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The Good News About Energy

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Like many others, the Council on Environmental Quality is concerned about the possible environmental impacts of continuing our historically high rates of energy growth. Projected to the turn of the century, these impacts could prove unacceptable to a major segment of the American people. Spurred by this concern, we undertook several months ago to investigate the potential for achieving lower energy growth in the United States and the implications of this low energy growth for the economy, the environment and government policy.

Our overall conclusion, described in detail in the following report, is that the United States can do well, indeed prosper, on much less energy than has been commonly supposed. The principal basis for this good news is the accumulating evidence that the means are available to wring far more consumer goods and services out of each unit of fuel that we use, whether it be a barrel of oil or a ton of coal or uranium.

The technology to increase greatly the productivity of the U S. energy system is at hand. It is also economical. Improved housing construction can save the homeowner several dollars for every dollar judiciously invested in making the house more energy efficient. Automobile users can economically reduce fuel costs by 50 percent or more by selecting vehicles with more efficient designs. Waste heat recovery systems available to industry today can often provide a 30 to 50 percent per year return on investment.

Energy productivity, as discussed in the following report, thus refers to getting more from the energy we use, not to a back-to-the-caves reduction in amenities. It means more efficient and durable products and buildings: automobiles with higher fuel economy, household appliances with improved designs to reduce energy consumption, and buildings with substantial amounts of thermal insulation and more efficient heating and air conditioning systems. And it means placing greater emphasis by industry on the cogeneration of electricity and process steam, and on the development of new, more efficient industrial processes.

The studies cited in the report indicate that increases in the productive efficiency of energy possible with today's technology would allow the U.S. economy to operate on 30-40 percent less energy. As a result of this large potential for energy savings, we can fuel the growth of the economy in years ahead in large part by increasing the productivity of the energy we now use rather than by greatly increasing our energy inputs. Energy-wise, a barrel of oil saved through increased efficiency is as useful as a barrel produced, and in other respects it is better.

The recent studies that support these conclusions also point out that in the decades immediately ahead the Gross National Product is not likely to grow as rapidly as in the past, principally because of slowed population growth. A continuation of this trend means that our demand for the things that energy can provide will be growing at a reduced rate at the same time that our ability to provide those

things with less energy is increasing.

Accordingly, if we take energy productivity seriously, we can have a healthy, expanding economy in the coming decades with energy growth far below that predicted only a few years ago. Then, and occasionally still today, simple extrapolations of historical energy growth "showed" that the U.S. would need to more than double its current energy consumption by the year 2000. Revised and more realistic estimates now indicate that with a moderate effort to improve energy productivity, our energy consumption in the year 2000 need not exceed current use by more than about 25 percent, and that with a determined effort it need not increase by more than about 10-15 percent. These estimates are obviously subject to uncertainties, but unforeseen developments seem far more likely to reduce energy growth than to increase it.

The feasibility of low energy growth is indeed good news, for it means that the tremendous difficulties posed by high energy growth to the environment and the economy can be largely avoided:

- Instead of over 500 new coal and nuclear power plants, we can limit the number of new plants needed by the year 2000 to a fraction (perhaps 25 percent) of what would otherwise have been required, thereby greatly reducing projected pollution, radiation hazards, and land disrupted by surface and underground mining and transmission corridors;
- Instead of deepening our dependence on foreign fuels, we can substantially cut our oil and gas imports from what they

otherwise would have been, thus aiding our energy security and our balance of payments;

- Instead of investing an ever increasing share of funds in new energy production facilities, we can adopt less costly conservation options, and in the process make capital available for more socially useful and job-producing investments; and
- Instead of depleting our fossil fuels at an ever increasing rate and facing the possibility of chronic or acute shortages, we can conserve our resources for the future and buy the time needed for the introduction of preferable renewable energy alternatives.

Achieving low energy growth will not be easy or cheap, but it will be far easier and less costly than achieving high energy growth. In an age increasingly beset by all kinds of limits (resource, environmental, and social), conserving energy through improving fuel productivity is the single most effective means of easing our long-term environmental and energy problems. And it provides an essential link in the inevitable transition toward an economy based on renewable energy sources.

With the passage of the National Energy Act, a major stride has been taken toward the achievement of a sustainable energy future. NEA policies and programs, together with President Carter's decision to make conservation the cornerstone of national energy planning, mark an important turning point in our national effort to address the energy problem. But further efforts are necessary, both to carry out existing conservation measures and to augment them with additional initiatives. A strengthened

national commitment, building on the progress of recent years, will be required to realize the many benefits of increased energy productivity and low energy growth. We must approach this task with an even greater intensity and determination than that we bring to our priority energy supply projects. In addition to individual action, the full range of federal, state, and local government initiatives is needed:

- Energy should be priced accurately at its replacement cost (including the costs not traditionally considered--such as environmental and national security) and programs implemented to cushion the impact on low-income people;
- Institutional barriers and market imperfections that inhibit cost-effective investments in energy conservation should be identified and removed; when this proves impossible, counter-balancing measures should be developed;
- Mandatory requirements should be adopted where necessary to ensure further but still economically sensible energy efficiency improvements, for example, in new autos, buildings and appliances;
- Support should continue for basic research and development for more productive and efficient designs and processes for use in all sectors of the economy; and
- Leadership and public education, essential to the success of energy conservation programs, should be provided.

In sum, with a determined national effort to increase energy productivity--an effort supported by an informed public and driven by

vigorous conservation policies at the federal, state and local levels and by the expected energy price increases--total U.S. energy use need not increase greatly between now and the end of the century, perhaps by no more than 10-15 percent. Such an effort is well worth the cost, for the cheapest, cleanest and least vulnerable energy option for the United States today is to use more of the large portion of our energy that is now lost through inefficient use. The resulting investment in increased energy efficiency will yield a higher return on investment and will have a more positive effect on GNP and employment than most supply expansion options.

The conclusion that the United States can maintain a healthy economy without massive increases in energy means that we can choose an energy future which greatly reduces the international, environmental and social risks the Nation must face in the 1980s, 1990s and beyond. An important point is that everyone can contribute to the achievement of this goal. Indeed, it will only be through countless decisions made by individual citizens that the many benefits of the wise use of our energy resources will ultimately be secured.

Charles Warren

CHARLES WARREN
Chairman

Gus Speth

GUS SPETH
Member

Jane Yarn

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Member

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I. A New Look at U.S. Energy Needs

In the years immediately prior to the 1973 oil embargo, U.S. energy studies routinely projected a continued rapid growth in energy demand based on historical trends.[1] Total demand was forecast to increase by 3 to 4 percent per year for the remainder of the century, leading to a year 2000 energy use more than 2.5 times that of 1970. Electricity demand was typically expected to grow at about 7 percent per year, resulting in an eight-fold increase over the same time period.

Since then, estimates of energy needs and requirements have changed dramatically. There has been a continuing stream of studies exploring the feasibility of low energy demand levels at the end of the century and beyond.[2] These analyses were conducted by a number of different groups: independent researchers, the National Academy of Sciences, the Oak Ridge Associated Universities' Institute for Energy Analysis, and the Ford Foundation's Energy Policy Project. While many assumptions and details of the analyses differ, each one points to the very real possibility of a low energy growth future, markedly lower than one might expect from historical trends, but still accompanied by an economy with steadily rising GNP.

A. Studies of U.S. Total Energy Needs

A study prepared by university researchers in 1977 for the use of the Joint Economic Committee examined the technical potential of fuel conservation through the turn of the century.[3] The study found that "it is feasible to maintain a healthy economy with much slower energy growth than we had in the past." The analysis concluded that slower energy growth will occur, in part because of established demographic trends and the continued evolution of the economy toward less energy-intensive activities. The study also concluded:

- Technical improvements in today's economy could eventually lead to an estimated 40 percent reduction in fuel consumption;
- If the present fuel savings potential were realized over the remainder of the century, the net effect would be a zero growth in energy consumption from 1985 to 2000;
- The wider application of technical innovation could lead to the extension of zero energy growth, or possibly negative energy growth, for a period near the turn of the century and beyond; and
- An expanded effort to increase energy productivity would create many new job opportunities and encourage productivity gains in the economy.

