders but will have to customize equipment for new buildings in each jurisdiction. This would have the very undesirable effect of unnecessarily driving up the cost of new construction or hindering it altogether. Also, locally originated energy conservation building standards could actually become counterproductive as new construction technological capabilities are developed, unless the standards were continually revised. To do such revisions would require research beyond the capabilities of many jurisdictions. Also, there are political obstacles to frequent building code revisions.

To remedy this situation, there has been a movement toward establishing a uniform nationwide energy conservation standard for new buildings. This movement was initiated by the National Conference of States on Building Codes and Standards (NCSBCS), which requested that the National Bureau of Standards (NBS) develop an interim standard for energy conservation in new buildings for consideration by the various state legislatures. After consultation with representatives of the building professions, NBS published a report entitled *Design and Evaluation Criteria for Energy Conservation in New Buildings* (NBSIR 74-452).

In his letter transmitting the NBS Report to the NCSBCS, the Director of the NBS Institute for Applied Technology stated, "It is also our recommendation that the states be advised not to use the document in its present form for regulatory purposes." Subsequently, the NCSBCS requested the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) to work further toward the development of a draft standard for energy conservation. Utilizing the NBS document as a technical base, ASHRAE has developed its Draft Standard 90P. This standard has recently been circulated for review within a consensus process. If the draft standard is approved (early 1975), it will be submitted to the American National Standards Institute (ANSI) to become an ANSI Standard. State and local jurisdictions could then reference the Standard in their building code legislation and allow for its administrative adoption.

The stated purpose of this proposed Standard is to provide performance-oriented criteria for designing buildings with high thermal resistance and low air leakage, and designing improved mechanical and electrical systems which promote the efficient use of energy. The criteria are intended to be flexible, encouraging designers and architects to use innovative procedures and techniques which achieve efficient utilization of energy. Also, the proposed Standard is to be continually reviewed and updated by ASHRAE so that it will reflect the changes in the state-of-the-art of building design.

Government officials should be aware of the position taken by the American Institute of Architects regarding the ASHRAE Draft Standard 90P:

> The present state of the art is such that no reliable standards can be set and the adoption of the standards approach in formal legislation even to the practices which are recommended in this present draft document may retard the nation's realization of its greatest potential in conserving energy in buildings. AIA emphasizes that its Energy Steering Committees have been analyzing the matter for more than a year and have come to the following conclusions:
>
> 1. Within the present state of knowledge we do not know exactly how and under what conditions certain actions might be effective.
> 2. Even if we did know these details, the variations of building situations would tend to make the "standards approach" ineffective.
> 3. We lack adequate knowledge of the psychological and physiological relationships of some energy conserving tactics.
> 4. We can specify many things that might conserve energy but at increased costs of operation.

The AIA does strongly support legislation which provides for broad incentives to conserve energy in all buildings, both new and existing. AIA is preparing a set of recommended criteria for evaluating legislative proposals and plans to issue recommendations for energy conservation legislation in early 1975.

Local governments can, in the meantime, begin training building inspectors in those aspects of code enforcement concerned with energy conservation which are not common practice. For example, inspectors may have to examine the installation of thermal insulation in dwelling units to assure compliance with forthcoming air infiltration and thermal resistance standards.

To obtain a copy of ASHRAE Draft Standard 90P, write to

Mr. Nicholas LaCourte
American Society of Heating, Refrigerating and
Air-Conditioning Engineers
345 East 47th Street
New York, New York 10017

For more information on AIA's work on energy conservation legislation, write to:

Mr. Joseph A. Demkin
Energy Steering Committee
American Institute of Architects
1735 New York Avenue, N.W.
Washington, D.C. 20006

Information on energy impact statements may be obtained from:

Professor Robert Socolow
Center for Environmental Studies
Engineering Quadrangle
Princeton University
Princeton, New Jersey 08540

Adoption of the measures for regulating new building design discussed in this section will have a major impact in future years on a community's total energy consumption. But there are other factors that have a more immediate effect on energy conservation in residential and commercial buildings. Energy audits of such structures show that almost two-thirds of their energy consumption is for comfort conditioning. The next two sections deal with cooling and space heating—the two components of comfort conditioning.

Heating Systems Space heating is the largest single energy use in residences. In an average home in a moderate climate, space heating accounts for over one-half the total energy delivered to the home. Obviously, notable energy and cost savings can be achieved by selecting the most energy-efficient heating systems for new construction. The most common residential heating systems are oil-fired furnaces; gas-fired furnaces; electric resistance baseboard, ceiling, wall, and duct heaters; and electric-powered heat pumps.

The relative merits of fossil fuel versus electric heating have been the subject of considerable controversy. Gas or oil furnaces have certain advantages over electric resistance heating in those parts of the country where gas and oil are sufficiently available and electric generating capacity is deficient. However, the heat pump is an electric heating system which is clearly more energy-efficient than electric resistance heating and, in many parts of the country, even more efficient than oil or gas heating (see Figure 14).

The major advantage in using electricity rather than oil or gas to heat buildings is that electric energy can be generated from a variety of sources—coal, hydroelectric, or nuclear power and geothermal power in some areas, as well as oil or gas. New power plants have the capability of switching to the most available fuel; residential fossil fuel furnaces do not have this flexibility. They are designed to burn only one fuel, and home heating fuels (both gas and oil) are now becoming more limited in availability.

A heat pump is a system in which refrigeration equipment is used in such a manner that heat is taken from a heat source and given up to the conditioned space when heating is wanted; and is removed from the space and discharged to a heat sink when cooling is desired (see Figure 15). Thus, heat pumps also serve as air conditioners. The heat source-heat sink can be either outside air or water. While heat pumps have been used most frequently in offices and other large buildings, reliable heat pumps are available today for homes. Prospective home buyers as well as those considering converting to electric heating should be made aware of the economic advantages of heat pumps. When properly sized and installed, a heat pump provides a 30-60 percent annual saving in operating costs compared with electric resistance heating. The actual efficiency of a heat pump (measured in BTUs delivered to the conditioned space per kwh of electricity) depends on the

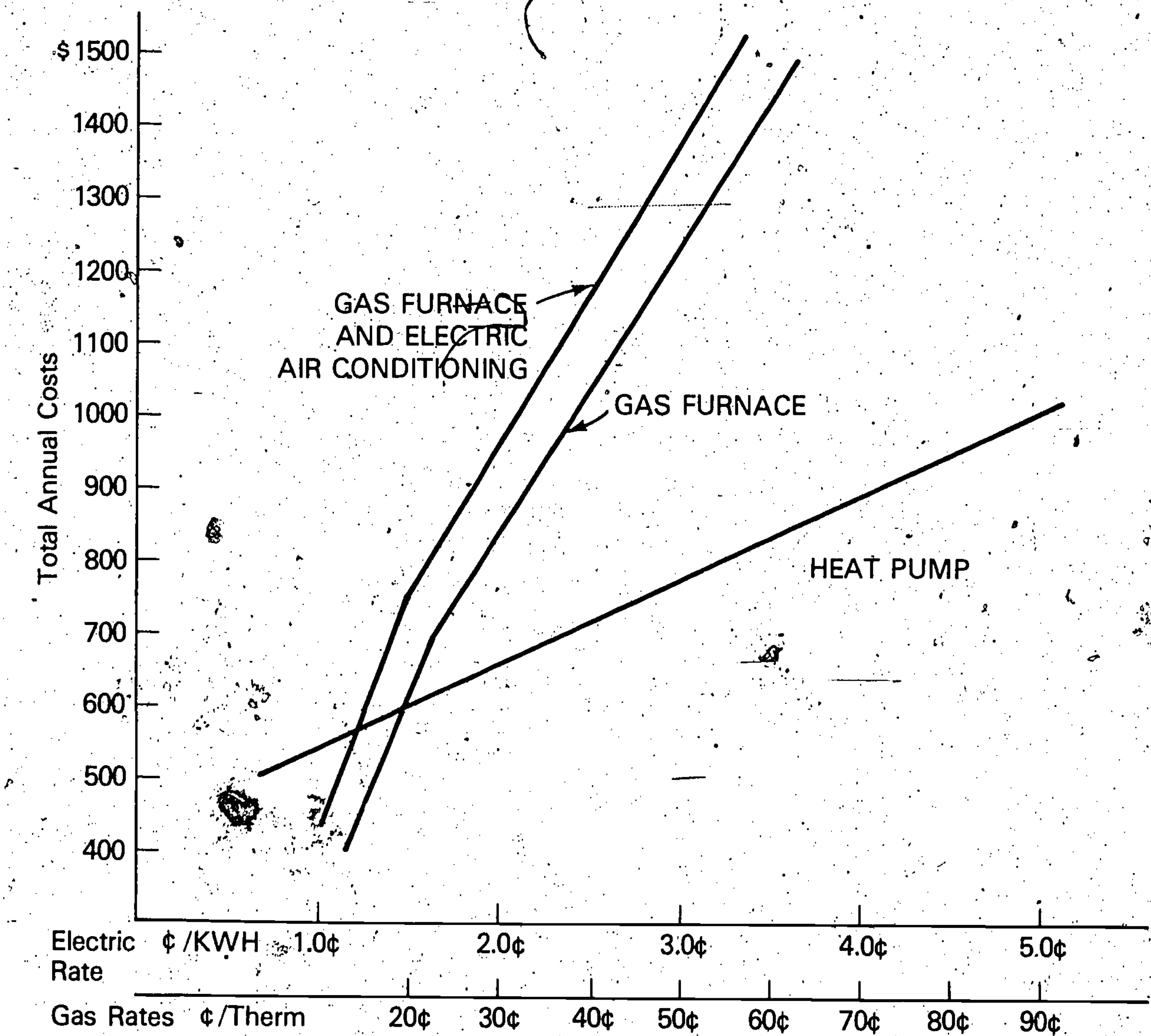


Figure 14. COMPARISON OF ALTERNATE HEATING SYSTEMS COSTS. In addition to saving fuel, the heat pump has become the lowest-cost method of heating a home, n[illegible] in operating cost but in total cost, in places where the temperature rarely falls below 40°F. Total annual costs shown in the graph include fuel, depreciation, capital, and maintenance. (Courtesy of Westinghouse Electric Corporation).

outdoor temperature. At higher outdoor temperatures, heat pumps are more efficient.

The reason for their high efficiency is that heat pumps actually extract heat from outdoors and use it indoors. Thus, they conserve energy by producing up to three units of heat for each unit of electricity supplied. Since the efficiency of a heat pump varies with the temperature of the outside air, the economic advantage of heat pumps depends on geographic location. In an area with average heating requirements of 7,000 to 7,500 degree-days per year (such as Milwaukee), heat pumps are 1.6 times as efficient as electric resistance heating. In an area with 2,500 to 3,000 degree-days per year (such as Atlanta), heat pumps are 2.2 times as efficient as resistance heating. Another economic advantage of heat pumps is that the same unit can provide both heating and cooling.

Unfortunately, many heat pumps installed in the early 1960s were poorly designed, thus resulting in a somewhat negative image regarding

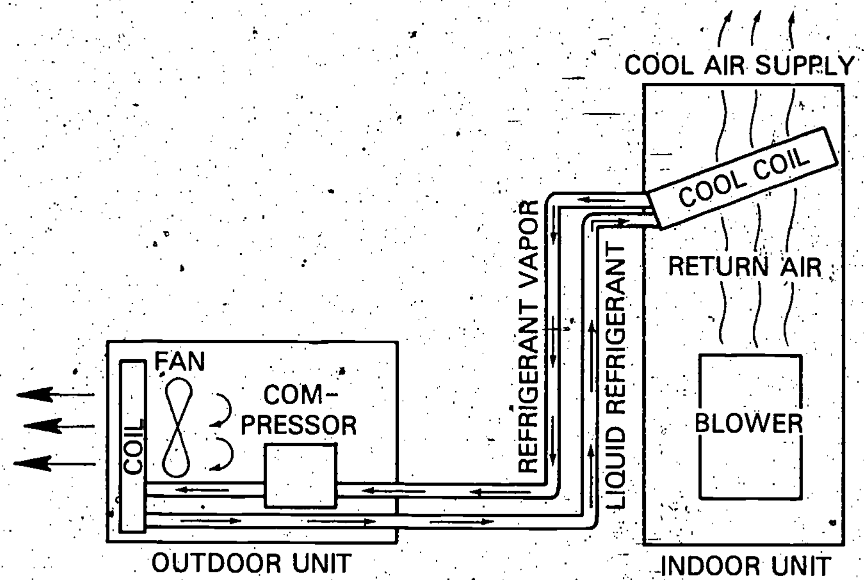


Figure 15a. HOW A HEAT PUMP WORKS. For cooling, the outdoor unit compressor feeds liquid refrigerant through its coil to the indoor coil. Warm indoor air is forced over the coil by the blower. The liquid refrigerant changes to vapor and absorbs heat, lowering the temperature of the indoor air blowing over the coil. Refrigerant vapor goes back to the outdoor unit. It is compressed and flows through the outdoor coil where its stored heat is released to the air. This is a continuous process as long as there is a need for cooling. (Courtesy of Lennox Air Conditioning Corporation)

their reliability. In fact, from 1964 to 1970 the percentage of electrically heated homes using heat pumps declined from 15 percent to 11 percent. However, since the mid-1960s, heat pump reliability has greatly improved. The Tennessee Valley Authority, for example, has conducted a certification program for heat pump manufacturers.

Local and state governments should encourage the installation of heat pumps in areas where local climatic conditions and relative availability of gas, oil, and electricity make the heat pump an attractive alternative to fossil fuel heating. Consumer affairs organizations can inform prospective home buyers of the heat pump's overall economic advantage. For additional information on building heating systems, write to:

Mr. R. S. Carlsmith
Director, NSF-FEA Energy Program
Oak Ridge National Laboratory
Energy Division
P.O. Box X
Oak Ridge, Tennessee 37830
(615)483-8611, X 31754

Center for Building Technology
National Bureau of Standards
Building 226, Room B-244
Washington, D.C. 20234

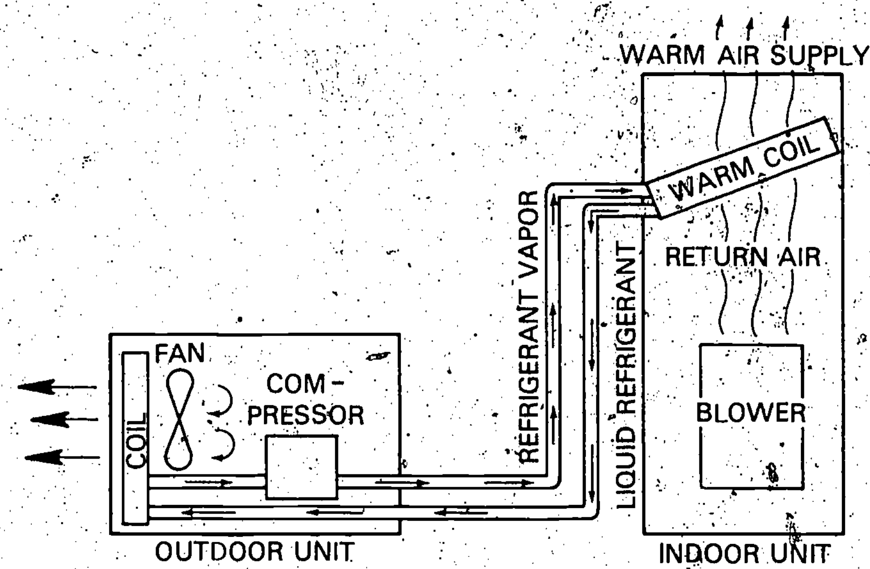


Figure 15b. HOW A HEAT PUMP WORKS. Changeover from cooling to heating is controlled by the thermostat. It works through the heat pump controls to reverse the refrigerant flow. Refrigerant in the outdoor coil absorbs heat from the air (even when the temperature is quite low) and the compressor pumps it, in hot vapor form, to the indoor coil. Heat is picked up from the warm coil by circulating indoor air. Liquid refrigerant returns to the outdoor coil to continue the cycle as long as there is a need for heat. (Courtesy of Lennox Air Conditioning Corporation)

For information on heat pumps, contact the following suppliers:

General Electric Company
Central Air Conditioning Department
Appliance Park WCE-501
Building 6, Room 220
Louisville, Kentucky 40225
(502)454-7511

Heat Controller, Inc.
1900 Wellworth
Jackson, Michigan 49203
(517)787-2100

Lennox Industries, Inc.
200 South 12th Avenue
Marshalltown, Iowa 50158
(515)754-4011

Air Conditioning Systems

Electricity consumption for air conditioning is increasing at a faster rate than for any other appliance. Room air conditioner sales have doubled every five years since 1960, and this growth rate may continue for some time.[42] Air conditioning is an energy-consuming function with great potential for improvement because there is a large variation in energy efficiency among available units. Air conditioner efficiency is the ratio of cooling capacity, measured in BTUs, to the electrical energy requirements of the unit, measured in watt-hours. This commonly accepted efficiency measure, called the EER (Energy Efficiency Ratio), is thus measured in BTUs per watt-hour.

In all-electric homes, air conditioning ranks third in energy consumption, behind space heating and water heating. Although air conditioning accounts for 8 percent of annual residential and commercial energy use, it contributes 30 percent to the summer energy load of residences and accounts for 56 percent of commercial energy consumption during the summer.[43] This is significant, particularly in metropolitan areas where peak electrical demand on hot days severely taxes an area's power-generating capacity.

An Oak Ridge National Laboratory survey reveals that about 400 models of room air conditioners are on the market today, sold under 52 different brand names. These air conditioners range in efficiency from 4.7 to 12.2 BTUs per watt-hour (EER). This means that the least efficient machine would consume 2.6 times as much electricity as the most efficient one to accomplish the same amount of cooling when operated under the same conditions.[44] The average prospective purchaser of an air conditioner probably does not know how to assess these differences. As a result, the buyer often chooses the unit having the lowest purchase price, without regard to operating cost, a choice that tends toward lower efficiency and higher energy consumption.

