Chapter 5

Policy Issues

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INTRODUCTION

The previous chapter describes six alternative views of the Nation's energy future presented as divergent scenarios of U.S. energy supply and demand by 2015. This chapter explores policy issues concerning each of these energy futures. The options are considered as they relate to the three major goals behind energy policy discussed in chapter l—economic competitiveness, environmental health, and energy security. These three goals are also recognized as preeminent in the Presidents National Energy Strategy (NES).[1]

As mentioned earlier, the scenarios in this report are not predictions. Their purpose is to convey outcomes for six alternative energy futures based on varying assumptions about the implementation of differing technologies that could affect energy supply and demand by 2015. This chapter is not meant as a general description of energy policy nor as a quantitative assessment of policy options. With few exceptions, the scenarios are developed without a priori assumptions about the exact nature and extent of policies used to attain the technological implementation assumed in each. Those decisions are left to policymakers and are not directly relevant to conveying the technological promise theoretically possible under each scenario.

Only the first case, the base scenario, could be implemented without altering existing Federal statutory and regulatory policies. The other scenarios, to varying degrees, draw on the following categories of policy initiatives: standards; financial mechanisms; energy taxes; information management; research, development, and demonstration programs; and Federal programs.

standards can be designed to promote energy efficiency, pollution reduction, or improvements in energy-using behavior. Automobile fuel economy, appliance efficiency, pollution control, and building code standards can improve the energy performance of new equipment or processes and can eliminate the manufacture or construction of the least efficient equipment or stock in the marketplace.

Although not typically conceived as such, pollution limits have the potential to save energy as well. If properly designed, pollution standards can encourage manufacturers, utilities, and consumers to increase their level of goods or services per unit of energy consumed, or per unit of emissions generated. For example, pollution standards that encourage the use of industrial wastes as feedstock or the implementation of cogeneration systems would lead to direct gains in energy efficiency.

Along with efficiency and pollution standards, a third type of requirement can induce energy-savings through behavior modification. For example, a mandated national speed limit of 55 miles per hour (mph) would slow average highway speeds and save a considerable amount of energy in transport.[2]

Financial mechanisms can increase the competitiveness of energy efficient measures, technologies, or fuels not otherwise economical or preferred by consumers. Financial mechanisms include incentives such as tax credits, low-cost loans, or direct payments by Government or, in the last two instances, by utilities. Financial mechanisms can establish a level field for competing goods or services by eliminating indirect subsidies that discourage energy conservation or by creating subsidies that encourage energy conservation. For example, consumer appliance efficiency rebate programs can spur energy-saving retrofits while reducing utility load requirements.

Other kinds of financial mechanisms use the market directly to improve energy use, e.g., tradable emissions permits. Tradable permits have been authorized under the U.S. Clean Air Act (CAA) to reduce emissions of sulfur dioxide ($S0_2$) at coal-fired electricity generating plants, and the concept could be extended to carbon emissions. By enabling firms to profit from exceptional emissions reductions, tradable permit systems provide an incentive

[1] *National Energy strategy: Powerful Ideas for America,* 1st ed. 1991/1992 (Washington DC: U.S. Government Printing Office, February 1991).

[2] A 1985 study on the effect of vehicle speeds on automobile fuel consumption found that the average fuel economy loss Of tested vehicles was about 18 percent when average speed increased from 55 to 65 mph. See Stacy C. Davis and Patricia S. Hu, *Transportation Energy Data Book: Edition 11*, ORNL-6649 (Oak Ridge, TN: Oak Ridge National Laboratory, January 1991), p. 3-68.

for polluting industries to reduce emissions beyond mandated standards, which by themselves offer no benefit or incentive for polluters to surpass once they are in compliance.

With the tradable permit system created under the CAA, utilities have been given a strong incentive to increase their energy production per unit of SO_2 emissions as a means of generating additional profit. Technologies now or nearly available, e.g., integrated gasification combined cycle (IGCC) and steam-injected gas turbines (STIG), offer both low emissions and high efficiency, and they may become more widespread as the new provisions of the CAA are implemented.

Thus, appropriately designed incentives could guarantee that energy efficiency becomes an integral rather than confounding feature in efforts to reduce emissions. Marketable emissions permits for carbon dioxide (CO_2) in the industrial and utility sectors would be even more useful than those for sulfur in promoting energy savings.

Energy taxes have the potential, if set high enough, to reduce energy consumption and petroleum imports, while encouraging investments in energy efficient equipment and technologies. Energy taxes may apply directly to energy purchases, e.g., gasoline taxes, or they may apply to the initial purchase of energy-using equipment, e.g., gas guzzler taxes for the least efficient vehicles in the new light-duty fleet market. A currently discussed alternative, a tax based on carbon emissions, would also improve the competitiveness of renewable and nuclear technologies, while reducing CO_2 emissions.

A disadvantage of energy taxes is that they are generally regressive, burdening lower income groups disproportionately. In the short term at least, energy taxes would reduce some economic activity and have an inflationary impact on the economy. These effects would be partially offset by a growth in energy efficient technologies and services. The general economic effects of energy taxes, however, would shrink as the economy became less energy intense in response to the price increases brought on by taxes. Finally, energy taxes would directly increase Treasury revenues and reduce the Federal deficit, but these benefits would be indirectly offset to some degree by reduced economic activity, at least in the short term, which would lower Federal tax revenues from other sources.

Information management—in the form of public or professional education, training, workshops, information dissemination, or program evaluation—educates consumers and professionals about options to improve energy efficiency and conservation practices.

Research, development, and demonstration (RD&D) programs develop new options or advance current options toward commercial availability. The last element, demonstration, can be vital, because research and development (R&D) programs often fail to demonstrate the practical applications of new or improved technologies or fail to improve the prospects of their commercial availability.

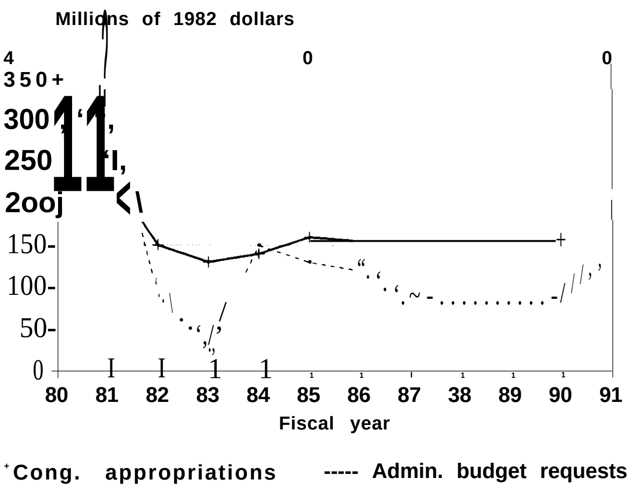
Promising energy technology R&D projects are shown in tables 2-1 and 3-1. Budget increases will be needed for many of these technologies to achieve widespread commercial availability. Reversing the drastic cuts in U.S. Department of Energy (DOE) R&D conservation budgets that began in 1982 would be an important step to improving the commercial prospects of these technologies (figure 5-l).

