

RENEWABLE ENERGY: A VIABLE CHOICE

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Published in Environment, Vol. 43 No. 10 (December 2001)

Renewable energy systems—notably solar, wind, and biomass—are poised to play a major role in the energy economy and in improving the environmental quality of the United States. California's energy crisis focused attention on and raised fundamental questions about regional and national energy strategies. Prior to the crisis in California, there had been too little attention given to appropriate power plant siting issues and to bottlenecks in transmission and distribution. A strong national energy policy is now needed. Renewable technologies have become both economically viable and environmentally preferable alternatives to fossil fuels. Last year the United States spent more than \$600 billion on energy, with U.S. oil imports climbing to \$120 billion, or nearly \$440 of imported oil for every American. In the long term, even a natural gas-based strategy will not be adequate to prevent a buildup of unacceptably high levels of carbon dioxide (CO₂) in the atmosphere. Both the Intergovernmental Panel on Climate Change's (IPCC) recent Third Assessment Report and the National Academy of Sciences' recent analysis of climate change science concluded that climate change is real and must be addressed immediately—and that U.S. policy needs to be directed toward implementing clean energy solutions.¹

Renewable energy technologies have made important and dramatic technical, economic, and operational advances during the past decade. A national energy policy and climate change strategy should be formulated around these advances. Despite dramatic technical and economic advances in clean energy systems, the United States has seen far too little research and development (R&D) and too few incentives and sustained programs to build markets for renewable energy technologies and energy efficiency programs.² Not since the late 1970s has there been a more compelling and conducive environment for an integrated, large-scale approach to renewable energy innovation and market expansion.³ Clean, low-carbon energy choices now make both economic and environmental sense, and they provide the domestic basis for our energy supply that will provide security, not dependence on unpredictable overseas fossil fuels.

Energy issues in the United States have created “quick fix” solutions that, while politically expedient, will ultimately do the country more harm than good. It is critical to examine all energy options, and never before have so many technological solutions been available to address energy needs. In the near term, some expansion of the nation's fossil fuel (particularly natural gas) supply is warranted to keep pace with rising demand, but that expansion should be balanced with measures to develop cleaner energy solutions for the future. Our best short-term options for the United States are energy efficiency, conservation, and expanded markets for renewable energy.

For many years, renewables were seen as energy options that—while environmentally and socially attractive—occupied niche markets at best, due to barriers of cost and available infrastructure. In the last decade, however, the case for renewable energy has become economically compelling as well. There has been a true revolution in technological innovation, cost improvements, and our understanding and analysis of appropriate applications of renewable energy resources and technologies—notably solar, wind, small-scale hydro, and biomass-based energy, as well as advanced energy conversion devices such as fuel cells.⁴ There are now a number of energy sources, conversion technologies, and applications that make renewable energy options either equal or better in price and services provided than the prevailing fossil-fuel technologies. For example, in a growing number of settings in industrialized nations, wind energy is now the least expensive option among all energy technologies—with the added benefit of being modular and quick to install and bring on-line. In fact, some farmers, notably in the U.S. Midwest, have found that they can generate more income per hectare from the electricity generated by a wind turbine than from their crop or ranching proceeds.⁵ Also, photovoltaic (solar) panels and solar hot water heaters placed on buildings across America can help reduce energy costs, dramatically shave peak-power demands, produce a healthier living environment, and increase the overall energy supply.

The United States has lagged in its commitment to maintain leadership in key technological and industrial areas, many of which are related to the energy sector.⁶ The United States has fallen behind Japan and Germany in the production of photovoltaic systems, behind Denmark in wind and cogeneration system deployment, and behind Japan, Germany, and Canada in the development of fuel-cell systems. Developing these industries within the United States is vital to the country's international competitiveness, commercial strength, and ability to provide for its own energy needs.

Renewable Energy Technologies

Conventional energy sources based on oil, coal, and natural gas have proven to be highly effective drivers of economic progress, but at the same time, they are highly damaging to the environment and human health. These traditional energy sources are facing increasing pressure on a host of environmental fronts, with perhaps the most serious being the looming threat of climate change and a needed reduction in greenhouse gas (GHG) emissions. It is now clear that efforts to maintain atmospheric CO₂ concentrations below even double the pre-industrial level cannot be accomplished in an oil- and coal-dominated global economy.

Theoretically, renewable energy sources can meet many times the world's energy demand. More important, renewable energy technologies can now be considered major components of local and regional energy systems. In California, solar, biomass, and wind energy resources, combined with new efficiency measures available for deployment today, could supply half of the state's total energy needs. As an alternative to centralized power plants, renewable energy systems are ideally suited to provide a decentralized power supply that could help to

lower capital infrastructure costs. Renewable systems based on photovoltaic arrays, windmills, biomass, or small hydropower can serve as mass-produced “energy appliances” that can be manufactured at low cost and tailored to meet specific energy loads and service conditions. These systems have less of an impact on the environment, and the impact they do have is more widely dispersed than that of centralized power plants, which in some cases contribute significantly to ambient air pollution and acid rain.