The U.S. Department of Commerce recently initiated a broad energy conservation program for home appliances. As of May 1, 1974, all room air conditioner manufacturers were required by administrative regulation to affix labels to their equipment specifying operating efficiency. The labels make use of the energy efficiency ratio (EER). The label displays the unit's energy efficiency ratio as well as the range of energy efficiency ratios for all air conditioners of a similar cooling capacity. Thus, the consumer is able to determine in advance whether a particular air conditioner is relatively efficient or inefficient. The National Bureau of Standards, in consultation with the Council on Environmental Quality and the Environmental Protection Agency, developed this air conditioner labeling standard. The Association of Home Appliance Manufacturers is cooperating in the room air conditioner labeling program. Figure 16 shows what the label looks like.

State and local governments can take several actions to encourage energy conservation among room air conditioner users:

- Consumer education programs can be sponsored to point out the wastefulness of low-efficiency air conditioners. The New York City Department of Consumer Affairs requires that the room air conditioner label carry not just the EER but also an annual operating cost (computed using the current electric utility rate and a standard number of hours of operation).
- State fair-advertising legislation can require that information about an air conditioner's efficiency be included in advertising.

The state of California has established minimum energy-efficiency labeling requirements for several classes of appliances sold in the state. Local governments should make information about home appliances available to citizens to assist them in their efforts to cut utility bills. Table 6 shows the relative energy demands for various common household appliances. The estimated kilowatt-hours are based on national averages. Figure 17 provides a more general overview of household uses of electricity. For further information on the energy

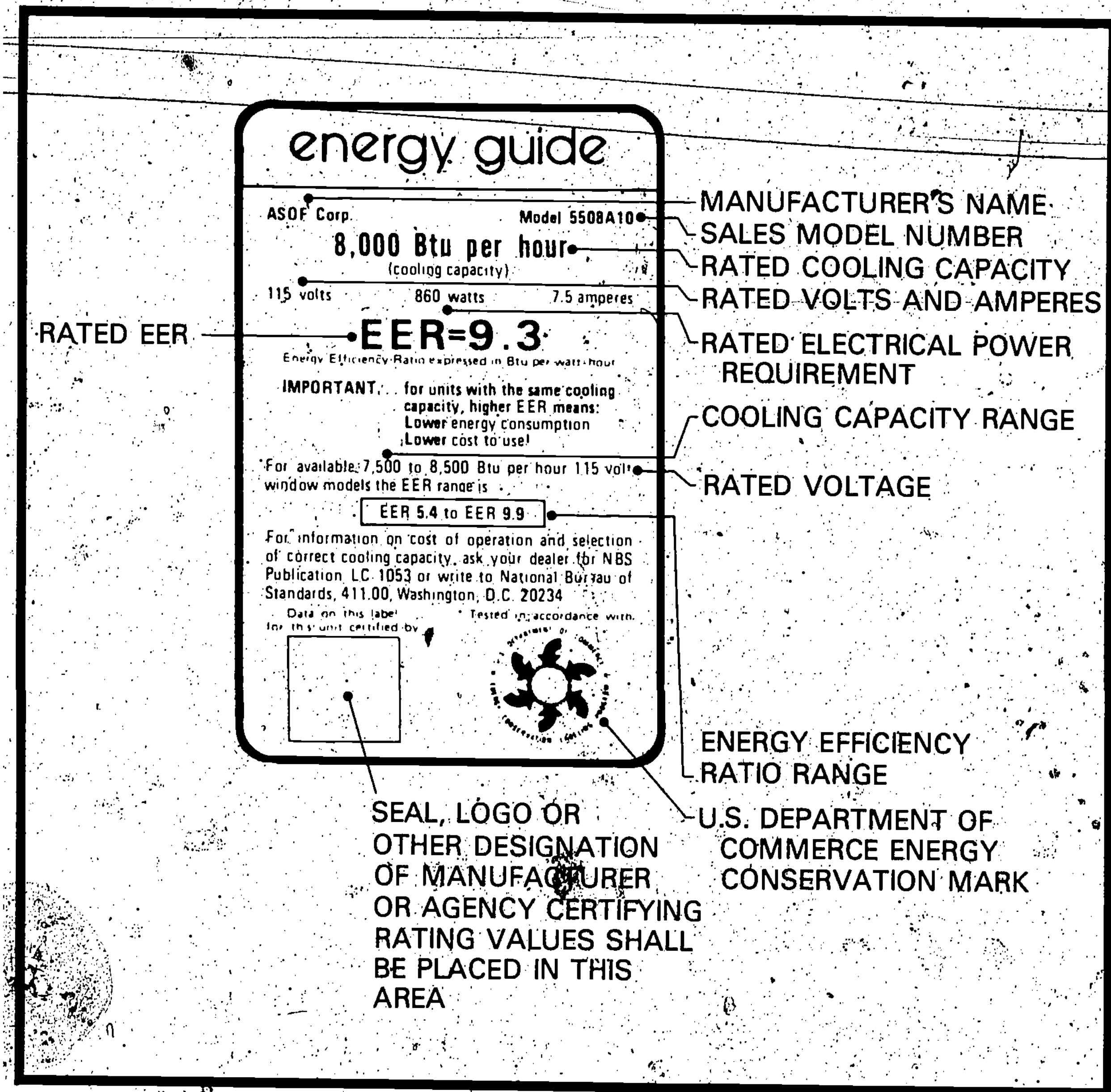


Figure 16. ENERGY EFFICIENCY LABEL. This air conditioner label, specified by the Department of Commerce, is part of a voluntary energy conservation program for home appliances. The label shows the consumer the energy efficiency of the air conditioner relative to other models of the same capacity. (Courtesy of National Bureau of Standards)

demands of various household appliances, contact the manufacturer's association at the address below:

Mr. William S. Comstock
Director of Governmental and Public Relations
Association of Home Appliance Manufacturers
20 North Wacker Drive
Chicago, Illinois 60606
(312) 236-2921

Thermal Insulation

Adequate thermal insulation—properly installed—can significantly lower heating and cooling costs by retarding the rate of heat escaping in winter

Table 6 ELECTRIC ENERGY CONSUMED MONTHLY BY COMMON HOUSEHOLD APPLIANCES

Appliance	Average wattage	Estimated kilowatt hours
Air conditioner (window)	1,325	110
Bed covering (automatic)	190	11
Broiler	1,560	8
Clock	2	2
Clothes dryer	4,350	70
Coffee maker (automatic)	850	8
Deep fat fryer	1,440	8
Dishwasher	1,180	29
Fan (attic)	365	27
Fan (circulating)	85	4
Food blender	290	1
Food freezer (standard 15 cu. ft.)	350	88
Food freezer (frostless, 15 cu. ft.)	440	127
Frying pan (automatic)	1,160	16
Grill (sandwich)	1,180	3
Hair dryer	260	1
Heat lamp (infrared)	250	1
Iron (hand)	1,085	12
Iron (mangle)	1,500	13
Radio	75	7
Radio-phonograph	115	9
Range	12,000	100
Refrigerator (standard, 12 cu. ft.)	265	71
Refrigerator (frostless, 12 cu. ft.)	295	79
Refrigerator-freezer (standard, 14 cu. ft.)	290	100
Refrigerator-freezer (frostless, 14 cu. ft.)	435	131
Roaster	1,325	17
Television (black & white)	255	30
Television (color)	315	38
Toaster	1,130	3
Vacuum cleaner	700	3
Portable heater	1,200	100
Washing machine (automatic)	600	7
Washing machine (nonautomatic)	280	5
Water heater	4,500	323

Source: City of Los Angeles.

and entering in summer (see Figure 18). Cities, counties, and states should use consumer education programs to inform prospective home buyers of the importance of adequate insulation in cutting home heating and cooling costs.

The Federal Housing Administration (FHA) establishes Minimum Property Standards (MPS) for insulation in federally subsidized housing. These standards determine the maximum hourly heat loss or gain for the structure. Also, these standards establish a maximum overall heat transfer coefficient which is measured in BTUs per hour per degree Fahrenheit (called the "U-value").

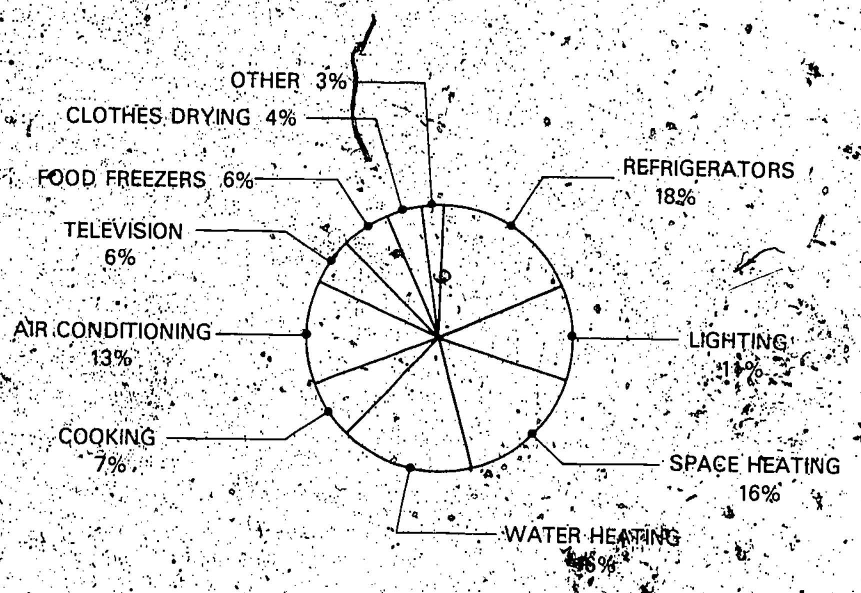


Figure 17. HOUSEHOLD USES OF ELECTRICITY. In 1970, average household electricity consumption was about 7,000 kwh. The chart above illustrates the nationwide consumption pattern by uses. This pattern varies by climate and type of heating, whether fossil or electric. (Courtesy of Oak Ridge National Laboratory)

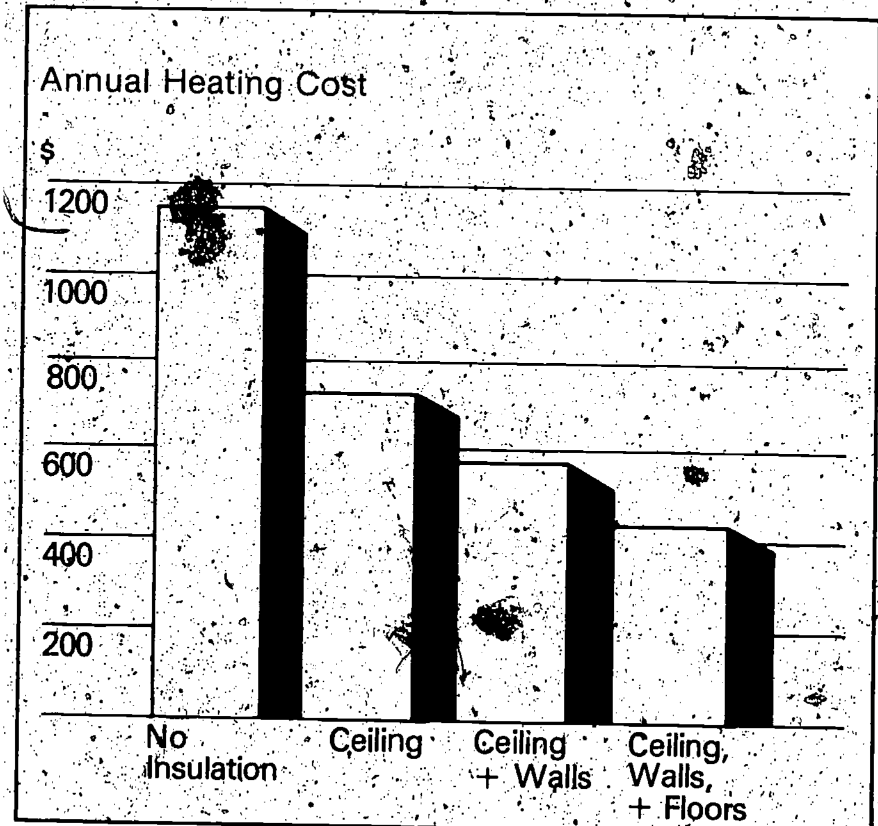


Figure 18. INSULATION CAN CUT ENERGY BILLS. This graph shows the cost of heating a 1,500-square-foot home in Knoxville, Tennessee, under four different levels of insulation. Heating costs are based on current electricity price of 3¢ per kwh. (Courtesy of Tennessee Valley Authority)

The Oak Ridge National Laboratory has performed an engineering study under the sponsorship of the NSF Research Applied to National Needs (RANN) program to determine the amount of insulation required to meet the FHA Minimum Property Standards. This study examined model homes in New York, Atlanta, and Minneapolis, which are representative of the central, southern, and northern climatic regions. The purpose was to determine the optimal insulation level for these homes. The optimal insulation level is a function of the insulation cost and the heating and cooling cost savings. Factors included in the analysis were mortgage interest rate, owner's tax bracket, the property tax rate, insurance rates, energy costs, and climatic data.

The conclusions of the study have significant implications for local building codes and standards since local jurisdictions may consider adopting the FHA Minimum Property Standards for all residential construction. Several jurisdictions have already established thermal insulation standards in their local building codes. At present, the state of Tennessee is considering legislation setting minimum insulation standards proposed by the Tennessee Valley Authority.

Increasing insulation, particularly in areas with moderate to severe winters, is definitely cost-beneficial if present insulation is below the present FHA standards. Energy savings in gas heating and air conditioning ranged from 20 percent in Atlanta to 50 percent in New York, and the cost savings in electrically heated homes varied from 25 percent to 38 percent.[45] These savings reflect a comparison of a house with a "typical" level of insulation with the "well-insulated" house. As fuel and electricity prices rise, the magnitude of these savings will increase.

In addition to the quantity of insulation in a home, the manner in which it is installed can have a significant impact on energy consumption. Air infiltration can account for as much as 50 percent of the heating load for a typical house. Prospective home buyers should be made aware of this fact. Also, home improvements such as weather stripping and calking should be encouraged as a means of cutting home heating bills.

The FHA in November 1973 amended its Property Improvement and Mobile Home Loan Insurance Regulations to provide for insured loans for fuel-conserving home improvements. These improvements include the installation of thermal insulation in walls, floors, and ceilings and the installation of storm windows and doors. As part of a communitywide energy conservation program, local officials can publicize these loan guarantee provisions to homeowners. For additional information on the Minimum Property Standards or on the new Property Improvement Loan regulations, contact the FHA at the address below:

Mr. Mervin Dizenfeld
Architecture and Engineering Division
Department of Housing and Urban Development
Minimum Property Standards
451 - 7th Street, S.W.
Washington, D.C. 20410
(202) 755-6590

For additional information on the use of thermal insulation to reduce heat loss or gain, write or call:

Mr. James W. Ward
Chief, Electrical Demonstration Branch
Power Marketing Division
Tennessee Valley Authority
401 United Bank Building
Chattanooga, Tennessee 37401
(615)755-2341

Mr. Sheldon Licht
Residential and Commercial Buildings
Office of Energy Conservation and Environment
Federal Energy Administration
Ben Franklin Station
Washington, D.C. 20461

Mr. John Moyers
Energy Division
Oak Ridge National Laboratory
P.O. Box X
Oak Ridge, Tennessee 37830
(615)483-8611 X 35722 or 31754

Mr. Sheldon H. Cady
Executive Director
National Mineral Wool Insulation Association
211 East 51st Street
New York, New York 10022
(212)758-5210

Mr. R. S. Littin
Merchandising Manager
Home Building Products Division
Owens Corning Fiberglass Corporation
Fiberglass Tower
Toledo, Ohio 43659
(419)259-3602

The Office of Energy Conservation in the Federal Energy Administration *Checklist* has compiled the following energy conservation tips for homeowners. The tips appear to be technically and economically sound. Nevertheless, all of these conservation measures do not apply all the time. Common sense must determine which measures should be applied in any specific case. These tips are ideal as "envelope stuffers" for mailing with utility bills. Additional materials for a public information program, including a copy of the *Citizen Action Guide to Energy Conservation*, may be obtained by writing:

Citizens Advisory Committee on Environmental Quality
1700 Pennsylvania Avenue, N.W.
Washington, D.C. 20006

Maintenance Measures

- Maintain an efficient heating plant. Clean heat-exchange surfaces and clean or replace air filters periodically.

- Repair leaking hot water faucets.
- Check refrigerator door gaskets for air leakage.

No-Cost Measures

- Close off rooms and closets not in use.
- Close window draperies in winter to reduce radiated heat loss, except on sunny days. Close draperies in summer to reduce solar load.
- Lower thermostat settings 10° during winter nights.
- Reduce domestic hot water temperature to 120° F.
- Turn off lights when not needed.
- Reset thermostats controlling room temperatures up 3° in summer and down 3° in winter.
- Eliminate gas yard lights. Ten gas lights use enough gas to heat a home.
- Do not use washing machines or dishwashers until a full load has accumulated.
- Reduce thermostats to a range from 65°-68° F in the winter.
- Lower thermostats to 60° F when leaving home for one day or more.
- Keep the garage doors closed, if the garage is heated.
- Close dampers completely when the fireplace is not in use.
- Avoid blocking radiators and hot-air registers with furniture, rugs, or draperies.
- Do not use portable electric heaters unless they are used to supplement central heating.
- Reduce exterior lighting consistent with safety.