Federal programs can increase energy conservation and efficiency in the Government and other sectors or increase energy supplies. A recent OTA report describes in detail the progress and prospects of improving Federal Government energy efficiency.[3] In addition to lowering Federal and State energy costs, Government programs can help new or experimental energy technologies reach the marketplace. Additionally, Federal efforts to push exports of domestically manufactured energy efficient technologies can improve their economies of scale in production, with the prospect of expanding the markets for these goods both domestically and internationally.

On the supply side, Federal policies determine areas available for oil, natural gas, renewable, and other supply source exploration and development. This category includes decisions about whether new areas, e.g., the Alaska National Wildlife Refuge,

[3]U.S. Congress, Office of Technology Assessment, *Energy Efficiency in the Federal Government: Government by Good Example? OTA-E-492* (Washington, DC: U.S. Government Printing Office, May 1991).

Figure 5-1—DOE Conservation R&D Budgets, Budget Requests, and Appropriations



SOURCE: U.S. General Accounting Office, *Energy R&D—Conservation Planning and Management Should Be Strengthened,* GAO/RCED-90-195, July 1990.

should be open to development. Federal programs also include the Strategic Petroleum Reserve (SPR).

At varying levels of implementation, these policy options are discussed below for the six scenarios given in this report. Each scenario covers the period 1989-2015.

BASELINE SCENARIO

The first scenario assumes that no major new energy-related policy initiatives are undertaken. In this scenario, fossil fuels remain the cheapest available energy source, and they continue to drive the economy. Total energy consumption climbs almost 1 percent per year, reaching 112.4 quads (quadrillion British thermal units) in 2015.

The baseline scenario is not meant to suggest that no energy policy changes will be implemented during the period 1989-2015. As national and international developments occur in this period, energy-related policy changes are likely to follow. The recent Gulf War suggests how quickly attention to energy policy is revived. Moreover, energy legislation proposed in the 102d Congress—including the proposed NES—promises to alter national energy policy in the near term. For the purposes of this scenario, however, we assume no changes that would significantly alter the framework under which energy decisionmaking takes place today.

Even without major policy changes, some energy efficiency improvements are expected. Under the conditions described in chapter 4, this scenario predicts modest efficiency improvements by 2015 through normal upgrading and equipment turnover. Use of available shell improvements will allow the 35 million new homes and apartments projected to be built between 1995 and 2015 to require 15-percent less heat and 8-percent less air conditioning than current new homes. Without changing current Federal fuel economy standards, new cars are projected to average 36.5 miles per gallon (mpg) by 2010. The appliance efficiency standards under the National Appliance Energy Conservation Amendments of 1988 (NAECA), Public Law 100-12, are assumed to remain in effect as well.

Under this scenario, U.S. oil import dependence would reach unprecedented levels, about two-thirds of consumption by 2015.[4] The prospects of climate change would worsen as well, and urban air quality would remain poor from continued transportation energy growth.

HIGH GROWTH SCENARIO

Government policies in this scenario focus on expanding supply rather than on diminishing demand to fuel a period of high economic growth. The high growth scenario envisions total U.S. energy demand rising to 127 quads by 2015, a growth rate of about 1.7 percent annually. Energy demand in this scenario exceeds that of the base scenario for all sectors. Like the base scenario, this scenario requires a plentiful supply of relatively cheap fossil energy during a period that introduces no major new environmental constraints that might induce controls on energy demand.

To meet the supply projections under the high growth scenario, coal, natural gas, and nuclear energy would all have to be expanded significantly. Efforts to bolster domestic oil production would also

[4] Recent U.S. Department of Energy (DOE) projections of U.S. petroleum import dependence suggest that foreign sources could represent over two-thirds of U.S. supplies by 2010 under their reference (base) case. The DOE reference case assumes nearly the same level of economic growth (2.1 percent) used here (2.3 percent). *Annual Energy Outlook 1991: With Projections to 2010,* DOE/EIA-0383(91) (Washington, *DC:* U.S. Government Printing Office, March 1991), pp. 3,43.

be necessary to keep domestic production from dropping too sharply by 2015. Policies would have to encourage increased domestic production of these sources, while protecting against supply disruptions to prevent shortages and drastic energy price rises.

The options to expand supply in this scenario echo the proposed NES. For example, the development and use of advanced oil recovery technology to extract currently unrecoverable domestic reserves in the range of 300 billion barrels would be important. Also, increasing exploration in offshore and other unexplored areas, such as the Alaska National Wildlife Refuge, would help meet the supply projections in this scenario. To expand domestic supply exploration and development, a variety of environmental concerns would have to be addressed, but they could not raise the cost of the final products by much or they would not be competitive under this low-price scenario.

If coal is to be used in the quantities assumed here, stricter SO_2 and nitrogen oxide (NO_x) emissions controls may be necessary to avoid violating air quality standards. Though coal remains abundant and cheap under this scenario, tighter emissions standards could not raise the price of energy significantly, or the low-price, high-growth conditions of this scenario would be compromised, and prices would rise and demand would shrink accordingly. Thus, expanding Government support for RD&D to improve combustion (e.g., fluidized bed or gasification in combined cycle plants) would help enhance generating efficiency while offsetting the emissions increases that are a major feature of this scenario. In addition, a tradable emissions permit system (broader in scope than that created under the Clean Air Act Amendments of 1990) could stimulate technological improvements in emissions control for coal burning or motivate an increase in the energy intensity of electricity generation beyond the levels expected under current legislation.

Heavy reliance on fossil fuels will negatively affect urban air quality (particularly in carbon monoxide and ozone nonattainment areas).[5] In response, this scenario assumes that the use of electric vehicles (EVs) becomes more widespread, which would require Government incentives to induce manufacturers to produce such vehicles on a larger scale. This option is an element of the NES, and some areas (e.g., California) are already beginning to incorporate EVs in their environmental and transportation planning. However, EVs are expensive and suffer from poor performance. Government RD&D and incentives are likely to be required if they are to be important contributors to urban air improvement in the short to medium term.[6]

To maintain low electricity prices, increasing competition could be vital. Changes to the Public Utility Holding Company Act of 1935 (PUHCA) could ease the financial and other constraints on utilities that service customers in more than one State. Though amending PUHCA could have a generally positive effect on competition, the full effects of any PUHCA changes need to be understood before major amendments are made to prevent either small or large generators from enjoying undue competitive advantages or disadvantages.