The most recent detailed look at the feasibility of a low energy growth future was published in 1978 by the Demand and Conservation Panel of the National Academy of Sciences' Committee on Nuclear and Alternative Energy Systems (CONAES).[4] Given time for the economy to

respond, the analysis concluded that a "major slowdown in demand growth can be achieved simultaneously with significant economic growth by substituting technological sophistication for energy consumption." More specifically, the study found that energy demand in the year 2010 could be roughly the same as today's level while providing a higher level of amenities, even with a total population increase of 35 percent. The study also determined that even if real energy prices were to stay at about their present level, growth in energy demand would be considerably slower than most past projections have indicated.

The CONAES panel report developed several possible low energy futures which differ with respect to energy price increases, energy conservation policy, and GNP growth rates. For each of the scenarios discussed below it was assumed that economic growth varies linearly in time, with real GNP in the year 2010 double that of 1975. (Higher GNP growth rates were also considered but have not been reported to date.) Assuming "very aggressive" energy conservation policies requiring some lifestyle changes and an energy price ratio of four (overall average real year 2010 price compared with 1975 price), CONAES Scenario I has a total year 2010 energy consumption of 63 quadrillion Btu (or "quads").* By way of comparison, total 1977 energy consumption was about 78 quads.**

---

*A quad is 10^{15} Btu. One quad per year is equivalent under typical operating conditions to the primary energy requirements of about 20 large (1000 megawatt electric) power plants which could meet the present electrical energy needs of roughly 10 million Americans; it is also equivalent to the production for one year of about 0.5 million barrels per day of petroleum.

**This includes 1.8 quads of biomass.

With "aggressive" energy conservation policies directed toward maximum efficiency plus minor lifestyle changes and an energy price ratio of four, energy demand in the year 2010 was found in Scenario II to be 77 quads, roughly today's level. Assuming conservation policies which slowly incorporate measures to increase efficiency and an energy price ratio of two, Scenario III has a total energy demand in the year 2010 of 96 quads. Finally, assuming a continuation of policies that were in effect prior to the passage of the National Energy Act and an energy price ratio of one (no energy price increases), energy demand in 2010 was estimated in Scenario IV to be 137 quads.

A paper presented at the December 1977 meeting of the American Economic Association analyzed year 2000 energy demands ranging from 139 to 70 quads and shows that energy growth can be restricted greatly without having to suffer comparably large economic costs in terms of reduced GNP and slower economic growth.[5] Although the authors believe that some economic penalty is associated with higher energy prices and reduced demand, one of their findings is that by 2000 energy consumption can be reduced 9 percent below current levels while GNP increases by 80 percent.

Another recent study concluded that "there is an enormous opportunity for reduced energy consumption per unit product in every sector of the economy..." [6] With an "Accelerated Conservation Policy" (energy efficiency increases about one percentage point every 2.5 years), it was found possible for GNP to increase at 3 percent per year with little or no increase in energy demand.

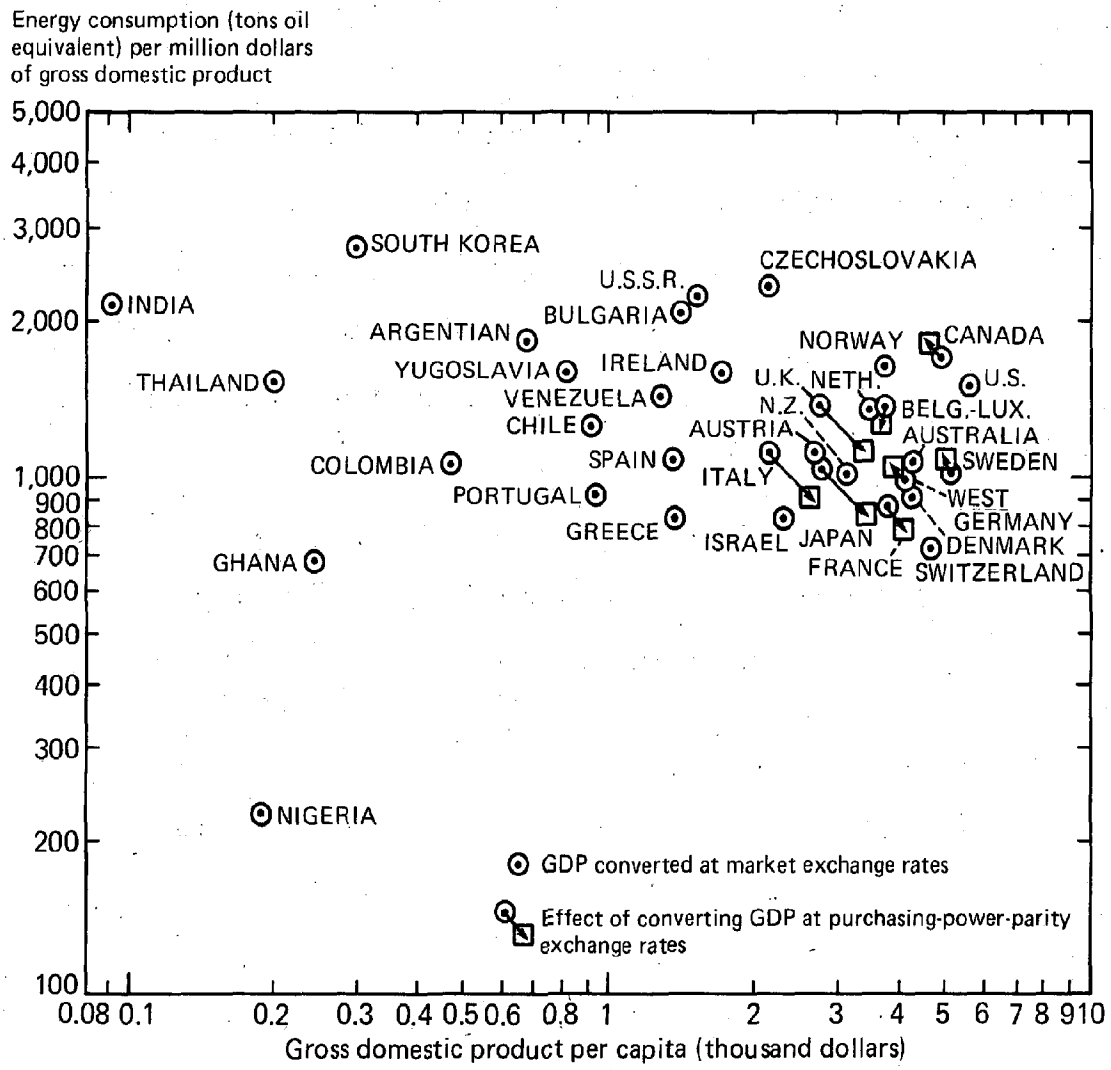
A study by Oak Ridge Associated Universities' Institute for Energy Analysis also examined U.S. energy and economic growth in some detail.[7] The report found that "both GNP and total energy demand are likely to grow significantly more slowly than has been assumed in most analyses of energy policy." Completed two years before the CONAES report, the numerical results illustrate a general trend of energy demand studies; the older the study, the higher the energy demand forecasts. Assuming a considerably higher GNP growth than the previous study, two energy futures were developed which have energy demand in 2000 ranging from about 101 to 126 quads. This range resulted from differing assumptions concerning demographic trends, labor productivity, the number of automobiles per capita, and GNP. When published in 1976, this was considered to be an unusually low estimate.

