executive summary

energy Innovations

A PROSPEROUS PATH TO A CLEAN ENVIRONMENT

JUNE 1997

A report by

Alliance to Save Energy

American Council for an Energy-Efficient Economy

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The ***Energy Innovations*** study was a nearly two-year effort involving several organizations and many individuals. The project was initiated and carried out as a collaborative effort by the Alliance to Save Energy (ASE), the American Council for an Energy-Efficient Economy (ACEEE), the Natural Resources Defense Council (NRDC), the Tellus Institute, and the Union of Concerned Scientists (UCS).

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energy *Innovations*

A PROSPEROUS PATH TO A CLEAN ENVIRONMENT

Throughout American history, technological and institutional innovation has increased our prosperity. Public leadership has encouraged businesses, workers, and consumers to invest in new ideas that meet the challenges of one generation, paving the path to a better world for the next generation.

The energy system that fuels our 20th century economy exemplifies such progress through partnership. Most of this system is built upon innovations of the 19th century, when coal was industrialized and oil commercialized, electricity was harnessed, and the automobile invented. From wildcat drillers to John D. Rockefeller to oil companies today, savvy deals, roughneck work, public subsidies—and sometimes military might—have pumped petroleum from wells worldwide to neighborhood gas stations. Government investments in roads and transit then enabled us to get to work and school, shop and visit family and friends, and convey goods to and from market. Thomas Edison's inventions were connected to public and private investments in power plants and power lines. From city to farm and from home to factory, Americans benefit from reliable electricity plus the appliances and machinery it powers, providing light in the night and air-conditioning in the summer.

Today's energy systems did not arise just through the hidden hand of market forces, though markets have played an important role. They are as much a product of strategic visions, wherein private investments melded with government incentives and policies to create the complex networks and industries that dominate the energy scene. Public policy guidelines were developed to ensure that benefits are broadly shared, to minimize the side effects of energy production and use, and to prevent undue harm. Such is the case with a fuel and power supply system now dominated by fossil sources.

Three concerns—our environment, our economy, and our security—compel us to rethink U.S. energy strategy.

Burning fossil fuels harms our health and damages the planet. Oil and coal combustion in particular contribute to smog and acid rain, and are the largest source of sooty fine particles that lodge in our lungs and shorten the lives of tens of thousands of Americans each year.

Fossil fuel consumption is also the chief source of the pollutants that are disrupting the earth's climate. Carbon dioxide (CO_2) is the inherent by-product of burning coal, oil, and (to a lesser extent) natural gas. As a result, concentrations of this gas have increased by 30 percent since the industrial revolution, and scientists have concluded that a human influence on global climate is already discernible. Continued buildup of carbon dioxide and other greenhouse gases threatens human health and well-being with many adverse consequences, including increased spread of infectious diseases, more frequent and severe heat waves, storms, droughts, and floods, rising sea levels and coastal inundation, and damage to ecosystems, risking serious social and economic disruptions.

Governments from around the world are currently negotiating an agreement to set binding limits on emissions of CO_2 and other greenhouse gases. These talks are scheduled to conclude in December 1997, at the Kyoto Climate Summit. As the world's largest contributor to global warming, the United States must take the lead in forging an international agreement that will put the world on track toward achieving the goal of the Rio Climate Treaty—preventing dangerous climate change. Because natural processes are very slow to remove excess CO_2 from the atmosphere, a commitment to substantial, timely, and continuous emissions reductions is essential. This study provides an independent analysis of policies that can reduce U.S. greenhouse gas emissions over the coming decades in order to help inform policy makers and the public in evaluating the wide variety of proposals that are on the table.

In addition to causing environmental damage, America's use of fossil fuels is costly. Our national energy bill amounts to over $500 billion per year, or more than $5400 per household (all costs are given in constant 1993 dollars). Too much of this bill is paid to foreign corporations and governments; little trickles back to provide jobs in our communities. The net energy import bill last year was $56 billion, almost all of which was for oil. Energy waste and overreliance on fossil resources now past their prime imply economic inefficiency, with lost opportunities for higher employment as well as inequitable distributions of income and wealth.

Moreover, the economic and security risks—particularly of oil dependence—are very real. Oil price shocks have already provoked two major recessions. Since the time of the first oil crisis, the monopoly cartel nature of the oil market has cost the U.S. economy over $4 trillion, nearly equal to a year's worth of economic income. With our oil import share now at nearly 50 percent and rising, and with burgeoning demand in Asia and elsewhere around the world, a continued failure to enact prudent energy policies places our nation at an ever greater risk of future economic crises and perhaps military conflict over oil.

Thus, the 19th century contrivances that seemed to serve our parents and grandparents so well are causing problems for us today. Without a new direction our children and grandchildren will be less prosperous, healthy, and secure than they can and should be. The fact is, the way we use energy today is not sustainable. Now is the time to choose a new path, marrying private innovation with public leadership to invest in new ways of producing and using energy.

The ***Energy Innovations*** study analyzes a balanced national strategy that can put the United States on an innovative, prosperous path leading to an economically and environmentally sustainable energy future. This ***Innovation Path*** is marked by a set of programs and policies that would guide our economy toward lower cost, less polluting, more secure, and more sustainable ways of producing and using energy. The approach involves setting fair performance standards, creating incentives, providing better information, and reducing transaction costs in order to foster investments in clean and efficient technologies. Policy packages tailored to each economic sector would provide the push to get us onto the ***Innovation Path***.

The policy set on which this report's results are based does not include an economy-wide carbon tax or energy tax. Rather, sector-specific market mechanisms would guide consumer and business decisions toward greater efficiency. Examples include an electric generation emissions allowance and tradable permit system; a revenue-neutral industrial investment tax credit, which can offset increases in energy costs by reductions in the cost of capital; and transportation pricing reforms such as pay-as-you-drive insurance, which would shift a portion of auto insurance premiums to a cost that varies with miles driven. Each such policy reallocates costs in order to motivate higher energy efficiency and lower emissions while avoiding a net increase of taxes or fees within the sector.

KEY ENERGY INNOVATIONS POLICY APPROACHES

- **RENEWABLES CONTENT STANDARDS.** These provisions would require an increasing percentage of electricity and motor fuels to come from renewable resources, such as wind, biomass, geothermal, and solar. The standards would be implemented through a credit-trading market mechanism that allows each producer flexibility to meet the standard or buy credits from another source that has a higher renewables content than required.

- **EMISSIONS PERFORMANCE ALLOWANCES.** These provisions would establish a level playing field for competition in the electricity market by establishing appropriate caps on emissions of sulfur dioxide, nitrogen oxides, and carbon dioxide, with emission allowances allocated to generators in proportion to their electrical output. Flexibility is provided with an emissions credit trading system similar to that for renewables content.

- **ADVANCED VEHICLES INITIATIVE.** This initiative includes a balanced set of programs, anchored with stronger fuel economy and emissions standards, to move advanced clean and efficient vehicle designs into the showrooms and onto the road. Standards would be backed by rebates on efficient vehicles paid for by fees on gas guzzlers, plus market introduction programs and technology research and development.

- **INVESTMENT TAX CREDIT.** This incentive would speed up the process of modernizing the industrial capital stock by providing a 10 percent tax credit for investments in new manufacturing equipment, paid for by fees on purchased energy. Fees collected would be rebated to firms, so the system would be revenue neutral, while encouraging investment in new, efficient production equipment that would increase productivity while reducing energy consumption and pollution.

- **MARKET INTRODUCTION INCENTIVES.** Technology demonstrations would be combined with manufacturer incentives, consumer education, and market innovations to reduce transaction costs, lowering a key hurdle between potential and realized energy savings by helping to move products from prototype designs into mass production. Once markets are established, minimum efficiency standards would improve the performance of similar products.

This sector-based approach is not intended to downplay the potential value of a broad-based approach rooted in fundamental changes to the federal tax system. Revenue-neutral tax reform could establish pollution charges to enable cuts in existing taxes on various forms of income. Sustainable economic development can be stimulated by equitably shifting some taxes from "goods" to "bads." Thus, this study also examines how equivalent energy savings and emissions reductions can be achieved through charges on carbon or other forms of pollution, as might be developed in the context of tax reform. Such an approach still requires a full range of technology-oriented programs and policies targeted to each sector.