The large diversion of coal (one-third of production) to synthetic fuel production under the modest price rises assumed for oil and natural gas in this scenario is not probable absent price incentives and expanded RD&D, both of which the Government would have to provide. Concerns about rising levels of petroleum imports, which are assumed in this scenario and likely in any event, would be the likely impetus for synthetic fuel production of this magnitude.

To expand domestic natural gas supplies, increased RD&D for gas recovery in tight sand and other unconventional formations would be necessary to exploit the greater part of U.S. reserves at reasonable cost. As noted in chapter 4, this scenario is largely contingent on the increased supply of relatively cheap natural gas and, without government help, domestic natural gas production is likely

5For the period 1987-89, the U.S. Environmental Protection Agency (EPA) determined that 96 areas (mostly major metropolitan areas) failed to meet the Federal ozone standard, and 41 areas failed to meet the Federal carbon monoxide (CO) standard in the period 1988-89. The total population in the areas violating these health-based standards was an estimated 66.7 million in 1989 for the ozone areas alone. Furthermore, the connection between these areas and transportation emissions is strong; in 1989,65 percent of national CO emissions were from transportation sources, while 35 percent of national volatile organic compound emissions, the precursors of ground-level ozone formation, were from transportation sources. U.S. Environmental Protection Agency, *National Air Quality and Emissions Trends Report, 1989, EPA-450/4-91 -O03,* February 1991, pp. 3-17,3-27,4-1,4-5.

6A detailed assessment of the prospects for increasing the use of alternative fuels in the transportation sector is found in U.S. Congress, Office Of Technology Assessment, *Replacing Gasoline: Alternative Fuels for Light-Duty Vehicles, OTA-E-364* (Washington, DC: U.S. Government Printing Office, September 1990).

to be waning by 2015, because the price assumptions used in this scenario would be insufficient to spur natural gas exploration at the levels projected here. As proposed, the NES supports R&D to improve natural gas production, as well as regulatory reform to prevent delays in building new pipeline capacity. Both of these steps would be important in this scenario.

Additional RD&D for enhanced oil recovery in existing fields may be required, as well as improved exploration and drilling techniques, especially off-shore. Increasing both imports and domestic production also suggests that improved safeguards against oil spills would be necessary. To reduce the potential for oil supply and price disruptions under the high growth scenario, exploiting protected areas in Alaska and off-shore would help prevent domestic oil production from diminishing too quickly. Even with expanded exploration of this kind, however, domestic oil production is expected to continue declining. For further protection against supply or price disruptions, the SPR would have to be enlarged.

To expand nuclear power, attention to RD&D, regulatory treatment, waste disposal, and decommissioning would be necessary, as well as a visible effort by the Government to restore public confidence in the industry. Standardizing designs and simplifying licensing are crucial ingredients for a revival. Proapproval of designs, and perhaps sites, might be possible. However, it could be very damaging to public acceptance if a streamlined licensing process is viewed as steamrolling opposition. Along with an improved regulatory environment, the nuclear industry itself would require improvement in financial and facility performance for nuclear power to expand to the 70,000 megawatts (MW) by 2015 assumed here.

Part of the effort to restore the credibility needed for the nuclear industry to gain wider public support will require faster progress on a waste disposal facility. OTA believes that the construction of new nuclear facilities will be limited until major progress toward an operable waste disposal facility is visible. In addition, public acceptance of expanded nuclear power is not likely to improve as long as the availability of cost-effective efficiency improvements remains great. Suggestions in the proposed National Energy Strategy to improve the acceptance and use of nuclear power fail to indicate how to address potential public concern about nuclear growth at a time when many options to implement cost-effective demand control are available.

The nuclear R&D program has been declining since the cancellation of the Clinch River Breeder Reactor in 1983. Increased RD&D for alternative reactor designs and processes could lead to technology that could more easily recapture public trust.

MODERATE EFFICIENCY SCENARIO

Improved efficiency has been the major energy success story since the first oil crisis in 1973. Had the pre-1973 trends in the growth of U.S. energy consumption continued unabated, total energy use here would have been 32 quads higher in 1986 than the actual 72 quads consumed that year. For the period 1973-86, this resulted in a cumulative savings totaling 171 quads, valued at over $950 billion (1986 dollars).[7] Despite these large gains, there are vast opportunities for further improvements.

In contrast to the previous scenario, therefore, the focus of the moderate efficiency scenario switches from increasing energy supply to reducing energy demand. As noted in chapter 4, this scenario assumes that available cost-effective, energy-savings opportunities are fully exploited due to direct policy intervention.[8] While this optimal level of cost-effective investment would theoretically benefit consumers and the Nation as a whole, it would be unprecedented, requiring the elimination or reduction of significant market, institutional, and behavioral barriers that prevent the full use of currently available cost-effective energy-savings opportunities.

A combination of policy options (energy taxes, standards, financial mechanisms, information programs, RD&D) would best serve the efficiency targets in this scenario, because each exerts unique effects in overcoming the barriers to optimal energy efficiency and conservation actions. The NES advo-

[7] U.S. Department of Energy, *Energy Conservation Trends: Understanding the Factors That Affect Conservation Gains in the U.S. Economy,* DOE/PE-0092 September 1989, p. 5; *and Annual Energy Review 1989, DOE/EIA-0384(89),* May 24, 1990, p. *7.*

[8] This maximum number is based on the energy price projections noted inch. *4,* and it considers only investments that yield net positive economic benefits when amortized over expected equipment life.

cates strongly only the last three options, while postponing or dismissing consideration of revising standards or broadening energy taxes. Nonetheless, a significant, broad-based energy tax is perhaps the single most effective means of improving efficiency in this or other scenarios. A gasoline tax in the range of $0.50 per gallon, with equivalent increases for other energy sources, would have a major impact on how consumers make energy-related decisions. For example, a recent OTA report suggested that a sustained increase in gasoline prices of 50 percent could lessen gasoline demand 8 percent (between 5 and 20 percent),[9] but the gasoline price elasticity assumed in this estimate is an extrapolation of empirical data. In other words, estimating gasoline price elasticity at such high prices is uncertain, because the United States has not experienced sustained gasoline price rises (in real terms) of this magnitude.