There has been significant progress in cost reductions made by renewable technologies (see Figure 1).⁷ In general, renewable energy systems are characterized by low or no fuel costs, although operation and maintenance costs can be considerable. Systems such as photovoltaics contain far fewer mechanically active parts than comparable fossil fuel combustion systems, and are therefore likely to be less costly to maintain in the long term.

Costs of solar and wind power systems have dropped substantially in the past 30 years and continue to decline. For decades, the prices of oil and natural gas have been, as one research group noted, “predictably unpredictable”⁸. Recent analyses have shown that generating capacity from wind and solar energy can be added at low incremental costs relative to additions of fossil fuel-based generation. Geothermal and wind can be competitive with modern combined-cycle power plants—and geothermal, wind, and biomass all have lower total costs than advanced coal-fired plants, once approximate environmental costs are included (see Figure 2).⁹ Environmental costs are based, conservatively, on the direct damage to the terrestrial and river systems from mining and pollutant emissions, as well as the impacts on crop yields and urban areas. The costs would be considerably higher if the damage caused by global warming were to be estimated and included.

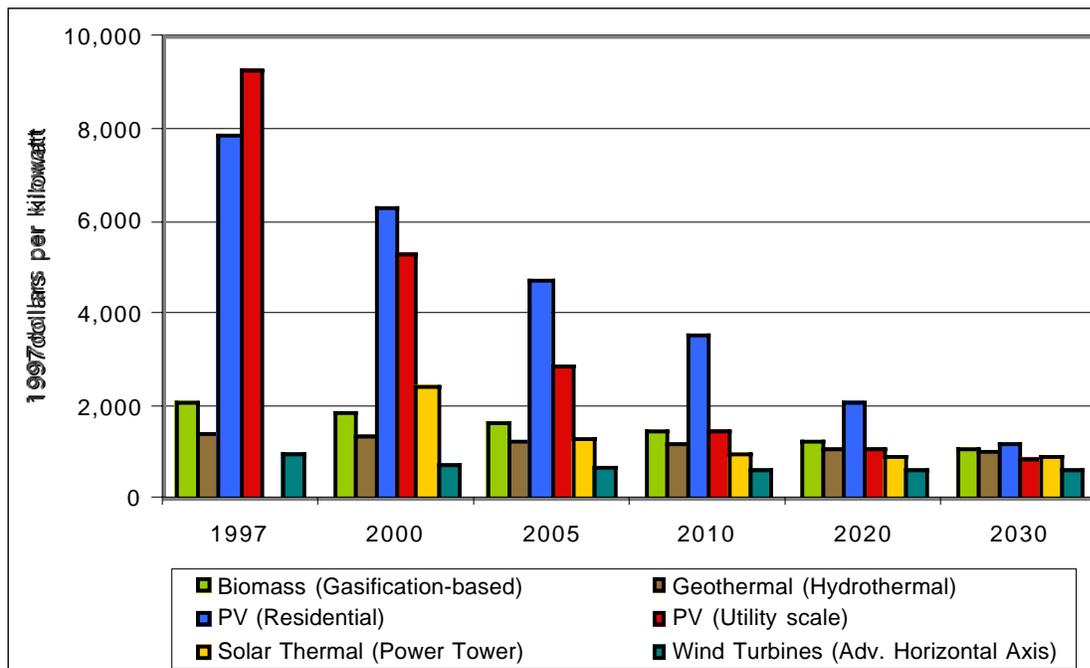


Figure 1. Capital cost forecasts for renewable energy technologies

SOURCE: U.S. Department of Energy (DOE), *Renewable Energy Technology Characterizations*, Topical Report prepared by DOE Office of Utility Technologies and EPRI, TR-109496, December 1997.

The push to develop renewable and other clean energy technologies is no longer being driven solely by environmental concerns; these technologies are becoming economically competitive. According to Merrill Lynch’s Robin Batchelor, the traditional energy sector has lacked appeal to investors in recent years because of heavy regulation, low growth, and a tendency to be cyclical.¹⁰ The United States’ lack of support for innovative new companies sends a signal that U.S. energy markets are biased against new entrants. The clean energy industry could, however, become a world-leading industry akin to that of U.S. semi-conductors and computer systems.

Renewable energy sources have historically had a difficult time breaking into markets that have been dominated by traditional, large-scale, fossil fuel-based systems. This is partly because renewable and other new energy technologies are only now being mass produced and have previously had high capital costs relative to more conventional systems, but also because coal-, oil-, and gas-powered systems have benefited from a range of subsidies over the years. These include military expenditures to protect oil exploration and production interests overseas, the costs of railway construction to enable economical delivery of coal to power plants, and a wide range of tax breaks.

One disadvantage of renewable energy systems has been the intermittent nature of some sources, such as wind and solar. A solution to this problem is to develop diversified systems that maximize the contribution of renewable energy sources but that also use clean natural gas and/or biomass-based power generation to provide base-load power (energy to meet the daily needs of society, leaving aside the peak in energy use associated, for example, with afternoon and evening air conditioner or heating demands).