Low-Cost Measures

- Use light colored paints and materials on the roof.
- Use stove hoods and exhaust fans in the summer.
- Insulate hot water storage tanks and bare pipes.
- Use the most efficient light sources.
- Use lighter colors on interior wall surfaces and furnishings.
- Insulate heating ducts and hot water pipes which pass through unheated spaces.
- Use capacitor ignition devices instead of pilot lights for gas appliances.
- Add a metal or aluminum foil shield behind radiators to reflect heat into the room.
- Reduce bulb wattage in lamps and fixtures to the minimum acceptable.

Low- to Moderate-Cost Measures (Payback within 5 Years)

- Weatherstrip windows and doors at movable joints.
- Install storm windows and doors.
- Install overhead and sidewall insulation. Six inches of insulation on the attic floor, compared with none at all, can cut fuel consumption by 50 percent.
- Close and seal all openings into the attic from occupied spaces.

Moderate-Cost Measures

- Plant deciduous trees or large shrubs around your home.
- Ventilate the attic to expel moisture and reduce temperature in the summer.
- Use high-efficiency air conditioners.

Public Transportation Services

Transportation consumes about one-fourth of the total energy used on a nationwide basis. Figure 19 shows the energy consumption of various forms of transportation. Around 95 percent of our transportation energy comes from petroleum. For this reason, the fuel shortage experienced in many areas of the country during the winter of 1973-1974 had its most visible impact on transportation. Since there are no alternative fuel sources for transportation available in the immediate future, state and local governments appear to have only three options to pursue—reduce the demand for transportation, increase the energy efficiency of existing and future equipment, and increase the number of people in each vehicle. Each option is discussed below.

Reduce Transportation Demand

In order to reduce the demand for transportation, the places people live must be closer to the places where they work, go to school, shop, and play. Energy conservation should be weighed heavily in planning for land use. Urban cluster or new town concepts which integrate residential, commercial, recreational, and school uses should be encouraged. In a similar fashion, high-density developments which facilitate commuting

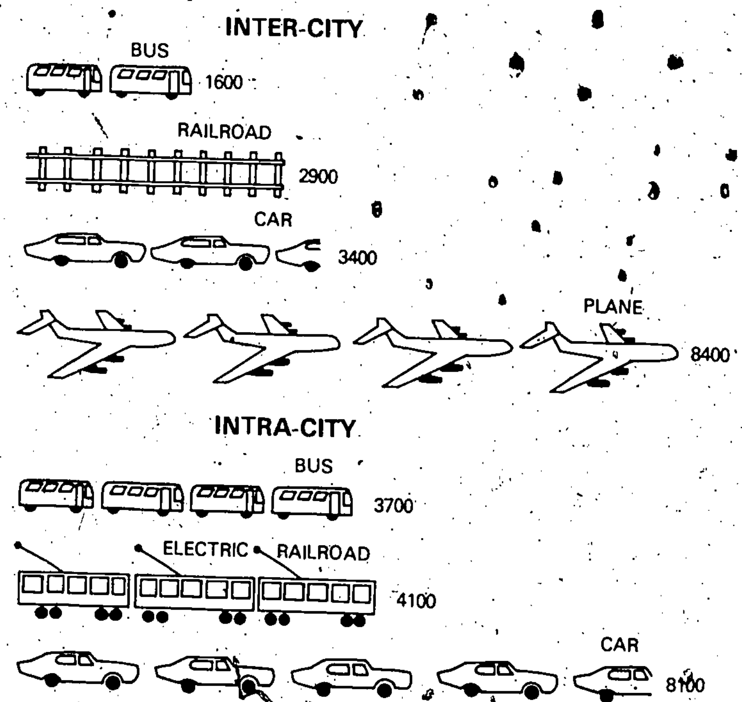


Figure 19. TRANSPORTATION ENERGY CONSUMPTION. This chart illustrates energy consumption per passenger-mile for common passenger transportation modes. Values are measured in BTUs per passenger-mile. These values take into account the percentage of occupied seats for each transportation mode. (Chart developed from information in *Science and Public Affairs* by Eric Hirst, 1973, p. 39)

by bus, subway, or train should be promoted. Parks with walkways and bicycle paths on dedicated streets offer a limited alternative to automobile travel. Obviously, these measures are long-term.

Increase Equipment Efficiency

State and local governments have limited authority to regulate energy consumption of existing transportation modes; however, they can establish and enforce speed limits and regulate traffic. Optimal fuel economy for most motor vehicles is achieved at about 40 miles per hour. Governments can effect fuel conservation by setting maximum and minimum speed limits, as dictated by safety considerations, and by synchronizing traffic signals to maintain a 40-miles-per-hour traffic flow whenever possible. State and local jurisdictions can establish public information programs to encourage citizens, businesses, bus companies, and taxi companies to adopt energy conservation measures. A public information program could draw upon the conservation measures discussed in the previous chapter on public fleet management.

Vehicle Load Factors

Automobiles were used for 97 percent of all intracity passenger miles traveled in 1970. Automobiles average 1.4 passengers per trip, while buses average 18.0 passengers per trip. Automobiles in moderate to heavy traffic average about 15 passenger miles per gallon, while buses under the same conditions usually average at least 40 passenger miles per gallon.[46] Thus, any conservation strategy which causes travelers to shift from cars to buses will significantly reduce overall gasoline consumption. This subsection on vehicle load factors discusses car pooling, minibuses or vans, Dial-a-Ride, and bus express lanes.

One well-publicized method of reducing load factors is car pooling. Car pool matching programs have generally been effective only when sponsored by a large employer as a service for its employees. Local jurisdictions can solicit the cooperation of business and industry in their area by assisting them to encourage workers to car pool. Car pooling can be further encouraged by putting commuters in touch with others who live and work nearby (see Figure 20). The Federal Highway Administration has developed a car pool matching guide to help run such programs. The guide provides information on three phases of a car pool program:[47]

- Collecting time-origin-destination information,
- Matching time-origin-destination information, and
- Distributing suggested pool combinations to prospective participants.

When the potential applications number fewer than 300, a manual matching technique is used; for larger numbers a computer program is available.

A communitywide car pooling program could be sponsored by a local government as an energy conservation measure or by a civic-minded enterprise such as a local radio or television station. State and local governments should consider allowing car pools to use bus express lanes on limited-access freeways. Government agencies and private businesses should be encouraged to give preferential parking incentives to their car pooling employees. For more information about how to establish car pooling programs, please write:

RETURN TO: HHP - 24
ROOM 3301

FEDERAL HIGHWAY ADMINISTRATION

DATA FORM FOR
CARPOOL/BUS COMMUTER PROGRAM

INSTRUCTIONS: PLEASE COMPLETE ALL QUESTIONS AND RETURN ONLY THIS PAGE WITHIN ONE WEEK THROUGH INTEROFFICE MAILS. PLEASE CALL 60210 IF YOU HAVE ANY QUESTIONS

SOCIAL SECURITY NUMBER

NAME 12 (LAST) 24 (FIRST) 35 (M)

ADDRESS 34 NUMBER 39 (STREET NAME)

51 (CITY) 66 (STATE) 68 (ZIP)

73 X 75 Y
HOME GRID NUMBER (SEE MAPS)

PLEASE LOCATE YOUR RESIDENCE CAREFULLY ON THE CORRECT MAP AND PLACE THE GRID NUMBERS HERE.

12 OFFICE PHONE (EXT.) 17 ROOM NUMBER 22 ROUTING SYMBOL

WHAT IS YOUR PRIMARY TRAVEL ARRANGEMENT TO WORK? (27)

BUS 1 WALK 4 BICYCLE 7

CAR-DRIVE ALONE 2 MOTORCYCLE 5 TAXI 8

CARPOOL 3 TRAIN 6 OTHER 9 ____________ SPECIFY

DO YOU DESIRE TO BE INCLUDED FOR CARPOOL MATCHING? (28)

YES 1 NO 0 { REMEMBER THAT A "YES" ANSWER PLACES YOU UNDER NO OBLIGATION. }

Figure 20. CAR POOL MATCHING. This questionnaire, designed by the Federal Highway Administration, can be used as part of a public or privately sponsored car pooling program. Analysis of the questionnaires can put commuters who live and work in the same vicinity in touch with one another. (Courtesy of Federal Highway Administration)

Mr. Lew Pratch
Urban Planning Division
HHP 26
Federal Highway Administration
Department of Transportation
400 Seventh Street, S.W.
Washington, D.C. 20590

One problem with car pooling is that there must be people willing to use their personal automobiles to transport others to work and back home. This problem is sometimes overcome by minibus or van pooling programs. Both the Tennessee Valley Authority (TVA) Employees Credit Union and the 3M Company have van pooling programs for their employees. The TVA Employees Credit Union leases six 12-passenger vans from a major leasing agency. These vans are loaned to responsible drivers who agree to carry ten subscription riders per day. Van pools are organized in small geographic areas in order to minimize passenger collection times. Riders pay a daily fare ranging from 38 cents to $1.45 depending on the distance from their homes to work. The fares are sufficient to pay the leasing charge and to cover fuel costs. For further information on this unique van pooling program, write or call:

Mr. Dave Burnett
TVA Employees Credit Union
507 Market Street
Knoxville, Tennessee 37902
(615)546-8911

In Northern Virginia, the Shirley Highway Express Bus project demonstrated a coordinated strategy for luring commuters from their cars to buses (see Figure 21). The express bus project features an exclusive bus lane in the freeway median, bus priority lanes in the downtown distribution area, fringe parking facilities coordinated with the bus service, and bus service extensions to additional residential areas. The express bus reduces travel time into downtown Washington, D.C., by 10 to 15 minutes. This express bus service has attracted many new riders and has reduced commuter automobile travel by about 3,000 vehicles.

A similar program in the San Francisco Bay Area gives priority treatment to commuters using either buses or car pools. This program reserves the toll plaza center lanes servicing the Oakland Bay Bridge for buses and car pools during rush hours. More than 20,000 bus passengers and 18,000 car pool passengers use these priority lanes. This project cost less than $100,000 to start.[48]

Contra-flow lanes provide a method for establishing exclusive bus lanes without expensive capital investment in new highway construction. Contra-flow lanes simply reverse the flow of traffic in the special bus lane. They have been used in Dade County, Florida, and in the New York metropolitan area. For further information about the express bus and car pooling lanes on freeways, contact:

Transit and Traffic Engineering Branch
Urban Planning Division
Federal Highway Administration
Washington, D.C. 20590
(202)426-0210

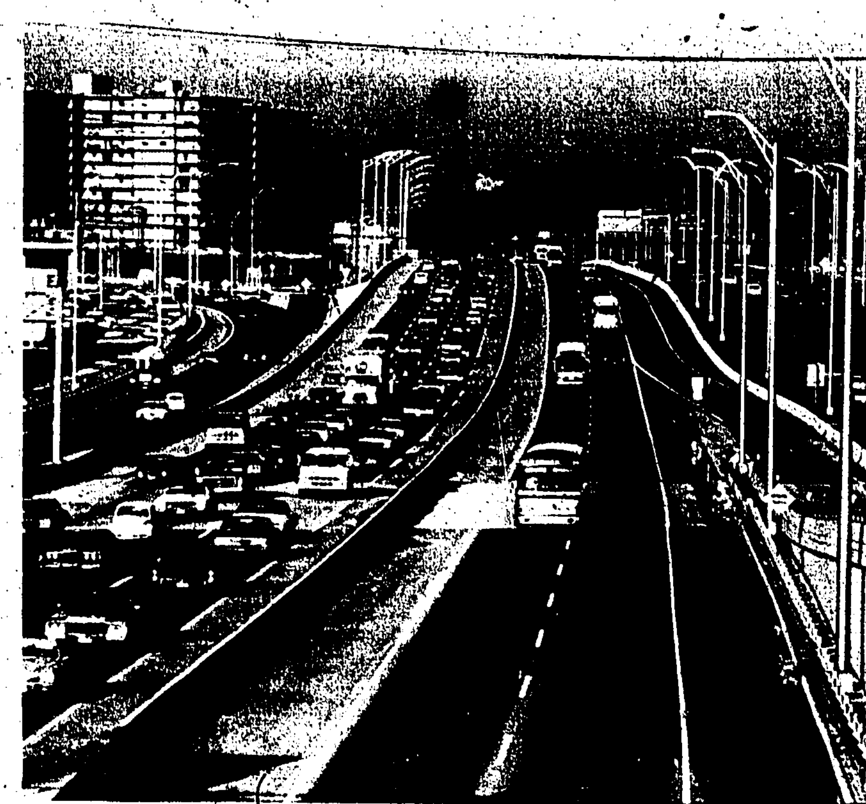


Figure 21: EXPRESS BUS AND CAR POOL LANES. This 11-mile long facility from Springfield, Virginia, to Washington, D.C., accommodates 16,000 round-trip passengers on 300 buses daily. Since many of these passengers would otherwise drive their own cars, exclusive bus lanes are a means of conserving energy. (Courtesy of Federal Highway Administration)

A demand-responsive bus service known as Dial-a-Ride offers another strategy for encouraging commuters to switch from automobiles to buses. A Dial-a-Ride program offers minibus service for up to 20 people in direct response to telephone calls from prospective passengers. The telephone calls are handled by a central radio dispatcher much like a regular taxi service.

There are now about 20 Dial-a-Ride programs operating on a nationwide basis and about 30 more programs in various planning stages. These programs have been used to provide public transportation where none existed before or to replace unproductive fixed bus routes. However, the most common application for Dial-a-Ride service is to act as a feeder to express train or bus service. Regina, Saskatchewan, experienced a 30 percent increase in transit ridership and a 50 percent decrease in transit operating costs by converting a local bus route to express service and using a Dial-a-Ride service to feed the express bus service.[49] The primary advantage of a Dial-a-Ride service from an energy conservation perspective is its personalized character which encourages people to switch from automobiles to buses. For further information about Dial-a-Ride minibus services, contact:

Office of Public Affairs
Room 9330
Urban Mass Transportation Administration
Department of Transportation
400 Seventh Street, S.W.
Washington, D.C. 20590
(202)426-4043

Checklist The energy conservation measures outlined have been compiled from several sources. These suggestions appear to be sound both technically and economically. However, state and local governments should evaluate each measure on its own relative merits. In some cases, a detailed cost-benefit analysis should be made to help determine whether a specific conservation measure is warranted.

Regulatory or Persuasive Measures

- Sponsor a public information program to encourage citizens, businessmen, bus companies, and taxi companies to adopt energy conservation measures to help save gasoline and diesel fuel.
- Encourage the siting of large commercial buildings near public transportation facilities to decrease dependence on private automobiles.
- Encourage urban cluster and new town developments which integrate residential, school, commercial, and recreational uses to decrease dependence on private automobiles.
- Assess the relative merits of sponsoring a Dial-a-Ride minibus service.
- Encourage commuter car or van pooling.
- Encourage large employers to stagger working hours to reduce rush-hour traffic congestion.
- Establish both minimum and maximum speed limits where appropriate. Synchronize traffic signals to maintain traffic flow at 40 mph when appropriate. Automobile gasoline efficiency is greatest at about this speed.

Moderate-Cost Measures

- Establish exclusive express lanes on freeways for buses and car pools.
- Develop new fringe parking areas for commuters who will use public transportation.
- Provide exclusive bus lanes and discharge zones along streets.
- Develop bicycle paths and pedestrian walks to provide an alternative to automobile transportation.

Industrial Energy Use Industry in the United States accounts for about 40 percent of our total energy consumption. According to the National Bureau of Standards, "It has been repeatedly demonstrated that conservation measures can reduce energy use (in industry) by 15 to 30 percent, or more, with justifying cost savings."[50] Since industrial operations are so diverse, this Guide will not attempt to list specific industrial energy conservation measures. Rather, this section presents the necessary information to assist the local and state government administrator in developing an intelligent energy conservation policy for industries.

The Ford Foundation Energy Policy Project estimates that through short-term measures requiring little or no capital investment, industry can achieve energy savings ranging from 10 to 15 percent.[51] The increasing price of energy will motivate many companies to initiate energy conservation measures in their own self-interest. According to the Ford Energy Project, "the industrial sector is probably the most responsive to the price of energy . . . . Hence, a general government policy of regulation or compulsory energy performance standards would appear to be unnecessary, difficult to administer, and, perhaps, counter-productive."[52] However, there are several things which local and state governments can do to encourage industrial firms to initiate conservation measures, particularly measures involving technological innovation and capital investment.

First, a government-sponsored program to disseminate information about new energy conservation technologies and processes would be a significant boon to smaller firms which often have little access to such information. The U.S. National Bureau of Standards in cooperation with the Federal Energy Administration has recently published *Energy Conservation Program—Guide for Industry and Commerce* (see bibliography reference 8), a guide to assist business and industry in establishing an on-going conservation program. This document outlines the steps in such a program and suggests specific ways to reduce energy use in manufacturing and commercial businesses. It also focuses on energy conservation opportunities which have already been identified by industry and have led to energy cost savings.

Second, jurisdictions should explore the possibility of long-range planning for combined power-steam generating systems. This would mean locating electric power plants in the vicinity of industrial plants which could use the waste heat that would otherwise be discarded by the power station. When electricity is generated alone, only about 30 to 40 percent of the energy content of the fuel is converted to electricity; in combined systems, where the waste heat is used for industrial process steam, about 80 percent of the available fuel energy is used.[53] Combined steam-electricity generation can be fostered either by encouraging industries to locate adjacent to the utility's power plants, in so-called energy-industrial parks, or by providing incentives for industries to generate electricity on-site as a by-product of steam production.

Both methods require government involvement. Energy-industrial parks require intensive long-range planning and coordination, particularly because electric utilities require such a long time (eight to ten years) to bring a new power station on-line.

The Transportation and Regional Planning Division of the New York City Planning Department has been exploring the potential for energy-industrial parks in New York. Few, if any, other jurisdictions have yet attempted to apply this concept. A major obstacle to the wider application of on-site power generation by industrial plants is the uncertainty about interconnections with the utility distribution system. This obstacle could be alleviated by state or local public utility regulations requiring interconnections at reasonable rates.