B. International Comparisons

The feasibility of a low energy growth future is also indicated by international comparisons which show the greater energy efficiency achieved by other countries as wealthy as the U.S. Several detailed studies have now been completed.[8] Although containing a number of important qualifications, these studies reinforce the view that "more efficient energy use will not interfere with and can in fact improve the functions of the United States economy over the long run."[9]

The energy consumed per dollar of national output is the most often cited measure of a nation's overall efficiency in energy use. In Figure 1, the 1972 ratio of energy consumption per unit of Gross Domestic Product is presented in comparison with per capita GDP for

Figure 1
Energy/output ratios versus national output per capita for selected countries, 1972.



Source: Joel Darmstadter, Joy Dunkerley, and Jack Alterman, *How Industrial Societies Use Energy: A Comparative Analysis* (Baltimore: The Johns Hopkins University Press, 1977), p. 6. Reprinted with permission.

selected countries.[10] (GDP is used rather than GNP to exclude income originating abroad, thereby better reflecting the economic activity related to domestic energy consumption.) The data show considerable variation in energy efficiency for a given range of per capita income. For countries with a GDP per capita over $1000, there is more than a factor of two variation in energy efficiency. Sweden, West Germany, and Switzerland have per capita incomes comparable to the U.S. but have substantially lower energy/output ratios. On a per capita basis, for example, Sweden uses only about 60 percent as much energy as the U.S. but has a comparable standard of living.

Such comparisons are too broad and aggregated to reveal much detail on what causes these differences. While a detailed treatment of this subject is beyond the scope of this review, Table 1 summarizes the principal factors which contribute to the much higher use of energy per dollar of output in the United States when compared to Western Europe.[11]

There is no single factor which explains the higher U.S. energy/output ratio. But over half the difference is attributed to a higher energy intensiveness in three areas: passenger transport, residential space conditioning, and industry. Some of our relative inefficiency in passenger transport is probably due to our less dense living patterns, but the data also indicate that our automobiles are less efficient, that we use less mass transportation and, less clearly, that we take more short trips in our autos, including trips in congested areas. In the residential sector, when corrected for climate, less efficient heating practices combined with a preference for larger homes

Table 1

Contribution of principal factors to higher use of energy per dollar of output in the United States than in Western Europe, 1972.

Activity or Sector	Percentage	
Total passenger transport	28	
Volume of passenger mileage		12
Energy intensity		11
Mix of transportation modes		5
Total freight transport	6	
Volume of ton mileage		15
Energy intensity		-1*
Mix of transportation modes		-8
Total residential space conditioning	8	
Size of units and prevalence of single-family dwellings		6
Heating practices		6
Degree day factor		-4
Total industry	20	
Energy intensity		61
Structure		-41
Sum of above	62	
All other (net)	38	
Total energy/GDP variability	100	

*Negative numbers represent those elements depressing U.S. energy/GDP below the European ratio.

Source: Adapted from Joel Darmstadter, Joy Dunkerley, and Jack Alterman How Industrial Societies Use Energy: A Comparative Analysis (Baltimore: The Johns Hopkins University Press, 1977).

and single family dwellings account for a portion of the difference. A major source of the difference between the U.S. and Western Europe is that industry-for-industry the U.S. is considerably less efficient: on the average the U.S. uses more energy to produce a given amount of industrial material or product (e.g., steel) than Western Europe.

These international comparisons provide direct real-world evidence that U.S. energy requirements per unit of output can be reduced substantially over the longer run. Among industrialized countries, variations in per capita energy demands result largely from differing prices and policies, rather than differences in customs or income.

C. The Potential for Increasing Energy Productivity

This section examines more concretely the conservation measures that are economically and technically possible today and in the future. The potential for fuel conservation is reviewed for each of the major consuming sectors.

Throughout our economy, substantial reduction in future energy requirements can be made without adopting measures which involve important changes in lifestyles. These possibilities have been examined in considerable detail by others and are briefly summarized below.[12] The results suggest that today's fuel consumption levels can be reduced by more than 40 percent through technical improvements which reduce the energy required per unit of output. Only modifications that are economic today on a life-cycle cost basis are incorporated in this estimate.

1. Residential/Commercial Sector

Technical changes in the residential/commercial sector could lead to a more than 40 percent reduction in its fuel requirements. A careful look at the energy actually used by homes and commercial buildings in 1973 suggests a wide array of specific opportunities for energy efficiency improvements. (See Table 2.) The more important technical improvements include:

- Reduce heating losses by 50 percent with better insulation, improved windows and reduced infiltration; this reduction is the single most important step in this sector, accounting for about one-half of the savings.
- Substitute heat pumps for electric resistance heating.
- Cut water heating fuel requirements by 50 percent through the addition of more insulation, reduced hot water temperature settings, and the use of solar energy or heat recovery from other appliances.
- Increase the efficiency of new air conditioners and refrigerators, and introduce total energy systems.
- Improve lighting systems to reduce energy requirements for lighting in commercial buildings by 50 percent.

The possibility of making these improvements has been well documented.[13] For example, it has been shown that energy consumption by refrigerators and air conditioners varies over a remarkably wide range. In the case of refrigerators energy use can vary by a factor of two within a single class of size and features with little correlation between energy requirements and first cost.[14] In addition to the

Table 2a
Potential annual fuel savings in the residential sector

(percent of 1973 total energy demand

Conservation Measures	Potential Savings
Replace resistive heating with heat pumps	0.8
Increase air-conditioner efficiency	0.5
Increase refrigerator efficiency	0.4
Cut water heating fuel requirements	1.4
Reduce heat losses	4.4
Reduce air conditioner load by reducing infiltration	0.6
Introduce total energy systems into 1/2 multifamily units	0.4
Use microwave ovens for 1/2 of cooking	0.3
Total	8.8*

Table 2b
Potential annual fuel savings in the commercial sector.

(percent of 1973 total energy demand)

Conservation Measures	Potential Savings
Increase air-conditioner efficiency	0.5
Increase refrigeration efficiency	0.3
Cut water heating fuel requirements	0.4
Reduce building lighting energy	1.3
Reduce heating requirements	3.0
Reduce air-conditioner demand with better insulation	0.1
Reduce air-conditioning demand by reducing ventilation rate and by using heat recovery apparatus	0.1
Use total energy systems in 1/3 of all units	0.9
Use microwave ovens for 1/2 of cooking	0.1
Total	6.6*

*Totals may not add due to rounding.

Source: Adapted from M.H. Ross and R.H. Williams, "Energy and Economic Growth," published in Achieving the Goals of the Employment Act of 1946 -- Thirtieth Anniversary Review (Washington, D.C.: U.S. Government Printing Office, 1977).

opportunities for more efficient appliances and space heating systems, the energy characteristics of most building themselves can be vastly improved. New buildings can be economically designed to reduce typical space heating requirements by 75 percent, with similar savings achievable in many older buildings.[15]

Attic and wall insulation can be increased. Storm windows, storm doors, and weather stripping can be added. The efficiency of heating and cooling can be raised through the increased use of heat pumps instead of electric resistance heating and by the substitution of improved air conditioners and oil and gas furnaces. And new homes can be built with many "passive solar" features such as overhangs, large southern exposures, and moveable insulated window panels.

2. Transportation Sector

Cost-effective energy savings in the transportation sector of up to 50 percent are possible. (See Table 3.) Given enough time for a changeover, these savings could be achieved with a relatively small increase in purchase costs which would be more than offset through savings in fuel costs. These savings could be accomplished by using existing technology to improve auto fuel economy by 150 percent. Obvious measures to improve automobile fuel economy include:

- Emphasize smaller light-weight vehicles. The greater use of light-weight materials and the adoption of new designs which reduce the amount of material needed for a fixed interior size have already reduced the weight of some models by several hundred pounds. To a first approximation, automobile fuel economy is inversely related to vehicle weight: the lighter the car, the

Table 3
Potential annual fuel savings in transportation.

(percent of 1973 total energy demand)

Conservation Measures	Potential Savings
Improve auto fuel economy 150 percent	7.9
35 percent savings in other transportation areas	4.3
Total	12.2*

Table 4
Potential annual fuel savings in the industrial sector.

