ENERGY
MINNESOTA'S OPTIONS FOR THE 1990s

The State Energy Policy and Conservation Report to the Legislature

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ENERGY plays a critical role in our rapidly changing world. How we use energy and our choice of energy sources will dramatically affect our environment, our economy, and our national security. The message contained in this report is that **we do have energy options**. For the environment, there are options to our continued reliance on fossil fuels; for the economy, there are options to a return to energy price inflation; and, for our national security, there are options to an OPEC-controlled oil market.

This report identifies the major energy policy decisions we face, particularly those that affect Minnesota directly; it reviews the important options that decisionmakers in government, the energy utility industry, and energy consumers representing homes, businesses, and industry have available when making energy decisions; and the report offers policy recommendations in those areas in which Minnesota's decisionmakers will have a real impact in shaping a more secure energy future.

A section-by-section summary of the major findings of this report is presented in part 1, along with an introduction to the major recent historical and current energy trends, and the recommendations of the Minnesota Department of Public Service. The remainder of the report covers in greater detail the energy developments affecting Minnesotans today.

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EXECUTIVE SUMMARY, INTRODUCTION, AND RECOMMENDATIONS

EXECUTIVE SUMMARY

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2. PROMINENT ENERGY ISSUES

Energy issues have returned to the spotlight; they range from critical environmental concerns to vexing problems of energy deregulation and supply. This report discusses five major issues being discussed and debated in the public forum that will require public action in the years just ahead. These issues are energy regulatory developments, electric supply options for Minnesota, environmental issues, petroleum issues, and transportation efficiency and alternative fuel sources.

ENERGY REGULATORY DEVELOPMENTS

Efforts to partially deregulate the natural gas industry have been underway for a decade, and similar efforts may lead to fundamental changes in the structure of the electric utility industry. The success of these regulatory changes will have a major impact on the cost of these energy resources, the availability of natural gas, and the reliability of electric supplies.

Electric Deregulation. The Federal Energy Regulatory Commission (FERC) is considering controversial regulatory changes that would seek to establish a competitive electric generation industry. Utilities would be able to purchase electricity from unregulated independent power producers and other sources through competitive bidding.

The proposed changes raise a number of issues. Many argue that a competitive generation industry is not possible without open access to utility transmission systems; FERC has not yet dealt with this difficult regulatory question. Other issues concern policy changes that could potentially reduce state regulatory supervision of electricity costs and utility-related environmental concerns.

Two regulatory issues concerning competition for electric retail sales include disputes over utility service areas and proposals for economic development and marketing programs.

Least Cost Planning. A second important development in electric utility regulation is least cost planning. Least cost planning involves an analysis of all options for meeting future electricity needs in an economically and environmentally sound manner, including construction of power plants, utility-sponsored conservation programs, and non-traditional supply sources. Utilities have been developing this more sophisticated approach to planning in response to greater uncertainty about future supplies and demand and to higher construction costs. State regulatory commissions are attempting to develop new approaches to utility regulation that incorporate these changes.

Minnesota already has several aspects of a least cost planning process in place, but the Minnesota Public Utilities Commission (PUC), Department of Public Service (DPS), and other state agencies are assessing possible regulatory or legislative changes that may be needed.

Natural Gas Deregulation. Natural gas prices are partially deregulated as a result of the Natural Gas Policy Act of 1978 and of action by FERC. A second regulatory initiative, the FERC-ordered "open nondiscriminatory transportation system," changes the relationship among buyers, sellers, and transporters of natural gas by encouraging utilities and large end users to deal directly with producers. Northern Natural Gas, the company that supplies most of Minnesota's natural gas and operates under the new open transportation rules, has increased the amount of gas it ships for others from 6 to 41 percent of its total shipments. FERC also seeks to provide an equitable means for pipeline companies to extricate themselves from long term "take-or-pay" contracts made with producers during the gas shortage of the late 1970s. Both nationally and in Minnesota the adoption of flexible pricing regulations has enhanced the market responsiveness of natural gas rates in cases where large customers can switch to competing fuels or other natural gas suppliers.

Deregulation is also creating a number of issues that need to be resolved. First is the question of who will assume the cost of the take-or-pay contract obligations. Second is the question of whether open transportation should be optional; currently, pipeline companies can choose not to operate under the open transportation rules and can deny certain producers and distributors the use of their pipelines. A third issue concerns marketing affiliates of pipeline companies and the potential this creates for discriminatory practices. The effect of large end users being able to bypass the utility is another concern since it could result in the utility's costs being shared by a smaller number of customers and raise rates for residential users. The need to provide incentives for reducing natural gas costs is also being considered. Finally, it is unclear what the ultimate effect of deregulation will be on gas prices after the current gas "bubble" has passed.

ELECTRIC SUPPLY OPTIONS FOR MINNESOTA

Demand for electricity is expected to exceed current supply levels within the next ten years in Minnesota. To meet this increased demand, a number of options are available.

Minnesota utilities can increase their capacity by constructing new generating facilities, purchasing electricity from the Manitoba Hydro Electric Board, and/or exchanging energy supplies with other utilities. Short term purchases from other utilities have also become increasingly important for meeting more immediate power requirements.

Additional supply can also be made available by decreasing demand. These "demand-side" options include load management programs that spread consumption over a broader time period, thereby reducing the daily and seasonal peaks in demand that create the need for added capacity. Improved energy efficiency that reduces overall electric use is another option.

Non-utility supply sources such as cogeneration and production of electricity from wind, sun, and hydropower are also available.

The long term electric supply situation could be altered dramatically by technological changes. These include high temperature superconductors, techniques for reducing emissions from coal-powered electric generation, and photovoltaic (solar) generation.

ENVIRONMENTAL ISSUES

Two of the major environmental problems of our planet—global warming and acid rain—are caused primarily by the burning of fossil fuels.

Acid rain—precipitation containing heavy concentrations of sulfuric and nitric acids—is destroying a large number of lakes in the northeastern United States, Canada, and northern Europe, and a number of lakes in northeastern Minnesota are threatened. Technologies are available to reduce harmful emissions, but these are costly and take time to institute. Another way to reduce emissions is to lower energy consumption and to use the savings to pay for control measures. One study estimates that this approach could result in a 56 percent reduction in emissions by 2000.

Warming of the earth's atmosphere by gases from fossil fuel combustion threatens severe impacts on the geographical foundations of civilization. Programs to advance understanding of this phenomenon and options for ameliorating action are being proposed, including reducing energy consumption through improved efficiency, decreasing reliance on fossil fuels for electric generation, and encouraging development of alternative fuels.

Other environmental problems associated with energy are much less widespread in their effects.

- High concentrations of radon gas can increase the risk of cancer and may be found in a variety of buildings.
- High voltage electric transmission lines are objected to for their negative aesthetic and economic impacts on the land. They do not appear to be a health hazard, but research continues as to possible harmful effects.
- Waste-to-energy plants that provide a means of avoiding the pollution caused by landfills and allow recovery of some of the costs of garbage disposal create pollution problems of their own. Technologies to reduce pollution are available but they also are costly.

PETROLEUM ISSUES

Minnesota and the nation are as dependent on foreign oil today as they were in 1973. The dependency on imports makes the nation—and Minnesota—vulnerable to the actions and policies of the OPEC nations and creates uncertainty regarding future petroleum costs and supplies.

One prominent proposal directed at increasing domestic production is to establish an oil import tax.

Supporters of an oil import tax argue that the resulting higher prices for petroleum would encourage energy efficiency and a switch to other fuels, benefit the oil producing regions of the nation, and generally help the U.S. economy. Opponents say that the benefits of the tax would not be worth the higher costs to consumers and that non-oil producing states as well as some oil using industries would be harmed.

Proposals to increase petroleum supplies by exploring in Alaska's Arctic National Wildlife Refuge, along the California coast, and in other environmentally sensitive areas have also received considerable attention. They are objected to on the grounds that the negative impact on the ecology and scenic beauty of these areas is not justified, particularly in view of the estimated modest amounts of any resources.

These proposals are directed at short term solutions. The long term solution to the nation's dependency on oil imports relies on improving transportation efficiency and developing alternative energy resources.

TRANSPORTATION EFFICIENCY AND ALTERNATIVE FUELS

Transportation uses more energy than any other consumer sector in the state and nation. Transportation also relies almost exclusively on one fuel source—petroleum. Developing a more efficient transportation system helps alleviate this dependency and its potential for economic disruption.

Nationally, adoption of the Corporate Average Fuel Economy standards is resulting in fuel savings estimated to total 410 billion gallons of gasoline by 1995. Developments in Minnesota transportation efficiency include a freeway system designed to encourage multiple vehicle occupancy; Minnesota Rideshare, a program to organize and promote car pooling; and proposed improvements in mass transit that may include construction of a light rail transit system.

Improved energy efficiency is an important part of decreasing the nation's dependency on oil, but the long term solution lies in developing a replacement fuel for gasoline. The potential of ethanol and methanol as transportation fuels particularly interests Minnesotans since the state has a significant supply of the crops from which these fuels can be produced.

Alcohol fuels have proven acceptability as automotive fuel, but conversion to pure ethanol or methanol would require changes in present vehicle design and materials. Gasohol, a blend of ethanol and gasoline in use today, cannot be considered a complete replacement fuel for gasoline. Methanol may be especially promising as an alternative fuel because it can be produced from a wider variety of renewable materials. A current problem for both fuels is that the cost of producing them from renewable sources is too high to compete with present gasoline prices.

3. MINNESOTA ENERGY CONSUMPTION AND SUPPLIES

Petroleum, natural gas, and electricity are the sources on which Minnesota and the nation have traditionally relied for their energy. Two significant factors—costs and improved energy efficiency—affect which and how much of these fuels are used. Use trends show that high costs have caused Minnesotans to switch to less expensive sources and have also brought about improvements in energy efficiency. Whether energy efficiency will continue to improve without the spur of high prices is not certain and remains an important factor affecting the supply outlook for the major energy sources.

MINNESOTA ENERGY TRENDS

Minnesota uses more energy today than it did in 1960, but growth has not been steady during these years. Until 1974, growth was fairly regular and was shared by all the major energy sources. Abrupt increases in oil prices in 1974 and 1980, however, caused overall energy consumption to drop and contributed to a long term trend toward greater use of electricity.

The period since 1960 has also seen a shift occur in the traditional relation of energy use and per capita income. Prior to 1975, income and energy use increased or decreased proportionately; since 1975, however, energy use has increased at a slower rate than per capita income, reflecting the trend toward improved energy efficiency.

Examination of energy use by fuel source shows that changing prices of various fuel sources cause significant shifts in the types of fuels consumed. Other factors affecting fuel choice are the pollution consequences and overall ease of use.

Energy use trends by economic sector reveal that transportation accounts for a much larger share of total energy use today than in 1960 and that it continues to rely almost solely on petroleum products. The residential and commercial sectors have increased their electric energy use significantly since 1960. Although it has increased its use of electrical energy, the industrial sector has decreased its total energy use by 40 percent since the early 1970s.

THE OUTLOOK FOR ENERGY SUPPLIES

Minnesota Electric Supply Needs. A major consideration in supplying electricity is the high seasonal and daily peaks in demand which require costly additions to generation capacity that otherwise would not be needed. The electric utilities serving Minnesota predict growth in both summer and winter peak demand that in ten years will exceed present generation capacity. The utilities plan a variety of strategies for meeting the growing demand for electricity in the state.

Construction of generation facilities is identified by Northern States Power (NSP) as one source of additional capacity. The company plans to build a 150 MW combustion turbine as early as 1994 and additional power plants may be needed between 1995 and 2004.

Purchases and exchanges of electric supply among utilities also help meet demand and are useful in Minnesota, with its mixture of summer and winter peaking utilities. In 1987, the utilities serving Minnesota increased their summer capacity by more than 1,200 MW through such arrangements.

This total included purchases from Manitoba Hydro.

Load management strategies, which eliminate or reduce the need for new capacity by spreading electric demand more evenly throughout the day and year, are being planned and implemented by Minnesota utilities. The strategies include charging lower rates for off-peak use and encouraging use of heating systems that switch to other fuels during peak periods.

Reductions in overall demand also cut the need for increased capacity. Several utilities have said they plan to use conservation programs to reduce demand. Efficiency improvements can achieve significant reductions in energy use without cutbacks in comfort or productivity.

Changes in technology and moves toward deregulation could dramatically affect the electric power industry in Minnesota and the present expansion plans of the utilities.

A base case forecast developed by the Minnesota Department of Public Service shows an annual growth in electric use of 2.5 percent per year, with manufacturing leading with a 3.8 percent increase per year. This compares to the utilities' forecast of a 2.6 percent average annual growth rate in electric use.

The Outlook for Natural Gas Supplies. Natural gas supplies, price, and distribution are extremely important to the large numbers of Minnesotans who heat their homes and buildings with natural gas. Residential users account for 42 percent of the natural gas sales in the state, followed by the industrial and commercial sectors with 24 and 31 percent, respectively.

Currently there is a surplus of deliverable supplies and prices have fallen, but the nation's reserves of natural gas are declining. Forecasts by both the U.S. Department of Energy and the Gas Research Institute show prices rising again during the 1990s. They also see an increase in natural gas consumption, with growing use of natural gas by electric utilities after 1995. Natural gas imports from Canada are likely to increase and may become a growing supply source for Minnesota.

The Outlook for Petroleum Supplies. Petroleum prices and supplies in Minnesota are largely determined by national and international markets. Minnesota and the nation are overwhelmingly dependent on petroleum for transportation; they also are dependent on foreign sources for more than a third of their petroleum needs. This dependency is expected to increase during the 1990s, causing concern about the nation's vulnerability to the actions of OPEC and creating uncertainty about future petroleum prices and supplies.

Forecasters generally agree that in the mid-1990s, OPEC nations will be able to exert greater control over oil prices than they do today. The U.S. Department of Energy has developed forecasts for the 1990s based on three possible scenarios. The high price scenario would result from OPEC nations maintaining stringent production agreements and would return petroleum costs to levels experienced in 1981.

The potential for a severe world oil supply disruption will become a growing concern. To mitigate the severity of such a disruption, the United States and other nations are developing strategic petroleum inventories.

Although Minnesota's petroleum supplies are largely determined by these international conditions, short term disruptions can occur as a result of weather, accidents, or other local conditions or incidents.

4. OPPORTUNITIES TO IMPROVE ENERGY EFFICIENCY

Improvements in energy efficiency are the legacy of the energy crises of the 1970s; spurred by sharp rises in energy costs, Americans have learned how to live comfortably and well and at the same time use less energy. These improvements and their potential for even greater energy savings in the future are one of the most significant and beneficial developments in the energy field. This section looks at efficiency trends by sector, recent developments in energy efficiency technology, and the impact of that technology on electric consumption.

ENERGY EFFICIENCY TRENDS BY SECTOR

Improvements in energy efficiency are enabling Minnesotans to increase their income and at the same time reduce energy use. This development is true for every economic sector in the state.

Despite a significant increase in air conditioning use since 1960, energy use per household has dropped 35 percent. More efficient appliances and furnaces and better insulated homes are a major factor.

The commercial sector is steadily increasing its overall energy use; however, the ratio of energy use to income also has dropped, demonstrating that commercial establishments have accomplished significant gains in energy efficiency. Major savings are possible through improvements in lighting, space cooling, and refrigeration.

Manufacturing and mining account for the largest reduction in energy use in Minnesota since 1960.

The reduction is due in part to a steady improvement in energy efficiency. Rapid improvements in the efficiency of industrial processes are likely to continue.

Agriculture, despite a trend toward more mechanized methods of production, has also steadily reduced its energy use per unit of output.

Finally, the transportation sector shows improvement in the average fuel efficiency of motor vehicles in Minnesota. Since 1973, the miles per gallon efficiency of all vehicles has increased nearly 27 percent; for passenger cars, the figure is about 40 percent.

RECENT DEVELOPMENTS IN ENERGY EFFICIENT TECHNOLOGIES

Major savings in Minnesota's energy consumption are occurring in the residential, commercial, and industrial sectors. Developments primarily accounting for these savings are energy efficiency improvements in refrigerators and other appliances, lighting, windows, furnaces, motors, cogeneration, and waste heat recovery.

POTENTIAL IMPACT OF IMPROVED EFFICIENCY ON ELECTRIC CONSUMPTION

Minnesotans could cut in half their electric consumption by taking advantage of all available, cost-effective energy efficient technologies. These potential savings were identified in a study prepared for the Minnesota Department of Public Service by PLC Incorporated, a firm with nationwide experience in evaluating electric issues. The savings in electric use could be achieved with no reduction in productivity or comfort.

Realizing this entire savings potential in the next five to ten years may be unlikely, but the estimates demonstrate the dramatic potential of improved efficiency in meeting electric supply needs.

The largest potential savings is from commercial lighting, which provides more than one-fifth of the total savings. Other major savings could be realized by adopting improved efficiencies in industrial motors (12 percent of the savings), residential refrigeration (8 percent), residential water heating (7 percent), and commercial refrigeration (5 percent).

5. ENERGY CONSERVATION PROGRAMS

Conservation programs sponsored by both public and private organizations help more people realize the benefits of improved energy efficiency and also encourage more widespread use of energy efficiency measures.

SURVEY OF MINNESOTA CONSERVATION PROGRAMS

Public information programs promoting energy efficiency, and measures to manage electric loads more efficiently, are the types of conservation programs most often sponsored by Minnesota public and private utilities, communities, and nonprofit organizations. These organizations were surveyed by Anderson, Niebuhr & Associates, Inc. of St. Paul concerning their energy conservation programs.

A high percentage—about two-thirds—of the groups surveyed sponsor public information programs, and many plan to expand these programs in the future. Programs with the most tangible savings effects, such as grants or loans for weatherization measures and rebates for efficient appliances, are sponsored by fewer than one-fourth of the organizations. The need for more public promotion and evaluation of these programs was cited by Anderson, Niebuhr & Associates.

EXAMPLES OF INNOVATIVE UTILITY CONSERVATION PROGRAMS

A number of innovative, utility-sponsored programs are achieving significant energy savings, both in Minnesota and other parts of the nation.

The Hood River Project in Oregon offered an extensive package of weatherization measures to residential electric users. Effective marketing and information services contributed to a high participation rate in this community-wide program. Annual electric use was reduced by 15 percent, and peak demand was cut by 10 percent.

Commercial building rebate projects offer financial incentives to commercial and industrial customers who install energy-efficient equipment. Incentives range from direct grants to zero-interest loans, and energy improvements often involve installing new lighting systems or improved heating and cooling systems. A Connecticut Light and Power Company program assists developers of new buildings in planning energy efficiency and has found that efficiency can be increased by up to 37 percent at no additional construction or installation costs.

Minnesota's Conservation Improvement Program, established by the Minnesota legislature, requires the state's major public utilities to invest in energy savings programs. Notable examples of these programs are Northern States Power Company's rebates to commercial and industrial customers for improving lighting systems and for purchasing energy efficient motors, and Minnegasco's new program of rebates to developers and building owners for incorporating energy efficiency into new buildings.

ENERGY EFFICIENCY STANDARDS

State and national legislation plays an important role in spurring developments in energy efficiency technologies and providing for their adoption.

Minnesota law provides for efficiency standards in air conditioning equipment and prohibits the sale of certain inefficient appliances and furnaces. National efficiency standards covering home appliances and lighting are expected to achieve substantial savings for consumers and a sizable reduction in peak electricity demand. One obstacle to reaping full benefits of this 1988 law is the environmental damage caused by chlorofluorocarbons (CFCs), a material that helps reduce the energy used by certain appliances. CFC production and use are being phased out by international agreement and currently there are no acceptable substitutes.

Changes in the Minnesota building codes made in 1984 are making significant differences in the amount of home energy use. Upgraded standards for commercial buildings are being proposed by the American Society of Heating, Refrigerating, and Air Conditioning Engineers; these standards are being evaluated for possible incorporation into the Minnesota commercial building code.

Another approach to increasing the efficiency of new buildings is a proposed Massachusetts law that would establish electric utility hook-up charges based on the cost of meeting future electric capacity requirements.

6. MINNESOTA ALTERNATIVE ENERGY RESOURCES

The long term answer to the nation's energy needs will require alternative fuels from renewable sources. Their current contribution to Minnesota's energy needs is small—approximately 5 percent—but some sources have the potential to be major suppliers in the future. Recognition of their importance continues to motivate interest in these fuels despite the difficulty of competing at current energy prices.

Biomass—including wood forest wastes and farm crop residues—is a valuable resource in Minnesota. Wood forest wastes are a significant source today and their use can be expanded without conflicting with the Minnesota forest products industry. Residues—now unused—from the 19 million acres of planted Minnesota cropland represent a source of heat energy equal to one-sixth of the state's total energy consumption. Potential energy crops, including hybrid poplar, corn, and sweet sorghum, are potential sources of heat energy and of ethanol and methanol, two possible replacements for gasoline.

Hydroelectric power provides 3 percent of Minnesota's electric energy; potential for future development lies mainly in updating existing facilities.

Municipal and industrial waste disposal is a major problem. Although reducing waste at the source is the most desirable solution, the immediate need to dispose of the 3.3 million tons of garbage produced annually in Minnesota is spurring development of waste-to-energy plants. The amount of energy produced by these plants is not significant in terms of the state's total energy needs.

Solar powered photovoltaic systems that convert light into electricity may, with further research, have potential to be a growing source of power in Minnesota as well as the nation: Minnesota has as much available sunlight as eastern Texas and all of Florida. Other types of solar applications in the state include water heaters and buildings designed with south facing windows and other components that enable them to capture, store, and release solar heat.

Wind energy potential in Minnesota is greatest in the southwestern part of the state where average annual wind speeds are higher. Rates paid for wind generated electricity are quite low in Minnesota, reducing the incentive for development. As economic factors become more favorable, the industry will no doubt grow in Minnesota.

7. DEPARTMENT OF PUBLIC SERVICE ENERGY ACTIVITIES

A broad range of energy information, services, rates, and policies that affect Minnesotans is administered by the Minnesota Department of Public Service.

The department, through its Energy Division, provides information and technical assistance to help individuals and groups improve energy efficiency, evaluates utility conservation investments and long term forecasts, collects and analyzes data on state energy use, and furthers development of Minnesota's alternative energy resources.

Through the Utilities Division, the department reviews and makes recommendations to the Public Utilities Commission regarding petitions for rate changes, evaluates requests from utilities to construct major facilities, reviews rates paid by utilities to alternative power producers, and studies electric costs and rate structure.

The Energy Issues Intervention Office represents the interests of Minnesota residents before regulatory agencies outside the state and other bodies that make or implement energy policies affecting Minnesotans.

8. RATE DESIGN POLICY OF THE MINNESOTA PUBLIC UTILITIES COMMISSION

The Minnesota Public Utilities Commission's responsibilities include setting rates (prices) for gas and electric utilities, issuing or denying Certificates of Need for large energy facilities, determining avoided-cost/buyback rates for cogeneration and small power production, and requiring utility energy conservation programs.

INTRODUCTION

A broad array of energy options is available to us now and into the 1990s. The options selected by decisionmakers at every level will affect our economy, the environment, and our national security.

We have witnessed some powerful changes in the energy picture over the last 20 years. The potentially devastating impacts of energy choices were brought home to us by nuclear reactor accidents at Three Mile Island and Chernobyl and by growing evidence of global warming. On the positive side, the swift response to rapidly inflating energy prices in the form of dramatic improvements in energy efficiency revealed the power of the consumer in the energy marketplace. Long lines at the gas pumps, brought about by an OPEC-dominated energy market, convinced us of the importance of developing home-grown energy sources and conserving foreign oil for the sake of our national security.

To make informed choices among the available options, decisionmakers must have an historical context and an understanding of current energy-related developments. This Introduction provides a frame of reference for the discussion of energy policy options and the recommendations that follow.

ENERGY AND THE ECONOMY

The United States spends about 10 percent of its Gross National Product for energy and imports more than a third of its petroleum needs. Energy consumption also plays a large role in Minnesota's economy. Energy expenditures in 1986 totaled $6.4 billion and accounted for 10 percent of Gross State Product. Average residential energy costs used up about 5 percent of 1986 household income.

Because energy is so significant in our economy, unexpected changes in energy prices and supplies can dramatically alter our economic welfare. To trace federal and state energy policy responses to changing economic conditions, we begin with a brief review of energy trends and major policy responses during the 1970s and into the '80s.

THE IMPACT OF RISING PRICES

In 1973, members of OPEC agreed to substantially increase the price of crude oil. As a result, the domestic price for crude oil increased by 65 percent between 1973 and 1975. In 1979, oil prices again jumped dramatically, almost tripling between 1978 and 1981. The rapid increases in oil prices substantially increased the costs of producing everything from plastics to automobiles. Firms believed these cost increases were permanent and charged higher prices for their final products. As general prices rose, the demand for final products decreased. Consequently, the country experienced several periods of rapid inflation, reduced production, and higher unemployment.

At the time crude oil prices were rising in 1973, many areas of the country were experiencing severe shortages of natural gas supplies. Moreover, as oil prices rose and gas supplies diminished, the electric industry incurred rising fuel costs. Prices of fossil fuels, which electric utilities use to produce electricity, increased by about 84 percent from 1973 to 1976 and 23 percent from 1978 to 1981.

The rapid increase in energy costs caused both federal and state governments to act. The Public Utility Regulatory Policies Act (PURPA), the Natural Gas Policy Act (NGPA), and deregulation of domestic crude oil producers represent part of the federal government's response to the oil price shocks and natural gas shortages of the 1970s.

Through PURPA, Congress sought to encourage development of alternative energy production technologies that do not rely heavily on fossil fuels, thus lessening the U.S. dependence on foreign oil. The NGPA, on the other hand, gradually eliminated wellhead price controls for natural gas. Congress deregulated domestic oil and gas producers to stimulate domestic exploration and production and reduce reliance on crude oil imports.

The Minnesota Public Utilities Commission (PUC) also responded to the unexpected rise in energy costs and natural gas shortage by instituting Purchased Gas Adjustment for gas utilities and Fuel Clause Adjustment for electric utilities so that retail electric and gas rates would increase and be "passed through" to consumers in step with increases in wholesale prices. In addition, the increase in energy prices and the federal initiatives such as PURPA prompted the state to encourage greater energy conservation. The legislature and the PUC ordered utilities to develop and implement a broad array of conservation programs for their customers. Furthermore, the state adopted procedures to encourage the development of power from non-utility sources, including power produced through cogeneration (electricity produced as a byproduct of an industrial process) and small alternative fuel power sources (i.e. hydroelectric facilities, wind generators, etc.). The

Minnesota legislature and communities and groups throughout the state initiated a wide variety of other programs to reduce energy use and promote development of alternative energy sources.

THE ERA OF FALLING PRICES

The trend of rising energy costs and shortages experienced during the 1970s reversed in the 1980s. The price of crude oil, after adjusting for inflation, fell more than 60 percent from 1981 to 1987.

Natural gas deregulation. In the natural gas industry, gas supplies exceed consumption by approximately 1.7 trillion cubic feet, causing a large "gas bubble" that tends to keep prices down. Domestic gas prices have also fallen in response to competitive pressures from falling petroleum prices.

The current surplus of natural gas induced the Federal Energy Regulatory Commission (FERC) to adopt a regulatory policy that encourages greater access to transportation capacity on interstate pipelines. This policy requires pipelines, if they choose to join the transportation program, to offer transportation services to all potential shippers. FERC's transportation program induced local gas utilities in Minnesota to develop special transportation rates. These rates protect the utility while allowing large customers to seek out their own gas supplies. In this way, large customers can have more direct control of energy costs and take more responsibility for securing supplies.

Minnesota's utilities have also sought innovative transportation opportunities arising from the federal initiative. Minnegasco, for example, has taken steps to diversify its sources of gas supply by building a 32 mile pipeline to connect with Midwestern Gas Transmission Company and by contracting for alternative gas supplies from Canada. Originally, Northern Natural Gas was Minnegasco's sole supplier.

The federal transportation initiative has given local utilities more choices and responsibilities. Minnesota regulation will need to find ways to ensure that gas costs are minimized and supplies are reliable.

Changes in the electric power industry. The drop in oil and natural gas prices has also reduced energy costs to electric utilities. Nevertheless, the environment for electric utilities has become increasingly uncertain. Economic conditions have widely fluctuated, making it more difficult for utilities to forecast demand and plan for their customers' future needs.

In Minnesota, for example, Minnesota Power built new capacity in the late 1970s to meet expected expansion of taconite customers. Economic conditions in the taconite industry, however, have been depressed, causing the taconite demand for electricity to fall below expectations, leaving Minnesota Power with unused capacity. The persistent presence of unused electric capacity has induced some states to look closely at utility investments that no longer appear necessary, and to not allow utilities to earn returns on new plant investments that are unnecessary.

Regulatory policies governing the electric industry are undergoing a reevaluation both at the state and federal levels. Competition from cogenerators and independent power producers has forced a reassessment of the industry's traditional monopoly structure. In addition, utilities in many parts of the country are reluctant to propose construction of new power plants for fear that regulators will later disallow recovery of the investment from ratepayers if the plant is not needed. Even in areas such as the Northeast, where new power supplies are needed immediately, environmental and safety concerns have prevented the completion of two large nuclear power plants.

To address these developments, FERC has proposed new rules that would significantly alter regulation of the electric industry. The proposed rules, for example, would require states to adopt a bidding procedure that would allow utilities and independent power producers alike to compete for the chance to build new power plants. They may also allow a company offering demand reduction through energy efficiency improvements to compete alongside potential electric suppliers.

The effect of a so-called "all sources bidding" procedure would be to partially deregulate the electric utility industry. It is unclear at this time what deregulation of electricity might mean. In areas of the country, particularly on both coasts and in Texas, where power produced by cogeneration has flourished, a bidding program may lead to increased competition and lower electric prices for consumers. Adding capacity through bidding may also result in smaller increments of capacity, alleviating the problem of building large facilities that prove to be not needed. And the incorporation of "demand-side" options (i.e. efficiency improvements) into the bidding scheme may allow utilities to avoid constructing environmentally problematic coal and nuclear plants.

Deregulating the generation portion of the industry, however, will not occur without greater access by all potential suppliers to the electric transmission system. Transmission facilities in this country are owned by the utilities who built them. Independent power producers must have access to transport their power to utilities or directly to large customers.

It is clear that the shape of the electric utility industry is changing rapidly. The effects of these changes are already becoming noticeable in Minnesota. In 1986, for example, Northern States Power Company (NSP) agreed to purchase a portion of Minnesota Power's Clay Boswell Number Four generating station. The proposal was an example of how utilities can use alternatives other than building new capacity to meet needs. The Minnesota Department of Public Service (DPS) and PUC investigated this proposal and determined that approving the proposal was in the best interests of ratepayers of both companies.

The Department of Public Service supports experimentation with limited regulatory changes that allow competitive bidding for electric utility supplies. In comments to FERC, however, Minnesota has emphasized that state regulatory bodies will need latitude to develop approaches to bidding as a method for meeting electric supply needs.

LEAST COST PLANNING

Prior to the 1970s, the electric utility industry was a declining cost industry – in other words, as more product was produced and sold, the price per unit declined in real terms. We might all recall with fondness the days when electricity was considered almost ''too cheap to meter''; however, oil price shocks, high inflation and interest rates, and environmental and safety concerns have created great uncertainty in the level of future electric demand and in the cost of meeting this new demand.

This new uncertainty has placed an imperative on electric utilities and state regulators to do a better job of finding the least costly ways of meeting electric demand growth. Many utilities and state regulatory agencies across the country have chosen a planning approach known as ''least cost planning'' (or integrated resource planning) to help reduce the risk of costly mistakes. With least cost planning, all reasonable options for both new electric supply (e.g. new power plants, cogeneration, renewables) and adjustments to growth in electric demand (e.g. conservation, load management) are evaluated to determine if they are environmentally and economically sound. The goal is to find the best mix of options for the utility in question. A benefit of this least cost planning process is expanded investment by utilities in energy efficiency programs. These programs may allow the utility to defer or avoid power plant construction; they may also result in lower electric bills for the utility's customers.

ENERGY AND THE ENVIRONMENT

None of the energy-related issues discussed in this report are of greater global significance than the burning of fossil fuels and their environmental consequences. The detrimental effects of our continued reliance on fossil fuels, particularly in electricity generation and the transportation sector, are becoming increasingly clear. Sulfur dioxide emissions, especially evident in coal-fired power production, are creating acidified precipitation (both rain and snow) that places many of our natural aquatic resources at risk.

A second and potentially more serious consequence of fossil fuel use—the global warming or ''greenhouse effect''—may also be a more difficult environmental problem to solve. Carbon dioxide, another byproduct of fossil fuel combustion, tends to block the escape of thermal radiation (created when the sun warms the earth), ultimately warming the lower atmosphere. Although the effects of such warming are difficult to predict, scientists agree that without substantial reductions in greenhouse gas emissions, major climatological disruptions will occur. These effects could include major shifts in precipitation patterns, increased frequency and intensity of violent storms, and a gradual sea level rise from melting ice caps resulting in catastrophic coastal flooding.

Acid rain is not a problem created in Minnesota. The Pollution Control Agency (MPCA) estimates that less than a third of the sulfur dioxide (SO_2) emissions that cause problems in the state are produced here. Texas is the major outstate contributor to acidic precipitation in Minnesota; Canadian sources account for 20 percent of the problem. Roughly 60 percent of all SO_2 emissions are from coal-fired electric generating plants, the balance coming from heavy industry and vehicle emissions. Since coal-fired electric generation is the largest contributor to the problem, regulatory efforts in Minnesota and nationally have focused on reducing emissions from electric utility sources.

Efforts to control emission sources within Minnesota are well underway. The adoption of acid rain control rules by the MPCA in 1986 has encouraged the use of a variety of control strategies by the state's electric utilities. These include using low sulfur western coal from Wyoming and Montana in place of high sulfur eastern coal, using sophisticated (but expensive) control devices, and experimenting with a new coal combustion technique known as fluidized bed combustion.

These control strategies alone, however, may not be enough to prevent widespread acidification of our lakes and forests. Electric utilities will need to employ other existing options including the use of renewable fuels and improvements in energy efficiency. NSP estimates that for every gigawatt hour (million kilowatt hours) of electricity saved, sulfur dioxide emissions are reduced by 7.5 tons. Using NSP's goal for planned efficiency programs, the company will be saving approximately 8,000 tons of SO_2 annually by the mid-1990s from efficiency programs alone.

The efficiency option is particularly appealing when efficiency programs are already proving cost-effective to the utility by reducing the need to build expensive new generating facilities. To the extent that these programs are cost-effective on their own and also reduce emissions, they achieve emission control at no cost.

The options for controlling the greenhouse effect are not as well developed or defined as the options for tackling acid rain. A major problem is that carbon dioxide cannot easily be removed from emissions after fossil fuels are burned. This fact eliminates from consideration a number of the pollution control technologies available for controlling sulfur dioxide emissions. The remaining options are (1) to do nothing to control CO_2 emissions and instead develop strategies for coping with the effects of global warming; or (2) to begin now to reduce our use of fossil fuels through use of alternative fuels (e.g., hydroelectric, nuclear, renewable fuels) and improvements in energy efficiency.

Proponents of the first strategy suggest that the world is already warming at such a rate that efforts to avoid the problem will be too little, too late. They propose instead that we begin now to cope with global warming by, for example, adjusting agricultural methods to adapt to the dramatic changes in precipitation levels that will accompany the warming. Most scientists agree, however, that it is almost impossible to predict the regional impacts of global warming. To begin now to relocate agricultural activities to potentially more favorable areas would almost certainly result in costly mistakes.

Nuclear energy advocates are quick to suggest that a switch to nuclear generated electricity may be the answer to the global warming dilemma. It is true that nuclear power does not result in the formation of greenhouse gases; however, nuclear energy has environmental as well as safety problems of its own. First of all, the United States has yet to find an acceptable method for storing nuclear waste. Any large scale switch to nuclear power would only compound the storage problem. Secondly, nuclear power is useful only for generating electricity. Estimates are that in the United States, electric generation accounts for 35 percent of CO_2 emitted into the atmosphere. Nuclear power cannot currently address the other problem sources which include transportation, 30 percent; manufacturing, 24 percent; and heating, 11 percent. Finally, a massive conversion to nuclear power also implies its worldwide development and a potential new round of nuclear proliferation.

The option that stands out after adaptation and nuclear power strategies have been considered is the energy efficiency option. Energy efficiency improvements can reduce every source of CO_2 emissions. In the area of transportation, strengthening vehicle efficiency standards, promoting concepts like Minnesota Rideshare, and mass transit options, such as the light rail system under consideration in the Twin Cities, could drastically reduce CO_2 concentrations. Fossil fuels used for space heating can be conserved through weatherization of homes and businesses, improvements to heating equipment, and recovery of waste heat.

Substantial efficiency gains also make it possible to reduce CO_2 emissions by electric utilities. A study of potential electric efficiency opportunities in Minnesota reports untapped savings possibilities amounting to over 50 percent of current statewide electric use. While efficiency gains on this scale depend on full customer acceptance of the improvements, the technologies needed to make the improvements are commercially available today. Further, such improvements are possible without sacrificing customer convenience or standard of living. The real appeal of the efficiency option is that CO_2 emissions are reduced and the cost of the energy savings are soon paid for by lower electric bills. While the other global warming options would be very costly in economic and other terms, only the efficiency option will save money and produce comprehensive greenhouse gas reductions.

MINNESOTA'S ENERGY OPTIONS

In sum, Minnesota's energy decisionmakers – homemakers to lawmakers – have energy options. The environmental and economic forces shaping the energy picture, however, are creating a renewed sense of urgency. Today, Minnesotans enjoy relatively clean air and water and relatively affordable energy supplies. Our strong positions in these areas contribute substantially to the high quality of life in Minnesota. To maintain these benefits, decisionmakers throughout the state must work together to face the challenges of a changing energy picture by taking advantage of the energy options available today.

RECOMMENDATIONS

The recommendations presented here by the Minnesota Department of Public Service (DPS) address those areas in which Minnesota decisionmakers can select options that will help to assure a secure energy future. The recommendations are divided into five topical areas: 1. Energy Regulatory Options, 2. Environmental/ Energy Options, 3. Energy Efficiency Options, 4. Alternative Energy Options, and 5. Low Income Energy Policy Options. Since energy policy decisions are made at every level in our society, the recommendations address actions to be taken at the federal, state, and local levels and decisions to be made by government, private business, and energy consumers. The recommendations are numbered within each area for ease in review.

1. ENERGY REGULATORY OPTIONS

FEDERAL INITIATIVES

Federal efforts to partially deregulate the supply of electricity and natural gas promise to radically transform the structure of these two industries. DPS regularly participates in Federal Energy Regulatory Commission (FERC) proceedings on matters of concern to Minnesota ratepayers. The following general recommendations summarize some of the most important issues that the department is currently emphasizing in FERC proceedings.

Electricity. FERC is attempting to reduce the role of regulated monopolies as owners and operators of electric power plants. Instead, utilities would supplement their electric supply needs by purchasing power from independently owned companies, known as independent power producers (IPPs).

> ***1.1. The Federal Energy Regulatory Commission should provide for assured, nondiscriminatory access to electric transmission systems before proceeding with initiatives concerning independent power producers.***

The FERC proposal regarding IPPs anticipates an electric industry where independently operated companies would compete for the opportunity to supply power to electric utilities and large end users.

This proposal does not adequately recognize that utility ownership and control of electric transmission systems does not permit the development of a competitive electric supply industry. A regulatory system needs to be devised that allows independent electric supply companies to use utility owned transmission systems for transmission (or wheeling) of power to other utilities.

On a closely related issue, DPS has emphasized that utilities should not be allowed to function as independent power producers in areas adjacent to their own service area or to supply their own electric needs through a separately owned IPP. Such a system would seriously reduce the ability of states to effectively regulate electric utilities. Utilities operating as IPPs would also have an incentive to use their control of transmission lines to their own advantage.

DPS supports experimentation with more limited regulatory changes that allow competitive bidding for electric utility supply needs. Regulatory changes to permit the development of IPPs should be pursued. The changes, however, should be carried out in a manner that protects consumer interests and addresses broader public concerns through effective regulatory oversight.

> ***1.2. FERC should continue to provide flexibility to states in implementing regulatory policies that encourage electric power purchases from non-utility sources.***

The Public Utility Regulatory Policies Act established guidelines for utility purchases of power from commercial/industrial cogeneration and from nonregulated hydro, wind, and solar powered electric generation. State regulatory bodies, including the Minnesota Public Utilities Commission, have developed more specific requirements for utility purchases from these sources.

Recent proposed rule changes and other actions by FERC have considered the basis for setting buyback rates paid by utilities to cogeneration facilities and small power producers for their power. A second issue has concerned the use of bidding by utilities to meet additional electric supply needs through contracts with non-utility electric power producers.

In comments to FERC, the Department of Public Service has emphasized that these regulatory changes should not limit state flexibility. No single method is clearly preferable for setting buyback rates or evaluating bids. For example, environmental factors need to be considered in a manner appropriate to local concerns. Increasing attention has also been given to including conservation activities in bidding to meet utility supply needs. State regulatory bodies will need latitude to develop and fine tune successful approaches to bidding as a method for meeting electric supply needs.

Natural gas. Partial deregulation of the natural gas industry has been underway since Congress passed the Natural Gas Policy Act in 1978. The most important issues remaining to be resolved by FERC concern access to natural gas pipelines.

> ***1.3. FERC should establish requirements that make open nondiscriminatory access mandatory for interstate and intrastate natural gas pipelines.***

Natural gas interstate pipeline companies have traditionally purchased and produced natural gas for resale to local utilities. In recent years, many pipeline companies have accepted a new regulatory option to act as transporters of natural gas purchased directly from producers by local utilities, large commercial/industrial users, and others. FERC has instituted the open transportation option and other regulatory changes as part of a policy to create greater competition in the natural gas industry.

In a 1987 petition for rulemaking, DPS argued that FERC has the legal authority to make open transportation mandatory and should exercise that authority. The department agrees that open nondiscriminatory transportation can increase competition by giving producers and a large number of potential purchasers direct access to each other; however, open transportation requires full participation by all pipeline companies before a truly competitive marketplace can develop.

On a related issue, DPS has initiated FERC rulemaking on the issue of marketing affiliates of pipeline companies. Marketing affiliates operate as independent brokers between buyers and producers. Measures to protect against pipeline companies giving their affiliates preferential treatment continue to be inadequate.

STATE INITIATIVES

Electricity. Federal proposals to deregulate portions of the electric utility industry create uncertainty and raise questions about the potential impact of these proposals on Minnesota.

1.4. A study analyzing the effects of electric deregulation on Minnesota should be conducted.

The study should examine possible benefits to the public from deregulation, including the impacts on consumer and business energy prices, the impacts on the development of alternative energy sources and conservation, the impact on the utility industry, and the general economic effects on the state. Such a study should be authorized by the legislature and conducted by the Department of Public Service.

Least cost planning legislation. Many utilities and state regulatory agencies across the country have begun a process of reevaluating electric supply and demand options and considering new options. Generally, this approach is known as least cost planning (LCP) or integrated resource planning. LCP is significantly affecting the way electric utilities and state regulators plan to meet the country's energy needs. At least 12 states have adopted an LCP process, either through legislative authority or public utility commission regulations, or from rate case decisions. Generally, the states have adopted one of two approaches to least cost planning. The *utility planning model* requires the utilities to prepare specific elements of supply/demand forecasts and resource plans under detailed reporting requirements set up by the public utility commission. The commission uses the information in these filings to assess the appropriateness of the utilities' resource plans and to approve, deny, or require modifications to the utilities' plans as necessary. The *statewide overview model* involves the preparation of statewide forecasts and resource plans by the state's public utilities commission or energy office. These forecasts and plans are then used as benchmarks for evaluating individual utility plans and adjusting these plans as necessary.

An additional 14 states are adopting LCP procedures now or actively considering such procedures. The federal Department of Energy has an LCP project and the Minnesota Department of Public Service is one of 14 grantees studying LCP techniques under this program.

A Least Cost Planning/Conservation Task Force has just begun (October, 1988) an examination of the need for least cost planning legislation/regulations within the state. The goal of this task force is to examine state regulation of electric companies and recommend changes needed to assure that energy is produced at the lowest environmental, economic, and social cost. The task force will look at restructuring regulation so that it rewards investments in saving, rather than selling electricity. Currently, for example, a utility's investment in new plant construction is treated as an asset and receives a rate of return. Investments in conservation, on the other hand, are recovered dollar for dollar and are not rewarded a rate of return. The present system tends to reward energy sales with higher profits, while efficiency programs reduce energy sales and, therefore, profits.

1.5. The Minnesota Least Cost Planning/Conservation Task Force should review possible solutions to the incentives problem and then prepare legislative and/or administrative rule recommendations as appropriate.

The loss of profits to utilities from greater investment in efficiency resources is a serious barrier to the implementation of least cost planning in Minnesota and elsewhere. A number of mechanisms to address the incentive problem are now being reviewed by regulators across the country. These include adjustment of overall rate of return based on containment of the average total utility bill, adjustment based on the difference between actual sales and sales volume used in establishing previous rates (California's Equal Revenue Adjustment Mechanism), and sharing the benefits of utility sponsored efficiency programs with shareholders and ratepayers based on the actual performance of the efficiency measures.

UTILITY LEAST COST PLANNING INITIATIVES

Minnesota's electric and gas utilities have already begun to implement least cost planning techniques. To build on these efforts, the following need to be more fully incorporated into utility planning functions:

1.6. Minnesota utilities should expand the development of cost-effective conservation and load management programs.

It is clear from the experience of utilities engaged in least cost planning around the country, that cost-effective conservation and load management (i.e. programs to encourage customers to shift use to off-peak periods) are often the preferred least cost options. They are often cheaper per unit (per kWh or Mcf), environmentally benign, and save customers money.

In determining the cost-effectiveness of conservation programs, the cost of efficiency improvements incorporated during building construction versus the cost of retrofits to existing buildings should be acknowledged. Experience in the Pacific Northwest and elsewhere clearly demonstrates the lower cost and improved efficiencies of buildings built to stricter energy efficiency standards. Waiting until the price of energy rises to justify building retrofits is a "lost opportunity." Utility programs that encourage energy efficient new construction capture these lost opportunity resources by assuring that new buildings are optimally efficient from the start.

1.7. Minnesota utilities should continue to strengthen their analysis of least cost energy options.

To better incorporate conservation and load management programs, utilities need to improve load shape analysis and end use forecasting methods. Load shape analysis allows a utility to determine periods of peak use (i.e. highest instantaneous use on the utility's system) and to plan demand adjustment programs accordingly. By bringing overall use down through conservation, and by shifting use to off-peak periods through load management, utilities might avoid costly commitments to new power plants or power purchase contracts.

Forecasting energy end uses (i.e. lights, appliances, space heating, etc.) allows utilities to determine the uses that contribute most heavily to growth in peak consumption. An end use forecast by an electric utility, for example, may reveal that hot summer weather in recent years is causing new growth in the air conditioning load. Since air conditioning is often a large part of peak use, a program to improve air conditioner efficiency may restrain further peak load growth.

The full incorporation of conservation and load management (collectively known as demand-side management) programs into a utility's resource portfolio will require integrated analysis of demand-side management and supply options. This means that utility planners must consider all viable options for meeting future load growth so that the least cost options from both the demand-side management and supply portfolios are put together in one plan of action for the utility. Of course, such plans will need to be flexible enough to respond to changing conditions. In many cases, the need for such flexibility favors the demand-side management options since they can be put into effect fairly quickly.

1.8. Minnesota electric utilities should conduct a comprehensive consideration of all supply options before committing to the construction of new power plants.

Even under plans that fully incorporate conservation and load management options, it may be necessary to construct new electric generating facilities in Minnesota. It is crucial, therefore, that supply options be considered comprehensively. The relatively low cost of coal as a fuel source and sophistication of coal burning technology have produced a bias in favor of large coal plants in Minnesota. The most recent example, the Sherco 3 generating plant, came into service in October, 1987. As the environmental concerns of acid rain and global warming continue to mount, however, electric utilities must begin to shift away from reliance on this type of generation.

Fortunately, there are numerous other options, including cogeneration and renewable energy sources such as wind and solar photovoltaics and hydropower, that are contributing more each day to the state's and nation's electric supplies. Adding power through purchases from utilities in the Mid-continent Area Power Pool is an attractive choice for Minnesota's utilities, both for those with excess capacity as well as those needing additional capacity. A utility may also purchase another utility's generating facilities, as in the proposed sale of Minnesota Power's Clay Boswell Unit Number Four to Northern States Power. Another option, already being pursued in Minnesota, is that of extending the life of existing power plants while also reducing harmful emissions from these facilities. NSP's conversion of its Black Dog Unit Number Two to fluidized bed combustion has extended the life of that facility while reducing emissions and expanding the flexibility of the unit to allow combustion of a variety of fuels.

2. ENVIRONMENTAL/ ENERGY OPTIONS

The detrimental effects of our continued reliance on fossil fuels, particularly in electricity generation and the transportation sector, are becoming increasingly clear. Acid rain threatens many of our lakes and streams, and the greenhouse effect—global warming—poses even more serious, potentially devastating results. Solid waste disposal is a third environmental problem.

Our first, most available, and most obvious option is to improve energy efficiency. Energy efficiency improvements can reduce every source of harmful emissions.

Recommendations to control or eliminate energy-related environmental problems range from actions to be taken at the local and state levels to efforts that require national and international cooperation.

ACID RAIN

Sulfur dioxide emissions, especially evident in coal-fired power production, are creating acidified precipitation (both rain and snow) which places many of our natural aquatic resources at risk.

2.1. The Minnesota Pollution Control Agency should continue to give priority to enforcement and upgrading of controls to limit acid rain deposition.

Adoption of the Acid Deposition Standard and Control Plan by the Minnesota Pollution Control Agency (MPCA) in 1986 was a clear signal that Minnesota intends to lead the nation in passing tough regulations to control acidic emissions. These regulations should be stringently enforced and toughened as necessary to limit further degradation of our aquatic resources. The MPCA Board and the Minnesota Public Utilities Commisson should also develop a joint strategy to encourage utilities to employ conservation measures to limit emissions and to reward utilities for investments necessary to achieve such demand reductions.

2.2. Federal acid rain legislation now pending before Congress should be quickly adopted and should contain provisions that give full credit to energy conservation as a control strategy.