For additional information on the planning implications of energy-industrial parks, please contact:

Mr. Robert Tanenhaus
Energy Planner
Transportation and Regional Planning Division
Department of City Planning
2 Lafayette Street
New York, New York 10007

A third area of potential state and local government involvement in industrial energy conservation is primary materials recycling. For several primary metals, a finished product from scrap or "recycled" metal requires significantly less energy than from the primary ore. Recycled aluminum, for example, requires only 5 percent as much energy to process as aluminum ore. According to the Ford Energy Project, "it is economical today to recover scrap metals from municipal wastes wherever incineration is the only practical or acceptable disposal method for solid wastes."[54] The project predicts the growth of a large-scale metals recycling industry in the United States over the next decade.

VI.

ELECTRIC UTILITIES

State and local governments should include public electric utilities in their community energy conservation programs for a number of reasons. State governments regulate utility rate structures, thereby influencing both energy supply and demand. County and city governments occasionally find themselves arguing before a state utilities commission regarding proposed changes in utility rate structures. State and local governments influence electricity consumption patterns with various policies that relate to tax incentives and disincentives, promotional activities, and consumer education. County and city governments are responsible for street lighting. In addition, about 2,000 jurisdictions operate their own electric utilities. This chapter discusses electric power demand, utility regulation, joint purchasing and distribution, plant equipment, and street lighting.

Consumer Demand

State and local governments have several options available for them to encourage electric power savings. These energy-saving options relate to public education, commercial promotional activities, government tax incentives and disincentives, and rate regulations.

Local governments should sponsor consumer education programs oriented toward electric power conservation. A public education program could be very important to jurisdictions operating their own electric power utilities. The Seattle City Light Company recently initiated an innovative energy conservation program known as "Kill-a-Watt." The program's consumer education activities are outlined below:

- Consumer advisory teams have been formed to help educate residential, industrial, and commercial customers. These advisory teams draw upon such experienced persons as home economists, service representatives, appliance servicemen, industrial sales engineers, and power supply engineers. These teams provide advice on such things as insulation, heating equipment, appliance care, service capacity, and in-house conservation.
- Two telephone message services have been established. One message service gives the listener tips on how to conserve electric power and tells where to write for more complete information. Another

message service logs customer requests for an energy specialist to inspect homes.

- Some hints for energy conservation have been prepared in decal form. These are distributed by appliance service repairmen and electric service representatives. Special notices about the energy conservation program services were mailed to the 500 largest customers.

All state governments and some local governments have authority to regulate promotional advertising and product labeling. These governments should explore the appropriate use of these police powers for conserving electric power. New York City, for example, now requires that air conditioner labels contain data on electric power consumption.

State and local governments should also assess the potential for using tax incentives or disincentives to encourage energy savings. As mentioned earlier, the state of Indiana offers a real estate tax break on homes utilizing solar energy. Also, a number of public utilities across the country offer low-interest loans to homeowners for the purpose of making home improvements which conserve energy. The Michigan Consolidated Gas Company, for example, provides short-term interest-free loans to homeowners for installing insulation in their homes.

State and local utility commissions should consider the possibility of allowing utilities to include, in their rate base, costs incurred in reducing the demand at the point of consumption. For example, in addition to supplying electricity, the utility would also be able to supply insulation and storm windows to its customers. The result would be equivalent to an increase in supply facilities at less capital expenditure. In this way, the utility could take a much more active role in promoting better energy utilization.

Apartment dwellers can be encouraged to use electricity more wisely by providing for individual metering of each dwelling unit in multiple-family residences. Several state governments presently prohibit individually billing tenants in multifamily dwellings for their electricity consumption. This prohibition tends to promote excessive electric consumption, since the tenants do not directly pay for their power. The Federal Energy Administration is currently studying the impact of individual metering on electricity consumption.

The reader who wishes to pursue a more detailed investigation of energy conservation measures to reduce electric power demand should contact appropriate sources listed:

Mr. Mike Sharar
Director of Community Relations
Seattle City Light Company
1015 Third Avenue
Seattle, Washington 98104
(206) 447-3110

Mr. Dennis Sudheimer
Energy Conservation Coordinator
Michigan Consolidated Gas Company
One Woodward Place
Detroit, Michigan 48226

Utility Regulation and Electricity Pricing

State governments can exercise a direct impact on electricity consumption through the authority of their public utility commissions.

These regulatory commissions control the prices charged by electric utilities, setting rates to cover costs and allowing these "natural monopolies" a fair profit.

Several recent studies, including the Ford Foundation Energy Policy Project, have concluded that the rate schedules used in most states actually encourage increased electricity consumption.[55] The most widely used electricity rate schedule charges customers according to their use of electricity; the more they use, the lower the unit price. This rate structure, the "declining block rate" system, generally charges one price for the first 250 kilowatt-hours, a lower price for the next block, and so on. By charging larger users less per kilowatt-hour than smaller users, the effect of this rate structure is to stimulate demand.

While these promotional rates reflected the trend of electric power industry costs when increased generation meant lower unit costs, this is no longer the case. The Ford Foundation energy project has shown that present rate designs, by promoting greater electricity use through price reductions for high consumption, force over-expansion of generating capacity to meet the increased demand. Realizing that the declining block rate system actually discourages energy conservation, five states have already taken action to "flatten" their utility rate structures (i.e., charge the same price per kwh for large consumers as for small). These are Wisconsin, New York, New Jersey, Florida, and Rhode Island.

There have been several studies of the impact of electricity rates on consumption. Understanding the nature of the relationship between price and growth in electricity demand is essential if public utility commissions are to use their rate-setting authority to promote energy conservation. The National Science Foundation RANN program has sponsored research at the Oak Ridge National Laboratory to develop a methodology for examining the influence of public policy on future electricity demand.[56] The researchers have developed an econometric (statistical) model which relates residential, commercial, and industrial demand for electricity to those factors which influence growth in demand: population, disposable income, the price of electricity, the price of natural gas (a partial substitute for electricity), and the price of electrical appliances. The model uses data from 47 states for the period 1947-71.

The significant finding of the Oak Ridge model relevant to regulatory commissions is determination of "long-run elasticities" (a measure of responsiveness of one variable to changes in another) for electricity demand in relation to the price of electricity. For residential customers, it was found, a 10 percent increase in price would eventually lead to a 12 percent decrease in demand, assuming the other variables were held constant. The response of course would not be immediate, but the researchers were able to predict that half of the demand reduction would occur in the first three years. For commercial customers, a 10 percent increase in price would lead to a 14 percent reduction in demand, and for industrial customers the reduction would be 17 percent. Both industrial and commercial customers would respond to a price change within the first year.

A fundamental problem confronting electric utilities is uneven demand. Electricity demand fluctuates by season and even by hour during the day. Electric generating equipment must be designed to accommodate the "peak-load" periods, even though this equipment is not needed at other times. Without the extra capacity, brownouts (reduced power at peak times) occur. In the United States, utilities have satisfied the peaks in demand by relying on special peaking generators (generally gas turbines) which have a higher energy cost than base-load generators. Also, during peak-load periods, older and less efficient generators must be brought on-line. For these reasons, it is highly desirable to encourage consumers to use less electricity at peak hours and during peak months. Then the peaking generators would not be needed and the overall energy efficiency of the power generation system would be improved.

Two approaches have been considered for reducing peak loads, thus smoothing the demand curve:

- Peak-load pricing—a time-dependent rate structure that charges more for electricity consumption during peak hours and peak months than during off-peak times.
- Remote-controlled load management—diversion of part of the peak load by technological means to off-peak periods.

The first approach, peak-load pricing, has not generally been used in the United States but has been employed in Western Europe to shift some of the load which would normally occur during peak periods to night-time, low-demand periods. In France, for example, one class of customers is charged 1.4¢ per kwh at night but 9.6¢ per kwh during the day. The impact of this time-dependent rate structure on demand is being studied by the National Science Foundation.[57]

In Wisconsin, a seasonal rate structure recently has been instituted by which summer electricity prices are about 20 percent higher than winter prices. The widespread use of air conditioning has led to a peak load throughout the summer. An experimental program is now being conducted in Wisconsin to determine the impact of a peak-load system of pricing. Customers will be billed according to the coincidence of their use with the system's peak. This will require the installation of a special time meter in each home and business.[58]

The second approach, load management, has been used by the Detroit Edison Company.[59] In the Detroit system there are 201,000 electric water heaters, each requiring about one kilowatt of power. Each has been equipped with a radio-controlled cutoff switch. At a beep from the company's computer-controlled radio transmitter, any or all of the heaters can be shut down instantly, releasing up to a maximum of 201 megawatts of power to accommodate peak loads, save operation of high-cost fuel generating equipment, or meet a system emergency.

From the utility's view, water heaters are an ideal part of the household electricity load to be diverted. They draw a large amount of current, are subject to a separate cutoff switch, and temporary disruption of service causes a minimum of inconvenience to the customer. Each customer is guaranteed at least 20 hours operation in a day. The instant cutoff switch, installed originally for $45 each, frees one kilowatt of generating capacity for use elsewhere. New generating equipment would cost from $300 to $400 per kilowatt of capacity and take years to build.

The reader who wishes to pursue a more detailed investigation of the relationship between public electric utility regulation and energy conservation should contact the sources listed:

Mr. George Bonner
Director, Energy Division
New York Public Service Commission
44 Holland Avenue
Albany, New York 12208
(518) 474-5441

Office of Systems Integration and Analysis
National Science Foundation
1800 G St., N.W.
Washington, D.C. 20550
(202) 632-4032

For more information on Wisconsin's electricity pricing and experiment in time-of-day metering, contact:

Mr. James Tanner
Administrator of Public Utility Rates
Public Service Commission of Wisconsin
Hill Farms State Office Building
Madison, Wisconsin 53702
(608) 266-1265

Joint Purchasing and Distribution

Public electric utilities can reduce their fuel costs by jointly purchasing fuel in larger quantities than would be practical for any single government. Joint agreements for the purchase of electric power in bulk have been used by cities in Illinois, Kansas, Massachusetts, and Ohio with substantial cost savings. Public utilities could also join together to develop a common energy source. The Northern California Power Agency is an example of a joint agreement by 11 cities and the Plumas-Sierra Rural Electric Cooperative to harness the geothermal resources in that region for electric power production.

Public utilities should also consider using interruptible sales agreements. An interruptible sales agreement specifies that when the total electric energy demand exceeds a certain level, service will be automatically discontinued until the peak demand period passes. These agreements offer a means of reducing peak demand, thereby enabling the utility to reduce its peak generating capacity. While this is not a pure energy conservation measure, it does enable a utility to lower power during peak loads and to avoid using expensive auxiliary generators. Interruptible sales agreements are most effective when there is a single large electric power consumer such as a metal or chemical plant in the community.

Plant Equipment

Electric power generation presently consumes about 26 percent of the primary fuels used nationwide. Based on current projections, the amount of energy consumed for electric power generation is expected to triple by 1990 (to 41 percent of total energy consumption). Electric power plant efficiencies increased from an average of only 15 percent in 1900 to 33 percent in 1965 due to technological improvements.[60] However, average fuel conversion efficiency has declined slightly since 1965 because older, inefficient plants have been pressed into service to meet peak-load demands during summers. The U.S. Office of Emergency Preparedness, in a 1972 report on energy conservation, concluded that there are essentially no means for making major improvements in fossil fuel-fired steam turbines at the current state of metallurgy technology.[61] However, there are a number of opportunities for electric utilities to increase efficiency as old equipment is replaced or capacity is expanded. Greater efficiencies can also be achieved through cooperative agreements that allow economies of scale.

There are three types of turbine generating units in use today—gas, steam, and combined cycle. Gas turbine generators are used for meeting peak power demands because they can be started and stopped quickly. Gas generators use natural gas or low-sulfur fuel oil distillates. Gas turbines are too expensive and inefficient to use for base-load generation. Steam turbine generators produce about three-quarters of all electric power on a nationwide basis. Most steam turbines are powered by coal, but many plants have been switching over to petroleum because air quality standards preclude burning high-sulfur coal. Combined-cycle generators use both gas and steam turbines. The base load power is produced by the steam turbine, while the gas turbine is used as a "topping" unit. Hot exhaust gases from the gas turbine are used to either boil water or preheat air for the steam turbine. Combined cycle generators have two advantages over steam turbines—they are usually more efficient energy users, and they can be installed in less time. Their construction cost is also competitive with steam turbines. Additional information about electric power generating equipment and practices can be obtained by writing or calling the organizations listed:

Public Information Representative
American Public Power Association
2600 Virginia Avenue, N.W.
Washington, D.C. 20037
(202) 333-9200

Edison Electric Institute
90 Park Avenue
New York, New York 10016
(212) 573-8700

Another electric power source that local governments should know about is the fuel cell. Fuel cells are devices which produce electric power directly from a fuel by a chemical reaction (see Figure 22). Unlike most generating systems, these devices do not burn the fuel or require generating machinery such as turbines, since their basic process is electrochemical. First employed as a source of electricity during the space program, fuel cells are an efficient means of converting the energy potential of fossil fuels directly to electricity.

Fuel cells have a potential thermal efficiency in the order of 45 percent, using conventional fuels (heating oil or methane). First-generation plants are expected to operate at about 37 percent efficiency. Fuel cells appear to offer the greatest potential as peaking units, since they are more efficient than gas turbines. They also will be a suitable way of generating power on-site for office complexes, major institutional buildings, and multiple-family dwellings. In this way, transmission losses would be reduced.

A fuel cell power plant consists of three components—a reformer, a fuel cell, and an inverter. The reformer is a device which breaks the primary fossil fuel into hydrogen and carbon dioxide. The basic fuel cell combines the hydrogen with oxygen to produce direct current (DC). The

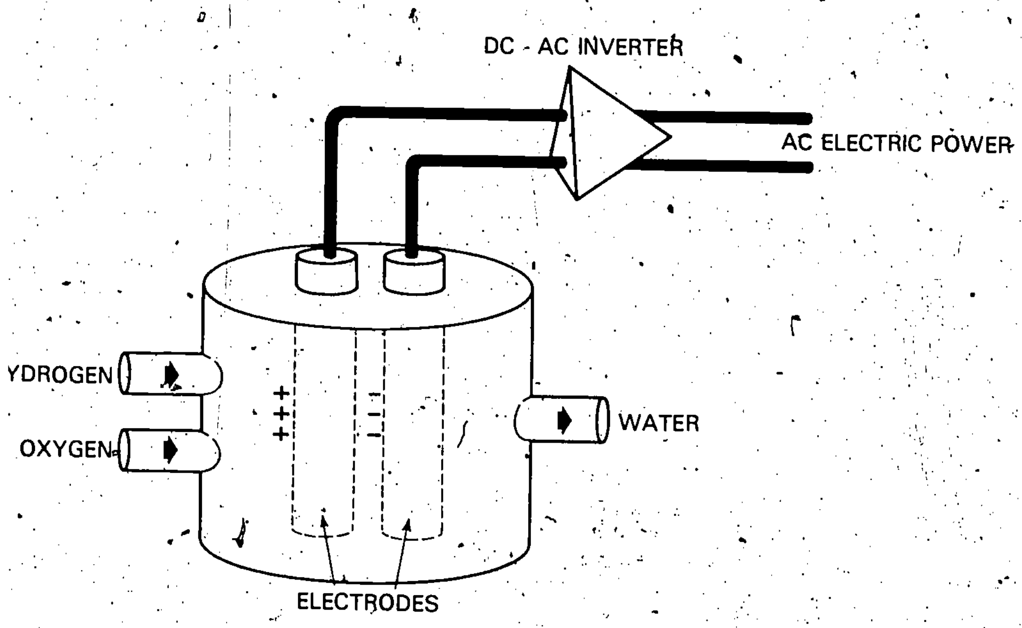


Figure 22. ELECTRICITY FROM A FUEL CELL. A fuel cell produces electricity by an electrochemical reaction in which hydrogen and oxygen combine to produce direct current. The energy produced is tapped by placing an electric load, such as an electric light, in the circuit. Fuel cells generate electricity more efficiently than do electric power plants.

only by-product of this chemical reaction is water. The inverter changes the direct current to alternating current (AC) for transmission and distribution.

Pratt and Whitney Aircraft Company has been engaged in a $42 million development program supported by nine electric utility companies to produce a 26,000-kilowatt fuel cell power plant. This would provide adequate electric power for a community of 20,000 population. The fuel cell power plant is to be demonstrated in 1977 and to go into production in 1978. Such power plants will cost an estimated $5 million each.

The Office of Coal Research and Westinghouse Electric Corporation are developing a prototype 100-kilowatt fuel cell power plant. This power plant uses a high-temperature gas reactor to gasify coal, producing hydrogen. The hydrogen is then reacted with air to produce water and electricity. The only by-products of this type of fuel cell are carbon dioxide and water.

Fuel cell power plants appear to have several advantages over conventional power plants. Large-scale fuel cell plants will probably be economically attractive—actually producing electric power at lower costs than future conventional power plants. Furthermore, fuel cell power plants will require relatively little space, they do not pollute the atmosphere, they are noiseless, and they will require a relatively short lead time. Some experts think fuel cells, when commercially available, can be installed and operating in as little as three months.[62]

State and local governments wishing to investigate fuel cell technology more depth should contact the following sources:

Mr. Carle Morrill
Fuel Cell Marketing Division
Pratt and Whitney Aircraft Company
P.O. Box 109
South Windsor, Connecticut 06074

Dr. Daniel Berg
Director, Energy Systems Research
Westinghouse Electric Corporation
Research Laboratories
Pittsburgh, Pennsylvania 15235
(412) 256-3423

Mr. Paul Jordan
Chief, Public Information Staff
Office of Coal Research
Department of the Interior
2100 M Street, N.W.
Washington, D.C. 20037
(202) 634-6605

Street Lighting

Street lighting is an almost universal public function often performed as an adjunct to electric power generation and transmission. Street lighting should be included as part of a comprehensive energy conservation program, but not without considering its possible impact on crime. Although all the nation's street lights consume less than 1 percent of the total electric power generated, a reduction in street lighting is a highly visible action which can serve to encourage public participation in other energy conservation activities.

