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Evaluating the Case for Renewable Energy

Is Government Support Warranted?

by Jerry Taylor and Peter VanDoren

Executive Summary

Solar, wind, geothermal, and biomass energy are used in about 2 percent of total U.S. electricity generation and are expected to produce only 2.8 percent by 2020. The use of renewable energy and forecasts of its growth are low because the cost of renewable energy–fired electricity is greater than that of its main competitor, combined-cycle natural gas. Few analysts believe that this will change any time soon.

Renewable energy sources are also capital intensive compared with combined-cycle natural gas. In deregulated electricity markets, investors lack any guarantee that capital costs will be recovered from customers. Accordingly, investors favor technologies that have higher marginal but lower capital costs, such as combined-cycle natural gas.

Advocates of renewable energy argue that the demand for renewables would rise if conventionally generated electricity were priced to reflect its pollution costs. But a reasonable interpretation of the evidence suggests that the additional cost of further pollution reduction would exceed the additional health benefits. Even if current regulatory costs are insufficiently reflective of true environmental costs, "getting prices right" will not significantly affect consumer choices of fuel. For example, reducing emissions of nitrogen oxides and sulfur dioxide by 75 percent below 1997 levels would increase electricity prices by only about 1 percent, too little to trigger a shift from coal or natural gas to renewable energy.

Cracking down on greenhouse gas emissions to comply with the Kyoto Protocol would provide economic help for renewable energy technologies, but such initiatives would result in only a 7 percent market share for renewable energy and a 43 percent increase in electricity prices in return for benefits that are still very uncertain.

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Introduction

Ever since the energy crises of the 1970s, the U.S. government has promoted the use of "renewable energies"—primarily wind, solar, biomass (burning wood and plant material for power), and geothermal (tapping the hot steam or rock beneath the earth)—as desirable substitutes for conventional fossil fuels. Renewable energy (which, for the purposes of this paper, does not include nuclear power or hydropower)[1] is widely thought to be not only more environmentally benign than coal or oil but also nearly as attractive economically.

The state and federal campaign to promote the use of renewable energy, however, has not yet significantly affected electricity generation patterns. Since the establishment of the U.S. Department of Energy in 1978, the federal government has spent more than $11 billion to subsidize—via investment tax credits, production credits, accelerated depreciation of capital costs, publicly funded research and development (R&D), and mandatory purchases at avoided cost—wind, solar, biomass, and geothermal power.[2] Yet those fuels account for only a tiny share of the electricity produced.

Advocates of renewable energy continue to insist that it is poised to gain significant market share over the next several years. Although renewable energy is still more expensive than conventional energy, production costs have come down significantly over the past 22 years, and the gap between the cost of conventional and renewable energy has narrowed substantially.[3] And if nations reduce greenhouse gas emissions, environmentalists argue, renewables will become the lowest-cost sources of electricity fuel on the market.

This study examines the economics of renewable energy in the electricity market and the case for government intervention to promote its use. We reach three conclusions:

- Renewable energy is not likely to gain significant market share in the foreseeable future without a significant increase in government subsidies or mandates.
- Rationales for subsidies for renewable energy and other preferences are without sound economic foundation.
- The threat of global warming is speculative, and such warming is not necessarily deleterious from an economic perspective. Even if restrictions on greenhouse gas emissions were necessary, replacing conventional energy sources with renewable energy would be more costly and less efficient than other emission abatement strategies.

The Economics of Renewable Energy

Although renewable energy is often thought of as an "infant industry" facing an uphill and unfair struggle against "Big Oil" and the coal industry, the truth is that the largest corporate conglomerates in America have long devoted themselves to making renewable energy markets a reality. Starting in the mid-1970s, Exxon, Shell, Mobil, ARCO, Amoco, General Electric, General Motors, Texas Instruments, and Grumman all initiated aggressive renewable energy R&D projects.[4]

The widespread belief that oil companies have incentives to stymie advances in renewable energy is belied not only by such facts; it's also belied by the economics of the electricity industry. According to the Energy Information Administration, a semi-independent agency of the U.S. Department of Energy, oil, which is primarily a transportation fuel, does not compete with renewable energy, which is primarily an electricity fuel.[5]

The most aggressive renewable energy development initiatives today continue to be undertaken by large multinational corporations. In the United States, Zond Energy Systems, owned by Enron Corporation (once the world's largest integrated national gas company with 1997 revenues of $20 billion), is the largest domestic wind turbine manufacturer and the only manufacturer of large-capacity turbines (those typically installed by electric generating companies).[6] Likewise, 65 percent of the global

market for photovoltaic cells (the key component of most solar power facilities) in 1999 was dominated by five large multinational corporations: British Petroleum, Kyocera, Sharp, Siemens, and Sanyo (in descending order of market share).[7]

To advocates of renewable energy, heavy corporate investment in renewable energy technologies is evidence of the potential competitiveness of alternative fuels in the near future. But some perspective is necessary. Total private-sector investment in solar, wind, and biomass energy in 1995 was less than 1 percent of total world energy investments.[8] Royal Dutch Shell's highly publicized planned expenditure of from $500 million to $1 billion on renewable energy development, for instance, is at most 10 percent of the corporation's $10 billion capital spending budget.[9]

As Table 1 indicates, solar, wind, geothermal, and biomass energy account for only about 2 percent of total U.S. electricity generation, according to the most recent data.

Cost Data

Accurate estimates of the cost of renewable energies are surprisingly hard to obtain. A 1997 study undertaken jointly by the U.S. Department of Energy and the Electric Power Research Institute[10] argued that no renewable energy source was competitive with combined-cycle natural gas turbine technology, the primary source of new electric power capacity, which produces electricity at about 3 cents per kilowatt-hour (kWh).[11]

Renewable energy costs, however, include numerous government subsidies and preferences that mask the true cost of generating electricity from those sources. The impact of preferences varies by fuel source and facility, but they reduce the true cost of renewable energy production by at least 2 cents per kWh.[12] The most important of those subsidies include

- a 1.7 cent per kWh federal tax credit for output produced during the first 10 years of operation for new wind power plants built before 2001;[13]
- a 10 percent investment federal tax credit for solar and geothermal technologies that generate electricity;[14]
- five-year accelerated depreciation for some renewable energies;[15]
- state-imposed "public benefit charges,"

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Table 1
Net Generation of Electricity from Various Fuels, 2000

Fuel	Kilowatt-hours (millions)	Percentage of Total Electricity Generation
Nonrenewables and hydro	3,799,944	97.79
Renewables		
Biomass	39,498	1.04
Waste combustion	24,590	0.65
Geothermal	14,197	0.37
Wind	4,953	0.13
Solar	844	0.02
Total renewables	84,082	2.21

Source: Energy Information Administration, Monthly Energy Review Interactive Data Query System, http://tonto.eia.doe.gov/mer.