Moreover, economy-wide energy or pollution taxes should be developed only as part of a fundamental tax reform effort that is premised on the need to enhance equity as well as efficiency. In practice, political factors, such as congressional committee jurisdictions and the extent of pressure for overhauling the federal tax system, would determine the approach, or combination of approaches, selected.

Whichever types of market mechanisms are involved, the ***Energy Innovations*** strategy will help us get more value and less pollution from each ton of coal, barrel of oil, or cubic foot of natural gas that we burn, while effecting a determined and orderly shift away from fossil fuels and toward safe and secure energy resources for the 21st century. Technological progress would be the cornerstone of such an achievement.

TECHNOLOGY HIGHLIGHTS OF THE *INNOVATION PATH*

➤ **FUEL CELLS.**
Originally developed for the space program, these devices convert the hydrogen in fuel directly into electricity without combustion. Recent advances make fuel cells very promising for achieving ultra-high efficiencies in electric-drive vehicles and for on-site electricity generation in buildings and industry. In the long-run, fuel cells supplied with hydrogen produced from renewable resources offer the potential of a truly zero-emissions energy system.

➤ **ADVANCED GAS TURBINES.**
These devices use combustion gases directly (rather than steam) to propel turbine blades. Applying materials and designs developed for jet engines has greatly increased gas turbine efficiency in recent years. Combined cycle systems (which use the turbine exhaust to produce steam for a conventional turbine) are the technology of choice for new power plants. Commercially available systems generate electricity at an efficiency of 50 percent (compared to conventional power-plant efficiencies of 30–35 percent), while efficiencies approaching 70 percent appear to be within reach.

➤ **INTEGRATED GREEN BUILDING DESIGNS.**
Dramatic reductions in energy requirements are achievable by using high-efficiency components in integrated designs that exploit synergies among building elements. For example, incorporating passive solar features and efficient lighting allows a reduction in the size of space conditioning equipment; incorporating whole-building control systems can further reduce operating costs while improving occupant comfort and productivity.

➤ **MEMBRANE TECHNOLOGY.**
Membranes represent an exciting alternative to traditional separation technologies, which are among the most energy-intensive industrial processes. Membranes can be used to treat wastes, to recover products as mundane as salt or as precious as silver, to purify chemicals, to produce corn syrup, or to concentrate orange juice—all at higher quality and with less energy and pollution than conventional processes.

➤ **FUELS AND ELECTRICITY FROM BIOMASS.**
Starting with wastes from agricultural and forest products and eventually using high-yield energy crops, advanced biomass conversion technologies can cost-effectively produce fuels and electricity while offering important opportunities for rural development. New biological and enzymatic processes can greatly boost the efficiency of ethanol production; a biomass gasifier coupled to an advanced gas turbine can generate electricity with much higher efficiency and lower pollution than direct combustion.

➤ **ADVANCED WIND TURBINES.**
The wind industry is already booming internationally, with more than 1200 megawatts of capacity added globally in each of the last two years. Advanced variable-speed designs and mass production can further reduce costs from 4–6 cents per kilowatt-hour today to 3–5 cents after the turn of the century.

➤ **PHOTOVOLTAIC MODULES.**
These solid-state devices ("solar cells") convert sunlight directly into electricity and are already cost-effective in many applications remote from the power grid. Improved efficiencies and reduced production costs promise to cut the cost of solar electricity by half within the next decade; thin film technology allows photovoltaics to be integrated into building materials, such as roofing shingles and facades, further reducing net system costs.

Summary Results

To evaluate the ***Innovation Path***, it was analyzed in comparison to a ***Present Path*** defined by a continuation of current U.S. energy trends. Table 1 summarizes the principal results from the analysis of the two paths. Following the ***Innovation Path*** yields immediate dividends of energy savings, pollution reduction, and decreased oil consumption.

Figure 1 compares U.S. primary energy use by fuel for the two paths. Along the ***Innovation Path***, primary energy consumption is 15 percent lower than the ***Present Path*** by 2010 and 42 percent lower by 2030. Oil and coal use decline, and an increasing share of our energy is supplied from renewable sources. Figure 2 shows the breakdown of renewable energy sources for the ***Innovation***

TABLE 1: ENERGY AND ECONOMIC RESULTS, PRESENT PATH VS. INNOVATION PATH

	1990	2000	2010	2030
Present Path				
Primary Energy (Quads)	84.6	95.4	104.5	119.4
Petroleum (Quads)	33.5	37.0	40.6	48.2
Renewables (Quads)	6.5	7.8	9.1	12.8
Carbon Emissions (MTc)	1,338	1,482	1,621	1,892
Nation's Energy Bill (B$)	540	556	648	n/a
Energy Intensity (kBtu/$)	14.0	12.5	11.2	8.6
Carbon Intensity (MTc/Quad)	15.8	15.5	15.5	15.8
Innovation Path				
Primary Energy (Quads)	84.6	88.6	88.9	68.8
Petroleum (Quads)	33.5	34.5	32.4	23.2
Renewables (Quads)	6.5	8.7	12.7	22.2
Carbon Emissions (MTc)	1,338	1,287	1,207	728
Nation's Energy Bill (B$)	540	542	563	n/a
Energy Intensity (kBtu/$)	14.0	11.6	9.6	6.4
Carbon Intensity (MTc/Quad)	15.8	14.5	13.6	8.2
Economics of Innovation Path				
Incremental Investments (B$)		28	73	
Fuel Cost Savings (B$)		38	131	
Net Savings per Household ($)		100	530	
Avoided Petroleum Imports (B$)		5	21	
Cumulative Investment (B$)		89	588	
Cumulative Savings (B$)		96	1005	
Cumulative Benefit/Cost Ratio		1.1	1.7	

All economic results are in constant 1993 dollars
Quads = Quadrillion (10^{15}) British Thermal Units
MTc = Million tonnes (metric tons) of carbon
B$ = Billion dollars
kBtu = Thousand British Thermal Units

FIGURE 1A: TOTAL PRIMARY ENERGY CONSUMPTION BY FUEL ALONG THE PRESENT PATH (1990–2030)

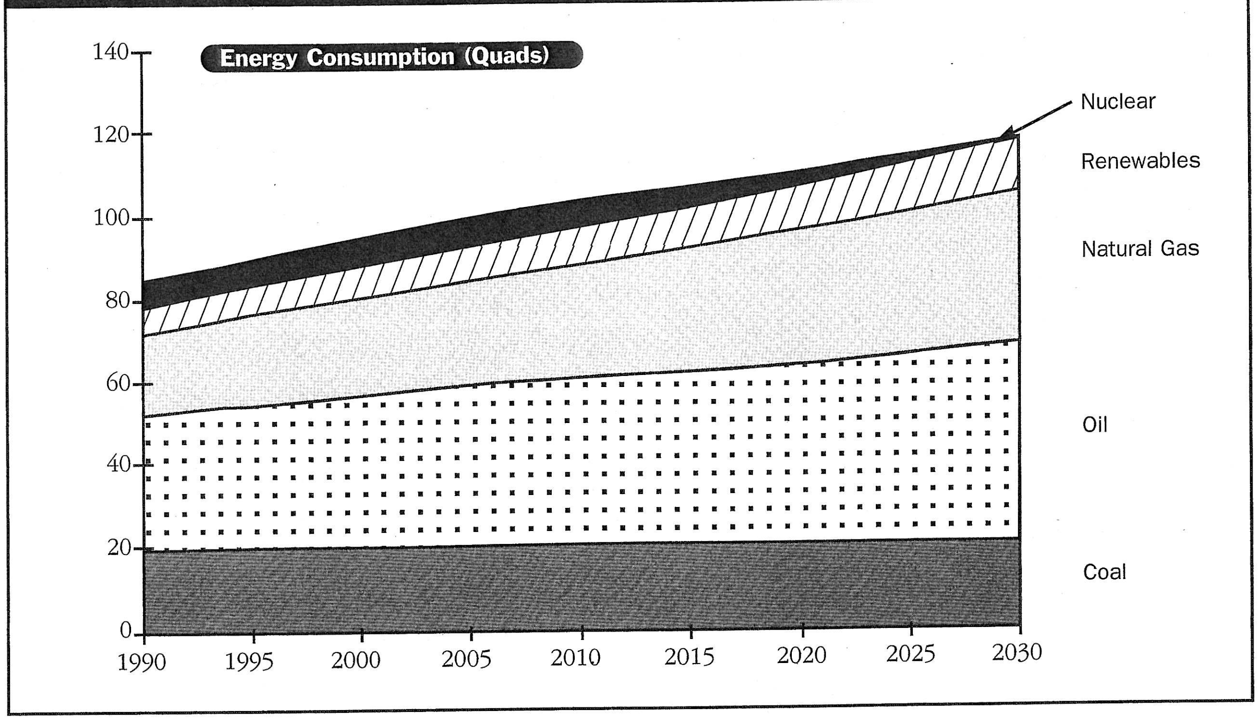


FIGURE 1B: TOTAL PRIMARY ENERGY CONSUMPTION BY FUEL ALONG THE INNOVATION PATH (1990–2030)