The Law Enforcement Assistance Administration (LEAA) recommends that any reduction of street lighting levels in a given area be made only after consultation with police officials and citizens. Certain areas should be maintained at present or even higher levels—commercial districts which generate substantial movements of pedestrians from reasonably crowded areas to less populous sidestreets; high- and medium-density residential areas, particularly those containing low-income housing; areas surrounding major arterial streets; and areas with a number of small commercial establishments. Some suggested areas for street lighting reduction include properties which have been cleared for freeway construction, midblock locations on low-density residential streets, areas where lighting is at a level well above standards in order to enhance commercial interests, areas where lighting is decorative or ornamental in nature, and streets on which pedestrian and automobile traffic are well below normal.

There are five ways to reduce the energy used by existing street lights in a given area:

- Deactivate some portion of the street lights such as every second, third, or fourth lamp.
- Turn off the lights at some time in the late evening or early morning.
- Dim the existing lights.
- Schedule lighting maintenance and relamping.
- Replace existing lamps with lower wattage lamps of the same type.

The last alternative is recommended from a citizen safety standpoint.

Table 7 ESTIMATED COSTS OF CONVERTING FROM INCANDESCENT TO MERCURY OR SODIUM VAPOR STREET LIGHTS

Lamp type	Watts	Lumens	Approximate costs per light*			
			Fixture	Lamp	Labor	Total
Incandescent	500	10,000	----	----	----	----
Mercury vapor	250	10,000	$100	$10	$60	$170
Sodium vapor	100	9,500	120	50	60	230

*Conversion costs assume use of existing poles and wiring.

An alternative to reducing lighting levels is to replace lamps with more energy-efficient ones. Table 7 illustrates the power requirements of three light sources, each of which produces approximately 10,000 lumens. Mercury vapor lights use about 50 percent as much electric power as incandescent lights, and high-pressure sodium vapor uses about 25 percent as much power to achieve the same lighting level. Inefficient incandescent lamps use about one-third of the electric power now consumed nationally by street lights.[63]

The following recommendations are made by LEAA to communities considering reductions in energy usage of street lights as a conservation measure:

- The power requirement for the community's street lights should be figured to make sure the savings measures are really worth the effort.
- Reductions in street lighting should be made only after consultation with police officials and citizens.
- Reductions in street lighting should be part of an overall conservation plan.
- No reductions in street lighting levels should be made until the community has fully explored the alternative of conversion to more efficient types of lights.
- Future street lighting projects should be carefully evaluated to insure that the most efficient street lights are installed.

Local governments wishing to dig deeper into energy conservation measures related to street lighting should write for the LEAA publication *Street Lighting, Energy Conservation and Crime*, Energy Report No. 2, March 1, 1974, at the following address:

Mr. Jeff Alperin
Law Enforcement Assistance Administration
Department of Justice
633 Indiana Avenue, N.W.
Washington, D.C. 20530
(202) 386-4451

VII. ALTERNATIVE ENERGY SOURCES

State and local governments should stay informed of alternative energy sources. Some projects involving such sources have progressed to the demonstration stage and offer promise. This chapter reviews several of these projects—solid waste used as a utility boiler fuel, energy recovery from incineration, pyrolysis, methane recovery from solid waste, and various other research and development programs.

Solid Waste Used as a Utility Boiler Fuel

State and local governments should be aware of the opportunities for using solid waste as a supplemental fuel for electric power plants equipped with boilers designed to burn coal. The city of St. Louis, Missouri, and the Union Electric Company are engaged in a demonstration project which uses residential solid waste to augment the fuel burned by an electric power plant (see Figure 23). This project is funded by the Environmental Protection Agency (EPA).

The St. Louis demonstration project required the construction of a special processing plant to prepare the solid wastes for burning and the modification of the power plant boiler by adding four solid waste firing ports. The solid waste processing plant was designed by Horner and Shifrin, Inc., and it includes materials handling equipment, solid waste storage facilities, a hammermill, and an air classifier. The solid waste processing facilities were designed to handle about 325 tons per eight-hour shift. The boiler furnace was originally designed to burn pulverized coal or gas. A cost-benefit analysis based on actual operating data is not available at this time. The use of refuse as a utility boiler fuel is also being planned in Ames, Iowa.

The Environmental Protection Agency conducted a survey in 1972 to determine the location, design characteristics, and solid waste burning capacity of most power plant boilers in the country. Results of the survey are reported in *Where the Boilers Are: A Survey of Electric Utility Boilers with Potential Capacity for Burning Solid Waste as Fuel* (SW - 88C), available from the U.S. Government Printing Office.

Readers who wish to obtain additional information on solid waste as a supplementary fuel for electric power plant boilers, or on the St. Louis demonstration project itself, should write or call the following organizations:

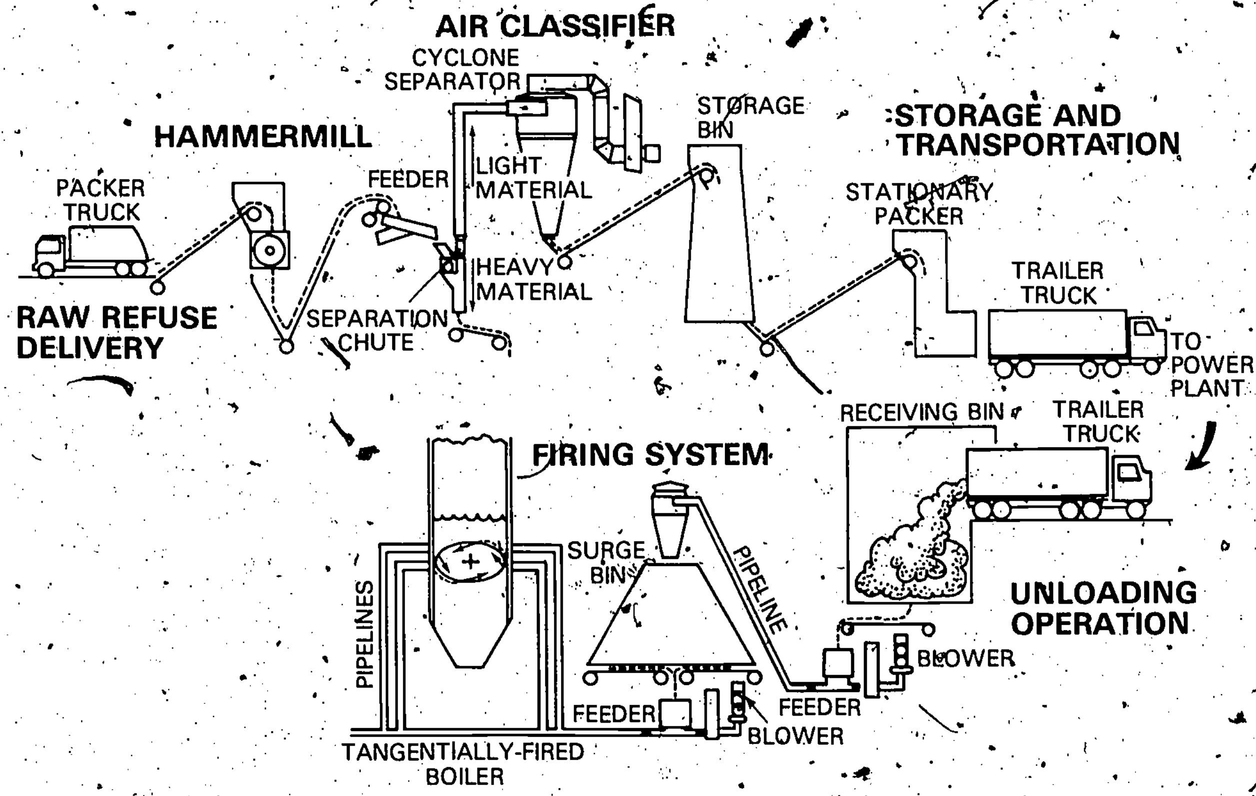


Figure 23. CONVERTING SOLID WASTE TO ELECTRIC POWER. This schematic illustrates the two-stage process for converting domestic solid waste in St. Louis to a utility boiler fuel for the Union Electric Company. First, the solid waste is ground up in a large hammermill and air-classified. The light combustible waste fraction is then fired pneumatically into the boiler. Heavier materials are landfilled or delivered to steel mills. (Courtesy of U. S. Environmental Protection Agency)

Mr. F.E. Wisely, Vice President
Horner and Shifrin, Incorporated
5200 Oakland Avenue
St. Louis, Missouri 63110
(314) 531-4321

Mr. Wayne Sutterfield
Division of Refuse Collection
City of St. Louis
4100 South First Street
St. Louis, Missouri 63118
(314) 353-8877

Mr. Robert Lowe
Resource Recovery Division
Environmental Protection Agency
401 M Street, S.W.
AW-563
Washington, D.C. 20460
(202) 254-7848

Energy Recovery from Incineration

Steam recovery is the best developed technique for recovering energy from solid waste. Steam can be generated for use in heating and cooling buildings and for industrial manufacturing. However, steam recovery is most suitable for cities which have steam distribution networks already established. This principle is being employed today in the city of Nashville, Tennessee (see Figure 24). More than two dozen downtown office buildings there are connected to a central heating and cooling plant. This plant is powered by a water-walled incinerator fueled by the city's solid waste.

The plant and district heating and cooling system are owned and operated by the Nashville Thermal Transfer Corporation, a non-profit corporation which was conceived by the Nashville-Davidson County Metropolitan Government. This unique project has two major advantages for the city. First, costs for future refuse disposal are reduced. Second, the use of no-cost fuel supplied by Nashville enables the corporation's customers, primarily government office buildings, to purchase heating and cooling at a price 25 percent less than the cost of owning and operating their own in-building boilers and chillers. The revenues from the sale of heating and cooling will cover all capital and operating costs of the incinerator and district heating system. Readers who wish to learn more about the Nashville Thermal Transfer Corporation should contact the company directly:

Public Relations Department
Nashville Thermal Transfer Corporation
110 First Avenue, South
Nashville, Tennessee 37201

Pyrolysis

Solid waste can be converted to oil or gas by a process known as pyrolysis. The pyrolysis process works to break down organic substances with heat in an oxygen-deficient atmosphere (see Figure 25). Solid waste pyrolysis produces a gaseous fuel consisting of hydrogen, carbon monoxide, methane, and ethylene. Also, a solid waste char is produced with about two-thirds of the heat value in coal. Both the gas and the char are low in sulfur.

Solid waste pyrolysis systems have been demonstrated in pilot plants by a dozen organizations. However, several full-scale plants should be in operation within the next year or two. Monsanto Enviro-Chem Systems,

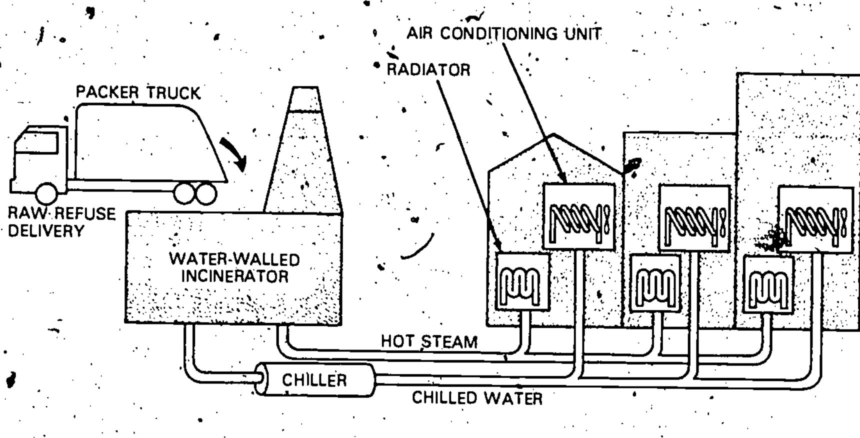


Figure 24. RECOVERING STEAM FROM SOLID WASTE INCINERATION. Steam generated in a water-walled incinerator can be used to heat buildings or to power water chillers for cooling. This technology has been successfully demonstrated in Nashville, Tennessee, where the primary energy source for 27 downtown buildings is solid waste.

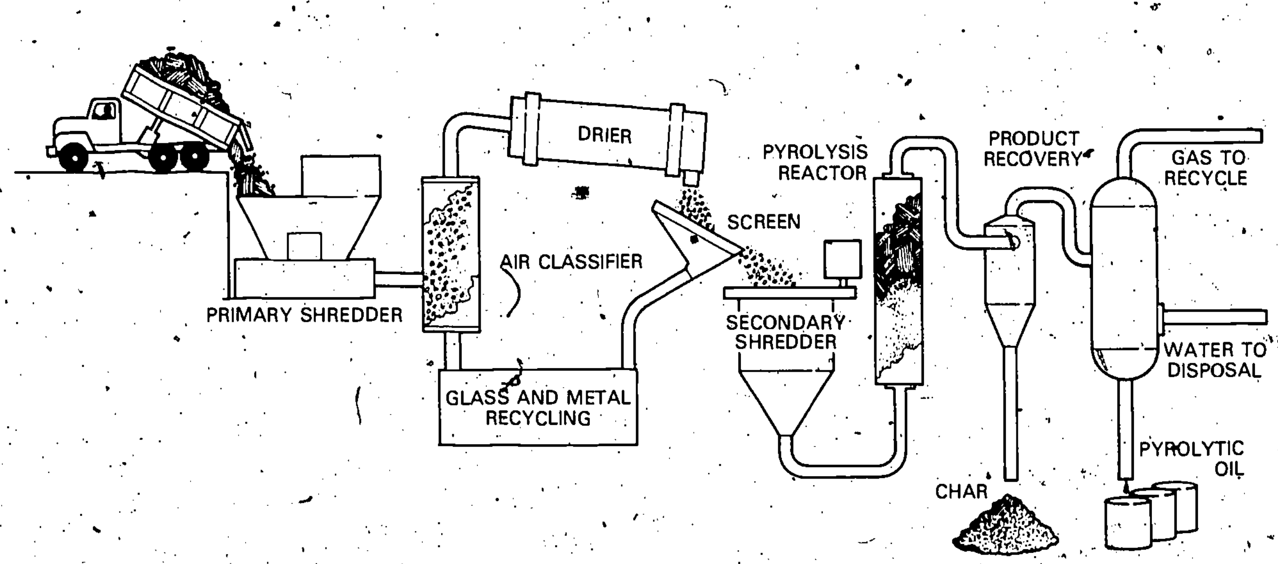


Figure 25. PYROLYSIS: CONVERTING SOLID WASTE TO OIL AND GAS. Pyrolysis is a process by which organic wastes are broken down into simpler compounds and elements by means of heating in the absence of oxygen. The final products of the process are gas and a low-sulfur oil and char. (Courtesy of Garrett Research and Development Company)

Inc., is now building a 1,000-ton-per day gas pyrolysis plant in Baltimore, Maryland, with financial support from the Environmental Protection Agency.

Union Carbide Corporation is constructing a 200-ton-per-day gas pyrolysis plant in South Charleston, West Virginia. Garrett Research and Development Corporation is building a similar plant in San Diego County, California. Sufficient experience should be gained with solid waste pyrolysis to make it a viable option for more widespread use by 1980. Readers who wish to obtain additional information about these solid waste pyrolysis plants should write or call the following organizations:

Mr. Theodor Buss
Sales Manager-Landgard Systems
Monsanto Enviro-Chem Systems, Incorporated
800 North Lindberg Blvd.
St. Louis, Missouri 63166
(314) 694-2384

Dr. George Mallan
Director of Resource Recovery Programs
Garrett Research and Development Corporation
1855 Carrion Road
La Verne, California 91750
(714) 593-7421

Mr. Thomas A. Donegan
Market Specialist
Union Carbide Corporation
270 Park Avenue
New York, New York 10017
(212) 551-4267

Methane from Solid Waste

Sanitary landfills produce gases as organic material is decomposed by bacterial action. One of these gases, methane, is the principal component of natural gas. Methane gas in sanitary landfills is a nuisance because it smells, burns, and occasionally explodes. However, methane gas can be recovered from a landfill by drilling a gas well. After impurities have been removed, the recovered gas can be used as a practical energy source.

At the present time, methane gas is being recovered at the Sheldon-Arleta Landfill owned by the city of Los Angeles. The Los Angeles Power and Water Company operates a pilot plant on the site, and plans are being made to expand it in the near future. Unfortunately, no one knows how long a landfill will produce methane gas. Nevertheless, methane gas recovery is likely to become more attractive as the price of natural gas increases. Additional information about the Los Angeles methane gas recovery operation can be obtained by contacting the power company:

Public Affairs
Department of Water and Power
City of Los Angeles
P.O. Box 111
Los Angeles, California 90051
(213) 481-4211

The Brooklyn-Union Gas Company has recently begun a similar methane recovery operation in New York City.

Other Research and Development Programs

Two other alternative energy sources—geothermal energy and coal gasification—represent options for the future that are presently under development.

Geothermal energy is heat in the earth's interior. Such energy is converted to steam or hot water when subsurface water comes in contact with very hot rocks in the earth's crust. Geothermal energy sources can be tapped by drilling wells directly into pools of this hot water or by drilling wells in hot rock and then pumping water into them to produce hot water or steam. Sources of geothermal energy in the United States are limited primarily to the West, the only known commercial plant in the U.S. being in a geyser field 85 miles north of San Francisco. The generating capacity of this plant is about 420,000 kilowatts—about one-half the power required by a city the size of San Francisco.

Coal gasification is a process for converting coal to methane gas. In this conversion process, coal is treated with high-pressure steam, and hydrogen from the steam combines chemically with carbon from the coal to produce methane gas. The methane gas is then piped to electric power plants where it is burned as fuel in gas turbine generators. Sulfur is removed in the conversion process.