Without policy privileges, the renewable energy industry (at least the portion that generates electricity for the power grid) would cease to exist.

which impose taxes on nonrenewable energy sources to subsidize renewable energy projects;[16] and
- state sales tax credits, investment tax credits, and subsidized low-interest loans to investors.[17]

Without policy privileges, the renewable energy industry (at least the portion that generates electricity for the power grid) would cease to exist. For instance, Christine Real de Azua, an analyst at the Wind Energy Association, concedes that "the fact remains that wind energy, while close to being competitive with conventional generating technologies . . . was still not competitive enough [as of 1998] to win all-source bids from utilities in the absence of policies that either created a steady assured market for renewable energy, or ensured that its environmental attributes were adequately captured and valued in the marketplace."[18] Stanford University engineers Mark Jacobson and Gilbert Masters concede that wind is competitive only if government intervenes to internalize environmental externalities of conventional electricity production (an issue addressed later in this paper).[19]

The cost estimates shown in Table 2 are too low for several reasons. First, they do not include the costs of transmission because those costs are site specific and hard to estimate.[20] The cost of transmitting electricity produced by renewable energy, however, is often higher than that of transmitting electricity generated from fossil fuel because the best renewable energy sites are far from urban areas. Transmission costs will thus increase the figures in Table 2.

Second, production costs of renewable energy vary tremendously by location. Ideal sites will produce lower-cost power, but the number of ideal sites in the United States (and, indeed, in the world) is limited,[21] a consideration so fundamental to the economics of wind power, for example, that the EIA states bluntly that "because of limits to windy land area, wind is considered a finite resource."[22] Moreover, ideal sites will be developed before higher-cost sites, so the expected trajectory should be rising, not decreasing, costs, all other things being equal.[23]

Finally, production costs and generation capacity of wind and solar power facilities are heavily dependent on weather conditions,

Table 2
Levelized Cost of Renewable Energy

Fuel	Cents per kWh
Geothermal/hydrothermal	3.3–3.9
Wind/advanced horizontal axis turbines	5.0–6.4
Biomass	7.3–8.7
Geothermal/hot dry rock	10.9
Solar thermal/parabolic trough	17.3
Photovoltaic/residential	37.0
Photovoltaic/concentrators	49.1
Phtovoltaic/utility scale	51.7
Solar thermal/dish engine	134.3

Source: U.S. Department of Energy, Office of Utility Technologies, Energy Efficiency and Renewable Energy, and the Electric Power Research Institute, "Renewable Energy Technology Characterizations," TR-109496, December 1997, p. 7-3.

which makes those energy sources unsuitable for continuous, or baseload, generation. For example, Traverse City Light & Power installed one of the largest wind generators in the country in 1996. But wind speeds have been 15–20 percent below projected averages, and the plant has produced only 67 percent of the electricity anticipated. The turbine was particularly unproductive during the summer months when peak demand was highest.[24]

"Green Power" Offerings in a Deregulated Market

While renewable energy is more expensive than conventionally generated energy, public opinion polls continue to suggest that consumers are willing to pay higher energy costs if doing so will improve environmental quality.[25] Accordingly, a number of independent power marketers in seven states have packaged "green power" electricity plans (made up almost entirely of wind-fired electricity) and marketed those plans to ratepayers in states that give consumers the right to choose their power suppliers.[26]

Eighty utilities in 28 states also offer special packages of renewable energy to ratepayers at a premium.[27] "Green power" costs from 0.4 cents to 20 cents per kWh more than conventional power in these plans, with a median premium of 2.5 cents per kWh.[28] Because of higher costs, no more than 1.5 percent of the retail customers in any state have signed up for such independently marketed programs, and participation in utility-sponsored programs is generally around 1 percent or less.[29] Clearly, there is a difference between what people tell pollsters about their "willingness to pay" for environmental quality and their actual willingness to pay in the marketplace.

While consumer preferences may change, even advocates of renewable energy concede that, until renewable-fired electricity costs become comparable to those of conventional energy, green marketing programs are unlikely to attract many customers.[30]

Forecasts for Growth

Advocates of renewable energy often use recent trends in the wind industry—a growth rate of nearly 70 percent from 1997 through 2000, for example—as the basis for predictions about future growth potential.[31] But such arguments can be charitably described as boosterism.[32]

The EIA generates predictions using the National Energy Modeling Systems, a sophisticated computer model of the industry that is used to forecast changes in energy markets.[33] NEMS forecasts are far less optimistic about the near or midterm prospects for renewable energy than are the forecasts of advocates of renewable energy.[34]

Absent significant changes in federal policy, the EIA projects that installed renewable energy capacity (including both direct generation and industrial cogeneration) will increase by 7.5 gigawatts by 2020, giving renewable energy 2.8 percent of net generation in the electricity marketplace and 3.1 percent of retail electricity sales.[35] Combined-cycle turbine plants, fired primarily by natural gas, are expected to account for 92 percent of new capacity over that same period[36] because their costs are expected to be lower than those of other sources of electricity.[37] Even coal-fired electricity is expected to add three times more capacity to the system than renewable-fired electricity generation.[38] To put the projected expansion of renewable energy into perspective, the additional expected power equals the electricity output from 3–4 moderately sized coal or nuclear power plants over the next 20 years.[39]

Of the 5,356 megawatts (MW) of renewable energy generating capacity currently planned through 2020, only 291 MW are being built voluntarily; the rest of the investment is a consequence of state mandates and orders.[40] Thus, government orders, not economic competitiveness, account for even the modest amount of new renewable generating capacity expected over the next two decades.

