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Renewable Energy: Not Cheap, Not "Green"

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Executive Summary

A multi-billion-dollar government crusade to promote renewable energy for electricity generation, now in its third decade, has resulted in major economic costs and unintended environmental consequences. Even improved new generation renewable capacity is, on average, *twice* as expensive as new capacity from the most economical fossil-fuel alternative and *triple* the cost of surplus electricity. Solar power for bulk generation is substantially more uneconomic than the average; biomass, hydroelectric power, and geothermal projects are less uneconomic. Wind power is the closest to the double-triple rule.

The uncompetitiveness of renewable generation explains the emphasis pro-renewable energy lobbyists on both the state and federal levels put on quota requirements, as well as continued or expanded subsidies. Yet every major renewable energy source has drawn criticism from leading environmental groups: hydro for river habitat destruction, wind for avian mortality, solar for desert overdevelopment, biomass for air emissions, and geothermal for depletion and toxic discharges.

Current state and federal efforts to restructure the electricity industry are being politicized to foist a new round of involuntary commitments on ratepayers and taxpayers for politically favored renewables, particularly wind and solar. Yet new government subsidies for favored renewable technologies are likely to create few environmental benefits; increase electricity-generation overcapacity in most regions of the United States; raise electricity rates; and create new "environmental pressures," given the extra land and materials (compared with those needed for traditional technologies) it would take to significantly increase the capacity of wind and solar generation.

Introduction

One of the centerpieces of the environmentalist agenda has long been the regulation of fossil-fuel consumption. Although anti-pollution controls are the accepted short-term solution to many of the environmental problems posed by fossil fuels, many people believe that the long-term answer is the gradual replacement of fossil fuels with other, less environmentally threatening fuel sources. That philosophy can perhaps best be described as eco-energy planning, the belief that government intervention in the energy economy is necessary to maximize environmental protection and, in the end, the nation's economic vitality.

Renewable energy--power generated from the nearly infinite elements of nature such as sunshine, wind, the movement of water, the internal heat of the Earth, and the combustion of replenishable crops--is widely popular with the public and governmental officials because it is thought to be an inexhaustible and environmentally benign source of power, particularly compared with the supposedly finite and environmentally problematic alternative of reliance on fossil fuels and nuclear power. Renewable energy is the centerpiece of eco-energy planning. Yet all renewable energy sources are not created equal. Some are more economically and environmentally viable than others. The list of renewable fuels that were once promising but are now being questioned on economic or environmental grounds, or both, is growing.

Wind power is currently the environmentalists' favorite source of renewable energy and is thought be the most likely renewable energy source to replace fossil fuel in the generation of electricity in the 21st century. Hydropower has lost favor with environmentalists because of the damage it has done to river habitats and freshwater fish populations. Solar power, at least when relied on for central-station or grid electricity generation, is not environmentally benign on a total fuel cycle basis and is highly uneconomic, land intensive, and thus a fringe electric power source for the foreseeable future. Geothermal has turned out to be "depletable," with limited capacity, falling output, and modest new investment. Biomass is also uneconomic and an air-pollution-intensive renewable.

Despite its revered status within the orthodox environmental community, wind power poses several major dilemmas. First, wind remains uneconomic despite heavy subsidies from ratepayers and taxpayers over the last two decades. Second, from an environmental viewpoint, wind farms are noisy, land intensive, unsightly, and hazardous to birds, including endangered species. With the National Audubon Society calling for a moratorium on new wind development in bird-sensitive areas, and an impending electricity industry restructuring that could force all generation resources to compete on a marginal cost basis, wind power is a problematic choice for future electricity generation without a new round of government subsidies and preferences.

Because of the precarious economics of acceptable renewable energy, eco-energy planners have turned to taxpayer and ratepayer subsidies for energy conservation as an alternative way to constrain the use of fossil fuels. Yet fundamental problems exist here as well. Multi-billion-dollar taxpayer and ratepayer subsidies over two decades have resulted in severely diminished returns for future subsidized (and even nonsubsidized) conservation investments. The potential reduction of electricity prices due to the introduction of electricity industry restructuring threatens to lengthen the payout period of energy conservation investments and consequently worsen the problem.

A major but largely unrecognized development in the public policy debate over taxpayer- or ratepayer-subsidized renewable generation and energy conservation has been the elevated role of natural gas in electricity generation. Not only is natural gas significantly cleaner burning and less expensive than a decade ago, it has increasingly become the "fuel of choice" for new generation capacity. The eco-energy planning agenda for electricity generation--developed with coal and fuel oil in mind--must now be reconsidered. Such a reconsideration places in question some of the most important public policy missions of government energy agencies, from the California Energy Commission (CEC) to the U.S. Department of Energy (DOE).

This study has six parts. The first defines eco-energy planning and differentiates it from market-based energy environmentalism. The second details the economic and environmental problems of wind power, the most favored renewable energy alternative. The third presents the problems of the other major renewables, including "negawatts," the environmentalist euphemism for subsidized energy conservation. The fourth is a study of the major challenges to eco-energy planning posed by the ongoing restructuring of the electricity industry. The fifth is a description of new developments with natural gas that have made it a benchmark for environmental comparison in the United States if not abroad. Finally, the author considers the public policy implications of the conclusions for the DOE, state public utility commissions, and state-level energy commissions.

Eco-Energy Planning

Eco-energy planning is a public policy paradigm favoring taxpayer and ratepayer subsidies and governmental mandates for renewable generation and energy conservation to promote "sustainable" energy development. With the end of energy shortages in the 1970s, the focus of federal energy policy shifted from price and allocation regulation to reducing fossil-fuel consumption to address ozone formation, acid rain, and climate change. [1] The key assumption of eco-energy planning is that state and federal air-emission standards alone are inadequate to address the public policy issues described.

The new (post-1980) mission of many state public utility commissions, the CEC, and the DOE has been to intervene in the market with incentives for renewable energy generation and conservation, particularly in the electricity- generation sector. Those government interventions or special preferences have included the following supply-side and demand-side alternatives:

Supply side:

- tax code preferences for renewable energy generation (federal and state); [2]
- ratepayer cross-subsidies for renewable energy development (state);
- mandatory utility purchases of power generated by renewable energy sources at the utilities' "avoided cost" (federal/state);
- imputed environmental costs ("full environmental costing") to penalize fossil-fuel-generation planning choices (state);
- fuel diversity premiums to penalize reliance on natural gas for power generation (state);
- government payments for renewable energy research, development, and commercialization (federal and state); and
- early entry into open-access programs for renewable energy generation (state).

Demand side:

- taxpayer subsidies for energy-efficiency programs (federal and state);
- ratepayer subsidies for energy efficiency, called demand-side management (state); and
- minimum energy-efficiency building and appliance standards (federal and state).

The cumulative taxpayer and ratepayer investment in the alternatives listed is substantial. The DOE has spent approximately $19 billion since its inception on electricity conservation ($8 billion-$9 billion) and nonhydro renewables ($10.7 billion), in 1996 dollars. [3] State demand-side management programs add approximately $16 billion more, as is explained in the subsection on Negawatts. The $30 billion to $40 billion cumulative 20-year investment--not including the substantial private costs associated with building and appliance energy-efficiency standards--represents the largest governmental peacetime energy expenditure in U.S. history, outranking the Strategic Petroleum Reserve program to date as well as the cumulative expenditure of the 1974-88 synthetic fuels program.

Eco-energy planning is presently confronting three major obstacles:

- renewable energy options, prominently including hydroelectricity and now wind power, have environmental drawbacks that have proven intractable to date;
- renewable energy subsidies and mandatory energy conservation are proving to be incompatible with a competitive restructuring of the electricity industry because of unfavorable economics and surplus existing capacity; and
- economic and environmental advances in the fossil-fuels industry, particularly in the use of natural gas in electricity generation and reformulated gasoline in transportation, [4] have reduced the environmental costs of fossil-fuel consumption necessary to justify subsidized alternatives to fossil fuels.

In contrast to eco-energy planning, *market-based* energy environmentalism relies on private property, tort redress, and market incentives to address environmental degradation. [5] Secondary, ad hoc programs to reduce energy consumption or substitute alternative energy technologies are rejected either as wholly unnecessary or as inefficient. They are unnecessary given the alternatives of amending the primary air pollution standards and programs with market-based regulations or tort redress, or both. They are inefficient, given the demonstrated inability of government regulators to intelligently plan the energy economy.

In sum, eco-energy planning is predicated on the idea that energy markets are so riddled with imperfections (largely because the environmental costs of consumption are not entirely accounted for in the pricing system) that major interventions are necessary to efficiently manage society's energy choices. Market-based energy environmentalism rejects the idea that the energy economy is rife with "market failures" and questions the idea that government regula-tors--no matter how intelligent or well-intentioned--can improve upon the private choices of millions of economic agents in the free market. Market-based energy environmentalists maintain that the best way to ensure the efficient use of both economic and environmental resources is to rely on undistorted price data and governmental protection of private property rights.