The El Paso Natural Gas Company is planning to install a commercial coal gasification plant pending Federal Power Commission approval. The major advantage of the process is that it permits electric power generation from coal without causing sulfur emissions. However, it has two disadvantages. First, the gas has a relatively low heat value so a conventional gas-powered generator cannot be used. Second, it is more feasible economically to process coal at the mine site, so plants are usually located great distances from the power demand. The U.S. Department of the Interior, in cooperation with the American Gas Association, is sponsoring three pilot programs to find better ways to oduce higher-quality gas using this basic process.

A major focal point for federal energy research is the NSF Research Applied to National Needs program. This research is focused in four areas: energy systems, energy resources, energy conversion, and energy transmission. Energy systems research covers problems related to estimating future energy supply and demand, conserving energy resources, assessing environmental impacts associated with alternative energy sources, and evaluating policy options. Energy resources research addresses problems related to utilizing geothermal energy sources, developing coal conversion technologies, and utilizing waste heat resources. Energy conversion studies focus on problems related to improving the overall efficiency of fossil fuel and nuclear power generation, exploring the application of magnetohydrodynamics (MHD) technology, minimizing the environmental effects of power plant effluents, developing new technologies for energy storage, and developing practical solar energy technologies. Energy and fuel transmission research covers problems related to low-temperature electric current movement, gas and liquid transmission systems, high-voltage direct current transmission, and power network monitoring and control. Special attention is being given to solar energy research. For additional information about the National Science Foundation programs, write or call:

Mr. George James
Division of Advanced Energy Research and Technology
National Science Foundation
1800 G Street, N.W.
Washington, D.C. 20550
(202) 632-7398

Office of Systems Integration and Analysis
National Science Foundation
1800 G Street, N.W.
Washington, D.C. 20550
(202) 632-4032

Several other federal agencies are also engaged in energy-related research and development. These include the Environmental Protection Agency, Federal Energy Administration, Federal Power Commission, General Services Administration, National Aeronautics and Space Administration, National Bureau of Standards, Oak Ridge National Laboratory, Tennessee Valley Authority, Department of Housing and Urban Development, and Department of the Interior. Addresses and telephone numbers for these federal agencies are listed in the appendix.

VIII.

CASE STUDIES IN ENERGY CONSERVATION

The fuel shortage and ensuing energy crisis have had a lasting impact on state and local governments. The American public seems to have a short memory now that gasoline is available again, but state and local governments must not allow themselves to forget that energy problems, in various forms, are going to be around for a long time. The energy crisis of the winter of 1973-1974 developed so rapidly that most state and local governments could only respond to it as an emergency situation. Formal energy conservation programs not only insure a more orderly approach in the event of a new crisis, but they also serve to minimize the effects of such a crisis and, indeed, help prevent its occurrence.

Obviously, the state or local government administrator who must formulate an energy conservation program would like to be able to turn to some sources for guidance. This Technical Guide has presented, in one place, the essential information on energy conservation required to start such a program. Each jurisdiction must assess the technical feasibility and economic practicality of each energy conservation measure in light of its own problems and resources. There is no way to avoid this, because there are very few universal answers—even to problems as common as those in the energy field.

This chapter reviews some of the energy conservation actions taken by state, county, and city governments. The reader should be able to get a feel for what is already working in other jurisdictions. The cases documented in this chapter represent positive, aggressive leadership in energy conservation at the state and local government levels.

State Programs

Several state governments anticipated the need for overall energy conservation programs well before the crisis appeared. (See Appendix D for state contacts for information on energy.) In such states, the typical approach to developing a program has been to establish a committee or task force to examine energy consumption patterns within various state agencies, set conservation goals, and monitor progress. In addition, many state programs have reached beyond state offices as such to affect energy conservation efforts of local governments and the private sector.

In January 1973, for example, Governor Williams of Arizona established a Research and Information System for Arizona (RIES) to join together professionals from various scientific disciplines to formulate policies on statewide energy demands, their impact on the environment, and the need for resource conservation. The governor also formed an energy advisory committee composed of representatives from business, industry, utilities, and universities. Energy conservation plans devised by these groups were supplemented by an energy task force comprised of the governor's office and legislative leadership of both parties.

In California the state legislature authorized establishment of the State Energy Resources Conservation and Development Commission to be composed of members representing engineering or physical sciences, law, environmental protection, economics, and the public at large. Duties of the commission are to assess trends in the use of electrical energy, collect and analyze forecasts, develop a program for energy research to examine alternative sources, and compile and adopt standards. Other functions of the commission are to approve applications for new facilities, prepare an energy shortage emergency plan, evaluate energy rate establishment, and serve as a clearinghouse on energy information.

New York State's energy conservation program began almost two years before the fuel shortage crisis. Former Governor Rockefeller appointed an Interdepartmental Fuel and Energy Committee in January 1972 to monitor the state's fuel and energy supply. This committee, comprised of the heads of eight major state departments and offices, singled out three areas of energy consumption for special attention—large buildings, transportation, and appliances and equipment. Experts from government, industry, professional organizations, and trade associations were appointed to advise the committee on these matters.

In May of 1973 the governor of Texas appointed an energy conservation task force which began with an initial effort to cut consumption of electricity and natural gas in the state's capitol complex by 30 percent. As the task force moved toward this original goal, its mission was expanded to include similar reductions in all types of energy by users in most sectors of the state's economy. The state's energy conservation program is based on a two-pronged strategy of setting conservation goals and allowing energy users to decide how best to meet them and then monitoring progress and publicizing outstanding conservation efforts.

Following is a summary of major energy savings measures inaugurated by states. These measures should be of significant benefit to other states and larger localities in operating their own programs.

1. Public Buildings

a. Governors in several states required implementation of conservation measures in state-owned and occupied buildings.
b. State departments and agencies may be required to submit an energy conservation plan and to file periodic progress reports. In Texas, the state publishes a report on notable conservation efforts by state agencies.
c. New York conducted workshops and sponsored seminars for state agencies on energy conservation in public buildings.

2. Transportation

a. Reduction of speed limits and the encouragement of urban car pools are major energy conservation efforts states have undertaken in the transportation area.

b. Arizona authorized state purchases of only intermediate and compact cars for 1974.
c. Arizona also required all state agencies to implement a plan of 25 percent gasoline reduction.
d. In New York, two peripheral parking lots and a shuttle bus system for transporting employees to work were established. The state also requires its employees to use public transportation for official business whenever possible.

3. Private Sector

a. Several states have encouraged commercial energy users to organize their own energy conservation programs and to file periodic reports to the state.
b. California requires environmental impact statements to include a statement of measures to conserve energy.
c. A private bank in New York City agreed to provide low-interest five-year loans to companies or individuals desiring to purchase energy-conserving equipment.

4. Public Utilities

a. States may require utility rate restructuring to discourage wasteful energy consumption. For example, in California each electrical utility is required to add a surcharge of 1/10th of a mill per kilowatt hour to the cost of electrical power sold to customers in the state. The added revenue will be spent on energy research and development.
b. New York restricts sales promotion advertising by gas and electric utilities.
c. Several states require public utilities to provide special customer services designed to conserve energy.
d. California is fostering increased research by public utilities on ways to conserve energy.
e. Several states have restricted electricity consumption for advertising, decorative lighting, and similar purposes.
f. Arizona has passed legislation to provide for curtailment of electric power in emergency situations.

Fairfax County, Virginia

The Fairfax County government was first notified of a potential fuel shortage in January 1973. The administration immediately passed the warning on to user agencies and began to take specific precautionary measures such as filling all fuel storage tanks to capacity. The Office of General Services established procedures for determining energy requirements and sources. Also, studies were initiated in problem areas related to heating plants, motor vehicles, and fuel storage areas.

The county executive was able to give directions to implement certain energy conservation measures as early as June 1973. The motor vehicle study resulted in a number of fuel saving measures. Also, the government began to purchase smaller vehicles. Several fuel storage and distribution sites were consolidated. Several buildings were converted from #2 heating oil to other more available fuels.

In October 1973, as the effects of the energy shortage became more apparent, the county's purchasing agency began to consolidate its fuel purchasing and distribution services with five other cities and towns. Alternate fuel sources were found for several volunteer fire departments. Additional actions taken included:

- Distribution of a car pooling questionnaire to employees.
- Initiation of a contest on energy conservation suggestions.
- Creation of an energy conservation committee representing a variety of public and private interests.
- Establishment of an Energy Monitoring Office in the Office of General Services.

A public press release was issued in November announcing specific conservation actions for schools such as canceling the use of school buses for field trips and for transporting students to athletic events, rescheduling of athletic events to daytime whenever possible, and extension of Christmas vacation for two additional weeks. Officials had considered instituting a four-day school week with split schedules, but this measure was deferred for use only in case of an extreme emergency.

In January 1974, as the fuel situation became even more serious, the county took a number of other actions:

- Antisiphoning devices were installed in larger vehicles.
- The number of vehicles responding to fires was cut back.
- Firefighters were reassigned to stations nearest their homes.
- A preferential parking program for car pooling employees was started.
- An experiment was conducted to test the feasibility of using waste automotive oil to supplement heating fuel.

In February and March 1974, attention shifted to working with regional, state, and federal officials to insure that citizens would be able to obtain gasoline, receive an adequate level of county services, and obtain accurate information on the fuel situation. To that end, the county implemented the state's "odd-even" numbered license plate gasoline rationing plan, negotiated increased fuel allotments for Northern Virginia, and participated in efforts to establish a regional energy clearinghouse.

Recent population growth, not reflected in early fuel allocations, made Fairfax County one of the hardest hit areas in the nation. With this comprehensive approach to energy conservation, it was able to exercise leadership in responding to a crisis situation. Even though the supply of fuel no longer presents an immediate problem, the county is going ahead with the implementation of additional measures to effect savings in fuel site locations, employee transportation, and service vehicle routing. A follow-up staff report concludes that the county will be able to meet its fuel needs if the international situation remains stable, if present energy conservation measures are retained, and if energy planning mechanisms are instituted now. The new energy planning mechanisms stressed are:

- Development of an overall energy contingency plan.
- Development of the capability to project long-range energy requirements.
- Development of an "energy variable" which considers the effects of energy supply and demand on planning and procurement.
- Development of information sources to keep abreast of technological advances in the energy field.

Readers who wish to learn more about the Fairfax County energy conservation program should write or call the following contact:

Mr. J. Hamilton Lambert, Director
Office of General Services
County of Fairfax
4100 Chain Bridge Road
Fairfax, Virginia 22030
(703)691-2315

Other Jurisdictions

The various state and Fairfax County, Virginia, energy conservation programs are to some degree atypical in the sense that they were started well before the crisis appeared, and they are rather comprehensive programs. Several other jurisdictions also took aggressive actions that focused on particular local problems.

Shaker Heights, Ohio, passed an ordinance requiring every new dwelling to have properly installed thermal insulation in the roof and exterior walls.

New Rochelle, New York, established an energy conservation advisory committee comprised of private homeowners, apartment house owners and tenants, and representatives of the business community and the oil industry.

Burbank, California, passed one of the most stringent and far-ranging ordinances of any jurisdiction in the nation. The ordinance provides that no person may use electric energy unnecessarily or permit such misuse. The ordinance bans the use of electricity for advertising, decorative lighting, exterior building illumination, floodlighting of outdoor areas, and the operation of air conditioners in commercial establishments when they are not open for business. Outdoor lighting for business purposes may not exceed 50 percent of normal use. Thermostats in commercial establishments may not be set higher than 68° F for heating nor lower than 78° F for cooling. Every consumer with an electric energy demand of 500 kilowatts or more is required to file an annual conservation plan.

The city of Spartanburg, South Carolina, implemented one of the country's most thorough programs for achieving fuel savings in vehicle operations. All out-of-town travel involving the use of a city vehicle must have the approval of the city manager's office. Savings in police operations have been achieved by discontinuing all house-check and funeral-escort services. Most interesting in Spartanburg's overall approach to conservation was an analysis of fuel consumption by department which showed the following:

City Manager		0.30%
Finance		0.37
Fire		2.63
Community Development, Planning, and Public Information		3.30
Parks and Recreation		3.60
Police		55.50
Public Works		34.30
Street Cleaning	12.00	
Garbage Collection	7.37	
Street Maintenance	7.17	
Other	7.76	
Total		100.00%

For the two major consumers, police and public works, four different contingency plans were prepared for achieving savings of 10%, 20%, 30%, and 40% respectively, depending on the severity of the fuel shortage. Similar plans were developed for the city's buildings.

Bellevue, Washington, promoted "park and ride" commuting by public transportation by getting churches to allow the use of their lots for fringe parking. The city also allowed the use of municipal vehicles for car pools of four or more employees.

In Eugene, Oregon, the city government encouraged bus commuting by purchasing bus tokens at a discount and reselling them at cost to city employees.

Scottsdale, Arizona, and Stillwater, Oklahoma, established bike pools for use by city employees making short trips in town.

University City, Missouri, cut its garbage haul costs in half by using a transfer station and trailer instead of having collection vehicles make direct trips to the landfill.

Lakewood, Colorado, realized substantial savings in police operations by curtailing the practice of cruising by police cars. Officers are required to stop near a major intersection for a portion of every hour. The city found that response to emergency calls was unaffected, while the high visibility of the unit helped to cut down on speeding and accidents.

Virginia Beach, Virginia, was able to cut gasoline consumption in municipal operations by 30 percent by instituting a number of very basic fuel conservation measures such as making phone calls instead of trips, checking tire pressures daily, tuning engines more frequently, and limiting the practice of allowing employees to drive city vehicles home.

One last response to the energy crisis is mentioned here because it represents a regional approach to energy conservation. The New England Regional Commission, which is composed of the governors of Connecticut, Maine, Massachusetts, Rhode Island, and Vermont, pledged a minimum of a 15 percent reduction in fuel consumption through a joint conservation program including the following measures:

- Urging state and local agencies, churches, and other private groups to reschedule functions in order to minimize the use of buildings that would otherwise be closed.
- Asking industrial and commercial establishments to curtail office hours, cut down on peak period electricity use, and eliminate unnecessary and excessive lighting.

In addition, the governors directed the New England Regional Commission staff to develop an energy information system in order to project supply levels, measure the success of conservation efforts, and keep federal and state officials and the public up to date on the progress of the energy situation.

State and local governments are the principal providers of basic and essential services to the citizens of this nation. They must have adequate and reliable supplies of energy in order to fulfill their obligations and responsibilities. A comprehensive, well-planned and executed energy conservation program is the best assurance at present that these responsibilities can be met.

APPENDIX A

SELECTED ENERGY INFORMATION SOURCES

Source	Type of Information
American Gas Association 1515 Wilson Boulevard Arlington, Virginia 22216 (703)524-2000	A computer program for analyzing building energy requirements (ECUBE)
American Institute of Architects 1735 New York Avenue, N.W. Washington, D.C. 20006 (202)785-7300	Conserving energy through better building design
American Institute of Architects Research Corporation 1735 New York Avenue, N.W. Washington, D.C. 20006 (202)785-8778	Research in energy conservation in buildings through improved design
American Petroleum Institute 1801 K Street, N.W. Washington, D.C. 20006	Statistics, research reports, and other materials on oil, gasoline, and natural gas
American Public Power Association 2600 Virginia Avenue, N.W. Washington, D.C. 20037 (202)333-9200	Energy conservation approaches of publicly owned electric utilities
American Public Works Association 1313 E. 60th Street Chicago, Illinois 60637 (312)324-3400	Energy conservation in motor vehicle equipment
American Society of Heating, Refrigerating and Air-Conditioning Engineers 345 E. 47th Street New York, New York 10017 (212)752-6800	Energy conservation as a function of building equipment systems and comfort conditioning
Association of Home Appliance Manufacturers 20 North Wacker Drive Chicago, Illinois 60606 (312)236-2921	The energy requirements of various household appliances

Source	*Type of Information*
Bureau of Mines 4015 Arlington Boulevard Arlington, Virginia 20240 (703)655-4000	Resource recovery from solid waste combustion, pyrolysis, coal gasification
Citizens Advisory Committee on Environmental Quality 1700 Pennsylvania Ave., N.W. Washington, D.C. 20006 (202)223-3040	How to promote energy conservation through a communitywide public information program
Department of Housing and Urban Development Division of Community Development Research 451 7th St., S.W. Washington, D.C. 20410 (202)755-5599	Total energy systems and other forms of localized power generation
Department of the Interior Office of Coal Research 2100 M Street, N.W. Washington, D.C. 20037 (202)343-5594	Fuel cell and coal gasification research
Department of Transportation 400 7th Street, S.W. Washington, D.C. 20590	
Energy and Environment Division (202)426-2022	Research reports and other materials on improving vehicle fuel economy through new and retrofit devices
Urban Mass Transportation Administration Research Development and Demonstration Programs (202)426-4043	Dial-a-Ride bus programs, fringe parking coordination
Urban Planning Division Federal Highway Administration (202)426-0210	Bus-on-freeway programs, exclusive bus and car pool lanes
Edison Electric Institute 90 Park Avenue New York, New York 10016 (212)573-8700	Electric utility operations and engineering, power system coordination
Environmental Protection Agency Resource Recovery Division 1835 K Street, N.W. Washington, D.C. 20006 (202)755-2673	Union Electric demonstration project in St. Louis, energy recovery from solid wastes
Federal Energy Administration Office of Energy Conservation and Environment New Post Office Building 12th and Pennsylvania Ave., N.W. Washington, D.C. 20461	Energy conservation checklists, energy conservation research, fuel allocation information, all aspects of federal energy regulations and legislation, lighting and thermal operations guidelines
Federal Housing Administration 451 7th Street, S.W. Washington, D.C. 20410 (202)755-6522	Minimum property standards for federally subsidized housing, property improvement and mobile home loan insurance regulations, thermal insulation standards