Across the board energy taxes would increase the level of energy efficient construction and manufacturing for residential and commercial stock, vehicles, appliances, and other equipment. In the industrial sector, energy taxes could motivate the wider adoption of adjustable-speed drive (ASD) and other motor efficiency improvements to save 10 percent of the energy projected for use by motors in the base scenario in 2015. Of course, taxes would have to be high enough to motivate improvements but low enough to allow consumers sufficient investment capital to afford such equipment and conservation measures.

Energy taxes could also be applied to the initial purchase of energy-using equipment. These taxes could be scaled in a way that would raise the cost of the least efficient equipment the most in order to produce a level field for similar products in consumer markets. Taxes on carbon emissions or imported oil would have similar but more selective results. These taxes could be justified as efforts to capture the environmental and social externalities of providing energy or they could be levied in an effort to reduce the Federal deficit. Raising prices through energy taxes to capture these externalities would be consonant with the combination of economic, environmental, and energy security goals outlined in chapter 1.

Of course, there are social costs to raising energy taxes significantly. In particular, energy taxes would be regressive; lower income individuals and families would experience a greater marginal burden if such taxes were imposed, because energy costs consistently account for a higher fraction of income in low-income households.[10] This report does not analyze social equity issues such as this. It merely notes that one of the most efficient ways to induce effective energy-saving decisions is to raise the cost of energy.

Barriers to maximizing cost-effective, energy-saving investments are not merely price-oriented. Reliable information on energy-saving opportunities needs to increase in all sectors. Most people, for instance, are aware that measures such as insulating residences or driving high mileage cars will save energy, but few are aware of the full range of investments that can profitably save money by saving energy. Information programs such as appliance labeling can be useful, but only if consumers are aware of them and understand them. The scope and clarity of Federal energy information programs could increase to assure consistent and meaningful information for appliances, building energy rating systems, and other energy-using equipment or stock.

Passive programs that simply supply some information, or supply information only when asked, will not reach a high proportion of consumers. Other actors that can aid or influence consumer decisions about energy use-builders, lenders, landlords, manufacturers, utilities, and the media-should participate to ensure that appropriate decisions about energy use are made. The assumed level of building retrofits in this scenario implies a key role for information programs, because the first step in retrofitting programs is generally informational.

Buildings, vehicles, and appliances possess a wide range of energy efficiencies. Stringent standards can eliminate the least efficient. Moreover, standards would correct a problem unique to buildings: many decisions about investing in energy

[9]Office of Technology Assessment, *Changing By Degrees: Steps To Reduce Greenhouse Gases*, OTA-O-482 (Washington, DC: U.S. Government Printing Office, February 1991), p. 165.

[10]For example, in 1984, low-income households (below $5,000) that used automobiles spent about $770 (15 percent) per year fOr motor fuel On average. Households earning more than $25,000 per year spent about $1,140 for motor fuel, or less than 5 percent of income on average. U.S. Department of Energy, "Energy Security: A Report to the President of the United States," DOE/S-0057, March 1987, p. E-6.

efficient design are made by builders and landlords, rather than subsequent buyers or renters. Unlike appliances and vehicles, the decision about whether to invest in energy efficient building design is made for the consumer in advance. Standards would help correct this basic problem.

In the moderate efficiency scenario, standards could be raised significantly in all sectors and still meet the criterion of life-cycle paybacks used in this scenario. The NAECA standards, for example, could be strengthened; at present, the method for revising these standards may effectively encourage the widespread use of three-year payback periods,[11] but the opportunity for efficiency gains typically increase when longer paybacks are used in setting standards. To be sure, there is *no* current requirement under NAECA to set standards at levels that would ensure paybacks strictly determined on a life-cycle basis.

Mandatory Federal building standards are currently restricted to Federal buildings, and they are not enforced strictly. Under this scenario, these standards could be strengthened to require high, but still cost-effective, efficiency levels, expanded to include residential and commercial structures, and enforced. State energy grants disbursed through the Federal State Energy Conservation Program (SECP) and other DOE and U.S. Department of Housing and Urban Development (HUD) programs could be restricted to States that have adopted the national Building Energy Performance Standards (BEPS) or other building codes, such as the Council of American Building Officials "Model Energy Code" (CABO "MEC"). One way to bolster enforcement programs is to attach major fries for noncompliance or encourage States and localities to deny occupancy permits to new buildings failing to meet efficient design requirements. Even if strictly voluntary, an aggressively promoted Federal standards program for buildings could dramatically improve energy efficiency in new residential and commercial structures.

Arguably, increasing energy prices might be more economically efficient in improving energy use in buildings compared to setting rigid standards for efficiency performance. However, estimating the effects between taxes and standards in the buildings sector is complicated by the diversity and uses of building types. Comparing the effects of taxes and standards for vehicles, on the other hand, is less complicated. Meeting the fuel economy targets given in this scenario might be achieved most efficiently through energy taxes, but experience in other industrialized nations suggests that such a tax would have to be high, as much as two to three times the current U.S. price.

Strengthening fuel economy standards directly is an alternative approach to taxes that appears to have been effective in the United States with lower cost to consumers. However, raising prices through energy tax increases would affect *all* vehicles, not just new ones. Raising energy prices and strengthening fuel economy standards together would encourage the scrappage of older, less efficient vehicles at a time when new vehicle fuel economy was rising. The effect would be to raise the efficiency of the entire fleet much more quickly than we have experienced in the United States with just new vehicle standards working by themselves.

In fact, fuel economy standards in this scenario would not need to increase much over levels expected in the base scenario to achieve significant energy savings. Year 2015 new auto fuel efficiency of 39 mpg and new light truck efficiency of 35.5 mpg could be achieved if regulations raised the fuel economy of these vehicles only about 10 percent above that already predicted by the base scenario where no regulatory changes occur. Along with reinstating the 55-mph speed limit, improving traffic flow in urban areas, and several other measures, growth in transportation energy use could be halved relative to the base scenario if existing vehicle efficiency standards were raised to the levels suggested above. While small increases in vehicle standards would not eliminate gas guzzlers, which tend to be the most expensive personal passenger vehicles, they would raise the fleet average.

The additional purchase cost (also known as first cost) of energy efficiency measures commonly

11 "If the [DOE] Secretary finds that the additional cost to the consumer of purchasing a product complying with an energy conservation standard level will be less than three times the value of the energy savings during the fiist year that the consumer will receive as a result of the standard, as calculated under the applicable test procedure, there shall be a rebuttable presumption that such standard level is economically justified. A determination by the Secretary that such criterion is not met shall not be taken into consideration in the Secretary's determination of whether a standard is economically justified."—42 U.S.C. 6295(l)(2)(B)(iii). There are varying interpretations of how this requirement for determining economic justification will play out but, under the conditions of the moderate efficiency scenario, this requirement would have to be strengthened to meet the condition of exploiting all life-cycle payback opportunities.

prevents firms or individuals from acquiring them. Financial mechanisms could soften or eliminate the first cost barrier. Tax credits applied, for example, to efficiency investments, conservation measures, or both could be set at minimal losses to the Federal Treasury while helping to reduce the flow of oil imports. Moreover, revenues lost from Federal tax and other incentive programs could be offset by increasing energy taxes to achieve no net effect on Government revenues.