GLOBAL WARMING

A second and potentially more serious consequence of fossil fuel use – the global warming or "greenhouse effect" – may also be a more difficult environmental problem to solve. Carbon dioxide, another byproduct of fossil fuel combustion, tends to block the escape of thermal radiation (created when the sun warms the earth), ultimately warming the lower atmosphere. Although the effects of such warming are difficult to predict, particularly for any given state or region, scientists now agree that major climatological disruptions will occur unless greenhouse gas emissions are substantially reduced.

Fossil fuel combustion is the source of more than half of all global warming gases, and most of the carbon from fossil fuel combustion comes from coal. Electric generation, which relies heavily on coal, is the major single source of global carbon dioxide emissions and accounts for 35 percent of U.S. CO_2 emissions.

2.3. Global Warming – As Congress considers legislation to address the global warming problem, priority should be given to:

- ***Efforts to reduce reliance on coal and other fossil fuels for electric generation;***
- ***Stronger fuel efficiency standards for vehicles and electric appliances;***

- ***Encouragement of state least cost planning efforts;***
- ***Research and development of non-fossil fuel renewable energy sources;***
- ***Global cooperation on the problem of deforestation in the Third World. (Deforestation is linked to the greenhouse effect because trees absorb CO_2 during the photosynthesis process);***
- ***Move with caution in the reexamination of nuclear energy as an alternative to fossil fuels for electric generation; nuclear energy continues to pose safety and environmental concerns (e.g. spent fuel storage, nuclear plant decommissioning, accident prevention, nuclear weapons proliferation, etc.).***

WASTE-TO-ENERGY

Fearing irreversible contamination of ground water supplies, communities throughout Minnesota have sought to limit or ban altogether the use of landfills for garbage disposal. A proposed solution is to build garbage incinerators that produce heat or electricity. Trash incineration raises concerns about dioxin emissions from the combustion of plastics and the release of ''heavy metals''. Emissions of these sorts, while partially controllable with sophisticated control equipment, are of great concern because of their cancer causing properties.

2.4. Broader environmental concerns should be considered in weighing waste-to-energy facilities against other disposal options.

For many public officials and policy analysts, garbage incineration is an attractive solution because of its ability to dispose of large amounts of garbage. It is also a relatively inexpensive option, given the prospect of revenue from energy production. In developing waste disposal plans, however, municipalities should consider all disposal options, including recycling, composting, and incineration. The Minnesota Environmental Quality Board and the Pollution Control Agency are working with Minnesota communities to find the best mix of disposal options for each. These efforts should continue with particular attention paid to the environmental effects of options chosen.

3. ENERGY EFFICIENCY OPTIONS

RESIDENTIAL, COMMERCIAL, INDUSTRIAL SECTORS

During the last decade, new technologies and products have substantially improved energy efficiency, and additional improvements are being developed. A variety of new products range from innovations in heat reflective window coatings to breakthroughs in high efficiency lighting.

For many reasons, adoption of these improvements is often gradual at best, creating significant lost opportunities for reducing energy costs. New appliances and new buildings use energy over useful lives of ten to thirty or more years. Thus, the decision to use more efficient products or building designs can capture energy savings that would otherwise be lost for years or even decades.

3.1. Publicly funded and utility sponsored energy conservation programs, as well as builders and architects, need to monitor developments in efficient appliances and building materials. More efficient new products should be selected as soon as their cost-effectiveness and overall performance are demonstrated.

Publicly funded and utility sponsored programs can play an important role in facilitating the availability and adoption of new products. This requires an ongoing review of each program's overall strategy and emphasis, including installed products, financial incentives, technical assistance priorities, and informational materials. Electric utility programs, in particular, need to maximize potential savings to reduce the need for costly new power plants.

Builders and architects also play a key role in adoption of new energy efficiency improvements. Many opportunities to use new products or approaches for overall design, lighting methods, building materials, equipment, and appliances are available during design and construction, and the choices made will establish a building's energy use for years to come. Developers of new buildings need to be informed of the latest available options.

3.2. Due to continuing changes and new developments, conservation programs need to engage in a constant process of evaluation and experimentation.

Many publicly funded and utility sponsored conservation programs have successfully adapted to changes in energy prices and continually improved their effectiveness. From initial efforts in the mid-1970s, a wealth of knowledge and experience has developed on how to reduce energy use and successfully gain participation from households and businesses.

Current programs can continue to increase their impact by continuing experimentation and evaluation. In addition to the use or promotion of new technologies discussed above, new approaches to increasing participation still need to be developed, tested, and fine tuned. A key component of this process is ongoing program evaluations that determine whether the program is cost-effective and whether a new approach is more successful.

Recent declines in petroleum and natural gas prices, and the likelihood that energy prices will continue to change, add to the importance of continually evaluating and updating conservation programs.

3.3. To improve further the energy efficiency of new buildings, Minnesota will need to conduct research, provide education to builders and designers, and make amendments to the state energy code.

Minnesota's current residential energy code helps to assure a high level of energy efficiency in new homes. With some minor modifications, the code will continue to serve as a model for other states.

More specific requirements are needed, however, to improve a current lack of compliance with standards to limit air infiltration. Education is needed to help builders become aware of the importance of increasing their care with caulking, eliminating bypasses (hidden openings to the outside), and other measures for building tighter houses. Future code modifications will outline proper construction practices to eliminate bypasses and reduce infiltration.

The American Society of Heating, Refrigerating, and Air Conditioning Engineers, which establishes industry standards for new construction, is currently completing a new energy code that will revolutionize approaches to designing more energy efficient nonresidential and large multifamily buildings. Significant features of the new standards will include greater emphasis on lighting efficiency (the largest use of energy in new buildings). Future changes to the Minnesota commercial and industrial energy code will allow builders to use these new standards as an option to current requirements.

The Department of Public Service has also conducted an initial round of testing to assure that available insulation materials are safe and effective. The department plans to continue a limited program of performance testing as a check on industry quality assurance programs.

TRANSPORTATION EFFICIENCY IMPROVEMENTS

Improvements in transportation energy efficiency are critical to our energy future, in part because transportation is the largest sector of energy use. An even more pressing issue is our nation's increasing dependence on oil imports. Passenger and freight transportation rely almost exclusively on petroleum for fuel, and continued improvements in efficiency can help reduce the need for imports.

3.4. Minnesota should support the strengthening of federal efficiency requirements for new cars and light trucks.

Current federal requirements have helped to improve automobile fuel efficiency by 40 percent since 1973. For these improvements to continue, the federal Corporate Average Fuel Economy (CAFE) standards for automobile manufacturers need to be strengthened or replaced by a new regulatory program.

The gradual turnover of existing cars adds to the need for continuing fuel economy improvements. Lower gasoline prices have reduced consumer concerns about fuel economy, but new cars purchased today will continue to be in use five and ten years in the future. Continued improvements would also help accelerate the development of new technologies for more efficient engines and vehicles.

3.5. Efforts to promote ridesharing through special programs and new roadway designs should continue.

Many Minnesotans rely on ridesharing to reduce the cost of commuting to work and other destinations. Ridesharing offers a number of valuable public benefits, including reduced rush hour congestion, better air quality, and greater energy efficiency. The MTC Minnesota Rideshare program, employer sponsored programs for employees, and roadway design improvements completed and planned by the Minnesota Department of Transportation are three important sources of continued support. Ridesharing can be an especially important energy saving activity in the event of a sudden return to higher gasoline prices. Increased use of car pooling could happen very quickly, without significant front end costs or extensive planning.

3.6. Public officials and transportation planners should consider vehicle energy use in their assessment of mass transit options and major highway projects.

Planning is currently underway for a possible light rail system centered in Hennepin County. The Minnesota Department of Transportation is also assessing the addition of a high occupancy vehicle lane to Interstate 35W or a light rail transit route. As new projects are considered, planners and decisionmakers should evaluate energy use and environmental implications of the alternatives. In some cases, one or more of the options may increase the use of more energy efficient transportation choices, such as buses, light rail, or ridesharing lanes, and help reduce Minnesota's long term energy needs.

3.7. Bicycle and pedestrian travel should be encouraged where practical as an energy efficient mode of transportation.

Bicycle and pedestrian travel represent a practical and growing means of energy efficient transportation. The U.S. Department of Transportation estimates that gasoline savings of roughly 15 million barrels per year would result from modest bicycle transportation improvements nationwide. According to the Minneapolis city engineer, the number of bicycles entering downtown doubled between 1981 and 1988. Identifying bicycle routes and providing bicycle lockers, parking, and "bike and ride" bus stops are measures that would increase cycling. These plans and others will help ease growing traffic congestion during the 1990s, and the alternatives will continue to be closely evaluated for their ability to meet transportation needs safely, conveniently, and economically.

4. ALTERNATIVE ENERGY OPTIONS

The ultimate depletion of nonrenewable energy sources, including petroleum and natural gas, continues to be a critical long term energy issue confronting Minnesota and our nation. The solution will inevitably require a growing reliance on alternative energy resources. Continuing research and development will be needed during the next decade to help reduce the cost and difficulty of this transition.

Despite declining energy prices, significant progress has been made since energy concerns became prominent in the 1970s. Demonstration projects and growing experience with the technologies have helped resolve many practical problems. Today, alternative energy resources can compete at much lower prices than would have been possible ten years ago.

Minnesota is well suited for directly producing a number of alternative energy resources. The opportunities include the use or development of wood fuels, crop residues, alcohol fuels, and wind energy. Continued experimentation and experience will increase our ability to develop these options and capture the economic benefits of using locally produced energy sources.

4.1. Minnesota should continue to encourage the use of wood fuels, wherever cost-effective and environmentally sound.

Wood is the one alternative energy resource that currently provides a significant share of Minnesota's energy needs. In 1986, use of wood for residential heating and as a commercial and industrial fuel, equaled 3 percent of Minnesota's total energy use. Additional resources are available. Wood waste from logging and lumber operations is currently an under-used resource. Modest increases in competing energy prices would permit wood wastes to become competitive at many commercial and industrial facilities.

4.2. Minnesota should continue to support the development and demonstration of projects using wood and crop residues as an energy resource.

Use of crop residues as a heating fuel is a significant untapped energy resource in Minnesota. Both wood and crop residues, however, present handling and combustion challenges. Ongoing experience using these fuels in various applications will lay the groundwork for more widespread use in the future.

4.3. Minnesota should support the development of alcohol fuels as a long term energy source for transportation.

State and federal tax credits have already helped establish ethanol blended gasoline (gasohol) as a transportation fuel. Falling gasoline prices in 1986 reversed an increase in the use of ethanol in Minnesota, but the processing capacity already in place and increasing familiarity with the fuel will help assure the availability of this energy source. Minnesota's two cent per gallon tax credit helps to encourage use of gasohol, and Minnesota's producer payment of 20 cents per gallon of ethanol is available for any ethanol plants built in Minnesota.

Methanol, another alcohol fuel, offers important advantages as a longer term alternative energy resource. Methanol can be produced from wood or field crops such as sweet sorghum, and it provides a high output of energy per acre of cropland. Minnesota should support any steps at the federal level for the study of methanol as a future transportation fuel and the demonstration of methanol powered vehicles.

4.4. Minnesota electric utilities and others should take steps to further the development of low head hydroelectric resources and wind powered electric generation.

Hydroelectric generation in Minnesota supplies a small portion of state electric needs, but some opportunities for additional generation are available. As public dams are repaired and updated, utilities should give priority to working with the responsible public authorities to increase electric generation capacity. Where economical improvements are possible, hydropower offers the advantages of no fuel costs and no adverse impacts on air quality.

State and federal approval for repair and expansion of a hydroelectric facility is a slow process that would benefit from greater simplification. An interagency task force in Minnesota facilitates relicensing of hydro projects.

Wind powered electric generation is not currently competitive with other sources of power, but wind speeds in western Minnesota are well suited to future development of wind generation. Continued utility participation in wind generation pilot projects will help to increase experience and identify methods for reducing costs.

4.5. State and local government operations should undertake demonstration projects for the use of photovoltaic power at remote facilities.

Recent improvements in photovoltaic cells and rechargeable batteries have created opportunities for low cost traffic control equipment, security lighting, and other governmental applications in remote locations. Demonstration and use of these new photovoltaic applications will help to expand roles and further reduce manufacturing costs.

5. LOW INCOME ENERGY POLICY OPTIONS

The price of energy, although stable as of late, continues to be a major concern for low income Minnesotans. As federal support for the energy assistance and weatherization programs has dwindled, the gap between incomes and energy costs has grown for these families. In recognition of these problems, the legislature created the Low Income Energy Task Force during the 1988 legislative session.

The legislature charged the task force to review existing programs and policies to determine their effectiveness in helping low income Minnesotans meet their energy needs. The task force will issue a report of its findings and recommendations for improvements to these programs and policies prior to the next legislative session.

5.1. The Department of Public Service urges the legislature to act promptly on the task force's recommendations to effect improvements in this vital area of energy policy.

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PROMINENT ENERGY ISSUES FOR 1989

Matters for public debate and public decisions, now and in the years just ahead.

ENERGY REGULATORY DEVELOPMENTS

Pressures to develop more flexible and responsive systems for effectively meeting future energy needs are creating fundamental changes in the electric and natural gas industries. Dramatic changes proposed for the electric generation industry include providing electric supply through competitive bidding and incorporating least cost planning into the utility planning process. Partial deregulation of natural gas prices and alterations in the rules regarding buying, selling, and transporting of natural gas are creating swift and substantial changes in the natural gas industry. The ultimate effect of these actual and proposed regulatory changes and how they should be managed are a source of uncertainty and disagreement. A description of the changes and the issues they raise is the focus of this section.

Two of our principal energy sources—natural gas and electricity—are supplied by regulated industries. To a large extent, companies operating in these industries have functioned as natural monopolies with prices and profits subject to state or federal regulatory oversight. The turmoil in energy prices since the early 1970s and other issues have created pressures for fundamentally altering the way in which these industries are regulated.

In both cases, the intent of the changes is to create industries that can be more responsive to change, more innovative, and better able to meet future energy needs. These objectives can potentially be met by developing greater flexibility in pricing and nurturing competition where ever possible.

A general consensus is that regulatory changes are needed. The uncertain future for energy prices and demand, continuing technological changes, and growing environmental challenges will require energy industries that can rapidly adapt to new conditions.

Nevertheless, the process of making these regulatory changes is complex and unpredictable. The many affected groups—including various segments of the industries and different groups of energy consumers—each have different competing interests. The regulatory changes that do ultimately unfold often produce unintended results.

One of the principal regulatory authorities for the natural gas and electric utility industries is the Federal Energy Regulatory Commission (FERC). The five presidentially appointed members of this commission are responsible for interstate regulatory policies. FERC is committed to a policy of significant regulatory change, and plays a major role in the development of new policies.

The Minnesota Public Utilities Commission (PUC) is responsible for regulatory policies within Minnesota. The PUC has developed new policies in several areas in response to changing industry conditions, state legislation, and federal requirements. The Department of Public Service intervenes in matters before the PUC and also intervenes in FERC matters on behalf of Minnesota.

Two regulatory trends are currently emerging in the electric utility industry. FERC is in the initial stage of developing policies for increased deregulation, and state regulatory authorities also continue to consider related issues at the state level. A second trend concerns the development of least cost planning. As noted in the Introduction, many state regulatory authorities are adopting this new approach to the evaluation of electric supply and demand options.

ELECTRIC DEREGULATION

Proposals for increased electric deregulation generally focus on the generation segment of the industry. Several characteristics and recent developments suggest that electric generation has a potential for functioning as a competitive industry.

One noteworthy feature of electric generation is the participation of major utilities in multi-state regional power pools. The utilities, coordinated by the regional agency, continuously sell power to each other as their individual supply needs fluctuate. Recent technological improvements have permitted utilities to make increasing use of spot power purchases in meeting customer needs, creating a very active market for short term power among utilities.

Second, utilities do not always own and operate all of their own power plants. They often establish long term contracts for purchases from other utilities, or two or three utilities may participate in the construction and operation of a single power plant.

Third, the Public Utility Regulatory Policies Act (PURPA) of 1978 has created an additional source of electric supplies. The act requires utilities to purchase electricity at established rates and terms from industrial/commercial cogeneration facilities that jointly provide heat and electricity. Electric generators that use renewable resources such as wind or hydropower or use municipal waste are also entitled to sell electricity to utilities. The electric suppliers covered by PURPA are referred to as qualifying facilities (QFs).

Fourth, and most significantly, public utility commissions and electric utilities in California, Massachusetts, Maine, New York, and other states have experimented with the use of bidding as a method for meeting future electric supply needs in the lowest cost manner. Some states have used bidding as a means for selecting proposed QF projects when the number of proposals exceeds a utility's needs for additional capacity. States have also opened the bidding process to non-QF power plants fueled by coal, natural gas, or other energy sources. Companies proposing these projects are referred to as independent power producers (IPPs) to distinguish them from the cogeneration, renewable resource, and other projects that meet the requirements for qualifying facilities.

An additional regulatory innovation has been to permit companies or non-profit organizations that conduct conservation programs to submit bids for meeting electric supply needs. By contracting to conduct a conservation program that provides an agreed on level of savings at a proposed cost to the utility, these contractors can implement energy efficiency improvements as a means for meeting future electric supply needs.

Several of the above supply arrangements are common in Minnesota. All of the largest Minnesota utilities participate in short term power purchases coordinated through the Mid-continent Area Power Pool, the regional power planning agency that serves Minnesota. The most recent example of a jointly owned power plant is the 800 megawatt Sherco 3 plant owned by Northern States Power and the Southern Minnesota Municipal Power Association. Long term contracts for power purchases are also widespread among local utilities.

Because Minnesota utilities have not proposed any new power plants in recent years, there have not been any IPP projects or bidding for additional capacity needs. There are some sales to Minnesota utilities from cogenerators and other qualifying facilities, but QFs do not make a significant contribution to local electric supplies. Their role in other regions of the country has been much more prominent.

FERC PROPOSALS FOR ELECTRIC DEREGULATION

The many possible methods of owning and operating power plants, the existence of markets for spot power purchases, and the development of IPPs and QFs have helped to support FERC's interest in developing competitive regional industries for generating electricity. FERC's intent is to establish independent power producers as an option for meeting future electric supply needs. When utilities need additional electric supplies, they would take bids from all potential supply sources. If the utility could not improve on the terms of the winning bid or bids, then power supply contracts would be awarded to the primary bidders. If no bids meet the utility's criteria, then the utility would plan to supply its own needs.

FERC proposed several regulatory changes in March of 1988 that would begin to implement this partial deregulation of electric generation. Completion of final rules in all areas, however, and complete resolution of the principal issues may require several years.

COMPETITION AND OPEN TRANSMISSION

Two closely related issues concern utility ownership of IPPs and access by other power producers to a utility's transmission lines. Both of these issues involve questions about how competitive the electric generation industry needs to be before it can perform better than the current system of regulation.

FERC has proposed its rule changes without making any provision for access to utility owned electric transmission systems. Thus, an IPP could only be assured of transmission access to the utility that selects it for an initial power supply contract. Sales to other utilities would require the use of transmission lines owned by two or more utilities or the construction of redundant transmission systems.

Critics argue that IPPs could not provide meaningful competition unless they have open, nondiscriminatory access to utility transmission systems. Without open access, utilities near several IPP power plants could still be effectively isolated from most of these potential suppliers, thereby limiting the degree of competition.

Related controversy has emerged over FERC's proposed policies on utility ownership of IPP facilities. The rules proposed in March of 1988 would permit utilities to form IPPs. These arrangements present opportunities for a utility to favor its own subsidiary in providing transmission access to competing IPPs. Critics argue that open, nondiscriminatory transmission is required to prevent a utility from treating its affiliated IPP preferentially. Critics also question FERC's definition of when a utility would have enough "market power" to influence the outcome of a bidding process.

The development of rules for open access to transmission would add significantly to the complexity of the FERC deregulation initiatives. The current transmission system is based on cooperation among utilities to increase reliability and reduce costs. Moving to a system that maintains reliability in a competitive environment would be a difficult challenge.* Thus, the argument that open transmission is needed before deregulation can be accomplished is, in effect, an argument that the deregulation process must proceed much more slowly than it would under present FERC proposals.

INCORPORATING CONSERVATION AND ENVIRONMENTAL COSTS

Controversy over the FERC proposals has also focused on the procedures for selecting winning bids from among independent power producers, qualifying facilities, and conservation projects. The proposed rule changes specify guidelines that state public utility commissions would be required to follow in approving utility bidding programs.

State regulatory authorities (including DPS) are concerned that FERC may interpret the proposed guidelines in a way that reduces the effectiveness of state regulatory oversight. States argue that greater flexibility to experiment and

*For further discussion of the extent to which deregulation of electric generation may impose costs on the generation and transmission segments of the electric industry, see the paper, "Do Cost Economies Arise from Vertical Integration in the Electric Utility Industry?" by Keith Gilsdorf, Energy Issues Intervention Office, Minnesota Department of Public Service.

develop approaches that meet local conditions are important to the success of utility bidding programs.

Recent comments to FERC by DPS note the difficulties of comparing the disadvantages of potentially diverse collections of proposed projects. Compared to a traditional power plant, conservation programs are a less proven, and therefore less reliable, source of meeting supply needs; but conservation programs also create no environmental impacts. The environmental costs of a coal fired power plant versus a natural gas fired cogeneration facility can be difficult or impossible to quantify. These costs may need to be assessed indirectly, in a manner that addresses local concerns and priorities.

The extent to which FERC would give states latitude in considering these issues is unknown, along with many other issues that have not been resolved at this early stage of federal regulatory changes.

REGULATORY ISSUES IN ELECTRICITY DISTRIBUTION AND SALES

In addition to regulatory issues concerning electric generation, two issues illustrate how competition can emerge in the retail segment of the utility industry.

Utility service territory disputes. To avoid duplication and assure reliable service, Minnesota statutes divide the state into territories to be served exclusively by assigned electric companies. Competition is becoming unavoidable, however, as allowances for population expansion in the original boundaries are being used up. Customers are comparing their rates with the rates of neighbors served by a different electric company. Those with higher rates clearly would like to be served by the other utility and, thus, the Minnesota PUC is reviewing more service area disputes.

This issue often involves legal and economic questions. An example is a dispute involving National Steel Pellet Company, a customer of Minnesota Power Company (MP), which wanted to be served by the city of Hibbing. Under the law, such an arrangement would have to compensate MP for revenues it would lose. Otherwise, losing such a large customer would likely mean higher rates for customers remaining on MP's system. To lower its costs, National Steel wanted to change this provision of the law. Before that effort was completed, MP and National Steel settled on lower rates for National Steel. These types of cases may happen more frequently as customers continue searching for lower-cost supply arrangements.

Economic development rates and marketing. Utilities would like to conduct marketing programs, provide business loans, or offer discount rates to attract new businesses into their service areas. A utility may see these activities as a means for competing with other utilities for new customers, using excess generation capacity, or contributing to the economic development of local communities. Utilities, consumer advocates, and regulators disagree over whether it is appropriate for utilities to recover these marketing costs from other customers or establish special economic development rates.

Economic development rates are common among nonregulated utilities in Minnesota that have excess generation capacity. These utilities include rural electric cooperatives and municipally owned utilities. The Minnesota PUC has not approved any economic development rates for regulated utilities.

In July of 1988 the PUC received a proposal from Dakota Electric Association for an economic development rate for large customers. In comments to the PUC, the Department of Public Service concluded that any additional sales to large customers at rates below the fixed costs of generation capacity would be more than offset by the reduction in rates, and this would lead to higher rates for other customers. In the longer term, the lower rates would create an incentive for less efficient energy use by large customers, hastening the need for a costly new power plant that would lead to higher rates for all customers.

A possible alternative to economic development is a concept known as ''real-time pricing,'' where rates for industrial users are calculated each hour to reflect the utility's cost of providing power for a given incremental load. Under such a pricing system, a customer's rate varies directly with the cost of providing service to that customer, with rates generally lower during off peak periods and higher on peak. In this way, large industrial customers can adjust production schedules to take advantage of rates when they are lowest. Depending on the utility's energy cost and the customer's use patterns, savings under real-time pricing can often be in the range of 10 to 30 percent.[1]

While not an issue in Minnesota, industrial/commercial electric cogeneration has been a third source of retail competition in regions of the country with high electric rates and excess utility generating capacity.

LEAST COST PLANNING

The past decade has witnessed important changes in how electric utilities plan for meeting electric supply needs, as well as what regulators expect from utilities when evaluating those plans. Collectively the changes are part of a developing approach to utility planning and regulation called least cost planning (or integrated resource planning).

Pressure for improved utility planning is partly the result of the increasing uncertainty that utilities face in planning for future electric needs. Since the mid-1970s, growth in demand for electricity has moderated. Forecasting future demand growth has become more difficult.

At the same time, the costs of building new power plants have increased sharply, and utilities in many regions of the country have faced difficult choices when evaluating the two traditional supply options: coal and nuclear power plants. Many regions of the country are too distant from low cost coal reserves, and requirements for pollution abatement equipment have added substantially to the cost of this option. Additional nuclear power plants have been largely ruled out by high construction costs and public concerns about safety.

These developments have led to substantial increases in electric rates in many regions of the country as utilities have made large investments to expand capacity. For many utilities, unexpected moderation in the growth of electric demand has made some already completed power plants unnecessary, resulting in even greater rate increases. Many of the most serious rate increases in recent years have resulted from construction of nuclear power plants that experienced excessive cost overruns.

Minnesota utilities have generally avoided the worst of these problems. Although generation capacity is plentiful, excess capacity in the region has not been as great as in other regions. The last nuclear power plant was completed by Northern States Power in 1974 before cost overruns became a widespread problem.

In addition to facing increasing uncertainty and higher construction costs, utilities need to examine an increasing number of options for meeting future supply needs. These include a wide array of methods for reducing demand through utility conservation programs or reducing demand specifically during peak demand periods through load management programs. Collectively, approaches to controlling or reducing growth in electric demand are referred to as demand-side management.

Options for increasing supplies are also more numerous. In addition to traditional coal-fired power plants, utilities can consider new coal burning technologies such as fluidized bed combustion, life extension projects for their older power plants, purchase of electricity from other utilities, or contracts to buy electricity from large industrial/commercial cogeneration projects.

The task of evaluating so many supply and demand-side options under differing assumptions about the future compounds the complexity of utility planning.

LEAST COST PLANNING AND ANALYSIS BY UTILITIES

Least cost planning is intended to serve as the planning process or methodological framework that meets the increasingly complex needs of utility planning. It is a process that evaluates all reasonable demand-side and supply-side options against a broad array of cost-benefit considerations, including sensitivity to varying forecasts of electric demand and other key variables. The process is referred to as least cost planning because the goal is to minimize the long term cost of providing electricity, taking into account environmental costs, reliability, and other important considerations.

Another commonly used term, integrated resource planning, emphasizes the importance of combining the comparison of demand-side and supply-side resources in a single analytical process. Thus, the costs and benefits of modernizing an old power plant might be directly compared to expanding a commercial lighting conservation program. Computerized models have been developed to permit the simulation of outcomes for many possible combinations of supply and demand-side options.

Utilities are increasingly recognizing the importance of more detailed methods of forecasting and analysis. The new methods are costly due to both the analytical requirements and the need for extensive data gathering. Compared to costs for new power plants and other supply options, however, the additional planning costs can be justified.

Least cost planning has contributed to increased analysis of data on utility load characteristics. Changes in daily and seasonal electric power needs (or loads) have always been important for determining how much utilities can rely on base load power plants, which operate over most of the year, versus peaking plants. Base load plants are more expensive to build but have much lower operating costs. More recently, evaluations of the cost-effectiveness of conservation programs consider how much they reduce electricity use during peak demand periods versus non-peak periods. For example, programs to increase air conditioner efficiency help reduce costly summer peaks in electric demand.

Analysis of conservation and load management activities requires combining analysis of load characteristics with data collection on electricity consumption by end use (lights, appliances, space heating, etc.). For example, many utilities offer special rates to residential customers who participate in load management programs to control electric hot water heaters. The success and design of these programs depend on how much of a particular utility's electricity sales are for hot water heating, and how much hot water heaters operate during the utility's peak demand periods.

Many utilities have been moving toward end use forecasting techniques. These techniques permit a greater understanding of how much specific uses of electricity may increase or decrease, how fast summer and winter peaks may change, and how much individual conservation or load management programs may contribute to meeting future electric needs.

End use forecasts have been applied most successfully to the residential and agricultural customer classes. The forecast begins with a forecast of the number of customers. For each specific end use (for example, electric water bed heaters), forecasts are made of saturation (percentage of customers with one or more water beds) and average annual electric use (kilowatt hours per water bed). Each of these forecasts is then combined into a single forecast of total electric sales for the customer class. Estimates of average use for each end use during peak demand periods permit the development of a very thorough peak demand forecast.

Econometric methods are a much more widespread approach to forecasting electricity sales. These methods rely on statistical relationships between historic electric sales and variables such as economic growth and energy prices. Econometric forecasts will continue to be important, but they do not provide the thorough understanding of future trends that is possible with end use forecasting.

LEAST COST PLANNING REGULATION

Most states have begun reviewing options for adopting a least cost planning approach to electric utility regulation. Least cost planning is seen as a means of avoiding future scenarios where the **only** way to satisfy the demand for electricity is by building more power plants. In at least 12 states,* either the public utility commission has ordered utilities to prepare least cost plans or the process has been established by state legislation. In most states—including Minnesota—state authorities have no regulatory role prior to approving the need for and siting of a new power plant or transmission line. By the time the application is received, the need to meet an impending shortfall in generation capacity often severely limits the potential for considering any alternative to the proposed facility. With least cost planning, alternative capacity options can be fully accounted for well in advance of any proposed construction projects. This allows regulators to make modifications while meaningful changes can still be implemented.

Least cost planning regulation is at an early stage of development. Most state requirements in this area have only been established since 1986. Wisconsin and Nevada are recognized as being the two states that have the greatest experience with the new process.

In 1983, Nevada passed the first state least cost planning legislation. The Public Service Commission then adopted detailed rules describing requirements for resource plans. Both the commission and the Public Service Department are involved in evaluating filings by Nevada's two electric utilities.

The Nevada legislation requires utilities to submit a plan to the Public Service Commission every two years. In addition to more specific requirements the commission may establish, the legislation requires that:

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* Connecticut, Florida, Illinois, Kentucky, Massachusetts, Nevada, North Carolina, North Dakota, Pennsylvania, Virginia, Washington, and Wisconsin.

- "Adequate consideration" be given to conservation, load management, cogeneration, purchases of power, and other alternatives;

- All prudent and reasonable costs in developing the plan be recovered in rates;

- Any new facility approved by the commission be part of an approved biennial plan.

Wisconsin passed a power plant siting law in 1975 that requires the state's two major utility working groups (Eastern Wisconsin Utilities and Western Wisconsin Utilities) to develop Advance Plans, which must be reviewed and approved by the Wisconsin Public Service Commission.

In August of 1986, the commission ordered utilities to prepare Least Cost Integrated-Resource Plans. The plans were to include:

- Twenty-year end use forecasts of energy and peak demand requirements;

- Plans for construction of proposed generation facilities over the next 15 years and transmission facilities over the next 10 years;

- An analysis of alternatives to the proposed generation and transmission facilities.

The utilities were also required to provide evidence in rate cases and Advance Plan proceedings that they were "vigorously pursuing conservation as least cost integrated planning develops." The two utility work groups completed their first least cost plans in October of 1987.

The Maine Public Utilities Commission has recently developed a new approach to least cost planning regulation through an "all source" bidding process for meeting electric supply needs. Bids for both conservation projects and supply-side projects are accepted in a single bidding process which permits the integrated consideration of many supply and demand-side options.

In a request for bids for 100 megawatts (MW) of capacity, Central Maine Power is considering 13 proposals for conservation programs totaling 36 MW and 19 supply side projects totaling 631 MW. Such an all source bidding process offers the advantage of a more competitive, market based approach to least cost planning and could potentially permit less regulatory oversight.

MINNESOTA ELECTRIC UTILITY REGULATORY REQUIREMENTS

Although there is no least cost planning regulatory process in Minnesota, the Minnesota Public Utilities Commission has several review and approval responsibilities related to utility planning.

- Minnesota legislation established in 1975 requires utilities to submit applications for a Certificate of Need for new large power plants and transmission lines. Before approving the application, the commission evaluates the utility's long term forecast and the utility's assessment of alternatives to the proposed facility, including conservation programs.

- Legislation passed in 1980 requires large public utilities to submit proposed Conservation Improvement Programs for making significant investments in conservation and alternative energy resources. The commission reviews and approves the programs annually.

- Legislation established in 1981 in conjunction with the federal Public Utility Regulatory Policies Act of 1978 provides for utility purchases of electric power from cogenerators and from small power producers that use renewable resources or waste as their power source. The commission reviews and approves utility rates for these purchases annually.

- Commission decisions on utility rate cases provide a final source of review and direction on utility operations and priorities.

Further discussion of commission requirements related to conservation and energy policy appears in section 8 of this report.

An additional utility planning requirement is administered by DPS and the Environmental Quality Board. Utilities are required to submit 15 year Advance Forecasts of electric sales and peak demand, as well as plans for new generation and transmission facilities. The Advance Forecast requirements serve as a public information resource and include no provision for approval of utility forecasts or plans.

The above requirements include many aspects of least cost planning regulation, but fall short of a complete process. There are no requirements for a full integration of supply and demand-side options. The Conservation Improvement Programs are developed separately from consideration of supply options. Certificate of Need applications require only an assessment of alternatives to a specific proposed power plant or transmission facility. There is no requirement for periodic submission and approval of utility least cost plans.

A Least Cost Planning/Conservation Task Force is currently reviewing potential regulatory or legislative changes. The task force is composed of representatives from the Minnesota Department of Natural Resources, DPS, the Department of Trade and Economic Development, the Pollution Control Agency, PUC, and the State Planning Agency.

DEREGULATION AND COMPETITION IN THE NATURAL GAS INDUSTRY

The Natural Gas Policy Act (NGPA) was passed by Congress in 1978 to improve distribution of natural gas within the United States and to stimulate domestic production. It significantly altered the regulatory environment of the natural gas industry that had existed for 20 years.

Before the act was passed, regulations held the price of gas sold to other states below the price of gas sold in the state it was produced. Proponents of the act argued that these dual market regulations made it more attractive to sell gas in the state where it was produced, thus creating shortages in nonproducing states. The act eliminated these regulations.

The act also sought to increase the nation's natural gas reserves by encouraging exploration and drilling through a gradual lifting of price controls on most "new" gas—that is, gas taken from newly discovered or drilled wells. By 1985, most price regulations for new gas at the source (wellhead) had been removed, but "old" gas (gas discovered prior to 1978) remained regulated, with the price allowed to rise only at the rate of inflation. This partial deregulation stimulated drilling and exploration, but it is still not clear whether the result will be an increase in long-term gas reserves.

A surplus in available gas supplies, or a "gas bubble," has developed since the act's passage. The surplus has been due to a drop in demand caused by increased energy efficiency, the switching of large industrial customers to alternative fuels, the availability of intrastate gas on the interstate market, and the discovery and production of new gas supplies.

Deregulation of some gas prices at the wellhead and the current gas glut have helped create considerable downward pressure on gas prices. Other major changes in the industry are in the process of occurring and are intensifying competition. These changes, their impact and the issues they raise, are described more fully below.

OPEN TRANSPORTATION

In October, 1985, the Federal Energy Regulatory Commission (FERC) issued Order 436 (subsequently replaced in September, 1987, by Order 500) that could dramatically change the relationships among natural gas producers, pipeline operators, local distributors (including utilities) and users. The order refers to what is called "open nondiscriminatory transportation."

Traditionally, interstate pipeline companies purchased natural gas from producers or acquired the gas through their own production facilities. They then transported this gas through their pipelines to their customers—the local distribution companies—who in turn delivered it to *their* customers—the end users.

Under the new order, pipeline companies would be obliged to transport gas for all who wished to ship it (provided capacity was available). The new regulations would enable local gas utilities and producers to deal directly with each other, using pipeline companies solely for transportation of gas purchased directly from producers. The regulations also would allow large users to bypass utilities and deal directly with producers. (Two options for permitting bypass are to allow large customers either to pay the local utility for the use of local distribution lines or, in some cases, construct a private line directly to a nearby interstate pipeline.) The theory is that open transportation would increase the number of buyers and sellers at the wellhead, resulting in more equitable prices for both producers and users. Pipeline companies acting as transporters would be paid for the volume of gas being shipped, with provisions for fees to cover the pipeline company's fixed costs.

Fifteen pipeline companies have so far chosen to operate under the open access transportation regulations. Northern Natural Gas (NNG), which provides 97 percent of Minnesota's natural gas,[1] has chosen to operate under the new regulations. Some of the pipeline companies interested in adopting the order have insisted on conditions that are inconsistent with at least some of the goals of the FERC regulations. Companies have also continued transporting gas under other mechanisms. Nationwide impact of the regulations will be determined by the number of interstate pipeline companies that agree to operate under them.

TAKE-OR-PAY CONTRACTS

The new order also seeks to remedy the problems caused by long term contracts between pipeline companies and producers. These 10-to 20-year contracts were sought by pipeline companies during the gas shortage of the late 1970s as a means of ensuring their supplies. The agreements provided for the pipeline companies to buy a certain amount of gas and to pay a fixed price for it. These are called take-or-pay contracts because the pipelines must pay for the gas whether they use it or not. As gas supplies increased and demand and prices dropped, these obligations became increasingly burdensome to the pipeline companies and their customers. Pipeline companies have attempted to extricate themselves from these agreements through lump-sum payments to producers. The FERC order includes provisions for passing part of these costs on to consumers or crediting part of the costs against the pipeline's payments to producers. Considerable controversy remains over how the losses from the contracts should be divided among pipeline companies, consumers, and natural gas producers. One possibility on future contracts is for the pipeline company to buy out the contracts and then recover at least a portion of the costs by adding an inventory charge to the gas it sells. A number of issues that FERC has not successfully resolved will need to be settled through future orders and litigation.

PARTIAL DEREGULATION OF GAS PRICES

Another major change in the natural gas industry occurred when FERC issued an order on June 6, 1986, that partially decontrolled the price of old gas. The price of natural gas varies widely according to its classification, ranging from well below average wellhead prices for some categories of old gas to much higher than average prices for some categories of new gas. The FERC order allows price ceilings for old gas to rise slowly to $2.57 per MMBtu (million Btu) as long as the increases do not violate existing contracts between producers and buyers. In 1987, the average price of gas purchased by interstate pipeline companies was $2.18 per MMBtu.[2]

The exact impact of deregulation on natural gas prices is uncertain. After a substantial increase in the early 1980s, prices began falling in 1983. A key reason for this drop has been the development of the gas bubble and the resulting competition among producers to sell surplus natural gas. A second factor has been the drop in petroleum prices in 1986, which led large industrial and commercial customers, as well as some electric utilities, to switch from natural gas to residual fuel oil. Partial deregulation contributed to the impact of these developments and to earlier price increases, but the role of each contributing factor is difficult to isolate.

Table 1 helps illustrate the effects that the natural gas surplus and petroleum prices have had on the cost of natural gas. In 1985, declining prices in the emerging natural gas spot market put downward pressure on interstate pipeline prices, helping to push interstate pipeline average wellhead prices to $2.82 per Mcf (thousand cubic feet). The sudden drop in residual fuel oil spot prices in 1986, to the equivalent of $2.59 per Mcf, created a second source of downward pressure.

FLEXIBLE NATURAL GAS RATES

Fluctuating petroleum and gas prices have required changes in the regulation of rates for large interruptible gas customers who can switch to residual fuel oil when prices are favorable. The temporary loss of these customers causes remaining customers to pay the utility's total costs. Northern Natural Gas and other pipeline companies initiated a program of temporary rate reductions in response to falling petroleum prices, and the Minnesota PUC approved a similar rate policy for Minnesota utilities.

This program was replaced by a new flexible rate policy after the Minnesota legislature passed a law allowing flexible gas rates. FERC also included guidelines for market responsive prices in its order establishing open transportation. The Minnesota Department of Public Service is studying the impact of flexible rates and will submit a report to the legislature.

Figure 1

Price Deregulation Status of U.S. Natural Gas Sales

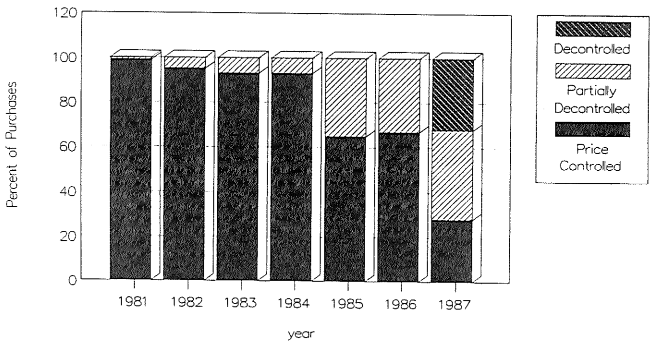


Table 1
Prices of Interstate Natural Gas and Residual Fuel Oil 1982-87

(Prices in constant June 1987 dollars per thousand cubic feet)

	Natural Gas Wellhead Prices		
Year	Interstate Pipeline Company Average	Spot Market Average	Residual Fuel Oil[1]
1982	2.88	N/A	5.94
1983	3.11	N/A	5.57
1984	3.09	3.09	5.70
1985	2.82	2.53	4.79
1986	2.36	1.67	2.59
1987	2.07	1.42	3.20

N/A = Not Available

1. Spot prices of New York cargoes of #6 fuel oil converted to dollars per thousand cubic feet. Sulfur content less than one percent.

Source: *Wellhead Purchases of Natural Gas Since the NGPA*, U.S. Department of Energy, Energy Information Administration, 1987.

IMPACT ON MINNESOTA OF CHANGES IN THE NATURAL GAS INDUSTRY

Nationally, the extent of deregulation can be seen in Figure 1 which shows the price control status of wellhead gas sold to major interstate pipeline companies during the years 1981-87. In 1981, about 98 percent of all purchases were under price control. In 1987, less than 30 percent still had price controls, about 41 percent were subject to the partial decontrol ordered by FERC in 1986, and more than 30 percent had no controls.

The impact of the open transportation regulations on Northern Natural Gas, the company that supplies most of Minnesota's gas, and on the nation's major pipeline companies is shown in Table 2. From 1981 to 1986, transportation of gas for others by NNG increased from 6 percent to 41 percent of total shipments. The average for major pipeline companies increased from 7 percent to 43 percent of total shipments.

Minnegasco, the largest local distribution company served by NNG in Minnesota, no longer looks at NNG as its sole supplier. An alternative source in Canada will soon be available to Minnegasco through the Midwestern Gas Transmission Company.

CURRENT REGULATORY ISSUES TO BE RESOLVED

The natural gas industry is in a state of flux; not only is the impact of changes made by the FERC orders being felt, the final form of these changes is yet to be determined. At least six key issues have emerged that need to be resolved.

Take-or-pay contracts. A question to be resolved is whether FERC should take a role in determining who will assume the costs of these obligations—producers, pipeline companies, consumers, or a combination of all three. If FERC does take a role, it will need to decide how the costs will be paid and how the amounts will be determined—whether by the regulatory commission or by market forces.

Table 2
Percent of Natural Gas Pipeline Company Shipments Transported for Others, 1981-86

Company	Total Gas Shipments[1] (billion cubic feet) 1986	% of Gas Shipments Transported for Others 1981	1986
Northern Natural Gas	678	6	41
ANR Pipeline	687	2	42
Colorado (CIG)	231	4	26
Columbia	899	1	41
Consolidated	251	3	53
El Paso	918	1	51
Florida	263	34	24
K N Energy	79	7	14
Natural	871	3	30
Northwest	223	13	50
Panhandle	403	6	43
Southern	353	4	26
Tennessee	842	7	46
Texas Eastern	822	16	24
Texas Gas	256	3	23
Transcontinental	1,032	9	67
Transwestern	239	*	48
Trunkline	455	23	63
United	539	6	76
Williams	258	*	1
AVERAGE		7	43

1. Includes gas purchases by the pipeline company and gas transported for others.

* = Less than 0.5 percent.

Source: *Wellhead Purchases of Natural Gas Since the NGPA*, U.S. Department of Energy, Energy Information Administration, 1987.

Access to pipeline transportation and establishing priorities for allocating gas are a second key issue. Currently, pipeline companies can choose not to be an open access transporter; that is, they can deny certain producers and distributors the use of their pipelines. The Minnesota Department of Public Service (DPS) takes the position that open, nondiscriminatory transportation should not be optional; it should be required of all pipeline companies. The department believes that mandatory open transportation will increase competition in buying and selling natural gas, resulting in lower prices for consumers. The department also supports a change in the system of allocating gas. Currently, if demand for natural gas exceeds the pipeline company's delivery capacity, the gas is allocated on a first-come, first-served basis. The department believes a more efficient method should be devised.

Marketing affiliates owned by pipeline companies that transport gas for others is a third issue of concern. Marketing affiliates operate independently of the pipeline company, seeking to act as a broker between natural gas producers and buyers or to sell natural gas supplies owned by the pipeline company. Operating these separate activities creates an incentive for the pipeline company to exchange privileged information, structure rates, or provide pipeline access in a manner that benefits its marketing affiliate and discriminates against other transporters. DPS initiated FERC proceedings that established requirements in this area, but the department continues to seek more comprehensive regulations to protect against such discriminatory practices.

Utility bypass. Fourth is the problem of large industrial users buying their natural gas directly from producers, bypassing the local utility or distribution company. The effect of this bypass is to spread the utility's fixed costs among a smaller number of customers, increasing the costs for residential and other captive customers. For this reason, state regulatory commissions tend not to be sympathetic to bypass. Because bypass involves both local utilities and interstate pipeline companies, a further complication is determining areas of jurisdiction between the states and FERC.

Incentive regulation. A fifth question concerns Minnesota regulations that require local utilities to simply pass on the cost of their gas supplies to consumers. Under open transportation, utilities will have opportunities to reduce their cost of gas by purchasing supplies directly from producers and arranging for transportation. The department has recommended that incentives to reduce natural gas costs be incorporated into current regulations, and the Minnesota PUC has authorized a task force including department and utility representatives to study this issue.

Price and supply. A sixth area of concern is the effect of price deregulation on the supply of natural gas. Because of the gas bubble, natural gas prices are low; questions are being raised, however, as to what effect deregulation will have on natural gas supplies and what will happen if shortages develop. How high will prices go? Because of these concerns, DPS has been among those contesting FERC's partial deregulation of gas prices.

ELECTRIC SUPPLY OPTIONS FOR MINNESOTA

Minnesota utilities are planning for an increase in electric demand that is expected to exceed current supplies within ten years. Constructing new generation facilities is only one of the options open to them. Other choices include supply-side options such as purchases of power from other utilities, cogenerators, independent power producers, and producers of renewable fuels; and demand-side options that include implementing energy efficiency measures and employing load management strategies such as time-of-day pricing, dual fuel systems, and interruptible service. These options and the possible impact of new technological developments are described in this section.

Demand for electricity is expected to exceed current supply within the next ten years in Minnesota. According to a combined forecast by the Minnesota electric utilities, this supply deficit is predicted to exceed 1,600 megawatts (MW) by the year 2002.[1] By comparison, the most recent addition to electric generation capacity, the Sherco 3 plant, is 800 MW. The Minnesota utilities expect the first electric supply deficits to occur by the summer of 1996. Northern States Power (NSP), which serves the Twin Cities, central Minnesota, and northern Wisconsin, anticipates the greatest need for increased capacity. The deficit will be greatest during summer peak demand periods caused by air conditioning.

Constructing and putting into operation new electric generation facilities requires considerable time; therefore, an examination of the various choices for preventing supply shortages must be undertaken without delay.

OPTIONS FOR MEETING FUTURE DEMAND

Construction of utility owned power plants. One option for increasing Minnesota's electric generation capacity would be to construct new base load power plants fueled by coal. Coal is an inexpensive fuel, and Minnesota's proximity to coal fields in Montana and other western states is a primary reason for the relatively low electric costs in Minnesota. The disadvantages of coal-fired electric generation, as compared to generation fueled by oil or natural gas, are the large capital (fixed) costs, long construction time, and pollution. Pollution abatement costs are lower in Minnesota than in some other regions because Minnesota utilities rely primarily on low sulfur western coal. Most coal deposits in eastern states have a higher sulfur content.

Another option for a base load plant is a nuclear-powered facility. Minnesota utilities, however, have no plans to build nuclear power plants. In an interview with the *Star Tribune*, James Howard, president and chief executive of NSP, said that there is no future for nuclear energy.[2]

For meeting seasonal peaks in electric demand, natural gas and oil-powered plants offer advantages and are being considered as an additional supply source for Minnesotans.

Power purchases among utilities. A possible alternative to constructing base load plants is large scale purchases of electricity from Manitoba Hydro Electric Board (MHEB). The recently signed U.S.-Canadian free trade agreement may make this low cost power even more economical, effectively competing with coal-fired plants. Currently, Minnesota utilities are purchasing sizable amounts of electric energy from MHEB and several Minnesota electric utilities are negotiating for additional purchases.

To meet demand in the near future, many utilities in Minnesota with different seasonal peak demand periods are exchanging energy supplies with each other: southern utilities receive additional summer capacity from northern utilities in need of higher winter capacity, and vice versa. These agreements hold down the need to increase generation capacity in Minnesota and permit summer peaking utilities to operate at higher demand levels during what would otherwise be off peak periods. The opportunities for more of these exchanges are limited due to the low capacity levels of the northern, winter peaking utilities.

Short term purchases and sales among utilities take place continuously and increase the options open to utility system operators in meeting their immediate power requirements. In Minnesota, the sales and purchases are coordinated by the Mid-continent Area Power Pool (MAPP), a regional coordinating body that includes the principal generation and transmission utilities in nine midwestern states and two Canadian provinces. MAPP is one of nine multistate agencies that help utilities coordinate their planning and transmission capabilities as a means of increasing the reliability of each utility's system.

In addition to improved reliability, short term sales and purchases provide two additional benefits: Utilities are often able to purchase power during peak demand periods at less cost than they could operate their own peaking plants; the transactions also provide an additional market for utilities with excess capacity.

Reducing demand for higher capacity through special programs and initiatives is an attractive alternative to increasing generation and transmission capacity. Providing incentives for shifting electric demand from peak periods to off peak periods, for example, helps eliminate fluctuations in demand. Utility conservation programs can reduce total electric demand. Given the high costs of providing additional capacity, such programs can be quite valuable.