Source	Type of Information
Federal Power Commission Union Center Plaza 825 N. Capitol St., N.E. Washington, D.C. 20426 (202)386-6102	Interstate sale and transmission of natural gas and electric power, coordination of electric power sources
General Services Administration Federal Supply Service 18th and F Sts., N.W. Washington, D.C. 20406	Tips for conserving gasoline in large vehicle fleet operations
General Services Administration Public Buildings Service 18th and F Sts., N.W. Washington, D.C. 20406 (202)343-6117	Energy conservation aspects of building heating, cooling, and ventilating systems; new building design; methods of conserving energy in existing buildings
Grumman Aerospace Corporation Energy Systems Division Plant #30 Bethpage, New York 11714 (516)575-9630	Energy conservation in buildings, particularly short-term measures; solar energy applications
Illuminating Engineering Society 345 E. 47th Street New York, New York 10017 (212)752-6800	Lighting systems, energy conservation aspects of lighting efficiency, heat of light recovery
Law Enforcement Assistance Administration Emergency Energy Committee 633 Indiana Avenue, N.W. Washington, D.C. 20530 (202)386-4551	Energy conservation, street lighting, and crime
Motor Vehicle Manufacturers Association 320 New Center Building Detroit, Michigan 48202 (313)872-4311	Fuel economy tips for purchasing new fleet vehicles, gasoline consumption aspects of axle and compression ratios and gross weight
Nashville Thermal Transfer Corporation 110 First Avenue, South Nashville, Tennessee 37219 (615)255-1460	Energy recovery from refuse incinerator; district heating and cooling system for buildings
National Aeronautics and Space Administration Office of Energy Programs Code N 400 Maryland Avenue, S.W. Washington, D.C. 20546 (202)755-3127	Solar energy, wind energy, fuel cells, other alternate energy sources
National Bureau of Standards Center for Building Technology Building 226, Room B-244 Washington, D.C. 20234 (301)921-3377 (Gaithersburg, Md.)	Technical information on building materials, comfort conditioning systems, and performance standards

Source	Type of Information
National Bureau of Standards National Conference of States on Building Codes and Standards Building 226 Washington, D.C. 20234 (202)921-3447	Energy impact statements, optimal thermal insulation standards, design and evaluation criteria for energy conservation in new buildings
National Center for Resource Recovery 1211 Connecticut Ave., N.W. Washington, D.C. 20036 (202)223-6154	Research reports and other materials on energy recovery from solid waste combustion
National Mineral Wool Insulation Association 211 East 51st Street New York, New York 10022 (212)758-5210	Diminishing heat gains and losses through thermal insulation
National Science Foundation 1800 G St., N.W. Washington, D.C. 20550	
Division of Advanced Energy Research and Technology (202)632-9793	Lead agency in solar energy research and development
Office of Public Technology Programs (202)632-4175	Solar energy applications
Office of Systems Integration and Analysis (202)632-4032	Energy conservation, energy systems, policy analysis (responsible for all NSF/RANN sponsored energy conservation research)
Oak Ridge National Laboratory Energy Division Post Office Box X Oak Ridge, Tennessee 37830 (615)483-8611	Building heating systems, thermal insulation research
Phoenix of Colorado Springs, Incorporated 3020 N. El Paso Colorado Springs, Colorado 80933 (303)633-2633	Solar energy utilization in residential construction
Public Technology, Inc. 1140 Connecticut Ave., N.W. Washington, D.C. 20036 (202)223-8240	Fuel conservation through more efficient vehicle routing and through more effective fleet management practices
The RAND Corporation Energy Policy Program 1700 Main Street Santa Monica, California 90406 (213)393-0411	State energy policy analysis, energy conservation in buildings and transportation, total energy system evaluation
Richard Stein and Associates 588 Fifth Avenue New York, New York 10036 (212)757-0284	Energy utilization in school design and operation

Source	*Type of Information*
Solar Energy Industries Association 1001 Connecticut Ave., N.W. Washington, D.C. 20036 (202)293-1000	Commercial utilization of solar energy
Tennessee Valley Authority Employees Credit Union 507 Market Street Knoxville, Tennessee 37902 (615)546-8911	Van pooling programs
Tennessee Valley Authority Power Marketing Division 401 United Bank Building Chattanooga, Tennessee 37401 (615)755-2341	Insulation and heat pumps to make homes more energy efficient

APPENDIX B

SAMPLE STATE LEGISLATION REQUIRING LIFE-CYCLE COST ANALYSIS OF STATE-OWNED AND ASSISTED FACILITIES*

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF WASHINGTON:

Section 1. The legislature hereby finds:

(1) That major publicly owned or leased facilities have a significant impact on our state's consumption of energy;

(2) That energy conservation practices adopted for the design, construction, and utilization of such facilities will have a beneficial effect on our overall supply of energy;

(3) That the cost of the energy consumed by such facilities over the life of the facilities shall be considered in addition to the initial cost of constructing such facilities; and

(4) That the cost of energy is significant and major facility designs shall be based on the total life-cycle cost, including the initial construction cost, and the cost, over the economic life of a major facility, of the energy consumed, and of the operation and maintenance of a major facility as they affect energy consumption.

Section 2. The legislature declares that it is the public policy of this state to insure that energy conservation practices are employed in the design of major publicly owned or leased facilities. To this end the legislature authorizes and directs that public agencies analyze the cost of energy consumption of each major facility to be constructed or renovated on and after the effective date of this act.

Section 3. For the purposes of this chapter the following words and phrases shall have the following meanings unless the context clearly requires otherwise:

(1) "Public Agency" means every state office, officer, board, commission, committee, bureau, department, and all political subdivisions of the state.

(2) "Major facility" means any publicly owned or leased building having twenty-five thousand square feet or more of useable floor space.

(3) "Initial cost" means the moneys required for the capital construction or renovation of a major facility.

(4) "Renovation" means revision to a major facility which will affect any energy system.

(5) "Economic life" means the projected or anticipated useful life of a major facility as expressed by a term of years.

(6) "Life-cycle cost" means the cost of a major facility including its initial cost, the cost of the energy consumed over its economic life, and the energy consumption related cost of its operation and maintenance.

(7) "Life-cycle cost analysis" includes, but is not limited to, the following elements:

(a) The coordination and positioning of a major facility on its physical site;

(b) The amount and type of fenestration employed in a major facility;

(c) The amount of insulation incorporated into the design of a major facility;

(d) The variable occupancy and operating conditions of a major facility; and

(e) An energy-consumption analysis of a major facility.

(8) "Energy systems" means all utilities, including, but not limited to, heating, air-conditioning, ventilating, lighting, and the supplying of domestic hot water.

(9) "Energy-consumption analysis" means the evaluation of all energy systems and components by demand and type of energy including the internal energy load imposed on a major facility by its occupants, equipment, and components, and the external energy load imposed on a major facility by the climatic conditions of its location. An

*Excerpted from proposed legislation for the state of Washington.

energy consumption analysis of the operation of energy systems of a major facility shall include, but not be limited to, the following elements:

(a) The comparison of three or more system alternatives;

(b) The simulation of each system over the entire range of operation of such facility for a year's operating period; and

(c) The evaluation of the energy consumption of component equipment in each system considering the operation of such components at other-than full or rated outputs.

The energy-consumption analysis shall be prepared by a professional engineer or licensed architect who may use computers or such other methods as are capable of producing predictable results.

Section 4. On and after the effective date of this act whenever a public agency determines that any major facility is to be constructed or renovated such agency shall cause to be included in the design phase of such construction or renovation a provision that requires a life-cycle cost analysis to be prepared for such facility. Such analysis shall be approved by the agency prior to the commencement of actual construction or renovation. A public agency may accept the facility design if the agency is satisfied that the life-cycle cost analysis provides for an efficient energy system or systems based on the economic life of the major facility.

APPENDIX C

SAMPLE PROMOTIONAL LITERATURE FOR USE BY GOVERNMENTS IN ENCOURAGING ENERGY CONSERVATION

A. Directed to Home Owners—Home Heating and Cooling

1. Consolidated Edison Company of New York, Inc. *How to Insulate Your Home* (Energy Saver #1) and *How to Keep Your House Warm 44 Ways* (Energy Saver #2). New York: The Company, 1974.
2. National Mineral Wool Insulation Association, Inc. *How to Insulate Homes for Oil Heating* (January 1973) and *How to Insulate Homes for Electric Heating and Air Conditioning* (February 1974). New York: The Association.
3. Tennessee Valley Authority. *Heat Pump—The Energy Miser.* Knoxville: The Authority, 1974.
4. U. S. Department of Commerce, National Bureau of Standards. *Home Energy Savings Tips from NBS* and *Energy Efficiency in Room Air Conditioners.* Pueblo, Colo.: Public Documents Distribution Center, 1974.
5. U. S. Office of Consumer Affairs. *7 Ways to Reduce Fuel Consumption in Household Heating Through Energy Conservation* and *11 Ways to Reduce Energy Consumption and Increase Comfort in Household Cooling.* Washington, D.C.: U.S. Government Printing Office, 1974.

B. Directed to Residents—Reducing Utility Bills

The following pamphlets and flyers distributed by the Consolidated Edison Company of New York, Inc., are illustrative of similar materials distributed by consumer-owned electric utilities:

How to Use Electricity and Gas Wisely and Safely, and Save Money Too (pamphlet)
Conserve Energy: Save Heat and Hot Water (flyer)
6 Ways to Save Money on Your Utility Bills (flyer)
How to Get the Most From Your Appliances (flyer)

C. Directed to Businesses and Light Industry

1. American Society of Association Executives. *A Guide to Energy Management: How to Conduct an Energy Audit.* Washington, D.C.: The Association, 1974.
2. Consolidated Edison Company of New York, Inc. *Energy Management Guide/Electricity.* New York: The Company, 1973.
3. U.S. Department of Commerce, Office of Energy Programs. *Energy Conservation Handbook for Light Industries and Commercial Buildings* (May 1974), *Energy Management: Economic Sense for Retailers* (February 1974), *How to Start an Energy Management Program* (October 1973), and *33 Money-Saving Ways to Conserve Energy in Your Business.* Washington, D.C.: U.S. Government Printing Office.

D. Directed to Car Owners and Drivers

1. Cummins Engine Company, Inc. *Trucker's Guide to Fuel Savings.* Columbus, Ind.: The Company, 1973.
2. Exxon Company. *Tips for Stretching Gasoline Mileage.* The Company, 1974.
3. U.S. Environmental Protection Agency, Federal Energy Administration. *1975 Gas Mileage Guide for New Car Buyers.* Washington, D.C.: Federal Energy Administration, 1974.

E. Directed to Building Design Engineers and Architects

1. Electric Energy Association. *Electric Space Conditioning in Residential Structures*. New York: The Association, 1974.
2. Syska & Hennessy, Inc., Engineers. *Energy Shortage—A Constraint or a Challenge?* (February 1974 issue of Technical Letter), New York: Syska & Hennessy, Inc.

APPENDIX D

STATE CONTACTS FOR INFORMATION ON ENERGY*

ALABAMA

Phillip E. LaMoreaux
State Geologist
Geological Survey of Alabama
University of Alabama
Tuscaloosa, Alabama 35486
(205)759-5721

ALASKA

J. Lowell Jensen
Executive Director
Department of Commerce
1100 Mackay Building
338 Denall Street
Anchorage, Alaska 99501
(907)272-1487

ARIZONA

Bob Beeman
Economist
Department of Economic Planning & Development
Suite 1704
3003 North Central Avenue
Phoenix, Arizona 85012
(602)271-5005

ARKANSAS

Richard W. Longing
Director
Arkansas Department of Commerce
151 Capitol Building
Little Rock, Arkansas 72201
(501)371-2231

CALIFORNIA

A. Earl Davis
Science and Technology Coordinator
Room 1311
1416 Ninth Street
Sacramento, California 95814
(916)445-4711

COLORADO

H. C. Kimbrough
Room K 244
State Capitol
Denver, Colorado 80203
(303)892-2087

CONNECTICUT

H. Raymond Sjostedt
Director
Civil Defense Division
360 Broad Street
Hartford, Connecticut 06115
(203)566-3180

DELAWARE

Clifton E. Morris
Chairman
Delaware Emergency Energy Planning Committee
Highway Administration Building
Dover, Delaware 19901
(302)678-[illegible]303

FLORIDA

Howell Ferguson
Administrative Assistant
Office of the Governor
Capitol Building
Tallahassee, Florida 32304
(904)488-2440

GEORGIA

Dr. Ted Mock
Science Advisor to the Governor
225 Peachtree Center South
Atlanta, Georgia 30303
(404)656-3991

HAWAII

Eugene Grabbe
Manager
State Center for Science Policy and Technology Assessment
Department of Planning and Economic Development
P.O. Box 2359
Honolulu, Hawaii 96804
(808)548-4195

IDAHO

John Hough
Governor's Administrative Assistant
State Capitol
Boise, Idaho 83701
(208)384-2100

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*This list was derived from *A Directory of State Energy Activities* compiled by George Scudella, Project Coordinator, Energy Task Force, State of New Mexico. The listings are as of July 1, 1973. Although at present some of those whose names are listed may no longer serve in the position noted, this listing is presented here as a useful compilation of sources with which to initiate state contacts.

ILLINOIS

C. F. Bertinetti
Assistant to the Governor
202 State Capitol
Springfield, Illinois 62706
(217)525-5160

INDIANA

Robert C. Morris
Executive Director
Department of Commerce
336 State House
Indianapolis, Indiana 46204
(317)633-4450

IOWA

Samuel Tuthill
Chairman
Governor's Fuel Board
State Geologist
University of Iowa
Iowa City, Iowa 52240
(319)353-2121

KANSAS

Darold D. Main
Secretary to the Chairman
Kansas Corporate Commission
Topeka, Kansas 66603
(913)296-3326

Terry Scanland
Director
Department of Economic Development
Topeka, Kansas 66603
(913)296-3481

KENTUCKY

Thomas O. Harris
Commissioner of Natural Resources
and Environmental Protection
Capitol Plaza Office Towers
Frankfort, Kentucky 40601
(502)564-3350

Damon W. Harrison
Commissioner
Department of Commerce
Capitol Plaza Office Towers
Frankfort, Kentucky 40601
(502)564-4270

LOUISIANA

Dr. Lyle St. Amant
Assistant Director
Wildlife and Fisheries Commission
400 Royal Street
New Orleans, Louisiana 70130
(504)527-9429

MAINE

Emilien A. Levesque
Director
Bureau of Civil Defense
Department of the Military
State House
Augusta, Maine 04330
(207) 622-6201

MARYLAND

Mike Smith
Emergency Resource Staff Officer
Maryland Civil Defense and
Emergency Planning Agency
Pikesville, Maryland 21208
(301)486-4422

MASSACHUSETTS

Louis F. Saba
Director
Civil Defense Agency
400 Worcester Road
Framingham, Massachusetts 01701
(617)237-0200

MICHIGAN

Richard Helmbrecht
Director
Department of Commerce
Law Building
Lansing, Michigan 48913
(517)373-1820

MINNESOTA

Gerald Christenson
State Planning Offices
802 Capital Square
St. Paul, Minnesota 55155
(612)296-6662

MISSISSIPPI

Dr. P. T. Bankston
Science Advisor to the Governor
State Capitol
Jackson, Mississippi 39205
(601)354-6517

MISSOURI

James Bash
Disaster Operations Office
Chairman, Governor's Emergency
Task Force
1717 Industrial Drive
Jefferson City, Missouri 65101
(314)751-2321

MONTANA

John Goers
Assistant to the Lieutenant
Governor
Office of the Governor
Helena, Montana 59601
(406)449-2511

NEBRASKA

Burl Johnson
Nebraska Civil Defense Agency
1300 Military Road
Lincoln, Nebraska 68508
(402)432-7641 Ext. 310

NEVADA

Noel A. Clark
Public Service Commission
Carson City, Nevada 89701
(702)882-7542

NEW HAMPSHIRE

Frederick D. Goode
Administrative Assistant to
the Governor
State Capitol
Concord, New Hampshire 03301
(603)271-2121

NEW JERSEY

John J. Kozak
Chief
Bureau of Resource Management
Division of Civil Defense/Disaster
Control
Department of Defense
Eggerts Crossing Road, Box 979
Trenton, New Jersey 08625
(609)292-3838

NEW MEXICO

G. E. Montes
Project Manager
George Scudella, Coordinator
Governor's Energy Task Force
117 Jefferson Street
Santa Fe, New Mexico 87501
(505)827-5368

NEW YORK

Joseph C. Swidler
Chairman
Public Service Commission
44 Holland Avenue
Albany, New York 12208
(518)474-2530

NORTH CAROLINA

William L. Bondurant
Secretary to the Governor
Department of Administration
Raleigh, North Carolina 27603
(919)829-7232

NORTH DAKOTA

Ronald D. Affeldt
State Emergency Planning Director
Division of Disaster Emergency Services
P.O. Box 1817
Bismarck, North Dakota 58501
(701)224-2113

OHIO

David Sweet
Director
Department of Economic and Community Development
State Capitol
Columbus, Ohio 43215
(614)466-3379

OKLAHOMA

James Hart
Executive Assistant to the Governor
Energy Advisory Council
State Capitol
Oklahoma City, Oklahoma 73105
(405)521-2345

OREGON

Joe Schantz
Governor's Assistant
State Capitol
Salem, Oregon 97310
(503)378-3100

PENNSYLVANIA

Eli Sobel
Program Manager
Office of Science and Technology
400 South Office Building
Harrisburg, Pennsylvania 17120
(717)787-4147

RHODE ISLAND

William Harsch
Special Assistant for Policy and Program Review
Executive Chambers
Providence, Rhode Island 02903
(401)421-7333

SOUTH CAROLINA

A. B. Holmes
Executive Secretary
South Carolina Energy Management Policy Council
233 Wade Hampton Office Building
Columbia, South Carolina 29201
(803)758-2946