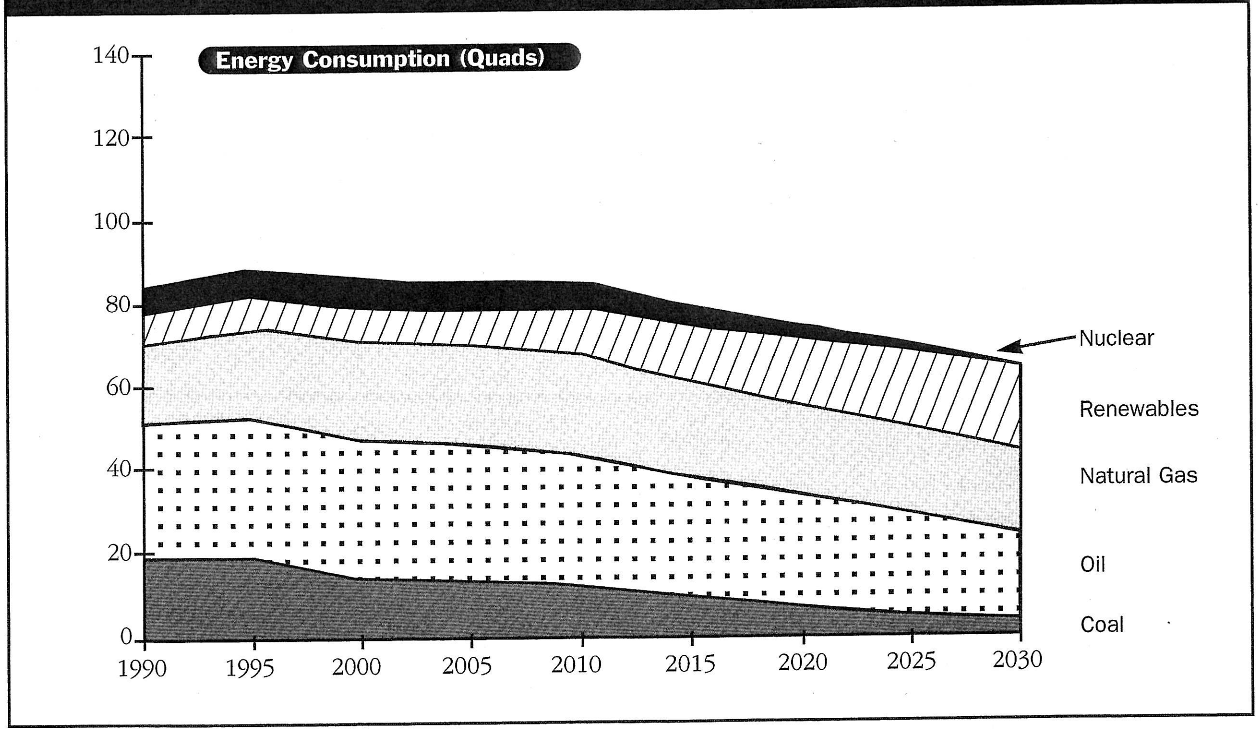
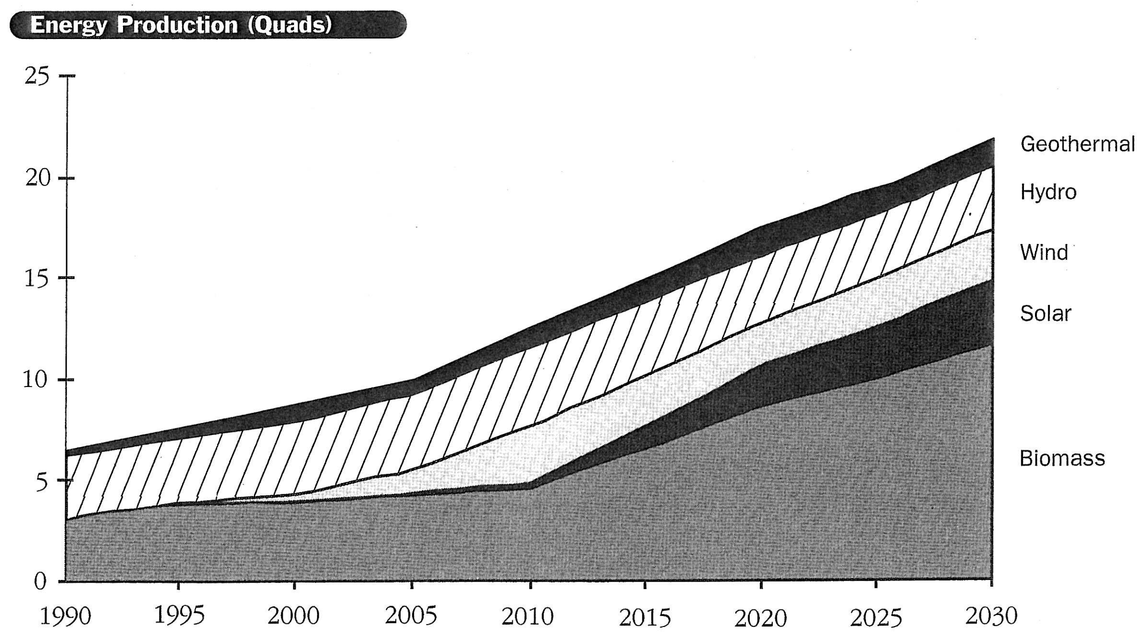


FIGURE 2: TOTAL PRIMARY RENEWABLE ENERGY BY FUEL TYPE UNDER THE INNOVATION PATH (1990–2030)