Projections of future global market share for renewable energy alternatives under a "business as usual" scenario are no more optimistic. The World Bank reports that only 1,000 MW of new renewable-fired electricity are being added annually around the world (out-

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put equivalent to that of one moderately sized coal or nuclear power plant a year),[41] compared to the annual global addition of 75,000 MW of fossil-fired generation.[42] Even the optimistic corporate renewable energy analysts, such as those at Royal Dutch Shell, concede that by 2010 renewable energy will probably increase its global energy market share to only 2 percent from its current 1 percent.[43]

The Capital Costs of Renewables

The forecasts for growth in the use of renewables are low because the costs of renewable energy are high. The levelized cost of renewable energy–fired electricity is greater today than that of its main competitor, combined-cycle natural gas. Few analysts believe that this will change soon[44] (we'll discuss trends in fossil fuel prices more extensively below). For example, the most competitive renewable energy resource, wind, is projected to have a levelized cost of 6 cents per kWh in 2005, 50 percent above the projected levelized cost for advanced combined-cycle natural gas power plants or advanced coal plants and only slightly less than that of nuclear power.[45]

The main disadvantage of renewable energy is its capital costs. As states deregulate their electricity markets, investors lose the guarantee that the capital costs of generators will be recovered from customers. Thus, investors find it riskier to invest in capital-intensive technologies than in technologies that have higher marginal but lower capital costs.

Table 3 illustrates the capital costs (incorporating the 10 percent federal investment tax credit for geothermal and solar) for various fuels using state-of-the-art technology.[46]

Renewable technologies not only have high capital costs per kW of capacity but also require costly upgrades of the existing transmission network because attractive sites are distant from most consumers.[47] In addition, given the amount of land necessary to collect wind and solar power in an economically viable manner, renewable energy would

Table 3
Capital Costs forVarious Electricity-Generating Technologies

Technology	Capital Costs per Installed kW
Gas/oil combined cycle	$445
Advanced gas/oil combined cycle	$576
Wind	$983
Coal	$1,092
Coal gasification cycle	$1,306
Waste and landfill gas combustion	$1,395
Geothermal	$1,708
Biomass	$1,732
Fuel cells	$2,041
Advanced nuclear	$2,188
Solar thermal	$2,946
Solar photovoltaic	$4,252

Source: Energy Information Administration, "Assumptions to the Annual Energy Outlook 2001" DOE/EIA0554 (2001), December 2000, Table 43, p. 69.

have to increasingly compete with other land uses—such as agriculture and recreation—resulting in increased fixed costs for land.[48]

According to EIA, capital costs for renewable sources increase linearly—and sometimes more than linearly—with increased capacity. Geothermal drilling costs increase 33 percent for each successive 20 percent production increase, and exploration costs increase 100 percent for each successive quintile of production increase.[49] For biomass, capital costs increase by 15, 50, 75, and 100 percent for successive 20 percent increments of supply. For wind power, capital costs increase 20, 50, 100, and 200 percent.

The forecasts for growth in the use of renewables are also low because renewable sources have a cost structure (high capital and low marginal costs) that is suited to baseload production but a generation pattern that is intermittent. Wind and solar power generate electricity only when the wind is blowing or the sun is out.[50] To circumvent the intermittent nature of wind and solar power, natural gas–fired generators provide backup capacity, but this adds cost and links renewable energy production to natural gas markets. How "renewable" is renewable energy that relies on natural gas?

Natural Gas Prices and Renewables

The trouble for renewable energy is competition from combined-cycle natural gas turbines that have low capital costs (Table 3) and declining marginal costs. From 1985 through 1999, natural gas prices declined 25 percent after adjusting for inflation.[51]

In November–December 2000 average natural gas prices increased dramatically from $2 to $10 per million British thermal units. In California they averaged $25 per million Btu[52] (and reached $60 per million Btu on December 9).[53] Mark Mazur, acting administrator of the EIA, testified to the Senate Energy and Natural Resources Committee that "gas prices previously had not remained this high for a sustained period of time."[54]

Is the natural gas price spike of 2000 temporary or long-term? If long-term, then market substitutes are viable, but coal, not renewable sources, would probably gain the most market share.[55] If temporary, then renewable energy's future is no brighter today than it was yesterday.

The evidence suggests that the natural gas price increase of 2000 was temporary. Natural gas prices in late September 2001 were $2 per million Btu and inventories were 9 percent above the six-year moving average for the date.[56] Futures contracts for natural gas on the New York Mercantile Exchange suggest moderate increases in price through 2004.[57]

Industry forecasters are also optimistic. The Department of Energy believes that natural gas prices will continue to fall at least through 2004.[58] The National Petroleum Council concurs, forecasting that the average wellhead price through 2010 will be approximately $2.74 per million Btu.[59] As a result, EIA expects that electricity prices will decline from 6.7 cents per kWh in 1999 to 6 cents per kWh in 2020.[60]

Fossil Fuel Electricity Costs with Proper Pollution Accounting

Generation of electricity from renewables is limited by costs. Advocates of renewable energy know this so they argue that the demand for renewables would rise if conventionally generated electricity were priced to reflect its pollution costs.

The argument that fossil fuel extraction and combustion foul the environment in ways that are incompatible with property rights and markets has some merit.[61] Air and water resources have been treated as a public commons rather than as private property. Advocates of renewable energy argue that consumers of fossil fuels have not had to indemnify anyone for the environmental consequences of their consumption and thus prices for fossil fuels are too low. Consequently, society consumes "too much" fossil fuel.

Although a world of relatively "unpriced" pollution existed prior to 1970 and the enactment of the Clean Air Act amendments,[62]

According to EIA, capital costs for renewable sources increase linearly with increased capacity.

environmental regulation since the 1970s has imposed large costs on firms, particularly new coal-burning utilities, and those costs have been passed on to consumers. So, in a sense, consumers of electricity *have* had to pay a premium for the environmental consequences of the fossil fuels they consume. For example, the costs of compliance with the Clean Air Act through the 1970s and 1980s (the "environmental tax" on fossil fuels) were about $25 billion to $35 billion annually.[63] The relevant question, then, is whether the regulatory cost paid by consumers already covers the environmental "cost" of fossil fuel consumption.