SOUTH DAKOTA

Steven Davis
Office of the Governor
State Capitol
Pierre, South Dakota 57501
(605)224-3608

TENNESSEE

Dr. Edward Thackston
Staff Assistant for Environmental Affairs
Governor's Office
1025 Andrew Jackson Building
Nashville, Tennessee 37209
(615)741-3621

TEXAS

Lieutenant Governor William P. Hobby
Chairman, Governor's Energy Advisory Council
Capitol Building
Austin, Texas 78701
(512)475-3535

UTAH

Don Spradling
State Disaster Coordinator
P.O. Box 8100
Salt Lake City, Utah 84108
(801)328-5271

VERMONT

Norman James
Assistant to the Governor
Governor's Office
Montpelier, Vermont 05602
(802)828-3333

VIRGINIA

Minor Hawley
Emergency Resource Coordinator
P.O. Box 1163
Room 407D
Richmond, Virginia 23209
(804)770-4711

WASHINGTON

Neil Miller
Administrative Officer
Department of Emergency Services
State of Washington
4220 East Martin Way
Olympia, Washington 98504
(206)753-5255

WEST VIRGINIA

Ronald G. Pearson
Commissioner
Department of Finance and Administration
Room West 118
State Capitol Building
Charleston, West Virginia 25305
(304)345-2300

WISCONSIN

James A. Gruentzel
State Emergency Planning Director
4802 Sheboygan Avenue
Madison, Wisconsin 53702
(608)266-3232

WYOMING

Charles Adam
State Emergency Planning Director
P.O. Box 1709
Cheyenne, Wyoming 82001
(307)777-7566

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2. *Ibid.*
3. U.S. Council on Environmental Quality, *Energy and the Environment* (Washington, D.C.: U.S. Government Printing Office, 1973), p. 1.
4. *Ibid.*
5. *Ibid.*, p. 7.
6. "Energy Crisis in America," *Congressional Quarterly*, 1973, p. 4.
7. *Ibid.*, p. 6.
8. *Ibid.*, p. 5.
9. *Ibid.*, p. 4.
10. "Electric Utility Statistics," *Public Power*, January-February 1973, p. 30.
11. U.S. Office of Emergency Preparedness, *The Potential for Energy Conservation* (Washington, D.C.: Government Printing Office, 1972), p. F-11.
12. National Bureau of Standards, *Technical Options for Energy Conservation in Buildings* (Washington, D.C.: U.S. Department of Commerce, 1973), p. 1.
13. Dubin-Mindell-Bloome Associates, *Energy Conservation Design Guidelines for Office Buildings* (Washington, D.C.: U.S. General Services Administration, 1974), Fig. 4-1.
14. National Bureau of Standards, *op. cit.*, p. 4.
15. *Ibid.*, p. 27.
16. *Ibid.*, p. 39.
17. *Ibid.*, p. 38.
18. *Ibid.*, p. 79.
19. Personal interview with Ken Bowlen, Vice President, Cargo Caire Engineering Corporation, Amesbury, Massachusetts, May 16, 1974.
20. National Bureau of Standards, *op. cit.*, p. 93.
21. *Ibid.*, p. 5.
22. Illuminating Engineering Society, *Recommendations for Better Utilization of Energy Expended for Lighting* (New York: The Society, 1973), p. 4.
23. Marguerite Villecco, ed., *Energy Conservation In Building Design* (Washington, D.C.: AIA Research Corporation, 1974), p. 10.
24. Dubin-Mindell-Bloome Associates, *op. cit.*, p. 4-1.
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26. Sarah Booth Conroy, "Who Says There's Nothing New Under the Sun?", *Washington Post*, June 23, 1974, p. H-1.
27. *Indiana Code 1971*, Title 6, Art. 1, Laws of 1974, Act 15, Approved 2-18-74.
28. Donnel Nunes, "Tax Break Studied for Solar Use," *Washington Post*, June 13, 1974, p. 1.
29. Personal interview with Irwin Barr, Vice President, AAI Corporation, Baltimore, Maryland, March 15, 1974.

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49. Personal interview with Eldon Ziegler, Urban Mass Transportation Administration, U.S. Department of Transportation, March 20, 1974.

50. Robert R. Gatts et al., *Energy Conservation Program Guide for Industry and Commerce* (Washington, D.C.: U.S. Department of Commerce, 1974), p. 1-1.

51. S. David Freeman et al., *A Time to Choose: America's Energy Future* (Cambridge, Massachusetts: Ballinger Publishing Company, 1974), p. 68.

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56. T. D. Mount, D. Chapman, and T. J. Tyrrell, "Electricity Demand in the United States: An Econometric Analysis," M.I.T. Conference on Energy: Demand, Conservation and Institutional Problems, February 12-14, 1973, Boston, Massachusetts.

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58. Personal interview with James Tanner, Administrator of Public Utility Rates, Public Service Commission of Wisconsin, October 23, 1974.

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60. U.S. Office of Emergency Preparedness, *op. cit.*, p. F-1.

61. *Ibid.*, p. 29.

62. Personal interview with Mr. Edward R. Cowles, Pratt and Whitney Aircraft Company, May 15, 1974.

63. Law Enforcement Assistance Administration, *Street Lighting, Energy Conservation and Crime*, Energy Report No. 2, (Washington, D.C.: U.S. Department of Justice, 1974), p. 11.

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1. American Society of Heating, Refrigerating and Air-Conditioning Engineers. *Design and Evaluation Criteria for Energy Conservation in New Buildings* (Proposed Standard 90-P). New York: The Society, 1974.

   Based on an earlier report by the National Bureau of Standards, this publication presents proposed uniform nationwide energy conservation standards for new buildings. Detailed performance requirements and criteria are directed toward the design of building envelopes with high thermal resistance and low air leakage, and toward requiring practices in the design of mechanical and electrical systems that conserve energy.

2. Daly, Leo A. *Energy and the Built Environment: A Gap in Current Strategies.* Washington, D.C.: American Institute of Architects, 1974.

   Report prepared by the chairman of the American Institute of Architects Task Force on Energy Conservation. Emphasizes the important role to be played by building design professions in energy conservation. Daly warns that more research is needed before injecting rigid energy standards into building codes or other forms of legislation.

3. Dubin-Mindell-Bloome Associates, et al., *Energy Conservation Design Guidelines for Office Buildings,* Washington, D.C.: General Services Administration, 1974.

   Guidelines developed specifically for new federal office buildings, but applicable to all office buildings. The document presents design criteria for all building systems and discusses the relationships between climate, site, building, and mechanical systems. The document also summarizes energy conservation opportunities at the various stages of building development and for each building service. In addition, alternative energy sources, solar energy, and wind and total energy systems are discussed as they can apply to office buildings.

4. Educational Facilities Laboratories. *The Economy of Energy Conservation in Educational Facilities.* New York: The Laboratories, 1973.

   An excellent guide to energy conservation in schools written for the school administrator, his operating staff, school board members, and design professionals.

5. Energy Policy Project of the Ford Foundation. *A Time to Choose: America's Energy Future.* Cambridge, Mass.: Ballinger Publishing Co., 1974.

   The culmination of a two-year, $4 million Ford Foundation study to identify the nation's energy policy choices. The study concludes that the U.S. can balance its energy budget, control pollution, and avoid reliance on foreign oil sources by slowing growth in energy consumption to about 2 percent a year. Considers such public policy issues as the economic and social power of the energy industry, nuclear energy problems, and coal strip mining.

6. Federal Energy Administration. *Project Independence Report.* Washington, D.C.: U.S. Government Printing Office, 1974.

Reports results of a massive interagency effort of the federal government to evaluate the nation's energy problems and provide a framework for developing a national energy policy. Evaluates the impact and costs of four different strategies for dealing with the energy problem.

7. Federal Power Commission. *Guidelines for Energy Conservation for Immediate Implementation: Small Business and Light Industries.* Washington, D.C.: The Commission, 1974.

Offers guidelines for fuel conservation in heating, combustion equipment adjustment, effective process control, and modification of equipment. Also presents guidelines for surveying energy conservation opportunities in a given plant.

8. Gatts, Robert R., et al. *Energy Conservation Program Guide for Industry and Commerce.* Washington, D.C.: U.S. Department of Commerce, 1974.

This is a guide to assist business and industry in establishing an on-going conservation program. The guide outlines the steps in an energy conservation program and suggests specific ways to reduce energy use in manufacturing and commercial businesses. Information was compiled largely from practices used or suggested as useful by engineers and energy managers in industry and commerce.

9. Hittman Associates, Inc. *Residential Energy Consumption.* Washington, D.C.: U.S. Government Printing Office, 1972-ongoing.

Study partially funded by the Research Applied to National Needs program of the National Science Foundation. A series of research reports sponsored by the Department of Housing and Urban Development to identify means for obtaining greater efficiencies in residential energy consumption in order to obtain lower per capita consumption without modification of existing life styles. The project identifies and quantifies the total energy balance in single- and multi-family housing in the Baltimore-Washington area. It then identifies technical innovations that minimize residential energy utilization while maintaining existing life styles.

10. Intertechnology Corporation. *The U.S. Energy Problem.* 2 vols. Warrenton, Va.: The Corporation, 1971.

Prepared for the Research Applied to National Needs program of the National Science Foundation. One of the most complete studies of energy production and consumption in all economic sectors. The report is geared primarily to evaluating current research and development in energy production. The section on solar energy conversion should prove useful to state and local governments. Also the graphic displays are effective in presenting consumption data. The study is useful to managers of electric utilities. It discusses the use of electrochemical systems for off-peak power storage as well as fuel cells.

11. Large, David B., ed. *Hidden Waste: Potential for Energy Conservation.* Washington, D.C.: The Conservation Foundation, 1973.

This clearly written overview of energy use discusses energy conservation measures for homes, office buildings, industry, and transportation, as well as the potential for tapping the energy from wastes. The author draws from a vast number of sources and professional opinions in the various technical disciplines concerned with energy use. The report is an excellent introduction to the subject.

12. Motor Vehicle Manufacturers Association. *Automobile Fuel Economy.* Detroit: The Association, 1973.

Booklet outlines the factors involved in determining fuel economy. It is especially useful in setting specifications for the purchase of new vehicles.

13. Moyers, John. *The Value of Thermal Insulation in Residential Construction: Economics and the Conservation of Energy.* Oak Ridge: Oak Ridge National Laboratory, 1971.

This study supported by the Research Applied to National Needs program of the National Science Foundation is a parametric evaluation of relative energy consumption and net annual cost as a function of several different insulation systems for different climatic regions and financing arrangements. The types of additional insulation considered in the study are glass fiber batts for walls and ceilings, storm windows, air gap, and foil under the floor. The insulation system satisfying FHA Minimum Property Standards for a single-family house is compared to the system found to be economically optimal for each climatic region.

14. National Association of Home Builders. *The Builder's Guide to Energy Conservation.* Washington, D.C.: The Association, 1974.

A manual on practical, cost-effective means for energy conservation in housing and light commercial buildings.

15. National Bureau of Standards. *Retrofitting Existing Housing for Energy Conservation: An Economic Analysis.* Washington, D.C.: U.S. Government Printing Office, 1975.

Technical study providing information to homeowners on how much insulation is needed for maximum return on investment. Energy conservation improvements covered in the study include insulation in various parts of a house, storm windows, storm doors, and weather stripping. Conclusions of the study are based on an economic model that takes into account fuel prices, climate, and costs of improvements. The study concludes that conservation measures studied will easily pay for themselves over the lifetime of the improvements.

16. National Bureau of Standards. *Technical Options for Energy Conservation in Buildings.* Washington, D.C.: U.S. Department of Commerce, 1973.

This report offers guidance to professional designers as well as building managers. Three levels of energy conservation measures are presented: (1) modifications in operations of buildings, (2) modifications to existing buildings, and (3) design features for new buildings. The recommendations apply to commercial, institutions as well as residential buildings. A final section discusses several policy mechanisms for implementing energy conservation technology in buildings.

17. National Science Foundation, et al. *Proceedings of the Conference on Energy Conservation in Commercial, Residential, and Industrial Buildings.* Washington, D.C.: National Science Foundation—Research Applied to National Needs, 1974.

Presents conference proceedings at which speakers discussed ongoing programs of retrofitting existing buildings for energy conservation and provided field data from current programs. The conference was attended by engineers, scientists, architects, building equipment manufacturers, and building plant operators.

18. Office of Conservation and Environment. *Lighting and Thermal Operations.* Washington, D.C.: Federal Energy Administration, 1974.

This publication contains guidelines on illumination levels, efficiency in lighting, and operating heating and cooling systems in public and commercial buildings. The approach is to present desirable targets that some organizations have now met and which others might adopt.

19. Redfield, Allen, ed. *Solar Heating and Cooling for Buildings Workshop.* College Park: University of Maryland, 1973.

This workshop sponsored by the National Science Foundation includes presentations by over 40 researchers on the applications for solar energy. Subjects covered are solar collectors, energy storage systems, solar air conditioning, hot water heating, and energy conservation in buildings.

20. Rizzuto, Joseph; Mathusa, Parker; and Colbeth, H. L. *A Summary of the Energy Management and Conservation Programs in New York State.* Albany: Department of Public Service, 1974.

This report outlines the important features of New York State's energy management program. The program concentrates on actions of the State Public Service Commission in regulating electric and gas utilities.

21. Seidel, Marquis R.; Plotkin, Steven E.; and Reck, Robert O. *Energy Conservation Strategies.* Washington, D.C.: U.S. Environmental Protection Agency, 1973.

This report examines various strategies for reducing national energy demand, evaluating the potential savings and costs of each alternative. The study examines what economists call the "market failure" which has caused the present "energy crisis" and discusses the kinds of government action that could rectify the failures and the likely response of the economy to moderate price increases.

22. Socolow, Robert H., and Harrje, David. *Energy Conservation in Housing.* Princeton, N.J.: Center for Environmental Studies, 1974.

This study is sponsored by the National Science Foundation's Research Applied to National Needs program. Using a planned-unit development in East Windsow, New Jersey, as a case history, this on-going investigation analyzes the complex structure of the development process which produces large tracts of residential units. It identifies critical points in the process for effectively initiating energy recommendations based on the conservation policies. Investigations fall into three categories: educational, financial, and regulatory. Home buyers as well as designers need more information about energy performance.

23. State of New York. *Report of Ad Hoc Committee on Energy Efficiency in Large Buildings to the Interdepartmental Committee of the State of New York.* Albany: State of New York, 1973.

This report offers an analysis of the overall energy requirements for large buildings and large multi-family residential complexes. Guideline recommendations are also presented in the areas of design, construction, and maintenance and operation.

24. Stein, Richard G., and Stein, Carl. *Research, Design, Construction, and Evaluation of a Low Energy Utilization School.* New York: New York City Board of Education, 1974.

Prepared for the Research Applied to National Needs program of the National Science Foundation. Reports findings of a study of energy use in New York City schools. Key observations were: (1) Substantial variations in lighting levels are not noticed by students and do not affect educational achievement. (2) A one-third reduction in ventilation levels would not adversely affect air quality. (3) Sealed, minimum-window school buildings consume up to three times more energy than do buildings with open-window air supply. (4) Solar energy can contribute to energy conservation in schools. With recommended new standards, schools can be designed to operate at energy-use levels 25 to 50 percent below current levels, the study concludes.

25. Tansil, John. *Residential Consumption of Electricity.* Oak Ridge: Oak Ridge National Laboratory, 1973.

This study supported by the Research Applied to National Needs program of the National Science Foundation documents the growth in residential electricity use between 1950 and 1970 and assesses the reasons for this growth. It evaluates a number of measures for improving the efficiency of electrical use in homes such as shifting from electrical resistance heating to heat pumps in planned homes. Many of the suggestions are implementable through local legislation.

26. U.S. Council on Environmental Quality. *Energy and the Environment.* Washington, D.C.: The Council, 1973.

After presenting an introductory discussion of energy supply systems and the trend in the nation's demand for energy, this report examines the environmental impact of various means for generating electricity. One section deals with the effect of energy conservation and improved efficiency on environmental damages.

27. U.S. Environmental Protection Agency. *A Report on Automobile Fuel Economy.* Washington, D.C.: The Agency, 1973.

Documents the conclusion of EPA-sponsored research into the factors affecting vehicle fuel economy. It should be useful for local governments in setting specifications for purchasing new vehicles.

28. U.S. Office of Emergency Preparedness. *The Potential for Energy Conservation.* Washington, D.C.: Executive Office of the President, 1972.

This staff report presents quantitative measures of energy consumption by end use and offers a program of energy conservation measures along with estimates of the impact of these measures on national energy consumption. The study concludes that the most significant conservation measures are: (1) the installation of improved insulation in both new and old homes, (2) the use of more efficient air conditioners, and (3) a shift of intercity freight from trucks to rail and urban passengers from automobile to mass transit.

29. Villecco, Marguerite, ed. *Energy Conservation in Building Design.* Washington, D.C.: American Institute of Architects Research Corporation, 1974.

This report discusses some of the ways architects can save energy in their building designs. It is easily understood by the layman as well. In addition to providing useful guidance in each aspect of building design, the report includes a discussion of alternative power sources, wind, and solar energy, which may be used for buildings.

30. Wildhorn, Sorrel, et al. *How to Save Gasoline: Public Policy Alternatives for the Automobile.* Santa Monica, Calif.: The Rand Corporation, 1974.

Study funded by the National Science Foundation. Develops analytical tools to evaluate the effects on private transportation of national energy conservation measures and applies these tools to evaluate alternative policies. The study concludes that: (1) Aside from limitations on gasoline supply, the only way to achieve significant gasoline savings in the near term is to increase the price. In the longer term, improvements in fuel economy offer

greater potential for energy conservation than do gasoline taxes. (2) Higher taxes on new-car sales prices offer little promise for gasoline conservation. (3) A combination of improved fuel economy and low new-car prices will best achieve the long-term effect of reduced gasoline consumption.