Load management—that is, eliminating fluctuations in electric demand—reduces the need for providing additional capacity and spreads the fixed costs of electric generation and supply over a broader base. Examples of load management programs include:

- **Time-of-day pricing**, by charging more for electric use during peak hours, encourages utility customers to shift their electric use to off peak hours. The system requires that electric use be monitored on an hourly basis.

- **Dual fuel space and water heating systems** reduce peak demand by eliminating electric loads when capacity is strained. Often dual fuel units are radio controlled by the utility and automatically switched off line to another fuel when demand is greatest. Dual fuel systems are commonly used by Minnesota's northern electric utilities and are directed mainly at residential customers.

- **Interruptible service** reduces peak demand in a manner similar to that of dual fuel systems, but this program is usually directed toward large industrial and commercial customers who may possess backup generation capability. A number of large electric utility customers in Minnesota operate under these types of arrangements.

Reducing capacity requirements through conservation is another alternative to increasing capacity. Conservation reduces total electric use, thereby reducing peak electric demand. Many electric customers have begun to reduce electric demand by using more efficient appliances, lighting fixtures, and industrial processes. Conservation programs sponsored by utilities include rebates to customers who replace old appliances with more efficient models. Variations of this type of program are used in the commercial and industrial sectors for replacement of low efficiency lighting with higher efficiency fluorescent or other types of lighting.

Programs that reduce demand could substantially affect electric supply in Minnesota. A consultant's study discussed in section 4 of this report indicates that improvements in energy efficiency could potentially reduce Minnesota's future electricity requirements by 52 percent. A significant portion of this savings could be realized through utility sponsored programs.

Non-utility supply sources. Two basic types of electric supply come from non-utility sources. The first type, cogeneration, refers to the simultaneous production of electricity and steam heat from a single source. For industrial processes that require large amounts of steam heat and electricity, cogeneration is more efficient than conventional electric supply. It is ideally suited for processes such as paper production that use large amounts of energy; it has also become economically viable for hospitals and hotels that use steam for space heating.

Because Minnesota has sizable paper production, health care, and other industries suitable for cogeneration, the state's potential for cogeneration could be substantial. The comparatively low electric rates in Minnesota, however, reduce the incentive for using cogeneration. Nationwide, particularly in regions with high electric rates, cogeneration is providing an increasing share of electric capacity.

Cogeneration can be an inexpensive source of new generating capacity. A substantial advantage of cogeneration is that the cogenerator, rather than the utility's rate payers, bears the financial risk of installing and maintaining electric capacity. A disadvantage of cogeneration is that the rates of other electric customers can be adversely affected if a utility loses large industrial customers to cogeneration.

The other type of non-utility capacity is provided by independent producers using wind, solar, or hydroelectric sources. The Public Utility Regulatory Policies Act of 1978 established provisions for sales to electric utilities of power produced from renewable energy sources or from cogeneration. The supply of electricity from renewable energy sources is quite small in Minnesota, but future improvements in the technology of wind generation and photovoltaics may make alternative supply sources competitive in Minnesota, especially in remote areas.

The Federal Energy Regulatory Commission (FERC) is considering regulatory changes to facilitate the purchase of power by utilities from independent producers who use nonrenewable fuel sources. These regulatory changes could significantly expand the future role of independent producers.

UTILITY EXPANSION PLANS

The utilities serving Minnesota are considering a variety of options to meet the increasing demand for electricity.

Northern States Power (NSP), which supplies roughly half of the state's electricity, expects to meet most of the increased demand by purchasing electricity from nearby utilities and by reducing peak load demand through load management and conservation. According to its 1988 plan,[3] NSP also plans to have a 150 megawatt (MW) natural gas or oil fired combustion turbine operating possibly as early as 1994. The utility anticipates a possible need for a 350 MW facility between 1995 and 2001, and for 250 and 350 MW additions between 1997 and 2004. The first 350 MW plant may be on line by 1997. Although the exact location of these new power plants is uncertain, a North Dakota site located near coal sources has been identified as an option. If the plants are located in North Dakota, a transmission line stretching the width of the state may be necessary. If NSP should decide to make large scale electric purchases from Manitoba Hydro rather than construct these additional facilities, a transmission line stretching the length of the state may be necessary. In either case a major transmission line in Minnesota seems likely if electric demand continues to grow at its present rate.

Other utilities serving Minnesota are not currently planning to construct power plants; for meeting their supply needs, they are examining some of the other options being considered by NSP.

TECHNOLOGICAL DEVELOPMENTS

The long term future of the electric power industry may be dramatically altered by technological changes. Areas that seem to offer the greatest promise are new developments in superconductivity, reduced emission coal technologies, and photovoltaics. Some of these technologies are currently available but are not yet economically viable. Increasing costs of conventional energy and improvements in the technology of alternatives will undoubtedly provide incentives for greater implementation of new energy choices.

High temperature superconductors. Recent developments in superconductors are creating considerable interest regarding possible applications in the electric industry. Superconductors conduct electricity with little or no power loss, leading to speculation on their possible use in electric transmission.

The electric power industry increasingly depends on longer and higher-voltage transmission lines, a result of a number of factors including the need to locate generation plants far from population centers and the connection of Minnesota utilities with Canadian hydroelectric facilities. Longer transmission lines increase electric losses. Transmission losses and the negative impacts of building additional transmission lines limit the potential for long distance sources of electricity. If high temperature superconductors could be developed for electric power transmission, power plants could transmit power to any location, no matter how remote, with little or no power loss. Power exchanges between different regions of the country could take place, eliminating the need for each region to maintain capacity surpluses. Reliability of the electric system would also improve, since a major power plant failure in one region could be offset by power purchases from another region.

High temperature superconductors also might solve the most vexing problem of electric energy—the absence of an inexpensive method for high capacity storage. Electric supplies well in excess of average electric demand must be maintained daily, throughout the year. If storage of electricity were inexpensive, electricity could be generated during off peak (or off season) periods for use during peak demand. The viability of solar and wind generation would dramatically improve, reducing pollution associated with large coal-fired capacity. A viable technology for storing electric power could potentially eliminate the need for new generation capacity in almost all areas of the country. In theory, a high temperature superconductive device could be used to circulate electricity, with no electric loss, until it is needed.

Reduced emission coal electric generation is a technology that is already developed and being implemented in Minnesota. Two prominent techniques for cleaner combustion of coal are fluidized bed combustion and coal gasification. A conventional coal plant is generally designed to burn a specific quality of coal and does not permit switching from one grade of coal to another as prices change. In addition to their higher efficiency, fluidized bed combustion and coal gasification technologies can use a much wider variety of coal types, thus permitting lower fuel costs. These techniques result in fewer emissions, reducing the costs of pollution control. An additional advantage of fluidized bed combustion is that it can be adapted to existing coal plants, reducing capital expenditures and extending plant lifetimes. NSP has installed this technology in one unit of its Blackdog plant in Burnsville.

Photovoltaics, in light of recent technological developments, continues to show promise as a future source of electric power. Ten years ago this process of converting sunlight into electricity cost $50 per watt of capacity compared to about $5 today.[4] With additional breakthroughs, cost reductions of a similar magnitude could take place, making large-scale photovoltaics a viable alternative. The advantages of solar generation over conventional techniques are low pollution and increased safety, eliminating the need for remote power plant siting. Currently, photovoltaic generation is used in a variety of consumer products and in locations with limited access to electric distribution lines. As costs fall, photovoltaics will see increased application in specialized uses in the near future.

ENVIRONMENTAL/ENERGY CONCERNS

Energy costs more than money. Burning fossil fuels causes some of the major environmental problems of our planet, specifically global warming and acid rain. Other problems associated with various energy sources are much less global in effect but are a source of concern to localities affected by them. These include high voltage electric transmission lines, waste-to-energy plants, and radon. These problems—their causes, possible effects, and suggested solutions—are described in this section.

The costs of energy are not solely financial. Providing and using energy creates significant impacts on the environment that need to be considered when energy decisions and policies are made.

Sulfur, nitrogen, and hydrocarbons are some of the dangerous pollutants produced when fossil fuels are burned. By the early 1980s, activities such as generating electricity, driving automobiles, and industrial production were annually releasing into the atmosphere more than 6 billion tons of carbon, almost 100 million tons of sulfur, and lesser quantities of nitrogen oxides.[1] Global carbon emissions are increasing, adding over 100 million additional tons to the environment annually.

Some of the energy related environmental effects are local and/or related to a specific fuel or use; others involve broad classes of fuels and uses and affect large geographical areas. In the latter category, two environmental effects predominate: acid rain and global warming. These problems share a number of characteristics: both present fairly clear and early evidence of having great potential for future harm; neither exerts an early impact on a large sector of the public; and they are international in scope and are expensive to alleviate, so that strong incentives arise to delay or suppress serious steps toward solution.

Of the two, acid rain is far simpler and better understood, less widespread, less delayed in effect, and easier to detect, diagnose, and cure.

ACID RAIN

Acid rain is precipitation—rain, snow, sleet, or fog—containing heavy concentrations of sulfuric and nitric acids. It is created when emissions from burning of fossil fuels combine with atmospheric water vapor to form sulfuric and nitric acid particles. Most of these particles are incorporated into clouds and deposited on the earth in precipitation.

The largest source of acid rain in the United States and Canada is sulfur dioxide (SO_2). Most SO_2 emissions come from sources in the northeast United States, and most come from coal-and oil-burning power plants. The acidity of rain in the eastern U.S. has more than doubled since the mid 1950s when reliable data began to be kept.[2] Although the amount of coal burned and the sulfur content of this coal have both increased since the 1950s, the increased acid rain is probably due mainly to installation of tall smokestacks. Tall smokestacks were installed to comply with local air quality regulations, and although they reduce serious local pollution problems, they substantially increase regional and distant downwind acid concentrations. Some of the increase can also be attributed to increases in emissions of nitrogen oxides (NO_x) from industrial plants and automobiles.

Damage from acid rain. Acid rain can increase the acidity of lakes and streams and soil, thereby causing particular harm to fish and other aquatic life and to plant life, including agricultural crops and trees. The extent to which soil and water are affected by acid rain depends on the buffering characteristics of the soil and the buffering capacity of the lake or stream. Soils rich in limestone, for example, are alkaline and can neutralize the acid. Some bodies of water also contain alkaline elements that can neutralize the acid. A lake that is acidified has a pH well below 6 (pH is a measure of alkalinity/acidity: a pH below 7 indicates acidity, above 7 indicates alkalinity). The aquatic life in such a lake is altered or nonexistent. In general, fish cannot survive in water with a pH of 5 or less.

Data obtained in the late 1970s and early 1980s indicate that damage from acid rain may be more extensive than previously thought. Extensive damage to lakes (and their fish population) has been documented in Canada, Finland, Scandinavia, and the United Kingdom. In the eastern United States, some 9,000 lakes are threatened; 212 lakes in the Adirondacks are devoid of fish.[3] High percentages of acid lakes are found in eastern Pennsylvania and Michigan's Upper Peninsula. In the western U.S., no aquatic systems are completely acidified as yet; the most sensitive lakes are in the Sierra-Cascades, Rockies, and Coast Ranges.

Possible solutions. Preventing—or at least alleviating—further damage from acid rain requires significant reductions in sulfur dioxide and nitrogen oxide emissions. Technologies are available to reduce emissions; one method, called flu-gas desulfurization (FGD), removes as much as 90 percent of the sulfur dioxide emissions, but creates waste that is difficult to dispose of and reduces the efficiency of a power plant. New power plant technologies have been developed that offer better solutions. These include atmospheric fluidized-bed combustion, pressurized fluidized-bed combustion, and gasification/combined cycle.

The major drawback to such technologies is cost—and the time involved in replacing existing plants. A recent report says that although retrofitting existing plants with FGD would be the fastest way to reduce emissions, the best solution may be to "repower" aging plants with one of the new plant technologies. The report concludes that government intervention in the form of a timetable may be needed to speed the process.[4]

Another approach to reducing emissions is to decrease demand for electricity (and thereby reduce fossil fuel consumption) and to use the economic savings to pay for control measures. A 1987 study by the American Council for an Energy Efficient Economy analyzed the effects of simultaneously implementing aggressive programs of electricity conservation and emissions reduction in five midwestern states. The study concluded that reducing the growth in electric demand from the currently projected 1.7 percent to only 0.9 percent per year could result in a 7 to 11 percent reduction in emissions from their 1980 level and a savings of $3.7-7.7 billion by the year 2000.[5] These savings could be used to pay for control measures that would reduce emissions by another 45 percent.

A 1986 study by the Minnesota Department of Energy and Economic Development, *Sulfur Dioxide Emissions Reduction Through Energy Efficiency Programs in the NSP System,* found that implementing cost-effective energy efficiency measures among commercial and industrial users would lead to substantial savings, estimated to be in the range of 93 to 186 megawatts by 1990 and resulting in up to a 4,478 ton (roughly 4 percent) reduction in sulfur dioxide emissions by 1990.[6]

GLOBAL WARMING

Global warming (the greenhouse effect) is created when certain gases in the atmosphere absorb thermal radiation emitted by the earth and prevent its escape, ultimately warming the lower atmosphere. Carbon dioxide (CO_2) is the most significant of these atmospheric gases, producing approximately half of the climatic effect. Other gases contributing to global warming are chlorofluorocarbons (CFCs), methane, nitrous oxide, carbon monoxide, and a number of other gases.

Electricity generation accounts for 35 percent of U.S. CO_2 emissions; other major U.S. sources are transportation (30 percent), manufacturing (24 percent), and residential heating (11 percent).[7] Future atmospheric CO_2 increases will continue to reflect closely the fossil fuel production ratio, since fossil fuel combustion accounts for more than half of all global warming gases. Further, most of the carbon from fossil fuel consumption comes from the use of coal, predominately used in electric power generation (see Figures 1-4).

The concentration of carbon dioxide in the atmosphere has varied over time. From the post-glacial period to the beginning of the 19th century, there were small natural variations in the CO_2 level (260-290 parts per million). From 1800 to the present, the human impact on the global carbon cycle has been clearly measurable in the atmosphere, in tree rings, in ice cores, and in the ocean. The world's increasing reliance on fossil fuel energy resources and on deforestation to clear land for agricultural and other uses has raised atmospheric CO_2 levels to 348 parts per million (an increase of 24 percent from 1800). Worldwide CO_2 emissions more than tripled between 1950 and 1980. Currently, CO_2 levels are increasing by 0.4 percent per year; about one-fourth of the world's CO_2 emissions are produced by the combustion of fossil fuels in the United States.[8]

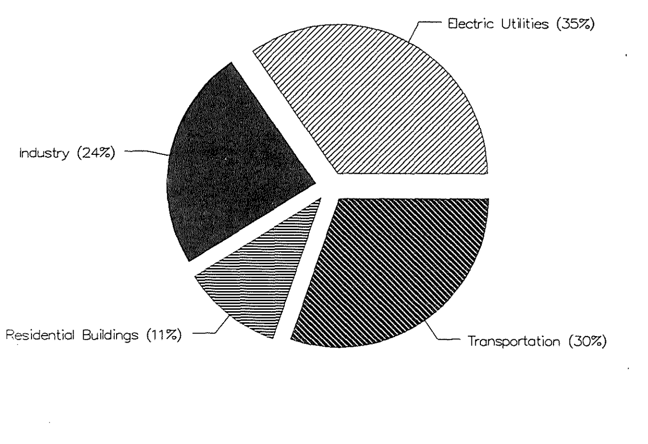
Since 1860, deforestation has contributed between 90 to 180 billion tons of carbon to the atmosphere, compared with 150-190 billion tons from the burning of coal, oil, and natural gas.[9] By 1950, most of the clearing of land for agriculture had ended in North America and Europe. Currently, the bulk of carbon dioxide added to the atmosphere by land use changes comes from tropical areas. Estimates of the amount of carbon released through forest clearing vary considerably due to uncertainties about the rates of forest conversion, the extent of forest regrowth after clearing, and the amount of carbon stored in the vegetation and soils of different types of forests. Scientists believe that deforestation currently adds between 1.0 billion and 2.6 billion tons of carbon to the atmosphere annually, or between 20 and 50 percent as much as the burning of fossil fuels.[10]

Atmospheric scientists generally agree that the continuing increase of carbon dioxide, combined with increases in the other trace gases, is likely to cause a detectable global warming over the coming decades. The extent of the temperature change and precise geographical effects, however, are uncertain. It remains unclear how much the oceans will delay the warming by acting as a heat sink; other uncertainties include how fast the warming will occur, how severe it will be, and precisely what the effects will be and where they will occur. Many effects may as yet be unanticipated and others are not well understood.

The 1987 average global temperature was .05 degrees Celsius warmer than during 1981 and 1983, the next two warmest years on record; the average global temperature has increased by about 0.5 degrees Celsius since 1861.[11] Experts caution that the persistent warmth of the 1980s may simply represent natural variability, but they also report that it could indicate increased concentrations of CO_2 and other greenhouse gases in the atmosphere.

Figure 1

U.S. Carbon Dioxide Emissions by Source



Source: Worldwatch Institute

Some scientists believe that *current* carbon levels, without any additions, are sufficient to produce a temperature increase during the next few decades that will make the earth far warmer than at any time since civilization began. Some climatic models indicate that the expected doubling of the pre-industrial level of carbon dioxide will raise the global temperature by between 1.5 and 4.5 degrees Celsius or more.[12] A temperature change of this magnitude is put

Figure 2

U.S. Sources of Energy

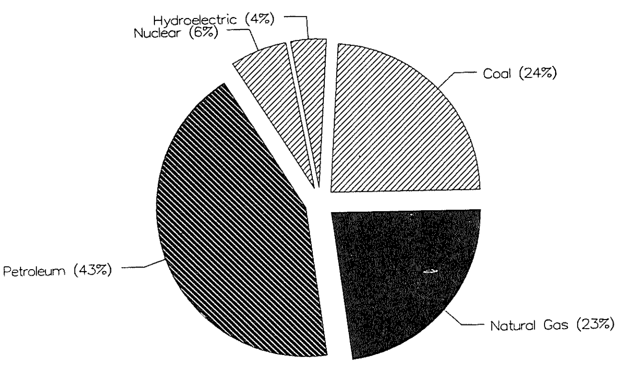


Figure 3

Fossil Fuel Emissions of Carbon Dioxide

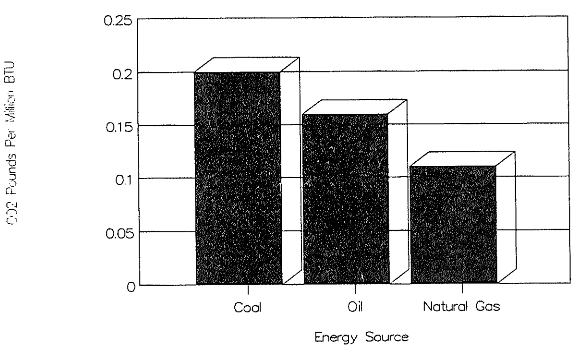
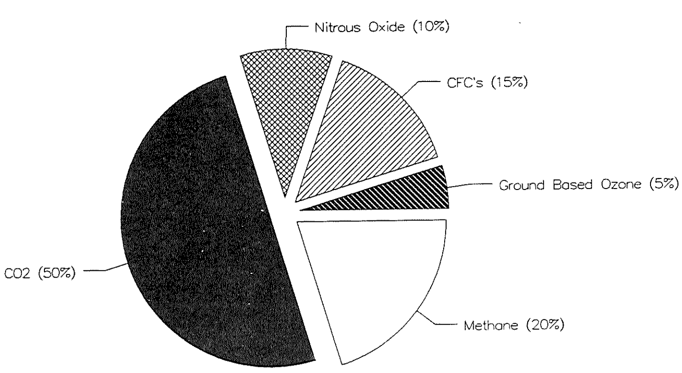


Figure 4

Gases Contributing to Global Warming



Source for Figures 2-4: Worldwatch Institute

into perspective by noting that at the depth of the last Ice Age, 20,000 years ago, the earth was an average of 5 to 7 degrees Celsius colder than it is today. Scientists believe that a 2.8 degree Celsius increase in the average global temperature will probably cause the arctic summer ice to disappear, an event that has not occurred in the past million years.[13]

Based on the present rates of deforestation and energy production (using present energy sources), projections show this temperature increase occurring between the years 2030 and 2050.[14] Many scientists believe that climate changes will occur abruptly, causing losses in agricultural production and a myriad of other changes that could not be adapted to readily.

Possible effects of warming. Scientists agree that the temperature increase will not be distributed evenly, but would be much greater in higher latitudes. As the earth warms, temperatures near the equator will rise slightly, while increases in the upper latitudes could reach twice the average projected for the earth as a whole. Shifts in ocean currents could make some areas, such as Northern Europe, colder.[15] The possible effects of a temperature increase include: a rise in the level of bodies of water causing changing patterns of hydroelectric generation, water supply systems, and population settlement; changes in rainfall and soil moisture patterns resulting in changes in agricultural productivity; extinction of certain species of plants and animals; and changes in the patterns of prevailing winds and ocean currents. Higher temperatures in some areas will create an overall increase in evaporation and rainfall, but since this will not be evenly distributed, some regions will become wetter while other regions become drier.

Scientists from the University of Minnesota report that the state of Minnesota would experience a change of the seasons. The spring-summer onset would come one month sooner and, thereby, create a lengthening of the hot/dry season at the end of summer by about one month. Further, the University reports that the implications of the shifting climate and a longer, drier summer for lakes, crops, forests, and wildlife in Minnesota are almost all negative.[16]

Two of the most serious effects of the projected warming would be the impact on agriculture and the impact on the sea level. Meteorological models suggest that two of the world's major food producing regions—the North American heartland and the grain growing regions of the Soviet Union—are likely to experience a decline in soil moisture during the summer growing season due to increased evaporation. If this occurs, land in the western U.S. Great Plains that now produces wheat would revert to grassland and the western U.S. Corn Belt would become semi-arid. As the warming proceeds and rainfall patterns change, irrigation and drainage systems would become obsolete.

As the water in the ocean warms, it will expand, and the amount of water trapped in glaciers and ice caps will decrease. Recent projections by the U. S. Environmental Protection Agency show a rise in sea level by the year 2100 of between 1.4 and 2.2 meters (4.7 to over 7 feet). This projected rise could affect many coastal cities. For example, a one-meter rise would threaten New Orleans, Cairo, and Shanghai.[17]

The earth's biological systems will also be affected by a global warming. If the temperature change occurs abruptly, it will most likely surpass the capacity of many species to adapt to the new conditions.

Current national, international action. Since the sources of global warming gases are geographically diverse, an effective amelioration of global warming requires action by many nations. Such action will be difficult to achieve because of the many uncertainties regarding the effects. Nevertheless, global warming is emerging as an important public policy issue. Domestic laws, U.S. programs, and international pacts related to climate change are beginning to emerge, as illustrated by the following:

- Global Climate Protection Act, passed by the U.S. Congress in December, 1987, requires the President to develop a coordinated national policy on climate change and requires the State Department to seek international cooperation in limiting such change.

- Montreal Protocol on the Ozone Layer, September, 1987, is an international agreement to limit production of chlorofluorocarbons (CFCs) and other chemicals that destroy stratospheric ozone. CFCs are also a significant contributor to the global warming phenomenon. To take effect, the protocol must be ratified by at least 11 nations representing two-thirds of the world's CFC consumption.

If ratified, the protocol will freeze CFC production in 1989 at 1986 levels and require a 50 percent reduction by 1999.

- The United States Environmental Protection Agency has established bilateral agreements with the Soviet and Chinese governments to explore global warming policy issues.

- The United Nations Environmental Program (UNEP) and World Meteorological Organization (WMO), in conjunction with a number of nongovernmental institutions, have sponsored several international conferences to discuss developing policies regarding global warming.

- The National Aeronautics Space Administration (NASA) recently disclosed details of a planned Earth Observing System project. The multi-national system will use a wide range of orbiting laboratories capable of such activities as detecting tiny movements along the San Andreas Fault and providing continuous measurement of changes in the ozone layer. The global warming issue was a primary element in the motivation for the project.

- The Environmental Protection Agency (EPA) is conducting case studies in four areas—the Southeast, Great Lakes, California, and the Great Plains—on the potential effects of climate change on forests, lakes, wetlands, agriculture, human health, and other aspects of the environment.

Options for ameliorating climate change. Several studies have examined the possibility of stripping CO_2 from coal-derived synthetic gas and storing or fixing it chemically to prevent it from entering the atmosphere. Methods examined include disposing of CO_2 by pumping it into the ocean, injecting it into deep natural gas reservoirs, or expanding its use in tertiary (more difficult to retrieve) oil recovery. Although these options are technologically feasible, they are not currently cost-effective: once carbon is combined with oxygen (to make CO_2), replacing it into the earth or otherwise disposing of it would use nearly the same amount of energy as the energy gained in the initial burning process.

Currently, it is not feasible to fix or store large amounts of CO_2, but with adequate research and development, workable options could possibly be developed.

Viable options thus far offered focus on slowing the buildup of heat-trapping gases in the atmosphere. Specifically, the key options seem to be: limiting combustion of fossil fuels, reducing emissions of CFCs, and reducing and reversing deforestation. Since fossil fuel combustion contributes more than half of all global warming emissions, the rate of climate change appears to depend primarily on future energy policies.

A World Resources Institute study suggests that ambitious investments in energy efficiency can keep energy use roughly constant over the next 30 years, yet still allow for economic and population growth.[18] Other less optimistic forecasts maintain that global energy use will at least double or perhaps triple by the year 2060.

Even if the world's energy demand remains roughly constant, fuels will be necessary to supply the demand. Some analysts argue that policies should encourage a switch away from coal toward other fuels. Natural gas is mentioned as an option since it releases only half as much CO_2 per energy unit as does coal. Further, if gas is burned in high-efficiency combustion turbines, electricity can be generated with only one-third the CO_2 output of conventional coal combustion.[19] Because nuclear fuel releases no global warming gases, there is increasing interest in research to develop simpler and safer reactor designs.

Renewable energy supplies—wind, solar, and biomass—also hold promise for electricity production in some settings, especially for low temperature applications such as water and space heating. Solar energy shows increasing promise, both in design options which save large amounts of heating, cooling, and lighting energy, and in photovoltaic electricity production. The potential of renewable resources to supply demand is difficult to ascertain due to the lack of research and development necessary to advance these resources to a mass commercial viability. The contribution of renewables to global energy supplies, however, has grown steadily over the past 15 years and is expected to increase in importance in the future.[20]

Greater emphasis on efficiency in energy supply and use is frequently mentioned as the most practical method of alleviating global warming and providing time to develop new technologies and strategies to deal with climatic changes. Some of the proposed solutions address only a fraction of the CO_2 emission problem. For example, the nuclear option would alleviate only a portion of electrical generation's contribution to global warming.

The energy efficiency option can address the entire scope of the CO_2 problem since energy efficiency improvements can reduce every source of CO_2 emissions. To illustrate, in the area of transportation, which accounts for 30 percent of the CO_2 emitted in the U.S., highly efficient automobiles, increased mass transit, and more efficient community design could drastically reduce CO_2 concentrations. In manufacturing, which produces 24 percent of U.S. CO_2 emissions, advances in industrial drive systems can ultimately lead to reductions in the burning of fossil fuel. Residential heating, accounting for about ll percent of U.S. CO_2 emissions, is also an area with a large percentage of untapped efficiency options.[21]

Most of the strategies mentioned to curb global warming would be extremely costly. Since investments in energy efficiency are cost-effective, they can already be justified by economic criteria alone. Further, the opportunities for greater energy efficiency are numerous.

An alternative energy forecast based on the global energy model of the Institute for Energy Analysis in the United States found that a successful effort to improve worldwide efficiency by 2 percent annually would keep carbon dioxide concentrations to 463 parts per million in 2075.[22] The world's climate might still be at least 1 degree Celsius warmer than today, but the most catastrophic climatic effects would probably be avoided. Irving Mintzer of the World Resources Institute in Washington, D.C., using another model, calculates that a 1.5 percent annual rate of improvement in efficiency—together with deliberate policies to limit coal use, to restrict the production of other greenhouse gases, and to halt deforestation—would reduce the warming projected for 2075 by half.[23]

Other specific proposals include a carbon tax to discourage the use of CO_2 releasing fuels (coal and CO_2-based synthetic fuels); stricter vehicle mileage standards; and a requirement that the climate implications of projects be considered in environmental impact statements.

Fossil fuel emissions contribute not only to global warming, but also to acid rain, urban smog, and stratospheric ozone depletion (nitrous oxide is implicated in the breakdown of ozone). Measures to control global warming by reducing the use of fossil fuels will, therefore, yield multiple environmental benefits.

RADON

Radon is a gas that comes from the decay of radium and, indirectly, from the decay of uranium. Both radium and uranium are present in almost all rocks and soil; thus radon is constantly being produced almost everywhere. Radon gas and its off-shoots are radioactive, emitting alpha rays which have been singled out as a cause of cancer in humans. The National Cancer Institute reports that radon exposure is the number one source of lung cancer among nonsmokers, accounting for as many as 30,000 deaths annually in the United States. Radon exposure has also been linked to stomach and bone cancer.[24]

Studies are underway to determine the extent of the radon problem in Minnesota. Preliminary data suggest that as many as one-third of Minnesota homes may be affected.[25]

Increasing the energy efficiency of homes by reducing air leakage has resulted in cost savings and improved housing for millions of Americans; however, questions have been raised as to whether it may also be increasing human exposure to radon. Studies to determine if there is a link between building tightness and higher radon levels have had mixed results, and the debate continues over whether such a link exists.

There is no inherent conflict between energy efficiency and a healthful, radon-free indoor environment. The solution to radon pollution lies not in reverting to inefficient, drafty homes, but in producing homes where the indoor environment is controlled for maximum efficiency, comfort, and health. This means making good ventilation systems an integral part of energy improvements. Other solutions include preventing radon from entering the house by such methods as sealing foundation cracks, sump holes, and other entry points.

TRANSMISSION LINES

High voltage transmission lines move electricity from power generating plants to consumers. Construction of these lines has concerned Minnesotans in the past, partly because of fear that the lines pose a hazard to human and animal life.

Transmission lines are of two types: alternating current (AC) or direct current (DC). For the longer distance transmission lines, DC lines are more commonly used because they lose less power. Most transmission lines in Minnesota are alternating current; a major direct current long distance line was the subject of controversy during the 1970s. Constructed by the Cooperative Power Association (CPA) and United Power Association (UPA), the line brings power from the generating plant in North Dakota and moves in a southeasterly direction toward the Twin Cities.

Land use issues. High voltage transmission lines, both AC and DC, are objected to on aesthetic grounds and because of loss of useful land. A major concern in the CPA/UPA direct current line controversy in Minnesota was that these large transmission facilities cross productive agricultural lands.

DC health effects. The Minnesota Environmental Quality Board, following a report from its science advisers, adopted a resolution in May, 1986, stating that there is no scientific evidence that the CPA/UPA direct current power line poses a hazard to the health of the general public. The board did, however, direct staff to follow ongoing research on air ion and electric field effects and to report to the board semi-annually.

Since the 1986 report, no new studies have been reported that would suggest that the board should reconsider its earlier conclusions on the DC power line issue. Research continues on DC field and ion effects at a number of locations in the United States.

AC health effects. An epidemiological study linking the exposure of magnetic fields from electric lines to an increase in childhood cancer was reported in the Twin Cities press in July, 1987. Conducted by Dr. David Savitz, an epidemiologist from the University of North Carolina, the study was one of 16 studies of possible health effects related to transmission line electric and magnetic fields supported by the New York State Power Line Project.

Dr. Savitz's results suggest an association between increased cancer risk and elevated magnetic fields. This association was most pronounced for leukemia. Savitz reported a modest excess of cases in homes with measured magnetic fields originating from distribution and service lines outside the home having a magnitude of 2.5 milligauss (a measure of magnetic intensity) or greater.[26] A great deal more study is needed, however, to establish whether there is any cause and effect relationship between cancer and magnetic field exposure.

WASTE-TO-ENERGY

Minnesota residents throw away more than 3 million tons of trash a year, an amount estimated to grow 6 percent annually.[27] Until recently, landfills met the need for a cheap and convenient form of waste disposal. Although landfilling remains the least costly method of disposal, many counties are seeking alternatives because aesthetic and environmental concerns have led to strict landfill design and operational controls. In fact, in the St. Paul-Minneapolis area, no unprocessed garbage may be deposited in landfills after 1990.

Specially designed plants that can convert waste to energy are an alternative to landfills in some areas. These waste-to-energy plants vary according to size, capacity, cost, and technology.

Environmental issues. A number of environmental risks are associated with waste-to-energy plants. Stack emissions from solid waste incineration include a number of pollutants—among them, sulfur oxides, nitrogen oxides, lead, acid gases, and metals such as cadmium and mercury. Maintaining efficient combustion and installing pollution control equipment are the two ways of controlling air emissions. Pollution control equipment currently in use includes electrostatic precipitators, fabric filters, wet scrubbers, and dry scrubbers.

Fly ash from pollution control equipment can contain concentrated amounts of heavy metals and require disposal as hazardous waste. Disposal of both bottom and fly ash is carefully regulated.

The high costs associated with pollution control add to the cost of waste-to-energy plants and make them a more economically risky venture. A successful waste-to-energy project has three prerequisites: an adequate supply of waste, accessible markets, and community and political support.

PETROLEUM ISSUES

Minnesota and the nation face an uncertain future regarding oil supplies and prices. The nation's dependence on oil imports makes it vulnerable to the actions and policies of the OPEC nations. Proposals to decrease that dependence by imposing an oil import tax and by expanding oil exploration and drilling off the California coast and in Alaska's Arctic National Wildlife Refuge are highly controversial. The arguments concerning these proposals are discussed in this section.

The decline in crude oil prices in 1986 introduced a new period in the volatile history of petroleum costs and supplies. Today consumers are enjoying prices for gasoline and other petroleum products that are no higher after adjusting for inflation than in the early 1970s.

The outlook for petroleum costs, however, is uncertain. Since 1973, prices throughout the world have been dominated by the policies of OPEC nations and events in the Middle East. The impact of OPEC on petroleum prices in Minnesota is evident in Figure 1: the average cost of gasoline in Minnesota more than doubled between 1978 and 1981 as OPEC nations cut back on production and successfully moved crude oil costs upward. And despite urgent calls for energy independence, the United States today is as dependent on oil imports as it was in 1973.[1]

OPEC nations do not appear capable of regaining their earlier dominance before the early 1990s, but their importance as the world's oil suppliers will increase during the next decade. United States dependence on imports will also increase during the next decade. Imports supplied 35 percent of our nation's petroleum consumption in 1987.[2] The outlook is for a continuing decline in domestic production due to the high cost of finding and developing our remaining oil resources. Any increase in consumption will need to be supplied through additional imports.

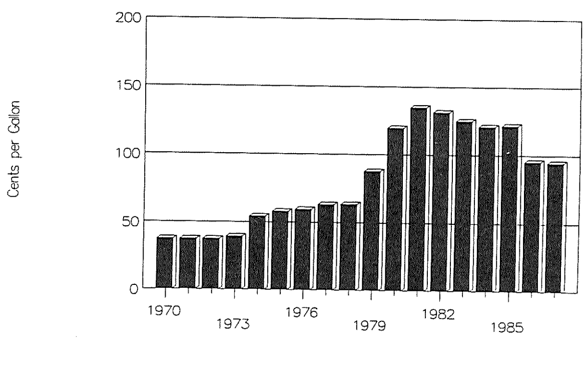
The policies of OPEC nations and their ability to maintain production agreements are a key—and unpredictable—political factor in the outlook for petroleum costs and supplies.

PROPOSALS TO SUSTAIN DOMESTIC OIL PRODUCTION

The collapse in oil prices during 1986 and subsequent increase in oil imports have led to a number of proposals for helping to boost domestic oil production. The two most prominent proposals are: (1) to establish an oil import tax and (2) to open the Alaskan Arctic National Wildlife Reserve to exploration. More efficient transportation and alternative energy resources also offer opportunities for reducing petroleum imports, and both subjects are discussed elsewhere in this report.

Figure 1

Minnesota Average Gasoline Price



Source: *Minnesota Energy Data Book, 1960-1986.* Minnesota Department of Public Service

Oil import tax proposals. Proposals for an oil import tax have received widespread national attention as an option for stimulating increased domestic oil production. The proposals became prominent in 1986 when the U.S. oil production industry faced the serious financial consequences of an unanticipated drop in crude oil prices.

The most common proposals are for a fixed tax on imports at $5 to $10 per barrel above domestic oil prices. A second approach is a variable import tax that would establish a floor price for imports. If a floor price were set at $25 per barrel, the import fee would be adjusted as necessary to maintain a domestic crude oil price of $25. The fee would fall to zero if world prices rose above $25 per barrel.

Supporters argue that the import tax provides important long term benefits by stimulating increased domestic oil production and reducing imports. They say that the resulting higher prices will encourage improved energy efficiency and fuel switching, benefit the oil producing regions of the nation, and provide a revenue source for reducing the federal deficit.

Opponents argue that imports should be reduced through policies that improve vehicle fuel economy and encourage development of alternative energy resources. They say that the higher costs for domestic oil would penalize consumers, accelerate depletion of domestic oil resources (eventually increasing our dependence on imports), and hurt U.S. industries that compete in international markets. They also say the tax would require establishing a complex regulatory procedure and would hurt the oil importing regions of our own nation. Minnesotans, for example, would pay roughly $370 million a year more for petroleum products as a result of a $5 per barrel import tax.[3]

The lack of consensus on these proposals will continue to make the oil import tax controversial. Overall support will depend in part on whether oil prices fall again or slowly recover to a somewhat higher level.

Exploration in protected and environmentally sensitive areas. Access to protected wilderness areas and environmentally sensitive areas is another subject of controversy. The United States is the most intensively explored region of the world, accounting for 80 percent of all oil wells ever drilled.[4] A major oil find that would fundamentally alter the outlook for domestic production is highly unlikely. Discoveries are possible, however, that could make a modest contribution to U.S. petroleum supplies.

Offshore drilling on the California coast is one area of recent conflict between oil development and environmental concerns. In 1986, California offshore reserves supplied over 2 percent of total U.S. demand for petroleum. Estimates of potential undiscovered resources range from 1.25 to 5 billion barrels. Proven reserves in California offshore areas totaled 1.5 billion barrels in 1987.[5]

The dispute centers around a number of environmental issues, including hazards for marine life, effects of nitrogen oxide emissions at the offshore oil rigs, impacts of related onshore facilities, effects on commercial fishing, and the aesthetic impact of oil rigs along one of our nation's most scenic sea coasts.

A second nationally prominent controversy emerged in the winter of 1987 concerning exploration on the coastal plain of the Arctic National Wildlife Refuge (ANWR). Geological formations on the coastal plain suggest that the potential for petroleum deposits is favorable. A study by the U.S. Department of Interior estimates that there is a 20 percent chance of finding any economical oil resources and a 1 percent chance of finding reserves in excess of 9 billion barrels. By comparison, U.S. petroleum consumption totaled 5.9 billion barrels in 1987.[6]

The source of conflict lies in the significance of the coastal plain as an arctic wilderness. The ANWR is unique as an area that encompasses a full range of arctic ecosystems in an almost pristine condition. The coastal plain in particular is significant for its diverse array of arctic animal and plant life.

Opponents argue that exploration would have a much greater impact in the ANWR than in more temperate regions because of the extreme climate conditions. Even if no oil were discovered, extensive test drilling would be required, and roads and other supporting infrastructure would be needed. Full development of any resources could not take place without a fundamental change in the character of the wilderness area.

TRANSPORTATION EFFICIENCY AND ALTERNATIVE FUEL SOURCES

Minnesota, along with the rest of the nation, depends on petroleum products for transportation. This dependency is a concern since a disruption in world oil supplies could drastically affect the economy. Improved energy efficiency can reduce this dependency; in the long term, development of alternative fuels will provide the solution. Minnesota's efforts to improve transportation efficiency, and the potential use of alternative fuels ethanol and methanol, which can be produced in Minnesota, are covered in this section.

Transportation is the largest energy consumer sector in Minnesota, accounting for 39 percent of the total end use* consumption of energy in Minnesota, more than twice the amount used by either the industrial or commercial sectors. The dominance of transportation compared to the other sectors of energy use has increased over the past 25 years: in 1960, transportation accounted for 26 percent of energy use, and in 1970 for 30 percent.[1]

Transportation's increasing share of Minnesota energy use parallels national trends. Transportation accounts for two-thirds of the oil used in the United States in 1986; this compares to just over 50 percent in 1973. Overall demand for oil has dropped in the United States, but most of this decline is accounted for by fuel switching and conservation measures among residential, commercial, and industrial consumers. The transportation sector remains overwhelmingly dependent on oil.[2]

This dependency on one fuel is a source of concern; a disruption of world oil supplies could have drastic and adverse effects on the economy. Since petroleum is supplied through national and international markets, there is little the state of Minnesota can do to guard against such a disruption. One opportunity available is to reduce the amount of petroleum needed by developing a more efficient system of transportation.

DEVELOPMENTS IN TRANSPORTATION EFFICIENCY

The freeway system. To improve transportation efficiency in the Twin Cities area, the Minnesota Department of Transportation is implementing and considering additional systems that encourage a higher automobile occupancy rate. These include express lanes set aside exclusively for vehicles with more than one occupant (so-called ''sane lanes''), special freeway entry ramps for vehicles with more than one occupant, and metered freeway entry ramps. A sane lane system, in use on state highway 12 west of Minneapolis as the route is converted into Interstate 394, has resulted in a 46 percent increase in car pools: that is, of the approximately 1,300 car pools that use the lane daily, close to 600 were formed expressly to take advantage of the special lane.[3] How many vehicles this has removed from the highway has not been determined. Some form of the sane lane will be included on other Twin Cities freeways. Preferential access ramps for multiple occupant cars, vans, and other vehicles are also being planned for some metropolitan area freeways. These ramps are located ahead of regular access ramps and are metered at a more rapid pace. Metering regular freeway ramps, although not designed to encourage multiple car use, does reduce pollution by improving the flow of traffic on freeways.

Mass transit system. A light rail transit (LRT) system is being considered for the metropolitan area. Available data suggest that direct energy consumption per passenger mile from an LRT system, not including electric losses, is greater than that of buses by almost 40 percent. Compared to the automobile, LRT uses about half as much energy per passenger mile; however, the energy required for feeder buses and automobiles to support LRT is not included in this figure.[4] LRT energy savings are directly related to number of riders; if LRT encouraged more people to take mass transit, the energy savings pér mile would increase significantly.

Minnesota Rideshare is a program operated by the Metropolitan Transit Commission to help Twin Cities area residents form car pools. Established 10 years ago as an energy conservation measure, Minnesota Rideshare is expanding its role to include reducing traffic congestion and pollution. In addition to matching riders for car pools and helping businesses establish car pools, Rideshare now works with businesses and communities to integrate car pool

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*End use is total consumption minus the energy lost in generating and transmitting electricity.

incentives into their transportation plans. Minnesota Rideshare reports these recent statistics: in 1987 it helped more than 2,500 people form car pools, reducing vehicle miles traveled by more than 12 million.[5]

National fuel economy standards. Nationally, conservation in the transportation sector has focused on improving vehicle efficiency. Title V of the Motor Vehicle Information and Cost Savings Act requires that the Secretary of Transportation administer a program for regulating the fuel economy of new passenger cars and light trucks in the United States by establishing Corporate Average Fuel Economy (CAFE) standards. As a result, the average miles per gallon (mpg) for new passenger cars increased from 19.7 for model year (MY) 1978 cars to 27.9 for 1986 cars (exceeding the actual standard of 26.0). Total fleet average for MY 1986 light trucks was 20.2 (slightly exceeding the standard of 20.0). The National Highway Traffic Safety Administration estimates that by 1995 the projected fuel savings resulting from these achievements since 1976 would amount to approximately 410 billion gallons.[6]

Despite these savings, the Secretary of Transportation recommended to the President in January, 1987, that the CAFE standards be repealed because they put U.S. manufacturers at a competitive disadvantage with foreign importers and threaten thousands of American jobs. Supporters of the standards say that energy efficiency provides a competitive edge in all markets. The CAFE standards were reduced from 27.5 mpg for MY 1985 to 26.0 in 1986, but will be increased to 26.5 mpg for MY 1989.

CAFE standards have also been criticized for resulting in lighter weight cars and trucks that cannot withstand crashes as well as heavier vehicles. Opponents of this argument contend that safety can be achieved through better design and that safety is compatible with light weight vehicles.

A proposed national energy bill would replace the CAFE standards with a Vehicle Energy Efficiency Program (VEEP) requiring a 15 percent improvement in vehicle efficiency by 1992, an additional 25 percent improvement by 1998, and tax and other incentives for decreasing energy use in transportation.

DEVELOPING AN ALTERNATIVE FUEL

Conservation is an important part of the nation's response to energy shortages and rising prices; improved energy efficiency alone, however, won't solve the problem of dependency on oil and oil imports. More than half of the world's oil reserves are located in the Middle East, and during the 1990s the United States will become increasingly dependent on this part of the world for its oil. Development of alternative transportation fuels, therefore, will be an important part of the long range solution to the nation's over dependence on oil.

The leading candidates as alternative energy sources for U.S. motor vehicles are alcohol fuels (including ethanol and methanol), compressed natural gas, and electricity.[7] Compressed natural gas (CNG) provides clean combustion, but vehicles using CNG need frequent fill-ups and require large, heavy fuel tanks. Costly modifications to current vehicles are necessary before CNG can be used. Currently, this fuel is best suited for certain fleet operations that do not cover large distances. Long term use of CNG also depends on the future availability of economical natural gas resources.

Electric-powered vehicles operate quietly and without any direct emissions, but are limited in the distance they can go without recharging or changing batteries. The batteries must also be kept warm in cold weather. A further barrier to development is the demand these vehicles could create for increased electric generation capacity. Currently, electricity is used to power fleets of small vehicles that travel limited distances.

Ethanol and methanol are of particular interest to Minnesotans, since the state has substantial supplies of agricultural and energy crops that can be used to produce these two fuels. Ethanol and methanol are fuels with proven technical acceptability: both have been used as automobile fuel and considerable data are available on their performance. Both are currently used for a variety of industrial purposes and can be produced from several sources. Most of the ethanol used in industry is produced from ethylene which is derived from petroleum and natural gas; industrial methanol is produced almost entirely from natural gas. Interest in their long term potential as automotive fuels, however, is partly based on the ability to produce these fuels from a variety of renewable sources. Ethanol can be made from fermentation of corn or other agricultural crops. Methanol can be produced from plant fiber or cellulose; sources include wood and agricultural crops.

Gasohol. Ethanol produced from grain is already used in the transportation sector as an additive to gasoline, blended in a proportion of 10 percent ethanol to 90 percent gasoline. When this blended fuel, called gasohol, first became available, questions were raised about its effect on engine performance. Replacement of the fuel filter after switching from gasoline to gasohol may be necessary to avoid clogging problems since alcohol is a solvent and may loosen deposits in the fuel system. Alcohol may adversely affect some small engines and some materials used in the fuel systems of older automobiles. All cars built since the late 1970s, however, are designed to accommodate gasohol. Numerous fleet and laboratory tests show that gasohol is not a problem for newer automobiles, especially those with fuel injection and closed-loop fuel control systems. Furthermore, the warranties of all major manufacturers of automobiles sold in the United States permit use of gasohol.

Although using gasohol is seen as a way to reduce gasoline consumption, the primary interest in gasohol comes from its positive effect on the farm economy.

Corn is the source for 85 to 90 percent of the ethanol produced in the United States for use in gasohol.[8] By providing a market for this agricultural crop, gasohol substantially benefits the agricultural economy. These benefits, according to a 1987 study of the cost-effectiveness of ethanol as gasoline additive, more than offset the federal costs of tax exemption and tax credits needed to make gasohol economically competitive with gasoline. "Ethanol currently provides billions of dollars of income and thousands of jobs throughout rural America, which in turn provide tax revenues and private funds that stimulate other sectors of the economy."[9] Furthermore, development of ethanol and other nontraditional industrial uses for grains is seen as a tool to increase long-term demand for agricultural products.

State exemptions from federal and state motor fuel taxes are shown in Table 1. In addition, other states (including Minnesota) offer payments to local gasohol producers.

Gasohol can also produce environmental benefits. Carbon monoxide (CO), emitted in vehicle exhaust due to incomplete combustion of gasoline, adversely affects human health. Transportation sources account for more than two-thirds of the nationwide CO emissions and, in many urban areas, as much as 90 percent of the emissions.[10] The high oxygen content of gasohol results in more oxygen reaching the engine for fuel combustion, with subsequent reduced CO emissions in the exhaust. (This is true for older cars with

Table 1

Gasohol Tax Exemptions in 1988

Jurisdiction	Exemptions (cents/gallon)
Alabama	3.0
Alaska	8.0
Connecticut	1.0
Hawaii	4%*
Idaho	4.0
Illinois	2%*
Iowa	1.0
Maine	2.0
MINNESOTA	2.0
Nebraska	3.0
New Jersey	6.0
New Mexico	8.0
North Dakota	4.0
Ohio	2.5
South Carolina	8.0
South Dakota	2.0
Tennessee	4.0
Texas	1.0
Washington	2.8

*Exemption based on a percentage, as shown, of state sales tax.

Source: *Petroleum Marketing Monthly*, June, 1988, p. 165, and *Alcohol Outlook,* July, 1988, p. 4.

catalytic converters; for newer cars with closed-loop fuel systems and electronic fuel controls, emission differences between gasohol and gasoline are less significant.) To help achieve the new federal air quality standards, Colorado has mandated the use of gasohol or other oxygenated fuels during the winter along the state's Front Range (which includes Denver, a city with serious air pollution problems).

Gasohol does have one negative environmental effect that should be noted: it increases the amount of evaporative hydrocarbon emissions, primarily during refills at gasoline stations. Hydrocarbons react in the presence of sunlight and heat to form ozone. This ''tropospheric'' ozone (ozone in the atmosphere closest to earth) has negative effects on the health of people and vegetation. Because sun and heat are important in ozone formation, ozone pollution is a problem mainly in the summer months. Suggested solutions for cities that do not meet federal standards for ozone levels are to take measures to reduce evaporative emissions or to limit gasohol use to the cold weather season. This latter approach has been taken by Colorado.