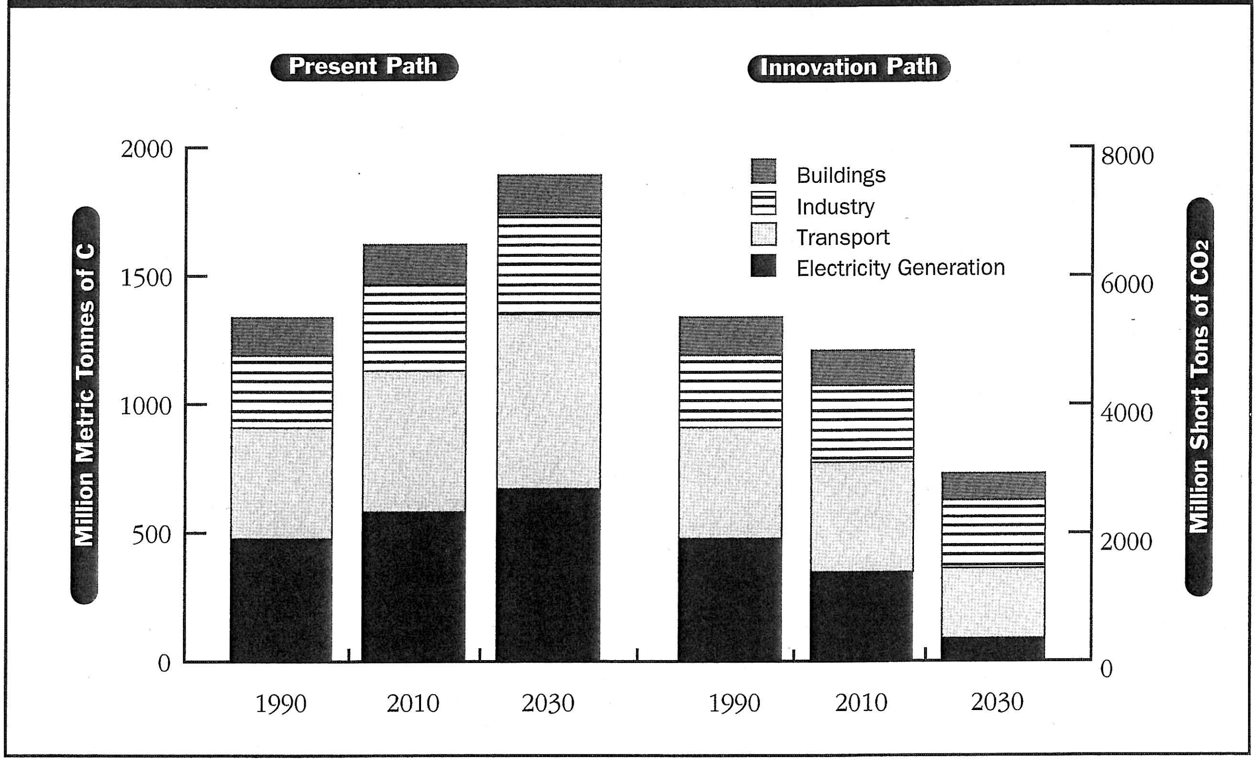


Path, along which renewables would come to supply 14 percent of U.S. energy needs by 2010 and 32 percent by 2030.

Moreover, with the ***Innovation Path*** our air will be healthier to breathe. Compared to 1990 levels, a 64 percent reduction in sulfur dioxide (SO_2) emissions (a primary precursor of fine particles) would be achieved by 2010 along with a 27 percent reduction in nitrogen oxide (NO_x) emissions (a key precursor of ground-level ozone). Emissions of other damaging pollutants, including fine particles, toxic metals, and hydrocarbons, would also be greatly reduced.

Figure 3 contrasts rising CO_2 emissions along the ***Present Path*** with the decreases projected for the ***Innovation Path***. Increases in energy efficiency and changes in fuel mix combine to reduce U.S. CO_2 emissions to 10 percent below 1990 levels by 2010, compared to a 21 percent increase in the ***Present Path***. Such CO_2 emissions reductions, coupled with carefully defined international trading protocols, would allow the United States to comply with the European Union's proposal for an international agreement requiring that by 2010, industrialized countries reduce greenhouse gas emissions by 15 percent compared to 1990 levels. Given the restrictive assumptions built into this analysis, we believe that even greater reductions would be feasible in this time frame.

FIGURE 3: TOTAL CARBON EMISSIONS FROM DIRECT FUEL USE BY SECTOR, PRESENT PATH VS. INNOVATION PATH



The ***Innovation Path*** also saves consumers money, with net savings reaching $58 billion nationwide, equivalent to $530 per household by 2010. These savings are the difference between total energy bill savings and increased investment costs on an annualized basis. Figure 4 shows annual costs and benefits averaged over five-year intervals between now and 2010. Investments in cleaner and more efficient buildings, appliances, automobiles, equipment, and power plants average $29 billion per year over the whole period. By comparison, savings from reduced expenditures on coal, oil, natural gas, and other fuels would average $48 billion per year. Moreover, as illustrated in the figure, net benefits grow each successive year, so that the benefits of the ***Innovation Path*** equal 1.7 times its costs for the 2006–2010 time period. These net savings don't even include the benefits to society of air pollution avoided by the ***Innovation Path***.

Compared to the ***Present Path***, following the ***Innovation Path*** starts us down a road of reduced petroleum dependence. Oil use drops from the 1990 level of almost 34 quadrillion British Thermal Units (Quads) to 32 Quads in 2010, instead of rising to 41 Quads, reducing the U.S. oil import bill that year by $21 billion.

Investing in a new generation of energy-efficient, low-pollution technologies also enhances U.S. employment. By 2010, following the ***Innovation Path*** creates nearly 800,000 additional jobs, beyond the baseline growth embodied in the ***Present Path***. Consumer savings on fuel costs will allow greater spending on non-energy sectors of the economy, which entail a greater number of jobs per dollar of purchases than the capital-intensive energy sectors. Reduced oil imports also contribute to expanded employment here at home. As illustrated in Figure 5, our macroeconomic

FIGURE 4: THE ANNUAL COSTS AND BENEFITS OF THE INNOVATION PATH

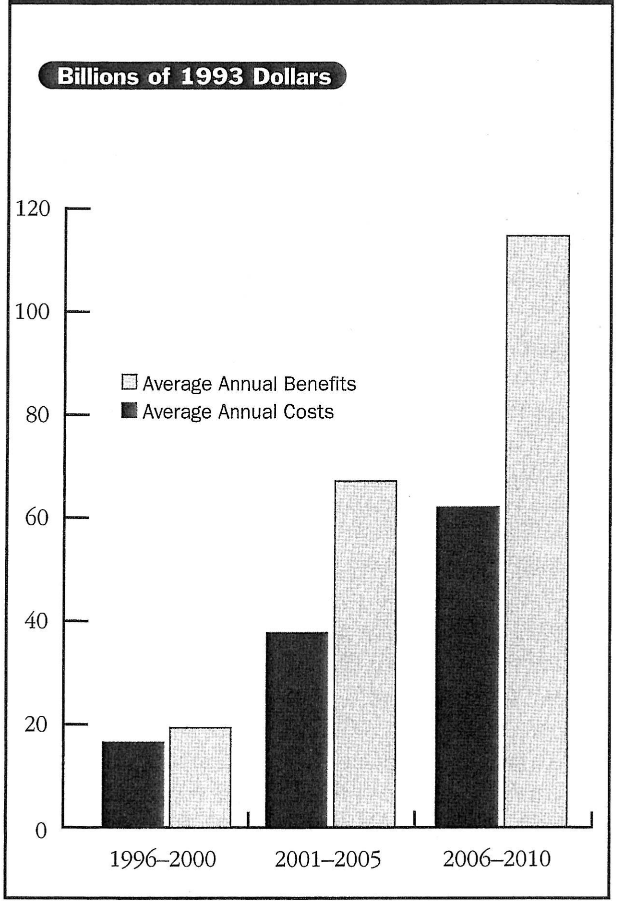
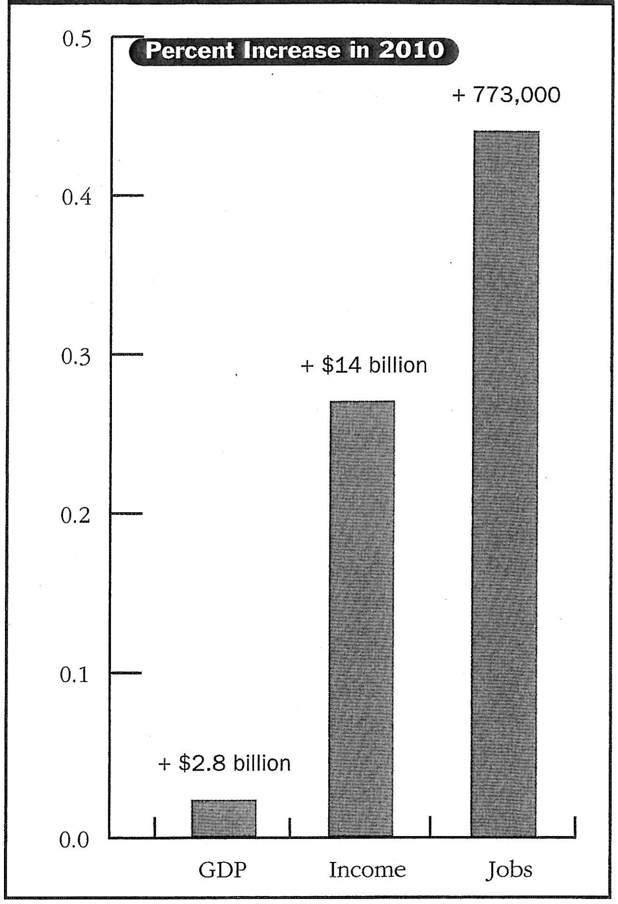


FIGURE 5: MACROECONOMIC BENEFITS OF THE INNOVATION PATH



modeling, based on detailed analysis of shifts in investment and energy demand, projects a modest increase ($14 billion) in wage and salary income as well as a slightly higher GDP (up nearly $3 billion) for the ***Innovation Path*** compared to the ***Present Path***.