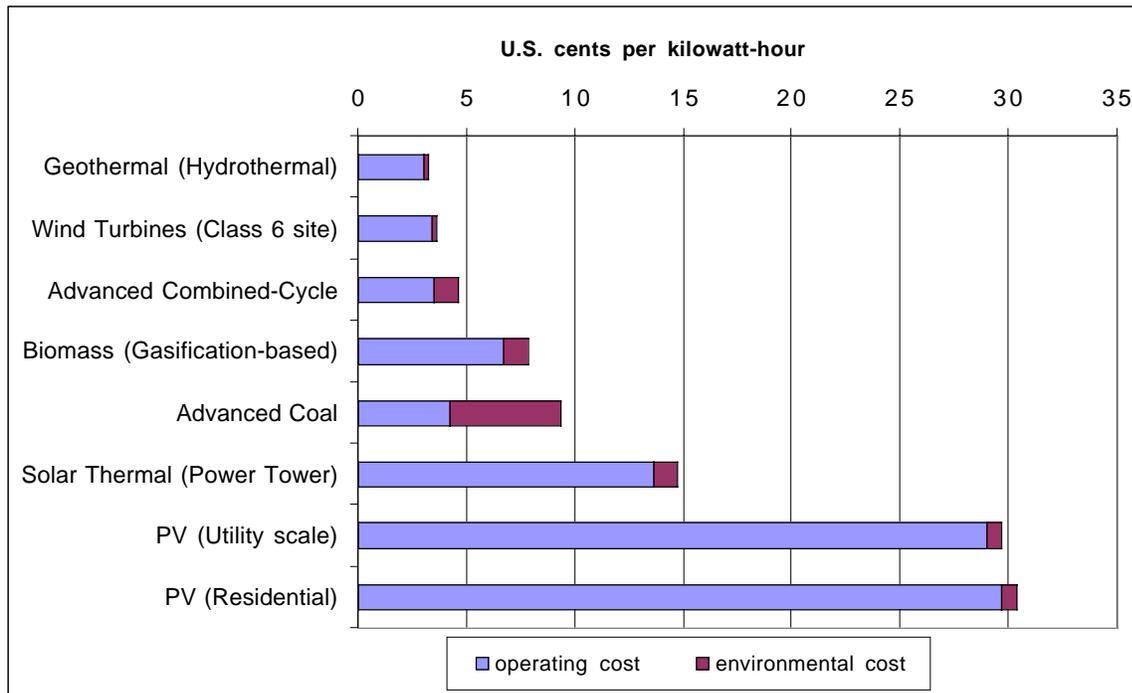


Figure 2. Actual electricity costs in 2000

SOURCE: R. L. Ottinger et al., *Environmental Costs of Electricity* (New York: Oceana Publications, Inc., 1991); and U.S. Department of Energy, *Annual Energy Outlook 2000*, DOE/EIA-0383, Energy Information Administration, Washington, D.C., December 2000

Renewable energy systems face a situation confronting any new technology that attempts to dislodge an entrenched technology. For many years, the United States has been locked in to nuclear- and fossil fuel-based technologies, and many of its secondary systems and networks have been designed to accommodate only these sources. The U.S. administration's recent National Energy Policy plan focused on expanding the natural gas supply, without any attention to the benefits of building a diverse energy system.¹¹ The plan would add one to two new power plants each week for the next several years. The majority of these plants would be fired by natural gas, making the country far more dependent on natural gas than it ever was on oil—even at the height of the OPEC crisis in the 1970s.

Renewable energy technologies are characterized by low environmental costs, but many of these environmental costs are termed “externalities” and are not reflected in market prices. Only in certain areas and for certain pollutants do these environmental costs enter the picture. The international effort to limit the growth of GHG emissions through the Kyoto Protocol may lead to some form of carbon-based tax, which continues to face stiff political opposition in the United States. It is perhaps more likely that concern about emissions of particulate matter and ozone formation from fossil-fuel power plants will lead to expensive mitigation efforts by the plant operators, and this would help to tip the balance toward cleaner renewable systems.

There are two principal rationales for government support of R&D to develop clean energy technologies. First, conventional energy prices generally do not reflect the social and environmental cost of pollution. Second, private firms are generally unable to appropriate all the benefits of their R&D investments. The social rate of return for R&D exceeds the returns captured by individual firms, so they do not invest enough in R&D to maximize social benefits.¹² Public investment, however, would help spread innovation among clean energy companies, which would benefit the public.