Ethanol and methanol as alternative transportation fuels. Ethanol blended gasoline, as noted above, is used primarily to help the agricultural economy and the environment. A long term solution to transportation's dependence on petroleum, however, lies in developing a fuel to replace gasoline. Pure (or ''neat'') ethanol and methanol are both being studied for their potential as replacement fuels.

The technical acceptability of ethanol and methanol as automotive fuels is well established. In Brazil, for example, about one-third of the automobiles run on fuel composed of 96 percent ethanol and 4 percent water, and in California, more than 600 light-duty, methanol-fueled vehicles accumulated more than 12 million miles of service in state agencies as part of the state's methanol evaluation program. (Improving air quality to meet federal standards was a prime reason, along with energy savings, for the California program.) Both fuels, when compared with gasoline, have substantially lower harmful emissions. With present size fuel tanks, however, both require more frequent fill-ups. Conversion to a pure ethanol or methanol transportation system also would require some changes in vehicle design and materials.

A more difficult problem is to assess the potential for large-scale production of ethanol and methanol. Meeting total current transportation needs from alcohol fuels may not be feasible due to the large commitment of agricultural or forest land that would be required. Future vehicles would need to be more efficient, and alcohol fuels may be part of a mix of transportation energy sources.

Currently the cost of producing methanol and ethanol from renewable resources is too high to compete with present gasoline prices, but in the long term this situation is likely to change as petroleum resources are depleted. When that time comes, alcohol fuels may become an important source of energy for transportation.

3

MINNESOTA ENERGY CONSUMPTION AND SUPPLIES

How Minnesota uses energy, and the outlook for future costs and supplies of the major energy sources.

MINNESOTA TRENDS IN ENERGY CONSUMPTION AND SUPPLIES

Minnesota's total energy consumption has increased since 1960, but this growth has not been steady. State energy consumption actually declined after the oil embargo of 1974 and the second oil crisis in 1979. Since 1974, per capita income in Minnesota has grown without comparable increases in per capita energy use. Factors accounting for these and other changes in energy use are the prices of the various fuel sources and such characteristics as their ease of use and pollution aspects. Improved energy efficiency is another important factor. This section examines Minnesota energy use by fuel source and economic sector.

TRENDS IN OVERALL ENERGY USE

A decreasing growth rate in overall energy use, a shift to electricity as a source of energy, and the emergence of economic growth without a corresponding increase in energy consumption are among the trends in Minnesota energy use during the past 26 years.

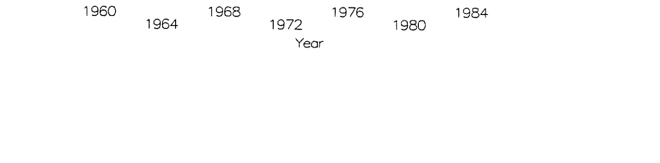
Growth rates and shifts in energy sources. Energy consumption in Minnesota has increased an average of approximately 1 percent each year since 1960. This growth has not been steady, however, nor has it been spread evenly among various energy sources. See Figure 1. Growth was fairly regular from 1960 to 1974 when energy use increased an average of 4.5 percent per year. Natural gas consumption increased 5 percent per year and petroleum use increased 3.3 percent annually. Consumption of fuels used primarily to generate electricity (coal, nuclear, and hydro) grew 3.2 percent per year.

This comparatively steady growth of energy consumption changed abruptly with the oil embargo of 1974 and the resulting increase in oil prices. From 1973 to 1976 natural gas consumption declined 11 percent and use of petroleum fell nearly 8 percent; in contrast, use of fuels to generate electricity increased by almost 35 percent. During this period Minnesotans responded quickly and vigorously to abrupt and significant energy price changes. (See Energy Expenditures, page 43.)

In the period 1975 to 1980, the rate of increase in energy use decreased markedly from earlier periods. Total Btu energy consumption increased only 0.3 percent each year, with use of natural gas and petroleum actually decreasing an average of 1 to 2 percent each year. Electric energy, on the other hand, and the fuels used to generate electricity, showed significant increases during these same years. Kilowatt hour use of electric energy increased an average of 4 percent per year from 1975 to 1980; consumption of coal, nuclear power, and hydroelectric power increased slightly more than 7 percent per year on average.

Figure 1

Minnesota Energy Use, 1960-1986



Source: *Minnesota Energy Data Book, 1960-1986*, Minnesota Department of Public Service

Much of the slowing in growth of energy use during this period occurred in one year—1980—and was the result of a second major oil price increase (this one precipitated by the Iranian revolution of 1979). Total energy use fell 8 percent in 1980, with the use of petroleum falling by 14 percent in just one year. Contrary to the effect on electric use of the earlier rise in oil prices, use of electric energy in 1980 fell 2.6 percent.

Higher petroleum prices in the 1970s, it is clear, caused a substantial revision in the sources of energy used in Minnesota. Figures 2, 3, 4, and 5 compare the mix of energy sources consumed in Minnesota since 1960. The dominant trend is the increasing reliance on coal and nuclear—both sources of electricity—and the decline in use of petroleum and natural gas. As recently as 1975, coal and nuclear accounted for less than 25 percent of primary energy consumption. By 1986 the share provided by these fuels had risen to 32 percent. The trend to greater use of coal and nuclear power is primarily the result of increases in electric use and is examined in greater detail in the section below on Energy Expenditures. The latest forecast by the U. S. Department of Energy anticipates that this trend will continue for the nation as a whole throughout the 1990s.[1]

Throughout the 1980s, overall increases in energy use have been quite moderate, averaging 0.4 percent each year from 1981 to 1986. The increases that have occurred have come primarily in electric use (up 2 percent a year), while use of petroleum and natural gas has declined. The decline in energy use and the substantial change in the mix of energy sources illustrate how responsive consumers can be to higher energy prices and how much conservation can, in effect, contribute to energy supply.

The relation of energy to income. Since 1975, decreases in per capita energy use have been accompanied by increases in per capita income, demonstrating that significant reductions in energy use can be made without equivalent reductions in standard of living.

Figure 6 shows the relationship between energy use and income before 1975 and the change that occurred after 1975. Prior to 1975, growth rates in income matched growth rates in energy use, but after 1975, growth in per capita income occurred without a growth in energy use. In 1977 per capita income grew more than 6 percent (1986 dollars) while energy use per person declined 3.2 percent. The phenomenon of energy use increasing at a slower rate than economic growth has been observed every year since 1979, with the exception of the recession year of 1982. A comparison of growth in income with growth in energy use reveals that in pre-embargo (1960-75) Minnesota, per capita income increased 39 percent and per capita energy use increased 43 percent. In the post-embargo period, 1976-86, per capita income increased 26 percent and per capita energy use declined 4 percent. Most recently, in 1986, the increase in per capita income was 10 times the increase in per capita energy use.

Figure 2

Minnesota Energy Mix, 1960
(Total = 664 trillion Btu)

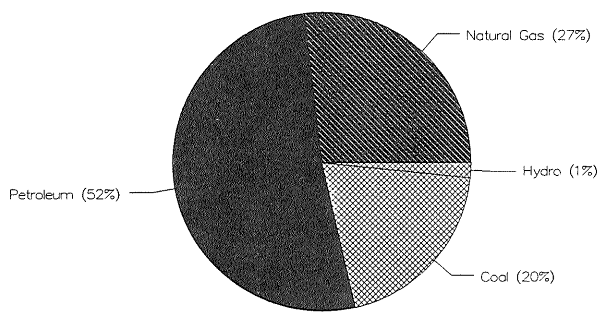


Figure 3

Minnesota Energy Mix, 1970
(Total = 996 trillion Btu)

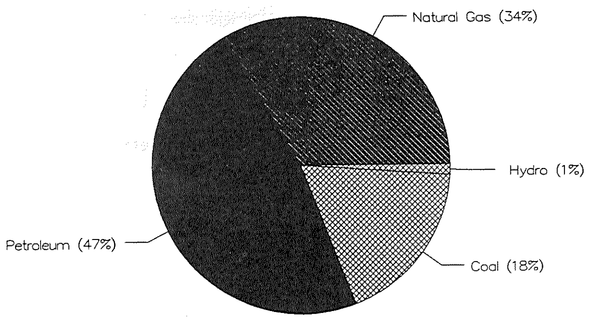


Figure 4

Minnesota Energy Mix, 1980
(Total = 1,104 trillion Btu)

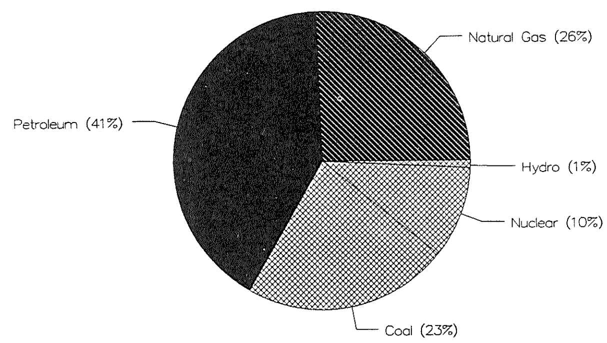
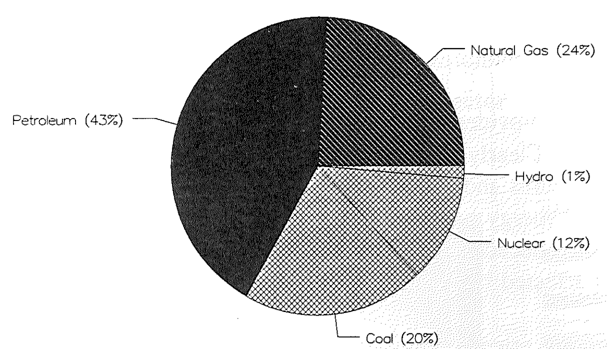


Figure 5

Minnesota Energy Mix, 1986
(Total = 1,038 trillion Btu)



Source for Figures 2-5: *Minnesota Energy Data Book, 1960-1986*, Minnesota Department of Public Service

ENERGY EXPENDITURES

Effects of price on consumption. Minnesotans spent $6.4 billion on energy in 1986. Almost half of this amount was for petroleum products, particularly gasoline which accounted for almost one-third of total energy expenditures. Rounding out expenditures on energy were payments for natural gas and electricity totaling $1.1 and $2 billion, respectively.

From 1960 to 1986 real* growth in energy expenditures averaged 2.5 percent per year. Disruptions similar to those that occurred in energy consumption are evident in the changes in energy expenditures. In the 1960s energy expenditures increased at 2.5 percent per year, totaling $4.4 billion dollars in 1970. In 1974, the high prices brought about by the oil embargo dramatically increased energy expenditures by 18 percent. A similar response occurred in 1979 with the second oil price increase resulting in a 16

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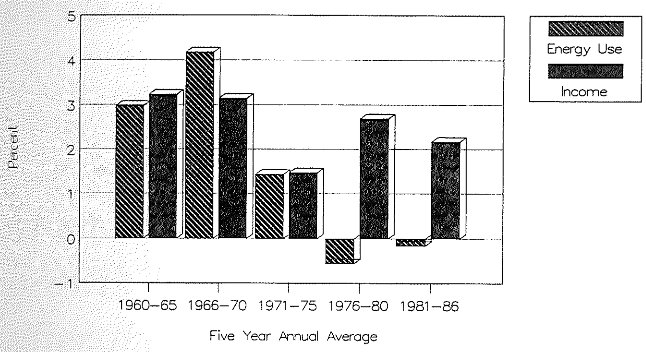
*"Real," as used in this report, refers to variables that have been adjusted for inflation and are based on 1986 prices.

Figure 6

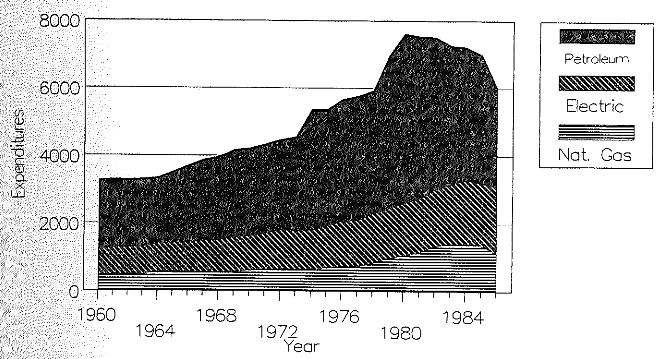
Growth in Minnesota Per Capita Income and Per Capita Energy Use



Sources: *Minnesota Energy Data Book, 1960-1986*, Minnesota Department of Public Service, and U.S. Department of Commerce, Bureau of Economic Analysis

Figure 7

Minnesota Energy Expenditures 1960-1986 (Million 1986 dollars)



percent rise in energy expenditures. Since 1981, however, abundant supplies of oil and natural gas, coupled with soft demand for energy, have brought lower prices. As a result, energy expenditures decreased 14 percent in 1986.

Figure 7 provides a graph of energy expenditures from 1960 to 1986. Clearly evident are the dominance of petroleum expenditures and the influence of oil prices. Expenditures on electric energy have increased fairly steadily throughout the past two decades, while expenditures on natural gas have been affected by changes in petroleum expenditures.

Changing prices of various energy sources have caused significant shifts in the type of fuels consumed in Minnesota. Figure 8 compares the changes in the cost per Btu of natural gas, electricity, and petroleum and the average cost of all energy sources measured in 1986 dollars. Note the period from 1979 to 1981 in which the Btu cost of petroleum grew rapidly compared to other fuels. Under these conditions many users of petroleum switched to natural gas or electricity.

Other factors affecting consumption. In addition to relative prices among different energy sources, other factors affecting the degree to which one form of energy will be substituted for another include the Btu content per unit weight, the pollution caused by the fuels, the ease of transportation (related to the Btu content per unit weight), and the overall ease of use, which includes equipment maintenance costs, cost and difficulty of storage, complexity of equipment needed to use the source, and availability. These considerations give oil and natural gas advantages over coal in that their Btu content relative to their weight is comparatively high and transportation costs are low. Equally important, oil and gas are cleaner burning, resulting in less pollution and less costly methods of combustion.

Figure 8

Minnesota Average Energy Cost, 1986 Dollars Per Million Btu

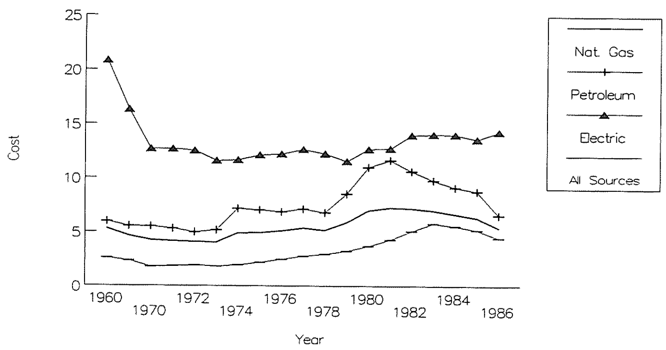
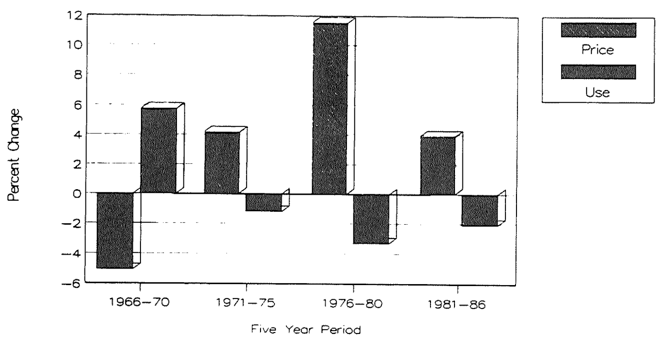


Figure 9

Minnesota Natural Gas Use vs. Price, Average Percent Change



Source for Figures 7-9: *Minnesota Energy Data Book, 1960-1986*, Minnesota Department of Public Service

Considering these factors, electricity has some advantages. The user of electricity faces zero storage costs and may readily convert the electricity into any form of energy (light, heat, mechanical energy, etc.). These factors explain the ability of electricity, even at high prices per Btu, to steadily increase its share of the energy market. Negative aspects of electric use include the need for transmission line access and routing, and pollution in the generation process.

Natural gas ranks next to electricity in ease of use: the capital requirements in burning natural gas are fairly small, there are no direct storage costs, and it creates few pollution problems, thus reducing maintenance and pollution control costs. A drawback to natural gas is its relatively low Btu content in relation to its volume, making it less desirable as a transportation fuel. Lack of access outside of densely populated areas is a second limitation.

Petroleum products have the highest Btu content by volume of commonly used energy sources, making petroleum the choice transportation fuel. Refined petroleum products also burn much cleaner than coal, but air emissions are greater than for natural gas, as are requirements for periodic cleaning of combustion equipment.

PATTERNS OF ENERGY USE BY SOURCE

Natural Gas. In 1986 natural gas accounted for one-quarter of Minnesota energy consumption. As Figures 1-5 show, this share has declined from the peak of almost one-third of total energy consumption reached in the first half of the 1970s. Much of the reduction in natural gas use can be explained by the increasing price of natural gas relative to petroleum and electricity. (See Figure 8.) Most recently, however, the price of natural gas has fallen considerably and is not expected to recover significantly in the near future.

The degree to which natural gas use might recover can be inferred from examining Figure 9 which plots, in five year periods from 1966 to 1986, the annual average change in use of natural gas against the annual average change in price per Btu of natural gas. In each five year period where price increased, natural gas use declined; and in each five year period where natural gas prices fell, use increased. Although factors other than price affect use, the strong relationship between price and use depicted in Figure 9 suggests that changes in the price of natural gas will significantly affect the use of natural gas in the coming years.

Petroleum. The use of petroleum products in Minnesota peaked in 1973 at 538.6 trillion Btus, slightly less than half of all the energy consumed in the state. Petroleum's large share of total energy consumption has held fairly constant, and consequently, changes in petroleum use have a large impact on the total energy picture in Minnesota. The long term growth trend (1960-86) in Minnesota indicates increases in petroleum use of less than 0.2 percent per year. Contrast this with the robust growth that occurred during 1960 to 1974 when petroleum use increased an average of 4 percent per year. Since the oil embargo of 1974, petroleum use has declined by an average of almost 1 percent per year, although most of the declines have come in three years—1974, 1980, and 1981. The most recent five year period has experienced moderate declines in use; in the past three years, however, consumption of petroleum products has increased.

Figure 10 shows the use of the major petroleum products in Minnesota since 1960. Petroleum consumption in Minnesota has historically been dominated by gasoline use for transportation. In 1960, gasoline accounted for exactly half of all petroleum consumption. By 1986 this figure had risen slightly to 57 percent of total petroleum. The increased share of gasoline in overall petroleum consumption has resulted from large declines in the use of distillate fuel oil, most noticeably by industrial users. The increased use of air travel increased the consumption of jet fuel significantly in the 1980s.

Consumption of petroleum products in Minnesota has exhibited considerable responsiveness to price changes. Figure 11 graphs average annual price changes for five year periods against average annual changes in use of petroleum. During the 1960s, prices either fell or remained constant, contributing to significant increases in petroleum consumption. The large price increase in the early '70s effectively halted large increases in use, while the second round of price increases sent petroleum use falling. The current decline in oil prices appears to have encouraged more use and, although other factors will play a part, if prices remain low in the near future increased petroleum use appears likely.

Electricity. The advantages of electricity have resulted in long term increases in electric use despite relatively high prices per Btu. Although its rate of increase has fallen, electric use—unlike petroleum and natural gas use—has declined in only one year since 1960. Figure 12 depicts electric use by customer class from 1960 to 1986. The stable and proportionate growth among all customer groups is particularly evident. Recently, however, growth has been slower and much more irregular than during the 1960s and mid-1970s; these changes increase the difficulty of predicting the outlook for electric use.

Figure 10

Minnesota Petroleum Use, 1960-1986

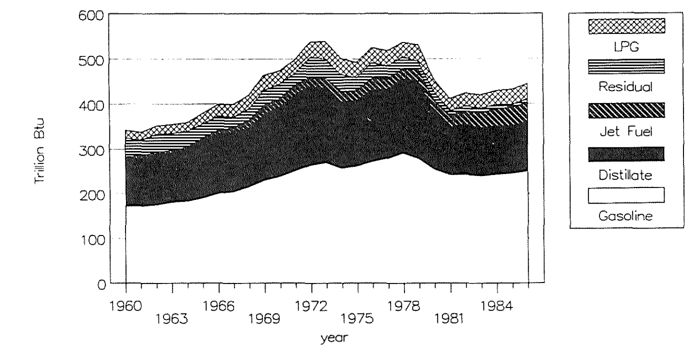


Figure 11

Minnesota Petroleum Use vs. Price, Average Percent Change

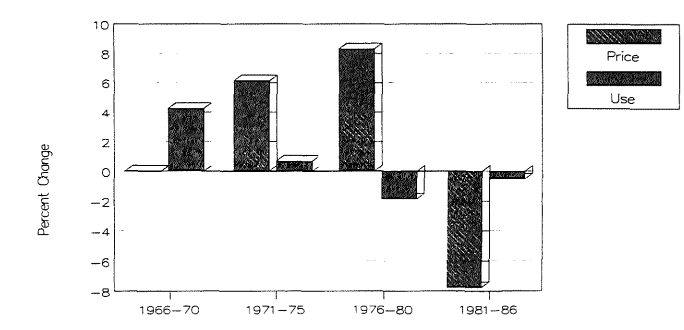
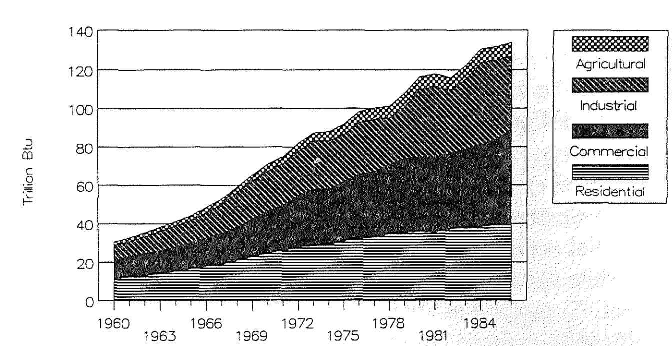


Figure 12

Minnesota Electric Use by Sector

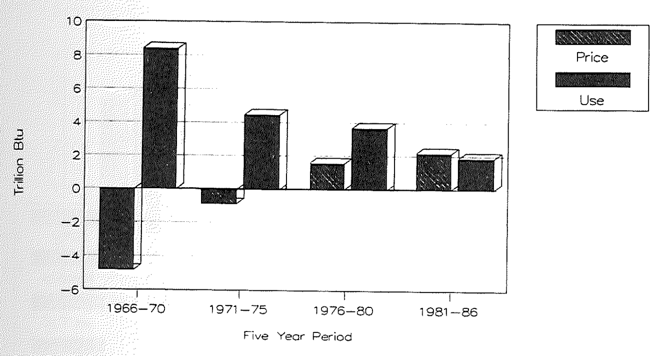


Source for Figures 10-12: *Minnesota Energy Data Book*, 1960-1986, Minnesota Department of Public Service

The slowdown in growth has been considerable when compared to the growth rate of the late 1960s. From 1966 to 1970 electric consumption grew an average of 10 percent per year in Minnesota. During this period the slowest growth rate was 8.5 percent. Strong growth continued in the 1970s— averaging 5 percent per year—but the instability of growth began to increase. Growth rates in 1977 and 1978 were 2 percent and 0.8 percent respectively, compared to

Figure 13

Minnesota Electric Use vs. Price, Average Percent Change



1979 and 1980 when they averaged 7 percent per year. Since 1980 instability in growth has continued while the average level of increases has declined. Increases in 1985 and 1986 were minimal, averaging just over 1 percent each year.

Figure 13 provides insight into the causes behind the slowdown in electric use. The figure plots average annual changes in electric use over each five year period against average annual changes in electric price. The high growth of the 1960s and mid-1970s was largely due to falling electric prices (see Figure 8); when price decreases leveled off in the early to mid-1970s, consumption increases began to diminish. Increases in the real price of electricity in the latter 1970s and early 1980s diminished growth further, despite significant increases in the price of energy substitutes. This trend suggests that any future increases in electric prices would increase adoption of efficiency measures and reduce growth in electric consumption.

ENERGY USE BY ECONOMIC SECTOR

Figure 14 portrays energy use by economic sector for 1960 to 1986. In 1960 the residential, industrial, and transportation sectors each accounted for slightly more than one-fourth of total energy consumption. By 1986 the share of energy consumed by the transportation sector had risen to nearly 40 percent, while residential and industrial energy use accounted for 20 and 17 percent, respectively. The commercial sector significantly increased its share of energy consumption, going from 12 percent in 1960 to 17 percent in 1986. The level of agricultural energy use remained fairly constant at around 50 trillion Btu.

Residential energy use in 1986 was dominated by natural gas and electricity. (See Figure 15.) Almost two-thirds of residential energy use in 1986 was in the form of natural gas, while electric use accounted for slightly more than 20 percent. Compared to 1960, use of petroleum products was significantly reduced, from 72.5 trillion Btu to 28.6 trillion Btu, but electric use increased nearly fourfold. Natural gas use has doubled since 1960; that increase and the rise in electric use have more than offset the drop in petroleum, resulting in a 1986 Btu energy consumption that is about 16 percent higher than in 1960.

The increases in energy consumption noted above occurred mainly between 1960 and 1970; since 1970, significant energy savings have been made in the residential sector. Electric energy was the only source of increase in energy use in the 1970s and early '80s, but even this source has leveled off in the past four years, with growth in residential electric use averaging about 1 percent each year. Clearly, higher petroleum prices in the 1970s and electric price increases of the early '80s have dampened residential energy demand.

Figure 14

Minnesota Energy Use by Sector

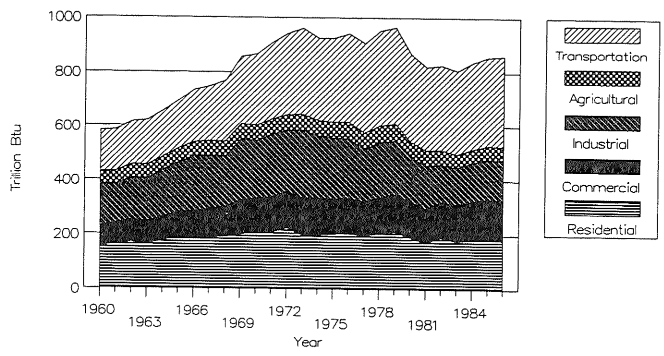
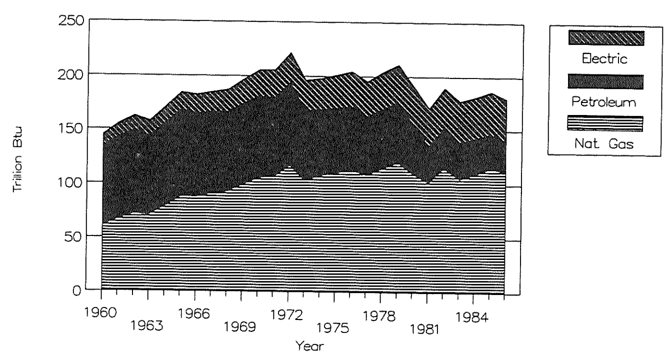


Figure 15

Residential Energy Use in Minnesota



Source for Figures 13-15: *Minnesota Energy Data Book, 1960-1986*, Minnesota Department of Public Service

The commercial sector, along with the transportation sector, has significantly increased its share of total energy consumption in the past two-and-a-half decades. Figure 16 depicts the growth trends and composition of commercial energy consumption. As in the residential sector, commercial energy consumption is dominated by natural gas (51 percent) and electricity (34 percent). Consumption of petroleum products is about the same as it was in 1970, but it accounts for only 13 percent of total energy use as compared to 17 percent in 1970. Commercial electric use has averaged nearly 7 percent annual growth since 1960. In the early 1970s the commercial sector became the largest user of electricity and has increased its share of total electric demand in the last decade. As seen in Figure 12, growth in commercial electric use has been considerably more steady than industrial growth, undoubtedly in large part due to increasing use of air conditioning and refrigeration.

The commercial sector has shown itself to be much more sensitive to changes in petroleum prices than to changes in electric prices. Energy demand from this sector is likely to be more skewed toward electricity and less dependent upon petroleum products regardless of moderate electric price increases. Significant reductions in petroleum prices, of course, could increase use of petroleum and possibly reduce growth in electric demand.

Industrial energy use. The industrial sector exhibits the most volatile demand for energy products, a result of unstable demand for the products of industry due to recessions and other economic fluctuations. The volatility is also caused by industrial processes that permit manufacturers to switch fuel sources rapidly or to change production processes and products as energy costs change. After peaking in the early 1970s, total energy use by industry decreased by 40 percent.

Figure 17 illustrates the dramatic changes that occurred in industrial energy consumption following the oil embargo of 1973. Industrial users reduced consumption of natural gas by 45 percent between 1973 and 1986. Petroleum use declined by 71 percent and coal use declined by 43 percent. The only area in which industrial users have increased energy use has been in electricity which increased by one-third between 1973 and 1986.

Some of the reduction in energy use has been the result of comparatively slow economic growth in manufacturing and mining. A significant portion of the reduction, however, is probably the result of alterations in industrial output away from energy intensive products and of improvements in production efficiency. (Minnesota manufacturers' products use less energy per value than U.S. manufacturers as a whole.) Since 1973, industry has reduced its energy use by 105 trillion Btus, more than any other sector.The combined demand from all other sectors, in fact, amounts to a net increase of 4.1 trillion Btus. Without the energy savings provided by industry, Minnesota's energy consumption would be considerably higher than it is today.

Figure 16

Commercial Energy Use in Minnesota

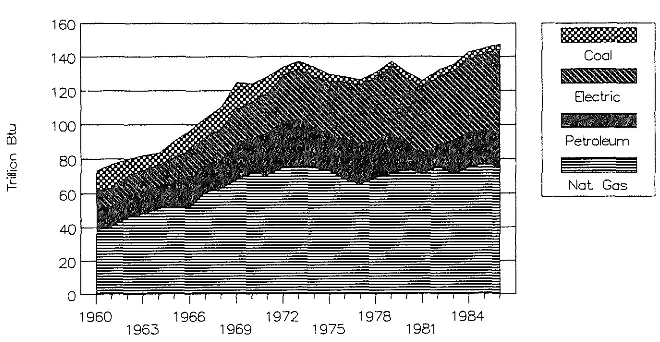
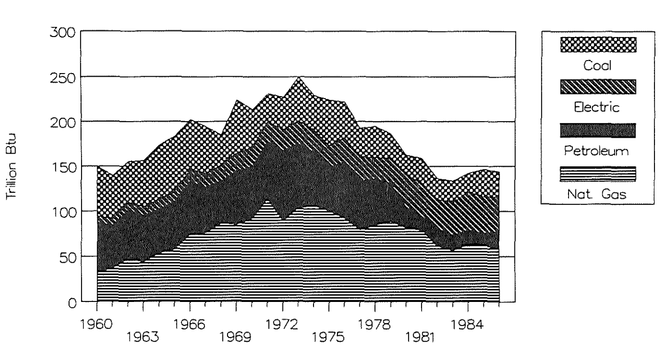


Figure 17

Industrial Energy Use in Minnesota



Source for Figures 16-17: *Minnesota Energy Data Book, 1960-1986*, Minnesota Department of Public Service

From 1974 to 1981, energy use significantly declined in the manufacture of paper products and refined petroleum products, two of the most energy intensive product groups in the state. More important, energy use in relation to the value of output of Minnesota industries declined significantly in nearly all product groups. This implies significant improvements in the energy efficiency of Minnesota manufacturers. Figure 18 shows the trend in Minnesota manufacturing use since 1971.

Mining has historically been a large energy user in Minnesota. During the boom period of the latter 1970s, mining accounted for 15 percent of total industrial electric use. The severe economic difficulties that beset this industry in the early 1980s, however, drastically reduced this share to less than 10 percent. Recently, economic conditions in mining have improved somewhat, but recovery has been modest and electric demand has been highly variable. Unfortunately, data on total energy use in mining are unavailable; however, electric energy accounts for the majority of energy expenditures in mining.

Agricultural energy use is dominated by petroleum products. The share of energy consumed by agriculture in Minnesota has fallen from 8 percent of energy consumption in 1960 to slightly more than 5 percent in 1986. Figure 19 shows the historic use patterns in the agricultural sector. The most noticeable feature is the decline in the share of gasoline from 73 percent in 1960 to 21 percent in 1986. Much of the decrease in gasoline use is due to an increase in the use of distillate fuel (diesel) for agricultural machinery. Use of liquefied petroleum gas (LPG) primarily in crop drying has increased.

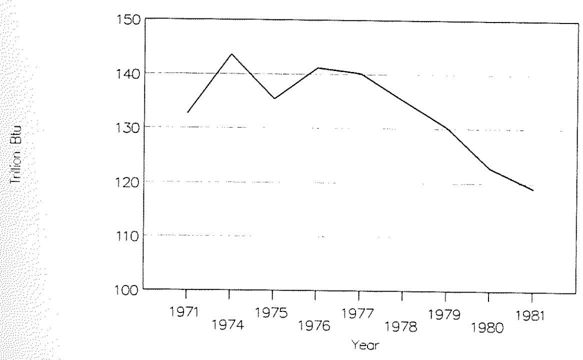
Electric energy has become a more important energy source in agriculture. Nonresidential uses of electricity in agriculture include irrigation and dairy farm operations. The share of energy used in the form of electricity increased from 3 percent in 1960 to 13 percent in 1986.

Transportation energy use. Nearly all energy consumed in the transportation sector comes from petroleum products, with a small amount of natural gas rounding out the remainder. Figure 20 illustrates the trends and composition of energy use in the transportation sector. Gasoline dominates transportation energy use, but has declined from nearly 90 percent of the total in 1960 to just over 70 percent in 1986. Much of this decline has been the result of increased use of jet fuel and distillate fuel oil (diesel) rather than a drop in gasoline consumption.

Energy use in transportation has been more resilient in its response to higher prices than has energy use in other sectors. After falling considerably in 1979, transportation energy use crept upward and by 1986 was back up to 1977 levels. This increase has been the result of more miles traveled rather than decreasing energy efficiency. Figure 5 in the section on Energy Efficiency Trends (page 63) provides information on the average fuel economy of all vehicle types operating in Minnesota from 1960 to 1986. Note the trend toward declining fuel economy throughout most of the 1970s and the dramatic turnaround beginning in 1979. The low oil prices of the last two years will likely stimulate further increases in transportation energy use and may eventually erode some of the fuel efficiency gains made in the past several years.

Figure 18

Manufacturing Energy Use in Minnesota, 1971-1981



Source: *Census of Manufactures and Annual Survey of Manufactures*, U.S. Department of Commerce, Bureau of Census, Reports from 1972 to 1982.

Figure 19

Agricultural Energy Use in Minnesota

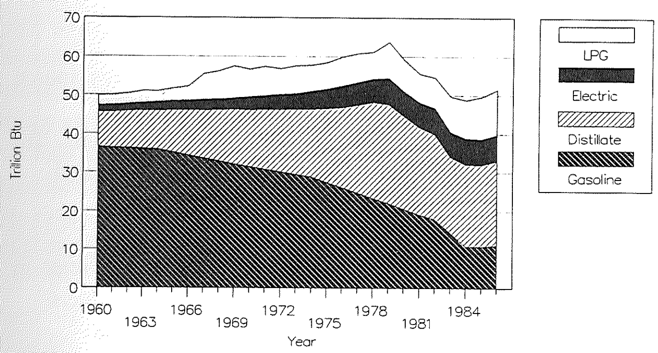
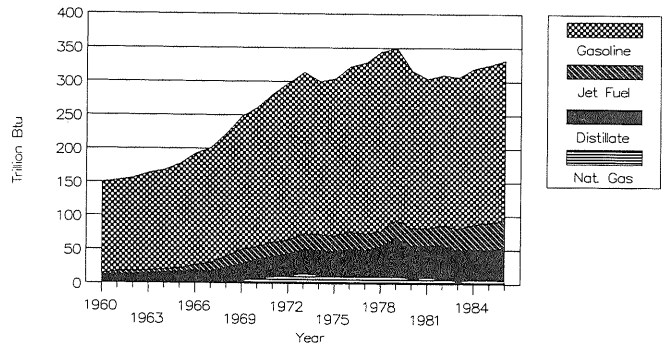


Figure 20

Transportation Energy Use in Minnesota



Source for Figures 19 and 20: *Minnesota Energy Data Book, 1960-1986*, Minnesota Department of Public Service

MINNESOTA ELECTRIC SUPPLY NEEDS

Demand for electric energy is increasing in Minnesota. A key underlying consideration in providing adequate supplies is the inability to store electricity: utilities must have the generation capacity to meet relatively brief periods of high demand. Rather than relying only on construction of new facilities to increase supply, Minnesota utilities plan measures to decrease capacity requirements by improving energy efficiency and reducing fluctuations in demand. This section describes the various options for ensuring adequate supplies and presents the electric supply and demand forecasts for Minnesota through the year 2002.

Electric use is increasing throughout Minnesota. Nearly all types of customers have increased their use of electricity and, given the multiple uses of this energy source, the trend is likely to continue.

Because high costs make storage unfeasible, electricity must be generated on demand. Electric use is characterized by short duration ''peaks'' that require generation significantly in excess of average consumption. If utilities do not have the extra capacity to meet these peak demands, brownouts or blackouts occur that can damage electrical equipment and the electric supply system. Consequently, an electric generating utility usually operates well below its capacity. Electric utilities in Minnesota, in fact, are required by the Mid-continent Area Power Pool to maintain a capacity 15 percent above their peak demand to ensure reliable electric supply. The need to generate electricity to meet peaks in demand requires costly investments in generating plants that are used for only brief periods.

SUPPLY AND DEMAND FORECAST BY UTILITIES SERVING MINNESOTA

The electric utilities that serve Minnesota consist of nine large generation and transmission utilities collectively known as the Minnesota/Wisconsin Power Suppliers Group (M/WPSG). The service areas of the utilities in the M/WPSG do not coincide with state boundaries; consequently, when evaluating the capacity of a utility, its total generation facilities must be considered and not just those that are within Minnesota. The generating capacity of these nine utilities is currently about 13,000 megawatts(MW); peak demand for these utilities in 1987 totaled about 11,700 MW. Electric demand in Minnesota is significantly higher in the summer than in other times of the year due to air conditioning. Hence the ''peak'' in Minnesota occurs in summer. The peak demand figures given above are for the summer.

From 1982 to 1987 summer peak demand for the nine Minnesota utilities grew at an average of 4.2 percent per year. Summer peak demand for Cooperative Power Association (CPA), Minnkota Power Cooperative (MPC), Northern States Power (NSP), Southern Minnesota Municipal Power Agency (SMMPA), and United Power Association (UPA) grew faster than the system average; however, only NSP and SMMPA are predicting a faster-than-average growth in future peak demand. Figure 1 depicts the system-wide actual and forecast summer peak demands and the actual and predicted capacity for the system from 1987 to 2002. The forecasts are based on the recent historic data of the nine utilities and the sum of their 1988 forecasts.

As Figure 1 shows, the utilities foresee a sizable deficit in summer capacity after 1997. At the end of the forecast period this deficit is expected to exceed 1,600 MW. Figure 2 illustrates the summer deficit/surplus status by utility for the years 1987, 1995, and 2002. NSP accounts for over 61 percent of the projected system-wide capacity shortfall at the conclusion of the forecast period. Other possible contributors to the summer deficit are SMMPA, accounting for 13 percent of the system-wide summer deficit, and Interstate Power (IPW), accounting for nearly 23 percent of the system deficit in the year 2002.

Several of the utilities, particularly in northern portions of the state, have higher peak demands in winter than in summer. For these utilities winter capacity is most crucial. Figure 3 illustrates the system-wide winter peak demand and capacity, both actual and forecast, from 1987 to 2002, based on the recent historic data of the nine utilities and their forecasts. As shown, winter capacity for the system as a whole is expected to be adequate until 1999. After 1999 winter capacity deficits increase to 600 MW by 2002. The system-wide forecast of summer peak demand expects average annual growth to equal 1.7 percent each year compared to growth in winter peak demand of 1.3 percent from 1982 to 1987.

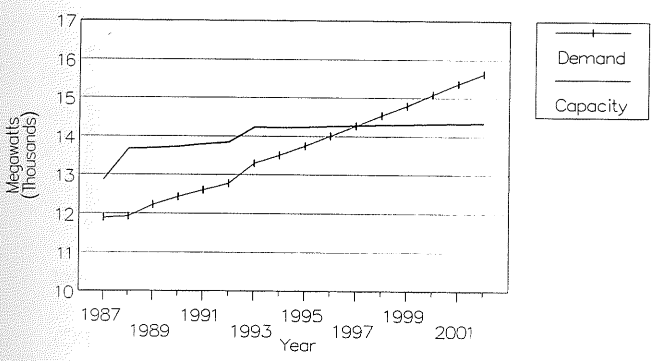
Figure 4 provides data on the winter capacity surplus/deficit for each of the major utilities serving Minnesota for 1987, 1995, and 2002. Northern States Power has the largest projected deficit in winter capacity for 1995, and Minnesota Power, Interstate Power, and Southern Minnesota also anticipate winter capacity deficits by 2002. Cooperative Power, Dairyland Power Cooperative, Minnkota, and United Power are anticipating winter capacity surpluses throughout the forecast period.

SUPPLY SOURCES

The sources used to generate electricity in Minnesota have changed significantly since the 1960s; the trend is toward less use of natural gas and more use of coal and nuclear power. The increase in the latter two fuels is due to increasing electric use. Figure 5 illustrates the sources of energy used to generate electricity in Minnesota for selected years. The use of natural gas to generate electricity has been almost eliminated, except for peak generation periods, while the use of coal and nuclear power has increased substantially in recent years. Imports of electricity from outside the state also increased between 1980 and 1986.

Figure 1

M/WPSG* Summer Peak Demand and Capacity, 1988 Advance Forecast



*Minnesota/Wisconsin Power Suppliers Group

Figure 2

Summer Capacity Surplus and Deficits, 1988 Advance Forecast

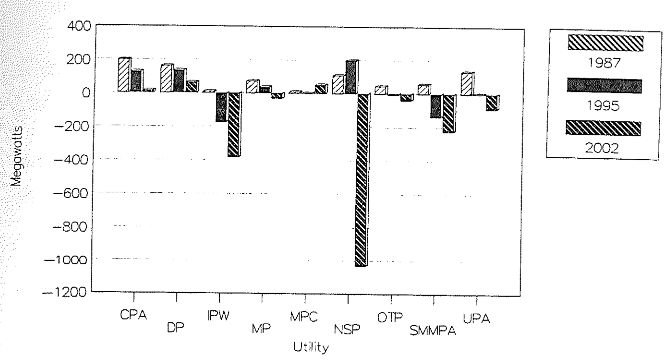


Figure 3

M/WPSG Winter Peak Demand and Capacity, 1988 Advance Forecast

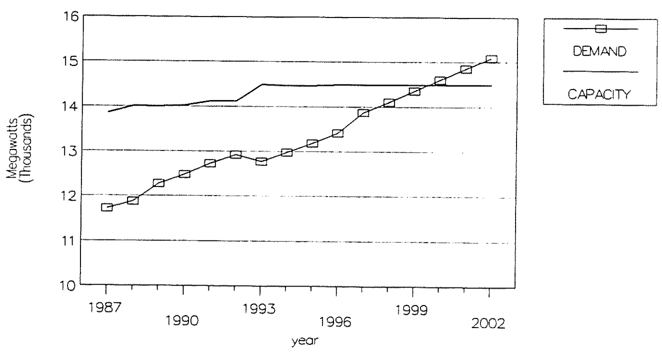
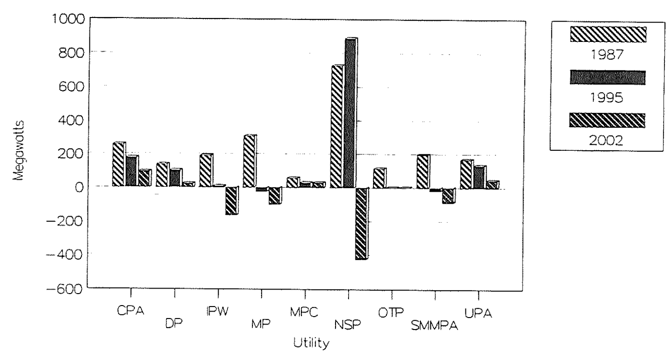


Figure 4

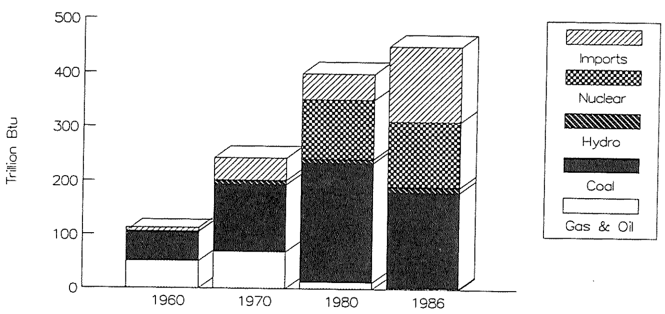
Winter Capacity Surplus and Deficits, 1988 Advance Forecast



Source for Figures 1-4: *1988 Advance Forecast Report to the Minnesota Environmental Quality Board and Department of Public Service*, Minnesota/Wisconsin Power Suppliers Group.

Figure 5

Sources of Electric Generation in Minnesota



Source: *Minnesota Energy Data Book, 1960-1986*, Minnesota Department of Public Service, Energy Division.

To meet predicted supply deficits, the utilities serving Minnesota anticipate the need to exploit several potential sources of generating capacity. Northern States Power, the largest of the utilities, has identified sources for meeting 74 percent of its additional capacity needs.[1] Under this energy supply plan, NSP will meet 28 percent of its additional capacity needs through load management and conservation, 37 percent through utility and non-utility purchases, 3 percent from extending and refurbishing current facilities (termed "life extension" programs), 2 percent from hydroelectric projects, and 4 percent from a new 150 MW combustion turbine. Sources for the remaining 26 percent of new capacity have not yet been identified. The large percentage of new capacity from utility purchases is likely to come from purchases of hydroelectric power from Canada. NSP anticipates purchasing an additional 200 MW (above current levels) from Manitoba Hydro beginning in 1993. It should be noted that large scale purchases from Manitoba Hydro or the construction of large coal-fired plants in North Dakota might require the addition of a major transmission line the length or width of the state.

New construction. Although other Minnesota utilities forecast supply deficits, NSP is the only utility that has identified possible construction options. In addition to the 150 MW combustion turbine identified in the energy supply plan and expected to be necessary as early as 1994, NSP sees the probable need for constructing 950 MW of additional capacity between 1995 and 2004. Timing of these additions, planned in three phases, will depend on updated demand forecasts and supply options. NSP also plans to add 36 MW at Jim Falls in western Wisconsin, 24 MW at Riverside in north Minneapolis, and 22 MW at Black Dog 2 in Burnsville, all scheduled to come on line in 1988.[2]

Purchase and exchange. All generation and transmission utilities in Minnesota engage in purchase and exchange agreements with other utilities. Purchase agreements are contracts in which one utility buys electricity from another at wholesale prices. Typical exchange agreements occur between winter and summer peaking utilities, where winter capacity is sold by the summer peaking utility in exchange for summer capacity from the winter peaking utility. Exchange agreements are well suited to Minnesota because four of the utilities peak in summer and five utilities peak in winter. In 1987, major agreements among utilities in the system exceeded 1,700 MW of capacity in the summer and 500 MW in the winter; these included purchases from Manitoba Hydro.[3] Other supply options for Minnesota utilities include purchases from electric utilities outside the immediate service areas of the Minnesota utilities.

Load management and conservation. To reduce the amount of unused capacity and the need for building additional generation capacity, many utilities engage in load management and conservation, collectively termed "demand-side management." Load management programs reduce capacity requirements by shifting some of the peak load demand to off peak periods. Examples of these programs include time-of-day pricing in which customers are charged more for electricity during peak periods than during off peak periods, cool storage air conditioning systems that produce ice during off peak periods for use during periods of peak demand, and interruptible service that allows switching to a substitute fuel such as in dual fuel water and space heating.

Conservation programs reduce capacity requirements by reducing overall electric consumption. Common conservation programs sponsored by utilities include payments or rebates to consumers for purchase of more energy efficient appliances, and similar lighting and motor efficiency programs.

Utilities find load management programs highly desirable since they reduce the peaks and valleys in electric demand without significantly decreasing sales. These programs have been vigorously pursued by numerous Minnesota utilities. Since conservation programs reduce overall electric sales—and revenue—as well as peak demand, impetus for these programs initially came from mandates by state and federal regulatory agencies. As these programs have developed, utilities have found them useful for deferring the need for new power plants. A review of recent developments in Minnesota utility conservation programs is found in the Minnesota PUC publication, *Conservation Improvement Programs Ordered by the Minnesota PUC*, 1988.

Several Minnesota utilities have identified load management and conservation programs as a method for meeting current and future peak demand needs. In the 1988 Advance Forecast, the nine utilities estimate that load management and conservation programs could cut peak demand by nearly 1,200 MW by the year 2002.[4]

A study for the Department of Public Service by PLC Incorporated estimates that conservation could substantially reduce capacity requirements. Table 1 estimates maximum reductions in capacity that could result from efficiency improvements affecting several large end uses. Most of the savings can only take place gradually as appliances are replaced and other improvements are made. Utility conservation programs can have a significant impact on long term demand requirements if they can capture a portion of these potential savings.

Table 1: Potential Capacity Savings From Conservation in Minnesota

End Use	Maximum Potential Peak Demand Reduction (MW)
Residential:	
Air Conditioning	54.1
Water Heating	271.5
Freezer	49.0
Refrigerator	232.6
Dryer	55.9
Lighting	92.9
Total:	756.0
Commercial:	
Cooling	121.7
Water Heating	34.5
Lighting	707.7
Total:	863.9
Industrial:	
Motors	368.1
Total:	1,988.0

Source: Minnesota Department of Public Service, Energy Division, based on data from *Conservation Potential in the State of Minnesota*, prepared by PLC, Inc. The capacity figures have not been adjusted to include line losses and reserve capacity. Were these included in the estimates the figures would be 20 to 25 percent higher.