(percent of 1973 total energy demand)

Conservation Measures	Potential Savings
Good housekeeping measures throughout industry	5.2
Fuel instead of electric heat in direct heat applications	0.2
Steam/electric cogeneration for 50 percent of process steam	3.5
Heat recuperators or regenerators in 50 percent of direct heat applications	1.0
Electricity from bottoming cycles in 50 percent of direct heat applications	0.7
Recycling of aluminum in urban refuse	0.1
Recycling of iron and steel in urban refuse	0.1
Fuel from organic wastes in urban refuse	0.9
Reduced throughput at oil refineries	1.2
Reduced field and transport losses associated with reduced use of natural gas	1.1
Total	14.0*

*Totals may not add due to rounding.

Source: Adpated from M.H. Ross and R.H. Williams, "Energy and Economic Growth," published in Achieving the Goals of the Employment Act of 1946 -- Thirtieth Anniversary Review (Washington, D.C.: U.S. Government Printing Office, 1977).

farther it will go on a gallon of gas. Over the longer term, automobile weights can continue to be reduced through the use of advanced composite materials.

- Improve the efficiency of the drive train. Options include the greater use of manual transmissions, the use of improved torque converters with lock-up and overdrive features, and the substitution of continuously-variable transmissions.
- Reduce rolling resistance through the substitution of improved tires. The use of radial tires in place of bias ply or belted bias tires can increase fuel economy by several percent.
- Improve vehicle aerodynamics by streamlining automobile designs to reduce air drag greatly.
- Improve engine efficiency through design modifications to the conventional Otto engine, or by greater use of alternative engines, such as Diesel and Stirling cycle power plants.
- Improve the operating efficiency of automobile accessories.

Increased energy productivity by airlines depends on continued R&D and the purchase of new, more efficient aircraft. Technical improvements include the use of more efficient propulsion systems, the application of more efficient aerodynamic designs, and improved aircraft structures. These modifications could lead to an overall improvement of 25 percent or more in aircraft efficiency by the end of the century. Load-factor increases could provide further efficiencies in air travel.

Improvements in freight efficiency are possible through the widespread adoption of diesels by the truck fleets and through drag reduction. Over the long term, the overall improvement in truck efficiency could be up to 50 percent. Less restrictive regulations could increase truck load-factors. Some modal shifts from trucks to the less energy intensive rail system would help to limit transportation energy requirements.

Additional energy savings could be achieved by encouraging the wider use of cost-effective mass transit in major urban areas. Efforts would be required to apply innovative concepts to increase the convenience and versatility of urban mass transit systems.

3. Industrial Sector

Substantial reductions are also possible in the industrial sector. (See Table 4.) Industrial energy demand in 1973 could have been reduced by about 30 percent through several specific changes including:

- Improve management and "housekeeping" practices with little or no changes in capital equipment. Examples of such improvements include adjusting temperatures for space heating and cooling, turning off unnecessary lighting, shutting down machines when not actually being used, repairing steam leaks, cleaning heat transfer barriers, and maintaining steam traps and boilers at peak efficiency.

- Produce 50 percent of the process steam through the cogeneration of steam and electricity, and generate electricity with bottoming cycles. Cogeneration can reduce by roughly 30 percent the amount of fuel required to separately generate the same amount of electric power and steam if done separately.
- Add heat recuperators or regenerators in one-half the direct heat applications.
- Reduce processing and transportation losses associated with energy conversion and transmission. In the near future electricity, for example, could be generated more efficiently with fuel cells, and transmission losses could be reduced by locating generation facilities closer to load centers or improving transmission lines.
- Recycle the steel and aluminum in urban refuse and use its organic material for fuel.

These are only a few of the more obvious improvements. Others include the substitution of more efficient electric motors, the replacement of obsolete plants and facilities, and the development of new basic processes or technologies.

Clearly, it will require time to improve or replace existing equipment and procedures, but over a period of two or three decades, incremental changes can lead to dramatic improvements.

D. Overview

As a group, these domestic and international studies suggest a number of important conclusions about U.S. energy needs at the turn of the century. These conclusions must be viewed with some caution given the great difficulties and uncertainties associated with estimating total energy demand two decades into the future. Nonetheless, the evidence strongly suggests that future energy demand is by no means predetermined and that low demand futures are quite feasible both technically and economically.

(1) Even without special efforts to slow the growth in energy consumption (and assuming little or no real energy price increases), energy demand is expected to increase well below historical rates (roughly 1.5 to 2.5 percent per year versus historical rates of 3 to 4 percent per year). This is the result of a general shift in the economy toward less energy-intensive activities and services, and slower GNP growth caused largely by reduced population growth. These trends suggest an energy demand in the year 2000 between 110-130 quads, compared with about 180 quads for a simple extrapolation based on historical energy growth.

(2) A moderate national effort to increase energy productivity (driven by slowly increasing real energy prices and successful implementation of federal conservation policies in recent legislation) could lower demand levels to the 90-110 quads range in the year 2000. This reduced energy growth need result in little or no reduction in expected GNP growth. Indeed, if government policies stay constant,

whether the high or low portion of the 90-110 quad range is reached could depend largely on the rate at which GNP grows during this period. (3) A determined national effort to increase productivity (driven by more significant energy price increases, more vigorous government conservation efforts, or both) could lead by the year 2000 to still lower energy demand levels in the 80-90 quads range. Again, if done carefully through well conceived energy and economic programs that can flexibly respond to changing conditions, this effort need not involve significant reductions in anticipated growth in goods and services. (4) Energy demand in the year 2000 could even be significantly less than today's while still allowing a steady increase in GNP (at about 2 percent a year). But this future would require aggressive government policies and some significant adjustments in customs and expectations. These changes might include (i) a shift in housing trends toward multifamily units with people living closer to their places of work, (ii) an acceleration of the trend toward a more service-oriented economy and more durable consumer goods, (iii) continued migration to the Sun Belt States, and (iv) expanded efforts to substitute technical sophistication for energy consumption.

II. Low Energy Growth: Implications for the Environment and the Economy

Increasing energy productivity along the lines suggested in Section I will bring with it a host of national benefits. By economically squeezing the same goods and services from fewer units of energy imputs, we can reduce the need for new mines, power plants, refineries, synthetic fuels plants, transmission corridors, and the like. Environmental impacts will consequently be reduced along the entire chain of energy extraction, delivery, and consumption. While it is difficult to quantify the environmental impacts in dollars, reduced energy use will have major indirect benefits which are not included directly in the GNP.

Economic benefits will also accrue from increasing energy productivity. A well-formulated, economically justified, long-term conservation strategy will sustain continued growth in GNP while reducing inflationary pressures from real increases in energy prices. Additional positive benefits can be anticipated on employment, on our balance of payments, and on our national security. We briefly discuss in this section these and other impacts that can be anticipated from programs to increase energy efficiency.

The full range of effects resulting from increasing energy productivity can best be assessed through the examination of alternative energy futures. Table 5 displays two possible energy supply scenarios for the year 2000, along with comparable values for 1977. Future I, with a total demand of 85 quads, reflects a strong, sustained commitment to conservation (higher energy productivity) and the use of renewable energy sources. Energy supply for this future consists of 40 quads

Table 5

Energy supply in 1977 and two supply scenarios for the year 2000 (quads of primary fuels)

	1977	2000	
		I	II
Oil and gas	56.5	40	46
Solar*	4.2	19	19
Nuclear	2.7	8	18
Coal	14.1	18	37
Total	77.5	85	120

*The Solar category includes all renewable energy sources. The 4.2 quads includes 1.8 quads from biomass which is usually not included in national energy statistics.

of oil and gas (a 30 percent reduction from the present value reflecting a continuing decline of domestic production and a strong effort to reduce imports); 19 quads of renewable energy (a value based on a "Maximum Practical" national effort as described by the Solar Domestic Policy Review); 8 quads of nuclear energy (equivalent to about 135 plants each of 1100 MW size); and 18 quads of coal (about 780 million tons, one-fourth more than we now consume). Since the U.S. now has the equivalent of about 135 nuclear power plants of the 1100 MW size either operating or under construction and about 243 coal-fired power plants (1100 MW) either operating or under construction, Future I does not expand reliance on nuclear or coal appreciably beyond the levels already committed.