Publicly funded market transformation programs (MTPs) for desirable clean energy technologies would provide an initial subsidy and incentive for market growth, thus stimulating long-term demand. A principal reason for considering MTPs is inherent in the production process. When a new technology is first introduced, it is more expensive than established substitutes. The unit cost of manufactured goods then tends to fall as a function of cumulative production experience. Cost reductions are typically very rapid at first and then taper off as the industry matures—resulting in an “experience curve”. Gas turbines, photovoltaic cells and wind turbines have all exhibited this expected price-production relationship, with costs falling roughly 20 percent for each doubling of the number of units produced.¹³

If producers of clean energy consider the experience-curve effect when deciding how much to produce, they will “forward-price,” producing at a loss initially to bring down their costs and thereby maximize profit over the entire production period. In practice, however, the benefits of production experience often spill over to competitor producers, and this potential problem discourages private firms from investing in bringing new products down the experience curve. Publicly funded MTPs can help correct the output shortfall associated with these experience effects.¹⁴

This suggests an important role for MTPs in national and international technology policies. MTPs are most effective with emerging technologies that have steep industry experience curves and a high probability of major long-term market penetration once subsidies are removed. The condition that these technologies be clean mitigates the risk of poor MTP performance, because the investments will alleviate environmental problems whose costs were not taken into account for the older, dirtier energy technologies. Renewable energy products are ideal candidates for support through MTPs, via federal policies that reward the early production of clean energy technologies.

Energy Efficiency

Energy efficiency improvements have contributed a great deal to economic growth and increased standard of living in the United States over the past 30 years, and there is much potential for further improvements in the decades to come. According to the U.S. Department of Energy (DOE), increasing energy efficiency could cut national energy use by 10 percent or more by 2010 and about 20 percent by 2020. The recent Interlaboratory Working Group study *Scenarios for a Clean Energy Future* estimates that cost-effective end-use technologies could reduce electricity consumption by about 1,000 billion kilowatt-hours (kWh) by 2020, almost entirely offsetting the projected growth in electricity use.¹⁵ This level of energy savings would reduce U.S. carbon emissions by approximately 300 million metric tons, and many of these changes can actually be accomplished with an increase in profits. Still more benefits can be had for investments of only a few cents per kilowatt-hour, far less than the energy cost of new power plants.

Energy efficiency is the single greatest way to improve the U.S. energy economy. Based on data published by the Energy Information Administration (EIA), the American Council for an Energy Efficient Economy (ACEEE) estimates that total energy use per capita in the United States in 2000 was almost identical to that in 1973, while over the same period economic output (measured by Gross Domestic Product or GDP) per capita increased 74 percent. Furthermore, national energy intensity (energy use per unit of GDP) fell 42 percent between 1973 and 2000, with about 60 percent of this decline attributable to real improvements in energy efficiency and about one-quarter due to structural changes and fuel switching. Between 1996 and 2000, GDP increased 19 percent while primary energy use increased just 5 percent. These statistics clearly indicate that energy use and GDP do not have to grow or decline in lock step with each other, but GDP can, in fact, increase while energy use does not.¹⁶

The federal government's energy efficiency programs have been a resounding success. Last year, DOE documented the results of 20 of its most successful energy efficiency and renewable energy technology initiatives over the past two decades.¹⁷ These programs have already saved the nation 5.5 quadrillion BTU (British Thermal Units) of energy, equivalent to the amount of energy needed to heat every household in the United States for about a year, and worth about \$30 billion in avoided energy costs. Over the last decade, the cost to taxpayers for

these 20 activities has been \$712 million, less than 3 percent of the energy bill savings that the programs created.¹⁸

In 1997, the President's Committee of Advisors on Science and Technology (PCAST), a panel that consisted mainly of distinguished academics and private-sector executives, conducted a detailed review of DOE's energy efficiency R&D programs. PCAST concluded, "R&D investments in energy efficiency are the most cost-effective way to simultaneously reduce the risks of climate change, oil import interruption, and local air pollution, and to improve the productivity of the economy." PCAST recommended that the DOE energy efficiency budget be doubled between fiscal years of 1998 and 2003. They estimated that this could produce a 40-to-1 return on investment for the nation, including reductions in fuel costs of \$15 billion to 30 billion by 2005 and \$30 billion to 45 billion by 2010.¹⁹ Funding for these DOE programs in the last several years has fallen far short of the PCAST recommendations.

Increasing the efficiency of homes, appliances, vehicles, businesses, and industries must be an important part of a sound national energy and climate-change policy. Increasing energy efficiency reduces energy waste (without forcing consumers to cut back on energy services or amenities), lowers GHG emissions, saves consumers and businesses money (because the energy savings more than pay for any increase in first cost), protects against energy shortages, reduces energy imports, and reduces air pollution. Furthermore, increasing energy efficiency does not create a conflict between enhancing national security and energy reliability on the one hand and protecting the environment on the other.