Possible effects of technology and deregulation. The future structure of the electric power generation industry is uncertain. Improvements in technology may permit inexpensive small scale generation, and a movement toward deregulating the industry might allow competitive bidding for future capacity requirements. These could significantly revise any expansion plans being formulated by the utilities. Technology changes and deregulation could radically transform the structure of the electric power generation industry in Minnesota.

OUTLOOK FOR ELECTRIC PRICES

Electric rates paid by Minnesota consumers are likely to remain stable through the early 1990s. Historically, the most important factor affecting electric rates has been the construction of new power plants, and Minnesota utilities will not be engaging in any substantial additions to capacity before the mid-1990s. Other factors (including wages and salaries, fuel costs, interest rates, changes in tax laws, and pollution abatement costs) are also not expected to cause any significant increases in electric rates in the near future.

The outlook for electric rates is more uncertain after 1995. Depending on growth in electric demand, Minnesota utilities may propose significant new additions to generation capacity during the late 1990s. Federal legislation to reduce acid rain could lead to higher pollution abatement costs. The impact in Minnesota, however, would probably be lower than in many states because Minnesota emissions requirements are currently much more stringent than federal requirements.

In the long term, growing concern over the contribution of carbon dioxide emissions to global warming could affect electricity costs. Minnesota utilities generate most of their electricity from coal, which produces higher carbon dioxide emissions than other fossil fuels. The eventual development of international agreements to reduce carbon dioxide emissions is a matter of speculation. Any requirements to reduce coal use significantly, however, would limit options for meeting future electric supply needs.

DEPARTMENT OF PUBLIC SERVICE FORECAST

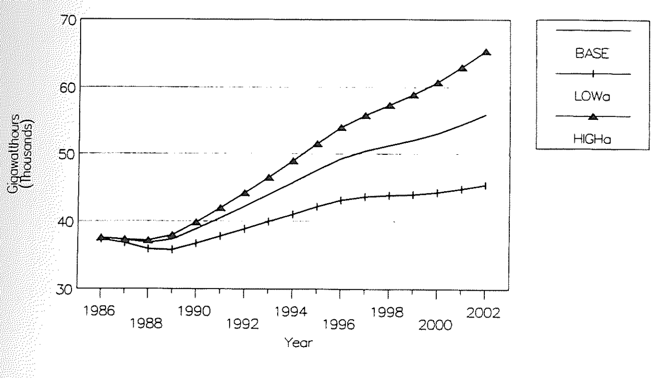
The outlook for electric supply is determined by the rate at which electric consumption increases. Growth in electric consumption in Minnesota has entered a period of increasing uncertainty. Conservation and increased availability of substitute energy sources make forecasting more difficult, but the need for accurate forecasts of electric consumption is becoming more critical. Forecasting electric sales (measured in megawatt hours) and seasonal peak demand (measured in megawatts) is important due to the long time needed to plan and construct new generating facilities.

The Department of Public Service has developed a forecast of statewide electric consumption to the year 2002.* The forecast consists of five separate forecasts, one for each consumer group: residential, commercial, manufacturing, mining, and agricultural. The forecast also includes three possible outcomes, each based on a set of assumptions regarding important variables that determine electric consumption, such as employment levels and oil prices.

The three outcomes are shown in Figure 6. The base case (or the outcome based on the most likely set of circumstances) anticipates average annual growth of 2.5 percent per year. By comparison, the utilities in the M/WPSG system anticipate that electric consumption in Minnesota will average 2.6 percent annual growth.

Figure 6

Forecast of Electric Consumption in Minnesota, 1987 to 2002



Within economic sectors, electric use by manufacturers is expected to lead other economic sectors with average growth of 3.8 percent per year. Residential growth is anticipated to average 1.5 percent per year, and commercial growth is predicted to increase by 1.8 percent throughout the forecast period. Mining electric consumption is expected to remain level after large increases in 1988 and 1989. Agricultural use is expected to decline 0.7 percent per year throughout the forecast period. A graph of the base case forecast by customer class is contained in Figure 7. Total electric consumption is expected to increase from its current level of 38,000 gigawatt hours to 56,000 gigawatt hours by the year 2002.

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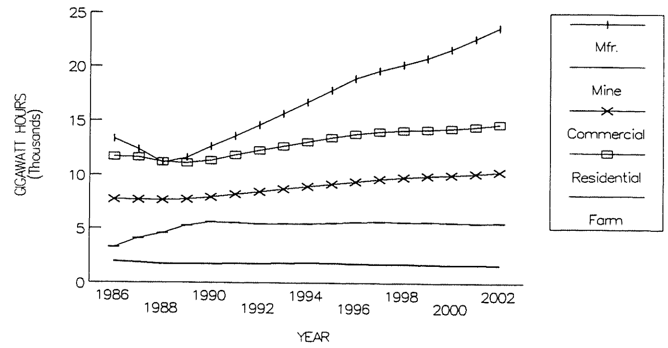
*Minnesota DPS, *Minnesota Energy Consumption Forecast, 1987-2000*, August, 1988.

Figure 7

Forecast of Electric Consumption in Minnesota by Sector, 1987 to 2002



Source for Figures 6 and 7: *Minnesota Electric Consumption Forecast 1987-2002*, Minnesota Department of Public Service

The methodology used in the forecasts was standard econometric regression analysis and related the effects of one or more variables to electric use. Common variables used in all the forecasts were the price of electricity, the price of substitute fuels, and a variable that captures the effects of economic activity. For example, in the manufacturing electric consumption forecast the variables included electric price, price of natural gas, and the value of shipments for each industrial group. The commercial forecast substituted employment in the commercial sector in place of value of shipments, and the mining forecast used iron ore produced in the United States plus net imports and the share of net imports of ore in the U.S. The residential forecast included a weather variable and personal income in the state. The agricultural model included agricultural expenditures and a weather variable.

The alternative outcomes were formulated by changing the assumptions of the variables used in the model. The high electric consumption growth for residential, commercial, and manufacturing assumed high economic growth (income, employment, and value of shipments), fairly stable electric prices, and increasing gas prices. In mining, the high growth outcome assumed that the import share of iron ore would fall slightly, the consumption for iron ore would grow somewhat faster than in the base case, and electric prices would remain stable. The high growth outcome anticipates average growth in electric consumption of 3.5 percent per year. At the end of the forecast period, electric consumption equals 66,000 gigawatt hours.

The low forecast assumes low economic growth for manufacturing, commercial, and residential customers, and low prices in fuel substitutes. In mining, the low outcome assumes high electric prices and an increase in the import share of iron ore over time. Under these circumstances electric consumption would grow about 1.3 percent per year and total electric consumption in the year 2002 would equal roughly 46,000 gigawatt hours.

Of course, any projection based on assumptions of economic variables is subject to significant uncertainty and limitations. The simple econometric models used in the forecast have the advantage of reducing the number of assumptions that must be made to predict electric consumption; however, they may not include all of the factors that ultimately determine electric use. One weakness of the forecast models is their inability to capture improvements in technology not induced by higher electric and fuel prices. To the extent that secular technological improvements reduce future electric consumption, the predictions of this forecast will be above the actual consumption level and growth in electric use will be correspondingly slower.

THE OUTLOOK FOR NATURAL GAS

Forecasters predict an increase in both natural gas consumption and prices during the coming decade, although a number of factors could alter these outcomes. The forecasts and the assumptions on which they are based, as well as a description of the natural gas distribution system, are provided in this section.

Natural gas is used by residential and commercial customers mainly for space heating, water heating, cooking, and clothes drying. It is specially suited for such tasks since it burns cleanly, without giving off odors or particulate matter. This characteristic also makes it valuable for certain industrial uses, such as drying milk, grain, and other food products. Other industries, including can and glass manufacturing, printing, and primary metals, use natural gas because it burns with a precise, steady flame.

Figures 1 and 2 show Minnesota and national consumption of natural gas by sector in 1987: The residential and commercial sectors are the largest users of natural gas in the state, followed by the industrial sector and electric generation. These percentages reflect a number of differences from national consumption patterns. Residential use of natural gas is higher in Minnesota due to a colder winter climate and heavier reliance on natural gas for space heating and appliances. The industrial share of state natural gas consumption is lower due to Minnesota's less energy intensive mix of industrial users. The state electric utility use of natural gas is lower than the national percentage due to the availability of low cost coal and because of the lower natural gas prices in some areas of the country.

THE PIPELINE SYSTEM

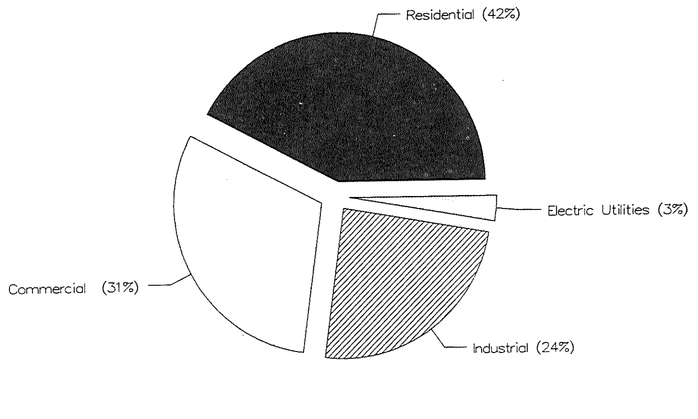
An extensive pipeline system connects the gas well to the natural gas customer. The United States has more than one million miles of pipelines, ranging in diameter from one to 42 inches, for the transportation of natural gas.

Minnesota receives about 97 percent of its gas through the Northern Natural Gas Company (NNG) pipeline system.[1] The remainder comes from the Great Lakes Transmission Company, Inter-City Minnesota Transmission Company, and Midwestern Gas Transmission Company. (See Figure 3). In the past, NNG delivered gas produced in the United States; the three other companies have obtained supplies from Canada.

Once the transmission pipeline brings the gas to a local distribution area (sometimes called the city-gate), the gas is distributed to customers by a local gas utility. There are 29 natural gas utilities in Minnesota. Table 1 shows natural gas sales by the largest of these utilities.

Figure 1

Minnesota Natural Gas Consumption, 1987

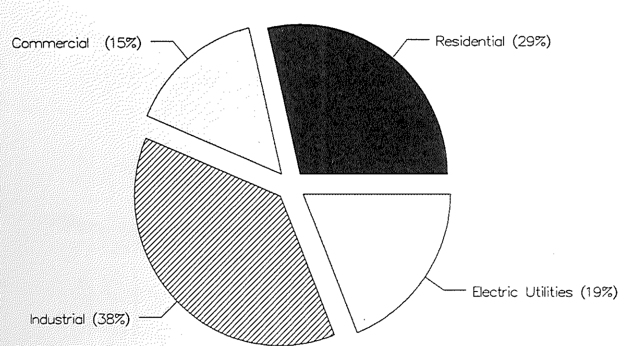


Source: *Natural Gas Monthly,* U.S. Department of Energy, Energy Information Administration

Since residential and commercial space heating accounts for such a large proportion of natural gas use, total demand varies considerably by season. A common method that utilities use to smooth out seasonal variations is sales to interruptible gas customers. These interruptible customers pay a lower price for gas because their supply can be cut off or interrupted when demand from noninterruptible, or "firm," customers rises significantly, as it does during cold weather. Most interruptible sales are to large commercial or industrial facilities, although smaller users such as schools and churches also may have interruptible service. These facilities normally are equipped to use another fuel when their natural gas service is interrupted. Fuel oil and propane are the most typical backup fuels.

Figure 2

U.S. Natural Gas Consumption, 1987[1]

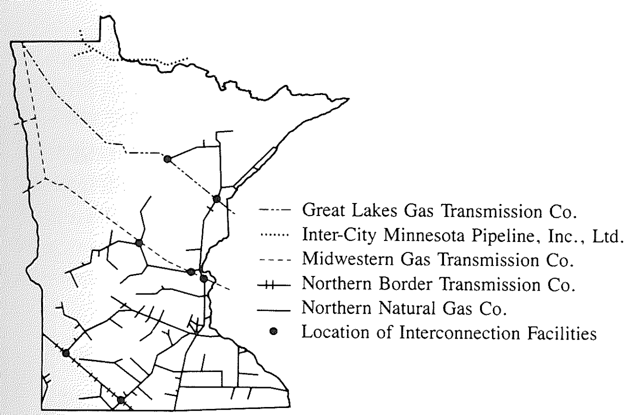


Source: *Natural Gas Monthly*, U.S. Department of Energy, Energy Information Administration

1. The U.S. Department of Energy definitions of commercial and industrial natural gas use are based on economic classification. Data for commercial and industrial use in other sections of the report are based on the size of the customer.

Figure 3

Gas Transmission Pipelines in Minnesota



Source: Minnesota Department of Public Service, Utilities Division

In the event that demand for natural gas exceeds available supplies, the federal government has established regulations detailing the order in which different classes of customers are to have their gas supplies curtailed. Residential and small commercial users receive the highest priority for obtaining gas supplies.

CURRENT SUPPLIES

Since 1968, gas produced in the United States has exceeded the additions to reserves resulting from new discoveries. For example, 15.6 trillion cubic feet were produced in 1986, but only 8.9 trillion cubic feet of total discoveries were added to reserves. Thus, the overall reserves of gas are declining in the U.S. Production itself has declined steadily since 1970.[2]

Northern Natural Gas is a subsidiary of the Enron Corporation (formerly HNG/Internorth) which operates the most extensive pipeline network in the U.S. NNG operates a 3,200-mile pipeline system serving customers in 14 states. About 83 percent of NNG's 1986 supply came from contracts with producers in Texas, Louisiana, and Oklahoma. About 8 percent of its supply was obtained from other interstate pipelines, 6 percent from Canadian suppliers, and 3 percent from company-owned sources.[3]

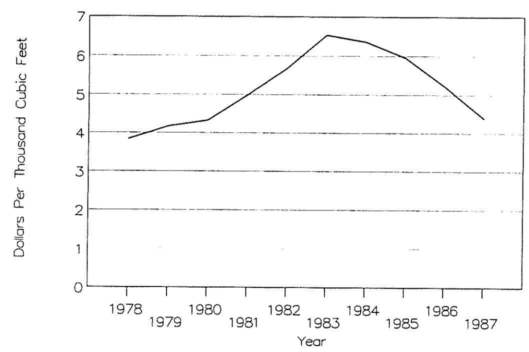
NNG can also sell directly to large customers, but the bulk of the company's gas (97 percent in 1986) is sold for resale. Minnesota utilities accounted for 51 percent of NNG's sales for resale in 1986.[4]

NATURAL GAS PRICE TRENDS

Recent natural gas price trends reflect two general periods. The first came in the mid 1970s when supply shortfalls led Congress in 1978 to partially deregulate prices paid to producers. Prices began rising in 1979, and higher prices for competing petroleum products added to the upward pressure on natural gas prices.

Figure 4

Average Cost of Natural Gas in Minnesota (1986 Dollars)



Source: *Minnesota Energy Data Book, 1960-1986*, Minnesota Department of Public Service. *Natural Gas Monthly*, U.S. Department of Energy, Energy Information Administration, May 1988

Table 1

Gas Sales by Minnesota Gas Utilities, 1986

Company	Billion Cubic Feet	Percent of Total
Minnegasco	116.1	46.1%
Northern States Power	61.3	24.3%
Peoples Natural Gas	33.8	13.4%
North Central Public Service	10.7	4.2%
Northern Minnesota Utilities	8.9	3.5%
Others	21.1	8.5%
Total	251.9	100.0%

Source: Minnesota Department of Public Service, Energy Division

After 1983, the upward pressure on natural gas prices began to reverse, ushering in a period of falling prices. Natural gas shortfalls were replaced by a surplus of available supplies. Competition from declining petroleum prices added to the downward pressure. An additional factor affecting prices has been partial deregulation of the natural gas industry.

Figure 4 illustrates the impact of the two periods on natural gas prices in Minnesota. The average cost to residential customers, expressed in 1986 dollars, increased from $3.83 per Mcf (thousand cubic feet) in 1978 to $6.53 in 1983. The price then fell steadily to $4.06 in 1987.

CANADIAN GAS

On January 2, 1988, President Reagan signed and forwarded to Congress a comprehensive trade agreement negotiated with Canada during the preceding year. In general, the accord aims at giving Canada secure access to U.S. markets and giving the U.S. secure access to Canadian markets, including energy markets.

Subject to legislative approval, both countries have agreed to prohibit restrictions on imports and exports, including quantitative restrictions, taxes, minimum import or export price requirements, and any other equivalent measures. The free trade agreement follows several other developments that permit more open Canadian access to U.S. natural gas markets: Since 1985 Canada has removed its most important regulatory impediments to gas exports by deregulating interprovincial gas sales and terminating the condition that gas sales to the United States could not be priced below the level of comparable sales to the domestic Canadian market.

NATURAL GAS SUPPLY AND PRICE OUTLOOK

Projections of future natural gas supplies and prices are provided by the U.S. Department of Energy (DOE) and the Gas Research Institute (GRI).

DOE projections. Table 2 shows projections by the U. S. Department of Energy based on the most likely set of conditions (or base case) of natural gas supply, consumption by sector, and average price by sector.

The trend of natural gas use in the U.S. has been downward since 1973. Between 1973 and 1986, the contribution of natural gas to the nation's total primary energy consumption declined from 30 percent to 23 percent. The Department of Energy estimates, however, that natural gas consumption increased in 1987 and it expects increased consumption to continue throughout the forecast period (1986-2000). According to DOE, there could be significant increases in gas consumption after 1995 due to competitive gas prices and the increased use of natural gas by electric utilities. Congress repealed restrictions on natural gas use for electric utility generation in 1987, opening the way for construction of natural gas fired power plants.

Table 2

DOE Base Case Projections,
Natural Gas Supply and Prices

(Trillion Cubic Feet, 1987 $/Thousand Cubic Feet)

	1985	1987	1990	1995	2000	Annual Percent Growth 1985-1990	Annual Percent Growth 1990-2000
Production	16.4	16.4	16.5	17	17.5	0	0.6
Net Imports	0.9	0.8	1.2	1.8	2.5	5.5	7.9
Net Storage Withdrawals	0.2	0.0	0.0	-0.0	-0.0		
Total Supply	17.6	17.2	17.6	18.7	20.0	0	1.3
Consumption By Sector							
Residential	4.4	4.4	4.6	4.5	4.3	0	0
Commercial	2.4	2.3	2.4	2.5	2.6	-0.4	0.1
Industrial	6.9	6.7	7.3	7.6	7.5	1.3	0.2
Transportation	0.5	0.5	0.5	0.6	0.6	0.6	1.3
Electric Utilities	3.0	2.9	2.5	3.2	4.7	-3.5	6.2
Total Consumption	17.3	16.9	17.3	18.3	19.7	0.0	1.3
Unaccounted for (3)	1	1	1	1	1		
Average Price By Sector							
Residential	$6.47	$5.51	$5.80	$6.54	$7.65	-2.2	2.8
Commercial	5.81	4.75	4.88	5.36	6.20	-3.4	2.4
Industrial	4.17	2.65	2.84	3.57	4.65	-7.4	5.1
Electric Utilities	3.75	2.34	2.53	3.40	4.67	-7.6	6.3
Minnesota Average Prices							
Residential	$5.80	$4.52	$4.76	$5.50	$6.61	-3.9	3.3
Industrial	4.05	2.59	2.72	3.45	4.53	-7.6	5.2

Source: *Annual Energy Outlook 1987*, U. S. Department of Energy, Energy Information Administration. Minnesota Department of Public Service, Energy Division

By 2000, natural gas consumption is forecast to have climbed back to about 19.7 trillion cubic feet annually, or about the same level as in 1978. Most of the rise is expected to come from increased use of gas by utilities. The increase in industrial consumption is due mainly to higher industrial output and an increase in cogeneration. In the residential and commercial sectors, consumption is forecast to grow at roughly the same rates as the housing stock and the square footage of commercial buildings, respectively.

Gas Research Institute (GRI) projections. Table 3 shows the GRI base case projections of natural gas supply, consumption, and average price by sector. The GRI forecasts a lower growth of supply from 1990 to 2000 with an average annual growth rate of 0.9 percent per year. DOE forecasts a growth rate of 1.3 percent per year.

In total consumption, DOE gives a higher forecast compared to GRI. This higher DOE forecast is largely a result of higher projections for the increased use of natural gas by electric utilities. The DOE forecasts a 6.2 percent per year growth rate after 1990 for electric generation using gas, compared to a 3.9 percent growth by GRI.

Price forecasts. The average price forecasts by DOE and GRI are similar. Projected growth rates for the period between 1990 and 2000 range from 2.4 to 6.3 percent per year for DOE and from 2.3 to 3.9 percent per year for GRI. Tables 2 and 3 summarize the base case results for each sector and the effect that these trends would have on prices in Minnesota.

As the current excess in natural gas supplies is diminished, the need for more drilling will lead to higher prices. The timing and extent of these increases is a significant source of uncertainty affecting the price forecast. The effect of higher or lower petroleum prices on the demand for natural gas is a second source of uncertainty.

Alternate forecasts. According to DOE, two critical variables determine future demand for natural gas: the price of oil and economic growth. Two projections were developed, therefore, in addition to the base case projection. One case combines low oil price with high economic growth; the other combines high oil price with low economic growth. These very different projections highlight the uncertainty underlying the future net imports of petroleum.

In the case of low world oil prices and high economic growth, a decrease in domestic oil production lowers both the production of gas from oil reservoirs and the drilling costs for nonassociated gas (gas that is not in contact with nor dissolved in crude oil in the reservoir). At the same time, lower prices for oil reduce the demand for gas relative to oil because large end-users can switch from gas to lower cost oil products. Nevertheless, overall demand is higher because this case involves high economic growth which tends to increase the demand for gas, as it does for all forms of energy.

For the high oil price and low economic growth situation, we get opposite results: higher supply of gas from oil reservoirs and higher costs for nonassociated gas; an increase in gas demand relative to other fuels, but lower overall gas demand because of a sluggish economy.

It should be noted that these forecasts do not address potential differences in Canadian gas supply. Canadian gas supply is expected to grow as a significant supply source for Minnesota. In its base case projection, GRI finds that natural gas transportation patterns will shift significantly in the future. For the North Central region, which includes Minnesota, a decline in deliveries from the west south central states (Louisiana, Texas, Oklahoma) is offset by growing supplies from the Mountain Region and exports from western Canada.

Table 3

GRI Base Case Projections
Natural Gas Supply and Prices[1]

(Quads, 1986 $/Million Btu)

	1986	1990	2000	Annual Percent Growth 1986-90	1990-2000
Production	16.6	16.8	17.2	0.3	0.2
Imports	.8	1.0	2.2	5.7	8.2
Total Supply	17.4	17.8	19.4	0.6	0.9
Losses and Exports	.8	.5	.6		
Total Consumption	16.6	17.3	18.8	1.0	0.8
Average Price by Sector					
Residential	$5.68	$5.77	$7.27	0.4	2.3
Commercial	5.01	5.13	6.59	0.6	2.5
Industrial	2.95	3.52	4.81	4.5	3.2
Electric Utility	2.15	3.01	4.43	8.7	3.9
Minnesota Average Prices					
Residential	$5.22	$4.76	$6.26	2.3	2.8
Industrial	3.38	3.41	4.70	0.2	3.3

1. Categories and historic tables appearing in the GRI forecast are not entirely consistent with the DOE forecast. GRI includes exports in production and combines imports with losses (unaccounted for gas). DOE maintains separate categories for net imports and unaccounted for gas.

Source: *GRI Baseline Projections of U.S. Energy Supply and Demand to 2010*, Gas Research Institute, 1987. Minnesota Department of Public Service, Energy Division

The two forecasts also do not consider the potential impact of higher than expected exploration costs or failure of the industry to develop reserves as new supplies are needed. If wellhead prices do not rise as needed to support additional drilling, natural gas production can be insufficient to meet demand. This can lead to short term price increases and lower natural gas consumption until sufficient drilling of new wells can be completed.

LONG TERM OUTLOOK FOR NATURAL GAS

Domestic natural gas resources will probably continue to be widely available during the first two decades of the 21st century, but a specific long term forecast would be highly speculative. Domestic natural gas resources (including undiscovered resources) in 1985 probably totaled between 500 and 800 trillion cubic feet (tcf).[5] The U. S. Department of Energy natural gas forecast predicts that domestic production between 1985 and 2000 will equal about 270 tcf. Thus, total natural gas resources may decline between 34 and 54 percent during this 15 year period.

Some level of imports will be available from Canada and perhaps Mexico, depending on the export policies of these countries. Synthetic natural gas from coal and liquefied natural gas imports from other nations are also potential sources of future supplies. These two options would be costly, however, and may not be able to compete with alternative energy sources.

THE OUTLOOK FOR PETROLEUM

Minnesota, along with the rest of the nation, increasingly depends on foreign oil sources. More than half of the world's oil reserves are located in the Middle East, leading forecasters to predict that in the 1990s OPEC nations will again be able to control oil prices and supplies. How this control might be exerted, and what its effect would be on oil prices and supplies in Minnesota, are examined in this section.

Petroleum price levels and supply conditions in Minnesota are largely determined by national and international market conditions. Figure 1 shows how closely Minnesota gasoline prices reflect national crude oil costs. It also shows, with the sharp increases and decreases, how both state and national costs are affected by international conditions.

World petroleum supplies and the emergence of OPEC played a major role in making energy a prominent concern of the 1970s. Significant events in the decade included the 1974 Arab oil embargo, the 1979 Iranian oil crisis, shortages at gasoline stations, and the dramatic rise in gasoline prices that began in 1979.

The decline in petroleum prices in 1986 provided substantial savings for consumers, but failed to ease concerns about world oil supplies in the coming decade. The importance of these concerns is heightened by our almost complete dependence on petroleum fuels for transportation. In Minnesota, petroleum expenditures for transportation totaled $2.3 billion in 1986. These expenditures accounted for 79 percent of total state petroleum costs and 36 percent of state energy costs.[1]

During the 1990s, the United States and other oil importing nations will become increasingly dependent on exports from OPEC nations. This dependence creates uncertainty about the future cost of petroleum.

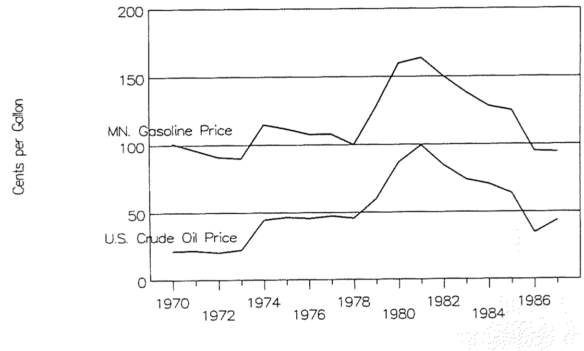
OPEC AND INTERNATIONAL OIL CONDITIONS IN THE 1980s

The strength of OPEC in the 1980s has been seriously eroded by the unsustainable oil price increases that occurred after the Iranian oil crisis. As Figure 2 illustrates, U.S. crude oil costs nearly tripled between 1978 and 1981, increasing from $12 to $35 per barrel.

The price increases set in motion an overwhelming market response that is summarized in Figure 3. Petroleum consumption by free market nations fell 11 percent from 1979 to 1982, and oil production by non-OPEC nations increased 26 percent between 1979 and 1984. The result was a dramatic decline in OPEC oil production from 31.7 million barrels per day in 1979 to 17.2 million barrels per day in 1985.

Figure 1

Average Cost of Gasoline and Crude Oil, Constant 1986 Dollars

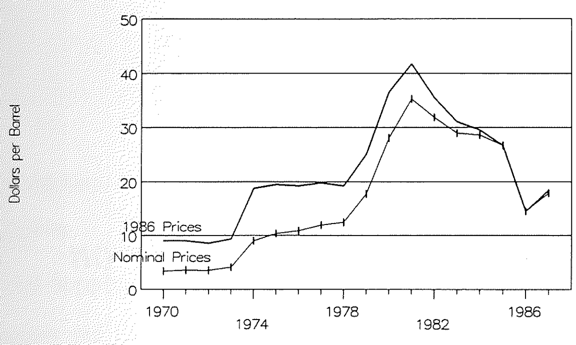


Source: Minnesota Department of Public Service, Energy Division. *Annual Energy Review 1987*, U.S. Department of Energy, Energy Information Administration

By 1986, OPEC members were economically unable to withstand any further cuts in production. The resulting collapse in world oil prices moderated in 1987 after OPEC members were somewhat more successful at maintaining production quotas. Their ability to keep world prices even as high as $18 per barrel remains uncertain into the early 1990s.

Figure 2

Cost of Crude Oil to U.S. Refiners



Source: *Annual Energy Review 1987*, U.S. Department of Energy, Energy Information Administration

OUTLOOK FOR REEMERGENCE OF OPEC

Forecasts of world oil production and demand since the 1986 price collapse generally agree that OPEC nations will be in a position to exert greater control over world oil prices by the mid-1990s. Figure 3 summarizes the results of a base case forecast presented in the U.S. Department of Energy's 1987 *International Energy Outlook.*

The forecast projects that petroleum consumption by free market nations will increase 6 percent between 1986 and 1995, but oil production by non-OPEC nations will decline 13 percent. As OPEC nations increase exports to meet world supply needs, their production levels will increase from 17.2 million barrels per day in 1985 to 26.4 million barrels per day in 1995. The tremendous concentration of oil resources among OPEC nations, and especially in the Middle East, makes inevitable the dominance of these countries in supplying world petroleum needs. In 1987 OPEC members held 55 percent of world oil resources (see Figure 4). An estimated 43 percent of world resources are located in the Middle East.

INCREASING U.S. DEPENDENCE ON IMPORTS

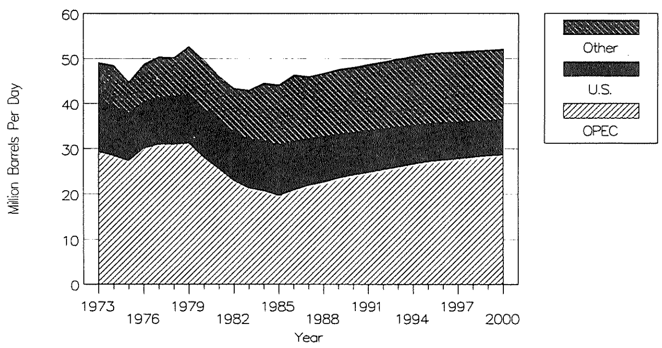
The United States will be among the nations dependent on OPEC. Declining domestic oil production will increase the nation's dependence on oil imports, making its economy more vulnerable to the impact of higher oil prices, especially in the event of a disruption in oil supplies.

Imports have supplied more than 20 percent of U. S. petroleum consumption since 1969. The percentage increased to a peak of 46 percent in 1977 before declining to a low of 27 percent in 1985. Domestic oil, because of exploration and production costs, is more expensive than foreign oil. The falling price of foreign oil in 1986 has already caused petroleum imports to jump to an estimated 36 percent of total consumption in 1988.[2]

U. S. oil production has remained stable in recent years, but extensive exploration and production have already taken place, and remaining oil resources will be expensive to find and develop. Petroleum industry observers anticipate that production will slowly decline during the 1990s and any increase in consumption will need to be supplied through increased imports. According to the forecast presented in the U. S. Department of Energy's 1987 *Annual Energy Outlook*, imports may increase to 51 percent of U. S. petroleum consumption in 1995 and to 55 percent by the year 2000. Even if high oil prices should occur, the forecast is that imports will rise to 44 percent in 1995.[3]

Figure 3

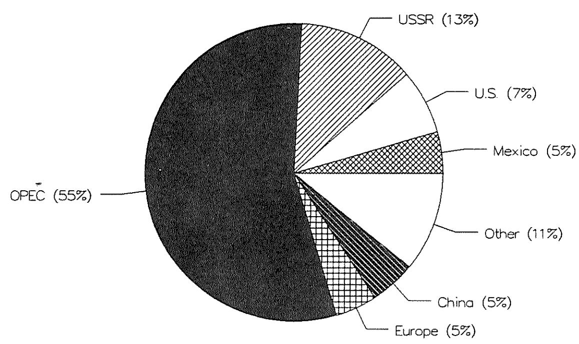
World Oil Production, Excluding Centrally Planned Economies, 1973-2000



Source: *International Energy Outlook 1987*, U.S. Department of Energy, Energy Information Administration

Figure 4

Distribution of World Oil Resources, 1985



Source: *World Resources of Crude Oil, Natural Gas, Natural Bitumen and Shale Oil*, U.S. Department of Interior, Geological Survey, 1987

PETROLEUM COST OUTLOOK

Future petroleum costs for Minnesotans are extremely uncertain due to political factors affecting world oil supplies. Gasoline and fuel oil costs could remain stable throughout the next decade, but political instability in the Middle East could also cause a sudden and unpredictable increase in petroleum prices.

The U. S. Department of Energy (DOE) forecasts referred to above are based on three oil price situations that identify the likely range of future crude oil costs through the year 2000. These scenarios, which are shown in Figure 5, are also representative of other forecasts of the U. S. energy and economic outlook.

The price outlook can be divided into two general periods, with the first period ending in 1993 to 1995. During this period OPEC will continue to face difficulty maintaining agreements to limit production. The low price forecast could result from a continuing inability by OPEC members to restrain their level of exports. The high price forecast could be maintained by a stringent production agreement and strong discipline in staying under agreed limits.

By 1995 the growing import needs of non-OPEC nations will permit a steady increase in production without a lowering of prices. OPEC members will then be better able to consider production restraints leading to the trend shown in the high price forecast. The base case situation could result from a decision to avoid prices that would enable other options (such as fuel substitutes or increased efficiency) to compete with OPEC oil. The low price forecast could occur if internal disagreements hampered OPEC's ability to adhere to serious production limits.

The high price scenario would have serious implications for Minnesota's energy future, but a potentially greater concern would be the short term impact that a disruption of world oil supplies could have on petroleum prices. For example, 30 to 40 percent of OPEC production is exported through the Persian Gulf via the strait of Hormuz. A prolonged disruption of these supplies could dramatically increase world oil prices. The impact would be especially severe after the early 1990s when the current excess in world crude oil production capacity would have diminished.

The physical shortages of supply that occurred in the United States during the 1974 Arab oil embargo and the 1979 Iranian oil crisis would not be the principal concern. These shortages occurred during a period of federal price and allocation controls on petroleum products that ended in 1981. The controls kept prices from rising rapidly and contributed to the spot shortages experienced by consumers.

In a future supply reduction, there would be fewer restraints on price increases, and consumers would cut back more quickly on nonessential uses of petroleum products in the face of much higher prices. The supplies would essentially be allocated according to users' willingness or ability to pay. The possible size of price increases cannot be easily predicted, but a reasonable forecast would be a tripling of petroleum prices, followed by a return to previous prices after six months.

The economic disruption caused by such a situation could be severe. Businesses dependent on travel and energy intensive industries could face serious financial difficulties. The impact on inflation and the overall health of the economy would be a concern, and low income households would be especially hard hit. Developing countries would be the least well prepared to handle the impacts of the disruption.

Efforts by the United States and other nations to develop strategic inventories of petroleum are one important response to potential supply disruptions. As of October 1988, the U. S. strategic petroleum reserve had an inventory of 554 million barrels, sufficient to supply 18 percent of national petroleum consumption for six months.[4] Current plans are to continue gradual filling of the reserve to its capacity of 750 million barrels.

Table 1 illustrates the effect that the DOE price forecast scenarios would have on the retail price of gasoline in Minnesota. In addition to crude oil costs, a number of other factors could also affect the refinery and retail margins for petroleum products. Retail outlets are currently responding to regulatory requirements for underground fuel storage tanks that will require substantial capital outlays. Forthcoming federal requirements to reduce the sulfur content of diesel fuel, limit the vapor pressure of gasoline, and address other environmental concerns would also increase petroleum refining costs. Another variable is whether motor fuel taxes will generally remain unchanged after adjusting for inflation.

MINNESOTA AREA PETROLEUM SUPPLIES

Although petroleum supplies and prices in Minnesota are largely determined by the conditions described above, local conditions can affect prices and supplies for short periods. During December of 1984 Minnesota experienced a shortage of No.1 fuel oil and diesel fuel. Use of this lighter fuel by diesel trucks increases dramatically during subzero weather when No.2 diesel fuel can cause engines to stall. During the 1986-87 heating season northeastern Minnesota became concerned about supplies when a pipeline between Duluth and the Twin Cities was closed following a fatal accident in Mounds View, Minnesota.

Minnesota can experience limited, short term supply problems because of its distance from major United States refining centers along the Gulf Coast of Texas and Louisiana.

Figure 5

Crude Oil Price Forecast, U.S. Department of Energy

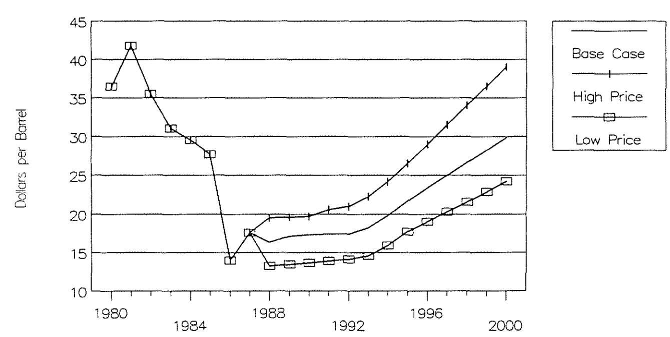


Table 1
Price Outlook for Crude Oil and Gasoline Under Three Scenarios

	Constant 1987 Dollars				Annual Percent Growth		
	1987	1990	1995	2000	1987-90	1990-95	1995-2000
U.S. Average Crude Oil Cost ($ Per Barrel)							
Base Case	18.11	17.81	22.40	30.76	-0.6	4.7	6.5
Low Price		13.61	16.40	24.93	-9.1	3.8	8.7
High Price		20.30	27.29	40.19	3.9	6.1	8.0
Minnesota Gasoline ($ Per Gallon)							
Base Case	.98	1.02	1.13	1.33	1.3	2.1	3.3
Low Price		.92	.99	1.19	-2.1	1.5	3.7
High Price		1.08	1.25	1.56	3.3	3.0	4.5

Source for Figure 5 and Table 1: *Annual Energy Outlook 1987*, U. S. Department of Energy, Energy Information Administration

Minnesota is supplied primarily by four local or nearby refineries—two in the Twin Cities area (Koch Refining and Ashland Oil); one in Superior, Wisconsin (Murphy Oil); and one in Mandan, North Dakota (Amoco Oil). These refineries receive crude oil by pipeline primarily from Canada and North Dakota and ship refined petroleum products by pipeline to distribution points throughout Minnesota and the Upper Midwest. Additional pipeline links to Kansas, Oklahoma, and the Gulf Coast link Minnesota to major U.S. refining centers. See Figure 6.

The four refineries generally produce enough gasoline and other fuels to supply Minnesota and the surrounding region. When unexpected changes occur in local production or demand, petroleum supply companies must ship additional supplies north by pipeline from refineries in Kansas and Oklahoma. If necessary, additional supplies must be shipped by pipeline into the Midwest from Gulf Coast refineries.

LONG TERM OUTLOOK FOR PETROLEUM

World petroleum resources could be widely available during the first half of the 21st century, but a specific long term forecast would be highly speculative. Because petroleum is a nonrenewable resource, current issues of supply and cost will inevitably become more important.

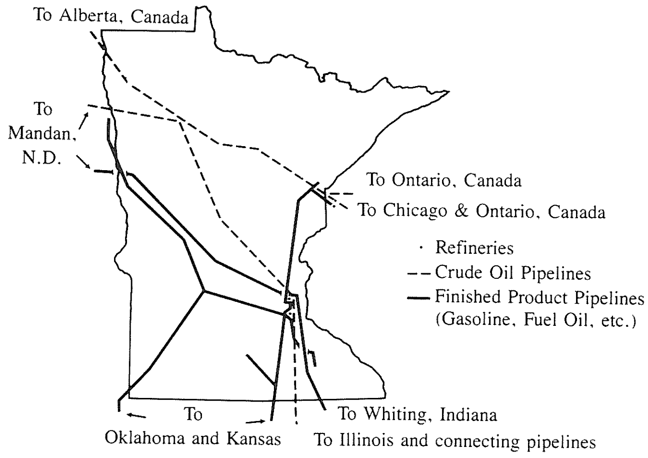
Comparing estimates of world petroleum resources to forecasts of world consumption suggests that total resources will be significantly lower by the end of the next decade. According to U.S. Geological Survey estimates, petroleum resources in the world's market economies, including both proved and undiscovered resources, totaled between 880 and 1,330 billion barrels in 1985. A forecast by the U.S. Department of Energy projects that free market countries will consume 287 billion barrels from 1985 to 2000. Thus, total resources may decline by 18 to 32 percent during this 15 year period.[5]

At least two factors could reduce availability of these resources after the year 2000. First, a pronounced growth in petroleum consumption could emerge in response to continued low prices, causing remaining resources to be depleted more rapidly. Second, reserves will continue to be concentrated in the Middle East; relations with Middle East nations, therefore, and the political stability of that region will continue to be very important.

Further increases in petroleum resources are also possible. Use of technologies to extract additional oil from depleted reserves (enhanced oil recovery) may increase in the future. Extraction of "extra heavy" (extremely viscous or thick) oil resources and of tar sands (sand impregnated with petroleum that dries to viscous or solid bitumen) is another possibility. These resources would be costly, however, and may not be able to compete with developments in renewable energy sources during coming decades.

Figure 6

Minnesota Petroleum Pipelines



Source: Minnesota Department of Public Service, Energy Division

4

OPPORTUNITIES TO IMPROVE ENERGY EFFICIENCY

Living well and using less energy; reaping the benefits of improved technology.

ENERGY EFFICIENCY TRENDS BY SECTOR

Minnesotans use energy much more efficiently today than in 1960. Conservation measures developed in response to the energy crises of the 1970s have altered the proportional relationship between income and energy use; income is now rising as per capita energy use is falling. This development affects every economic sector in Minnesota. This section examines this trend for each Minnesota sector, using various measures to determine the ratio of energy use to economic output.

Growth in income in Minnesota has far exceeded growth in energy use. This is a new phenomenon, energy use and income having previously increased in proportion to each other. This new relationship between energy use and income may reflect improving energy efficiency. Following is an examination of energy efficiency trends by economic sector, using various measures to determine the ratio of energy use to economic output. In the case of the residential sector, energy use per household is the standard used.

RESIDENTIAL SECTOR

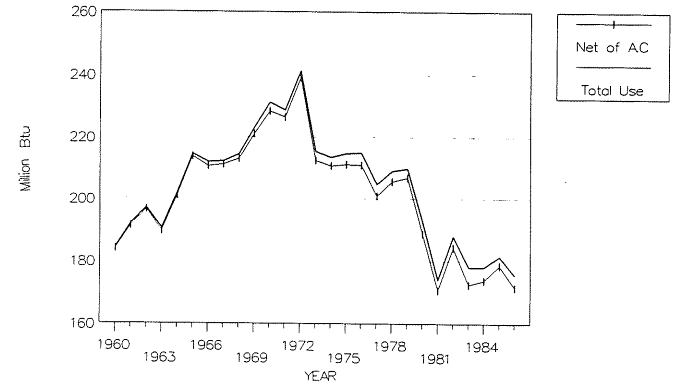
The opportunities for residential consumers to conserve energy have increased substantially in the past several years. New major appliances such as refrigerators, water heaters, and air conditioners use much less energy than previous models. Many energy saving devices such as highly efficient furnaces, double and triple pane windows, and improved insulation have become standard features in most newly constructed housing.

Figure 1 illustrates the trends in energy use per household in Minnesota since 1960. The top line in Figure 1 is total energy use in Minnesota divided by the number of households. This measure understates the conservation that has occurred in the past few decades because it does not take into account the increased portion of energy consumed by air conditioning. Air conditioning is much more prevalent in the 1980s than it was in the 1960s. The lower line in Figure 1 indicates energy use *minus* estimated Btu consumption by air conditioners, thus showing a greater drop in energy use for activities other than air conditioning.

Clearly evident from Figure 1 is the rapid improvement in residential energy efficiency that occurred after the first major oil price increase of 1973. Also evident is the increasing share of energy used by air conditioning. Air conditioning is the major contributor to peak electric demand in the summer, thus straining the capacity of the electric grid.

Figure 1

Residential Energy Use Per Household in Minnesota



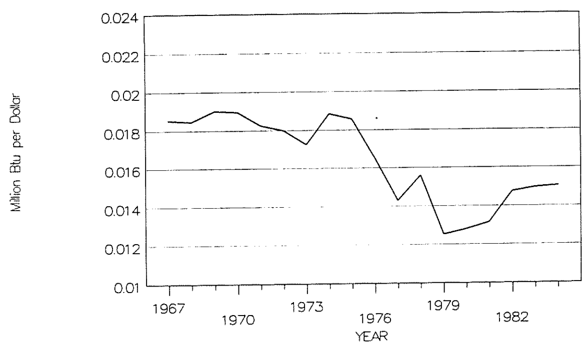
Source: *Minnesota Energy Data Book, 1960-86*, Minnesota Department of Public Service, Energy Division. Estimates of air conditioning energy use from Minnesota Department of Public Service, Energy Division.

COMMERCIAL EFFICIENCY

The rapidly growing commercial sector has increased its energy use faster than other economic sectors have, but it has also become more efficient in its energy use. Figure 2 shows the ratio of energy use to income in the commercial sector. Following the oil price increase of 1973, energy use per dollar of income fell dramatically. A more rapid drop in this ratio occurred following the second major oil price increase. The recent leveling off of petroleum prices has altered this drop in the ratio of energy use to income. Low energy prices will likely encourage more energy use in the commercial sector. Future improvements in energy efficiency, however, could also be significant if new technologies for lighting, space cooling, and refrigeration are adopted. Lighting, for example, accounts for more than half of the electric energy used by the commercial sector.

Figure 2

Ratio of Minnesota Commercial Energy Use to Personal Income*



*Total wages, salaries and other income from employment in the commercial sector.

Source: Minnesota Department of Public Service, Energy Division. Data sources include U.S. Department of Commerce, Bureau of Economic Analysis and U.S. Department of Energy, Energy Information Administration.

INDUSTRIAL SECTOR

The large reductions in energy use over the past two decades by the industrial sector account for the greatest share of the reduction in energy use in Minnesota, and they are due in part to significant improvements in energy efficiency. Figure 3 shows the ratio of energy use in manufacturing to value of shipments in the United States, and the ratio of energy use per unit of manufacturing output in Minnesota. (The industrial sector also includes mining, but comparable data are not available for mining.) The significant difference between the two graphs is most likely the result of differences in products between Minnesota and the U.S.: that is, Minnesota has fewer energy intensive industries such as primary metals, chemical products, and petroleum refining. Figure 3 also suggests that Minnesota manufacturers are improving their energy efficiency somewhat more rapidly than manufacturers are in the rest of the nation. It should be noted, however, that another interpretation is possible: Minnesota manufacturers may simply be changing to less energy intensive products at a faster rate than the country as a whole. Future efficiency gains in manufacturing are likely to come from rapid improvements in electric motor efficiency and heat recovery, and from continued development of more efficient manufacturing processes.

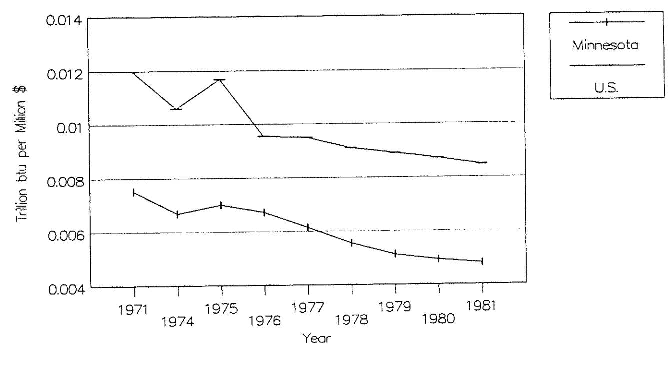
AGRICULTURAL SECTOR

Agriculture is heavily dependent on petroleum products for machinery and crop drying. Agricultural energy use has shifted away from gasoline toward distillate fuel oil. To the extent that this represents a switch from gasoline to diesel-powered machinery, improvements in energy efficiency have resulted.

Figure 4 illustrates the ratio of energy use in Minnesota agriculture to agricultural output. The drop in this ratio has been quite continuous and would appear to have accelerated in recent years, occurring at the same time as the farm population has dwindled. The decreasing farm population, combined with increased output, suggests more mechanized methods of production are used; these, in turn, are frequently associated with high energy use. The fact that Minnesota farmers have been able to reduce their energy intensiveness under these circumstances is even more remarkable.

Figure 3

Ratio of Energy Use in Manufacturing to Value of Shipments*

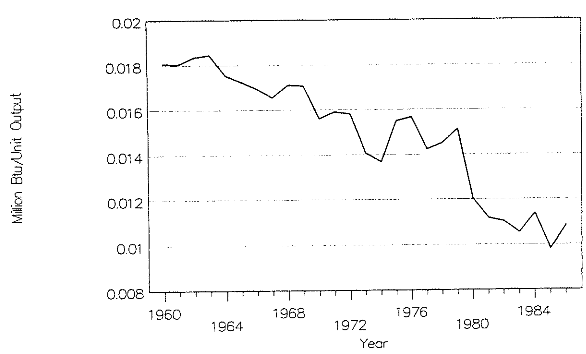


*Value of shipments is adjusted to exclude inflation.

Source: *Annual Survey of Manufactures and Census of Manufactures*, U.S. Department of Commerce, Bureau of the Census

Figure 4

Minnesota Energy Use and Agricultural Output*

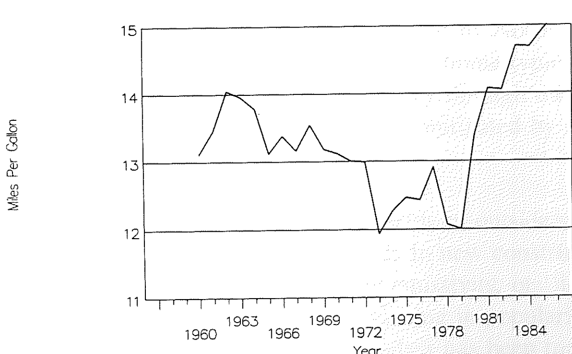


*Value of agricultural output, adjusted for changes in commodity prices.