These economic results contrast sharply with the conclusions of analyses sponsored by fossil fuel interests. Such analyses have examined unrealistic policies using misleading assumptions that exclude many proven cost-effective energy efficiency opportunities, neglect the potential for technological innovations, and often fail to count the net savings of reduced energy bills.

Although our full economic analysis is limited to 2010, we did extend the energy analysis to 2030. Following the ***Innovation Path*** for the additional two decades yields much greater benefits as savings from efficiency investments compound, technology innovation provides yet greater payoffs, and renewable energy technologies come into extensive use. Instead of ***Present Path*** primary energy consumption reaching 119 Quads in 2030, the ***Innovation Path*** would cut it to 69 Quads, of which 22 Quads would come from renewable resources. Petroleum dependence declines to 23 Quads rather than rising to 48 Quads. Air pollution from energy use would be a fraction of what it is today.

By 2030, moreover, the United States would be well along the way to a sustainable future, with CO_2 emissions cut to 45 percent below the 1990 level and dropping further with each successive year. Then, as today's first graders reach their 40s, we would have bequeathed them a better world—healthier, more stable and secure—where they can meet the new challenges of the next century rather than be saddled with the risks, costs, and unsolved problems of fossil fuels from the century past.

ABOUT THE ANALYTIC TOOLS

The results described here are based largely on the National Energy Modeling System (NEMS) developed by the Energy Information Administration (the statistical arm of the U.S. Department of Energy) as the primary analytical tool. Experts on the technologies for the residential, commercial, industrial, transportation, and electricity generation sectors reviewed the detailed specifications used in NEMS and updated them as appropriate.

For the industrial sector, a more sophisticated model (Long-range Industrial Energy Forecasting: LIEF) was employed because the structure of NEMS does not provide sufficient flexibility to allow for meaningful analysis. Some parts of the transportation sector and of renewable technologies analyses were also developed separately and then incorporated into NEMS. Moreover, since the NEMS model used here provides outputs only through 2010, our long-run results are based on sector-specific models that estimate results through 2030.

NEMS was chosen for this study to facilitate comparison to government studies and because it provides an independent framework for energy forecasting. However, NEMS also entails some restrictions that limit the completeness of its results. The 1995 version of the model used for this study could not calculate energy price and economic activity feedbacks with the up-to-date economic and price inputs needed for the study. Furthermore, the model's basis in mainly short-term responses causes it to underestimate long-term shifts in the composition of economic output and opportunities to introduce new technology.

In order to examine the impacts on the overall economy, details on investment costs and changes in energy expenditures from NEMS and the supplemental models were fed into a macroeconomic model, known as IMPLAN, also developed by the federal government. This model represents interactions among all parts of the economy in order to produce projections of changes in employment, wage income, and Gross Domestic Product (GDP) implied by the changes in energy use.

From the Bottom Up

The sections below highlight key elements of the policy strategies needed to follow the ***Energy Innovations*** path in each of the major sectors of the economy. The sector-by-sector results that form the basis of the integrated national results described above are also presented.

PLUGGING INTO CLEAN POWER

New technologies are the motivating force behind the current restructuring of our electricity supply system. Combined with efficiency improvements wherever power is used and expanded cogeneration of heat and electricity, we have before us the choice to cut pollution and decrease costs by pursuing fair and balanced policies in a newly configured industry. In contrast, a myopic pursuit of the lowest possible short-run electricity commodity prices poses a great threat that the windfall from restructuring would accrue to a few large industrial customers, while vested interests in dirty and dangerous power plants thwart true competition, resulting in excess pollution and rapidly rising CO_2 emissions.

Despite considerable progress since the original Clean Air Act of 1970, electricity generation remains our largest source of air pollution. In 1990 power plants emitted 21 percent of airborne mercury, 37 percent of NO_x, 81 percent of SO_2, and 36 percent of CO_2 emitted in the United States. Most of this pollution comes from older coal-fired power plants exempted from meeting the cleaner emissions standards that apply to newer units.

For the electricity supply sector, the issue of business-as-usual is moot. The rules of the game are already changing; the real issue is how they will change. Thus, the ***Present Path*** for electricity reflects not so much the absence of new policies, but rather the risks of new rules that evade fair environmental standards, ignore the need for equitable services, and lack adequate incentives for investing in energy efficiency and renewable technologies.

A simplistic drive to retail competition could mean the elimination of incentives to invest in end-use efficiency for all consumers, research and development, and renewable energy supplies that had been established in many states during the last decade. Without such public guidance, highly-polluting power plants are likely to be used more intensively, and annual CO_2 emissions from power plants would climb to 580 million metric tonnes of carbon (MT_C) per year by 2010, 22 percent higher than in 1990.

We can follow a better path, plugging into clean power—and plugging into it with energy-efficient products and equipment—by enacting a set of sensible safeguards when writing the ground rules for a competitively restructured industry. The ***Innovation Path*** would address the above concerns through a set of policies that preserve incentives for equity, efficiency, renewables, and lower pollution:

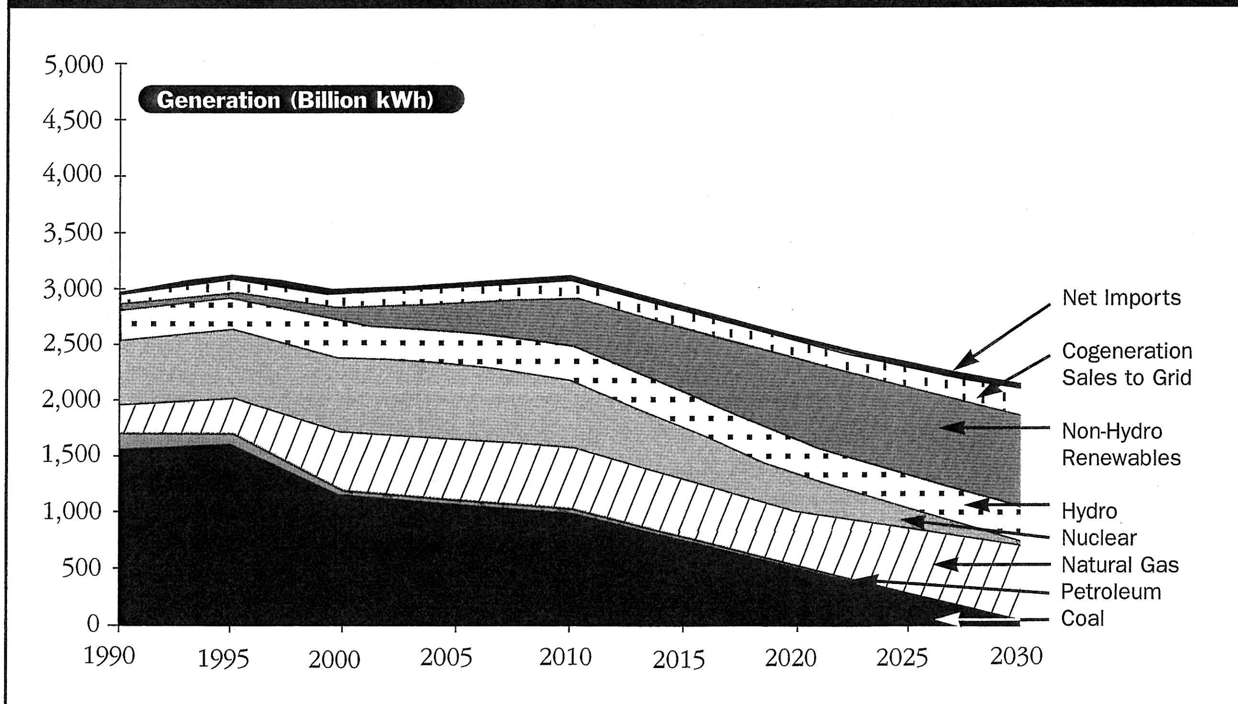
- A system benefits charge, levied on access to the transmission system, would generate federal matching funds for state programs that ensure the delivery of crucial public services, including end-use efficiency (modeled in the end-use sectors), low-income services, and research and development.
- A renewables portfolio standard would ensure continued expansion of the share of electricity coming from emerging clean technologies, such as wind, geothermal, and solar energy. Alternatively, funds from a systems benefits charge could be used to ensure this result (which is how the modeling was conducted).
- Caps on NO_x, particulate matter and CO_2 emissions from electric generation, and a more stringent SO_2 cap, lowered to less than 4 million tons by 2010, would ensure that emission goals were met. Such pollution allowances can be allocated in a competitively neutral manner by distributing them based on uniform output-based (pounds per megawatt-hour) generation performance standards.