Climate Change

The threat of global climate change is finally producing a growing understanding and acknowledgement by some in U.S. industry and government that a responsible national energy policy must include a sound global climate-change mitigation strategy. President George W. Bush has rejected the Kyoto Protocol, but the U.S. Congress, in particular the Senate, appears poised to take action to reduce domestic GHG emissions. For example, Senators Jim Jeffords (I-Vt.) and Joe Lieberman (D-Conn.) and Representatives Sherwood Boehlert (R-N.Y.) and Henry Waxman (D-Calif.) recently introduced legislation in Congress to reduce the emission of four pollutants from electricity generation. The legislation puts a national cap on power plants' emissions of nitrogen oxides, sulfur dioxide, mercury, and carbon dioxide, and requires every power plant to meet the most recent emission control standards. It allows market-oriented mechanisms such as the trading of emissions credits, which is widely seen as a way to control pollution and stimulate innovation at the lowest cost. In emissions trading, total emissions are capped and then a market is created involving those firms that have excess credits to sell (resulting from decreased emissions due to efficiency and other improvements) and those firms needing to purchase credits due to emissions exceeding an allocated 'baseline'. In the United States, nitrogen oxides and sulfur dioxide markets have been highly successful. The CO₂ reductions required by the legislation would bring emissions back to 1990 levels by 2007, and

the costs of implementing such measures would likely be dwarfed by the resulting benefits of industrial innovation.²⁰

Legislation that controls the four major pollutants from power plants in an integrated package will help reduce regulatory uncertainties for electric generators and will be less costly than separate programs for each pollutant. Although voluntary action by companies is an attractive idea, in the last 10 years, voluntary actions have failed to reduce carbon dioxide emissions in the United States. Instead, emissions have increased by 15.5 percent since 1990, with an annual average increase of 1.5 percent since 1990, and they continue to increase.²¹ EIA recently released data showing an increase of 2.7 percent in U.S. carbon dioxide emissions from 1999 to 2000. Solutions will become more costly and difficult if mandatory emissions reductions are not enacted now.

Policy Options

The ultimate solutions to cost-effectively meeting the nation's energy needs cost-effectively and reducing GHG emissions must be based on private-sector investment bolstered by well-targeted government R&D and incentives for emerging clean energy technologies. The United States now has the opportunity to build a sustainable energy future by engaging and stimulating the tremendous innovative and entrepreneurial capacity of the private sector. Advancing clean energy technologies requires a stable and predictable economic environment.

Research and Development Funding

Federal funding and leadership for renewable energy and energy efficiency projects has resulted in several notable successes, such as the U.S. Environmental Protection Agency's (EPA) Energy Star and Green Lights Programs, which have been emulated in a number of countries. Fifteen percent of the public-sector building space in the country has now signed up for the Energy Star Buildings Program, saving more than 21 billion kWh of energy in 1999 and reducing carbon emissions by about 4.4 million metric tons. According to EPA, that has resulted in \$1.6 billion in energy bill savings. Despite these achievements, funding in this area has been scant and so uneven as to discourage private sector involvement. By increasing funding for these EPA programs, their scope could be considerably expanded.

The Bush administration's proposed cuts in its 2002 fiscal year budget for DOE's renewable energy and energy efficiency programs would harm existing public-private partnerships as well as R&D. This budgetary roller coaster harms all investments and sends mixed signals to industry.²⁴ Steadily increasing funding would transform the clean energy sector from a good idea to a pillar of the new economy.

Tax Incentives

The R&D tax credit, which goes to companies based on their R&D expenditures, has proven remarkably effective and popular with private industry, so much so that there is a strong consensus in both Congress and the administration to make this credit permanent. To complement this support of private-sector R&D, tax incentives directed toward those who use the technologies would provide the “demand pull” needed to accelerate the technology transfer process and the rate of market development.

Currently, non-R&D federal tax expenditures aimed at the production and use of energy have an unequal distribution across primary energy sources, distorting the market in favor of conventional energy technologies. Renewable fuels make up 4 percent of the United States’ energy supply, yet they receive only 1 percent of federal tax expenditures and direct fiscal spending combined (see Table 1).²⁵ The largest single tax credit in 1999 was the Alternative Fuel Production Credit, which totaled more than \$1 billion.²⁶ This income tax credit, which has gone primarily to the natural gas industry, was designed to reduce dependence on foreign energy imports by encouraging the production of gas, coal, and oil from unconventional sources (such as tight gas formations and coalbed methane) within the United States. However, support for the production and further development of renewable fuels, all found domestically, would have a greater long-term effect on the energy system than any expansion of fossil-fuel capacity.

A production tax credit (PTC) of 1.7 cents/kWh currently exists for electricity generated from wind power and “closed loop” biomass (biomass from dedicated energy crops and chicken litter). The wind power credit, in particular, has proven successful in encouraging strong growth of U.S. wind energy over the last several years—with a 30-percent increase in 1998 and a 40-percent increase in 1999. Approximately 2,000 megawatts (MW) of wind energy will be under development or proposed for completion before the end of 2001 (a 40-percent increase from

Table 1. U.S. energy consumption and federal expenditures

Fuel Source	Primary energy supply 1998 consumption		Direct expenditures and tax expenditures (1999)	
	Value (quadrillion Btu)	Percent	Value (millions of \$)	Percent
Oil	36.57	40	263	16
Natural Gas	21.84	24	1,048	65
Coal	21.62	24	85	5
Oil, Gas, and Coal Combined			205	13
Nuclear	7.16	8	0	—
Renewables	3.48	4	19	1
Total	90.67	100	1620	100

NOTE: The Alternative Fuels Production Credit accounted for \$1,030 of the \$1,048 in expenditures for natural gas. Oil, gas, and coal combined includes expenditures that were not allocated to any one of the three individual fuels. Research and development are not included in direct expenditures and tax expenditures.