Source: Minnesota Department of Public Service, Energy Division

Figure 5

Minnesota Average Miles Per Gallon for All Vehicle Types*



*Includes automobiles, trucks, and other highway vehicles.

Source: *Highway Statistics, Summary to 1985* and *Highway Statistics 1986*, U.S. Department of Transportation, Federal Highway Administration

TRANSPORTATION SECTOR

Efficiency improvements in the transportation sector have been sustained throughout the past decade. Figure 5 plots the average fuel efficiency of all motor vehicles in Minnesota from 1960 to 1986. Vehicle efficiency has improved nearly 27 percent since 1973. For passenger cars, improvement in miles per gallon has probably been close to 40 percent. It is noteworthy that these improvements in fuel economy have been accomplished at the same time that motor vehicle emissions have been greatly reduced.

Future trends in transportation efficiency are likely to be affected by improvements in technology, the rate at which consumers replace old vehicles with more efficient models, federal standards to increase motor vehicle efficiency, and changes in consumer tastes and petroleum prices. It is impossible to predict the rate at which changes in technology will occur, but possible innovations include ceramic engines, improved aerodynamics, new materials that reduce vehicle weight, and improved electric motors and storage devices that make electric transportation economically viable. Replacement of vehicles is likely to be strongly related to growth in personal income; replacement of old vehicles would result in higher overall fuel economy. Consumer tastes also affect fuel economy. The recent popularity of light trucks and four wheel drive vehicles (although they are fuel efficient compared to vehicles of the past) would indicate a lessening of consumer preference for energy efficiency in motor vehicles. Finally, if oil prices continue to remain relatively low, improvements in energy efficiency are likely to slow.

RECENT DEVELOPMENTS IN ENERGY EFFICIENCY TECHNOLOGIES

Rapid—and in many cases spectacular—advances in energy efficiency are making dramatic energy savings possible in all economic sectors. Technological developments in lighting, appliances, building components, cogeneration, and heat recovery provide the largest opportunities for energy savings. This section describes some of these developments and their potential application in homes, businesses, and industry.

RESIDENTIAL SECTOR

Refrigeration accounts for the largest share—22 percent—of residential electric end use.[1] According to Northern States Power estimates, the average refrigerator in use consumes about 1,249 kWh per year, with new 1985 units using 1,101 kWh.[2] The National Appliance Energy Conservation Act, passed in 1988, specifies minimum efficiency standards for appliances; the new guidelines include a mandate to lower energy consumption by refrigerators to 950 kWh by 1990. By replacing existing appliances with new ones meeting the standards, residential energy users in Minnesota will, by 2001, save 30 percent in energy costs to operate refrigerators, air conditioners, and freezers, and 15 percent in energy costs to operate hot water heaters.[3] Considering such savings, the early replacement of older, inefficient refrigerators is often cost-effective.

The new minimum standards require improved compressors, better gaskets, and improved insulation in other household appliances including freezers, ranges, and dishwashers.

Lighting. Another opportunity for lowering residential energy use is converting from incandescent lighting to fluorescent lighting.

Residential consumers must first accept the different physical appearance and lighting qualities of fluorescent lighting. The bulbs and tubes available today have improved color characteristics over the bulbs and tubes first put on the market. Traditional problems associated with fluorescents, including hum and flicker and a generally poor quality of light, have been substantially resolved. Problems with the bulkiness of fluorescent bulbs have been reduced by the introduction of low-wattage screw-in compact fluorescent bulbs and doubled tubes which will fit into most existing fixtures. A new circular screw-in fluorescent operates at a very high frequency which eliminates most of the flicker and all of the hum.

Several manufacturers now make compact fluorescents in various wattages and styles available to consumers. So far, manufacturers have not been actively marketing compact fluorescents. Although only a select number of outlets currently stock fluorescents, availability will likely increase as consumers become convinced of the substantial energy savings and easy adaptability of the lighting. For example, certain integral styles (with screw base, ballast, bulb, and cover all in one unit) cost approximately $10 and have an average life of 9,000 hours. They can replace a 60 watt bulb which costs about 70 cents and has an average life of 1,000 hours.[4] The higher front end cost combined with longer life means that fluorescents are especially cost-effective when they are purchased for high use locations. One common new fluorescent light would cost the equivalent of 2.32 cents per kWh if used 900 hours per year and cost the equivalent of 1.36 cents per kWh if used continuously. The compact fluorescents generally use 25 percent to 35 percent of the energy of incandescents for the same amount of light.[5]

Windows. According to findings reported by Northeast Utilities, a conventionally well insulated home typically loses about 24 percent of its heat energy through the windows.[6] These energy losses can be mitigated by several new window options.

A traditional single-glazed window with an outside storm has an insulation value of about R-2. In new construction it is often cost-effective to install low emissivity, or ''low-E'', windows and this type of glass is gaining in popularity among new home builders. Low-E glass has been treated to cut radiation losses or gains and does so with fewer glazings and less weight and bulk than traditional windows. Low-E windows can have R-values ranging from 5 to 8 or more, surpassing in value an uninsulated wall which has an R-value of about 5.

Gas filled windows are not common in the United States but could be more widely used in the future. These windows have several glazings with a heavier-than-air gas sealed between the panes. The gases, including argon, carbon dioxide, or other safe gases, slow the formation of convection currents between the glazings, thereby increasing the insulation value. Gas filled windows are often combined with a low-E coating, and some manufacturers claim an insulation value of almost R-6 for a double-glazed gas filled window.

Furnaces. The national average for furnace efficiencies has also improved from 61 percent for a natural gas or liquid propane furnace in 1976, to a 73 percent efficiency for the same type of furnace purchased in 1984.[7] Fuel oil furnaces have improved from 60-70 percent efficient in 1976 to 80-90 percent efficient in 1984, primarily because of the development of ''flame retention'' burners. At a cost of $600, with a three year payback, the flame retention burner is a very cost-effective retrofit.

COMMERCIAL SECTOR

Lighting represents approximately 47 percent of the commercial sector's electric consumption.[8] According to Minnesota Power estimates, the utility's commercial and industrial customers (excluding the large power customers) currently gain about 30 percent of their lighting needs through incandescents, nearly two-thirds through fluorescents, and the remaining presumably through high-intensity-discharge (HID) lighting.[9]

A new conservation development in commercial lighting is solid-state ballasts. Ballasts, which supply the proper voltages to activate the fluorescent light, also serve to prevent the light from quickly burning out by regulating the flow of electricity to the lamp. These new solid-state ballasts, which operate lamps at a higher frequency, cost about one-third more than traditional ballasts but last twice as long. Electronic ballasts also produce more light from the lamps with the same energy input as standard ballasts. Further, electronic ballasts are ideally suited for microelectronic sensing controls and other developing control technologies designed to prevent energy waste. Occupancy sensors will automatically turn off the ballasts when a room is unoccupied, saving an average of 50 percent of total use depending on the building type and function. PLC Incorporated* notes that the cost of occupancy sensors for a room varies, but that an average cost might be $2 per lamp with a maximum of $7 per lamp for smaller spaces.[10]

HID lighting and low pressure sodium lights are becoming attractive alternatives to incandescents in many commercial and industrial situations where high color quality is not required such as in parking lots, gymnasiums, and warehouses. HID lighting, which includes metal halide and high pressure sodium lights, provides from three to five times more light than incandescents while expending the same amount of energy. The energy savings easily makes up for the higher lamp costs and the expense of replacing bulbs.

Refrigeration accounts for approximately 10 percent of estimated Minnesota commercial energy consumption. The biggest users of refrigeration are food stores, food wholesalers, and restaurants. Many of the new developments that affect residential refrigeration are also being implemented in the commercial sector. These include minimum efficiency standards for these appliances and use of microprocessor-controlled compressors. In the commercial sector, parallel compressors can be employed for more efficient operation of cooling sources.

Cooking. Induction cooktops, which can save approximately 30 percent of currently consumed cooking energy,[11] will soon be readily available. Induction cooktops directly heat the metal of the stove and then the cooking pot rather than transferring heat from a stove element to the pot. If a commercial resistance stovetop uses 4,000 kWh per year (about 10 times the normal residential use), the cost of the conversion to an induction stovetop would be about 3.7 cents/kWh over a 20-year life. Also soon to reach the market will be biradiant ovens which operate using convection currents. Biradiant ovens use 65 percent less energy than traditional ovens.

Thermal storage. Substantial energy savings in both the industrial and the commercial sectors may be made through thermal storage. The process involves collecting and storing a building's internal heat (generated during the daytime by people, appliances, and lights) and using it to heat the building at night.

Air conditioning costs can be saved through thermal storage by the same storing and release process. Some institutions have already demonstrated how the process can work. A storage tank (or tanks) for cold water is installed in the building's air conditioning system. At night, the chiller cools the water in the tank. The chiller is turned off during the day and the precooled water circulates throughout the building, reducing significant peak energy demands.

INDUSTRIAL SECTOR

Motors. Currently representing over 70 percent of electric energy end use within the industrial sector, motors will be the prime focus for energy efficiency developments in that sector in the future.[12] Existing conservation measures that may be taken to curb electric energy use by motors are discussed in the section on Electric Conservation Potential, page 68.

Cogeneration. Cogeneration may be up to one-third more efficient than conventional power generation for certain industrial and commercial uses that can incorporate low pressure steam heat. Microprocessors, used to control cogeneration equipment, have been available for several years, but their recent price decline has allowed initial investment costs to drop significantly. This particularly affects small commercial cogeneration systems, since with larger systems, the initial investment costs are a smaller percentage of the total costs.

Use of cogeneration by small commercial facilities is encouraged through 1978 legislation that requires utilities to purchase excess energy produced by cogenerators. The law also requires that the energy be made available to utilities at reasonable rates. Major benefits of more widespread commercial cogeneration would be fewer investments in new power plants, less dependence on energy imports, and a lessening of fossil-fuel-fired generation.

Waste heat recovery—use of heat energy that would otherwise be released as waste— has been employed by about 40 percent of the state's industrial companies over the last 20 years.[13]

Mines, dairy companies, and food processing plants, among others, are reclaiming heat by applying methods unique to their processing needs. In most cases, the heat that is reclaimed is used to heat either water or air, thereby conserving energy and reducing operating costs and peak loads.

One of the more common techniques of heat recovery involves reclaiming waste heat from refrigeration systems. The heat normally rejected and wasted from the condenser is used to heat either domestic or process water, or air. The heated water or air is used to warm the buildings. This technique is used by restaurants, food stores, dairy farms, and food processing plants.

Another common improvement made in recent years is using air-to-air heat exchangers to transfer heat directly from one

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*See introduction to next section, page 68.

air stream to another. In winter, the heat energy removed from the exhaust air is used to preheat the incoming makeup air. In summer, some precooling of the makeup air is possible.

Several large Minnesota industrial plants installed heat recovery systems and have reported phenomenal savings in heating and cooling costs.

POTENTIAL IMPACT OF IMPROVED EFFICIENCY ON ELECTRIC CONSUMPTION

What is the potential for savings in electric energy consumption in Minnesota? PLC Incorporated, a firm with nationwide experience analyzing electric utility issues and options, identified available technology for improving electric efficiency and estimated its potential savings in Minnesota. The study did not address the problems or requirements—such as product availability or customer acceptance—involved in adopting such energy saving technologies. Rather, it sought to identify the technical potential for conservation and thereby allow energy saving options to be considered when public policy recommendations and decisions are made.

Substantial progress has been made over the past two decades in improving energy efficiency, but much more could be accomplished at comparatively low cost to energy consumers. A study of the electric conservation potential in Minnesota, performed by PLC Incorporated for the Department of Public Service, found that a substantial percentage of the electricity currently consumed could be saved without any reduction in convenience or standard of living.* Moreover, the cost of these energy savings would soon be paid for by lower electric bills. Some of the conservation measures cited by PLC are technically feasible, or conceivable for adoption in the very near future, but are not yet available on the consumer market.

The PLC study thoroughly examined electric consumption in Minnesota. Figures 1, 2, and 3 depict the uses of electricity by customer class for seven large electric utilities serving Minnesota. In the residential sector, water heating and refrigeration predominate, accounting for almost half of the total electric use. Although air conditioning consumes only a small share of total electricity used, its use is concentrated at certain time periods and plays a big role in creating peak demands that require high generating capacity.

Commercial electric use is dominated by lighting and air conditioning and ventilation which together account for almost 70 percent of electric use by that sector. In industry, electric motors account for more than 70 percent of all electric use. In some industrial groups—mining, for example—this share is considerably higher.

Figures 1 through 4 provide an overall view of electric use: Commercial and residential consumers each account for 30 percent of electric use, industry uses 27 percent, agriculture (excluding residential use on farms) consumes 3 percent, and other uses account for the remaining 10 percent. The

Figure 1

Residential Electric End Uses*

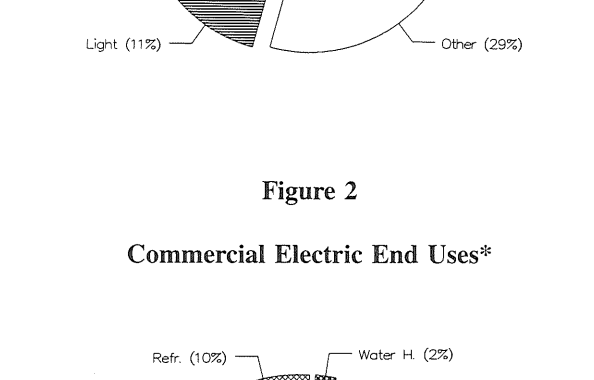
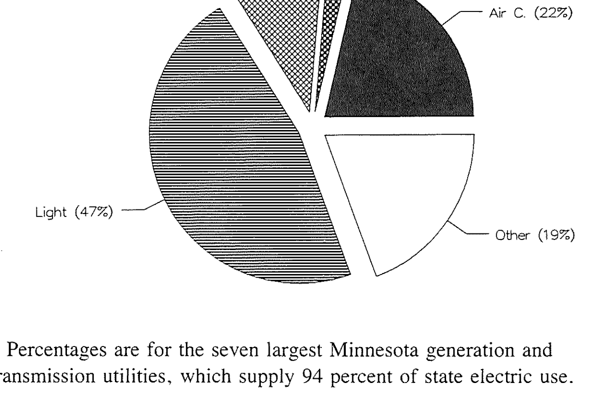


Figure 2

Commercial Electric End Uses*



* Percentages are for the seven largest Minnesota generation and transmission utilities, which supply 94 percent of state electric use.

Source: *Conservation Potential in the State of Minnesota*, PLC Incorporated, 1988.

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*Data presented in this section are all taken from *Conservation Potential in the State of Minnesota, Volumes I and II*, prepared by PLC, Incorporated for the Minnesota Department of Public Service, June, 1988.

Figure 3

Industrial Electric End Uses*

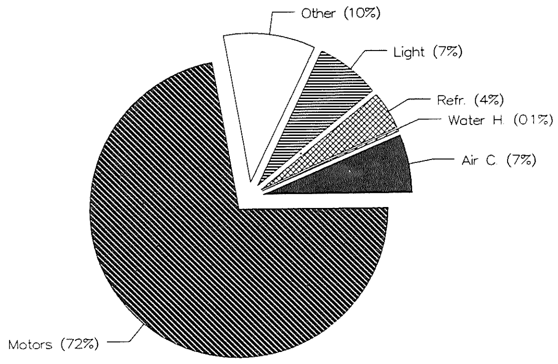
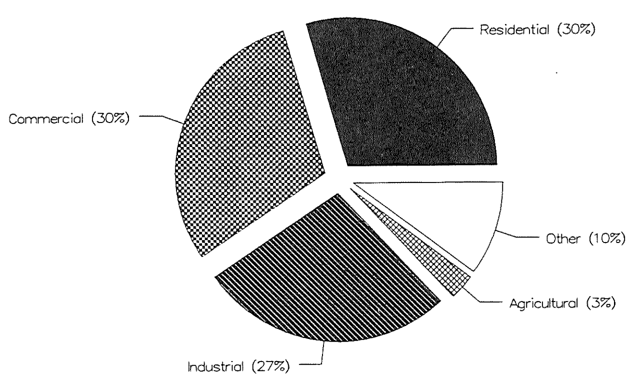


Figure 4

Electric Use by Customer Class*



* Percentages are for the seven largest Minnesota generation and transmission utilities which supply 94 percent of state electric use.

Source: *Conservation Potential in the State of Minnesota*, PLC, Incorporated, 1988.

Table 1: Electric Consumption by End Use

End Use	Consumption (GWh)	Percent of Total Electric Consumption
Air Conditioning	4,750	9.9
Water Heating	3,270	6.9
Freezer	1,060	2.2
Refrigeration	4,790	10.0
Dryer	890	1.9
Lighting	9,190	19.3
Motors	9,420	19.7
*Other	5,630	30.0
Total	39,000	100

* Includes cooking, space heating, dishwashers, agricultural process uses, etc.

share of particular end uses in total electric consumption is found in Table 1.

Most evident from Table 1 is the large concentration of electric consumption in comparatively few end uses. Lighting and motors together use almost 40 percent of the electric energy sold by Minnesota utilities. Obviously, comparatively small efficiency improvements in either of these uses would substantially affect electric consumption in Minnesota.

COST-EFFECTIVE ENERGY SAVINGS

In evaluating the cost-effectiveness of an energy saving measure, the cost of the measure (depreciated over its lifetime), the amount of energy savings, and the cost of electricity must all be considered. In calculating the cost of electricity, the impact of *not* saving electricity must be considered. In the absence of energy conservation, electric consumption will increase, thereby requiring new generating capacity. Additions to capacity increase electric rates. The cost of electricity, therefore, must include not only the direct costs of generating electricity (coal, operation, and maintenance), but also the costs of future capacity additions.

PLC used a "rough screening" cost, sometimes referred to as an avoided cost estimate, that included all of the above factors to determine which conservation measures would be cost-effective. The bulk of the conservation measures included in the total savings estimates, however, could be completed for less than half of full avoided cost.

ENERGY SAVING MEASURES

In terms of today's energy use, Minnesota consumers could theoretically save 19,700 gigawatt hours (GWh) of electricity if they took full advantage of the existing potential for electric energy conservation. This potential savings amounts to more than half (52 percent) of the energy used for lighting, refrigeration, and other major end uses. The potential for savings in each of these uses is illustrated in Figure 5. The amount of energy that could conceivably be saved through the efficiency measures described below could be compared to the amount generated annually by two large electric plants operating at maximum output. Figure 6 shows that the measures could theoretically reduce a utility's capacity requirements by 1,998 megawatts (MW).

The largest potential savings is from commercial lighting, which makes up over one-fifth of the total. Other major end use contributions to conservation potential come from industrial motors (about 12 percent), residential refrigeration (8 percent), residential water heating (7 percent), and commercial refrigeration (5 percent).

The improved efficiency measures now available that provide such a large potential for savings are summarized below. The PLC report includes a more detailed discussion of the savings estimates for all end uses within each sector. The estimates are of technical savings potential, that is, those savings that could be achieved with current products or readily available technologies. In all cases, the new products would not require any compromises in performance or other characteristics compared to current products.

The estimates are not adjusted for a number of barriers that can limit adoption. Some products are available but not widely distributed, and some new technologies are available but are not yet in production. The estimates are intended to be conservative enough, however, to recognize limited consumer acceptance of some new technologies. For example, some consumers may not prefer more efficient stove top surfaces that are now available.

Technical savings potential includes improvements in efficiency that will naturally take place over time through replacement of older, less efficient appliances and other actions. Additional savings would need to be accomplished through public or utility sponsored programs or strengthened energy efficiency standards.

Figure 5

The Potential for Electric Conservation by Major End Use

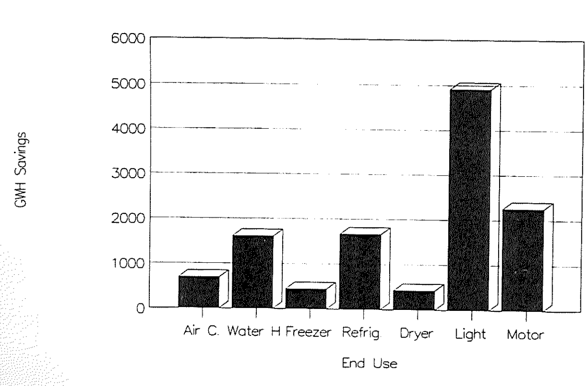
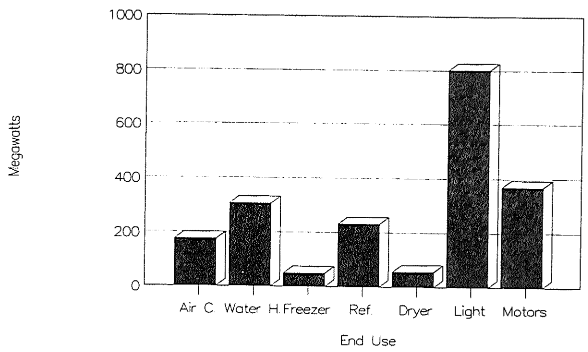


Figure 6

Capacity Savings From Conservation (Technical Potential = 1,988 MW)



Source for Figures 5 and 6: Minnesota Department of Public Service, Energy Division. Estimates based in part on *Conservation Potential in the State of Minnesota*, PLC Incorporated, 1988. See Table 1 of the section on Minnesota's Electric Supply Needs for further information (page 51).

RESIDENTIAL SECTOR

Refrigeration represents about 20 percent of residential electric end use. Refrigeration efficiency can be improved through better insulation, improved compressor and evaporator design, improved motor efficiency, reduced leakage through door seals, and separation of the refrigerator and freezer functions. Table 2 illustrates the costs and effectiveness of proposed efficiency improvements that could be made by the manufacturer at the production stage. Based on a traditional refrigerator using 1,354 kilowatt hours, simply substituting foam insulation for existing insulation in the door, at a cost of $7.38, would reduce the kWh use to 1,208. Substituting a more efficient compressor at a cost of $7.44 would further reduce the refrigerator's energy consumption to 1,072 kWh Adding an anti-sweat switch to control condensation during warm weather, priced at $8.17, would bring the kWh use per year down to 978. At this point the cumulative cost is equivalent to 0.54 cents per kWh with an investment of $22.99.[12]

The PLC report stated that if the conservation measures described above and in the table were adopted, refrigeration energy use would be reduced by 80 percent.

Table 2. Savings and Cost-effectiveness of Possible Improvements to Refrigerators at the Time of Manufacture

Measure[1]	Use kWh/yr	Measure Cost	Incremental Cost per kWh Saved (Cents/kWh)
Base Case	1354	$ 0.00	0.00
Foam Insulation substituted in door	1208	$ 7.38	0.45
Increase compressor EER* to 3.65	1072	$ 7.44	0.49
Anti-sweat switch	978	$ 8.17	0.77
Increase door thickness to 2″, cabinet insulation to 2.4″, and freezer insulation to $2\frac{1}{2}$″	768	$18.64	0.81
High efficiency fan	688	$10.98	1.22
Added cabinet insulation & freezer insulation	613	$13.18	1.57
Increase EER to 4.5	518	$27.45	2.57
Evacuated panel	228	$88.40	2.72
Increase EER to 4.8	217	$ 5.49	4.5

1. Measures are listed in order of cost-effectiveness

* EER—Energy Efficiency Ratio

Table 3. Cost-Effectiveness of Added Insulation: 80-Gallon Water Heater

Added Fiberglass[1] (inches)	Annual kWh Losses Total	Incremental Cost per kWh Saved (cents/kWh)
—	1314	—
3	554	0.75
6	383	0.56
9	307	1.57
12	264	3.38

1. Addition of insulation to a standard water heater with two inches of fiberglass insulation

Water heating, representing approximately 21 percent of the residential total, is equal to refrigeration in residential electric use. Water heating is particularly amenable to conservation. Standby losses from water tanks and piping are about 1,000 kWh per year on a standard water heater. Standby losses are caused by the substantial difference between the water temperature and the surrounding air temperature and the relatively large area involved. High-efficiency tanks with twice the insulation value of standard tanks have 50 percent less heat loss.

Standby losses on standard tanks can be reduced substantially by wrapping the tank with insulation. Table 3 shows the savings based on insulation thickness and the difference between the heated water and the air temperature. For example, three inches of fiberglass insulation added to an 80 gallon tank with a temperature difference of 85 degrees would reduce the annual standby losses from 1,314 kWh to 554 kWh.

Turning down the water tank temperature setting to a recommended 120 degrees Fahrenheit will reduce standby losses and losses in clothes washers, tubs, sinks, and showers when extremely hot water is not necessary. A survey conducted by Northeast Utilities found that 71 percent of its consumers set their tank temperature at 140 degrees Fahrenheit. The utility advised those customers that they could save approximately 443 kWh a year by reducing the setting to the recommended level.

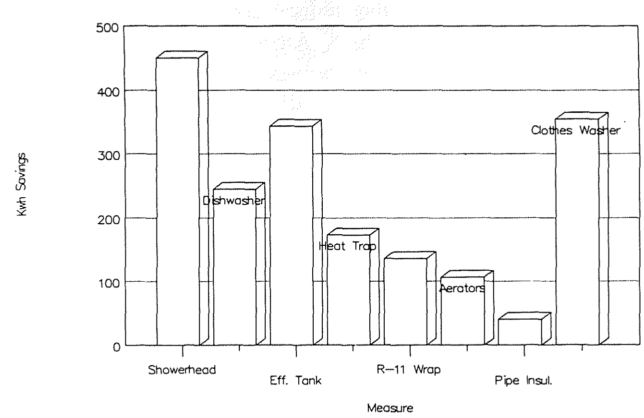
The bottoms of water heaters and pipes can also be insulated and will result in savings. Northeast Utilities estimated that insulating a 20-foot pipe located in the basement would cost about $12 (in 1983 dollars) and would save 40 kWh a year. Heat traps, which are S-shaped curves, can be added to the pipes when a new water heater is installed to reduce the passive circulation of hot water in the piping. A bottom board of high insulation value foam can also be added easily at the time of tank installation. The Northwest Power Planning Council estimates that such a bottom board can save 26 kWh if the new tank has an R-value of 20. For standard tanks, the savings would be closer to 50 kWh. The heat transfer from the heating elements to the water can be improved by draining the sediment from the tank. Draining the sediment will reduce annual electric consumption by about 200 kWh.

More efficient devices such as showerheads, faucet aerators, and clothes washers with better fill controls and a "suds saver" cycle will also use less hot water. Energy efficient dishwashers, which incorporate such features as increased pressure and reduced water volume, are on the market and cost no more, and sometimes even less, than inefficient models.

PLC found that all of the measures described above are cost-effective at current electric rates. If all of the measures were adopted, the savings would equal about 2,600 kWh or 35 percent of water heating energy use. Figure 7 shows the savings for implementing each measure.

Figure 7

Water Heating Savings (kWh/Yr)



Source: *Conservation Potential in the State of Minnesota*, PLC Incorporated, 1988.

Another step to make water heaters even more efficient is to replace resistance heating with a water heating heat pump. Add-on heat pump units cost about $600 installed. Assuming that other efficiency measures have already been made and that the consumer is using 2,000 kWh per year or more for water heating, the heat pump is cost-effective at $600. For households that consume over 2,000 kWh of hot water energy, heat pumps could reduce total water heating energy use by 40 percent or down to 1,200 kWh from the standard 4,000 kWh.

Lighting. Opportunities for saving in lighting, the third largest area of residential end use at 11 percent of the total, were described in some detail in the previous section. Most of the energy efficiency measures for lighting are relatively new developments. By implementing such available technologies as compact fluorescents, switchers, timers, and occupancy sensors, residential lighting costs could conceivably be reduced by about 50 percent.

Cooling. Residential air conditioning accounts for only 6 percent of energy sales, but represents approximately 20 percent of residential contribution to summer peak electric loads. A disproportionately large fraction of air conditioning load is concentrated in the Twin Cities metropolitan area, served mainly by Northern States Power. The normally short cooling season in Minnesota makes the highest levels of air conditioner efficiency less cost-effective than they are in other areas; since peak loads directly affect energy costs, however, it is prudent to initiate peak load conservation measures.

Residential air conditioning loads can be reduced by improving efficiency in the air conditioners themselves, by reducing heat gain in the building, and by using alternative methods of cooling buildings and their inhabitants.

Ground-water and earth-coupled heat pumps will generally provide cooling efficiencies. A central air conditioner condenser or the unit can be shaded from the sun or cooled with a mist when in operation. Ceiling fans can produce sufficient air motion in some cases to allow 15 percent to as much as 50 percent reductions in cooling energy consumption. Low-emissivity window coatings, increased insulation levels, and shade trees and shrubs can all lessen the need for air conditioners.

Overall, residential cooling conservation of 35 percent could be achieved, according to PLC.

COMMERCIAL SECTOR

Lighting. Lighting dominates electric end use in the commercial sector, representing nearly half of the total energy consumption in that field. PLC estimates that the commercial sector could reduce present energy use for lighting by 80 to 90 percent if developing and currently available options were adopted.

Conventional fluorescent lighting holds many opportunities for conservation. The efficiency of the light fixture can be increased by adding a mirror (specular) coating, which directly reflects light back into the room. Where a somewhat dirty fixture is refitted with a specular reflector, half of the tubes can be removed without any appreciable loss of light. This represents a 50 percent energy savings if the corresponding ballasts are also removed and replaced with energy efficient ballasts.

Standard ballasts can be replaced with electronic ballasts using 2 watts, rather than 8 watts, per lamp. The energy efficient ballasts cost about one-third more than standard ballasts but last twice as long. As a result, the overall 12 kWh savings comes at no additional cost.

Cooling. Many of the cooling conservation measures described above in the residential section may be applied in both commercial and industrial situations. Briefly, these are: shading windows, walls, and roofs; increasing insulation; improving the thermal performance of windows; and selecting light colored paints and roofing materials. Energy use for cooling is much higher for commercial users than for the residential sector: many commercial buildings require cooling for a major portion of the year, even when outdoor temperatures are low and residential buildings require heating. The difference is due to the large amount of solar heat gain in high-rise offices and the internal heat gains from occupants and equipment.

Internal heat gains can be reduced by directly venting loads, such as waste cooking and computer heat, to the outside. Schools, other institutions, and office building cafeterias could implement this measure. Light fixtures can be designed so that a large fraction of the waste heat is captured by the exhaust air stream and carried out of the building.

Other means can be used to reduce energy use for cooling. When outside air temperatures are cool, this air can help cool the inside of the building by employing an "economizer cycle." Another method is to reduce the temperature of the cooling cycle heat sink by using an evaporative cooling tower, surface water, ground water, or a ground-coupled water loop as the heat sink. These lower-temperature energy sinks may reduce cooling energy requirements by about one-third. Air-to-air heat exchangers allow for the recapture of the coolness of air which is being exhausted to the outside and also allow for reclaiming heat that would otherwise be exhausted in the winter.

Control of the chiller equipment can affect the cooling load. Chillers, like many other types of equipment, operate inefficiently at half load. Automatic control equipment can distribute the cooling load among unequally sized parallel units, so that the most efficient combinations are used to meet any load. Control systems can cycle or turn off equipment when it is not needed and adjust evaporator and condenser temperatures for optimal operation. These controls can save 15 to 30 percent or more of cooling use, depending on the particular winter temperatures.

Passive heat pumps may be used in seasonal ice storage. In this instance, the pump can be used to direct the cold refrigerant to an evaporator in a bottle of water, which would freeze over the winter. The ice block can be arranged around a storage space and used for simple refrigeration, or it can be used as a heat sink for the condenser of refrigerators, freezers, and central air conditioning.

The total potential for commercial space cooling energy reductions depends on a number of details, such as the distribution of system designs, the availability of adjacent land space for ground/water-coupled cooling and seasonal ice storage, building designs and orientations, and the efficiencies of existing equipment and operating cycles. Considering the wide range of options, PLC estimated the achievable potential to reduce commercial cooling cost to be 50 percent or more.

Air conditioning represents 22 percent of commercial sector end use, second only to lighting. A 50 percent reduction in commercial cooling represents a savings of about 1.8 percent of all electric energy consumption in the state.

Refrigeration represents approximately 10 percent of estimated Minnesota commercial electric consumption; its use is concentrated in food stores, food wholesale buildings, and restaurants. Commercial refrigeration energy use can be reduced through most of the strategies discussed in the residential refrigeration section. Those strategies include improved compressor efficiency, improved wall insulation and gaskets, anti-sweat switch, and passive cooling. Commercial refrigeration can also adapt some of the methods used in commercial cooling, such as variable-speed controls and use of multiple parallel compressors controlled by a microprocessor for combinations of cooling sources. The following are some opportunities unique to commercial refrigeration.

Open display cases in retail food stores can be partially closed off by doors or plastic strips during the sales period, and closed off and insulated when the store is closed to customers. These measures reduce the load on the refrigeration equipment and extend the life of the equipment.

Some refrigerated warehouses and food store storage areas can be retrofitted with additional insulation. Very high levels of insulation can be very cost-effective in frozen food storage areas where large temperature differences exist.

PLC surmised that the commercial refrigeration energy savings potential is 80 percent or higher. Many of the new efficiency options in the commercial sector can be implemented quickly because they can be added onto existing systems as individual measures, unlike the residential sector which is serviced mainly by single appliances.

Ventilation. Approximately 8 percent of Minnesota's commercial electric energy use goes toward powering the fan motors of ventilation systems. Most of those fans operate continuously at a constant speed, regardless of the needs of the building. Fan use can be reduced through better control and motor efficiency improvements. Variable air volume systems (VAV) are one method for reducing energy use. Reducing air flow reduces proportionately the speed of the fans and dramatically reduces their energy requirements. A speed reduction of 25 percent, for example, reduces energy requirements by 58 percent. Adding electronic variable-speed fan drives and automatic controllers can produce very large savings whenever the ventilation system is not operating at full output. In Minnesota, which has high maximum temperatures but a fairly low number of hours close to those conditions, savings from VAV systems are likely to be greater than in many parts of the country. Ventilation savings of 50 percent are typical at a cost of a few cents per kilowatt hour.

It may be feasible to reduce ventilation of some buildings while maintaining air quality. The ventilation rates of many buildings can be reduced either as part of a VAV system that reduces fan speeds or use to more accurately reflect need. These reductions need to be consistent with building code requirements for ventilation.

Cycling the ventilation system on and off, though less efficient than VAV systems, is effective in that it will prevent overheating or over cooling. Cycling is also a very inexpensive method of reducing ventilation energy use.

High-efficiency fan motors, compared to standard motors, provide energy savings at a cost of 1 cent or less per kilowatt hour saved. Early replacement of existing fan motors may be cost-effective, at roughly 5 cents per kWh. PLC found that these motors, when combined with better drive belts, motor controls, and similar equipment, might conceivably reduce ventilation energy use by 20 percent.

INDUSTRIAL

Motors. Motor loads represent approximately 72 percent of industrial electric end use. There are many ways to reduce electric use from motors.

Standard motors can be replaced by high-efficiency motors that use stronger wire windings, higher quality steel cores, and improved geometry. Efficient motors save 5 to 15 percent of energy over new standard motors, for units of 50 horsepower (HP) or less, and 2 to 5 percent for larger motors. For motors of 1 HP or more, the efficient unit is cost-effective for new or required replacement motors with duty factors below 10 percent. (See Table 4.)

The early replacement of standard motors with high-efficiency motors will also be cost-effective for motors run 100 percent of the time and for those run only 18 to 25 percent of the time, depending on motor size.

Savings are even greater if the motor being replaced is not as efficient as today's standard motors. The cost-effectiveness of early replacement of motors installed during the 1960s is high since most of the old motors would have to be replaced within the next 10 to 15 years.

The materials of the motors and their bearings deteriorate with age and wear. Often, burned-out motors have been rewound rather than replaced with new motors. Rewound motors are generally less efficient than new motors because of damaged cores and less efficient wiring. Replacing older motors may result in a 5 to 15 percent savings depending on the size of the motor and the level at which it is used—from half load to full load. Replacing older motors with today's efficient motors is an economical investment in almost all cases.

Table 4. Efficiency and Price Differentials for Standard and Efficient Motors

Motor Size (hp)	Added Cost ($ Per hp)	Efficiency Improvement at Partial and Full Loads 1/2	3/4	Full	Cost Per kWh Saved* (Cents)
1	66	21.5%	14.6%	14.3%	0.45
5	20	4.2%	5.6%	6.8%	0.39
10	13	7.1%	6.8%	6.8%	0.22
25	9	4.0%	4.0%	4.9%	0.25
50	8	5.5%	4.6%	4.6%	0.18
200	8	2.4%	2.1%	2.7%	0.38

* Based on 20 year motor life and an average of $\frac{1}{2}$ and $\frac{3}{4}$ loads.

Many industrial motors may be oversized for their use. Reducing the size of the motor, as its full-load efficiency is upgraded, will further increase the energy savings. The cost of downsizing is far outweighed by the resulting savings. If a booster motor or other control system is necessary to overcome starting loads, there may be a small cost. In some cases, oversizing is used to avoid overheating in dirty or hot environments. In these situations, an air or water cooling system must be added to allow downsizing. Depending on the sizes of motors and of loads, the potential for reduced electric use may be 1 to 2 percent of current consumption.

Partially-loaded motors tend to have poor power factors, increasing line losses throughout the electric distribution system. Line losses can be reduced by correcting the power factor of motors close to the location of the motors, rather than at the plant entrance or at a more remote site. Since the cost of the correction is about the same at either location, the reduced losses are essentially free.

Motors that drive pumps or fans may operate much more efficiently at lower speeds. For example, blowing more air with a larger, slower fan, will be much less demanding of energy than blowing less air with a small, high-speed fan.

Many fans and pumps operate at constant speed, and the output is reduced as required by dampers or throttle on the flow into or out of the fan/pump, or by cycling the motor on and off where constant flow is not important. At best, these strategies reduce energy use only proportionately from the full-load level. More typically, throttles and dampers may decrease energy use by less than a third of the reduction in flow. A much more efficient alternative is an electronic variable-speed drive, which reduces induction motor speed to match the load by changing the frequency of the input power.

Variable-speed drive prices are in the neighborhood of $100-400 per horsepower for motors of 10 HP or greater, and $1,500 per HP for 1 HP motors, with prices falling as the technology is developed.

Motor speeds can also be controlled by power factor controllers (PFCs), which vary voltage rather than frequency. PFCs are usually applied to small motors, and therefore complement the variable-speed drives.

Motors operating pumps, fans, blowers, vacuum pumps, and compressors can save large amounts of energy through applications of microprocessor control systems; these systems allow motors to achieve optimum operating levels in milliseconds, reduce inefficiencies in the flow, and provide for safe operation with a minimum of wasted energy. Three-phase motors operate less efficiently if voltages supplied to the three phases are unequal. Unbalanced motors may be a few percentage points less efficient than balanced units.

A large portion of motor output can be lost in slippage and friction in drive systems. Improved drive systems, such as fiberglass-reinforced belts notched to engage slots on the drive wheels (or sprockets), can produce 15 percent savings in those applications.

Collectively, the energy improvements described above could improve the efficiency of motor use by 10 to 50 percent, depending on the type of industrial customer and its existing efficiencies. Food processing (the largest electric consuming group in manufacturing), chemicals, pipelines, and other industries that move large amounts of fluids would tend to have the higher savings potential, as would industries with many smaller motors. Large grinding motors, such as those in the taconite mills and pulp-and-paper mills, probably have the lower-range potential. Overall, a 30 percent improvement in motor efficiencies is probably achievable, according to PLC findings.

Other than motors and process energy uses, the major industrial energy uses are similar to major uses in the commercial sector: lighting, refrigeration, space cooling, ventilation, and space heating. The conservation options for these end uses will be similar to those in the commercial sector, with the following differences.

Other industrial energy uses. For lighting, lamps with poor color rendition are more acceptable in many industrial settings; also, the high ceilings of many industrial facilities allow for the use of high-output lighting that would be too bright in many commercial buildings. These factors tend to increase savings potential for the industrial sector and to reduce the cost of achieving these savings. PLC found that the lighting conservation potential, at 85 percent, is likely to be slightly higher in the industrial than in the commercial sector.

Industrial refrigeration systems tend to be even larger than commercial systems, allowing for more sophisticated controls and more efficient chilling equipment. Because industrial systems do not have the simple savings option for covering food display cases, the potential savings in industrial refrigeration at 70 percent will be a little less than that of commercial savings potential, according to PLC.

Specific processes using electric energy include process heat for melting, drying, and curing materials; radiation for treating materials, curing adhesives, and shrinking wrappers; electro-chemical processes, such as electroplating and electrolysis; compressors other than for refrigeration; and many others. Just as the end uses vary, the conservation opportunities vary among the processes.

Taconite mills consumed 4,100 gigawatt hours of electric energy in 1987. Although their use fluctuates yearly, the taconite mills could help determine the potential for Minnesota process energy efficiency. Virtually all of the taconite electricity is used in motors, for drilling, shoveling, crushing, transporting, grinding, concentrating, drying, and shaping the ore. The energy efficiency of the taconite producers varies widely depending on the size of the operation and the technologies they have adopted. The magnitude of the potential energy savings makes the taconite mills a very important area of industrial energy conservation.

AGRICULTURAL SECTOR

Dairying is the dominant electric consuming activity in agriculture, accounting for almost half of all electric energy use within the sector. Much of the electric energy use in dairying is in refrigeration which can be lessened through added insulation, improved compressor efficiency and controls, and other improvements described in the residential, commercial, and industrial sections. Dairy refrigeration use can also be reduced by precooling fresh warm milk in a heat exchanger or heat pump. The captured heat can then be used to heat or preheat some of the large supply of hot water required in dairying. Further cooling can also be accomplished with a well water heat exchange or with seasonal ice storage.

OTHER SECTORS

Governmental and seasonal residential electric use are included in the ''other'' sector. Some of the governmental electric uses are similar to commercial uses for offices, hospitals, prisons, and schools. Other governmental uses are more similar to those in industry, such as sewage treatment systems or water supply systems. Seasonal residential electric consumption goes for uses similar to those of regular customers. The reduced occupancy, however, may decrease the cost-effectiveness of some conservation measures.

The conservation potential for the ''other'' sector is estimated at between 34 to 61 percent, representing the range of conservation potential in the residential, commercial, industrial, and agricultural sectors.

Table 5 summarizes the technical savings potential for all the sectors. The end uses by sector are in the first column. The current percentage of use by end use is in the second column. The third column lists the percentage of conservation potential for each end use and the achievable kWh savings are found in the fourth column. The total savings estimate of 52 percent includes a wide array of specific efficiency improvements for each sector and end use of electricity.

Table 5

Conservation Potential by Sector, by End-Use[1]

End-Use	Percent of Use	Conservation Potential (%)	kWh Savings Potential (%)
Residential, Including Farm Residences			
Main Source Space Heat	3.4%	50%	1.7%
Dual-Fuel Space Heat	0.9%	50%	0.5%
Water Heat	6.2%	70%	4.4%
Central AC	1.2%	35%	0.4%
Room AC	0.5%	35%	0.2%
Refrigerators (Total)	5.9%	80%	4.7%
Freezer	1.2%	60%	1.3%
Electric Range	1.9%	40%	0.8%
Clothes Dryer	1.9%	65%	1.2%
Dishwasher	0.3%	85%	0.3%
Waterbed Heater	0.8%	43%	0.3%
Lighting	3.3%	50%	1.7%
Miscellaneous	1.4%		0.0%
TOTAL Residential & Farm	29.7%	58%	17.2%
Commercial			
Space Heat	1.7%	40%	0.7%
Water Heat	0.6%	80%	0.5%
Cooling	3.6%	50%	1.8%
Ventilation	2.9%	50%	1.5%
Refrigeration	3.1%	80%	2.5%
Cooking	0.7%	40%	0.3%
Lighting	14.1%	81%	11.4%
Miscellaneous	3.4%		0.0%
TOTAL Commercial	30.0%	62%	18.5%
Industrial			
Space Heat	0.4%	40%	0.2%
Water Heat	0.1%	80%	0.1%
Cooling	0.9%	50%	0.5%
Ventilation	0.9%	50%	0.5%
Refrigeration	1.1%	70%	0.8%
Process	2.2%		0.0%
Motors	19.8%	30%	5.9%
Lighting	1.9%	85%	1.6%
Miscellaneous	0.4%		0.0%
TOTAL Industrial	27.5%	35%	9.5%
Agricultural Uses	2.5%	48%	1.2%
Other (Government Sales, Seasonal Residential, etc.)	10.2%	50%	5.1%
TOTAL Minnesota[2]	100.0%	52%	51.5%

1. Percentage savings estimates for cooling and residential air conditioning include savings from more efficient lighting and other appliances. Less waste heat from several end uses can reduce cooling requirements.

2. Percentages are for the seven largest Minnesota generation and transmission utilities, which supply 94 percent of state electric use.

5

ENERGY CONSERVATION PROGRAMS AND STANDARDS

A representative sample of how government and industry, public and private organizations encourage energy efficiency.

SURVEY OF MINNESOTA CONSERVATION PROGRAMS

*How do Minnesota non-profit organizations and utilities encourage energy conservation? To answer this question, the Minnesota Department of Public Service hired an independent market research firm to conduct a survey of energy conservation programs in Minnesota. Minnesota electric and natural gas utilities and non-profit organizations sponsor a variety of energy saving programs, according to the survey. These programs include public information, energy audits, weatherization services, rebates for efficient appliances, furnace maintenance and repair, and activities to reduce the peaks in electric demand. A summary of the survey results follows.**

The Department of Public Service limited the survey to those organizations that offer at least one of the following energy conservation programs for their customers: public information, energy audits, weatherization, rebates, load management, and furnace services. The department was also interested in examining the costs and savings associated with conducting these programs. The survey did not include seven large electric and gas utilities that have implemented conservation programs in response to requirements administered by the Minnesota Public Utilities Commission.[1]

SURVEY PARTICIPANTS

Anderson, Niebuhr contacted 228 organizations, and 211 participated in the survey. Following is a breakdown of participants by category:

Rural electric cooperatives primarily serve residents in rural areas but they also provide service to some of the urban areas of the state. Twenty-five percent of the survey respondents are rural electric cooperatives. Each cooperative serves an average of 7,200 customers.

Municipal utilities – electric, gas, both. Forty-eight percent of the respondents are municipal utilities that provide only electricity. They have an average of 1,770 customers. Three percent of the respondents are classified as municipal utilities that provide only gas. They have an average of 6,470 customers. Seven percent of those surveyed are municipal utilities that provide both electricity and gas. An average of 4,480 customers are served by these utilities.

Non-profit organizations included in the survey are those community action groups that administer the U.S. Department of Energy's low-income energy programs and local government energy programs. Fourteen percent of the respondents are included in this category.

Other. Approximately four percent of the respondents for small utilities did not include their organizations in the categories described above. Two percent of the organizations are privately owned utilities that provide gas, one percent are privately owned utilities that provide electricity, and less than one percent provide both gas and electricity.

ENERGY CONSERVATION PROGRAMS

Public Information. Sixty-six percent of the respondents stated that their organization sponsored a public information program during the 12 months prior to the survey. All of these organizations provided information regarding energy conservation to residents. Eighty-six percent of the organizations indicated that they have provided information to businesses within the last 12 months.

Information programs included distribution of literature, with organizations sending out an average of 20,241 pieces during the year. Organizations answered an average of 493 calls from the public regarding energy conservation. Three-fourths of the organizations using public service announcements reported using radio, and 20 percent mentioned using television.

The total cost spent by all of the organizations on information programs was $1.1 million.

Energy audits. Forty-one percent of the organizations had conducted energy audit programs within the past 12 months. Nearly all of these organizations provided the service for single family homes (99%) and renters in single family homes (94%). At least 85 percent of the organizations offered energy audits to owners and renters in multi-family buildings. Sixty-eight percent of the organizations made energy audit programs available to both owners of and

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*Data presented in this section are from *A Survey of Organizations Concerning Energy Conservation Programs*, prepared by Anderson, Niebuhr & Associates, Inc. for the Minnesota Department of Public Service, July, 1988.

renters in multi-family buildings with five or more units. Three-fourths of the organizations offered energy audit programs to businesses in their area.

The number of audits conducted during the 12 month period averaged 211 per organization. The total cost paid by all of the organizations was $2 million.

Weatherization. Approximately one-fifth (21%) of the organizations offered weatherization programs. These services were offered to businesses by 10 percent of the organizations and to low income residents by 12 percent of the organizations. Seventeen percent of the organizations were involved in cooperative efforts with another weatherization provider.

Respondents indicated that the average amount of savings as a result of a weatherization program was $199 per participant. The average energy savings per participant was 270 ccfs for natural gas customers, 1,380 kWh for electric space heat customers, and 130 gallons for fuel oil customers.

The average cost to the organizations to conduct weatherization programs was $216,538. The costs ranged from $0 to $2,500,000. The total spent on weatherization programs by those organizations responding to the survey was $9.6 million, including state and federally funded low-income weatherization programs administered by local community action programs. (These programs were included in the non-profit category of survey respondents.)

Rebates for efficient appliances. Only utilities were asked about appliance rebate programs. Twenty-four percent of the respondents indicated they provided a rebate program during the last 12 months. The most often mentioned appliances included in the rebate programs were water heaters (84%), followed by furnaces (34%) and air conditioners (16%). One percent of the utilities offered rebates for refrigerators. Other appliances eligible for rebates mentioned in the survey were electric heating equipment, dual fuel units and pumps, electric thermal storage units, irrigation, central air conditioning, heat pumps, and dehumidifiers.

All of the utilities that offered rebate programs offered them to residents. Ninety-one percent offered rebates to businesses. The average number of participants in rebate programs, per organization, was 181 and the average dollar saving per participant was $207.

A total of $21 million was spent by the organizations on this type of program.

Load management programs. Only utilities that supply electricity were asked about load management programs. These programs can include a wide variety of activities to reduce customer electric load during peak demand periods, thereby reducing the need for higher electric generation capacity.

Sixty percent of the utilities reported having load management programs. Sixty percent of the organizations with load management programs offered residents radio-controlled devices to manage their appliances. Fifty-two percent of the organizations offered radio-controlled devices to businesses for appliance management.

Seventeen percent of the organizations offered timing devices without remote control by radio to manage residential and business appliances as load management devices. Seventy-two percent of the organizations offered curtailable or interruptible rates for businesses. Off-peak rates for residential space or water heating were offered by 83 percent of the organizations, with 80 percent offering this service to businesses.

All of the organizations together spent $4.2 million on load management.