The answer, unfortunately, is not at all clear. The estimates of the economic damage caused by fossil fuel consumption are all over the map. If we accept EPA's estimates as a reasonable point of analytic departure, however, we find that biomass and coal are somewhat undertaxed relative to their external costs, natural gas is substantially overtaxed, and gasoline is taxed correctly.[64]

But analysis cannot stop there. Economic efficiency—the explicit goal of advocates of renewable energy who cite market failure as a rationale for government intervention—requires that the additional benefits obtained from expenditures for pollution abatement exceed the additional costs. Subsidies to renewable energy sources are necessary to correct for the costs of air pollution *if and only if* incremental net benefits would arise from reduced pollution relative to the status quo. And even then an economically justified subsidy would equal only the *difference* between the existing prices of fossil fuels (which include the cost of existing pollution controls as well as some taxes) and a price that included all pollution damages.[65] Most analysts, however, conclude that the incremental costs of air pollution controls established over the past decade have far exceeded the incremental benefits.[66]

Because pollution policies already control emissions and a reasonable interpretation of the evidence suggests that the additional cost of further exposure reduction exceeds the additional health benefits, the economically efficient subsidy for alternative electricity sources is probably zero.

Even if current regulatory costs are insufficiently reflective of true environmental costs, they are not so far off the mark that "getting prices right" would significantly affect consumer decisions about fuels. The U.S. General Accounting Office reported,

> The consideration of externalities in the planning process for electricity has generally had no effect on the selection or acquisition of renewable energy sources [because] electricity from renewable energy usually costs so much more than electricity from fossil fuels that externality considerations do not overcome the difference.[67]

Moreover, as we'll see below, tightening environmental regulations on coal- and gas-fired power plants would have little effect on renewable energy's ability to compete in the electricity marketplace.

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Does Global Warming Alter the Conclusion?

Does the threat of global warming alter the conclusion of the last section? This study will not provide a thorough review of the scientific disputes surrounding global climate change,[68] but scientists do not agree on whether anthropogenic greenhouse gases will have a significant deleterious effect on either the economy or the environment.[69]

Even if the scientific alarmists are correct about the effects of anthropogenic greenhouse gas emissions, it is not clear that the benefits of restricting fossil fuel consumption outweigh the costs.[70] And unless the benefits of "doing something" about global warming outweigh the costs, the efficient greenhouse gas "tax" on coal- or gas-fired electricity is zero.

Accordingly, the case for promoting renewable energy to "do something" about global warming is empirically weak. Moreover, as we discussed earlier, embracing a policy of "doing

something" about global warming does not necessarily translate into a policy of subsidizing renewable energy; there are far less costly means of reaching that end.

Do Subsidies for Traditional Fuels Justify Subsidies for Renewables?

The EIA reported that energy subsidies in fiscal year 1999 totaled $4 billion.[71] The oil industry received $312 million,[72] the coal industry received $489 million, and the natural gas industry received $1.2 billion (almost all of which was a tax credit for the production of alternative fuels, primarily gas from tight sands and coalbed methane).[73] Renewable energy was the recipient of $1.1 billion in subsidies in 1999.[74] Subsidies for fossil fuels amount to only 1 percent of total energy purchases[75] and are, according to EIA, "too small to have a significant effect on the overall level of energy prices and consumption in the United States."[76]

R&D dollars have not handicapped renewable energy technologies. Over the past 20 years, those technologies have received (in inflation-adjusted 1996 dollars) $24.2 billion in federal R&D subsidies, while nuclear energy has received $20.1 billion and fossil fuels only $15.5 billion.[77] To the extent that nuclear power has received heavy favor from government, the primary victims have been oil, gas, and coal—not renewable energy.

The best way to "level the playing field" is to eliminate subsidies for traditional sources rather than enact new programs for renewables.

If You Can't Sell Renewables, Mandate Them

Renewable energy has made remarkably little progress in the electricity marketplace because of its costs. And proper consideration of the pollution externalities of, and subsidies for, coal- and gas-fired electricity would not increase its price enough to close the gap. Proponents of renewable energy have responded by advancing proposals to mandate the consumption of renewable energy. This section surveys the most common proposals advanced to promote additional reliance on renewable energy.[78]

Renewable Energy Portfolio Standards

Ten states have adopted renewable energy portfolio standards (RPS), which require that a certain percentage of the state's electricity supply be produced from eligible renewable energy sources.[79]

The Clinton administration proposed a federal RPS that would require all U.S. electricity suppliers to obtain renewable energy credits equal to 7.5 percent of sales from 2010 through expiration in 2015. Under the administration's plan, credits could be obtained by generating electricity with specified renewables (one credit for every kilowatt-hour), purchasing credits from others, or purchasing credits unsupported by generation from the Department of Energy at 1.5 cents per credit, effectively setting a cap on the price of renewable energy.

Because actual renewable sources of electricity have costs that exceed 1.5 cents per kWh, retail suppliers would for the most part buy credits from the Department of Energy rather than actually purchase or produce renewable energy. The EIA estimated that the Clinton RPS would increase renewables' market share only to 3.4 percent in 2020.[80] Approximately 82 percent of the 36 billion kWh increase in renewable energy would come from mixing biomass (essentially, wood chips, paper, and various specialty plants) with coal in existing coal-fired power plants.[81] Removing the 2015 sunset provision would increase the predicted market share for renewables to 4.2 percent.[82]

The impact of the Clinton RPS on electricity prices would be small because the credit system spreads the cost of the 1.5 cent tax across all electricity sales. Costs would peak in 2010 under each of the various RPS plans (up to a 3.2 percent increase in price under a no cap, no sunset RPS) but would fall by about half under each RPS alternative by 2020.[83]

Since the unveiling of the Clinton proposal,

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proponents have introduced even more aggressive RPS plans in Congress. Most of those legislative proposals require that between 10 and 20 percent of retail electricity sales by 2020 come from specified nonhydro renewable energy sources without any sort of price cap on the cost of tradable renewable energy permits and without any sunset provision.

A "hard" 20 percent RPS would provide the equivalent of a 5 cent per kWh subsidy for renewable-fired electricity,[84] increasing the amount of renewable energy sold on the market from the 135 billion kWh otherwise projected in 2020 to 932 billion kWh, a 690 percent increase.[85] Approximately 57 percent would come from biomass cofired with coal, 30 percent from wind-powered turbines, 11 percent from geothermal facilities, and 2 percent from landfill gas.[86] According to EIA, electricity prices would be 3 percent higher in 2010 and 4 percent higher in 2020 under a hard 20 percent RPS.[87]

None of the legislative proposals on the table to promote renewable energy would have much effect on greenhouse gas emissions.