Tax credits could also be applied to equipment using renewable energy sources (solar, wind, geothermal). The Federal Government has experience with both types of credits in the residential, commercial, and industrial sectors, particularly under the Energy Tax Act of 1978 (ETA), Public Law 95-618, and the Windfall Profits Tax Act of 1980 (V/PTA), Public Law 96-223. Tax credits would lower Federal Treasury revenues directly, but they would indirectly raise some of these revenues by stimulating economic activity that might not otherwise have occurred but for the incentives.

The marginal benefits that tax credits actually provided the industrial sector under the WPTA was uncertain, because many firms may have made their efficiency investments regardless. Other mechanisms, e.g., low-cost loans and direct payments, might be targeted and administered more effectively by States and utilities, as they can often evaluate better fuel use, load, and cost changes in balance with projected demand and supply growth, but the Federal Government could go far to ensure that such programs are created and reach a wide audience.

Accelerated capital depreciation is also a financial mechanism that has been cited as an option to encourage investment in new equipment. The effect of accelerated depreciation can be mixed, however. By reducing the period in which businesses can write off investments, companies lower their tax bills, presumably leaving more for investment, but U.S. Treasury receipts are lowered as well.[12]

A vigorous RD&D program could accelerate the commercialization of new or emerging efficiency technologies. Most of the options listed in table 2-1 would improve efficiency. For example, compact fluorescent light bulbs are economical under some conditions but are too costly and bulky for wide-

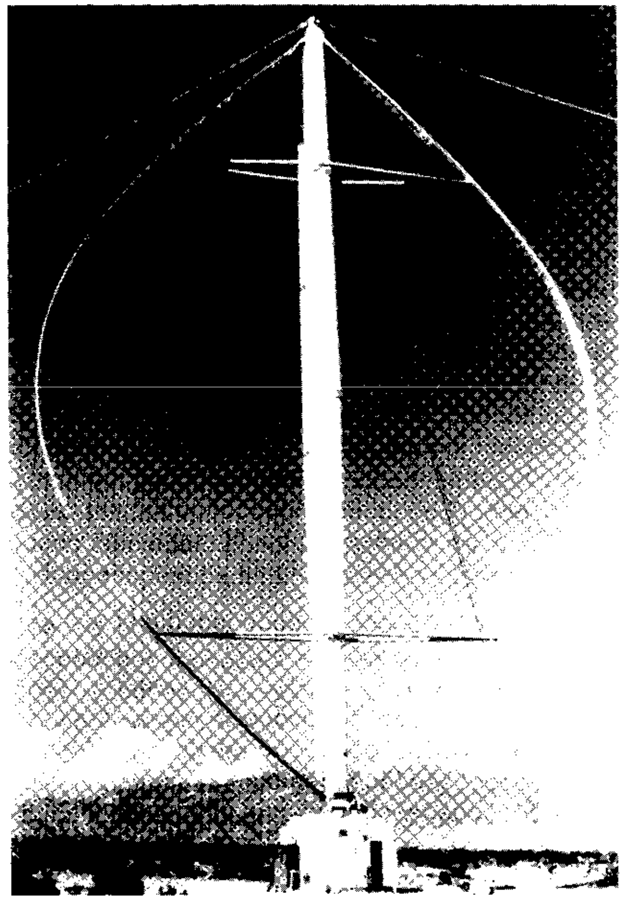


Photo credit: Southern California Edison Co.

A 500-kW wind turbine mounted on a vertical axis in California.

spread application. As these problems are solved, more of these bulbs should become interchangeable with incandescent. Most efficiency RD&D programs could be usefully increased, which would improve the chances of implementing this scenario even though existing technology is nominally sufficient.

Many of the policy measures noted here could also be valuable on the supply side. In particular, energy taxes, regulatory changes, financial mechanisms, or some combination of them could expand the fossil and nonfossil supply base. Any of these mechanisms could be used singly or in combination to meet the moderate growth in energy supply assumed in this scenario. These tools could be used singly or in combination to expand the contribution

[12]A more detailed discussion of the history and role of financial incentives in the U.S. industrial sector can be found in U.S. Congress, Office of Technology Assessment *Industrial Energy Use, OTA-E-198* (Washington, DC: U.S. Government Printing Office, June 1983), pp. 56-58.

of renewable sources of energy, which are assumed to cover 40 percent of new electricity demand by 2010. In addition, these tools could achieve the extensive use (70 percent) of cogeneration in new and replacement industrial steam boilers by 2015.

Federal energy use could be improved through mandatory building, equipment, and fleet efficiency standards; retrofitting existing shells and lighting systems; and participating in local utility demand-side management efforts. Furthermore, committed Federal efforts to invest in cost-effective energy efficiency technology through serious procurement efforts would be essential to bolster Federal credibility if major national programs are created to reduce U.S. energy use. Federal legislation or executive orders may be well-intentioned but have experienced poor results historically. To ensure that such efforts attain their desired results, financial support, enforceable provisions, appropriations contingencies, or some combination of these could be used to achieve Government efficiency and conservation improvements that maximize cost-effective options. Revisions to Federal procurement and leasing guidelines and requirements could also promote new demand- and supply-side technologies.

There are three general reasons for pursuing energy savings through some or all of these policies. First, maximizing cost-effective energy savings reduces the cost to produce U.S. goods and services in the domestic and international markets, thereby making those goods and services more competitive. Second, energy savings under this scenario would dampen U.S. reliance on imported petroleum.

Finally, energy savings of the kind noted here would soften the local and global environmental impacts of providing and using energy, including reductions in combustion emissions by raising the level of delivered energy services per unit of emissions. In fact, the environmental rationale may prove the most compelling if the magnitude of global climate change is as serious as some analysts predict. On this last point, achieving this scenario would limit the growth of U.S. CO_2 emissions 20 percent by 2015 relative to base scenario projections.

HIGH EFFICIENCY SCENARIO

This scenario incorporates many energy efficiency investments that are beyond the level at which life-cycle paybacks would be realized. This scenario, therefore, is more difficult to justify than the moderate efficiency scenario under current economic, security, and environmental conditions. For this scenario to become a national goal, extreme threats to energy security or the global environment would probably be necessary.