Furnace programs. Only the organizations that provide gas and electricity or gas only, and non-profit organizations were asked about their furnace programs. Utilities that provide only electricity and rural electric cooperatives were excluded from this portion of the survey.

Slightly more than half (51%) of the organizations reported having provided minor furnace repairs or modification for residents. An average of 588 residents participated in the furnace programs that were offered.

The average annual dollar saving per participant in the furnace programs was $74. The average energy savings per participant was 60 ccfs for natural gas furnaces and 150 gallons for fuel oil furnaces.

CONCLUSIONS

Based on the data received, Anderson, Neibuhr made the following conclusions:

- Energy conservation programs offered most frequently were public information and electric utility load management programs. Public information programs were offered by approximately two-thirds of the organizations surveyed; at least one type of load management program was offered by 80 percent of the electric utilities surveyed.
- Less than one-fourth of the organizations offered weatherization or rebate programs.
- Average costs for programs varied widely, especially for weatherization programs where very high costs were reported by one or two organizations.
- Among the electric utilities that have rebate programs, over half of the respondents were unable to provide the information requested regarding peak load reductions.
- In terms of future programs, half of the organizations plan to expand their public information and load management programs.

The survey results suggest that Minnesota utilities and non-profit organizations have been actively involved in encouraging their customers to participate in energy conservation. Most of the involvement, however, has been in public information and utility load management programs. The low level of participation in some of the program areas that have tangible effects, such as rebates for efficient appliances, furnace repair or modification, and weatherization, indicates that greater efforts may be needed to promote public acceptance of conservation programs. The survey also revealed that there is a disparity among utilities in the extent of their conservation programs.

EXAMPLES OF INNOVATIVE UTILITY CONSERVATION PROGRAMS

Innovative and effective utility conservation programs from elsewhere in the nation are models that could be adapted to Minnesota. In addition, the state has its own examples of significant energy saving programs developed by utilities under the state's Conservation Improvement Program. Descriptions of these programs follow.

THE HOOD RIVER PROJECT

The effectiveness of a community wide program to improve energy efficiency among residential users of electricity was evaluated in the Hood River Conservation Project in Oregon.* The project sought to determine how much both overall electric use and peaks in electric use can be reduced by fully weatherizing electrically heated homes; how effective various marketing approaches are in achieving participation in the program; and what the dollar costs and social impacts are of such a program.

The Hood River Valley, northeast of Portland, Oregon, was chosen for the study because its climate, mix of rural and urban population, and variety of housing types and ages would make the results more applicable to other areas. The project was funded by the Bonneville Power Administration and operated by the Pacific Power and Light Company. It began in 1983 and ended in 1987.

Energy efficiency measures. The project goal was to install extensive weatherization measures in 100 percent of the electrically heated homes in the area at no cost to the household. The measures were aimed at reducing electric use for space heating and water heating, but did not include replacing heating or water heating equipment. They did include ceiling insulation, storm windows, door weather stripping, and outlet gaskets (installed in more than two-thirds of the homes), and duct insulation and thermal doors (installed in less than 15 percent of the homes).

Project development, marketing, and participants. A regional advisory group, composed of experts from diverse fields, was established to guide the project and maintain its research integrity. A community advisory committee, composed of Hood River residents, was formed to educate residents about the project and to learn of community concerns and questions. Participants for special projects were enlisted before community promotion began, and they proved crucial in promoting the project by word of mouth.

Participants were offered an extensive package of weatherization measures generally installed at no cost to the household. Prospective participants needed to make just one phone call to initiate the process. Of the eligible households, about 91 percent received at least an evaluation or audit of their energy efficiency needs; of these, 85 percent had major measures installed.

The participation rate for the Hood River Project was much higher than for other conservation programs. More than half of the participants learned about the project by word of mouth; information was also disseminated through newspapers, special articles, radio, TV, and billboards. The weekly newspaper was the second most important source, accounting for 28 percent of the participants' first awareness of the project.

The project attracted larger shares of low-income households, occupants of multi-family units, and renters. Non-participants were more likely to live in single-family homes, own their own homes, have higher incomes, and own newer homes.

Energy savings. Following installation of weatherization measures, participating households reduced their annual electric use by 15 percent, or an average of 2,600 kilowatt hours per household. Most of the savings were for space heating. In addition to lowering annual electric use, the measures decreased peak demand by about 10 percent (an average of 0.5 kilowatts per house). Due to a variety of factors (access to wood, high unemployment, and increases in electricity prices), electric use in the Hood River area was generally low before the weatherization program. For areas with higher electric use, savings even greater than these are probably possible.

Costs. The Hood River Project allocated money for weatherization measures based on the amount that would have been required to increase generating capacity. This

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*Information is taken from *The Hood River Conservation Project*, by Eric Hirst, Oak Ridge National Laboratory, Oak Ridge, Tenn., 1987.

amount was roughly four times the amount used in other residential weatherization programs in the Northwest. The total budget was $20 million: $14 million went for implementation and installation of weatherization measures; $1.6 million covered administrative costs; and $5 million went for research and evaluation. Average cost of the energy improvement measures was $4,400 per house, of which the project paid for 99 percent. Only 20 percent of the households paid any costs, with the average payment being $430.

Summary. The extremely high participation rate in the Hood River Project was due primarily to high community involvement and one-on-one communication, and to the full cost reimbursement for the weatherization measures.

COMMERCIAL BUILDING REBATE PROJECTS

Rebates offered to commercial and industrial customers who install energy-efficient equipment are the most popular energy saving measure sponsored by utilities, according to a recent survey by the Oak Ridge National Laboratory. Within five years, the number of utilities offering this type of incentive has grown from less than 10, located mostly on the West Coast, to almost 60 located throughout the country. The purpose of these rebate programs is to reduce both overall and peak demand, thereby deferring the need to construct new generating plants.*

Although deferring construction of generating plants is not an issue for municipal utilities or power cooperatives (since they purchase wholesale power and distribute it on their own systems), rebates have nevertheless become more prevalent among them. The Palo Alto Utility Department, for example, a municipal utility in California, has cut its load by 4.5 to 5 megawatts annually as a result of its rebate program.

Rebate programs focus on lighting and thermal energy storage, and most often feature straight payments per kilowatt saved or per piece of equipment. The scope and method of the rebate programs have widened in the past year, however, with some utilities offering grants and zero-interest loans for entire projects. Third-party rebates are offered by some equipment manufacturers or energy suppliers, such as interstate pipeline companies, and passed through the local utility to the end user who installs the qualified equipment.

Following are examples of utility operated commercial rebate programs that incorporate innovative approaches.

Northeast Utilities, Connecticut, began its lighting rebate/shared savings program in 1986. The utility offers incentives for installing energy efficient lighting fixtures, lamps, and ballasts in all types of buildings. Northeast's effort involves a limited shared savings program, whereby the utility serves as an energy service company, working with commercial customers in deciding what steps to take and negotiating a contract. The customer then pays the contractor based on how much energy is actually saved. Northeast's four-year goal is to reduce winter load by 28 megawatts and summer load by 34 megawatts.

Seattle City Light offers two types of rebates and plans to achieve its goal of improving energy efficiency in 150 buildings by 1989. Customers who use 6,000 to 48,000 kilowatt hours per year are eligible for rebates on specific actions recommended by an energy audit. Customers consuming more than 48,000 kilowatt hours per year also receive an energy audit to identify energy saving measures. If the measure will result in more than 2.5 years of savings to the customer and falls below an upper limit of 50 mills per kilowatt hour, the Bonneville Power Association will pay for the measure.

Commonwealth Electric, Wareham, Mass., and its subsidiary, Cambridge Electric, employ a shared savings or guaranteed savings contract. Any residential, commercial, or industrial consumer who has been a customer for a year or more is eligible for a rebate for installing energy saving equipment or practices, with the exception of fuel switching or cogeneration systems. The customer works through a contractor who guarantees the performance of the installed equipment either by a guaranteed savings contract or a shared savings contract. The contractor must be able to measure energy savings. The amount of the rebate varies and is based on the amount of energy saved and the type of equipment and its expected life.

Wisconsin Electric Power Company, Milwaukee, offered a zero-interest loan and rebate program to the Milwaukee School District. The district purchased 378,000 new fluorescent lamps at a cost of $1.08 per lamp and received a rebate from the utility of $1 per lamp. The district also received a five-year, zero-interest, $2.7 million loan from the utility to pay for the purchase of 75,000 electronic ballasts that will be installed by the district.

Puget Sound Power and Light's commercial and industrial energy conservation project gives the option of a grant of up to 71.8 percent of the amount of the energy efficiency project or a 10-year, zero-interest loan. Since 1980, after paying rebates to customers of $30 million, demand for the utility's electricity has been reduced by nearly 200,000 megawatt hours, or by an average of 23 megawatts per year.

Connecticut Light and Power Company, Hartford, sponsors an Energy Conscious Construction Program for developers of new commercial and industrial buildings. The program provides free consultation services and rebates for energy efficient heating, cooling, and lighting systems. The utility plans to serve about 44 buildings in 1988. Building construction plans are evaluated with a simulation model developed by the Lawrence Livermore National Laboratory, California, for the U.S. Department of Energy. Computer simulations determine energy use and costs based on original blueprints. Utility energy consultants then make recommendations and conduct a second simulation to show energy efficiency gains and cost savings. The utility has found that energy efficiency can be increased by up to 37 percent at no additional construction or installation costs, and that greater efficiency gains are often possible at a cost that can be paid for within a year by the savings realized.

MINNESOTA'S CONSERVATION IMPROVEMENT PROGRAM

Minnesota public utilities with operating revenues of $50 million or more are required by law to invest in conservation measures when the cost of the measures is less than the cost of increasing supply. (Minnesota statute 216B.241) The law requires that conservation projects be "cost-effective" and that special consideration be given to projects that benefit renters and low-income energy users.

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*Information on these rebate programs is taken from "Oak Ridge Study Spotlights Six Utilities with Model Incentive, Rebate Programs," *The Energy Report*, March 21, 1988, pp. 203-4; and "Utility Rebates," *Energy User News*, March 7, 1988, p.1.

The following are examples of Conservation Improvement Programs (CIP), directed at commercial users, that could produce substantial cost-effective energy savings.*

The Lighting Efficiency Improvement Project, operated by Northern States Power (Electric) Company (NSP), offers rebates to commercial and industrial customers for purchasing more efficient equipment for existing lighting systems, for replacing existing lighting systems with more efficient systems, and for installing efficient lighting equipment in newly constructed buildings. The project also extends to agri-business applications. NSP plans to spend about $1.5 million on the project in 1988 and expects a 12.9 MW demand reduction as a result.

The Motor Efficiency Improvement Project, operated by NSP Electric, promotes the purchase of energy efficient motors by offering rebates to commercial, industrial, and farm customers and to motor distributors. NSP plans to spend about $121,000 on the project in 1988, and expects a resulting 1,000 kW demand reduction.

The Commercial New Construction Rebate Project, operated by Minnegasco, Inc., Minneapolis, offers rebates to developers and building owners for incorporating specified levels of energy efficiency in new buildings. The project also includes an information program on the advantages of energy efficient buildings. Using both direct and mail contacts, Minnegasco promotes the project to key decision makers in the local new commercial building sector, including small commercial and multi-family building owners, designers, engineers, architects, and builders.

*For a complete review of the Minnesota CIP programs, see *Conservation Improvement Programs Ordered by the Minnesota Public Utilities Commission*, Minnesota Public Utilities Commission, 1988.

ENERGY EFFICIENCY STANDARDS

Energy efficiency technologies are promulgated through legislation and building codes that establish energy efficiency standards for appliances, equipment, and buildings. Minnesota and federal regulations, and their effect on energy conservation, are described below.

APPLIANCE AND LIGHTING STANDARDS

Legislation mandating energy efficiency has spurred research into developing new, more efficient appliances and methods of lighting. In many cases, industry has supported laws that conserve energy and protect the environment.

State legislation. An energy conservation measure passed by the Minnesota legislature in 1977 placed efficiency requirements on the sale of certain appliances.

The law stipulates that all room air conditioners and room air conditioner heat pumps sold in the state must have an energy efficiency ratio of 7.8 or higher. Among appliances with pilot lights that are prohibited from sale in the state are forced air type furnaces, gas cooking appliances equipped with an electrical cord, and clothes drying equipment designed to burn natural gas.

National legislation. Large efficiency gains are expected from new National Appliance Efficiency Standards for residential appliances. The law establishing these standards was passed by Congress and signed into law by the president in March, 1988. The new standards, according to one estimate, will result in a $26 billion net savings for consumers nationally, and a 21 gigawatt reduction nationally in peak electricity demand by the year 2000.[1] To benefit fully from these appliance standards and avoid new investment in power plants, utilities must factor the standards into their energy forecasts and plans.

An amendment to the standards, establishing minimum efficiency standards for fluorescent lamp ballasts, was signed into law by President Reagan on June 28, 1988. The standards establish minimum efficiency levels that correspond to high efficiency electromagnetic ballasts and are expected to save approximately 7,100 megawatts of capacity nationally by the year 2000. Corresponding dollar savings to building owners and occupants are estimated at almost $11 billion by the year 2000.[2] Appliance and lighting product manufacturers supported these measures.

Environmental concerns. Currently it is unclear how much difficulty manufacturers will encounter in meeting the requirements of both the national efficiency standards and new international environmental standards for chlorofluorocarbons (CFCs), a material used to increase the energy efficiency of certain appliances. Chlorofluorocarbons are suspected of depleting the stratospheric ozone layer which shields the earth from harmful solar ultraviolet radiation; continued loss of the ozone layer could cause widespread damage to the environment and to human health.

An international approach to inefficient and environmentally harmful appliance components was agreed to in the Montreal Protocol of September, 1987. The agreement, approved by representatives of 49 countries, will freeze CFC production in 1989 at 1986 levels and require a 50 percent cut in CFC production by 1999.

U.S. manufacturers of refrigerators and freezers face a paradoxical situation in attempting to meet both the 1990 National Appliance Efficiency Standards and the Environmental Protection Agency CFC regulations. To comply with the National Appliance Efficiency Standards, the use of CFCs for cooling and insulation would have to be increased by about 30 percent. Further, there are currently no acceptable substitutes for CFCs that could be mass produced in the U.S.

In March, 1988, the Du Pont Company, inventor of CFCs and the world's largest producer of the chemical, called for a total phaseout of CFCs, citing serious damage to the ozone layer as the reason for its position.

The U.S. Department of Energy is conducting research to identify and evaluate alternative technologies that do not use CFCs. The goal of this research, conducted in cooperation with the Environmental Protection Agency and appliance industry, is to develop cost-effective, energy efficient alternatives to CFCs and better methods of disposing and maintaining equipment operating with CFCs.

BUILDING CODES

Residential. Overall energy consumption for heating residential buildings is showing a dramatic decline following 1984 changes in the state building codes.

A typical Minneapolis or St. Paul home built to meet 1976 building standards and heated with natural gas, used 1,543 ccf (one hundred cubic feet) of natural gas or 154.3 million Btus annually. The same home built to code in 1984 used significantly less natural gas—689 ccf. Consumption from electrically heated homes declined from 107.0 million Btus or 31,359 kWh in 1976, to 57.1 million Btus or 16,736 kWh in 1984. Similar declines were also realized with fuel oil and propane as heating sources.

The 1984 codes provide standard requirements for ceiling, wall, basement, window, door, and infiltration products.

Commercial. The American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) has released proposed standards that will, if codified by states, upgrade existing commercial building codes. The Society's objective has been to develop cost-effective standards that encourage construction of more energy efficient commercial buildings. The new standards for lighting focus on three areas of concern: consideration of daylighting in the design process, improved lighting system controls, and reducing the power allotted for lighting systems through use of more efficient lighting fixtures and lamps.

Other major features of the new standards are to establish codes that consider the building's orientation and external shading and the coupling of external and internal loads when specifying materials for building exterior envelopes or shells.

The Minnesota Department of Public Service is evaluating the ASHRAE recommendations for possible incorporation into the Minnesota commercial building code. The new ASHRAE standards may be adopted by the state within one or two years as an alternative to existing standards.

A Massachusetts Act to Promote Energy Efficiency in New Construction (H.5308), under consideration by the Massachusetts legislature, is an innovative approach to increasing efficient use of electricity in new commercial and residential buildings and in renovated, existing buildings. Developed in response to tightening electric supplies in the northeastern United States, the measure would require developers to pay, in advance, for the capital costs of additional inefficient electric use imposed on the electric system.

The proposed program will charge a flat fee per square foot for new or substantially renovated residential buildings that use less than 350 kW of electricity and use electric/resistance space heating. Residential buildings that use electric/resistance space heating, but are superinsulated, according to standards established by the Massachusetts Secretary of Energy, will not be subject to a fee.

Further, financial incentives will be provided for new customers whose buildings exceed the defined electric energy performance standards for buildings within their customer class, and surcharges will be levied on new customers whose buildings fail to meet the standards. The financial incentives and surcharges will be based on the full avoided cost of power, and will take into account the costs of electricity generation and distribution to the electric company or municipal light department obligated to serve the new customer.

All fees and surcharges collected by an electric company or a municipal light department will be used to supply customers with electrical services at the lowest possible cost.

6

MINNESOTA ALTERNATIVE RESOURCES

Developing Minnesota's nonconventional energy resources.

MINNESOTA ALTERNATIVE ENERGY RESOURCES

Using nonconventional fuel sources such as crops, wind, and sun continues to be a tantalizing prospect for Minnesota and the nation: potentially, alternative fuels could alleviate the fears of foreign control, resource depletion, and environmental damage associated with conventional fuels. The technology for producing, distributing, and applying these fuels is emerging, but large scale replacement of conventional fuels by alternative resources remains a long term possibility. This section describes the various sources and their development in Minnesota.

Alternative sources in Minnesota produced 5.1 percent of the energy used in the state in 1986, up from the 3.7 percent produced in 1980. The largest portion of this production comes from wood. The two historically significant sources of renewable energy have grown dramatically since 1980: hydropower has increased by 50 percent, wood by 38 percent. Other sources, although they continue to provide small percentages of total energy use, have increased significantly. See Table 1.

Finding replacements for oil, natural gas, coal, and other established sources of energy is a goal that holds several attractive prospects or possibilities: First, producing replacement or alternative energy from local and national resources would lessen our nation's dependence on foreign oil and the accompanying vulnerability to sudden disruptions and economic shocks.

Second, developing alternatives from renewable resources would ensure a continuing energy source, with all the stability and security that implies.

Third, developing alternative energy from Minnesota resources would strengthen our state's economy.

Finally, using alternative resources would enable us to reduce the environmental problems associated with some of the established fuels.

When these prospects will be attainable is a matter of speculation. A number of cost-effective applications of alternative fuels are available and are noted elsewhere in this section, but no alternative fuel has yet developed to the point where it can significantly replace oil or other conventional fuels. In most cases, this lack of development is due to lack of economic incentive: the cost of oil and other conventional fuels has remained too low for a developing source to be competitive. Without the promise of a near term economic reward, research lags on all the various aspects of production, distribution, and use.

The prospects held out by alternative fuels are, nevertheless, too important to ignore. Continued development of these sources is necessary for the long range security and health of our state and nation. Minnesota can make its own contribution to this search for alternative energy sources, especially in developing energy from biomass, a resource with which our state is richly endowed.

Following are reports on alternative fuel developments in Minnesota.

BIOMASS: CROPS FOR HEAT ENERGY

Minnesota is especially rich in biomass—plant material. More than 43 million acres of the state's land is devoted to forests or agricultural land.[1] These plants can produce energy either directly, as fuel burned to produce heat, or indirectly, by conversion to the liquid fuels of ethanol and/or methanol.

Wood forest wastes, a traditional renewable fuel that is widely used, provides over 3 percent of the state's energy consumption. What is not widely recognized is that Minnesota has large resources of other crops that could contribute to the state's energy needs. See Table 2. Note that the energy potential for wood is based on surplus wood that could not be used by the forest products industries. It is also based on the amount of forestland that could be harvested annually without depleting the resource.

Agricultural crop residues. Currently, there are 30 million acres of agricultural land in Minnesota, of which 19 million are used as cropland. A minimum of one ton per acre in residues may be harvested from this land. Residues from about half of the state's current cropland could furnish 10 percent of the state's energy needs.[2]

Field corn, another crop resource, is typically planted on 7 million Minnesota acres. This crop produces both shelled

Table 1
Estimated Alternative Energy Consumption From Minnesota Sources (Trillion Btu)[1]

	1980	1986
1. Hydro[2]	8.257	12.393
2. Biomass		
Wood (Gross Resource Consumption)		
A. Residential[3]	26.650	34.252
B. Commercial	0.181	0.770
C. Industrial	8.552	13.800
Total Wood	35.383	48.822
Biomass Ethanol	0.016	0.110
Biomass Gas Methane	––	0.020
Total Biomass	35.542	48.952
3. Municipal Waste		
Solid Waste	N/A	0.701
Sludge	N/A	1.330
Total Municipal Waste	N/A	2.031
4. Wind Energy[2]	0.016	0.025
5. Solar (Gross Output)		
A. Residential	0.120	0.367
B. Commercial	0.001	0.006
Total Alternative Energy Consumption	43.936	63.774

1. Does not include imports from alternative energy sources outside of Minnesota. However, any net imports of wood from Wisconsin are not excluded.

2. Hydro and wind electric production estimates are given in coal equivalent Btus.

3. Because of differences in sources, the 1986 residential wood estimate may not be directly comparable to the 1980 estimate.

Source: *Minnesota Energy Databook, 1980-86*, Minnesota Department of Public Service.

Table 2

Biomass Resource Potential, Heat Energy Uses

ENERGY CROPS	Million Btu Per Acre[1]	Acres to Supply 10% of State Energy Use[2]
Crop Residues, Average	13	12,000
Corn Stover	43	2,700
Corn, Grain and Residue	75	1,600
Sweet Sorghum, Entire Plant	154	800
Hybrid Poplar[3]	68	1,700

SURPLUS WOOD AVAILABLE FOR ENERGY

	Trillion Btu
Limited Value Timber	10
Forest Product Industry Residue	2
Logging Residue	14
Other Forest Fiber[4]	24
TOTAL	50

1. Assumed combustion efficiencies of each biomass fuel are based on air drying to 20% moisture content.

2. State energy use of 1,177.2 trillion Btu in 1986.

3. Average annual energy production based on a growing cycle of several years.

4. Wood from land clearing, natural tree mortality, etc.

Source: *Status of Fiber Fuel Use In Minnesota*, Minnesota Department of Natural Resources, Minnesota Department of Energy and Economic Development, Fiber Fuel Institute, 1986. Minnesota Department of Public Service, Energy Division.

grain (the principal source of ethanol) and residues (corn stover). Both grain and stover could be used for heat energy, providing an estimated 75 million Btus per acre.[3] (This estimate is based on using all available crop residues—about 4.2 tons per acre. Depending on soil characteristics, more limited residue collection offers a more conservative approach to maintaining soil quality without increased fertilizer use.)

Hybrid poplar trees are a specially developed energy crop; they grow fast, reaching harvest size for use as fuel in a few years. After they are harvested, they grow back from stumps. Research conducted by the Minnesota Department of Public Service at Oklee in Red Lake County indicates that hybrid poplar can yield 10 tons of green biomass per acre per year.[4]

Sweet sorghum is being studied for its potential as a feedstock for ethanol; its relatively high energy production—154 million Btus per acre—also makes it suitable as a source of heat energy.[5]

BIOMASS: CROPS FOR LIQUID FUELS—ETHANOL AND METHANOL

Ethanol and methanol are among the fuels being evaluated as possible replacements for gasoline in the transportation industry. Although both fuels can be made from natural gas and other conventional fuel sources, their long term potential as alternative fuels is based on the ability to produce them from renewable biomass.

Minnesota is familiar with the use of ethanol as a blend with gasoline in the fuel gasohol. Some ethanol is also produced in the state: several small commercial plants are operating on farms in southern Minnesota, and a larger plant is under construction in Marshall.

Although corn is the major source of the ethanol produced for automotive use, Minnesota is evaluating sweet sorghum as a feedstock for ethanol. The plant appears to have a number of advantages over corn, including higher yield and simpler processing. Sweet sorghum yields 450 gallons of ethanol per acre compared to 250 gallons per acre from shelled corn.[6] The sugar in sweet sorghum can be extracted by pressure, whereas corn must be heated in water with enzymes to convert the starch to sugar.

Minnesota's potential as a supplier of methanol and ethanol is significant based on its biomass resources. Minnesota uses about 240 trillion Btus (nearly 2 billion gallons) of gasoline annually.[7] Following is an estimate of the potential of two promising ethanol and methanol source crops in Minnesota, based on the resources required to meet 20 percent of current state gasoline consumption.

Corn stover (all the corn plant except the grain) is produced on the nearly 7 million acres that are typically planted to corn in Minnesota. Assuming similar yields of methanol from corn stover as from aspen, 20 percent of the state's gasoline could be produced from about 43 percent of the state's corn crop residues. In addition, the corn grain from about 33 percent of the state's corn, with a yield of 21.2 million Btus per acre, could produce ethanol to displace 20 percent of the state's gasoline use.[8]

Sweet sorghum could produce dry biomass for conversion to methanol, yielding 74.9 million Btus per acre.[9] This fuel would be in addition to the 38 million Btus provided by the ethanol produced from the same crop. This means that sweet sorghum, planted on some 440,000 acres (which equals 6 percent of Minnesota's corn crop acreage), could displace 20 percent of the state's gasoline use.

The above percentage estimates for liquid fuels and fuels for heat energy do not include the effect of energy crops on overall state energy use. Some crops, such as corn and sweet sorghum, require substantial energy inputs for planting, cultivation, fertilizer, and harvesting. Whether using these crops for energy would increase state energy use depends on a number of factors, including the extent to which they replace cultivation of crops for other purposes and the energy use required for various crops at future energy price levels.

PEAT

Peat is partially decayed material that has accumulated in a wet environment over thousands of years. Unlike trees and agricultural crops, peat renews itself so slowly that it is considered a nonrenewable resource. Minnesota has about 7 million acres of peat.[10] The potential for using peat as a fuel is limited by the high cost of extracting the peat and removing the moisture content, and the relatively low cost of other fuels. Peat does have a number of non-energy uses, particularly in horticulture where it has many applications.

HYDROPOWER

Hydropower facilities in Minnesota supply approximately 3 percent of Minnesota's electric power. Additional, substantial amounts of hydroelectric power come into Minnesota from facilities in neighboring states and Canada. Hydropower has been used in Minnesota for more than 100 years, and the potential for growth lies mainly in expanding capacity at present facilities and re-establishing power generation at existing dams.

Twenty-nine hydroelectric plants now operate in the state and have a combined capacity of 179.5 megawatts (MW). Since 1983, hydropower capacity has increased in the state by 36.3 MW.[11] Most of the increases have been made in conjunction with repairs or changes to the dams to improve their safety. (This gain was reduced by 8.3 MW with the loss of the Northern States Power hydroelectric plant at St. Anthony Falls in November of 1987.)

Completed projects are at Granite Falls on the Minnesota River; Blanchard, Hastings, St. Cloud, and Sartell on the Mississippi; Lanesboro on the Root; Rapidan on the Blue Earth; and Byllesby on the Cannon.

Because of the high cost of construction and the relatively low price the facility receives for the sale of its electric power, future development of hydropower is likely to continue to be made in conjunction with needed dam repairs and updating existing facilities rather than by building new facilities.

During the coming decade, many existing sites in the state will come up for re-licensing. As part of the re-licensing procedure, the Federal Energy Regulatory Commission will look at maximum use of site resources as well as dam safety and environmental impacts of the project. This review process is stimulating several facility operators to consider expansion to coincide with license renewal.

MUNICIPAL AND INDUSTRIAL WASTE

Minnesotans produce about 3.3 million tons of garbage annually, or almost one ton per person per year, an amount that is growing by about 6 percent a year.[12] Disposing of this waste is becoming increasingly difficult. Deposit in landfills has been the principal means of disposal, but pollution of ground water and lack of space are forcing counties and municipalities to search for other solutions.

Reducing waste at the source—by less packaging, for example,—is the most obvious and most desirable solution, one that would conserve energy and money and reduce health and environmental risks. Public attitudes and customs stand in the way of this solution, however. The most desirable alternative to reducing waste is to separate and recycle materials at the source, thereby reducing the amount of waste requiring disposal. This choice is somewhat dependent on the markets for recyclable materials (paper, glass, cardboard, metals, and plastic), and is expensive. Cost can be reduced with widespread public cooperation. Another choice is to compost the entire waste stream in a mechanized system. (St. Cloud has such a system, and Fillmore County composts that part of the waste stream that is not recyclable.) Again, pollution and costs are problems. Metals and other hazardous materials must be removed (an expense) and there is not a big market for compost.

Waste-to-energy plants. In the search for means of disposal, various methods are being developed for using garbage as an energy source. The method currently receiving the most attention is incineration in specially designed "waste-to-energy" plants. Minnesota has 11 waste-to-energy facilities (compared to three in 1984) with the capability of processing about 2,270 tons of garbage per day, or about a fourth of the state's total. See Table 3. By 1990, waste-to-energy plants will be able to process some 5,300 tons per day (58 percent of the current waste), producing 47.7 billion Btus (17.4 trillion per year), or about 1.6 percent of Minnesota's total energy consumption.

Seven of the Minnesota facilities are "mass-burn" operations, which burn unprocessed waste to produce steam and/or electricity that is used on or near the site. Four of the plants produce a Refuse Derived Fuel (RDF) which is shipped elsewhere and burned with wood, coal, or oil, or used as the sole fuel in a boiler.

Problems or drawbacks of burning waste to produce energy are chiefly financial and environmental. The cost of constructing and operating waste-to-energy facilities is high, and recovering a portion of these costs by selling the energy produced is hindered by the low cost of oil and other competing energy sources. In many areas, not enough waste is generated to operate an efficient mass-burn facility; nor are there sufficient markets for the energy.

The second major drawback—pollution—is also partially a financial problem. Acid gases, heavy metals, dioxins, and furans can be emitted into the air through the smokestack or into the ground by ash disposal. Equipment capable of removing these hazardous materials is available but expensive—installing a combination of scrubbers and an electrostatic precipitator to remove all types of hazardous byproducts can as much as double the operating costs.

The future role of waste-to-energy plants as both a method of garbage disposal and an alternative energy source will undoubtedly be influenced by the cost of competing energy sources and by development of other systems or new technologies that allow for a more economical process with adequate safeguards for the environment. Among the latter are three promising technologies now emerging: (1) Pyrolisis conversion heats organic wastes in a starved air environment to produce combustible gases that can be stored and used as a fuel for further processing or for generating power. (2) Controlled biological decomposition produces methane gas that can be stored and sold. (3) A fluidized bed system uses material with a high melting point, such as sand, to improve combustion.

Industrial wastes also create disposal problems, and converting some of these wastes into energy is seen as a partial solution. As in the case of municipal waste, the motivation is waste disposal, and the contribution to the state's energy needs is minimal.

About 24 million gallons of waste industrial and lubricating oil are produced annually in Minnesota. Approximately 19 million of these gallons are recycled as fuel; disposal of the remaining 5 million gallons poses a threat to the environment.[13] Re-refining waste oil for re-use as lubricating oil is an option, but re-refining is currently not economical.

Scrap tires are another environmental threat that could be disposed of by converting them to fuel. A plant in Babbit, Minnesota, currently processes scrap tires for fuel.

Some 400,000 railroad crossties are replaced each year in Minnesota.[14] Braxton Industries, a Minnesota based corporation, is processing crossties from Minnesota and surrounding states and supplying Blandin Paper Company and others with ties for fuel. The ties are being processed at a rate roughly comparable to the number of waste ties produced in Minnesota.

Table 3

Waste-To-Energy Facilities in Minnesota, October, 1988

DEVELOPER/LOCATION	ON LINE	SIZE	MARKET
1. Richard's Oil Shakopee	1980	63 tpd*	Process Heat
2. City of Red Wing	1982	72 tpd	Steam for an Industrial Customer
3. WLSSD/Duluth	1985	120 tpd	Incinerating Sewage Sludge
4. Pennington Cty/Thief River Falls	1985	40 tpd	Pelletizing for Resale
5. Quadrant, Inc./Perham	1986	100 tpd	Steam for an Industrial Customer
6. Olmsted County Rochester	1987	200 tpd	Electric Generation and Steam for Resale
7. Pope-Douglas Counties Alexandria	1987	70 tpd	Steam for an Industrial Customer
8. NSP Newport	1987	900-1200 tpd	Processing for NSP Power Plant
9. Rueter Inc./Eden Prairie	1987	400 tpd	Recycling and Pelletizing for Resale
10. Fergus Falls	1988	75 tpd	Supply Heat to State Hospital
11. Polk County/Fosston	1988	80 tpd	Steam for an Industrial Customer
12. Hennepin County/Mpls	1989	1000 tpd	Electric Generation
13. NSP/Anoka County	1989	500-1000 tpd	Electric Generation
14. East Central Solid Waste Comm.	1989	250 tpd	Processing for WLSSD/Duluth
15. Winona County/Winona	1990	150 tpd	Processing for Electric Generation
16. Dakota County	1992	800 tpd	Processing for Electric Generation

* tons per day

Source: Minnesota Department of Public Service, Energy Division.

SOLAR ENERGY

Photovoltaics. A photovoltaic (PV) cell directly converts light into electric energy. A photovoltaic system will produce as much electricity annually in Minnesota as in eastern Texas and all of Florida—190 kilowatt hours per square meter.[15] Despite its cooler temperatures, Minnesota has as much available sunlight as these areas.

Photovoltaics has the potential to be a significant source of power in Minnesota and the nation. As more systems are installed, the volume of sales will lower the cost of individual units, opening the way for more cost-effective applications. In addition, new developments in technology promise more effective units, including cells that transform a higher percentage of the sun's energy into electricity. Large scale use of photovoltaics for utility electric generation is a future possibility that would provide many advantages, including low pollution and increased safety.

Nationwide, use of photovoltaics is growing, particularly in military and state government operations. The U.S. Navy reports 21,000 applications that are saving it $176 million per year; the U.S.Coast Guard uses PVs at 9,000 buoys and shoremarkers. U.S. shipments of PV systems increased 20 percent between 1986 and 1987.[16] Manufacturing costs of PV systems dropped from approximately $300 per watt several years ago to below $5 per watt in 1987. Furthermore, PV systems require little maintenance or operation costs, so in some situations they can be much cheaper than other forms of energy, especially in sites remote from an electric utility grid.

To demonstrate the effectiveness of photovoltaics in these types of situations in Minnesota and to learn more about their operation, the Minnesota Department of Public Service is collaborating with the Minnesota Departments of Natural Resources and Transportation in the installation of three PV demonstration projects. One is installed at a DNR water monitoring station in a remote site in northern Minnesota. A second site is a boat launch on Loon Lake, south of Mankato, that needs night lighting for safety and security. A third test case will use a PV system to monitor traffic speed and flow along I-35 south of Wyoming, Minn. The same type of system can be used to power traffic counters at more remote locations in the future.

Active and passive solar heating. Heating homes and buildings with solar energy has been the focus of considerable interest. Heating with solar collector equipment that uses a separate solar collection device is defined as active solar; designing buildings so that their site placement, windows, and other components capture and store solar energy is referred to as passive solar.

Nationwide sales of residential and commercial solar heating systems dropped 85 percent between 1984 and 1987, and comparable decreases are estimated for Minnesota. The decreases are attributed to the relatively low cost of natural gas and electricity and to the loss of tax credits for residential solar systems.

Passive solar has a wide range of applications, beginning with increased amounts of south-facing windows to a complete system including a thermal storage mass that absorbs, stores, and releases heat.

A national program to develop guidelines tailored to specific climates, for builders to use in building passive solar homes, was developed by the Passive Solar Industries Council with funds from the U.S. Department of Energy and the Solar Energy Research Institute. The new guidelines are designed to be simple and reliable to use and enable the builder to assess cost and benefits of individual passive solar features. Guidelines are currently available for three specific locations in Minnesota—Moorhead, Duluth, and the Twin Cities.

WIND ENERGY

Wind energy is in the research and development stage in Minnesota. A January, 1988, survey revealed approximately 165 wind generators in the state, most of them with capacity between 10 and 40 kilowatts.[17] Some 30 of these are operated by businesses or institutions, and the remainder by individuals. Included in the total are three 65-kilowatt turbines owned and operated by Northern States Power on its wind farm in southwestern Minnesota. Minnesota is also home to three manufacturers of wind turbines, two dealers, and one manufacturer of wind turbine blades, the latter a major national supplier.

Relatively low electric rates hinder wind development in Minnesota. Under the Public Utility Regulatory Policies Act of 1978, utilities must buy power from independent producers, but pay them a price (known as the "buyback rate") that is determined by the "avoided cost"—that is, the cost the utility avoids by not having to provide the power itself. In Minnesota, buyback rates are quite low. Small wind generators (under 40 kW) in Minnesota receive buyback rates equal to the utility's average retail rates.

Performance data for the first year of operation of the NSP wind farm revealed a production of 320,000 kilowatt hours (kWh) of electricity, worth about $19,000 at the current NSP average retail rate for electricity of approximately $.06 per kWh. The annual energy production topped 1,600 kWh per installed kilowatt of power.[18] This compares to the national average of 1,326 kWh/kW.

Other parts of the nation, notably California, use the wind resource more extensively than Minnesota. (Nearly 18,000 wind turbines are operating in the nation today.) Wind speeds in western Minnesota provide potential for a higher production of wind energy in the state, and as economic factors become more favorable, the state will probably see a growth in the industry. National and international expansion, for example, is causing a price drop in wind turbines. The average installed cost of a wind turbine in the United States by the end of 1987 was under $1,000 per kilowatt capacity, compared to $3,100 in 1980.[19]

7

DEPARTMENT OF PUBLIC SERVICE ENERGY ACTIVITIES

Assuring widespread and equitable distribution of energy.

DEPARTMENT OF PUBLIC SERVICE ENERGY ACTIVITIES

The Minnesota Department of Public Service provides centralized energy services to the people of Minnesota and provides direction for establishing and implementing Minnesota's energy policy. The department's Energy Division administers a number of programs and activities relating to the efficient use of energy; the Utilities Division administers activities relating to utility rate-making at both the state and federal levels. This section describes these major responsibilities.

The Department of Public Service administers or participates in a wide range of activities to help assure the availability of energy resources at a reasonable cost and to help consumers improve energy efficiency and reduce energy costs.

The Energy Division provides energy information and technical assistance to a wide variety of consumers, administers financing of conservation improvements for public facilities, and carries out other responsibilities to encourage cost-effective improvements in energy efficiency and long term development of alternative energy resources.

The department's Utilities Division is responsible for providing testimony and recommendations to the Minnesota Public Utilities Commission concerning electric and natural gas utility rates, major new energy facilities, and other issues. The division also comments on federal energy regulatory issues on behalf of Minnesota.

The above responsibilities permit the department to develop an integrated policy for addressing Minnesota's short term and long term energy concerns.

ENERGY DIVISION

Major responsibilities of the Energy Division are to:

- provide information and technical assistance to Minnesota schools, institutions, businesses, local governments, and private citizens to improve energy efficiency and reduce energy costs;
- collect and analyze statewide energy supply and use data and serve as a central clearinghouse for energy information;
- administer financing for efficiency improvements in tax-supported institutions (schools and local governments); and
- support the cost-effective development of indigenous energy resource production and use.

The Energy Division currently operates in five major program areas:

Energy Information and Analysis activities include operating the Energy Information Center, compiling and analyzing statewide energy supply and use data, preparing consumer publications and public service announcements, testifying before the Public Utilities Commission on the Utility Conservation Improvement Program (CIP), reviewing electric utility long term forecasts and supply plans, and providing statewide promotion of energy conservation programs.

Sample Activities:

The Energy Information Center made 24,000 client contacts and distributed over 137,000 publications in fiscal year (FY) 1988. Energy Information Center staff answer questions about energy use and conservation technologies on a daily basis. The Information Center staff write, edit, and distribute two newsletters and numerous news releases, guides, brochures, and fact sheets for residential and commercial energy users. The Information Center also maintains an energy library that is used as a resource by staff and the general public.

Data Collection and Analysis activities include maintenance of the Regional Energy Information Service (REIS), a computerized database that includes historic and forecast information submitted by electric and natural gas utilities. The REIS data are used for internal analysis and by businesses, energy suppliers, students, and the general public who request the information. The activity also monitors petroleum supply conditions and responds to energy supply concerns.

Conservation Improvement Program analysis activities involve evaluating utility energy programs and making recommendations to the Public Utilities Commission on the appropriateness of utility investment in conservation programs. The Energy Division has assisted utilities in developing investment plans which resulted in approximately $8.9 million in conservation investments last year.

Minnesota's principal generation and transmission utilities provide annual forecasts and capacity plans to the Department of Public Service and the Environmental Quality Board. Review of these forecasts and analysis of related issues identify long term concerns in advance of regulatory proceedings.

Alternative Energy activities promote cost-effective and environmentally appropriate development of indigenous energy resources including wood, wind, agricultural residues, energy crops, solid waste, and photovoltaics. The activity provides a wide range of technical and economic analysis, on-site engineering assistance, information, and demonstration programs designed to promote appropriate development of Minnesota fuels.

Sample Activities:

Waste-to-energy programs of the division provide technical assistance to a number of outstate communities to identify and evaluate their options for disposing of solid waste.

Wind Resource Assessment, operated in cooperation with the utilities, monitors wind speeds in areas around the state to identify appropriate development corridors for wind energy production.

Test burns of agricultural residues and other fuels are conducted to examine environmental impacts, Btu content, etc., and identify appropriate markets for indigenous fuels.

Energy Crop Demonstration Programs help determine the financial feasibility of producing indigenous energy. A study funded by the Legislative Commission on Minnesota Resources involves raising hybrid poplar and producing it as fuel on marginal agricultural land. This study examines such things as output per acre, cost-effective harvesting and processing technologies, and identification of end-user markets.

Demonstrations of remote photovoltaic applications are being conducted to reduce state government operating costs in such areas as parks and recreation, traffic monitoring, and water monitoring.

Energy Efficiency Education activities develop educational initiatives to improve energy efficiency in all sectors of the Minnesota economy. A broad range of educational services to educators, building operators, professional energy service personnel, and construction industry professionals is provided. The activities also translate technical research into consumer information. Support is also provided to a broad range of constituents in meeting energy building codes, appliance efficiency, rental housing efficiency, and insulation product standards.

Sample Activities:

Workshops have been provided to a broad cross section of clients. Last year, 30 workshops were conducted in cooperation with Area Vocational Technical Institutes (AVTI) on such topics as air conditioning and refrigeration, steam trap testing and repair, operation of energy management systems, and preventive maintenance programs.

Builder education and training activities provide information and training to builders, contractors, and lumber dealers on energy efficient construction practices. Ten editions of a newsletter for builders have been published and distributed to 10,000 builders and other industry related personnel. Eleven workshops on preventing moisture and indoor air quality problems were presented to builders and remodelers. Northern States Power and Minnesota Power provided funding for the workshops.

Insulation product standards is one area in which the Energy Division provides regulatory compliance support to product manufacturers. In response to concerns about the safety of insulation materials, the legislature mandated the development of standards for materials testing and installation procedures. The division has reviewed product filings from 50 manufacturers covering 205 different products sold in Minnesota.

The Energy Division is now in the process of developing efficiency standards for commercial lighting.

Municipal Finance. This program provides low-interest loans and/or federal grants to public schools, cities, counties, and private, non-profit schools and hospitals for purposes of improving energy efficiency in these institutions. Low interest loans are provided to implement building improvement projects in all of the above categories. Federal matching grants provide additional funds for retrofitting private, non-profit schools and hospitals. State-funded cost-share audit grants are also provided to assess the technical and economic feasibility of projects proposed for financing.

Sample Activities:

Municipal loans have been provided to over 120 public school districts, cities, and counties. Nearly $20 million in loans have been distributed through the program, resulting in retrofits being completed in over 400 buildings. Most loans issued have gone to small, rural school districts, cities, and counties with limited capital budgets.

Federal matching grants have been distributed to over 1,000 public and private non-profit schools and hospitals. Over $21 million dollars has been distributed since 1980 for building efficiency improvements in this sector.

The Institutional Building Revolving Loan Program is a financing program that has been developed out of the Exxon oil overcharge settlement. Approximately $6.5 million was allocated for the purpose of providing matching loans to institutions in Minnesota. The program provides zero interest capital to leverage financing sources for schools, local governments, and health care facilities. This program began operation in June, 1988.

Community Energy. The purpose of this program is to strengthen Minnesota's economy by helping communities gain control over their local energy costs. The program provides technical assistance to communities to develop and implement local energy programs, and provides competitive matching grants to support local efforts.

Sample Activities:

Community Energy Councils have been formed in 75 communities and are composed of local volunteers appointed by the city council or county board. Program guidelines encourage partnerships between local governments, utilities, poverty programs, business and labor organizations, and senior citizen groups.

Community Energy Grants create partnerships by combining resources from state grants, local governments, utilities, and other sources. Results through fiscal year 1988 include approximately 30,000 residents and businesses served. On average, every dollar of state grants has been matched by two dollars of project funding from local sources.

Local programs have included: ''Seniors Helping Seniors,'' a home weatherization project; home energy check-ups; small business energy consultations; low interest business energy loans; energy analyses for resort owners; free car care clinics through the AVTIs; a rural carpool program; and bringing energy education materials into the public school curriculum.

UTILITIES DIVISION

The Utilities Division energy responsibilities are housed within three offices: the Energy Unit, the Computational Services Unit, and the Energy Issues Intervention Office.

General Rate Cases. Both the Energy Unit and the Computational Services Unit review each general rate case petition filed by an electric or gas company. The Computational Services Unit submits recommendations to the Public Utilities Commission regarding the utility's capital structure, required return on equity, rate base, and expense levels. The Energy Unit submits rate-design recommendations, which involve the apportionment of the revenue requirement, rate structures for all customer classes, and non-pricing conditions of service.

Miscellaneous Rate Petitions. The Energy Unit processes utilities' requests for miscellaneous rate changes that do not require determinations of gross revenue requirements. The staff reviews the utility's petition, requests additional information if necessary, and issues a written recommendation to the Public Utilities Commission. The petitions usually involve either minor changes in rates for existing services, the institution of new services, revisions to non-pricing service provisions, service area issues, or affiliate transactions.

Cost Studies. The Energy Unit is developing approaches for estimating marginal costs and reflecting them in electric retail rates. The objective is to encourage a more efficient use of society's resources by sending proper price signals. The Energy Unit has sponsored marginal-cost studies in three general rate cases, and is participating in a generic investigation of different approaches toward estimating and using marginal costs.

Certificate of Need. The Computational Services Unit and the Energy Unit evaluate utilities' requests to construct major plant additions, including generating stations, high-voltage transmission lines, gas pipelines, gas storage facilities, and storage facilities for nuclear waste. The staff reviews the need for such facilities based on forecasts of peak demand, total use, and environmental impacts. It also evaluates alternatives to the utility's proposed addition, including the potential of deferring construction through conservation efforts.

Alternative Energy Production. The Energy Unit assists the development of alternative power production in Minnesota by reviewing buyback rates and non-pricing provisions offered by electric utilities to Qualifying Facilities (QFs) under the Public Utility Regulatory Policies Act (PURPA). The staff reviews the standard rates for small facilities (under 100 kW), as well as standard contractual terms and rates offered to larger QFs willing to sign long-term contracts. The Energy Unit then issues recommendations to the Public Utilities Commission. Participating QFs include small wind generators, hydro plants, and cogeneration plants. Also, several waste-to-energy facilities are scheduled to sell power and energy in the 1990s and beyond.

The Energy Issues Intervention Office (EIIO) represents the interests of Minnesota residents, businesses, and governments before regulatory agencies outside the state or before legislative and judicial bodies that make, interpret, or implement national and international energy policy. The office seeks recommendations for intervention activities from the appropriate public and private interests to determine the state's needs and where the EIIO's activities would have greatest impact on the broad public interest. This is done by:

- coordinating with other state agencies concerning federal regulatory issues;
- monitoring utility and FERC activity to prevent unreasonable price increases for Minnesota's energy consumers;
- conducting analysis and research on alternative regulatory policies that best meet the state's energy needs; and
- working with Minnesota's representatives in Congress to help protect the state's residents from adverse federal actions.

8

RATE DESIGN POLICY OF THE MINNESOTA PUBLIC UTILITIES COMMISSION

RATE DESIGN POLICY OF THE MINNESOTA PUBLIC UTILITIES COMMISSION

This section describes the Minnesota Public Utilities Commission's rate design policy. Cogeneration and small power production, energy conservation programs, and the state's general energy policy receive special attention in this discussion.

Minnesota's energy policy includes the following goals:

- Increase efficiency in energy consumption.
- Minimize the need for increases in fossil fuel consumption.
- Minimize the need for additional electrical generating plants.
- Develop and use renewable resources.[1]

The Commission implements this energy policy through the following actions:

- Setting rates (prices) for gas and electric utilities.
- Issuing or denying certificates of need for large energy facilities.
- Determining avoided-cost buyback rates for cogeneration and small power production.
- Requiring utility energy conservation programs.

Rates for Gas and Electric Utilities

The Commission regulates the rates of only investor-owned gas and electric utilities. An exception is cooperative electric associations, whose members may elect to be rate-regulated by the Commission. Out of 52 electric cooperatives in Minnesota, only one is rate-regulated at this time.

Gas and Electric Utility Rate Structures

The Commission strives to set the lowest reasonable rates for consumers. At the same time, the Commission requires each utility to provide adequate and reliable service. Also, the Commission must permit a fair return to each utility's investors. Rates must not be unreasonably preferential, prejudicial, or discriminatory.

The Commission attempts to design rates that reflect true economic cost and efficiency. This is tempered by the impact of rate changes on customers' bills and by other factors. When the true costs of energy are reflected in rates, cost-effective conservation programs and alternative energy resources are encouraged.

Declining block energy charges provide a lower rate for higher levels of energy use. Such rates tend to promote uneconomic consumption and send improper price signals to customers. The Commission has eliminated declining blocks for all major natural gas utilities. However, electric utilities have historically had rate structures containing many blocks. Therefore, the billing impacts have often been too severe to eliminate declining blocks completely. The Commission's goal is to eliminate all declining blocks that promote uneconomic consumption.