In Future II, 120 quads, energy demand grows by 1.9 percent per year. A demand of 120 quads is obviously high by comparison with scenario I, but it is low compared with many forecasts made within the past few years.[16]

In Future II, oil and gas would supply 46 quads, about 20 percent less energy than at present. At this level, these sources would account for only 38 percent of supply, however, compared with a contribution now of 75 percent. As in Future I, renewable sources displace 19 quads of primary fuels. Nuclear plants would supply 18 quads and coal 37 quads. The values in Future II for oil and gas, nuclear, and coal are very close to those of the "Most Probable" forecast of the Department of Commerce.[17]

A. Relative Environmental Impacts of Alternative Futures

The most important differences in energy supply between the two futures described above arise from the need to place great emphasis on coal and nuclear in Future II. In the high-growth future these two sources collectively supply 2.1 times as much energy (an additional 34 quads) in the year 2000 as they would in the low-energy future. Although it is not feasible to describe completely the details of these two futures, specific, important environmental impacts related to the additional use of coal and nuclear energy in Future II have been estimated and are presented in Table 6. These impacts are briefly discussed next.

Table 6 shows that by the year 2000 a 120-quad future could require the mining of almost 1.7 billion tons of coal per year, more than twice what would be required in the low-growth future and almost three times our present level of consumption. Over the remainder of the century, Future II would require the mining of 9.5 billion tons of coal more than in Future I. Under the assumptions listed in the footnotes to Table 6, we estimate that the high-growth future could lead to the strip mining of some 2000 square miles through the end of the century, an area about the size of Delaware. Much of the strip mined coal would be derived from the arid western states where rainfall is sparse and rehabilitation of the lands is still unproven.[18] Additional social, economic, and cultural impacts could be anticipated on these western states if large numbers of conversion facilities--power plants and synthetic fuel plants--are constructed there to service other regions of the Nation.

Table 6

Relative impacts of low- and high-growth futures.

	1977	2000	
		I	II
Coal production (millions of tons/year)[a]	613	782	1,609
Cumulative coal mined, 1977-2000 (millions of tons)[b]	--	16,000	25,500
Cumulative area stripmined, 1977-2000 (square miles)[c]	--	1,200	2,000
Cumulative area affected by subsidence (square miles)[d]	--	1,400-3,300	2,300-5,300
Number of coal power plants (nominal 1100 MW)[e]	200	243	500
Number of nuclear power plants (nominal 1100 MW)[f]	43	135	304
Area required for transmission lines for new coal and nuclear plants (square miles)[g]	--	3,900	16,500
Radioactive tailings to supply uranium for 1977-2000 (million tons)[h]	--	400	800
Volume of low-level radioactive wastes generated, 1977-2000 (millions of cubic feet)[i]	--	34	66
Spent fuel generated, 1977-2000 (thousands of tons)[j]	--	61	120
Total spent fuel generated over lifetimes of plants constructed through the year 2000 (thousands of tons)[k]	--	121	274

a. Nominal tons at 23 million Btus each.
b. Assuming linear growth in production.
c. Assuming (i) one-half of coal is mined in the West; one-half in the Midwest and East, and (ii) all of Western coal and one-half of rest is stripmined. Area disturbed: 50 acres per million tons in West and 100 acres elsewhere. See Energy/Environment Fact Book, DOE/EPA, December 1977, page 60.
d. Assuming 230 to 529 acres affected per ton of coal mined, depending on mining techniques. See Energy Alternatives: A Comparative Analysis, University of Oklahoma, Science and Public Policy Program, May 1975, pages 1-56.
e. Assumes 70 percent of coal will continue to be used by electric utilities, capacity factors will average 55 percent and individual plant efficiencies of 35 percent.

(continued)

f. Assumes capacity factors of 60 percent and average efficiencies of 33 percent.
g. Based on an average value of 17,188 acres per GW of capacity. See Energy and the Environment: Electric Power, CEQ, August 1973, page 42, note 8.
h. Assuming 0.1 percent uranium ore, 0.25 percent tailings assay, and annual loading of 30 tons of fuel per reactor per year.
i. Based on an annual volume of 16,500 cubic feet per plant-year. See "Report to the President by the Interagency Review Group on Nuclear Waste Management," DRAFT, TID-28817, October 1978, page D-6.
j. Assuming 30 tons discharged per reactor per year.
k. Assuming 30 tons discharged per reactor per year and 30-year plant lifetimes.

Underground mining of coal will also have its impacts. Table 6 indicates that with high coal use in Future II between 2300 and 5300 square miles of land could be affected by subsidence over the remainder of the century, in the worst case an area larger than the state of Connecticut. When the earth subsides, or sinks, from the collapse of abandoned underground mines, whatever is on the surface above can be damaged or destroyed.

Assuming that electric power production continues to account for 70 percent of U.S. coal consumption, Table 6 shows that under the high energy growth future about 300 new, large coal-fired power plants would have to be built between 1977 and 2000, approximately one plant completed per month for the remainder of the century. Finding environmentally acceptable sites and adequate cooling water for these plants would surely pose difficult planning problems for the states where they will be located. Under the high-growth future a total of about 260 new nuclear plants would also have to be constructed, for a total of about 304 by the turn of the century. Because of safety requirements and greater need for cooling water, their siting problems could be anticipated to be at least as difficult as those for coal plants. Table 6 also shows that a very large amount of land would have to be dedicated to transmission corridors for electric power to support rapid energy growth. In Future II about 16,500 square miles would be required, an area almost twice the size of Massachusetts. Under a low-growth future siting and other problems would be greatly diminished: only 25 percent of the total new plants required in Future II would have to be built in Future I.

Table 6 also gives an indication of the large volumes of radioactive wastes that could be generated over the next 21 years. Over 800 million tons of sand-like radioactive tailings, about ten times what has been created in the past, would be generated in the western states through the extraction by mills of uranium from ores. Tailings, in these amounts, could be expected to continue to pose a knotty, long-term disposal problem. Similarly, upwards of 66 million cubic feet of low-level wastes (sludges, paper, clothing, tools, etc.) would be generated at nuclear power plants in Future II. Because of their large volumes, low-level wastes would continue to be difficult to dispose of in an environmentally desirable and safe manner. Lastly, the volume of high-level wastes, in the form of radioactive spent fuel, would grow much more rapidly under Future II than in the low-growth scenario. Upwards of 120 thousand tons of new spent fuel would be added to existing inventories under Future II compared with 61 thousand tons under Future I. Over the lives of these plants 121 thousand tons of spent fuel would be generated in Future I compared with 274 thousand tons in Future II.

The list of potential environmental impacts in Table 6 is by no means exhaustive. Others exist which may be equally or more significant; these impacts are, though, somewhat more difficult to quantify and evaluate. Air pollution from the burning of coal is one example. Increasingly stringent and expensive emission requirements could significantly abate this problem, however. Similarly, water consumption and thermal pollution in power production can be significantly reduced or eliminated through the use of closed cooling systems. In the case of

nuclear energy there are a number of impacts whose risks are all but impossible to quantify but which would be expected to grow in proportion to the use of nuclear power. These impacts are related to nuclear safety and to terrorism involving nuclear facilities or shipments. Because of the great uncertainties surrounding them, we have not attempted to quantify or assess these impacts.