Problems of Wind Power

Of immediate concern to eco-energy planning is wind power, beloved as a renewable resource with no air pollutants and considered worthy of regulatory preference and open-ended taxpayer and ratepayer subsidies. Despite decades of liberal subsidies, however, the cost of generating electricity from wind remains stubbornly uneconomical in an increasingly competitive electricity market. Many leading wind-power providers have encountered financial difficulty, and capacity retirements appear as likely as new projects in the United States without major new government subsidy. [6]

On the environmental side, wind power is noisy, land- intensive, materials-intensive (concrete and steel, in particular), a visual blight, and a hazard to birds. The first four environmental problems could be ignored, but the indiscriminate killing of thousands of birds--including endangered species protected by federal law--has created controversy and confusion within the mainstream environmental community.

Unfavorable Economics

Relative prices tell us that wind power is more scarce than its primary fossil-fuel competitor for electricity generation--natural gas, used in modern, state-of-the-art facilities (known in the industry as combined-cycle plants). [7]That is because wind power's high up-front capital costs and erratic opportunity to convert wind to electricity (referred to as a low capacity factor in the trade) more than cancel out the fact that there is no energy cost for naturally blowing wind. [8]

Low capacity factors, and still lower dependable on- peak capacity factors, are a source of wind power's cost problem. In California, for instance, where some 30 percent of the world's capacity and more than 90 percent

of U.S. wind capacity is located, wind power operated at only 23 percent realized average capacity in 1994. [9] That compares with nuclear plants, with about a 75 percent average capacity factor; coal plants, with a 75 to 85 percent design capacity factor; and gas-fired combined-cycle plants, with a 95 percent average design capacity factor. [10] All those plants produce power around the clock. Wind does not blow around the clock to generate electricity, much less at peak speeds.

Peak demand for electricity and peak wind speeds do not always coincide. [11] A study by San Diego Gas & Electric in August 1992 concluded that wind's dependable on-peak capacity was only 7.5 megawatts per 50 MW of nameplate capacity (a 15 percent factor). [12] The CEC consequently has recalculated the state's 1994 wind capacity from 1,812 MW to 333 MW, an 18 percent dependable capacity ratio. [13]

The cost of wind power declined from around 25 cents per kilowatt-hour in the early 1980s to around 5-7 cents (constant dollars) in prime wind farm areas a decade later. [14] By the mid-1990s, wind advocates reported that a new generation of wind turbines had brought the cost down below 5 cents per kWh and even toward 4 cents per kWh in constant dollars. [15] A DOE estimate was 4.5 cents per kWh at ideal sites. [16] However, even at the low end of the cost estimate, the total cost of wind power was really around 6-7 cents per kWh when the production tax credit and other more subtle cost items were factored in, as discussed later. The all-inclusive price in the mid-1990s was approximately *double* the cost of new gas-fired electricity generation--and *triple* the cost of existing underused generation.

The total cost of wind power is higher than the advertised estimates for several reasons.

1. Wind receives a 1.5 cent per kWh federal tax credit, escalating with inflation, which is approximately one-third of its (as-delivered) selling price. Accelerated depreciation is also given to wind-powered facilities, further lowering their tax rate. Gas-fired electricity generation does not have a tax credit or an option of accelerated depreciation, and natural gas extraction has a total deduction (primarily a scaled-back percentage depletion allowance) of less than 2 percent of its wellhead price. [17] State severance taxes, which totaled $45 billion for oil and gas extraction between 1985 and 1994, swamp the wellhead deduction. [18] Thus wind power's entire tax credit should be added back in for an apples-to-apples comparison with gas-fired alternatives. Local tax incentives for wind, such as in California, would increase the add-back.
2. Low-cost wind depends on select sites with strong, regular wind currents (Class 4 and above wind speeds), whereas other power generation facilities can be built in larger increments in far more places, or converted or repowered in existing locations. Remote wind sites [19] often result in additional transmission line construction, estimated to cost as much as $300,000 to $1 million per mile, [20] in comparison with locally sited gas-fired electricity. The economics of transmission are poor because, although the line must be sized at peak output, wind power's low capacity factor ensures significant underutilization. That adds 0.5 cent per kWh, sometimes more and sometimes less, to the levelized cost of wind. [21]
3. Because wind is an intermittent (unpredictable) generation source, [22] it has less economic value than fuel sources that can deliver a steady, predictable source of electricity. Utilities obligated to provide firm service must either "firm up" the intermittent power at a premium (estimated by power traders to be around 0.5 cent per kWh) [23] or penalize the provider of interruptible supply. Output uncertainty also increases financing costs of outside lenders compared with more predictable, proven power generation. [24] Therefore, a premium has to be added to the interruptible wind rate to compare it with firm generation alternatives such as gas-fired combined-cycle plants.
4. Wind power becomes more expensive if any account is taken of negative environmental externalities as mainstream environmentalists do for fossil-fuel plants (full-cost pricing). Whereas coal and gas plants have incurred higher costs for emission reductions pursuant to Clean Air Act mandates (and in some cases have been penalized in resource planning decisions where state regulators add "externality adders" to plant costs), no penalty has been imposed for the environmental problems of wind farms--noise, land disruption, visual blight, avian mortality, and air emissions associated with

the incremental materials required in wind turbine construction. [25] Neither has there been an allowance for the substantial social cost of taxpayer subsidies. [26]

All-inclusive wind prices, factoring in the hidden incremental costs mentioned, are quite different from the advertised price of new wind capacity. [27] Complained San Diego Gas and Electric about its "winning" wind-power bids of about 8 cents per kWh in a 1993 auction,

SDG&E observes that the resulting price to wind developers of 6-6.5 cents per kilowatt-hour when added to the 1.8 cent [federal and state] tax credit is so far above the five cents/kilowatt- hour revenue wind developers have reportedly claimed they require as to indicate that the BRPU auction would result in unfair costs to consumers. Before the [California Public Utilities] Commission commits to such high prices, wind developers should be asked to explain why the price customers must pay to them is so much higher than what they claim they need. [28]

San Diego Gas & Electric's bid experience was approximately the same as the calculated cost of a proposed (but more recently canceled) 45 MW wind project in northern California that would have sold power to the Sacramento Municipal Utility District. [29] A new 35-MW wind-power project in West Texas, where the winds are better, has a 25-year fixed-price contract for 4.7 cents per kWh. Adding in the federal tax credit, 0.5 cent per kWh for incremental transmission expenses for the 400-mile trip to Austin, and 0.5 cent for nonfirm delivery, however, the cost is around 7 cents per kWh from the get-go--not including the implicit costs due to the incidence of off-peak production and higher financing costs.

A December 1996 report from the Northwest Energy System, a group of electricity stakeholders in the Pacific Northwest, including environmental groups, reconfirmed the severe economic plight of wind as well as other renewable energies.

Utility-scale solar, wind and geothermal technologies still are more expensive than gas-fired combustion turbines and current market prices. . . . Several renewable resource projects designed to confirm various technologies under Northwest conditions . . . are anticipated to produce electricity that is from one and one-half [wind] to four times [geothermal] more costly than gas-fired combustion turbines. [30]

That estimate for wind does not account for implicit costs, which would add approximately 1 cent per kWh to its price, making it double the cost of gas-fired generation and triple the cost of widely available economy energy in the Pacific Northwest.

Paul Gipe, in his treatise on wind power, estimates that the best technology (as of 1995) could deliver wind power for $1,050 per kW, or for between 7.5 and 8.3 cents per kWh. [31]This estimate, adding the incremental costs discussed earlier, again confirms the conclusion that as of the mid-1990s wind energy was double the cost of new gas-fired generation and triple the cost of surplus energy (called economy energy, which refers to the price of electricity on the spot market).

New gas-fired combined-cycle capacity in the same period, the early to mid-1990s, could generate electricity for between 3 and 5 cents per kWh, according to the Federal Energy Regulatory Commission (FERC). [32] San Diego Gas & Electric and the Sacramento Municipal Utility District estimated the cost of their gas-fired generation alternative at about 4 cents per kWh. [33] This is firm generation with the flexibility to be located near customer demand; thus it avoids the subtle costs that wind faces.