Following the ***Innovation Path***, energy efficiency improvements in industry, homes, and offices trim U.S. electricity generation 17 percent by 2010, from a ***Present Path*** level of 3780 billion kilowatt-hour (kWh), down to 3120 billion kWh. Incremental investments in new electric supply technologies average $11 billion annually through 2010, partly offset for power plant fuel cost savings averaging $4 billion per year over the same period. Although the average price per kWh would rise, the nation's power bill would drop, saving consumers $41 billion in 2010.

As illustrated in Figure 6, the ***Innovation Path*** starts a clear transition toward renewable and sustainable sources of electric power, providing a measured but progressive phaseout of both coal and nuclear power by 2030. As discussed below for the industrial sector, investments in combined heat and power facilities contribute to the steady drop in demand for purchased electricity that occurs after 2010. By 2030, the industrial sector meets all of its net electric power needs through self-generation and cogeneration.

Lower electricity usage combined with cleaner power sources produces substantial cuts in air pollution and carbon emissions. Following the ***Innovation Path***, electric sector NO_x emissions are cut 48 percent by 2010, SO_2 emissions are cut 77 percent, and direct particulate emissions are cut 38 percent compared to the 1990 levels. CO_2 emissions from power plants fall to 346 MT_C in 2010, 27 percent below 1990 levels. By 2030, CO_2 emissions from power generation are cut to 80 MT_C, more than an 80 percent reduction compared to 1990.

FIGURE 6: ELECTRIC GENERATION BY SOURCE UNDER THE INNOVATION PATH (1990-2030)



A GREENER WAY TO GO

As the 20th century rushes to a close, we stand at the threshold of promising changes in how we transport products, services, and ourselves from place to place. Ongoing progress in vehicle technology, cleaner fuels, insights in urban planning, and pricing reforms offer hope that the U.S. transportation system can one day provide its amenities at lower social and environmental cost.

Aided by microprocessors and computer-aided designs for building better power trains and structures, and with electric drivetrains entering the market and fuel cells on the horizon, progress in automotive engineering can lead to a new generation of vehicles far safer, cleaner, and more efficient than those of today. Combined with new fuels (ultimately derived from renewable resources), advanced vehicles can greatly reduce petroleum imports, cut carbon emissions, and reduce air pollution.

Fresh approaches to planning, greater emphasis on interconnecting different transportation modes, and pricing reforms can support more balanced transportation choices. Strategic investments in infrastructure, ranging from renewed transit systems that are better coordinated with land use to high-speed rail systems linking major cities, could create new transportation choices.

Yet our transportation future is far from certain. In many ways and in spite of the great potential for progress, the U.S. transportation system is in a rut: the well-worn track of growing traffic by oil-guzzling cars and trucks. Technology advances are not, by and large, applied to address problems of petroleum dependence and environmental damage. The car and light truck market pushes ever more mass and horsepower, unable to balance market desires with environmental concerns. Federal and state transportation dollars are too often squandered in vain attempts to pave our way out of congestion. Family transportation choices are choked off by sprawl development that mandates car use for work, school, shopping, recreation, and every errand in between.

America finds itself today with a transportation system that is 97 percent dependent on oil and responsible for 77 percent of carbon monoxide, 45 percent of NO_x, 38 percent of volatile organic compounds, 27 percent of fine particles (PM_{10}), and 32 percent of CO_2 nationwide. With a road-dominated system and fuel prices failing to account for true costs, transportation fuel demand and its associated adverse impacts are growing steadily. The ***Present Path*** anticipates both energy use and carbon emissions from transportation rising 29 percent above the 1990 level by 2010 and 60 percent by 2030.

Public policy leadership is essential for putting the country on a path that can avoid the growing costs and risks of our currently unsustainable transportation energy system. The ***Innovation Path*** for transportation involves a set of policy packages covering the major factors influencing this sector:

- An advanced vehicle strategy, including fuel economy standards to raise the new car and light truck fleet average by 1.5 miles per gallon per year, stronger emissions standards, incentives to encourage purchase of advanced vehicles, market introduction programs, and better-focused research and development for next-generation vehicle technologies.
- A "greener trucking" initiative providing incentives and voluntary programs backed by research and development, demonstration, and informational efforts leading to significant efficiency improvements and emissions reductions for freight trucks.
- Ongoing research and development and other measures to accelerate the adoption of technological and operational energy efficiency improvements in commercial aircraft, plus strategic investments in intercity high-speed rail links to alleviate airport congestion and displace shorter flights.

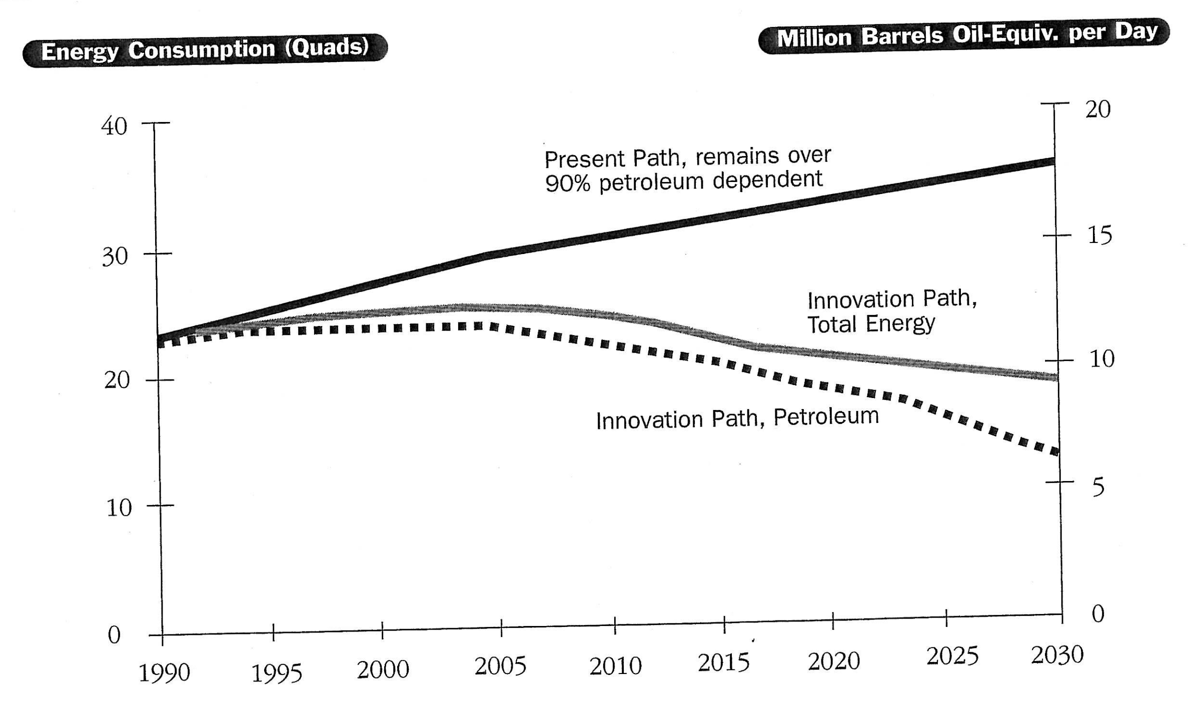
- Renewable fuels incentives comprising fuel composition standards or a motor fuels carbon content cap with tradable credits, linked to full fuel cycle greenhouse gas impacts; incentives for commercialization of and infrastructure provision for low greenhouse gas fuels, plus research and development of renewable fuel supply technologies.

- Strengthening the intermodal efficiency, planning, and public participation provisions of national transportation legislation to enhance transit and other mode choice opportunities; foster mixed-use, transit-oriented, bicycle- and pedestrian-friendly community designs; encourage intermodal shipping; and redirect spending away from road expansion toward a richer set of mobility choices.

- Transportation pricing reforms including parking subsidy reform and uniform commuter benefits; shifting hidden, fixed, or indirect costs to road user fees; pay-as-you-drive auto insurance; and more equitable and environmentally sound road use cost allocation.