Other longer-term environmental threats--equally difficult to quantify--will also be exacerbated by increasing energy use. The buildup of carbon dioxide, whose release is directly proportional to the amount of fossil fuels burned, is one. By absorbing a portion of the earth's outgoing radiation, carbon dioxide could lead to a long-term warming trend with potentially disastrous effects on the world's climate. Pollution of the atmosphere by small particles from combustion is another. Both of these effects have the potential for altering the earth's climate in ways that are unknown at present. Similarly, global thermal pollution from the ever increasing burning of fuels--fossil or nuclear--could also affect global climate though probably on a much longer time frame than with the previous two. Although the total impacts of all these trends is highly uncertain, it is nonetheless clear that a national--indeed, global--policy emphasizing energy conservation and reduced growth rather than expanded supply will allow the world more flexibility and time to maneuver in the event of incipient, adverse developments.

B. Benefits to the Economy

Probably the main concern raised against low energy growth is the belief that it could lead to adverse impacts on national economic

growth and employment. Thus, in its forecast of energy use through the year 1985, the Chase Manhattan Bank asserted that analysis of the uses of energy reveals little scope for major reduction without harm to the Nation's economy and its standard of living.[19] Similarly, advertisements have been placed in major national newspapers and periodicals with cartoons expressing the simple message "Generate Less Energy. Sure. And Generate Galloping Unemployment."

Unfortunately, such claims have in the past received widespread and, often, uncritical acceptance, leading to the view that only increased energy production and use can guarantee economic well being.

Conservation and reduced energy use are sometimes associated with shortages and curtailment, and there is little doubt that sustained energy shortages can hurt the economy. While "doing without" may be required during a national emergency, such as the 1973-1974 oil embargo, it does not represent what we mean by conservation in the present discussion. Rather, as we have previously stated, conservation refers principally to increasing energy productivity through cost-effective measures--to wringing more goods and services out of our energy inputs.

The extent to which energy productivity measures are economically justified is dependent in large degree on the prices that consumers pay for fuels and electricity both now and in the future. Until relatively recently the real costs of energy have been declining: between 1950 and 1970 the weighted-average real price of fuels in the United States dropped by almost one-third.[20] Throughout this period, widespread optimism prevailed that new energy technology and improvements in old

ones would lead to a continuing decline in energy prices, even to the point of making electricity "too cheap to meter."

Moreover, prices have historically been subsidized through federal tax policies, price controls, and unpaid environmental and national security costs. Electricity, natural gas and petroleum were priced substantially under their replacement costs, due to federal price controls in oil and gas and state regulation of utility rates. The federal government provided tens of billions of dollars in energy subsidies in the period from 1918 to 1976.[21] Fossil fuels have been subsidized, for example, through the use of depletion allowances, foreign tax credits, intangible drilling expenses and accelerated depreciation. Nuclear power has been subsidized through large R&D programs, low-cost fuel-cycle services, waste handling facilities, and federal limitations on the industry's liability in the event of a major accident.

Besides prices, a number of institutional "barriers" have worked against achieving high productivity from energy inputs. A long series of market imperfections and government policies have prevented the economy from taking advantage of energy conservation opportunities that were economical even with low, subsidized energy prices.[22] These barriers include misplaced incentives, lack of information (or misinformation), ineffective regulation, and market structure imperfections.

As a consequence, a number of factors have combined to leave us with <u>stocks</u> (including homes, buildings, vehicles, appliances, machines and factories), <u>institutions</u> (such as utility rate structures, energy subsidies and building codes), and <u>habits</u> (too numerous to mention)

suited to an era of energy abundance--a period of energy plenty that was part real but part illusion.

Energy prices have, of course, risen significantly during the 1970s and are likely to continue to do so for the remainder of the century. In addition, as reflected in the National Energy Plan, we have learned the shortsightedness and waste of subsidizing increasingly scarce energy fuels by pricing them below replacement costs. And the U.S. is now also moving to address institutional barriers and other market imperfections that in the past have hampered investments that would increase energy productivity.

As a result, the U.S. economy now faces a situation in which the opportunities for cost-effective investments in energy conservation have increased dramatically and are likely to expand further in the future. We must expect that the economy will be improved, not harmed, by investments in energy conservation which result from more accurate pricing of energy and the elimination of market imperfections.

This conclusion is supported by recent macroeconomic analyses that suggest a more loose and flexible linkage between energy use and the economy than previously supposed.[23] These new studies generally conclude that low energy growth can be consistent with continued economic expansion and a high standard of living, can have a positive effect on employment, and can provide an important weapon in the fight against inflation. Perhaps the most recent and thorough analysis confirming these conclusions is the CONAES' work already discussed. The CONEAS

panel concluded that "As long as the transition to energy-efficient capital stocks occurs smoothly and over a significantly long period of time, there is no reason to expect major adverse effects on the GNP."

Essentially this same conclusion was reached earlier by the Ford Foundation's Energy Policy Project. After analyzing various possible energy futures characterized by varying total demands, the study concluded that "the lower energy growth scenarios provide major savings in energy with small differences in the GNP from historical growth trends. Employment opportunities are, if anything, better. In all three scenarios, the real GNP for the year 2000...is more than twice what it is today."[24]

One recent analysis of the economic effects of low energy growth focused in detail on the economic impacts of progressively more stringent federal policies designed to dampen energy growth by increasing energy costs.[25] Perhaps its most significant finding is the relatively weak linkage between future GNP and energy demand: "On average, each percentage point reduction in energy input leads to only a 0.2 percentage point reduction in real GNP." The study estimated that conservation policies over the next two decades could lower energy demand in the year 2000 from a value of 116 quads to 90 quads (a 22 percent reduction) with a loss in GNP in the year 2000 of only 4 percent. Despite this small loss, GNP would almost double in this 90 quad future between 1977 and 2000. Moreover, this study's conclusions may be overly pessimistic for reasons which several reviewers have noted.[26]

Investment Opportunities - Low energy growth can lead to major opportunities for investment in other nonenergy areas relative to high-growth scenarios. For example, the Energy Policy Project found that its "Technical Fix" scenario would save the Nation about $300 billion on capital investments over the next 25 years relative to its higher-demand Historical Growth future. Such savings could be plowed into other productivity-enhancing investments that might assist in the fight against inflation.

These savings arise because measures to conserve a given amount of energy generally require less investment than programs to develop or install new energy supply systems. For example, the power requirements of window air conditioners can be reduced at a cost of only $90 per kilowatt, while new peak generation and distribution capacity costs over $400 per kilowatt.[27] Similarly, having a contractor insulate a previously uninsulated attic will lead to a considerable savings in home heating oil over a period of, say, ten years, at an effective cost of less than $0.05 per gallon saved, less than 10 percent of the current price of such fuel. Insulating walls would also lead to a major savings in oil, at an effective cost of less than $0.30 per gallon saved, about 60 percent of current prices. Similar capital savings can be realized in industry. Waste heat recuperators can save energy at a cost less than half that of new supplies.[28] Some bottoming cycles which generate electricity using industry waste heat require less than half the investment a utility would have to make for the same electrical output.

As energy conservation measures like these are widely adopted, the aggregate savings in the energy sector will be enormous. One study found that technical conservation measures could lead to an energy demand of about 80 quads while saving the Nation $430 billion in energy-related capital investments compared with those required in a government-published higher growth future.[29] In each of the futures examined GNP was assumed to grow at 3 percent per year. These capital savings have great importance for the economy as a whole. If investments in energy supply require progressively larger fractions of business capital, less will be available for other, perhaps more socially and economically desirable purposes, and interest rates will go up.

Inflation - As a way to thwart inflation, energy conservation is hard to beat. The examples given above indicate that energy saved through currently available conservation measures can cost as little as 10 to 50 percent that of new supply. Under these circumstances the macroeconomic advantages of conservation as an alternative to new supply can only be favorable.

Balance of Payments - Much of the savings from conservation will be realized in the form of reduced imports of oil and natural gas for which we pay a high price both economically and in terms of national security. Improvements in our balance of payments can be anticipated principally due to reduced dollar outflows for direct purchases of foreign fuels. These improvements will bring benefits in the fight against inflation and in maintaining a strong dollar in international monetary markets.