Serious climate change would probably serve as the strongest rationale. This scenario represents a major effort and investment to back out coal use. No new coal-fired generating capacity would be installed; new supply requirements would be covered by a combination of renewable, nuclear, and natural gas technologies. Some coal-freed plants are closed and carbon emissions at others are lowered by natural gas co-firing. Existing fossil fuel plants would have to be retired entirely after 40 years (rather than the typical 60). While the natural gas, renewable, and nuclear industries would grow slightly, the coal industry-and coal states in particular-would suffer abrupt economic declines unless adequate State and National contingency planning were conducted successfully in the short term.

Tax incentives (e.g., a 2- to 5-cent per kilowatt hour (kWh) credit for renewable electricity generation), accelerated plant depreciation schedules, and information programs could encourage the use of low- or no-carbon fuels, cogeneration, or help speed the retirement of coal-fired generating plants. However, in an aggressive demand-side effort such as this scenario implies, information programs and consumer-oriented financial mechanisms are less useful policy tools: more coercion than convincing or consumer financial assistance would be required. For example, eliminating the construction of new coal-fried capacity would be a basic regulatory requirement under this scenario. Moreover, the Government would have a major role in coordinating activities within and among the sectors to make the transition to such a highly energy efficient economy as smooth as possible, especially as the effects of such policy changes are likely to be substantial.

Higher taxes, aggressive efficiency standards, other regulatory changes (e.g., requirements disallowing the installation of new coal-fried generation capacity), and sustained, high levels of RD&D funding together would be the most valuable policy tools in such a scenario. In this regard, the high efficiency scenario would require an intensification of the same policies suggested in the moderate efficiency scenario. Accordingly, this scenario and the policies that would be needed to implement it are, for the most part, a major departure from the NES.

In combination with other policies, higher taxes would be essential, probably at least double the cost of energy, which would still leave U.S. energy prices lower than in some other countries. A carbon tax in the range of $75 to $150 per ton would encourage fuel switching and conservation. A tax of this magnitude would make natural gas more competitive than coal at many electricity generating facilities.[13] To offset the potential economic effects of increasing prices through energy taxes, the Federal Government could lower other taxes on individuals and firms.

High-efficiency standards would be a major part of this policy package. Buildings and appliances would be required to meet the highest efficiency now achievable. As a result of such standards, new residential units by 2015 could require 85-percent less heating and 45-percent less air conditioning than the average home today, and retrofits could be aggressively applied to all buildings such that their energy needs drop 30 percent. In the transportation sector, as part of an intensification of the other demand-curbing measures given in the moderate efficiency scenario, fuel economy standards for new autos would rise to 55 mpg (holding the current fleet size mix and performance characteristics constant). With a shift to smaller vehicles, which is likely with high fuel costs, the average fuel economy of the new car fleet could rise to 58 mpg by 2010. With standards this aggressive, the first costs for these consumer products are expected to increase, and consumer choice would be reduced, as fewer products would be available in the market that meet these tough standards, at least in the short term.

RD&D would be essential to expand the menu of available technological options. As noted, this scenario assumes that technologies expected to be available in 10 years are widely implemented by 2015. Expensive projects such as automobile engines and transmissions would have a high priority. The total estimated net cost of this high-efficiency package could be nearly as high as 1.8 percent of gross national product (GNP), or could result in a net savings of a few tenths of a percent of GNP. This compares with total current U.S. environmental GNP costs of 1.5 percent and the total current GNP costs of direct fossil fuel and electricity consumption of roughly 9 percent.[14]

A key part of a high-efficiency scenario is Federal Government energy use. In several ways, Government efficiency lags behind other sectors, which is not only expensive but diminishes credibility .15 Use of standards, changes in procurement guidelines, and realistic energy performance goals are some of the major ways the Federal Government can reduce its energy use if policymakers determine that this should be a priority. Although specific changes in Government energy use are not a defined element in this scenario, such improvements would be necessary to achieve the goals outlined here.

In addition, the Government would need to increase expenditures for improving transportation and industrial infrastructure. Increased mass transit finding is assumed in this scenario to improve high-speed intercity rail systems enough to curb interurban car travel by 5 percent and air travel by 10 percent.

HIGH RENEWABLES SCENARIO

The high renewable scenario represents a major but less aggressive effort than the high efficiency scenario to back out coal use to reduce quickly CO_2 emissions. Implementing policies for a high level of renewable could be easier than efficiency measures, because the need to influence directly individual consumers would be reduced. In large part, the development of renewable energy sources-specially for electricity generation—would require policies targeting utilities and industry. Financial incentives could be the most important policy tool in this scenario, because each sector will require investments in technological supply options that simply are not competitive in current markets. Historically, tax incentives in particular have hastened the commercial availability of renewable technologies, and they appear to have had the added effect of encouraging private sector RD&D when

[13] U.S. Congress, Office of Technology Assessment, op. cit., footnote 9, p. 26.

[14] U.S. Congress, Office of Technology Assessment, op. cit., footnote 9, pp. 10-11, 321.

[15] U.S. Congress, Office of Technology Assessment, op. cit., footnote 3.

Federal Government RD&D support sharply dropped beginning in 1982.[16]

As a result, the Government might consider tax credits, low-cost loans, or direct payments to subsidize the growth of solar, wind, and geothermal electricity generation, as well as the increased production of biomass fuels (such as ethanol for transportation). Accelerated capital depreciation schedules coupled with investment credits that favored renewable could also speed the wide-scale adoption of renewable supply technologies by encouraging their acquisition more quickly and easily than the market generally would by itself.

Financial incentives would clearly help correct the current inability of renewable energy sources to compete with fossil fuels, the sources that are currently cheaper (and that are likely to remain so in a price system that consistently fails to capture environmental externalities). To pay for such incentives, and to help create a level field between more expensive renewable and less expensive nonrenewable energy forms, some energy taxes could be established (e.g., carbon emissions) while others could be increased (e.g., gasoline). The combined effect of incentives and taxes has the potential to push the expansion of the renewable energy supply base further than either option would alone.

The most expeditious way of promoting large-scale, renewable energy use would be assured by direct regulatory intervention. If the use of renewable technologies to generate electricity, for instance, was favored as a first option by regulation, the need for additional incentives or energy taxes could possibly be eliminated.