SOURCE: Energy Information Administration, *Federal Financial Interventions and Subsidies in Energy Markets 1999: Primary Energy*, U.S. Department of Energy (Washington, D.C., 1999).

2000), when the federal wind-energy PTC is scheduled to expire. Currently, Germany has twice the U.S. installed wind energy capacity, and the major wind turbine manufacturers are now in Europe.²⁷

This production credit should be expanded to include electricity produced by “open loop” biomass (including agricultural and forestry residues but excluding municipal solid waste), solar energy, geothermal energy, and landfill gas. The extension and expansion of the PTC has recently been garnering strong and consistent support in the U.S. Congress. Investment tax incentives are also needed for smaller-scale renewable energy systems, such as residential photovoltaic panels and solar hot-water heaters, as well as small wind systems used in commercial and farm applications. In these cases, an investment credit in capital or installation expenditures is preferable to a production credit based on electricity generated, due to the relatively high capital cost of these smaller-scale renewable technologies and the fact that the electricity and heat produced is used directly.

Many new energy-efficient technologies have been commercialized in recent years or are nearing commercialization. Tax incentives can help manufacturers justify mass marketing and help buyers and manufacturers offset the relatively high initial capital and installation costs for new technologies. A key element in designing the credits is for only high-efficiency products to be eligible. If eligibility is set too low, there may not be enough energy savings to justify the credits. These tax credits should have limited duration and be reduced in value over time, because once these new technologies become widely available, costs should decline. In this manner, the credits will help innovative technologies get established in the marketplace but will not become permanent subsidies.

Recent federal tax credit legislation to encourage the use of high-efficiency technologies includes incentives for highly efficient clothes washers, refrigerators, and new homes; innovative building technologies such as furnaces, stationary fuel cells, gas-fired pumps, and electric heat-pump water heaters; and investments in commercial buildings that have reduced heating and cooling costs. The incentives currently being proposed in Congress and by the administration will have a relatively modest direct impact on energy use and CO₂ emissions. Savings may only amount to 0.3 quadrillion BTU of energy and 5 million metric tons of carbon emissions per year by 2012. However, if these proposed tax credits help to establish innovative products in the marketplace and reduce the first-cost premium so that the products are viable after the credits are phased out, then the indirect impacts could be many times greater than the direct impacts. It has been estimated that total energy savings could reach 1 quadrillion BTU by 2010 and 2 quadrillion BTU by 2015 if these credits are successfully implemented.²⁸

Vehicle Fuel Economy Standards

New vehicles with hybrid gasoline-electric power systems are now produced commercially, and fuel cell-electric vehicles are being produced in prototype quantities. These

vehicles combine high-efficiency electric motors with revolutionary power systems to produce a new generation of motor vehicles that are vastly more efficient than today's simple cycle-combustion systems. The potential for future hybrid and fuel-cell vehicles to achieve up to 100 miles per gallon (mpg) is believed to be both technically and economically viable in the near future. In the long term, fuel-cell vehicles running directly on hydrogen promise to allow motor vehicle use with very low fuel-cycle emissions.

The improvements in fuel economy that these new vehicles offer will help to slow growth in petroleum demand, reducing our oil import dependency and trade deficit. While the Partnership for a New Generation of Vehicles helped generate some vehicle technology advances, an increase in the Corporate Average Fuel Economy (CAFE) standard, which has been stagnant for 16 years now, is required to provide an incentive for companies to bring these new vehicles to market rapidly.

Recent analyses of the costs and benefits of motor vehicles with higher fuel economy have been conducted by the Union of Concerned Scientists, Massachusetts Institute of Technology, the Office of Technology Assessment, and Oak Ridge National Lab/ACEEE.²⁹ These studies have generally concluded that with longer-term technologies, motor vehicle fuel economy can be raised to 45 mpg for cars with a retail price increase of \$500 to \$1,700 per vehicle, and to 30 mpg for light trucks with a retail price increase of \$800 to \$1,400 per vehicle.³⁰ These improvements could be the basis for a new combined fuel economy standard of 40 mpg for both cars and light trucks. The combined standard could be accomplished between 2008 and 2012. The net cost would be negligible once fuel savings are factored in, if the auto industry is given adequate time to retool for this new generation of vehicles. A lower combined standard could be implemented sooner and then raised incrementally each year to achieve the 40 mpg goal by 2012.

Tax credits for hybrid electric vehicles, battery electric vehicles, and fuel-cell vehicles are an important part of the puzzle. These funds could, in principle, be raised through a revision of the archaic "gas guzzler" tax, which does not apply to a significant percentage of the light-duty car and truck fleet. The tax penalty and tax credit in combination could be a revenue-neutral "fee-bate" scheme—similar to one recently proposed in California—that would simultaneously reward economical vehicles and penalize uneconomical ones.