Employment - Most measures to improve energy productivity will also have a beneficial effect on total employment and the unemployment rate. This benefit occurs because the energy-producing and energy-intensive sectors of the economy tend to have lower labor intensity. Energy conservation measures should lead to relatively greater growth in the more labor-intensive sectors, including, of course, the many different activities that lead to greater energy productivity. One recent study found, for example, that installing ceiling insulation in all existing homes to the economic optimum would require about 400,000 person-years of effort and save about two-thirds of one percent of total energy used in the United States.[30] Similarly, if the country were to shift entirely from throwaway to refillable beverage containers, energy demand would be reduced, and net employment would be increased (though the average wage would drop). The study's conclusion is that the national goal of full employment could be reached by using conservation measures to improve our fuel efficiency by only 5 to 10 percent.

Energy Shortages - We have only limited domestic supplies of oil and gas remaining, and either acute or chronic shortages of these fuels can lead to disruptive economic and employment effects. Through low energy growth and increased energy productivity, we can minimize the risk of serious disruption, conserve our fossil resources for the future and buy time for the transition to the post-petroleum era.

III. Energy Productivity: Achieving Low Energy Growth

It is not especially difficult to conceive how our present energy system might have been made much more efficient. In fact, given a different set of federal energy policies beginning in the 1950s and continued through the 1960s, the United States could well have had a GNP comparable to today's level but consumed 30 to 40 percent less energy with much smaller oil imports and sharply enhanced environmental quality. Unfortunately, both this possibility and its potential importance were not generally understood until the mid-1970s.

This section first reviews existing federal initiatives aimed at reducing energy demand growth and then discusses the additional steps that can be taken by individuals and government to improve energy productivity.

A. Federal Conservation Programs

Recognition of the benefits of improved energy productivity led the Carter Administration and the Congress to make conservation the cornerstone of the national energy planning:

> "The sixth principle and the cornerstone of National Energy Policy is that the growth of energy demand must be restrained through conservation and improved energy efficiency...America needs to embrace the conservation ethic..." [31]

Since the 1973 oil embargo, the growing recognition of the importance of conservation has led to a series of federal programs which are destined to exert substantial influence on our energy requirements in the 1980's and beyond.

- Automobile Economy Standards

  The 1975 Energy Policy and Conservation Act established mandatory model year average mileage requirements for all new car manufacturers. These standards require a 53% improvement in average mileage for new cars by 1985, when the sales-weighted model year average must reach 27.5 mpg for each manufacturer. The mandatory standards are backed up by substantial fines for violating firms.

- Gas Guzzler Taxes

  The 1978 National Energy Act applies substantial taxes to the sale of automobiles which exhibit mileage significantly below the mandatory fleet averages. This program is expected to help accelerate the elimination of gas guzzlers from the new car fleets.

- Building Energy Performance Standards

  The Energy Conservation and Production Act requires the development of nation-wide energy performance standards for new buildings. The standards are currently under development by HUD and DOE. As in the case of automobiles the program will substantially increase the efficiency of new buildings and, over time, greatly reduce building energy consumption.

- Retrofit Building Conservation Tax Credits

The National Energy Act provides tax credits to homeowners for investments in energy conservation. This policy is designed to accelerate conservation in the retrofit market and to complement the new building standards. The tax credits are backed up by programs (also established in NEA) to require utilities both to offer "turnkey" energy audits and to offer to arrange for the installation and financing of conservation measures. Further, NEA eliminated numerous barriers to conservation retrofit particularly by broadening the (federal) secondary market for conservation loan instruments.

- Appliance Standards

The National Energy Act strengthened the appliance standards legislation originally adopted in 1975. Major appliances will now be subject to minimum efficiency standards established by the federal government. These include refrigerators, freezers, water heaters, room air conditioners, kitchen ranges and ovens, central air conditioners, furnaces, and clothes dryers.

- Direct Federal Subsidies

Several ongoing programs have been established (and strengthened by NEA) to provide direct grants to low-income persons and non-profit institutions for the installation of energy conserving improvements in buildings. These measures generate both financial benefits for recipients and energy budget reductions for the Nation.

- Federal Energy Management Programs

The President ordered as a part of the National Energy Plan a 20 percent improvement in federal building energy budgets by 1985, and a 45 percent improvement for new federal buildings. The National Energy Act established statuatory programs to allow achievement of these goals.

- Cogeneration

The National Energy Act contains several provisions to accelerate the use of cogeneration technologies including:

  o exemption for cogenerators from Public Utility regulation;
  o requirements that utilities buy back power from cogenerators at fair prices and provide back-up electric services;
  o authority to permit DOE under certain circumstances to exempt cogenerators from the coal conversion program;

- Industrial Conservation

The National Energy Act also established an additional 10 percent investment tax credit for industrial investment in alternative energy property and recycling equipment.

- Utility Rate Structures

The National Energy Act requires the development of a number of voluntary standards of rate design, including time-of-the-day-rates, seasonal rates, lifeline rates, and prohibition of declining block rates. State regulatory authorities and utilities are required to consider each standard and determine if they are appropriate for conservation.

- Natural Gas Pricing

The regulatory distinction between interstate and intrastate gas is eliminated. Price controls for various categories of natural gas will be removed over the next several years.

The conviction behind government conservation efforts is demonstrated by the breadth of this program. In the keystone areas of automobiles and buildings, mandatory programs have been established to encourage conservation at an accelerated rate through about 1985. Mandatory standards are also applied to appliances. These mandatory programs are backed up by incentive and subsidy programs, especially building tax credits and various outright grants, to accelerate further the efficiency improvements for the existing stock of buildings. These major program elements are backed up by State Energy Management Plans heavily subsidized by the federal government and numerous supporting federal programs. Finally, the Department of Energy manages a $700 million research and development program to demonstrate new conservation technologies and accelerate their adoption.

The scope of the program and its very recent genesis make it impossible to offer precise impact estimates. We judge that with determined implementation and broad public support the program is likely to result in substantial reductions in long-term energy demand growth.

B. Additional Federal Opportunities

Passage of the National Energy Act clearly represents a major step forward on the part of the federal government toward improving the Nation's energy productivity. The provisions of the Act will affect virtually every segment of the economy, and, vigorously carried out, it should take us a considerable way toward achieving the many benefits of conservation identified in Section II. To ensure effective government-wide implementation of the five laws constituting the Act, the President, on September 27, 1978, established a Cabinet-level Energy Coordinating Committee whose purpose is to coordinate the many federal agencies charged with enforcing the many provisions of the Act.

Two of the functions of the Energy Coordinating Committee are to monitor the NEA's progress and to "make recommendations for improvements in the implementation of Federal energy policies..." In this section of the report we bring together a number of recommendations for further possible actions that have been offered in support of our national conservation effort. Some of these were proposed by the President in the 1977 National Energy Plan, while others have been suggested in studies of conservation and national energy policy.

Energy Prices - As the National Energy Plan noted, the price of energy should "reflect the economic fact that the true value of a depleting resource is the cost of replacing it." In other words, energy prices should accurately reflect replacement costs. For some time, there has been broad agreement that price may be the most important policy tool capable of improving the efficiency with which we use energy. The case for accurate pricing of energy has been strengthened by recent price elasticity studies which suggest that long-run energy demand may be roughly twice as sensitive to price as generally estimated only a couple of years ago.[32] If further research confirms this result, it is likely that energy demand will be even less than is now forecast with the expected rises in prices. This would make less difficult the problem of attempting to limit energy demand growth through price increases while at the same time controlling overall inflation.

While important progress has been made with the passage of the NEA, a considerable number of the price-related recommendations that have been offered have not yet been acted upon:[33]

- Permit oil prices to rise gradually to world levels while imposing a tax on domestic oil production to avoid excess profits; revenues from this tax could be returned in a progressive manner to the public through per capita tax credits.
- Where possible, reduce or remove subsidies (such as depletion allowance and intangible drilling expensing) to energy consumption and production; until this is accomplished, energy conservation should receive similar tax advantages and other benefits in line with its potential.