The efficiency standards used in the moderate efficiency scenario are assumed to be implemented here. In addition, changes in the efficiency standards required of qualifying facilities (QFs) under the Public Utility Regulatory Policies Act of 1978 (PURPA), Public Law 98-617, could be made that would discourage the expansion of fossil-fuel-based generating capacity while promoting the adoption of more efficient and less polluting systems, e.g., cogeneration or IGCC technologies. A special category of PURPA qualifying facilities could be created that allowed more favorable treatment of generators that actually operated solely on renewable sources, but the contribution of such generators would probably be small (absent price or other regulatory incentives) in the timeframe of this scenario. Under our current regulatory system, merely increasing the PURPA size qualifications for QF status will have the effect of encouraging more gas-fired (rather than renewable source) electricity generation, because gas is the cheaper option. As it is currently written, PURPA grants QF status to many small, fossil-fried generators, which are commonly more efficient but not necessarily driven by renewable sources.

As suggested in the NES, efforts to expand hydropower would be eased if regulations governing siting, permitting, and environmental review were streamlined, but such regulatory changes could not simply cloak efforts to reduce or effectively eliminate adequate public review of the licensing process. The enhancement of existing hydropower capacity also is an important option.

To expand the market for alternative transportation fuels (whether produced from biomass, coal, or natural gas), their use as gasoline additives could be made required practice, but the environmental trade-offs would have to be evaluated. Similarly, the required use of alternative transportation fuels in U.S. fleets would increase their production and distribution but at an undetermined cost. At a minimum, their adoption in Federal fleets for all nonmilitary and select military use would be appropriate if the Government decided to promote or require their increased use.

RD&D is essential for this scenario. Many renewable technologies remain too expensive to compete with conventional fuel technologies, but many show considerable promise for improvement. In addition, intermittent energy sources, e.g., photovoltaics, solar thermal, and wind, will not develop as significant contributors to online electrical capacity until improved storage technologies are developed.

The high costs of this scenario, occurring at a time when conventional sources remain relatively inexpensive, suggest why the demand-side measures implemented in the moderate efficiency scenario are retained here to balance supply and demand forces

[16] An extended analysis and discussion of the role of financial mechanisms, e.g., tax incentives, to encourage renewable energy growth is contained in U.S. Congress, Office of Technology Assessment, New *Electric Power Technologies: Problems and Prospects for the 1990s,* OTA-E-246 (Washington, DC: U.S. Government Printing Office, July 1985). See especially pp. 290-294.

together. Efficiency measures meeting the original condition of achieving life-cycle paybacks will help moderate the need for what are currently the more expensive energy sources (renewable).

HIGH NUCLEAR SCENARIO

The high nuclear scenario assumes that a major commitment to nuclear power is deemed essential, most probably because of global climate change. As a result, this scenario exploits nuclear power as much to reduce coal combustion as to increase electricity production. Most coal plants would be retired to reduce U.S. CO_2 emissions, one-third of which currently derive from electricity generating plants. Unlike renewable sources, the amount of nuclear power capacity that is built in the coming decades depends more on political decisions and less on resource constraints or industrial capability.

Like the high renewable scenario, the high nuclear scenario assumes that expensive efforts to expand the supply base will be matched by the same level of demand-side controls called for in the moderate efficiency case. Thus, these three scenarios assume the same level of end-use energy demand by 2015, and the demand control options discussed in the moderate scenario would all apply here.

Reviving nuclear energy as a viable option would require a major change in public acceptance, which could be induced by serious global climate changes or intense Government efforts to improve the safety and public acceptance of this power source, such as imposing stricter standards on plant design and operations. In the absence of serious global climate change, Government efforts to revive public acceptance of nuclear power would mirror those mentioned in the high growth scenario: regulatory improvements, expedited waste disposal (including resolution of the national disposal facility issue), and expanded RD&D.

Previous Government and industry programs to improve public acceptance of nuclear power have had mixed results. To meet the high growth of nuclear capacity assumed here, these programs would need to demonstrate the safety and necessity of the new reactors. Nuclear technology and management have improved considerably, and controlled growth would present fewer risks to society than previously, but the case has to be made credibly.

As discussed under scenario 2 (high growth), a large part of the problem is waste disposal. Since this scenario envisions even faster growth, faster progress is necessary. Waste siting is difficult but must be done with sensitivity to local needs, addressing the technical difficulties is also urgent.

As noted in the high growth scenario, standardization of designs and stable licensing are crucial for a revival. Proapproval of designs, and perhaps sites, might be possible. However, it could be very damaging to public acceptance if a streamlined licensing process is viewed as steamrolling opposition.

In the short term, a revival of nuclear power does not depend on new reactor technology RD&D. Instead, good design, public acceptance, and implementation of existing technology are more important to achieve the sharp growth in nuclear generating capacity for this study period. RD&D will be more important over time. As noted in chapter 4, current light water reactor technology may not be adequate if hundreds of reactors are installed. Even if it is, the economic advantages in diversifying design approaches would probably outweigh the costs of developing new reactors, e.g., the high-temperature gas reactor. In this regard, a decision is to be made in 1991 on which technology will be used for the tritium production reactor for the weapons program. This report has not examined the question of which technology is best for production, nor does it recommend which technology should be used in that military application. However, it is clear that the decision over which technology is used for military tritium production could have implications for civilian nuclear energy supply options in the future, particularly if the gas reactor technology is used. R&D will also be important in resolving the remaining safety issues, waste disposal, enrichment, and other areas.

COMPARING SCENARIOS

The six scenarios used in this report contain different assumptions about economic growth, energy supply and demand, and environmental constraints that the U.S. could face in the period 1989-2015. The scenarios are not meant as predictions, nor do they contain all the potential elements of what our energy future may look like. However, the varying assumptions in the scenarios are a collection of plausible outcomes. Because the scenarios vary greatly, the best policy packages for achieving them vary as well. As a result, comparing the major features of the scenarios will convey their relative merits and suggest which policies could be the most appropriate or valuable in the future. The policy issues most relevant to all scenarios (except the baseline) are summarized in table 5-1.

Scenarios 4,5, and 6 are extreme outcomes based on the growing chance of an extreme problem: global climate change. These scenarios rapidly reduce the use of coal in electricity generation, despite our large resource base, in order to reduce $C0_2$ emissions. A somewhat different package of such extreme policy measures could be warranted if severe threats to energy security develop. The cost of implementing any of these three scenarios could be high, but the cost of not implementing them if global climate change proves as disrupting as some analysts predict would be higher.[17]

Scenarios 4, 5, and 6 assume that major policy decisions and Federal budget commitments are made long before the problem that would precipitate these changes—serious climate change--is likely to occur. This fact, however, does not diminish the value of considering these scenarios, their policy requirements, and their effects to counter global climate change (or severe threats to energy security); it merely postpones their provable urgency. Our current understanding of the lagtime in atmospheric responses to changes in trace gas concentrations, e.g., $C0_2$, suggests that the urgency **of making policy decisions similar** or **identical** to the last three scenarios could **be appropriate** now.