A gas-fired project can even lock in long-term gas prices to remove price risk for consumers and ensure a price saving over renewable-energy projects with relatively high capital costs. The advantage is imperviousness to short-run gas prices, even a near doubling of prices such as occurred last winter. Because of a "backwardation" curve, long-term prices became substantially below near-term prices, reflecting the

long-term supply optimism of the market. [34] The result was that 10-year fixed gas prices and the resulting price of electricity were little changed. [35]

It is erroneous to conclude that even if wind is not competitive now, it soon will be. Wind is competing against improving technologies and the increasing abundance of natural resources. The cost of gas-fired combined-cycle plants--the most economical electricity-generation capacity for central-station power at present--has fallen in the last decade because of improving technology and a 50 percent drop in delivered gas prices adjusted for inflation. [36] The energy-efficiency factors of gas turbines have increased from just above 40 percent in the early 1980s to nearly 60 percent today. [37] Forecasts by the DOE and other sources expect continued efficiency improvements in the years 2000 through 2015 for gas-fired generation. [38] One forecast is that new gas-fired generation of virtually any capacity will cost from $200 to $450 per kW, generating power at 2 cents per kWh. [39]

To illustrate the point, compare the most recent nominal levelized prices of advanced wind technologies operating in prime wind areas with new-generation gas turbines. Long-term fixed-price wind contracts are available at about 3 cents per kWh (nominal) in prime areas, translating into an all-inclusive price of 5 to 6 cents per kWh (a price that factors in the tax preferences and other implicit costs, as discussed). The price of combined-cycle gas turbines in 1996-97 also has reached new lows, between $400 and $500 per kW, bringing electricity below 3 cents per kWh and even below 2.5 cents per kWh in select regions such as the Pacific Northwest, where natural gas prices are the lowest. That suggests that the historic delivered-price discrepancy still holds and may continue to hold. Indeed, technological change can be congruent between different energy technologies, and falling gas prices and electricity prices from gas-fired generation are lowering wind turbine costs as well. But even if the gap were cut in half, a 50 percent premium for new wind capacity is substantial.

Head-to-head comparison of wind power and other generation alternatives for new generation capacity is mostly a hypothetical debate. An even greater competitive problem for wind, and an environmental problem as well, [40] has been and continues to be surplus sunk-cost capacity with very low incremental costs that exists in many markets around the country. California, in particular (where the U.S. and world wind-power industry is centered), [41] has had substantial surplus gas-fired capacity that in the early to mid-1990s was generating electricity for as little as 2 cents per kWh. [42] New wind capacity had to compete with 2-cent existing power, not 3-cent new power, which made new wind capacity between 100 percent and 300 percent more expensive than the relevant competition. That insurmountable competitive disadvantage for wind, ironically, had been created partly by California's multi-billion-dollar investment in demand-side management programs, which idled gas-fired capacity and helped to remove the need for new generation capacity in the state. [43]In northern California, where the state's wind industry is concentrated, new capacity is not forecast by the CEC until 2004. In southern California, where the solar industry is centered, new capacity is not forecast until 2005. [44] Moreover, this gas-fired capacity, experiencing use rates of 30 percent and less because of low demand, [45]has been retrofitted pursuant to California's stringent air quality rules to become virtually environmentally benign. [46]

The surplus capacity problem for prospective wind power exists outside California as well. Most other regions have surplus gas-fired (if not coal-fired) generating capacity, particularly off-peak, and that surplus will increasingly become national as electricity-industry restructuring makes the grid more interconnected.

The analysis just given pertains to central-station wind power. Regarding residential wind systems, the American Wind Energy Association states, "As a general rule of thumb, a turbine owner should have at least a 10 mph average wind speed and be paying at least 10 cents per kWh for electricity." [47] Properties need to be one acre or more to support an 80- to 120-foot tower, and noise levels "about half as much as . . . a lawn mower" can be expected. [48]

Assuming optimal wind speeds and the right-sized property, the 10-cent criterion at the residential level leaves 11 states--Alaska, California, Connecticut, Hawaii, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont--as potential sites. [49] With the impending restructuring of the electricity industry (to be discussed), 10-cent electricity will become a thing of the past in the lower 48 states. Opening the national electricity grid likely will equalize rates across state boundaries and reduce the nation's 8 cent per kWh average residential rate, leaving still fewer economic applications.

Ratepayer and Taxpayer Subsidies

Ratepayer and taxpayer subsidies to wind power have been substantial for two decades. Ratepayers typically pay three times more for wind power than they would pay for electricity in today's spot market, [50] and the premium could be higher. The obligation stems from the Public Utility Regulatory Policies Act of 1978 (PURPA), which requires utilities to purchase power from "qualifying facilities" at the utility's "avoided cost." [51] PURPA, concluded one study, "almost single-handedly created the renewable energy industry." [52] California became the nation's renewable energy capital when its public utilities commission instructed utilities in the state to enter into PURPA contracts at avoided costs that soon escalated far above market prices. Standard Offer no. 4 contracts, awarded to qualifying facilities in California between 1982 and 1988, in particular, were predicated on oil prices' approaching $100 per barrel. [53] Thus, the State Utility Commission's avoided-cost guidelines locked in prices that today are about 12 cents per kWh. [54] With many of the contracts reverting to market prices (about 2 to 3 cents per kWh) in the 1996-98 period, many renewable projects face retirement without new government help. [55]

PURPA's encouragement of renewables was augmented by preferential state and federal tax treatment of renewables. Between 1978 and 1986--the period in which tax preferences were greatest--such preferences funneled as much as $2.0 billion to renewable energy projects. [56] During that time, the combined California and federal investment tax credit was as high as 50 percent, a two-year payout. [57] That incited a flurry of first-generation wind capacity that encountered operational problems and hurt the entire industry's credibility. [58] "Wind farms," concluded one study, "were sometimes operated as tax farms." [59] Complained another pro-wind study about the "sledgehammer" approach, "Some of the early companies knew more about tax minimiza-tion than they did about engineering." [60]

After several years of relatively neutral tax treatment, a tax credit of 1.5 cents per kWh was established in the Energy Policy Act of 1992 [61] for electricity generated with wind and closed-loop (organic) biomass. The credit applied to such qualifying facilities placed in service between 1993 and 1999. Phasing down began at a reference price of 8 cents per kWh; the tax credit was to be phased out at a reference price of 11 cents per kWh. Both the 1.5 cent and 8 cent rates would increase with inflation beginning with 1994 generation. [62] The production tax credit is currently set to expire on June 30, 1999.

For government and nonprofit entities that could not use the tax credit, the secretary of energy was authorized to make "incentive payments" of 1.5 cents per kWh (adjusted for inflation from base year 1993) for all renewable electricity-generation technologies, excluding hydroelectricity and municipal solid waste. [63] The tax credit was for 10 years and applied to qualifying facilities placed in service between October 1993 and September 2003. [64]

The DOE spent $900 million (constant 1996 dollars) on wind energy subsidies through fiscal year 1995. [65] Yearly DOE wind expenditures ranged from $10 million in FY90 to a high of $129 million in FY79. The CEC's Wind Program (founded 1977) and Energy Technologies Advancement Program (founded 1984) have provided tens of millions more dollars in wind subsidies. [66] Foreign governments have spent hundreds of millions of dollars (equivalent) more on research and commercialization. [67]

A conservative estimate of the total U.S. government (i.e., taxpayer) subsidy to wind power totals over $1,200 per installed kilowatt, even greater than the direct capital cost of wind under advanced technology of

around $860 per kilowatt [68] and certainly more than the installed capacity cost of gas-fired combined-cycle plants of approximately $580 per kilowatt. [69] On a dependable capacity or capacity factor basis, the subsidy cost and capital cost premium to market is severalfold greater.

Wind power has proven itself to be a perpetual "infant industry," with its competitive viability always somewhere on the horizon. Proponents have always argued for continued subsidies on the rationale that commercialization is in sight. In 1985 congressional hearings, for example, an executive of the American Wind Energy Association testified that "the goal for this industry, the achievable goal, according to the CEC, is the lowest-cost source of electricity, along with hydro, available to a utility by 1990." [70]

The need for more subsidy continues. The 1995 report of the DOE-appointed Task Force on Strategic Energy Research and Development (Yergin task force), [71] concluded that $350 million in future research and development funding was still needed for "wind characterization, aerodynamics, structures and fatigue, and advanced concepts and components." [72]

What the Yergin task force fails to consider is that the federal government's crash course in wind-related research and development has been a bust to date, and further commitment may be doomed as well. Gipe, one of the nation's leading advocates of wind energy, has pronounced the U.S. effort through the early 1990s "a chimera . . . nothing more than 'welfare for the educated.'" [73] He explains,

The United States lavished nearly half a billion dollars on the aerospace industry from 1974 to 1992 [for wind-power R&D]. . . . [Yet] with the exception of U.S. Windpower's model 56-100, none of the U.S.-designed machines in California can be called a success. . . . By the mid-1990s there were no major U.S. manufacturers selling commercially proven wind turbines to independent developers in the United States and there were practically no U.S. wind turbines operating in Europe. [74]

One byproduct of DOE centralization and largesse has been the professional corruption of the American Wind Energy Association, which, Gipe states, fell into the trap of measuring its success by the size of taxpayer subsidies. [75]

The aggregate ratepayer and taxpayer commitment makes the embedded cost of wind power, conservatively estimated at 10 cents per kWh, [76] one of the highest for any kind of electricity generation in the present era. Wind power ranks with high-cost nuclear generation (above 10 cents per kWh compared with average generation costs of 4 cents per kWh), [77] synthetic oil (around $57 per barrel versus spot crude of around $20 per barrel), [78] Strategic Petroleum Reserve oil (around $60 per barrel versus crude of $20 per barrel), [79] and synthetic natural gas ($3 to $7 per MMBtu versus spot gas of around $2 per MMBtu). [80]

The "Avian Mortality" Problem

The universal rationale for the massive public commitment to wind power is that it is environmentally benign. But wind power has at least one major environmental problem--the killing of bird populations--that has begun to cause serious concern among mainstream environmentalists.