In sum, moderate RPS programs accomplish little and aggressive RPS programs would prove quite expensive. Moreover, because the primary beneficiary of those programs would be biomass, which would be mixed with coal in existing coal-fired power plants, the environmental benefits would be far less than we might expect. That even aggressive RPS programs are insufficient to significantly expand the market share of wind- and solar-powered electricity underscores just how uncompetitive those technologies are today in the marketplace.

Would Stricter Pollution Controls Increase Renewable Energy Generation?

Regardless of the merits of the claim that conventional sources of electricity are underpriced because of inadequate regulation of pollution emissions, what would happen to the renewable energy industry if pollution rules were tightened on conventional electric power plants?

The main legislative proposals to reduce pollution from power plants address sulfur dioxide (a contributor to "acid rain" and regional haze), nitrogen oxides (a contributor in some regions to summertime urban smog), mercury (a toxic constituent thought by some to harm both human and ecological health), and carbon dioxide (one of the most important greenhouse gases) jointly in coordinated, comprehensive fashion. Those proposals are commonly referred to as "multi-emission" or "4-pollutant" bills.[88] President Bush, after initially calling for adoption of just such a 4-pollutant bill during his campaign for the White House, now supports instead a "3-pollutant" bill addressing sulfur dioxide, nitrogen oxides, and mercury but *not* carbon dioxide.

Reducing emissions of nitrogen oxides and sulfur dioxide by 75 percent below 1997 levels (the most common proposal) would increase electricity prices by only about 1 percent, too little to trigger a shift from coal or natural gas to renewable energy.[89] The EIA notes that, while "scrubbers, selective catalytic reduction, and selective noncatalytic reduction (the most popular technologies for controlling such emissions) can be expensive, they generally are not costly enough to make existing coal-fired plants uneconomical."[90]

Reducing mercury emissions by 90 percent below 1997 levels (the most common proposal) also would not increase renewable energy generation because, according to the EIA, "the [mercury] cap can be met more cost-effectively by retrofitting and switching from coal to natural gas than by switching to more costly renewable energy technologies."[91] In the meantime, combining the proposed mercury regulations with the proposed reductions in emissions of nitrogen oxides and sulfur dioxide (the 3-pollutant approach) would increase electricity prices by 3–4 percent by 2020.[92]

Can Renewable Energy Contribute to a Campaign against Global Warming?

Perhaps the most common argument for government promotion of renewable energy is that renewable energy can play a significant role in achieving affordable greenhouse gas emission reductions. But as Table 4 indicates, none of the legislative proposals on the table to promote renewable energy would have much effect on greenhouse gas emissions.

Because the United States must reduce greenhouse gas emissions by 30–42 percent below projected levels to meet the require-

Table 4
Carbon Dioxide Emission Reductions by 2020 under Alternative Scenarios

Scenario	Emission Reduction (million metric tons)	Emission Reduction (percentage)
EIA "high renewables" scenario	12	1.6
Clinton RPS with 1.5 cent price cap and 2015 sunset	1	0.002
Clinton RPS without price cap or sunset	32	4.2
Hard 10% RPS	56	7.3
Hard 20% RPS	137	17.7

Source: Energy Information Administration "Annual Energy Outlook 2000," DOE/EIA-0383 (2000), December 1999, p. 72; and Energy Information Administration, "Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants: Sulfur Dioxide, Nitrogen Oxides, Carbon Dioxide, and Mercury and a Renewable Energy Portfolio Standard," SR/OIAF/2001–03, July 2001, Table 10, p. 32.

ments of the Kyoto Protocol (much greater than the 17.7 percent reduction created by even the hard 20 percent RPS), it's clear that renewable energy, no matter how optimistic we might be about the technology, cannot significantly contribute to Kyoto compliance without recourse to extreme mandates.[93] Even if the government required large reductions in carbon dioxide emissions but left the compliance details to the market, firms would find it cheaper to reduce emissions by replacing coal with natural gas than by replacing fossil fuels with renewable technologies.[94]

For example, if a 7 percent reduction of carbon dioxide emissions below the 1990 baseline were mandated (a 30–42 percent reduction from projected levels), the likely increase in the market share of renewable energy would be 27 percent by 2010 and 32 percent by 2020,[95] giving renewable energy technologies 7 percent of the electricity market in 2020.[96] Biomass (primarily cofired with coal) would achieve the largest market gain, followed by geothermal and wind technologies, respectively.[97]

The costs of such a plan, however, would be significant. Absent an international emissions trading regime, electricity prices would increase by 43 percent in 2010[98]—an average annual "tax" of approximately $218 per household in 2010 and $174 by 2020.[99]

Actually stabilizing greenhouse gas concentrations at present levels would require a 60–80 percent cut in present greenhouse gas emissions[100] and, thus, the nearly complete elimination of fossil fuel consumption because fossil fuel combustion creates about 80 percent of total greenhouse gas emissions.[101] Such an undertaking is simply not conceivable.

Reducing emissions of conventional pollutants such as nitrogen oxides, sulfur dioxide, and mercury would do little to advance renewable energy technologies. Cracking down on greenhouse gas (carbon dioxide) emissions would advance renewable energy technologies, but such initiatives would still fail to give those technologies double-digit market shares and would be expensive.

Conclusion

Renewable sources of electricity are more expensive than combined-cycle natural gas. This fundamental fact inhibits their use now and in the future. Advocates of renewable energy argue that the demand for renewables would rise if conventionally generated electricity were priced to reflect its pollution

Renewable sources of electricity are more expensive than combined-cycle natural gas. This fundamental fact inhibits their use now and in the future.

The main effect of reducing nitrogen, sulfur dioxide, and mercury emissions would be to induce a shift from coal to natural gas rather than renewable energy.

costs. But the main effect of reducing nitrogen, sulfur dioxide, and mercury emissions would be to induce a shift from coal to natural gas rather than renewable energy. Only a severe reduction in carbon dioxide emissions would advance renewable energy technologies, but such initiatives would still fail to give those technologies double-digit market shares and would be expensive.