- Require marginal cost pricing by utilities, with the windfall profit returned directly from the utility to each customer on a per capita basis with refunds computed separately for various types of residential and nonresidential sectors.
- Enact pollution taxes supplementary to regulatory actions to reflect the environmental costs associated with fuel extraction and use.

These provisions must, of course, be combined with well thought-out measures to assist low-income people. Utility lifeline rates, for example, can help ensure that everyone has enough energy to meet essential needs.

Existing Conservation Programs - Most of the existing conservation programs are either relatively new or were only recently mandated with the passage of the NEA. Partially because of their newness and the fact they were created by number of separate pieces of legislation, many suggestions have been made to coordinate and improve these efforts:[34]

- Ensure that the Energy Conservation and Production Act building energy performance standards for new construction require the full range of cost-effective energy-saving technology; strengthen standards as new technologies become available, and reward builders who exceed federal conservation standards.
- Expand industrial conservation incentives to include an additional investment tax credit for industrial and utility cogeneration equipment.
- Raise post-1985 fuel efficiency standards above the 27.5 mpg level, which is far from being a long-term technical limit.

- Extend efforts to speed the widespread use of passive energy conserving designs for buildings.
- Expand use of recycled or refurbished products where the cost is justified or where necessary to overcome institutional barriers.
- Streamline and improve the effectiveness of existing federally funded regional, state and local conservation grant programs. (These programs include the State Energy Conservation Program created by the Energy Policy and Conservation Act, the Supplemental State Energy Conservation Program created by the Energy Conservation and Production Act, the Weatherization Program, the Energy Extension Service, and NEA-mandated conservation programs for public buildings.)
- Expand efforts to determine the conservation benefits of improved voltage control by electric utilities.
- Expand the use of design/performance awards to encourage energy efficiency improvements by recognizing outstanding achievements which increase energy productivity.
- Set strict performance standards on the energy efficiency of common industrial equipment.

Institutional Change - Programs which only improve the energy efficiency of our everyday equipment and production processes exclude a very important part of the opportunities for fuel conservation through system changes. A system change, for example, in the transportation sector could involve increasing automobile load factors as opposed to improving the fuel economy of the automobile itself. A number of opportunities with the potential for saving large amounts of energy have been noted:[35]

- Decrease the energy required for commuting by developing incentives to increase automobile load factors and providing more energy efficient alternatives (such as buses and van pools).
- Remove parking subsidies for government and other employees and provide greater support for regional transit systems.
- Modify the regulations and policies on trucks, railroads, and pipelines to increase system energy efficiency.
- Incorporate conservation provisions into existing regulations on the use by state and local governments of general revenue sharing funds.
- Expand the application of industrial cogeneration technology by supporting demonstrations which involve a variety of institutional arrangements: utility ownership, industrial ownership, and third party ownership; examine the adequacy of the changing regulations for industrial cogeneration associated with the NEA.
- Allow exemptions from coal conversion requirements for facilities using high-efficiency/high-electricity-to-steam ratio cogeneration technologies based on oil and natural gas.
- Modify provisions of the Internal Revenue Code which bias utilities towards capital intensity and away from conservation.
- Provide homeowners directly with accurate conservation information through the use of "house doctors," professionally trained inspectors who could advise householders as to the most cost-effective conservation investments.

- Involve gas and electric utilities more directly in conservation by increased efforts to reward utilities for conservation and the efficient use of existing capacity rather than for capacity expansion.
- Develop energy performance standards that are enforceable when buildings are sold.
- Require utilities to exhaust economically practicable conservation and renewable energy alternatives prior to initiating new central-station power plants.
- Encourage mortgage extensions for energy conservation investments.
- Include heat pumps as approved energy conservation measures eligible for the residential conservation tax credit.
- Support land use planning to increase transportation system energy efficiency.
- Encourage recycling, mandatory bottle deposit legislation, the purchase of more durable products, and the use of refinished or remanufactured products.
- Encourage states and localities to consider parking limitations, gasoline taxes, differential tolls, taxi and bus deregulation, and auto-free zones and to review freeway construction plans.
- Expand efforts to provide more information on the benefits of fuel conservation to the state and local levels; provide technical assistance to homeowners to identify cost-effective conservation measures.

Federal Conservation RD&D Programs - Funding for energy conservation RD&D programs within DOE and its predecessors has increased several-fold in the last few years, from roughly $40 million in FY 1975 to more than $320 million in FY 1979. Each of the major program areas (Buildings and Community Systems, Industrial, and Transportation) has received substantial increases in funds. But the Department's total FY 1979 budget for conservation is less than one-third of its budget for energy supply,[36] and it contains items which are as closely related to supply as they are to conservation (e.g., electric utility system reliability). Furthermore, conservation research per se is only a relatively small part of the conservation budget, and most of it is directed to "near term" rather than "long term" efforts. A large fraction of the projects DOE terms "research" are actually projects which are demonstrating existing technology.

Even though there has not been a detailed review of DOE's conservation RD&D programs, several recent studies suggest that large additional energy savings are achievable through a sharply expanded program of basic and applied research of an advanced technical nature.[37] These studies suggest a number of rather major changes in DOE's conservation R&D effort:

- Develop a substantial program in basic and applied research aimed at the better understanding of fundamental processes and properties of inherent interest to conservation.

- Restructure the R&D program explicitly to encourage unsolicited proposals directed toward new ways of doing things rather than incremental improvements. (The development of fundamentally new processes provides the greatest opportunity for improved productivity.)
- Provide increased emphasis on energy transformation and conversion at the point of end use. Develop more efficient small-scale conversion systems.
- Expand non-hardware research to improve the understanding of the relationships among energy, its substitutes, and the economy. (This research includes an examination of existing public policies (e.g., real estate taxation, direct and indirect transportation subsidies, and corporate tax policy with respect to R&D and capital investment) so as to develop options for consideration.)

C. Opportunities for Individual Action

As discussed above, government must play an important part to foster and encourage for increased energy productivity, but is is the countless decisions by individual citizens that will utlimately prevail. The opportunity to increase fuel efficiency rests in large measure on the individual.

The selection and purchase of more energy efficient goods and services is only the most obvious opportunity. Individual awareness and sensitivity of how equipment is maintained and operated is also important. As an example, recent studies examining the energy

consumption of essentially identical townhouses in New Jersey have found roughly a factor of two spread in the energy used for space heating.[38] This variation was found to be primarily assignable to the resident. When houses changed owners, new occupants were found to consume energy at levels nearly unrelated to their predecessors.

There are many detailed reviews of suggested individual action related to energy productivity.[39] Some of the more important suggestions include:

- Make fuel economy an important consideration in the purchase of your next automobile.
- Reduce the amount of energy used for commuting. If possible, walk or bicycle to work; if not, use public transportation, join a car pool, or organize a van pool.
- Make sure your home is energy efficient with ample insulation, storm windows and weather stripping. If applicable, use the conservation tax credit to help lower the cost of reducing energy needs.
- When searching for a new house or apartment, carefully evaluate the expected energy costs related to operation and maintenance.
- When purchasing appliances and other power equipment, carefully consider the differences in energy efficiency so as to factor into the decision the reduced operating costs of the more efficient models.
- Keep major energy-using equipment in good condition (e.g., automobiles, furnaces, air conditioners, and heat pumps).

In our homes, offices, and factories, as well as in transportation, there are many clearly identified opportunities for using energy more thriftily. The choice that we face is one of making enlightened investments in conservation now in order to avoid dislocations and environmental problems in the future. Wise energy planning requires the clear recognition that our energy problem is long-term in nature and that our quality of life can only be enhanced by emphasizing the efficient use of our energy resources.

Notes

1. See, for example, W.G. Dupree and J.A. West, United States Energy Through the Year 2000, U.S. Department of the Interior, December 1972.

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