The base case **requires** no policy **changes. It assumes** no **major changes in environmental** conditions **(e.g., global** climate **change), U.S. energy supply security, and U.S. energy demand growth. This future is plausible but risky. At** a time **when U.S. production of** natural gas **and oil has slowed** or **dropped,** political **stability in the Middle East** is as uncertain as ever, the prospects **for large contributions** from **alternative and renewable energy supplies are** on a **capricious and lingering threshhold, and the steady buildup of atmospheric CO_2 continues** unabated, **the probability** that the **availability, price, and supply of oil fuels will all remain stable** is not **high.**

Scenario 2 is even **more optimistic.** That scenario assumes that **continued fossil fuel** use will not be **curbed by domestic** or **international concerns about global** climate, that fossil fuel reserves will actually **expand, and** an **uninterrupted level of** economic growth not seen in two **decades will be fueled by abundant and relatively inexpensive energy.**

Scenario 3 is a **moderate effort** to **curb U.S. energy demand, but** it **would require** an **unprecedented** use of **cost-effective investments and** success in energy **efficiency and conservation. Though** it **requires less** extreme measures than the **high-efficiency** measures in **scenario 4,** it **would still require a prodigious effort by Government and citizens** to be **realized.**

Scenario 4 adopts the same approach as scenario **3 (demand control), but** its measures **and outcome are more** extreme. **This** is the **only scenario** that actually results in *lower* total **energy demand at the end of the study period. Such** an **outcome would require many investments in energy efficiency** that **would exceed life-cycle paybacks suggesting** that extreme threats to the **global environment** or energy security **would be** necessary to impose policy measures this economically severe.

Scenarios 5 and 6 entail aggressive **supply-oriented** measures, **but they exploit the same level of demand-side** measures as scenario **3 and** thus **provide** an **illustrative lesson about mixing supply and demand-side** measures in an energy policy.

Any of these scenarios could be the right choice depending on the resolution of several critical but presently unknowable factors. In particular, the specter of climate change could invalidate the frost three scenarios, technical developments could make the last three much more feasible, and unexpected resource discoveries could lead to the high growth of scenario 2. Prudent policymaking will protect society against negative outcomes while maximizing the possibility of positive developments. The value judgments and risk assessments that determine the decisionmaking ultimately guiding the country along its actual path are beyond the scope of this report. It is hoped that the above discussion provides a background for understanding where decisions about the nation's energy future fit in the overall context of the national goals of economic well-being, environmental quality, and security.

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[17]As mentioned earlier, the estimated net cost of the hi@ efficiency scenario alone could be a positive several tenths of 1 percent of GNP to as much as a negative 1.8 percent of GNP. Depending on its magnitude, the cost of climate change could be as great or greater; it could also be lower.

Table 5-l-Summary of Policy Options

Scenario	Financial mechanisms	Taxes	Info management	RD&D	Standards	Federal programs
High growth	Credits, loans and payments for synfuels; tradable permits for coal emissions; incentives for electric vehicles.	No change from baseline scenario.	No change from baseline scenario. Improve public acceptance of nuclear power.	Clean coal technologies; advanced oil and gas recovery; synfuels; fluidized bed and IGCC; electric vehicles.	No changes needed in energy performance standards; emissions reductions in utility and transportation sectors probably necessary.	PURPA/PUHCA revisions to expand resource base, increase competition; eased plant siting to keep costs down; OCS/ANWR opened; SPR increased; improved nuclear licensing and waste disposal facility.
Moderate efficiency	Tax credits and accelerated depreciation for quicker equipment turnover; tradable permits for emissions reductions, (industry and utilities), coupled with tougher emissions standards.	Energy taxes; gasoline tax in the range of 50 cents; other energy taxes raised accordingly; carbon tax of at least $75 to $150/ton; added taxes on inefficient equipment.	Increase Government and utility efforts to impart life-cycle opportunities (retrofits & new equipment).	Vigorous for all sectors.	Raise building and equipment performance standards (NAECA, BEPS); CAFE to 39 mpg; tradable permits; 55-mph speed limit; HOVs and carpooling programs; and utility demand-side management programs.	Aggressive FEMP; increased funding for urbanhterdty rail; Federal procurement and technology transfer are key.
Tough efficiency	Similar to moderate efficiency scenario, but at a higher level.	Energy taxes and especially carbon taxes of at least $150/ton; purchase taxes that levelize prices of equipment with varying efficiencies.	Same as moderate efficiency scenario.	Extremely aggressive; technologies available by 1999 implemented by 2015.	CAFE 55 mpg; most energy efficient design for buildings and equipment; stronger utility emissions reductions; ban new coal-fired generating plants.	Aggressive retirement of coal plants; natural gas cofiring; stronger DSM programs; aggressive FEMP; high national priority tied to infrastructure funding.
High renewable	Renewable investment tax credits for electricity generation & biomass fuels production; low-cost loans; accelerated capital depredation for existing fossil-powered systems; same demand controls as moderate efficiency scenario.	Energy taxes on fossil fuel use only; carbon taxes as an alternative; same as moderate efficiency scenario.	Same as moderate efficiency scenario.	Especially for storage technologies.	Same as moderate efficiency plus standards for generating plants that favor renewable.	Favorable regulatory treatment encouraging renewables; fleet use of alternative fuels; extended and improved hydro (existing capacity).
High nuclear	Accelerated depreciation schedules for utilities committed to investing in nuclear plants; investment tax credits for new nuclear construction; same demand controls as moderate efficiency scenario.	Large carbon tax on utilities to encourage nuclear growth.	Same as moderate efficiency scenario. Improve public acceptance of nuclear power.	RD&D needed for advanced reactor designs; modular components; waste disposal technologies.	Same as moderate efficiency; also higher standards for non-nuclear plants.	Streamlined licensing; waste disposal facility.

ABBREVIATIONS: BEPS . Building Energy Performance Standards; CAFE = Corporate Average Fuel Economy Standards; DSM = Demand-Side Management; FEMP - Federal Energy Management Program; HOVS = High Occupancy Vehicle lanes; IGCC = Integrated Gasification Combined Cycle; NAECA = Nationai Appliance Energy Conservation Act; OCS/ANWR = Outer Continental Shelf/Arctic National Wildlife Refuge; PURPA/PUHCA = Public Utility Regulatory Policies ActiPublic Utility Holding Company Act; RD&D = Research, Development, and Demonstration; SPR = Strategic Petroleum Reserve

SOURCE: Office of Technology Assessment, 1991.