Wind blades have killed thousands of birds in the United States and abroad in the last decade, including endangered species, which is a federal offense subject to criminal prosecution. [81] Although bird kills are not considered a problem by everyone, they are a problem for environmental groups that lobbied to put the laws on the books, made cost assessments for dead birds and other wildlife after the *Valdez* accident, and vilify petroleum extraction activity on the North Slope of Alaska as hazardous to wildlife. [82] Such groups as the Sierra Club and the National Audubon Society have criticized wind power's effects on birds, but many eco-energy planners have ignored the problem in their devotion to wind power, in light of the limited number of acceptable alternatives.

There have been numerous mentions of the "avian mortality" problem in the wind-power literature (the Sierra Club labeled wind towers "the Cuisinarts of the air"). [83] An article in the March 29-April 4, 1995, issue of *SF Weekly* was particularly telling. The cover story in the San Francisco newspaper was no less than an exposé, written not by a free-market critic but by an author sympathetic to the environmental agenda.

The article concerns the world's largest wind-power farm, the 625 MW Altamont Pass project, owned by independent developers with long-term purchase contracts with Pacific Gas and Electric. Some major points of the article follow. [84]

- "It now appears that windmills are annually killing *thousands* of birds worldwide [including] . . . red-tailed hawks, American kestrels, turkey vultures, assorted owls--and federally protected species like *Aquila chrysaetos*, the golden eagle. And it turns out that the Bay Area . . . is the windmill bird-death capital of America."
- The National Audubon Society has called for a moratorium on new wind farms until the bird kill problem is solved, a position that the wind industry opposes.
- Some of the bird kills at Altamont Pass are a federal crime under the Migratory Bird Treaty Act; killing bald eagles is also a crime under the Bald Eagle Protection Act. The U.S. Fish and Wildlife Service is considering prosecution.
- Traditional environmental groups will not condemn wind, which they see as "throwing the baby out with the bathwater." They hope that the mortality is not too great and that current remediation efforts will succeed.
- "So intense has the windmill 'avian mortality issue' become in wind and wildlife circles, some fear for their jobs if they speak out; others fear for their research dollars, while the companies fear for their futures."
- "How many dead birds equal a dead fish equals an oil spill?" asks the author. One wind energy expert responds, "The trade-offs aren't easy--there aren't any charts or formulas to guide you."
- Environmentalists blocked a proposed wind farm in eastern Washington state because of the avian mortality problem.
- Federal money is going toward trying to find a solution to the bird kill problem, such as a study by the DOE's National Renewable Energy Laboratory.

Author Amy Linn pointedly concludes her article:

By accepting the compromises of the real world and enthusiastically supporting the establishment of the wind industry, [environmentalists] entered the devil's bargain that now prevents them from fighting the power companies. . . . Here in the almost wilds of Altamont Pass, the environmentalists and Kenetech have reached the point where solutions become problems--the point at which there is blood on the answer. [85]

The avian mortality problem of wind power is different from bird mortality due to stationary objects. Explained one study, "Wind farms have been documented to act as both bait and executioner--rodents taking shelter at the base of turbines multiply with the protection from raptors, while in turn their greater numbers attract more raptors to the farm." [86]

"How many dead birds equal a dead fish equal an oil spill?" Ten thousand cumulative bird deaths [87] from 1,731 MW of installed U.S. capacity are the equivalent of 4.4 million bird deaths across the entire capacity of the U.S. electricity market (approximately 770 GW). A 20 percent share of U.S. capacity, a figure that the American Wind Energy Association forwarded some years ago in congressional hearings (see above), would equate to 880,000 cumulative bird deaths. Calculated on an average operating capacity basis, the number would rise severalfold. Not every potential wind farm would be an Altamont Pass, which was sited to be near existing transmission systems with little thought to bird activity, but the mortality-per-megawatt ratio of existing capacity should give pause.

A 1992 study commissioned by the CEC "conservatively" estimated that 39 golden eagles were being killed at Altamont Pass each year, a significant figure given a total population of 500 breeding pairs. [88] On a percentage basis, the mortality rate per year at Altamont Pass under the estimate is eight times greater than the bald eagle kill from the Valdez oil spill in Prince William Sound in 1989, and it recurs every year. [89]

American kestrels and red-tailed hawks also were considered at risk from Altamont Pass, according to the CEC study. Although those facts could be ignored by the pro-wind-power community, the National Audubon Society's call for a moratorium on wind-power projects in bird-sensitive areas (a position spearheaded by Audubon's San Francisco chapter) cannot. Jan Beyea, Audubon's vice president for science policy, explained the national chapter's stand:

We do not want to see the wrong types of wind turbines built, nor do we want to see them built in the wrong places. That is why I, and some Audubon chapters, have called for a moratorium on new wind developments in important bird areas. This has gotten some of our environmental friends worried and some in industry very angry. The National Audubon Society is not taking such a strong position because of a concern for individual bird kills; rather, we are concerned about possible impacts on populations in the decades ahead when wind turbines may be all over the country. [90]

Beyea elsewhere expressed specific concern about

golden eagles in California and the situation with the griffon vulture in Spain. We are also wondering what's going to happen to cranes and ducks that migrate through Nebraska, Kansas, and the Dakotas. [91]

With opposition from local Audubon chapters in Maine, Oregon, and Washington, Beyea warned that "wind-power could face the same fate as low-head hydro, which was dropped from the environmentalist agenda and from significant government support, even though, in fact, there may have been a middle ground that could have been located through dialogue." [92]

The problem of avian mortality is not unique to the United States. *Windpower Monthly* reported that the largest wind farm in Europe was "wreaking havoc with the natural order of raptor life on two continents." [93]The feature story added:

The data collected so far include telling photographs of decapitated vultures that collided with some of the site's 269 wind turbines [that were] . . . either killed on impact or by electrocution on power cables. All of the species are protected by Spanish and European Union law. [94]

The From the Editor section of the same issue echoed the concerns of the National Audubon Society, explaining as follows its decision to show on its cover a full-color photograph of a bloody vulture cut in half by a windmill blade:

The decision to print this month's cover was not taken lightly. It will have a significant impact, both on the world of wind power and elsewhere. . . . There is a real problem with bird deaths at Tarifa. It cannot be kept quiet and it will not go away of its own accord. . . . There are parallels between the problems of raptors in the Altamont Pass . . . and the Tarifa controversy. [95]

Proponents of wind power have argued that the bird death problem is being effectively addressed and should not slow the growth of the industry. Yet the problem, which has been studied since the mid-1970s, [96] continues unabated two decades later. [97] Like the claims that wind power will soon be economic, claims that (in the words of a U.S. Windpower representative) "we have almost met our objective of being an environmentally benign power resource" [98] ring hollow. Even if a technological breakthrough addressing bird kills is achieved (which is certainly possible), any incremental cost of using that technology would further worsen the competitive plight of wind power.

Other Environmental Drawbacks

A distinct air-emission problem of wind capacity is created when a new project is built where there is surplus electricity-generating capacity. Because wind farms require hundreds of tons of energy-intensive materials, virtually all of the air emissions associated with the gas or electricity used to make the materials (such as cement or steel) must be counted against the "saved" air emissions once the farm comes on line and displaces fossil-fuel-generated output. For a recently announced wind farm of 45 effective MW, for example, the emissions associated with 10 million pounds of materials must be calculated. [99] If there were not surplus capacity, on the other hand, only the incremental emissions associated with constructing a wind facility instead of a fossil-fuel facility would be used. Although not calculated here, the air emissions associated with the construction of wind capacity that is not needed to meet either peak or baseload demand would be substantial enough to create an environmental externality from the viewpoint of its proponents.