Automobile efficiency improvement is a critical part of the ***Innovation Path***, which would push the fuel economy of new cars to 45 miles per gallon (mpg) and new light trucks to 35 mpg with 10 years of lead time (by 2008). As advanced, "next generation" technologies replace conventional designs, this rate of improvement can be continued so that by 2030, the combined new car and light truck fleet reaches 75 mpg, meeting the tripled-efficiency goal of the government/industry Partnership for a New Generation of Vehicles announced in 1993.

FIGURE 7: TRANSPORTATION ENERGY USE AND OIL DEPENDENCE, PRESENT PATH VS. INNOVATION PATH (1990–2030)



Developing a new fuels infrastructure requires a long lead time, so more dramatic impacts occur post-2010. By 2030, the ***Innovation Path*** combines a 19 percent reduction in travel demand, tripled light vehicle efficiency plus improvements in other modes, and increasing use of low-carbon fuels to push CO_2 emissions down to 270 MT_C, or 35 percent below the 1990 level.

The benefits of this ***Innovation Path*** for transportation far outweigh the costs. Guided by the policy strategy, annual investments in improved vehicle technology average $5 billion per year through 2010, but fuel saving benefits average $19 billion per year. The societal benefits would be even larger due to avoided air pollution and oil import costs. The sector also begins to wean itself away from oil dependence. As illustrated in Figure 7, following the ***Innovation Path*** cuts transportation oil use to less than half of what it would be along the ***Present Path*** by 2030.

INVESTING IN INDUSTRIAL INNOVATION AND EFFICIENCY

Industry accounts for 36 percent of total U.S. primary energy consumption, amounting to nearly 32 Quads in 1990. This sector is more diverse than the others, encompassing agriculture, mining, construction, and manufacturing. The processes used, energy requirements, and pollution from each industry are as different as the products they produce. Electricity accounts for about one-third of the primary energy consumed by industries, with natural gas and oil each comprising 26 percent. Moreover, many industries use fossil fuels as their feedstocks, also accounting for a significant share of consumption.

Historically, the overall energy intensity of the U.S. industrial sector has dropped at an average rate of just over 1 percent per year. The rapid increases in energy prices of the early 1970s accelerated this rate of decline to 2.5 percent per year through the mid-1980s. This rate could not be sustained, however, since the easy and inexpensive efficiency opportunities were implemented, leaving the more difficult opportunities. Thus, with the decreases in energy prices that began in the late 1980s and continue today (in inflation-adjusted terms), the trend of declining energy intensity has slowed. Technological innovation has continued, however, and is the underlying reason for reduced industrial energy intensity. Production processes and equipment have become more energy efficient, and products have also changed, reflecting a trend toward the use of less physical material to make products. Despite these improvements, expanding output has pushed total industrial energy consumption up steadily since 1991.

One way to revitalize energy efficiency progress is for firms to embrace these issues from a financial perspective. It is critical that all the savings related to industrial projects, both energy and non-energy (such as reduced waste and improved productivity), be included in the financial analysis so that decision makers know the complete costs and benefits. Many cost-effective efficiency opportunities remain unimplemented today because industrial resource allocation procedures often fail to systematically seek out such projects or to account for the full benefits.

As indicated by recent increases in energy consumption in this sector, the current marketplace cannot be expected to mobilize to fully capture such innovations without policy support. Thus, four types of policies are needed to help place industry on the ***Innovation Path***:

- Establish revenue-neutral tax incentives, with a 10 percent investment tax credit for investment in new production equipment, and other rebates to firms paid for with fees on purchased energy equivalent to $25 per ton of CO_2 ($92 per ton of carbon).
- Double research, development, and demonstration investment (public and private), and enhance information and education activities to accelerate adoption of efficient technologies.

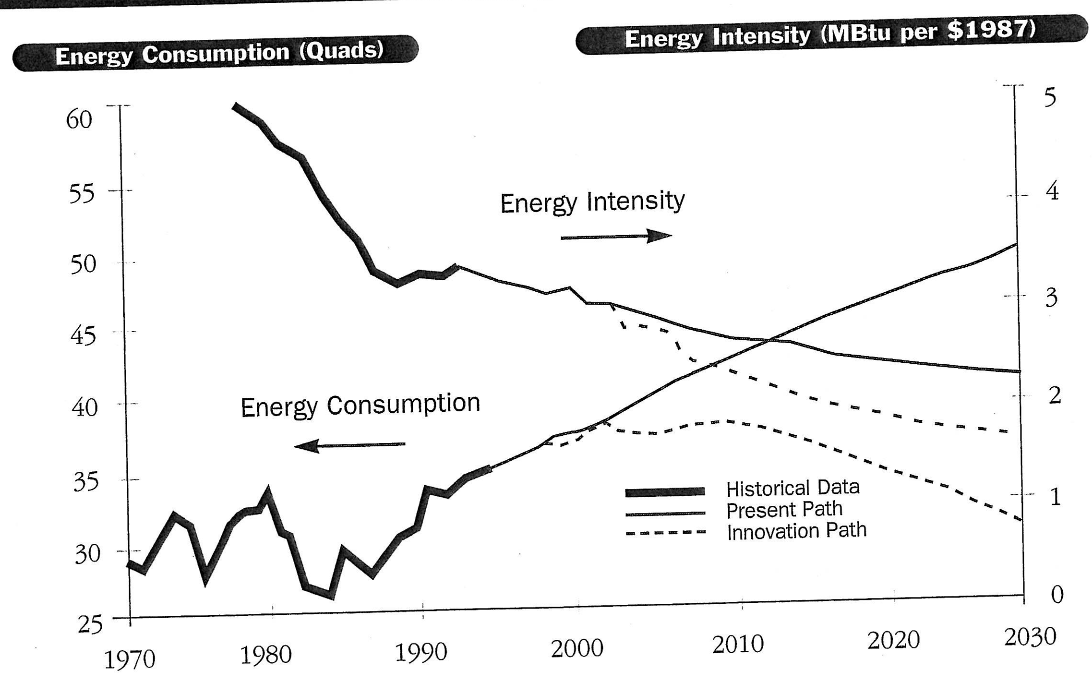
- Promote increased availability and use of recycled feedstocks.

- Remove barriers to combined heat and power technologies by establishing full and fair competition in electricity markets, with output-based environmental standards that recognize the efficiency gains from cogeneration.

Estimating the magnitude of potential energy savings in the industrial sector is difficult because manufacturing processes account for a large portion of industrial energy consumption. Since technologies and processes vary not only from industry to industry, but from plant to plant, the potential for energy efficiency improvement is unique to individual plants. Cost-effective technological opportunities exist, but they have to be sought out by knowledgeable industrial experts. While many of the largest energy-consuming industries have the resources needed to carry out the appropriate assessments, smaller firms have been less successful in this regard. This is problematic. Smaller manufacturers (with fewer than 500 employees) account for almost 99 percent of U.S. manufacturing facilities and consume 42 percent of all industrial energy use. Thus, a tremendous energy savings opportunity remains untapped.

The potential for renewable energy sources to replace fossil fuels in this sector is less clear, except in the wood products industries where the promise is great. The combination of cheap conventional sources of energy and the potential for further efficiency improvements is likely to discourage the use of alternative fuels in the near term. Nevertheless, opportunities exist for innovations, especially for replacement of petroleum-based feedstocks with biomass and for combined-cycle combustion turbines that can generate electricity and heat on-site.

FIGURE 8: TOTAL PRIMARY INDUSTRIAL ENERGY CONSUMPTION AND MANUFACTURING ENERGY INTENSITY



While research and development influences the supply of new technologies, the pace of investment in modernizing manufacturing processes and the priority put on energy costs by corporate financial and technical staff will drive the rate at which energy efficiency and renewables are adopted in the industrial sector. The availability of recycled materials and the emphasis placed on recycling as a means of reducing feedstock volumes and waste streams will also influence overall energy requirements. In addition, institutional and technical arrangements that allow the fulfillment of heat and power needs to be combined (cogeneration) can substantially reduce energy use, pollution, and carbon emissions.