Efficiency Standards

A critical strategy for effectively promoting energy efficiency is implementing new standards for buildings, appliances, and equipment. Tax credits do not necessarily remove all the market barriers that prevent clean energy technologies from spreading throughout the marketplace. These barriers include lack of awareness, rush purchases when an existing appliance breaks down, and purchases by builders and landlords who do not pay utility bills.

Significant advances in the efficiency of heating and cooling systems, motors, and appliances have been made in recent years, but more improvements are technologically and

economically feasible. A clear federal statement of desired improvements in system efficiency would remove uncertainty about and reduce costs of implementing these changes. Under such a federal mandate, efficiency standards for equipment and appliances could be gradually increased, helping to expand the market share of existing high-efficiency systems.³¹

Standards remove inefficient products from the market and still leave consumers with a full range of products and features from which to choose. Building, appliance, and equipment efficiency standards have proven to be one of the federal government's most effective energy-saving programs. Analyses by DOE and others indicate that in 2000, appliance and equipment efficiency standards saved 1.2 quadrillion BTUs of energy (1.3 percent of U.S. electric use) and reduced consumer energy bills by approximately \$9 billion, with energy bill savings far exceeding any increase in product cost. By 2020, standards already enacted will save 4.3 quadrillion BTU per year (3.5 percent of projected U.S. energy use) and reduce peak electric demand by 120,000 MW (more than a 10-percent reduction). ACEEE estimates that by 2020, energy use could be reduced by 1.0 quadrillion BTU by quickly adopting higher standards for equipment that is currently covered under federal law, such as central air conditioners and heat pumps, and by adopting new standards for equipment not covered, such as torchiere (halogen) light fixtures, commercial refrigerators, and appliances that consume power while on standby.³² Energy bills would decline by approximately \$7 billion per year by 2020.³³

A Federal Renewable Portfolio Standard

The Renewable Portfolio Standard (RPS) is akin to the efficiency standards for vehicles and appliances that have proven successful in the past. A gradually increasing RPS is designed to integrate renewables into the marketplace in the most cost-effective fashion, and it ensures that a growing proportion of electricity sales is provided by renewable energy. An RPS provides the one true means to use market forces most effectively—the market picks the winning and losing technologies.

A number of studies indicate that a national renewable energy component of 2 percent in 2002, growing to 10 percent in 2010 and 20 percent by 2020, that would include wind, biomass, geothermal, solar, and landfill gas, is broadly good for business and can readily be achieved.³⁴ States that decide to pursue more aggressive goals could be rewarded through an additional federal incentive program. In the past, federal RPS legislation has been introduced in Congress and was proposed by the Clinton administration, but it has yet to be re-introduced by either this Congress or the Bush administration.

Including renewables in the United States' power supply portfolio would protect consumers from fossil fuel price shocks and supply shortages by diversifying the energy options. A properly designed RPS will also create jobs at home and export opportunities abroad. To achieve compliance, a federal RPS should use market dynamics to stimulate innovation through a trading system. National renewable energy credit trading will encourage development of

renewables in the regions of the country where they are the most cost-effective, while avoiding expensive long-distance transmission.

The coal, oil, natural gas, and nuclear power industries continue to receive considerable government subsidies, even though they are already well established in the marketplace. Without the RPS or a similar mechanism, many renewables will not be able to survive in an increasingly competitive electricity market focused on producing power at the lowest direct cost. And while the RPS is designed to deliver renewables that are most ready for the market, additional policies will still be needed to support emerging renewable technologies, like photovoltaics, that have enormous potential to become commercially competitive.

The RPS is the surest market-based approach for securing the public benefits of renewables while supplying the greatest amount of clean power at the lowest price. It creates an ongoing incentive to drive down costs by providing a dependable and predictable market. An RPS will promote vigorous competition among renewable energy developers and technologies to meet the standard at the lowest cost.

Analysis of the RPS target for 2020 shows renewable energy development in every region of the country, with most coming from wind, biomass, and geothermal sources. In particular, the Plains, Western, and mid-Atlantic states would generate more than 20 percent of their electricity from renewables.³⁵ Texas has become a leader in developing and implementing a successful RPS that then-Governor Bush signed into law in 1999. The Texas law requires electricity companies to supply 2,000 MW of new renewable resources by 2009, and the state is actually expected to meet this goal by the end of 2002, seven years ahead of schedule. Nine other states have signed an RPS into law: Arizona, Connecticut, Maine, Massachusetts, Nevada, New Jersey, New Mexico, Pennsylvania, and Wisconsin. Minnesota and Iowa have a minimum renewables requirement similar to an RPS, and legislation that includes an RPS is pending in several other states.