Wind power's land disturbance, noise, and unsightly turbines also present environmental drawbacks, at least from the perspective of some if not many mainstream environmentalists. Yet at least one well-known environmental group has a double standard when considering wind power versus other energy options. In testimony before the California Public Utilities Commission (CPUC), Ralph Cavanagh of the Natural Resources Defense Council argued against opening the electricity industry to competition and customer choice because of the

development of significant new transmission and distribution lines to link buyers and sellers of power. In addition to the visual blight of additional power lines on the landscape, these corridors can displace threatened or endangered species. [100]

Christopher Flavin of Worldwatch Institute applies the same rigorous standard to gas development that "at least for a time, mars the landscape with drilling rigs, pipelines, and other equipment." [101]

Yet Altamont Pass's 7,000 turbines (located near Cavanagh's San Francisco office) have a record of sizable avian mortality, large land-use requirements, disturbing noise, and "visual blight." [102] The irony of visual blight was not lost on environmental philosopher Roderick Nash, who, referring to the Santa Barbara environmentalists, asked, "If offshore rigs offend, can a much greater number of windmills be any better?" [103]

Wind (like solar) "mars" the landscape all the time, not "at least for a time." [104] Environmentalists have raised concerns over erosion from service roads cut into slopes (an important problem for California, where mud slides are a hazard), [105] "fugitive dust" from unpaved roads, [106] flashing lights and the red-and-white paint required by the FAA on tall towers, [107] rushed construction for tax considerations, [108] fencing requirements, [109] oil leakage, [110] and abandoned turbines. [111] The "not in my back yard" problem of wind turbines may seem a trivial nuisance for urbanites, but for rural inhabitants, who "choose to live in such locations . . . primarily because the land is unsuitable for other urban uses," [112] there is an environmental cost.

The ancillary environmental problems are not minor, even to wind power's leading proponents. Gipe, author of *Wind Power for Home & Business* and *Wind Energy Comes of Age*, in an October 15, 1996, letter to the chairman of the CEC, called for a moratorium on new wind subsidies until the problems of previous construction were addressed. Stated Gipe,

I am a longtime advocate of wind energy in California and my record in support of the industry is well known. I have chronicled the growth of California's wind industry for more than twelve years. It therefore pains me greatly to urge the Commission to . . . recommend to the legislature that no funds from the [California Competition Transition Charge] be distributed to existing or future wind projects in the state. Funds that were destined for this purpose should instead be deposited in a wind energy cleanup fund to be

administered by the Commission. Money from this fund could then be used to control erosion from plants in California, to remove abandoned and nonoperating wind turbines littering our scenic hillsides, and to mitigate other environmental impacts from the state's wind industry. [113]

As Gipe has reminded his audience elsewhere, "The people who build wind farms are not environmentalists." [114] The Union of Concerned Scientists also has been quick to point out "environmental concerns" with wind power, stemming from "not only avian issues, but also . . . the effects of road construction, tree felling, and visual impacts." [115]

Another problem of wind farms appears to be fire and smoke. Summarized one article,

Wind farm operators are feeling the heat from the state Department of Forestry and Fire Protection over blazes in Altamont Pass. Causes range from electrical shorts to exposed wires to flaming birds. [116]

Wind farms also fail the land-use test compared with fossil-fuel alternatives. A wind farm requires as much as 85 times more space than a conventional gas-fired power plant. [117] Gipe estimates the range to be between 10 and 80 acres per megawatt--from 30 to more than 200 times more space than needed for gas plants. [118] Wide spacing (a 50 MW farm can require anywhere between 2 and 25 square miles) is necessary to avoid wake effects between towers. [119] The world's 5,000 MW (nameplate) wind-power capacity in 1995 consisted of 25,000 turbines [120] little bang for the land usage and visual blight buck.

The argument that the actual space used by wind towers is much smaller than the total acreage of wind farms ("as little as 1 percent of the land is actually occupied") [121] is the "footprint" argument that eco-energy planners refuse to consider for petroleum extraction in the Arctic National Wildlife Refuge in Alaska. [122] Consistency aside, "the visual impact of wind turbines on the countryside is one of their most contentious issues." [123]

Another environmental consideration with wind projects is created when they are combined with gas turbine backup to lower the weighted average cost of power and to achieve reliability as a firm source of electricity. Gas-wind hybrids (or gas-solar hybrids) blur the distinction between renewable energy and fossil fuels and beg two questions: why not have a gas-only project, and is the project really needed at all given existing overcapacity?

High Costs as a Virtue: The Jobs Rationale

A jobs-creation rationale for wind power is marshaled by supporters, almost as a last line of defense. The American Wind Energy Association trumpets the fact that about $3.5 billion is invested in the U.S. [wind-power] industry, where watt-for-watt, dollar-for-dollar, that investment creates more jobs than any other utility-scale energy source. In 1994, wind turbine and component manufacturers contributed directly to the economies of 44 states, creating thousands of jobs for American communities. [124]

The high-cost propensity of wind power is a negative, not a positive, aspect of the industry. Prices reflect relative scarcity, and the price of wind-power energy is substantially higher than the price of electricity from other sources. Resources devoted to wind power are thus wasted in an economy where wants are greater than the resources available to meet them, and better alternatives are forgone. Without subsidies, less renewable energy infrastructure would have been built and consumers would have had lower cost electricity. The saved resources (land, labor, and capital) would have gone to a more competitive source of electricity or, more likely, given electricity-generation overcapacity, to a different endeavor entirely. Electricity consumers, in turn, would have incremental savings to spend elsewhere in the economy. The result of wind-power investments in California is the existence of an uneconomic renewable energy industry and an underused natural gas infrastructure. Consequently, it has contributed to artificially high rates and a substantial ratepayer surcharge for stranded cost recovery (jargon for generation facilities and third-party contracts

incapable of delivering power at competitive prices in a restructured market; utility companies argue that the public should compensate them for those now uneconomic investments) in the restructuring period.

Subsidizing renewable energy for its own sake is akin to "creating" jobs by digging holes and filling them back up. The fundamental law of economic efficiency--"employ[ing] the available means in such a way that no want more urgently felt should remain unsatisfied because the means suitable for its attainment were employed for the attainment of a want less urgently felt" [125] is violated.

Proponents of renewable subsidies argue that if the subsidies do not continue, U.S. firms will lose out to foreign firms whose governments will continue to subsidize them. [126] Tax incentives and government grants are sparking new wind-power capacity in a variety of countries. [127] The subsidies have resulted in "many strong European and Japanese competitors in the market place . . . actively marketing products internationally." [128] Concluded the Yergin task force,

Continued cost reductions fostered by [DOE's] strategic research, development, and deployment activities can ensure the United States a place in an emerging multibillion-dollar clean energy market. The establishment of footholds by U.S.-based firms in international sales activity is clearly vital. [129]

Warnings that foreign companies will replace U.S. renewable energy companies just when commercialization is in sight have been heard since the 1980s [130] another argument that is wearing thin. Not surprisingly, however, U.S. companies are finding the best markets abroad where electricity is more scarce and the cost of new power is higher. Whereas almost 80 percent of the world's wind-power capacity was based in the United States in 1990, less than 50 percent is in the United States today. [131] If U.S. subsidies contract, the wind-power industry will likely be a foreign-subsidized experiment rather than a U.S.-subsidized experiment as in the past.

Today's renewable export industry is a very small portion of total U.S. energy-related export activities. A $500 million annual renewable export industry accounts for under 1/10 of 1 percent of the total U.S. export market. [132] Unwise and uneconomic subsidies abroad do not justify unwise and uneconomic investments at home. Should foreign subsidies result in major technological breakthroughs to make wind power economically and environmentally viable in niche markets, the United States can "free ride" by importing the technology or equipment, or both. U.S. ratepayers and taxpayers would be spared, and, in fact, U.S. consumers would have been advantageously subsidized by foreign taxpayers or ratepayers.

A Dying--or Resurrected--U.S. Industry?

A 1976 study by the DOE estimated that wind power could supply close to one-fifth of all U.S. electricity by 1995, a fact trumpeted by the American Wind Energy Association in congressional hearings in 1984. [133] Going into 1996, instead of 20 percent, wind had a 1/10 of 1 percent share of the U.S. electricity market--an overestimate of 20,000 percent.

In 1995 and 1996, the U.S. wind-power industry was very sick if not on its deathbed. National production was down in 1995. California's wind-power capacity had fallen from its 1991 peak, [134] leading a spokesperson of the CEC to conclude that "the wind energy industry in California has reached a plateau in its growth cycle." [135] An even greater dropoff was feared when wind power's PURPA contracts--scheduled to pay as much as 14 cents per kWh for some 650 MW of wind capacity in California alone--were scheduled to expire. [136] With the going market rate for spot generation estimated to be 2 cents per kWh, existing facilities with old technology, low capacity factors, and high maintenance faced retirement without new subsidies. [137] Plant modernization, such as proposed for Altamont Pass by Kenetech, also faced uncertainty given competition from sunk-cost capacity, the possible loss of tax credits from tax reform, and problems with the company's new technology (KVS-33 blades). [138]

Kenetech, the market leader in the United States, declared bankruptcy in the spring of 1996 because of equipment problems at existing sites and a dearth of new business. [139] WindMaster went to a skeleton crew. Other firms such as FloWind and Cannon cut staff significantly. [140] Existing projects, operating under long-term operation and maintenance agreements with the same companies, faced new uncertainties--one reason why the Sacramento Municipal Utility District canceled Phase II of its Kenetech wind farm project in the spring of 1996. [141] Numerous complaints were heard at state and federal forums that the industry would not survive without redoubled government support in an intensely competitive, restructured industry.