To promote conservation, the Commission has required relatively low fixed (or customer) charges, especially for residential users. (This also helps low-use, low-income customers to pay their bills.) More emphasis is thus placed on the energy charge, to which the customer can respond by reducing use.

Electric Utility Rates That Promote Conservation and Efficiency

The Commission has required electric utilities to develop rates that promote conservation and electric efficiency. Examples of such rates are described below. These rates can slow the growth in peak demand, which in turn defers the need for new power plants and transmission lines.

Time-of-day-rates: Under time-of-day pricing, electricity is priced higher during a utility's peak hours. Northern States Power Company (NSP) offers voluntary time-of-day rates. The Commission has recently required NSP to develop ways to increase participation in its commercial/industrial time-of-

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1. See Minnesota Statutes Section 116J.05 (1986)

day rates program. Interstate Power Company (IPC) has time-of-day rates for large customers. Additionally, the Commission has ordered Otter Tail Power Company (OTP) to implement an experimental time-of-day rate for commercial/industrial customers.

Off-Peak Rates: Off-peak rates tend to restrict consumption to off-peak periods. OTP and IPC offer off-peak stored space heating rates. NSP has an experimental rate schedule which limits consumption to certain late night and early morning hours.

Seasonal Rates: Under seasonal rates, demand or energy rates are higher during the utility's peak season. For example, NSP's electric rates are higher in the summer, when NSP's load peaks because of air conditioning.

Interruptible Rates: Interruptible rates allow a utility to interrupt all or a portion of a customer's load when it is nearing its peak. NSP has several such rates, mostly for large customers. OTP and IPC also offer interruptible rates to their larger customers.

Controllable Rates: Controllable rates allow the utility to control a customer's load directly. OTP has an extensive program of radio-controlled loads, including controlled water-heating rates for most customer groups. IPC offers controlled water heating for residential and commercial customers. NSP's commercial and industrial customers can choose among different types of controllable rates.

The above rates illustrate the Commission's involvement in conservation and energy efficiency through rate design. This involvement may appear to lean toward electric utilities rather than natural gas utilities. However, that apparent leaning is due mainly to the more complex nature of electricity production. The Commission is committed to conserving both electricity and natural gas.

Certificates of Need 216B.243 (1986)

In determining the need for new large power plants and transmission lines, the Commission considers conservation as an alternative. Conservation is considered on an equal footing with traditional and alternative energy sources.

Long-term forecasts of energy requirements create a starting point for evaluating certificate of need applications. The forecast then would be adjusted for the conservation effects not captured by the forecast. The Commission also would review the ability of cogeneration and small power production to fulfill the forecasted demand. Finally, the proposed facility would be compared with a range of alternatives. The Commission would grant a certificate of need only if the proposed facility is the most reasonable and prudent alternative.

Cogeneration and Small Power Production 216B.164 (1986)

The Commission gives the maximum possible encouragement to cogeneration and small power production consistent with protection of the ratepayers and the public.[2] The Commission does this by requiring electric utilities to pay fair rates for power purchased from qualifying cogeneration and small production facilities. The Commission also has reduced the transaction costs and improved the negotiating ability of qualifying facilities.

The Commission defines the full costs which an electric utility can avoid through purchases from a qualifying facility. The Commission requires that electric utilities pay those costs to qualifying facilities. Payment of higher rates than those would require ratepayers to subsidize cogeneration and small power production facilities. Lower rates would fail to give maximum encouragement.

The Commission requires "net energy billing" and a uniform statewide contract for small (under 40 kilowatt) qualifying facilities. This simplifies the process for individuals looking to serve small loads (such as households) with renewable resources. The relatively high rates are balanced by reduced transaction costs for the small units involved.

The Commission has encouraged "standard offers" by electric utilities. Standard offers provide tables of rates for qualifying facilities of up to 5 megawatts. Also, the standard offers form a starting point for negotiating rates for larger units. The standard offers make it easy for a potential qualifying facility to determine what rates it will be paid and what conditions it must satisfy to qualify for those rates. This reduces negotiation time and feasibility study costs. Thus, standard offers are another means by which the Commission encourages cogeneration and small power production.

Energy Conservation Programs 216B.241 (1986)

Commission encouragement can help consumers overcome barriers to conservation. One major barrier to conservation is that some consumers are unaware of the specific conservation actions that would reduce their energy bills. In addition, low-income families and renters face special difficulties regarding energy use. They may lack the resources needed to invest in conservation improvements. Additionally, landlords may make their energy payments, thus insulating them from the benefits of conservation.

All ratepayers, and society in general, benefit if an electric utility is able to avoid future capacity additions. In addition, significant environmental benefits can result from reduced electricity demand. The benefit of avoiding capacity additions may not be fully reflected in the rates paid by consumers. Conservation programs can allow those who conserve energy to capture those benefits.

In addition to energy conservation projects, the Commission has directed several electric and gas utilities to develop a renewable resource pilot project, as required by Minnesota Statutes section 216B.241 subd. 2. The Commission considered numerous potential renewable resource projects and directed that development of projects regarding wind, solar and biomass be pursued. A wind assessment project is being conducted jointly by several electric utilities. The Comission has also approved a wind hardware demonstration project and a solar demonstration project for NSP. Preliminary study on a biomass fuel project has been completed.

The Commission requires large natural gas and electric public utilities to make significant investments in or expenditures for energy conservation.[3] The Commission has proposed rules to use in determining whether an investment or expenditure is significant. The rules would require the Commission to consider the following information in determining significance:

- Impact of the program on energy consumption.
- Cost to the utility of the energy saved compared with the cost to the utility of new energy supplies.
- Impact of the program on utility rates.

2. See Minnesota Statutes section 216B.164 (1986) subd.1.

3. See Minnesota Statues section 216B.241 (1986).

- Number of low income and rental customers benefiting from the program.

- Total amount spent on energy conservation, compared with the utility's gross revenues.

- Total customers expected to participate in the program compared with the total customers in the utility's service area.

- Diversity of customer classes expected to participate in the program.

- Benefits of the program to participants.

- Other relevant information.

Ideas for conservation improvements have been received from many sources, including the following:

- Utilities.

- Community-based, non-profit energy service providers.

- Community action programs.

- Local governments.

- Private businesses.

- State agencies such as the Department of Public Service and the Commission itself.

Not all of the proposed projects have been approved by the Commission. In resolving disputes, the Commission balances the need to insure that utilities make significant and effective investments against the need to insure that ratepayers do not pay excessive utility rates. The Commission intends that ratepayers receive full value for the amounts they contribute to conservation programs.

Ratepayers ultimately pay the cost of the Conservation Improvement Programs (CIP). Therefore, the Commission has been careful to insure that all ratepayers have an opportunity to participate in the conservation projects. Furthermore, the Commission requires assurance that the projects can achieve their objectives at minimum cost.

The Commission has ordered a wide variety of conservation projects. One of the largest is NSP's electric appliance rebate program. It encourages consumers to purchase more efficient electric appliances by offering rebates for purchasing more efficient models. It had an annual budget of $1,436,555 during the 1987-88 project year.

The Commission has also ordered relatively small projects designed to serve small towns and rural areas. In addition to its other projects, Peoples Natural Gas Company has six projects designed specifically to serve small towns and rural areas. Their current annual budgets range from $3,700 in West Concord to $18,700 in Preston. A listing of all CIP projects approved by the Commission since the program began in 1984 appears in a report entitled *Conservation Programs Ordered by the Minnesota Public Utilities Commission, 1984-1988*.

The CIPs are continually monitored. Projects which do not meet expectations are discontinued or modified. Projects which have been successful for one utility have frequently been ordered to be implemented by another utility. Also, utilities have operated projects jointly where their service areas overlap (i.e. one utility provides electricity, another provides natural gas) or where cooperation yielded other benefits.

The Commission continues to seek new, effective conservation programs that will benefit ratepayers. At the same time, it is committed to maintaining established conservation programs that have proven their worth.

Recommended Administrative and Legislative Actions

The Commission continues to research and work with the Department of Public Service on least cost planning for electric utilities. Least cost planning includes both demand-side and supply-side alternatives in the utility planning process.

Supply-side alternatives include power plants and power purchases. Demand-side alternatives include conservation, alternative energy sources, and load management. Least cost planning would put demand-side alternatives on an equal footing with supply-side alternatives in the utility planning process. The Commission will seek authority to implement least cost planning in Minnesota.

9

PUBLIC COMMENTS

PUBLIC COMMENTS

A draft copy of this report, "Energy: Minnesota's Options for the 1990s," was published in November, 1988. A notice in the "State Register" of November 14, 1988, announced the availability of copies and invited the public to submit comments, either in writing within 30 days or in person at public meetings on the afternoon and evening of Tuesday, November 29, at the State Office Building. In addition, letters inviting review and comment and draft copies of the report were sent to persons and organizations with special interest in energy matters. Major excerpts from the comments received are presented in this section.

COMMENTS FROM NONPROFIT ORGANIZATIONS

ENERGY CENTS COALITION

"Energy: Minnesota's Options for the 1990s" gives little attention to the impact of energy costs on low income households and little emphasis to residential conservation measures. Projections of energy costs to consumers should also be included.

The report's recommendations are very general when addressing conservation concerns. It is generally understood that conservation is the most cost-effective method for lowering energy costs, especially when environmental and supply issues are taken into consideration.

To better understand the energy problems which low income households face and the programs which have been developed to relieve them, the Coalition undertook a research effort that resulted in the report "Energy: A Survival Issue of the Poor." One of the points that became apparent from this analysis was that programs targeted to low-income Minnesotans can actually benefit all people of the state. Conservation programs are an obvious example. If low-income people are helped to conserve energy by such means as weatherizing their homes, the total energy use of the state is reduced. A reduction in total energy use can delay, or even eliminate, the need for new supplies: for instance, the construction of a new electrical energy generating facility. That, in turn, delays or eliminates financial expenditures that would drive up rates for all consumers, as well as delaying or eliminating operations that could have significant environmental consequences for all Minnesotans.

The reverse of the second point is also true. Programs aimed at holding down or reducing the financial, environmental, and social costs of producing and supplying energy for everyone in the state can also be of specific help to low-income Minnesotans.

Energy costs that are lower for everyone are particularly important to low-income consumers, who, as a result, can devote a smaller percentage of their limited pool of dollars to meeting a single need. Because of this, the efforts of other groups and policy statements such as "Energy: Minnesota's Options for the 1990s" can be very significant for low-income Minnesotans.

Minnesota, because of its climate, is in a difficult situation vis-a-vis its need for large amounts of energy for heating, the high percentage of funds low income households must use to purchase fuel for heating, and the variety of energy providers people depend upon. While the report does discuss the rapid rise of energy prices during the 1970s, it leaves the impression that these have leveled off and have decreased in proportion to overall household income. While this may be the case for most middle and upper income families, this does not hold for low income households.

Low income Minnesotans face an energy crisis every day as they struggle to meet the costs of utilities in their homes. They have not been able to benefit from the leveling off of energy prices.

A recent survey by the National Low Income Energy Consortium (NLIEC) found that most Americans do not consider the affordability of energy a top issue of the day. But, for the millions of Americans with incomes near or below the poverty level, energy costs are a life and death concern. For these Americans who are disproportionately poor, elderly, and infirm, energy remains as critical a concern today as it did to every American in the most ominous days of the oil embargo.

From 1972-73 to 1984-85, residential energy consumption declined for poverty or near poverty households by 14 percent. However, actual dollar expenditures for residential energy for these households increased from $284 to $969 per year (a 241 percent increase). As a proportion of total yearly income, this meant an average increase from 11 percent to almost 15 percent for poverty or near poverty households. By the mid-1990s, another large increase may again be experienced. The long term impact of energy costs on low income households must be taken into consideration when setting state policy.

Because energy costs are usually the largest housing expense after rent or mortgage payments, they become a critical determinant of housing affordability for low income households. Low income citizens, especially in the metropolitan area, are primarily renters living in housing which is generally more expensive to heat than other housing. In 1983, energy costs for those below poverty amounted to 37 percent of total housing cost. For middle income households energy costs were 20 percent of total housing cost. (NLIEC)

The decline in the cost of energy has led many policy makers to believe that poor families do not need as much help with energy costs as they once did. In reality, the gap between assistance for the poor and the level they need has grown steadily since 1980. Estimates based on U.S. Department of Health and Human Services data for fiscal 1986 show that the Low Income Household Energy Assistance Program (LIHEAP) funds covered only 9.4 percent of the energy costs of federally eligible poor households. LIHEAP paid less than 20 percent of their basic heating and cooling costs. In 1980, LIHEAP paid for about 40 percent of these costs. ("Narrowing the GAP," Northwest Midwest Institute). And, while LIHEAP calls for the promotion of energy conservation activities among low income citizens, no resources are made available with which this can be carried out. The federal low income weatherization is facing the same situation with large cutbacks, unstable funding cycles, and long waiting lists.

Heat is a life and death issue in Minnesota. As a state we must ensure that no Minnesotan is left in an unheated dwelling during the winter or forced to live on the streets because of the inability to pay utility bills. All state policy decisions regarding energy issues must be considered in this context.

The following comments are directed to specific recommendations put forth in the report based on the research and analysis undertaken by the Coalition over the last several months.

Energy Efficiency Options: Residential, Commercial, Industrial Sectors. Publicly funded and utility sponsored programs can play an important role in facilitating the availability and adoption of conservation efforts. It is important that specific recommendations for these programs be addressed:

1. *The enforcement of the existing residential energy code.* Currently enforcement is limited to a few of the larger cities in the state.

2. *The establishment of a rent escrow system* that would enable a tenant who lives in a unit which has:

(a) Violations of any state or city health, safety or energy codes; (b) Violations of covenants of habitability; or (c) Violations of oral and written agreements;

to pay their rent into an escrow account and the court would decide the course of action. This is an easy way for the tenant to have an impact on conservation deficiencies in a living unit where the landlord is not interested in undertaking such improvements.

3. *Weatherization/oil overcharge funds.* To maintain a base level of funding for the low-income weatherization program at $18 million state-wide, utilizing a state appropriation if other funds are not available. To legislate or clarify that 50 percent of future oil overcharge funds will be allocated directly to low-income weatherization agencies for low income weatherization assistance.

4. *To modify the Conservation Investment Program as follows*:

To define significant investment to mean a minimum of .005 of utility gross revenues as defined by the Public Utilities Commission for years one and two of the program and .01 of utility gross revenues for year 3 and beyond.

To assure that 50 percent of this amount shall be set aside and used for energy conservation activities for low income residents in the utility's service delivery area.

"Low-income" shall be defined as a family eligible for assistance under the LIHEAP Block Grant.

For regulated utilities covered by the CIP law, which provide energy for space heat, services to low income households would be energy conservation activities per standards as promulgated by the Minnesota Department of Jobs and Training subject to a maximum grant of $2,000 per household and that no activity will be undertaken unless there is a ten year or better payback.

For regulated utilities covered by the CIP law, which provide nonspace heat, cost-effective nonspace heating conservation will be mandated. Service would be provided to low income customers in all areas served by the regulated utility. Programs would be designed and implemented by low income energy providers.

The local DOE weatherization provider and/or the LIHEAP Program operated by the local delivery agency shall operate the Conservation Improvement Program unless the local agency chooses not to deliver the program. In such cases, organizations with the capacity to deliver low income conservation programs would be selected.

Low Income Energy Policy Options. As energy costs increase, conservation activities and statewide energy policy can have a noticeable impact on the survivability of low income households in Minnesota. We feel that this report should address these needs by taking into account the following:

Conservation policies and programs which benefit low income citizens.

Increased funding for the low income weatherization program (see above).

Development of a state funded targeted comprehensive energy program.

Marcy Shapiro, Spokesperson
Energy CENTS Coalition
Minneapolis, Minn.

(*Editor's Note*: A copy of the report, "Energy: A Survival Issue of the Poor," by the Energy CENTS Coalition, and a list of legislative recommendations were included with the comments.)

LEGAL SERVICES ADVOCACY PROJECT

Overall, this draft report provides a technically sound analysis of Minnesota's energy choices. However, the report fails to focus on energy policies which impact directly on low-income Minnesotans.

The observation that the price of energy continues to be a major concern for low-income Minnesotans is accurate. The questions left unresolved by this report are the policy options that will make the cost of energy more affordable for the less affluent.

Energy Conservation. This report explores a number of methods that have potential for improved energy efficiency. The regulatory concepts of ''least cost planning'' and ''avoided costs'' and the impact that conservation efforts might have on Minnesota's need to import more energy could be improved by including some discussion on the potential for increased activity under the low-income weatherization program. It is generally agreed that not only do conservation improvements reduce low-income consumers' energy costs but they also make energy more affordable for all consumers by reducing the amount of energy we must import.

The low-income weatherization programs have been on a funding roller-coaster since 1977. The level and extent of funding should be certain each year. The reductions in funding from the federal government should be supplemented with funds from other sources. For example, Stripper Well and Exxon overcharge funds could be utilized more effectively to guarantee that low-income consumers have access to conservation improvements. This report should at least determine if a state appropriation of funds for weatherization is an appropriate response to the lack of stable funding for the weatherization activities.

This report points to Minnesota's Conservation Improvement Program and the fact that utility investment measures benefit renters and low-income energy users. However, the report fails to provide useful insight into how well these PUC ordered programs have benefited renters and low-income consumers. The question of how much of this resource should be used to meet this mandate for renters and low-income users is left unanswered. We agree that least cost planning and conservation investments of the kind identified in the report are important, but we also need to know if a shift in emphasis is needed to more effectively balance the state's conservation needs. Utility investment in conservation activities should be rewarded to a greater extent than is currently the case by state regulation; it should also include incentives that encourage participation by low-income consumers and renters.

Residential Building Codes. The report concludes that Minnesota's current residential energy code helps to assure a high level of energy efficiency in new homes. What about *older homes* and enforcement of the codes to assure ongoing compliance? I disagree with the conclusion that with some minor modifications, the code will continue to serve as a model for other states. A major commitment is needed here to vigorously enforce the code by monitoring and enforcement where necessary throughout the state.

When the legislature first enacted the residential energy code in 1980, money was appropriated for code enforcement. The department was able to hire state inspectors who had the authority to order the owner of rental property to make repairs required by the code. This activity was subsequently defunded, resulting in no state enforcement of the residential energy code. This draft report should be revised to include discussion and recommendations for effective enforcement of the residential energy code.

Recommendations are also needed regarding those communities which do not have local housing codes and inspectors to enforce the state energy code. Without state or local inspections, the majority of these communities do not have the capacity to impose an effective remedy for violations. It appears that some substantial savings could result to the benefit of renters and low-income consumers if an enforcement system were re-adopted at the state level.

The low-income tenant who must reside in housing which costs considerably more due to the failure to maintain it in compliance with the residential energy code, obtains little relief knowing that standards exist which are not subject to enforcement.

Regulation of Utility Providers. The availability of affordable energy is a crucial issue for low-income consumers. These Minnesotans depend on effective regulation of monopoly utility providers. Again, this report provides a superb technical analysis, but fails to recommend improved regulatory policies directed at the problems low-income people experience. The most pervasive concern confronting many of these consumers is the threat of losing service.

First, the PUC should re-evaluate its Customer Service Rules regarding billing disputes, applications for new service, the definition of customer, disconnection restrictions for occupied residential units, and the landlord/tenant rule. In September, 1987, the PUC sought comments on proposed revisions to these rules. No further action has commenced regarding implementation of these proposed modifications.

Second, the Minnesota PUC Cold Weather – Rule should be amended to provide greater protection for those who experience payment difficulties. For instance, should consumers who have paid a designated percentage of their annual income on utility bills be free from the threat of winter shut off of service? The income guidelines under the rule have not changed since the rule was initially adopted. Should the income guidelines for this rule be changed? I would argue that they should and that a reasonable index would be 185 percent of the federal poverty level.

How does this rule, and how should this rule, factor into Minnesotans' energy options? Moreover, many unregulated utilities provide service to countless Minnesotans. Should the state policy on energy options for low-income consumers provide some shut off protection for these energy users?

Finally, I was disappointed that this report did not mention anything about the future of Percentage of Income Payment Plans. Minnesota has completed two pilot demonstration projects to determine if this was a viable option for use of Low-Income Energy Heating Program (Fuel Assistance) funds. The results of these pilots should be a part of this report. This may be a creative use of dwindling federal assistance to help with payment for fuel bills by low-income people. Policy makers should be aware of the results and the potential impact it could have on our energy future.

Harold Turner, Director
Legal Services Advocacy Project
St. Paul, Minn.

NORTH AMERICAN WATER OFFICE

Least cost planning. If ''least cost'' energy management were truly our goal, the entire discussion of electric energy would focus on policy capable of capturing that potential, and the environmental and economic benefits of doing so, rather than telling us that demand will soon outstrip supply.

The expectation of capacity deficits within ten years makes no sense when placed in the context of very inexpensive end-use efficiency improvements having the potential to eliminate over half of all electricity consumed. This is the correct context for electric supply options if you are attempting to direct policy-makers away from the historical supply-side bias, because the fraction of the efficiency improvement potential that is actually captured in the next ten years is clearly a matter of policy. Electrical energy policy is the factor determining whether or not existing capacity will be sufficient in ten years.

The end-use efficiency improvement opportunity needs to be much more emphatic. Very few people actually understand the significance of that potential, and how its tremendous size, with the correct policy support, utterly overwhelms all other options combined in terms of economic, social, and environmental benefits. In order to put a more realistic focus on the end-use efficiency improvement opportunity, we would suggest that the following language be the very first recommendation:

> The Legislature and/or the Public Utilities Commission should mandate the establishment of a cost recovery methodology that shall make $0.02/kWh demand or supply-side investments more profitable for regulated electric utilities than $0.03/kWh demand or supply-side investments; $0.03/kWh demand or supply-side investments more profitable than $0.04/kWh investments, etc.
>
> This cost recovery methodology shall provide for the capture of at least 10 percent of the cost-effective technical potential for end-use electrical efficiency improvements on an annual basis.

Forecasts. The forecasts of electric consumption in Minnesota in Section 3 are presented in terms of exponential annual growth. Such a methodology destroys the ability to use a forecast as a tool to help enact and deliver policy, if the policy is to maximize cost-effective efficiency improvements, because market penetration of efficiency improvements is treated as simply one of many variables bounded by assumptions and ranges, rather than the target of a policy goal.

Forecasts of electric demand and consumption should be based on how much electricity is presently being used for specific sector-by-sector functions (data are available), the cost-effective technical potential for efficiency improvements sector-by-sector and function-by-function (data available), the sector-by-sector, function-by-function efficiency improvement investments and their impact (a matter of policy), and growth/saturation/decline within the system (a matter of econometric conjecture). Such forecasts would be powerful tools to determine appropriate levels for end-use efficiency improvement investments, and in measuring the actual impact of efficiency improvement investments on demand and capacity levels.

Efficiency Potential. While the electrical end-use efficiency improvement potential identified in the report is the 52 percent figure supplied by PLC, Inc., it should be noted that this is a very conservative figure due to an inexhaustive analysis of efficiency improving measures. The Rocky Mountain Institute, which has conducted a more thorough and systematic assessment of the latest (May, 1987) hardware in upward of 73 classes of technology, for a region of the country that has less potential than we have due to a hotter climate (Austin, Texas), reports an end-use efficiency improvement potential for Austin of 78 percent of annual and 80 percent of peak system load at an average cost of 0.87 cents per kilowatt hour.

Technical Development – Fuel Cells. The Technical Developments referred to on pages 29-30 would benefit from a description of the virtues, costs, and potential of fuel cells. (See "Fuel Cells for the '90's," *EPRI Journal*, September 1984.)

Petroleum Issues. Activities such as exploring in the Alaskan National Wildlife Refuge and along the California coast would more accurately be characterized as "short-sighted responses" rather than "short-term solutions" (page 3).

Waste Disposal. Trash burners should be called trash burners, particularly since it is recognized that "waste-to-energy" plants are not significant in terms of the state's total energy needs. Without the facade of producing needed energy, trash burners are not viable economically or politically.

The energy analysis of burning trash should be more complete. For example, trash burners may produce 17.4 trillion Btus per year by 1990, but how many trillion Btus must be expended per year to extract and process virgin materials into products that could have been made with trash that was burned instead? In short, what is the net energy contribution of trash burners?

Recycling and composting compete with trash burners for people's garbage. These options, along with reducing waste at the source, will reduce the amount of garbage available for incineration quite quickly as people learn more about the economic and environmental liabilities of trash burning, compared to the other solid waste management options. An economic analysis should therefore be conducted to determine how much of the various components of the solid waste stream can be denied trash burners before they are no longer able to generate enough energy revenue to be economically viable, and how much paper and plastic in particular can be denied them before they actually require an additional Btu contribution from natural gas in order to maintain adequate combustion time, turbulence, and temperature?

George Crocker, Director
North American Water Office
Lake Elmo, Minn.

(*Editor's Note*: A summary of the above points was presented in oral testimony by Mr. Crocker at the public meeting held at 1:30 p.m. Tuesday, November 29, in Room 10, State Office Building. Included with Mr. Crocker's written comments were two attachments: "Advanced Electricity-Saving Technologies and the South Texas Project," by the Rocky Mountain Institute, Old Snowmass, Colo., 1986; and "Fuel Cells for the '90s," *EPRI Journal*, September, 1984.)

COMMENTS FROM STATE AGENCIES

MINNESOTA DEPARTMENT OF ADMINISTRATION, STATE ENERGY CONSERVATION DIVISION

The report is well-documented and nearly complete in its treatment of energy options. The following are noted:

The section on Transportation Efficiency and Alternative Fuel Sources, pages 38-40, omits any reference to solar-powered transportation.

Recommendations regarding natural gas regulatory concerns should include a request that the Minnesota legislature pass a law that makes pipeline companies showing preferential treatment to their affiliates illegal and subject to a fine.

In making recommendation 1.5. calling for a review of ways to provide economic incentives for utility investment in conservation (page 14), the report states that efficiency programs reduce energy sales and, therefore, profits. This conclusion is unfounded; just because sales are reduced profits don't necessarily go down; with a higher price the profits could increase.

The recommendations regarding Alternative Energy Options (pages 17-18) should include a call for a study to judge the effectiveness of electric automobiles powered by solar cells. This technology, although not yet fully developed, would greatly improve the greenhouse problems because carbon dioxide would not be produced except in the production of the batteries and solar cells. In the last ten years the cost per watt of a photovoltaic system dropped from $50 to $5.

MINNESOTA DEPARTMENT OF JOBS AND TRAINING

"Energy: Minnesota's Options for the 1990s" includes only one recommendation directed to low income energy issues, but it is a broad and appropriate one, since the Legislative Task Force on Low Income Energy Issues will be recommending policies prior to the next legislative session. We would like to see this report include recommendations of its own, however.

The position of energy as a necessity for life, a major part of the poor household's budget, and a determiner of the quality of life means that few energy policy decisions will not have an impact on the poor. Those impacts ought to be part of each discussion of energy policy so that the evolution of energy policy decisions does not further victimize an already energy vulnerable population.

The Department of Jobs and Training (DJT) would like to see low income issues addressed as an integral part of this report, including:

1. Inclusion of descriptions of low income energy programs currently operated in the state; and

2. Discussion of low income concerns within the discussion of pertinent energy issues or policy decisions.

Two categories of energy issues addressed in this report, regulation and energy efficiency, should include recommendations targeted to low income households. A third category, state response to federal action, should also be addressed.

State Response to Federal Action

Recommendation: That the state of Minnesota take a position on the problem of reduced funding for low income energy programs and demonstrate a commitment to these programs.

Recommendation: That the state of Minnesota include in its study analyzing the effects of electric deregulation, if undertaken, an examination of the effects on low income households, on the costs of housing, and on the problems of homelessness.

Recommendation: That DPS and other state agencies include as part of their advocacy for a free energy market a plan to alleviate the impact of deregulation on the poor. Protective measures for the victims of a free market should be part and parcel of deregulation plans.

State Regulatory Response

Recommendation: That the state examine the impact of local utility policies on low income households. Since the Cold Weather Rule protects only customers of the few regulated utilities, the customers of thousands of nonregulated utilities have no protection at all.

Similarly, the Cold Weather Rule has payment requirements that are not compatible with programs to pay fuel bills. For example, budget plans under the Cold Weather Rule are established before the Energy Assistance Program begins and do not take those payments into account. Yet families must continue to pay the budgeted amount to retain Cold Weather Rule protection even after part of their bill has been paid by Energy Assistance.

Recommendation: That Minnesota study and make recommendations on efforts by other states to share low income families' energy cost burden. Some states are examining ways to include utilities in the solution. Others have committed state resources so that tax payers share the burden.

Energy Efficiency

Recommendation: That the state support and find additional sources of tax or non-tax dollars for the Low Income Weatherization Program and the Energy Assistance Program. These two programs have had major success in making energy efficient dwellings and heating systems available to low income households but Congressional support for both programs continues to dwindle.

Recommendation: That low income households be included in all plans to increase residential or transportation energy efficiency. Many energy efficient options are available only to those who have the ability to pay for them. New products such as energy efficient appliances and new technologies for retro-fitting existing housing require up-front investments that are out of reach for most poor people. Program innovations by both public and private organizations must be encouraged to allow poor households to continue to reduce their energy consumption.

Recommendation: That energy efficiency standards for rental residential properties include penalties, be enforceable, and be enforced.

Recommendation: That any new taxes on energy include a counter activity to alleviate the impact on the poor.

These recommendations comprise the testimony of the Economic Opportunity Office on the State Energy Policy and Conservation Report to the legislature. Because energy issues are of major concern to the low income population, the energy situation is not static, and future additions or revisions are likely.

Carol A. Raabe
Energy Assistance Coordinator
Economic Opportunity Office
St. Paul, Minn.

MINNESOTA DEPARTMENT OF NATURAL RESOURCES

In the section on Minnesota Alternative Energy Resources, table 1 (page 85) lists residential wood consumption as totaling 34.252 trillion Btus. This figure should be 28 trillion Btus. The 1984/85 Residential Fuelwood Use in Minnesota survey done by the Minnesota Pollution Control Agency found a total residential wood use of 1.4 million cords. 1.4 million cords at 20 million Btus per cord is equivalent to 28 trillion Btu. This is the same survey as was done in 1980 and the figures are comparable.

Dave Martodam, Division of Forestry
Grand Rapids, Minn.

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT strongly supports the report's state energy policy, and applauds the Department of Public Service's efforts in identifying energy issues and recommending actions which can encourage more efficient use of energy for Minnesota. The recommendations on page 17 specifically address transportation issues. We wish to comment with the following information on these issue areas.

3.4. Mn/DOT supports increasing fuel efficiency in new vehicles. However, it should be noted that with increased gas mileage efficiency, the traditional base of funding (motor fuel tax) is diminished for highway improvements. This puts a greater burden on states to diversify highway funding sources.

3.5. Mn/DOT recognizes the importance of ridesharing in solving traffic congestion, and has long supported ridesharing since the beginning of the Minnesota Rideshare program at Mn/DOT in the 1970s. The Interstate 394 design includes several components to encourage ridesharing, such as a high occupancy vehicle lane, park and ride lots, and parking garages for car poolers. Mn/DOT will continue to strongly consider roadway designs which promote ridesharing in urban freeway projects.

3.6. As noted in the report, Mn/DOT is currently assessing the addition of a high occupancy vehicle lane and light rail transit as one alternative in the Draft Environmental Impact Statement for the Interstate 35W corridor. Mn/DOT consistently evaluates energy use for major highway projects within the context of the environmental review process. The evaluation considers both construction and operational energy use in comparing alternatives.

3.7. Bicycle and pedestrian travel consume less energy per passenger mile than any motorized form of transportation. Minnesota can make a noticeable impact on energy consumption through expansion of bicycle/pedestrian options. Mn/DOT actively pursues and encourages the development of appropriate bicycling and pedestrian facilities in roadway construction and reconstruction projects.

Darryl E. Durgin, Assistant Commissioner
Minnesota Department of Transportation
St. Paul, Minn.

COMMENTS FROM UTILITIES

INTERSTATE POWER COMPANY

This report portrays unavailable conservation measures as options. It appears that some options might not be cost-effective for all consumers. Interstate will continue to cooperate with Minnesota agencies in disseminating conservation information to Minnesota consumers. However, Interstate does not want to disseminate misleading information.

A.D. Cordes, Vice President
Interstate Power Company
Dubuque, Iowa

MINNEGASCO

The Outlook for Natural Gas Supplies. This section refers to natural gas prices rising again during the 1990s; most experts predict the rise in prices will be at the rate of inflation.

Least Cost Planning/Least Cost Planning and Analysis by Utilities. In discussing least cost planning, the report does not always specify "electric utilities." Minnegasco does not believe the blueprint for electric utilities can be directly applied to gas utilities. Minnegasco relies upon load profile studies, integration of supply planning, requirements forecasting, and load management for peak days. Minnegasco does not believe the data and expenses required for end use modeling are justified for Minnegasco for the value received. Recommendations 1.5 and 1.7 should refer only to electric utilities.

Flexible Natural Gas Rates. Minnegasco commends the state of Minnesota for its foresight in allowing utilities to utilize flexible rates to compete with alternate fuels. We believe flexible rates should be made permanent and we hope to have the opportunity to comment on the benefits of flexible pricing when the DPS drafts its report on flexible pricing to the legislature later in 1989.

Current Natural Gas Regulatory Issues to be Resolved

Access to Pipelines is becoming a non-issue as most pipelines have voluntarily opened their systems and the rest will be "forced" into it by FERC and market conditions over time.

Marketing Affiliates have been placed under strict guidelines by FERC Order 497 and are in a good position to provide services. We should only insure they do not receive unfair preferences from their pipeline affiliates. They should not be prohibited.

In the area of **Incentive Regulation**, it should be noted that each natural gas utility's rates could be impacted differently, based on geographic access to suppliers, load profiles, and other factors difficult or impossible to control.

In the area of **Price and Supply**, it should be noted that regulation has never produced additional supplies. Minnegasco does not support reregulation of natural gas prices.

Acid Rain. Select use of natural gas burned in combination with coal should be cited as one possible solution to the acid rain problem.

Transportation. Compressed natural gas (CNG) is a particularly well-suited, economically feasible, environmentally attractive, alternative fuel for use in transit buses, school buses, garbage trucks, delivery trucks, and other fleet vehicles operating within a metropolitan area. We suggest that DPS add a recommendation to the Transportation Section (page 17) encouraging use of CNG as an alternative vehicle fuel for these uses.

Minnegasco questions the promotion of alcohol fuels as a long term solution mainly because, from a thermodynamics perspective, alcohol fuel is a net energy loser when calculating "energy-in" versus "energy-out." We believe Recommendation 4.3 should be amended to insure that the development of alcohol fuels for transportation should be promoted as long as "energy-in" is less than or equal to "energy-out" and the concept is acceptable to the general public.

Energy Efficiency Trends. Residential energy use has declined significantly. A point should be made that the decline in energy use per household in Minnesota has resulted largely from conservation measures in the natural gas sector.

Also, providing rebates for such things as electric water and space heating may be counter productive to natural gas utilities' efficiencies. It promotes higher use of electricity for uses that are better accomplished with natural gas, especially in view of the supply problems forecasted for electricity within the next decade.

Recent Developments in Energy Efficient Technologies. It should be noted that gas furnaces are now available in efficiencies up to 96 percent Annual Fuel Use Efficiency (AFUE). The hourly efficiency of gas furnaces in 1976 was typically 80 percent, but the AFUE was about 65 percent because of the cycling effect (loss of usable heat up the stack during the off cycles). Technology today reduces the stack temperatures to as little as 20 degrees above the ambient temperature and thus squeezes more usable heat out of each Btu. In addition, the new high efficiency furnaces do not have conventional chimneys to draw off heat during the off cycles but instead vent only when they are running.

The reference to fuel oil furnaces being 80 percent to 90 percent efficient in 1984 (page 66) needs further explanation. The application of flame retention burners could not bring the oil furnace to an AFUE of 80 percent to 90 percent. It could, however, raise the hourly efficiency to as high as 85 percent. To get into the 80 percent to 90 percent AFUE, oil furnaces would have to employ the same technology as gas furnaces, which reduces flue gas temperatures.

Rate Design Policy of the PUC. Some electric rates designed to promote conservation and efficiency may be counter productive to the efficiency of natural gas utilities. The dual fuel rate that allows a very low electric rate is an example. This rate may result in existing natural gas customers adding electric heat pumps and using gas only during the winter "peak" periods of the electric system. This could have negative impacts on gas distribution in Minnesota, since it could increase peak load while resulting in little or no off-peak load.

Off peak electric rates which promote electric heating (at incremental rates sometimes just above the cost of fuel) may be displacing natural gas for heating. Under this scenario, the state is importing about 3 Btus of energy for every one that is delivered to the customer in the form of electricity. Even though the higher end use efficiency of electricity may offset some of the difference, it will normally be better from an efficiency and total energy standpoint to use natural gas, rather than electricity, for space heating.

The report cited the role of cogeneration as a means to reduce the need for electric utility plant expansion. However, the amount of new cogeneration in the state has been very small. The "maximum encouragement provided by the Commission," referred to on page 95, is needed to make cogeneration a reality.

Tracy Bridge, Director
Rates and Tariffs
Minnegasco, Minneapolis, Minn.

NORTHERN STATES POWER COMPANY (NSP)

From NSP's perspective, these are the key energy issues facing us in the 90s:

1. Environmental Impact of Fossil Plants: acid rain and the greenhouse effect

2. Nuclear Issues: cost of regulation and disposal of wastes

3. Right of competitors to sell electricity: independent power producers and transmission access

4. Right of customers to choose their supplier (including mergers)

5. Utility mergers

The report, "Energy: Minnesota's Options for the 1990s," sets environmental protection as Minnesota's primary energy policy goal. NSP and state policy makers historically have recognized the need to balance environmental goals with economic goals. Protecting our environment is important; protecting our state's economic health is also important. Demand side management can help protect the environment and help meet the state's energy needs at a reasonable cost; but we must pursue both of these goals through a balanced approach that ensures our state's economic health. While NSP has not yet ascertained what the optimal level of demand side management is, and we might increase our efforts in the future as we learn more, we believe it would be an expensive mistake for Minnesota to attempt to meet all of its new energy needs through demand side management.

NSP's Commitment to Demand Side Management. NSP is committed to managing the demand for its product. Uninhibited electric growth and the construction program that would result present NSP with unacceptable business risks. Consequently, NSP has initiated programs to motivate conservation and load management. In 1988 alone NSP developed the following new programs to motivate customers toward wise use of electricity:

> industrial audits, lighting reflectors, financing for industrial conservation measures, and detailed studies of commercial and industrial customers' electricity use.

NSP has more than 40 programs motivating customers to conserve or manage electricity use.

NSP's long range resource plan (forecast) clearly shows its ongoing commitment to demand side management. NSP estimates that more than 30 percent of its future growth in electric peak demand will be eliminated through conservation and load management. If NSP achieves this goal, NSP will not have to build new power plants equivalent to one and one-half Sherco 3s. This outcome reduces NSP's business risk.

Least-cost planning. Regarding regulatory initiatives known as "least cost planning," NSP believes that Minnesota's existing regulatory structure works well. Minnesota's excess capacity problems are small and isolated, our customers generally enjoy reasonable rates, and our environmental record is laudable.

Perhaps implementation of existing programs can be fine-tuned, within the existing regulatory framework. But major revisions to the regulatory structure are not needed at this time.

DPS Conservation Potential Study. The quadrennial report references the large amount of electric conservation potential (52 percent) that was determined in the Conservation Potential Study conducted by PLC, Inc. This conservation report has many flaws and is inadequate to use as a benchmark for the achievement of additional conservation in Minnesota. Estimation of conservation potential is a very involved and detailed process which is being studied at some expense by utilities and research firms nationwide. PLC, Inc. estimated Minnesota's conservation potential on the basis of limited data and resources. Major flaws include:

1. The study fails to consistently and explicitly allow for conservation that has occurred historically. Utility forecasts already include the continuation of existing conservation trends.

2. The study is static in nature, and therefore does not consider growth in electric demand due to growth in the economy or growth due to new electric products.

3. The study does not consider the costs of installing electric efficient technologies when an intermediate level of efficiency already exists. It only compares the most efficient options to the least efficient options.

4. The avoided cost estimate which PLC, Inc. uses as the basis for determining the cost-effectiveness of the conservation measures, is unrealistic. It is substantially higher than NSP's avoided costs.

In summary, the Conservation Potential Study is useful in presenting rough estimates of conservation potential from a theoretical and technological perspective, but is not a credible analysis of cost-effective conservation potential. This severely limits the ability of the report to further utility conservation policy and program planning.

Natural Gas. The natural gas industry has undergone a regulatory revolution in the last five years. FERC, pipeline, and gas distributor regulatory initiatives have introduced a significant degree of competition to the wholesale gas supply and pipeline transportation business. In 1985, NSP Gas purchased its entire gas supply from Northern Natural. NSP Gas now purchases approximately 50 percent of its supplies from numerous unregulated suppliers, and large customers may also purchase their own gas supplies and transport them through NSP's distribution system. Increased competition and regulatory flexibility allow NSP to reliably serve residential and commercial customers at significantly lower rates, while enhancing NSP's ability to serve the extremely competitive large volume energy market. Future gas regulatory initiatives should be aimed at fine-tuning the gains to date rather than imposing new FERC requirements (capacity brokering, mandatory carriage, affiliate transaction rules) which could impinge on the benefits achieved since 1983.

NSP gas CIP conservation programs differ from NSP electric programs, reflecting the two fundamentally different energy markets. As the DPS report notes, gas customers are conserving. Residential and commercial firm customers have installed conservation improvements, and cost conscious industrial customers dramatically increased gas use efficiencies. (For example, weather-normalized annual gas use for a typical residential space heating gas customer fell from about 160 Mcf in 1978 to 120 Mcf in 1987, a 25 percent decline.) NSP gas sales were essentially flat over the decade, even though NSP added 48,500 new gas customers (a 21 percent increase). Since most customers are already conserving, NSP gas CIP programs focus on serving low income and rental customers unable to finance their own conservation improvements, consistent with MSA Chap. 216B.241. NSP gas CIP expenditures per customer are consistently among the highest of all Minnesota gas utilities.

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(*Editor's Note*: NSP included with its written comments attachments that stated NSP's position on "FERC Notice of Proposed Rulemaking: Regulations Governing Independent Power Producers, Regulations Governing Bidding Programs, and Administrative Determination of Full Avoided Costs, Sales of Power to Qualifying Facilities and Interconnection Facilities.")

UNITED POWER ASSOCIATION

We have several comments. Our primary concern relates to the use of the PLC Conservation Study. Quoting the PLC Conservation Study in this document would seem to place the Department of Public Service in the position of ratifying the results of the PLC study. Rather than quoting it, the study should be refuted.

One example of the erroneous use of the PLC data is on page 70 of the report. A table shows how a *standard* water heater with 12 inches of fiberglass insulation added can save 1,050 kilowatthours per year. Since the average water heater only loses 1,000 kWh (also noted on page 70), this level of savings cannot occur in the average water heater. In fact, adding insulation to the typical water heater that is being sold today results in savings so small as to be insignificant.

The Hood River Conservation Project in Oregon is presented as a successful conservation program. Some lessons learned from this project are that the savings were 57 percent less than expected from the conservation measures. Demand was reduced 10 percent at a cost of $9,000 per kilowatt. This reduction in demand was clearly not cost-effective.

The results of the Hood River Project are presented as if they transfer to Minnesota. Less conservation is available because Minnesotans have already undertaken the most cost-effective conservation measures. The people in Minnesota use less electricity because of the higher prices for electricity. Less additional conservation is available in Minnesota at a higher cost.

The PLC Study uses Hood River data to justify calculating the potential residential conservation as *slightly lower than 60 percent*. The Hood River Project was designed to test the upper limits of home energy conservation. Yet this super retrofitting conservation project yielded only a 15 percent savings. The project indicates that the upper limit conservation potential for Minnesota households is 15 percent rather than 60 percent. The actual potential for additional conservation is probably much lower than 15 percent in Minnesota.

A critical examination of this study would be in the best interest of the citizens of Minnesota.

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GLOSSARY

GLOSSARY

Definition of some general terms used in this report

Alternative energy sources—fuel sources other than nuclear or the conventional fossil fuels that are renewable or a resource endogenous to Minnesota. A renewable resource is one that can be replaced at a rate greater than or equal to its rate of use.

Avoided cost—the cost a utility avoids paying by not constructing additional generation capacity. This cost is used to determine the price a utility pays to a qualifying cogenerator or small power producer for additional power that otherwise would have been provided by the new construction.

Base case forecast—a prediction based on the most likely set of conditions.

Base load—the portion of electrical demand that a utility must supply continuously over the course of the year. See "Peak load."

Base load plant—a power plant that provides the lowest cost method for meeting base load electric demand. Base load plants generally have high fixed costs and are operated continuously when not shut down for maintenance or repair.

Buyback rate—The price a utility pays for electric power from a qualifying cogenerator or small power producer. See "Avoided cost."

Cogeneration—production of electricity and heat energy from the same fuel source. Systems are of two kinds: one uses a fuel source such as oil or gas to generate electrical or mechanical power and captures the rejected or waste heat and applies it to the process; the other system applies the primary fuel source to a useful heating process and captures the rejected or waste heat to generate electrical power.

Demand-side management—Action to avoid the need for additional power plants through load management and utility sponsored conservation programs. (See "Load management.")

Electric generation capacity—The maximum power output for a particular plant or system.

End use electric consumption—total electric consumption minus the electric losses related to generation and transmission. Unless stated otherwise, electric consumption figures used in this report refer to end use consumption.

Federal Energy Regulatory Commission (FERC)—established in 1977 (replacing the Federal Power Commission) with the primary responsibility of ensuring the nation's consumers adequate energy supplies at just and reasonable rates and providing regulatory incentives for increased productivity, efficiency, and competition. Its primary functions are to establish and enforce rates and regulations regarding interstate aspects of the electric, natural gas, and oil industries. It also issues licenses for nonfederal hydroelectric plants and certifies small power production and cogeneration facilities.

Fossil fuels—materials found in the earth's crust and formed from organic matter as a result of geological processes occurring over many millions of years. The conventional forms of energy in wide use today—coal, petroleum, and natural gas—are all fossil fuels.

Independent power producers—Private investors in electric power production facilities that sell power to one or more electric utilities but do not meet requirements for qualifying facilities. See "Qualifying facilities."

Least cost planning (integrated resource planning)—A planning process used by electric utilities and state public utility commissions that evaluates all supply options and demand-side management alternatives against a broad array of cost-benefit considerations. (See "Demand-side management.")

Load management—managing electric demand to reduce peaks and provide for a more uniform rate of demand.

OPEC—Organization of Petroleum Exporting Countries, an international cartel formed in 1960. Current member nations are Saudi Arabia, Kuwait, Iran, Iraq, Venezuela, Qatar, Libya, Indonesia, United Arab Emirates, Algeria, Nigeria, Ecuador, and Gabon.

Peak load—The portion of electrical demand that a utility must sell during short periods when total demand is at the highest level. For example, summer peak demand for many utilities occurs on the hottest days of the summer when late afternoon peaks in air conditioning loads coincide with many other uses of electricity.

Public Utility Regulatory Policies Act (PURPA)—Passed by Congress in 1978, this act is designed to encourage cogeneration and alternative energy production. It seeks to conserve electric energy, increase energy efficiency, and achieve equitable rates for electric consumers. Under provisions of the act, FERC requires electric utilities to purchase power from cogeneration and from small power production facilities that use renewable sources. (See "Avoided cost" and "Qualifying facility.")

Qualifying facility (QF)— A non-utility electric generation facility from which utilities are required to purchase power at established rates and terms. Provisions for qualifying facilities were established by the Public Utility Regulatory Policies Act of 1978. They include cogeneration facilities and small power producers that use renewable resources or waste products as their energy source.

Common units of measure used in this report

Btu—abbreviation for British thermal unit, a measure of heat. One Btu is equal to 252 gram calories or to the amount of energy required to raise one pound of water one degree Fahrenheit (under certain conditions of pressure and temperature).

Watt (W)—basic unit of electric power produced at a particular moment or instant in time.

Watt hour—Amount of energy equal to that expended by one watt for one hour.

Kilowatt (kW)—1,000 watts.

Kilowatt hour (kWh)—unit of energy equal to that expended by one kilowatt for one hour; equal to 3,412 Btus.

Megawatt (MW)—1,000 kilowatts; 1 million watts.

Megawatt hour (MWh)—the amount of energy expended by one megawatt in one hour.

Gigawatt (GW)—1 billion watts.

Gigawatt hour (GWh)—the amount of energy expended by one gigawatt in one hour.

Horsepower (HP)—A unit of power equal to 746 watts.

Glossary of environmental terms

Carbon dioxide (CO_2)—compound of carbon and oxygen formed whenever carbon is burned. It is a major cause of the global warming phenomenon.

Carbon monoxide (CO)—compound of carbon and oxygen produced by the incomplete combustion of carbon. It is emitted by automobiles and is a major air pollutant with adverse effects on human health. It is also a contributor to the global warming phenomenon.

Chlorofluorocarbons (CFCs)—one class of halogen compounds useful as aerosol spray can propellants and refrigerants. Eventually absorbed into the upper atmosphere, CFCs precipitate a reaction that results in destruction of stratospheric ozone (see "Ozone"). Increasing concentrations of CFCs are also a contributor to the global warming phenomenon.

Magnetic field—a force field surrounding a conductor, such as a wire, carrying an electrical current. Magnetic fields around AC conductors oscillate at 60 cycles per second. Magnetic fields surrounding DC transmission lines create a steady state field.

Nitrogen oxides (NO_x)—class of air pollutants that includes several forms of the compound Nitrogen Oxide. Nitrogen oxides are produced by the burning of fossil fuels and are involved in formation of harmful smog. They also are a contributor to acid rain.

Ozone—a gas found in trace quantities throughout the atmosphere, with the largest concentrations located in a layer between the altitudes of 9 and 18 miles. This stratospheric ozone layer plays a critical role for the planet by absorbing harmful ultraviolet radiation that otherwise would be transmitted to earth. Ozone is also produced in the atmosphere at the earth's surface (the troposphere) where it plays a harmful role in the environment: it is involved in the formation of smog and in the production of acid rain.

Sulfur dioxide (SO_2)—a compound of sulfur and oxide generated principally by the combustion of fuels containing sulfur. A major source of acid rain.