Without policy privileges, the renewable energy industry (at least the portion that generates electricity for the power grid) would cease to exist. Advocates of renewable energy understand that and are now promoting direct use of government authority to mandate the use of renewable sources. Such policies use the power of government to impose the consumption preferences of advocates of renewables on others without any legitimate philosophical or economic basis.

Notes

1. This paper does not examine two fuels that some analysts consider renewable energies—nuclear power and hydropower—because nongovernmental advocates of renewable energy generally oppose those fuels. They oppose nuclear power because of concern over both radioactive waste and general safety. They oppose hydropower because of the damage that its use does to riparian ecosystems. See Robert L. Bradley Jr., "Renewable Energy: Not Cheap, Not 'Green,'" Cato Institute Policy Analysis no. 280, August 27, 1997, pp. 26–28. Accordingly, when we use the term "renewable energy," we're referring to wind power, solar power, biomass, waste combustion and landfill gas combustion, fuel cells, and geothermal resources.

2. Ibid., p. 5.

3. James McVeigh et al., "Renewable Energy: Winner, Loser, or Innocent Victim? Has Renewable Energy Performed as Expected?" Resources for the Future Discussion Paper 99–28, June 1999.

4. Robert L. Bradley Jr., "The Increasing Sustainability of Conventional Energy," Cato Institute Policy Analysis no. 341, April 22, 1999, p. 6.

5. Only 3 percent of the electricity generated in this country is produced from oil, and that figure is expected to decline somewhat through 2020 as oil-fired steam generators are replaced with gas turbine technologies. Energy Information Administration (EIA), "Annual Energy Outlook 2001," DOE/EIA-0383(2001), p. 74.

6. U.S. General Accounting Office, "Renewable Energy: DOE's Funding and Markets for Wind Energy and Solar Cell Technologies," GAO/RCED 99-130, May 1999, pp. 15–16, 23.

7. Peter Holihan, "Technology, Manufacturing, and Market Trends in the U.S. and International Photovoltaics Industry," in EIA, "Renewable Energy Outlook 2001: Issues and Trends," February 2001, http://www.eia.doe.gov/cneaf /solar.renewables/rea_issues/solar.html. Enron, interestingly enough, sold its stake in Solarex (a joint project dedicated to commercializing sales of solar power to utility grids) to British Petroleum in 1999. According to business analyst Carl Kirst, Enron's solar investments were "costing them money and not turning a profit in the near-term. It didn't make sense to spend money on this technology." Quoted in Ann de Rouffignac, "Enron Pulls the Plug on Solar Power Operation," *Houston Business Journal*, April 16–22, 1999.

8. Martin Daniel, "Finance for Energy," *FT Energy News*, Summer 1997; and EIA, "Challenges of Electric Power Industry Restructuring for Fuel Suppliers," DOE/EIA-0623, September 1998, p. 20.

9. "Shell Unveils Renewable Energy Plan As US, EU Disagree on Climate Change," *Oil Daily*, June 15, 2001.

10. Still, Thomas Petersik, a senior renewable energy analyst at the EIA, believes that the EPRI/DOE figures reported in Table 2 are somewhat too optimistic about the true levelized cost of renewable energy and that the estimates should be adjusted upward by about a penny or two. Personal conversation with Jerry Taylor, June 26, 2001.

11. Levelized costs are the estimated capital and marginal costs of an energy facility discounted to net present value (NPV) divided by the project's energy output to yield a value in cents per kWh. The calculations in Table 2 assume a market-based rate of return approach to building, owning, and operating a power plant and balance sheet finance. U.S. Department of Energy, Office of Utility Technologies, Energy Efficiency and Renewable Energy, and the Electric Power Research Institute, "Renewable Energy Technology Characterizations," TR-109496, December 1997 pp. 7-1 through 7-3.

12. Bradley, "Renewable Energy," pp. 8–15, 28–36.

13. EIA, "Assumptions of the Annual Energy Outlook 2001," DOE/EIA-0554(2001), December 2000, p. 123.

14. Ibid.

15. Glenn Schleede, "The US Department of Energy's 'Wind Energy Initiative': A Truly Unrealistic

Proposal," Energy Market & Policy Analysis, January 7, 2000, pp. 13–15, empainc @aol.com.

16. California's state program is the most aggressive in this regard. For details, see EIA, "Annual Energy Outlook 2001," p. 12.

17. Christine Real de Azua, "The Future of Wind Energy," *Tulane Environmental Law Journal* 14, no. 2 (Summer 2001): 511.

18. Ibid., p. 501.

19. Mark Jacobson and Gilbert Masters, "Wind versus Coal," *Science*, August 24, 2001. For critiques of the article beyond those generally found in this study, see Glenn Schleede, "Science Article Is Wrong in Claiming That Wind Energy Is Cheaper Than Coal," Energy Market & Policy Analysis, August 26, 2001; and energy consultant Catharine Lawton, "Conclusions in Science Policy Forum Article on Wind Energy and Coal Are Unsupported and Contradicted by Other Evidence," September 17, 2001 (both documents available from the authors).

20. U.S. Department of Energy and the Electric Power Research Institute, p. 6-4.

21. The economics of wind power is heavily dependent on geographic wind characteristics. See "Wind Energy Resource Atlas," United States Pacific Northwest National Laboratory, http://rredc.nrel.gov/wind/pubs/atlas/. Central station solar power is obviously more economically attractive in desert areas than elsewhere. See U.S. Department of Energy and the Electric Power Research Institute, Figure 2, p. 4-3. Geothermal energy is profitable only where heat intersects with water below the earth, sites which are far from ubiquitous. "Geothermal Energy Could Provide 8% of World's Electricity," *Energy Report*, April 12, 1999. See also, generally, EIA, "Annual Energy Outlook 2001," p. 244, and EIA, "Assumptions to the Annual Energy Outlook 2001," DOE/EIA-0554(2001), December 2000, pp. 118–23.

22. Ibid., p. 119.

23. All extractive industries are subject to the same phenomenon. For a discussion of the economics of site exploitation for natural resource industries, see M. A. Adelman, *The Economics of Petroleum Supply* (Cambridge, Mass.: MIT Press, 1993), pp. 1–302.

24. "Wind Turbine Fails to Meet Expectations," *Detroit News*, August 19, 1999.