In an earlier draft of this study, I wrote,

Only a sizable taxpayer or ratepayer bailout will prevent the large majority of the state's heavily indebted wind-power capacity from going the way of synthetic oil and gas production. The "power surge" from wind to help fuel "the coming energy revolution," (as anticipated by the Worldwatch Institute) will require a near miraculous technological turnaround and soon. Evidence exists that this turnaround will have to occur without the taxpayer or ratepayer largesse as in the past. . . . It is ironic yet illustrative how the eco-energy planning supply-side portfolio has contracted over time. Nuclear power was endorsed in the 1960s by the environmental establishment and abandoned in the 1970s. Hydro was endorsed until the 1980s for new capacity. Will wind power, the choice of the 1980s, be abandoned in the 1990s? [142]

Yet in 1997, with state and federal restructuring initiatives promising billions of dollars of new subsidies for qualifying renewables, prominently including wind, and a leading energy company entering the moribund wind-power field, [143] the industry seems to have escaped from the brink. The inordinate political clout of the eco-energy planners once again showed that, while eventual market verdicts cannot be repealed, they can be delayed.

Appendix: Subsidies and Capacity

Table A.1
Department of Energy Civilian Subsidy Program (dollars in thousands)

REAL DOLLAR ANALYSIS	FY 1978	FY 1979	FY 1980	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986	FY 1987
1996=$1.00	Stat	Stat	Stat-D	Stat	Control	Control	Control	Control	Control	Control
Direct Energy Subsidies Per Source:	(1-25-79)	(1-23-80)	(1-12-81)	(2-4-82)	(2-4-83)	(1-20-84)	(6-11-85)	(2-24-86)	(2-10-87)	(2-08-88)
Nuclear	2,772,117	2,360,621	2,058,617	1,810,322	1,765,400	1,629,285	1,143,117	887,831	885,041	840,208
Conservation	1,294,168	1,363,362	1,484,091	1,224,303	236,407	676,006	649,785	667,023	610,116	320,930
Coal	1,608,783	1,526,360	1,437,421	1,259,538	816,147	369,408	361,291	365,535	492,733	483,941
Oil	189,187	217,961	117,509	99,751	63,996	37,413	45,605	46,216	41,677	35,800
Gas	65,939	73,071	58,537	53,531	19,043	21,550	23,256	14,789	12,173	11,009
Wind	88,316	128,708	115,304	133,771	55,931	49,449	39,817	41,347	35,483	22,936
Solar	773,522	802,053	797,187	673,602	291,136	217,097	181,176	157,765	121,293	106,116
Hydro	25,058	84,657	39,870	5,520	4,878	3,144	1,133	652	689	622
Geothermal	296,551	316,352	284,444	233,577	117,234	91,022	48,882	43,481	38,028	28,731
Other Renewables	361,433	394,824	383,424	338,264	186,269	118,565	118,447	107,027	89,444	79,406
Total:	7,475,075	7,267,969	6,776,406	5,832,178	3,556,440	3,212,940	2,612,509	2,331,665	2,326,677	1,929,697
	FY 1988	FY 1989	FY 1990	FY 1991	FY 1992	FY 1993	FY 1994	FY 1995	FY 1996	
	Control	Control	Control	Control	Control4	Cong2	AppCont	Actuals	Actuals	
Direct Energy Subsidies Per Source:	(1-05-89)	(1-26-90)	(1-31-91)	(4-22-92)	(5-05-93)	(3-15-94)	(2-01-95)	(3-28-95)	(2-5-97)	TOTALS
Nuclear	790,944	771,706	409,126	380,984	413,108	376,561	383,976	231,644	143,071	20,053,679
Conservation	408,910	397,070	439,494	530,946	571,791	608,624	708,365	551,827	552,893	13,296,111
Coal	571,147	544,210	988,571	778,716	767,707	257,013	410,119	124,573	119,625	13,282,838
Oil	39,078	48,480	46,859	68,190	63,175	66,900	78,634	57,654	54,935	1,419,021
Gas	13,971	14,404	17,321	18,280	13,892	31,509	100,364	115,307	109,790	787,735
Wind	11,226	11,084	10,428	12,799	23,800	25,887	30,862	31,915	31,420	900,482
Solar	86,278	80,582	74,215	92,995	110,028	113,662	152,036	197,669	106,391	5,134,803
Hydro	0	0	0	1,144	1,150	1,133	1,100	18,531	3,483	192,763
Geothermal	93,871	24,542	20,715	34,578	30,058	25,247	19,596	19,561	29,399	1,795,871
Other Renewables	69,036	70,615	61,701	90,351	105,249	111,714	134,632	47,358	(35,768)	2,831,992
Total:	2,084,460	1,962,694	2,068,431	2,008,982	2,099,958	1,618,250	2,019,685	1,396,039	1,115,239	59,695,295

Source: Department of Energy, Office of Chief Financial Officer; Consumer Price Index, Bureau of Labor Statistics

Table A.2
U.S. 1995 Renewable Energy Capacity (megawatts)

Source	*Utility*	*IPP*[a]	*Total*	*U.S. Percentage*	*U.S. Total*
Hydro	75,274	3,399	78,673	10.2	769,530
Geothermal	1,747	1,295	3,042	0.4	
Biomass	567	10,347	10,914	1.4	
Wind	8	1,723	1,731	0.2	
Solar	4	354	358	0.0	
Photovoltaic	4	-	4	0.0	
Total	77,604	17,118	94,722	12.3	
Nonhydro total			16,049	2.1	

Source: Energy Information Association, *Electric Power Annual*, 1995, vol. 2, Table 1.
a. IPP = independent poser producer.

Table A.3
U.S. 1995 Renewable Energy Capacity (million kilowatt-hours)

Source	*Utility*	*IPP*[a]	*Total*	*U.S. Percentage*	*U.S. Total*
Hydro	293,653	14,774	308,427	9.2	3,356,418
Geothermal	4,745	9,912	14,657	0.4	
Biomass	1,649	56,975	58,624	1.7	
Wind	11	3,185	3,196	0.1	
Solar	-	824	824	0.0	
Photovoltaic	4	-	4	0.0	
Total	300,062	85,670	385,732	11.5	
Nonhydro total			77,305	2.3	

Source: Energy Information Association, *Electric Power Annual*, 1995. vol. 2, Table 1.
a. IPP = independent power producer.

Notes

The author wishes to thank Tom Tanton of the California Energy Commission in particular for his helpful comments. [1]. Although a public policy evaluation of these issues is beyond the scope of this paper, a "worst case" and "best case" can be assumed for externality adders to compare different fuels on an economic and environmental basis. See later subsection, "Greening" Electricity Prices.

[2]. Preferential taxation is not a government intervention in the marketplace or a net economic loss. While nonneutral taxation can be criticized for misallocating resources away from other alternatives to the area of tax preference, less taxation per se allows the private sector to retain earnings and increase activity. This reduction of government takings is differentiable from "corporate welfare." See, for example, the argument in Stephen Moore and Dean Stansel, "Ending Corporate Welfare As We Know It," Cato Policy Analysis no. 225, May 12, 1995, p. 10.

[3]. Department of Energy, Office of Chief Financial Officer, Appropriations History Table, FY 1978-FY 1995, File: Approp. (jjg), updated printout of February 6, 1995. The nominal dollars in this DOE-supplied

Excel spreadsheet were restated in 1996 dollars using the Consumer Price Index. Referred to hereafter as DOE Budget Study.

[4]. This paper will not critically examine federal and state subsidies to renewable transportation energy (ethanol), which accounts for only .4 percent of the transportation market and .01 percent of the total energy market. Energy Information Administration, Renewable Energy Annual, 1995 (Washington: U.S. Department of Energy, 1996),pp. 9, 11.

[5]. For a market-based evaluation of mainstream environmentalism, see Jonathan Adler, Environmentalism at the Crossroads (Washington: Capital Research Center, 1995).

[6]. This subsidy appears to be the case with California's $540 million renewable fund. See the later subsection, Deregulate: Do Not Reregulate.

[7]. Combined-cycle technology, developed in the 1960s from jet engine research, captures waste heat created from primary generation to produce additional electricity. It is the most efficient technology for electricity generation today. See Walter Vergara et al., Natural Gas: Its Role and Potential in Economic Development (Boulder, Colo.: Westview, 1990), pp. 55-57.

[8]. Wind does have operating costs after capital costs become sunk. In addition to costs of periodic maintenance and repair, landowner royalties of between 2 percent and 5 percent of revenue and property taxes are paid. Paul Gipe, Wind Energy Comes of Age (New York: John Wiley & Sons, 1995), p. 403.