On the ***Present Path*** industrial energy consumption is expected to rise with growing economic activity even with an assumed 1 percent per year average decline in energy intensity, reaching 40 Quads of primary energy by 2010. If this trend is to change, aggressive energy efficiency policies must be implemented that reflect the unique characteristics of American industries. As illustrated in Figure 8, the policies included in the ***Innovation Path*** reduce primary energy use by 14 percent compared to the ***Present Path*** in 2010, boosting the rate of energy-intensity decline to 2 percent per year.

By 2030 the industrial sector could be a net electricity producer, rather than a net consumer (thereby also reducing generation requirements and pollution from the electricity sector). Combined with end-use efficiency improvements, this development reduces primary consumption by over 50 percent compared to the ***Present Path*** in 2030. In terms of carbon emissions, these policies reduce direct reductions from industry by 12 percent compared to the ***Present Path*** in 2010 and by one-third in 2030. Incremental investment costs and fuel savings are almost equal in the industrial sector, each averaging about $8 billion per year through 2010.

SAVING ENERGY IN HOMES AND OFFICES

When the first oil crisis put the spotlight on energy problems in 1973, much attention was devoted to looking for ways to make residential and commercial buildings use less energy, while providing comparable "services" in terms of heating, cooling, and lighting. Improved designs and equipment have been successful, not only in terms of enhanced energy efficiency, but also in delivering other benefits such as improved fire safety, lower maintenance costs, quieter operation, more durable materials, faster cooking times, and greater use of natural lighting to please the senses.

Today, American homes consume substantially less energy per square foot than they did 25 years ago. Yet residential and commercial buildings still account for 37 percent of U.S. primary energy use, mostly due to their appetite for electricity. Indeed, growth in electricity demand has caused total primary energy use attributable to buildings to increase by 36 percent, even while direct fuel consumption has fallen compared to 1973.

Many efficient new products have been introduced over the past decade, including compact fluorescent lights and efficient electronic ballasts, more efficient refrigerators and other appliances, solar heat pumps, passive cooling systems, multipaned windows, and spectrally selective window glazings. These innovations are just the beginning.

New means of getting these technologies into the marketplace have also been advanced. Governments and utilities have learned how to encourage or require energy-efficient retrofit of existing buildings, researchers have transferred advanced technology to builders, and public and private entities have found ways to finance improved efficiency. For example, energy efficiency standards for appliances were adopted and a Super Efficient Refrigerator Program was established to encourage manufacturers to develop an even more advanced product. Manufacturers, public interest groups and the government recently negotiated a third round of minimum efficiency standards for refrigerators and freezers.

Despite readily available innovations with favorable economics, market failures continue to exist, slowing the adoption of even highly cost-effective measures to save energy in buildings. Furthermore, deregulation of the utility industry threatens to halt new investments in energy efficiency, as utilities that were once leading the charge for efficiency cut their demand-side management programs drastically as they slash costs to position themselves for competition under rules that remain uncertain in most of the country.

The ***Innovation Path*** to comfortable and efficient buildings lies primarily in fostering market acceptance of the many technologies that already exist. Many policies that encourage energy efficiency, upstream pollution abatement, and carbon emission reductions in residential and commercial buildings are poised for action. Promising strategies include the following:

- Set strong guidelines for quality and efficiency by developing progressive standards for energy-efficient appliances and equipment, adopting and refining flexible building codes, and assisting code conformity and compliance efforts by state and local officials.

- Enhance the power of markets to spur innovation and adoption of products and services providing greater efficiency through information and outreach programs (such as EPA's Green Lights and Energy Star programs) and tax incentives for the adoption of renewable technologies for space conditioning and water heating.

- Provide public sector leadership by improving the efficiency of federal, state, and local government buildings.

- Increase research, development, and demonstration of energy-efficient technologies for buildings and equipment, and develop better tools for measuring building energy use.

The ***Innovation Path*** reflects the effect of these policies on over two dozen highly efficient building technologies—ranging from furnaces and boilers to air-conditioners and chillers. The result is a reduction of primary energy consumption in buildings by 11 percent compared to the ***Present Path*** in 2010 and 22 percent in 2030. Most of these reductions would occur in commercial buildings. Technological innovations in space heating, water heating, space cooling, and lighting account for the greatest gains in energy efficiency and carbon savings. Moreover, the use of renewable fuels increases significantly in the ***Innovations Path*** for buildings. By 2010 CO_2 emissions from fuels used directly in buildings drops 27 percent compared to 1990 levels, and by 2030 emissions are reduced by 30 percent. To produce these reductions in energy consumption, incremental investment costs average about $5 billion per year through 2010, producing energy cost reductions of $17 billion per year.

Conclusion

In the United States today, our system of energy supply and use dampens the economy and damages the environment. Inefficient use of energy and reliance on polluting energy sources, such as coal and oil, reduces our productivity and harms our health, that of our children, and that of our planet.

But past need not be prologue. As shown on the next page, the ***Innovation Path*** is the right choice for America's energy future. With public policy guidance, we can cut energy costs, increase employment, and protect the environment. By 2010 the United States would have a national energy system that, compared to the ***Present Path***, reduces net costs by $530 per household, reduces global warming CO_2 emissions to 10 percent below 1990 levels, and has substantially lower emissions of other harmful air pollutants.

This study demonstrates that the ***Innovation Path*** is also the prosperous path. Maintaining the ***Present Path***, with antiquated technologies and inefficient use of fossil fuels, means lost opportunities for new jobs and higher incomes, greater risks of economic loss from rising oil imports, as well as higher pollution both global and local. But if we so choose, the United States can take a path to a truly sustainable energy future, with reliance on energy efficiency and renewable resources rising, and with pollution and energy bills falling, each successive year. The ***Energy Innovations*** strategy will lead to the sustainable energy future that Americans want and deserve.

energy *Innovations*

A PROSPEROUS PATH TO A CLEAN ENVIRONMENT

CHOOSING OUR ENERGY FUTURE

THE PRESENT PATH

National energy consumption rises from 85 Quads in 1990 to 105 Quads in 2010 and 119 Quads in 2030.

Economic growth averages 2.2% per year under *Present Path* assumptions.

In spite of economic growth, many job opportunities are lost due to energy waste and rising oil imports.

National energy bill rises to $650 billion in 2010 from $540 billion in 1990.

Fossil fuels, which account for 85% of U.S. energy use today, still account for 85% in 2010.

The United States remains fossil-fuel dependent for the foreseeable future, with renewable resources meeting only 11% of our energy needs in 2030.

Petroleum use rises from 17 Mbd (million barrels of oil per day) to 21 Mbd in 2010 and 25 Mbd by 2030.

U.S. oil import bill rises to $104 billion annually by 2010, continuing to add to our trade deficit and drain the economy.

Energy intensity of the U.S. economy declines at 1.1% per year.

Air pollution from nitrogen oxide (NOx) emissions persists with little change from present level of 20 million tons per year.

Sulfur dioxide (SO_2) emissions decline only slowly, from 19 million tons annually today to 13 million tons by 2010.

Global warming emissions of carbon dioxide (CO_2) rise steadily from 1338 MTc (million metric tons of carbon per year) in 1990 to 1621 MTc in 2010 and 1892 MTc in 2030.

THE INNOVATION PATH

National energy consumption held to 89 Quads in 2010 and is cut to 69 Quads in 2030.

Economic growth averages 2.2% per year under the *Innovation Path.*

Energy savings result in job creation, with a net employment boost of nearly 800,000 jobs nationwide by 2010.

National energy bill held to $560 billion in 2010. Net savings amount to $530 per household per year in 2010.

Fossil fuel dependence drops to 79% by 2010 and down to 68% by 2030.

The country starts a clear transition toward renewable resources, which meet 14% of U.S. energy use needs by 2010 and 32% by 2030.

U.S. petroleum use trimmed to 16 Mbd by 2010 and then drops to 12 Mbd by 2030.

Oil import bill cut to $83 billion by 2010, saving $21 billion per year that would be otherwise largely lost to the economy.

U.S. energy intensity declines at 1.9% per year, falling 32% by 2010.

NOx air pollution is reduced 24% below the 1990 level by 2010, falling to 15 million tons per year.

SO_2 pollution is reduced 64% below the 1990 level by 2010, dropping to 7 million tons per year.

U.S. CO_2 emissions are cut to 1207 MTc, 10% below the 1990 level, by 2010 and reductions continue, pushing emissions down to 728 MTc, or 45% below the 1990 level, by 2030.

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