25. The U.S. Department of Energy recently surveyed a random sample of Americans and asked them if they agreed with the statement, "We must protect the environment, even if it means paying higher prices for electricity and gasoline because of it." Fifty-five percent agreed, 38 percent disagreed, and 7 percent were unsure. "Save the Environment! (And Turn Up the Air Conditioner)," *New York Times*, May 20, 2001, sec. 4, p. 5.

26. The most successful programs are being marketed in California, New Jersey, and Pennsylvania, although California suspended its retail consumer choice program on September 20, 2001. Other states where "green power" marketing is conducted include Connecticut, Maine, Massachusetts, and New York. Blair Swezey and Lori Bird, "Green Power Marketing in the United States: A Status Report," 5th ed., National Renewable Energy Laboratory, NREL/TP-620-28738, August 2000, pp. 1–2. For a critique of those green pricing programs, see Robert L. Bradley Jr., "Green Energy," in *Macmillan Encyclopedia of Energy*, ed. John Zumerchik (New York: Macmillan, 2001), vol. 2.

27. Ibid., p. 1.

28. Ibid., p. 6.

29. Ibid., pp. 1–2, 7.

30. Real de Azua, p. 519.

31. EIA, "Analysis of Strategies for Reducing Multiple Emissions from Power Plants: Sulfur Dioxide, Nitrogen Oxides, and Carbon Dioxide," SR/OIAF/2000-05, December 2000, p. 47.

32. For a good example of the typical arguments, see Christopher Flavin and Seth Dunn, "A New Energy Paradigm for the 21st Century," *Journal of International Affairs* 53, no. 1 (Fall 1999): 167–90.

33. For a discussion of the NEMS, see EIA, "Annual Energy Outlook 2001," Appendix G. For a discussion of the major underlying assumptions of the NEMS model, see EIA, "Assumptions of the Annual Energy Outlook 2001," pp. 2–12.

34. EIA's forecasts for renewable energy, interestingly enough, are a bit more optimistic than similar forecasts published by the U.S. Environmental Protection Agency, the Electric Power Research Institute, and the Environmental Law Institute, all agencies generally considered to be more bullish about the prospects for renewable energy. EIA, "Strategies for Reducing Multiple Emissions from Power Plants," 2000, Table 22, p. 70. For an overview of how the assumptions underlying the NEMS model and the forecasts differ generally from those of other analyses, see EIA, "Annual Energy Outlook 2001," pp. 102–11.

35. EIA, "Analysis of Strategies for Reducing

Multiple Emissions from Electric Power Plants: Sulfur Dioxide, Nitrogen Oxides, Carbon Dioxide, and Mercury and a Renewable Energy Portfolio Standard," SR/OIAF/2001-03, July 2001, p. 58.

36. EIA, "Annual Energy Outlook 2001," p. 73.

37. Ibid., p. 95.

38. Ibid., p. 73.

39. U.S. General Accounting Office, "Renewable Energy," p. 7 n. 9.

40. For a summary as well as a state-by-state, project-by-project breakdown, see EIA, "Assumptions of the Annual Energy Outlook 2001," pp. 123–25.

41. Ibid.

42. "World Bank Chief Says 'Systemic' Change Needed to Help Renewable Generation," *Energy Report* 27, no. 11, March 13, 2000.

43. "Shell Unveils Renewable Energy Plan As US, EU Disagree on Climate Change."

44. "The use of renewable energy technologies for electricity generation is projected to grow slowly because of the relatively low cost of fossil fuel generation and because electricity construction favors less capital intensive natural gas technologies over coal and baseload renewables." EIA, "Annual Energy Outlook 2001," p. 5.

45. EIA, "Strategies for Reducing Multiple Emissions from Power Plants," 2000, p. 18.

46. Capital costs are referred to as "total overnight cost including contingencies" in the electricity trade.

47. EIA, "Annual Energy Outlook 2001," p. 244.

48. Ibid; and EIA, "Assumptions to the Annual Energy Outlook 2001," p. 118.

49. Ibid.

50. Of course, low winds can generate power from wind turbines, but not economically. "Since the energy that wind contains is a function of the cube of its speed, small differences in average winds from site to site mean large differences in production and, therefore, in cost." Real de Azua, p. 492.

51. Alex Barrionuevo, John Fialka, and Rebecca Smith, "How Federal Policies, Industry Shifts Created the Natural Gas Crunch," *Wall Street Journal*, January 3, 2001, p. A1.

52. Edward Krapels, "Was Gas to Blame? Exploring the Cause of California's High Prices," *Public Utilities Fortnightly*, February 15, 2001, pp. 31–32.

53. Bruce Radford, "Key to the Citygate," *Public Utilities Fortnightly*, January 1, 2001, p. 4.

54. Mark Mazur, "Statement to Committee on Energy and Natural Resources, U.S. Senate," 106th Cong., 1st sess., December 12, 2000, p. 1, http://www.eia.doe.gov/pub/oil_gas/natural_gas/presentations/2000/testimony_on_natural_gas_demand/1211sen-test.pdf.

55. As noted earlier, the levelized cost of coal-fired electricity is quite a bit lower than that of renewable energy alternatives (the price differential is almost as large between renewables and coal as it is between renewables and natural gas); the capital costs of coal-fired electricity are virtually the same as those of the most competitive renewable, wind. Moreover, the EIA expects coal prices to drop dramatically over the next couple of decades, from $16.98 a ton in 1999 to $12.70 a ton in 2020 (a 1.4 percent annual decline); the price of coal delivered to utilities is expected to decline at almost the same rate (1.1 percent annually through 2020). EIA, "Annual Energy Outlook 2001," pp. 3, 92.

56. EIA, Natural Gas Weekly Update October 1, 2001, http://tonto.eia.doe.gov/oog/info/ngw/ngupdate .asp.

57. For a review of the size of North American natural gas reserves, see "Industry Confident U.S. Has Enough Gas to Meet Demand," *Energy Report*, March 5, 2001, p. 10; "Report Estimates U.S. Gas Supplies Good for 60 Years," *Energy Report*, April 9, 2001, p. 10; "Canadians Cheer White House Pro-Gas Remarks," *Energy Report*, April 9, 2001, p. 12; and Judith Gurney, "U.S. Faces Natural Gas Price Shock," *Energy Economist* 229 (November 2000): 15–18. For a discussion of technological advances on the near horizon that could dramatically expand natural gas supplies if prices stay high, see Jennifer Considine et al., "North American Natural Gas Markets," *Oxford Energy Forum*, February 2001, pp. 7–9.