[9]. California Energy Commission, Wind Project Performance: 1994 Summary (Sacramento: CEC, August 1995), p. 1. Cited hereafter as Wind Project Performance. Total operating capacity of 1,609 MW produced 3.2 GWh of power in 1994. Ibid., p. 25. An average capacity factor is a broader measure than dependable on-peak capacity because off-peak performance is measured as well.

[10]. Energy Information Administration, Annual Energy Review, 1995 (Washington: Government Printing Office, 1996), p. 261; Resource Data International, Energy Choices in a Competitive Era (Alexandria, Va.: Center for Energy and Economic Development, 1995), p. 6 (cited hereafter as CEED Study); Enron Corp., The Natural Gas Advantage: Strategies for Electric Utilities in the 1990s (Houston, Tex.: Enron Corp., 1992), p. 11.

[11]. Wind, for example, often peaks in the early evening, whereas the demand peak occurs in midafternoon. Se Christopher Flavin and Nicholas Lenssen, Power Surge: Guide to the Coming Energy Revolution (New York: W.W. Norton, 1994), p. 125. See also Alfred Cavallo et al., "Wind Energy: Technology and Economics," in Renewable Energy: Sources for Fuels and Electricity, ed. Thomas Johansson et al. (Washington: Island Press, 1993), p. 151.

[12]. San Diego Gas & Electric, "Response to CEERT's Additional Testimony on Resource Case Analysis," ER-92 Proceedings, California Energy Commission, August 28, 1992, p. 5.

[13]. California Energy Commission, 1994 Electricity Report, November 1995, pp. 94, 97.

[14]. Secretary of Energy Advisory Board, Energy R&D: Shaping Our Nation's Future in a Competitive World: Final Report of the Task Force on Strategic Energy Research and Development (Washington: U.S. Department of Energy, June 1995), Annexes 2-4, p. 184. Hereafter cited as DOE Task Force Study. A DOE study similarly estimated that wind costs had fallen from 50 cents per kWh in 1980 to 5 to 7 cents by 1993. Julie Doherty, "U.S. Wind Energy Potential: The Effect of the Proximity of Wind Resources to Transmission Lines," Energy Information Administration, Monthly Energy Review, February 1995, p. viii. See also

Statement of George Pres-ton, Electric Power Research Institute, Hearing of U.S. Senate Committee on Energy and Natural Resources on the Department of Energy FY 1995 Budget, March 8, 1994, p. 3.

[15]. Conversation with Randall Swisher, executive director of the American Wind Energy Association, March 22, 1996.

[16]. Joseph Romm and Charles Curtis, "Mideast Oil Forever?" Atlantic Monthly, April 1996, p. 64.

[17]. Total oil and gas tax incentives at the wellhead are estimated to be around $1 billion for 1996. Office of Manaement and Budget, Analytical Perspectives, Budget of the United States (Washington: Government Printing Office, 1996), p. 62. With natural gas accounting for approximately 60 percent of total U.S. oil and gas production on a Btu basis, the tax allocation is $0.03 per Mcf of 1995 production, under 2 percent of the 1995 wellhead price of $1.59 per MMBtu. Energy Information Administration, Monthly Energy Review, March 1996, p. 125.

[18]. See Independent Petroleum Association of America, The Oil & Gas Producing Industry in Your State (Washington: IPAA, 1996), p. 103.

[19]. "Wind-driven electricity generating facilities must be located at specific sites to maximize the amount of wind energy captured and electricity generated. However, many good wind energy sites are on ridges or mountain passes, where siting and permitting difficulties, land restrictions, aesthetic objections, the potential for bird kills, and harsh weather conditions often constrain development." Doherty, "U.S. Wind Energy Potential," p. x.

[20]. CEED Study, p. 14. This generic estimate is applicable for a high-voltage (230 kV) line from a wind farm in California, and with substation expenses it would be more. Conversation with Don Kondoleon, supervisor, Transmission System Evaluation Unit, California Energy Commission, February 13, 1996. A lower estimate of $286,000 per mile, based on a study using information from before 1993, is made inJ. P. Doherty, "Wind," in Energy Information Administration, Renewable Energy Annual, 1995, p. 88.

[21]. The 0.5 cent estimate was offered as typical by Randall Swisher and is an actual cost for the 35 MW West Texas wind project of the Lower Colorado River Authority. Conversation with Tom Foreman, manager of Marketing and Energy Services, Lower Colorado River Authority, October 4, 1995.

[22]. "Wind resources cannot yet be predicted with precision for a specific 24 hours in advance." Comments submitted by the American Wind Energy Association to the Federal Energy Regulatory Commission, quoted in "Various Parties Protest California IOU's ISO and Power Exchange Proposals Filed in Response to CPUC Restructuring Order," Foster Electric Report, June 26, 1996, p. 5.

[23]. This differential prevails, for example, at the California-Oregon border pricing point, the most active trading point for spot electricity in the country.

[24]. Doherty, "U.S. Wind Energy Potential," pp. ix-x.

[25]. The material requirements for wind turbines could be 40 to 50 times greater than for gas power plants per unit of output, creating significant incremental electricity consumption and the emissions associated therewith. This rough estimate is made by comparing the materials of the 1,875 MW Teesside gas project in the United Kingdom (circa 1993) with those of the recently announced 112.5 MW Zond project in Iowa. Upstream gas facilities (wellhead, pipeline) would reduce but not negate that differential. For a discussion of this problem with solar facilities, see the later subsection, Solar: The Smaller, the Better.

[26]. For an estimate of the social cost of renewable subsidies, see the later subsection, "Greening" Electricity Prices.

[27]. Artificially low estimates for wind power can also result from substituting a real for a nominal price (where future prices are discounted to the present) and hidden benefits such as utility financing or free land use.

[28]. San Diego Gas & Electric, "Comments on Proposed Policies Governing Restructuring Electric Service Industry and Reforming Regulation," Submitted to the California Public Utilities Commission, June 8, 1994, p. 35.

[29]. Conversation with Marino Monardi, supervising resource planner, Sacramento Municipal Utility District, January 30, 1996.

[30]. Northwest Energy System, "Toward a Competitive Electric Power Industry for the 21st Century," Portland, Ore., December 12, 1996, p. 20. The new-capacity gas cost was 2.93 cents per kWh for 3,356 MW; the new-capacity wind cost was 4.1 cents per kWh for 117 MW and 4.94 cents per kWh for the next 116 MW. Conversation with Jeff King, Northwest Power Planning Council, March 6, 1997.

[31]. Gipe, pp. 238-39.

[32]. Federal Energy Regulatory Commission, "Promoting Wholesale Competition through Open Access Nondiscriminatory Transmission Services by Public Utilities, Recovery of Stranded Costs by Public Utilities and Transmitting Utilities: Proposed Rulemaking and Supplemental Notice of Proposed Rulemaking," 60 Federal Register (April 7, 1995): 17669-70. Another recent estimate--between $0.028 and $0.045 per kWh--is made by Henry Lee and Negeen Darani, "Electric Restructuring and the Environment," Harvard University, Environment and Natural Resources Program Study 95-13, December 1995, p. 65.

[33]. Conversation with Monardi.

[34]. The "backwardation" curve is a result of knowledge of such forthcoming market changes as major pipeline capacity additions in Canada, where surplus gas is selling at a significant discount to U.S. lower-48 gas, expected in late 1998. See U.S. Department of Energy, Natural Gas Imports and Exports, Second Quarter Report, 1996, pp. iii-v.

[35]. For example, 10-year fixed-priced gas in December 1996, when the front month was selling at $4.575 per MMBtu, was $2.635 per MMBtu. Ten-year, fixed-price gas in January 1997, when the front month price fell nearly 50 percent, was $2.555 per MMBtu, only a $0.08 per MMBtu difference. Translated into electric rates, this 3 percent increase in gas prices equates to less than one mill per kWh.

[36]. Energy Information Administration, Natural Gas Monthly, March 1996, p. 11. These statistics have been restated in 1995 dollars using the Consumer Price Index. Higher wellhead prices that began in late 1995 and are continuing in early 1997 are expected to be reversed with new deliverability from the lower 48 states and Canada, explaining the aforementioned backwardation curve.

[37]. Wolfgang Gajewski, "Using Gas for Power Generation," in The Petroleum Economist and Gas World International: Fundamentals of the Natural Gas Industry (London: Petroleum Economist, October 1995), p. 110. Coal plants have also been improved, with a one-half decline in coal input prices and a one-third fall in installed capacity costs in the last 10 to 15 years. CEED Study, pp. 3-9 to 3-10.

[38]. Energy Information Administration, Annual Energy Outlook, 1996 (Washington: U.S. Department of Energy, January 1996), p. 32.