While the participation of 12 states signals a good start, this patchwork of state policies would not be able to drive down the costs of renewable energy technologies and move these technologies fully into the marketplace. Also, state RPS policies have differed substantially from each other thus far. These differences could cause significant market inefficiencies, negating the cost savings that a more comprehensive, streamlined, market-based federal RPS package would provide.

Small-Scale Distributed Energy Generation and Cogeneration

Small-scale distributed electricity generation has several advantages over traditional central-station utility service. Distributed generation reduces energy losses incurred by sending electricity long distances through an extensive transmission and distribution network (often an 8- to 10-percent loss of energy). In addition, generating equipment located close to the end use allows waste heat to be utilized (a process called cogeneration) to meet heating and hot water demands, significantly boosting overall system efficiency.

Distributed generation has faced several barriers in the marketplace, most notably from complicated and expensive utility interconnection requirements. These barriers have led to a push for national safety and power quality standards, now being finalized by the Institute of Electrical and Electronics Engineers (IEEE). Although the adoption of these standards would significantly decrease the economic burden on manufacturers, installers, and customers, the utilities are allowed discretion in adopting or rejecting them.

In designing credits, highest priority should go to renewable or fossil fuel systems that utilize waste heat through combined heat and power (CHP) designs. While a distributed generation system may achieve 35- to 45-percent electrical efficiency, the addition of heat utilization can raise overall efficiency to 80 percent. Industrial CHP potential is estimated to be 88,000 MW, the largest sectors being in the chemicals and paper industries. Commercial CHP potential is estimated to be 75,000 MW, with education, health care, and office building applications making up the most significant percentages.³⁶

A National Public Benefits Fund

Electric utilities have historically funded programs to encourage the development of a host of clean energy technologies. Unfortunately, increasing competition and deregulation have led utilities to cut these discretionary expenditures in the last several years. Total utility spending on demand-side management programs fell more than 50 percent from 1993 to 1999. Utilities should be encouraged to invest in the future through rewards (such as tax incentives) for companies that reinvest profits and invigorate the power sector.³⁷ A national public benefits fund could be financed through a national, competitively neutral wires charge of \$0.002 per kWh.

Cost and Benefit Analyses

A range of recent studies are all coming to the same conclusions: that simple but sustained standards and investments in a clean energy economy are not only possible but would also be highly beneficial to future prosperity in the United States.³⁸ If energy policies proceed as usual, the nation is expected to increase its reliance on coal and natural gas to meet strong growth in electricity use (42 percent by 2020). To meet this demand, it is estimated that 1,300 300-MW power plants would need to be built, with electricity generated by non-hydro renewables only increasing from 2 percent today to 2.4 percent of total generation in 2020.³⁹ A set of clean energy polices could meet a much larger share of our future energy needs, with energy-efficiency measures projected to almost completely offset the projected growth in electricity use.⁴⁰ A clean energy strategy would build energy security and result in a large decrease in emissions from the utilities sector. In fact, through a steady shift to clean energy production, power plant carbon dioxide reductions (as proposed in the current legislation before Congress), would not be difficult or expensive to meet.⁴¹

Recent analysis by the Union of Concerned Scientists focused on the costs and environmental impacts of a package of clean energy polices and how the package would affect fossil fuel prices and consumer energy bills. They found that using energy more efficiently and switching from fossil fuels to renewable energy sources will save consumers money by decreasing energy use.⁴² A whole-economy analysis carried out by the International Project for Sustainable Energy Paths has also shown that Kyoto-type targets can easily be met, with a net increase of 1 percent in the nation's 2020 GDP, by implementing the right policies.⁴³

One of the greatest advantages that energy efficiency and renewable energy sources offer over new power plants, transmission lines, and pipelines is the ability to deploy these technologies very quickly. They can be installed –and benefits can be reaped–immediately.⁴⁴ In addition, reductions in CO₂ emissions will have a “clean cascade” effect on the economy because many other pollutants are emitted during fossil fuel combustion.

The renewable and energy-efficient technologies and policies described here have already proven successful and cost-effective at the national and state levels. Supporting them would allow the United States to cost-effectively meet GHG emission targets while providing a sustainable, clean energy future.⁴⁵

We stand at a critical point in the energy, economic, and environmental evolution of the United States. Renewable energy and energy efficiency are now not only affordable, but their expanded use will also open new areas of innovation. Creating opportunities and a fair marketplace for a clean-energy economy requires leadership and vision. The tools to implement this evolution are now well known. We must recognize and overcome the current roadblocks and create the opportunities needed to put these renewable and energy-efficient measures into effect.

This article is based on testimony provided by D. M. Kammen to the U. S. Senate Commerce, Science and Transportation (July 10, 2001) and U. S. Senate Finance (July 11, 2001) Committees. Antonia V. Herzog and Timothy E. Lipman are postdoctoral researchers and Jennifer L. Edwards is a research assistant at the Renewable and Appropriate Energy Lab (RAEL), Energy and Resources Group (ERG), at the University of California at Berkeley. Daniel M. Kammen is a professor of Energy and Society with ERG and a professor of Public Policy with the Goldman School of Public Policy.

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NOTES

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