58. Mazur, p. 7.

59. "Group Calls on FERC to Cap Wholesale Prices," *Energy Report*, February 12, 2001, p. 11.

60. EIA, "Annual Energy Outlook 2001," p. 3.

61. Murray Rothbard argues that air pollution should be governed by the common law strict liability rule. Murray Rothbard, "Law, Property Rights, and Air Pollution," *Cato Journal* 2 (Spring 1982): 55–99.

62. For a review of air pollution trends and regulatory policies before the Clean Air Act of 1970, see Indur Goklany, *Clearing the Air: The Real Story of the War on Air Pollution* (Washington: Cato Institute, 1999). Goklany reports that there was far more state and local regulatory activity before 1970 than most analysts realize and that air quality had been improving for decades prior to passage of the Clean Air Act. The explanation of suboptimal emissions control policies prior to 1970, according to Goklany, is that scientists came rather late to the conclusion that nitrogen oxides and other substances were truly pollutants worth worrying about. One can't fault state and local governments for not regulating substances that weren't on the public health radar screen.

63. For the 1970–90 period, Clean Air Act direct compliance expenditures are estimated to have been $500 billion. In 1978 Clean Air Act direct compliance expenditures were estimated to have been $35 billion. See J. Clarence Davies and Jan Mazurek, *Pollution Control in the United States: Evaluating the System* (Washington: Resources for the Future, 1998), pp. 128–30.

64. W. Kip Viscusi et al., "Environmentally Responsible Energy Pricing," *Energy Journal* 15, no. 2 (1994): 23–42.

65. Albert Nichols, "How Well Do Market Failures Support the Need for Demand Side Management?" National Economic Research Associates, Cambridge, Mass., August 12, 1992, p. 9.

66. The 1990 Clean Air Act amendments, for example, will probably result in additional costs that are double the additional benefits. See Paul R. Portney, "Economics and the Clean Air Act," *Journal of Economic Perspectives* 4 (Fall 1990): 173–81.

67. U.S. General Accounting Office, "Electricity Supply: Consideration of Environmental Costs in Selecting Fuel Resources," May 19, 1995, p. 2, quoted in Paul Ballonoff, *Energy: Ending the Never-Ending Crisis* (Washington: Cato Institute, 1997), p. 55.

68. For an overview of the scientific disputes, see Patrick Michaels and Robert Balling, *The Satanic Gases: Clearing the Air about Global Warming* (Washington: Cato Institute, 2000).

69. Intergovernmental Panel on Climate Change, *Climate Change 1995, Impacts, Adaptations, and Mitigation of Climate Change: Scientific-Technical Analyses* (New York: Cambridge University Press, 1996), pp. 411, 439.

70. For a review of the cost/benefit arguments, see *The Impact of Climate Change on the United States Economy*, ed. Robert Mendelsohn and James Newmann (Cambridge: Cambridge University Press, 1999); and Thomas Gale Moore, *Climate of Fear: Why We Shouldn't Worry about Global Warming* (Washington: Cato Institute, 1998).

71. The details about subsidies come from EIA, "Federal Financial Interventions and Subsidies in Energy Markets 1999: Primary Energy," SR/OIA/99-03, September 1999. Some analysts describe the Overseas Private Investment Corporation and the foreign tax credit as subsidizing oil production; see "Subsidizing Big Oil's Foreign Investments: Importing Oil, Exporting Jobs, and Making War," Citizen Action, Washington, September 1996. We will not discuss these policies because they are available to all corporations. However, the government provision of risk insurance for overseas investment does violate market principles.

72. For a more complete discussion of oil subsidies, see Ron Sutherland, "Big Oil at the Public Trough? An Examination of Petroleum Subsidies," Cato Institute Policy Analysis no. 390, February 1, 2001.

73. EIA, "Federal Financial Interventions and Subsidies in Energy Markets 1999: Primary Energy," Table ES1, p. ix.

74. Ibid.

75. Ibid., p. 5.

76. Ibid., pp. ix–x.

77. Data from the Department of Energy reported in Bradley, "Renewable Energy," p. 63.

78. This section does not explore the employment or macroeconomic impacts of the various emissions reduction or renewable energy portfolio programs discussed herein. For a review of such effects, see EIA, "Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants," 2001, pp. 63–69.

79. Texas and New Jersey have adopted the most aggressive standards. Other states that have adopted RPS programs include Arizona, Connecticut, Maine, Massachusetts, Nevada, New Mexico, Pennsylvania, and Wisconsin. For details about the Texas and New Jersey programs, see EIA, "Annual Energy Outlook 2001," p. 12.

80. EIA, "Annual Energy Outlook 2000," DOE/EIA-0383, 1999, p. 19.

81. Ibid.

82. Ibid.

83. Ibid.

84. EIA, "Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants," 2001, p. xviii.

85. Ibid., pp. xxiv–xxv.

86. Ibid., p. 59. For an examination of the regional impacts of a hard 20 percent RPS, see ibid., pp. 62–63.

87. Ibid., p. 32.

88. For a review of the various proposals, see ibid., pp. 1–2; and EIA, "Analysis of Strategies for Reducing Multiple Emissions from Power Plants," 2000, pp. 1–2.

89. EIA, "Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants," 2001, p. ix.

90. Ibid., p. xv.

91. Ibid., p. 59.

92. Ibid., p. ix.

93. Michaels and Balling, p. 200.

94. Council of Economic Advisers, "The Kyoto Protocol and the President's Policies to Address Climate Change," http://www.whitehouse.gov /WH /New/html/Kyoto.pdf. For a full discussion of that report, see Peter VanDoren, "The Cost of Reducing Carbon Emissions: An Examination of Administration Forecasts," Cato Institute Briefing Paper no. 44, March 11, 1999.

95. Ibid., p. 33.

96. Ibid., p. 60.

97. Ibid.

98. Ibid., p. x. To review the various assumptions that drive the cost estimates of carbon dioxide emission reductions, see VanDoren.

99. EIA, "Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants," 2001, p. xvii.

100. Michaels and Balling, p. 199.

101. EIA, "Annual Energy Outlook 2000," p. 40.

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