[39]. Joseph Schuler, "Generation: Big or Small?" Public Utilities Fortnightly, September 15, 1996, p. 30.

[40]. Surplus capacity means that all electricity-related air emissions associated with building the wind farm are incremental and must be subtracted from later air-emission displacement.

[41]. "California grew to dominate worldwide wind development during the early 1980's because the state has some of the most energetic winds in North America, and where these occur, low-cost land was abundant; at the time California had the most favorable purchase power rates and the most cooperative utilities in the nation; it had an abundance of wealth; it had a favorable investment climate; and California offered lucrative incentives to match those of the federal government." Gipe, p. 30.

[42]. "Our marginal generation cost for oil in the 1970s and early '80s was six cents per kWh. Today it is two cents per kWh using natural gas." Vikram Budhraja, "Generation as a Business--Fact, Fumbles, Fictions and the Future," Electricity Journal, July 1995, p. 37.

[43]. See Southern California Edison Company, Application for Off-System Power Sales Incentive Mechanism, Application 93-08-006, August 2, 1993, p. 2.

[44]. "[The California Energy Commission's 1994 Electricity Report] demonstrated that there is a sufficient reserve margin within the PG&E service territory [northern California] through 2003." Letter from PG&E to the California Energy Commission, Re: Docket 95-ER-96, January 9, 1996. "Edison agrees with conclusions reached by the CEC in ER 94 that no new resource additions are needed in the Edison system until 2005." Southern California Edison, "Testimony on Submittal of Supply-Side Data," CEC Docket no. 95-ER-96, May 15, 1996, p. 2.

[45]. Institute for Energy Research, "Comments to the California Energy Commission in the Matter of Preparation of the 1994 Energy Efficiency Report and 1994 Electricity Report," April 4, 1995, p. 13.

[46]. See later subsection, The Increasing Environmentalism of Natural Gas.

[47]. American Wind Energy Association, "Is a Residential Wind System for You?" May 1995, p. 1. The up-front costs of a home wind system range from $6,000 to $22,000, with an estimated payout from displaced utility electricity of between 6 and 15 years.

[48]. Ibid.

[49]. Energy Information Administration, Electric Power Monthly, March 1997, p. 76.

[50]. Wind Project Performance, p. 1.

[51]. Public Law 95-617, 92 Stat. 3117 (1978).

[52]. CEED Study, pp. 1-7.

[53]. Ibid., pp. 2-3.

[54]. Ibid. See also Gipe, pp. 33-34.

[55]. CEED Study, p. 2-3. See also later subsection, Deregulate, Do Not Reregulate.

[56]. Sharon Pollard, secretary, Office of Energy and Natural Resources, Testimony, Solar Development Initiative Act of 1987 and the Renewable Energy and Energy Conservation Competitiveness Act of 1987: Hearing before the Subcommittee on Energy Research and Development of the Senate Committee on Energy and Natural Resources, 100th Cong., 1st sess. (Washington: Government Printing Office, 1987), p. 88. For a history of federal subsidies to renewables, which began on a large scale with the Energy Tax Act of 1978, see Robert L. Bradley Jr., "The Rise and Coming Fall of Political Electricity," unpublished manuscript, January 1996, pp. 90-99.

[57]. Michael Lotker, "Solar Generation Flowers, Fades," Forum for Applied Research and Public Policy, Summer 1992, pp. 90-91.

[58]. "The rush to build wind turbines brought many poorly designed machines to market which failed miserably in the field. The reputation of the wind industry was further damaged by naive and sometimes dishonest operators who oversold their products. These problems left a legacy of public scorn and skepticism about wind power that has only recently begun to fade." Michael Brower and Michael Tennis, "Catching a Steady Breeze: Putting Wind Power to Work on Electric Utility Systems," Electricity Journal, March 1995, p. 33. See also Murray Silverman and Susan Worthman, "The Future of Renewable Energy Industries," Electricity Journal, March 1995, pp. 15-16.

[59]. Cavallo et al., p. 150.

[60]. Michael Grubb and Niels Meyer, "Wind Energy: Resources, Systems, and Regional Strategies," in Renewable Energy,p. 173.

[61]. Public Law 102-486, 102 Stat. 2776 at 3021-22 (1992).

[62]. Ibid.

[63]. Ibid. at 2969-70.

[64]. The Energy Policy Act of 1992 also made permanent a 10 percent energy investment tax credit for solar and geothermal, and, under separate IRS rules, wind investments received accelerated depreciation. Ibid. at 3024.

[65]. DOE Budget Study. See also Appendix, Table A.1.

[66]. The Energy Technologies Advancement Program has granted more than $20 million to various renewable energy programs alone. California Energy Markets, May 19, 1995, p. 3.

[67]. Paul Gipe estimates the total expenditure on wind energy development by world governments (in nominal dollars) at more than $2 billion, $1.4 billion of which was spent in the United States. Gipe, p. 73.

[68]. California Energy Commission, 1994 Electricity Report, p. 104.

[69] ICF Kaiser Study, Prepared for Enron Corp., September 1995.

[70]. Angus Duncan, American Wind Energy Association, Statement, Renewable Energy Incentives: Hearing before the Subcommittee on Energy Conservation and Power of the House Committee on Energy and Commerce, 99th Cong., 2d sess. (Washington: Government Printing Office, 1985), pp. 189-90.

[71]. The chairman of the DOE-appointed task force was Daniel Yergin, president of the industry consulting firm, Cambridge Energy Research Associates; author of The Prize (1991) and of two books related to the eco-energy planning perspective; and coeditor of Energy Future (1979). The 32-member task force was dominated by a pro-renewable group of academics, industry executives, trade group heads, and environmental representatives; free-market, fuel-neutral representatives were absent.

[72]. DOE Task Force Study, Annex 1, p. 61.

[73]. Gipe, p. 93.

[74]. Ibid., pp. 71-72. He adds, "Centrally directed R&D's most spectacular failure was in the ultimately unsuccessful attempt to build the giants of the wind turbine world: the multimegawatt machines" (p. 96).

[75]. Ibid., pp. 89-90.

[76]. This estimate is composed of 8 cents per kWh in direct and indirect ratepayer costs and 2 cents per kWh in DOE subsidies. The DOE "social cost" of wind is calculated in the later subsection, "Greening" Electricity Prices.

[77]. Representative of high-cost nuclear power, PG&E's 2,160 MW Diablo Canyon nuclear units cost ratepayers between 11 and 12 cents per kWh in 1993-95. Pacific Gas and Electric Company, 1995 Annual Report, p. 39. The market value of those two units under competitive pricing is estimated by PG&E to be a negative $10 billion. Ibid., p. 15.

[78]. This was the variable cost of producing coal oil at the Parachute Creek, Colorado, plant before it closed in early 1992. Robert L. Bradley Jr., Energy Choices and Market Decision-Making (Houston: Institute for Energy Research, 1993), p. 17. Up-front capacity costs would make the estimate substantially higher.

[79]. The total cost of the Strategic Petroleum Reserve, primarily for crude oil acquisition, is around $22 billion. Restated in 1995 dollars, the total cost is more than $36 billion, which divided by total inventory of 591 million barrels is in excess of $60 per barrel. DOE Budget Study.

[80]. This range was taken from the contract prices of gas produced at the Great Plains coal gasification project, which began at $6.75 per MMBtu and more recently had a commodity charge of $3.70 per MMBtu. Foster Natural Gas Report, February 8, 1996, pp. 3-4. Operating costs alone were estimated to be around $3 per MMBtu in 1988. Paul Duke, "U.S. Finds Buyer for Big Synfuels Plant but Won't Recoup Its Initial Investment," Wall Street Journal, August 8, 1988, p. 36.

[81]. Killing endangered species, including golden eagles, prohibited under two federal acts, is a felony punishable by two years in jail and a fine of up to $250,000. Gipe,p. 344.

[82]. "The impacts of major oil and gas development in the Arctic environment are significant, chronic, cumulative, and difficult or impossible to mitigate and prevent. . . . [A U.S. Fish and Wildlife Service] report documented extensive loss of vegetation, and concluded that most bird species in the area have declined in population, as have bears, wolves and other predators." Lisa Speer, Natural Resources Defense Council, Testimony, Arctic Coastal Plain Competitive Oil and Gas Leasing Act: Hearing before the Senate Committee on Energy and Natural Resources, 101st Cong., 1st sess. (Washington: Government Printing Office, 1989), pp. 116, 121.

[83]. Gipe, p. 450.

[84]. All the material quoted below is from Amy Linn, "Whirly Birds," SF Weekly, March 29-April 4, 1995, pp. 11-12, 14.

[85]. Ibid., p. 15.

[86]. CEED Study, pp. 2-15.

[87]. This estimate is based on 7,000 estimated bird deaths at Altamont Pass alone through 1991. California Energy Markets, May 8, 1992, pp. 16-17.

[88]. Biosystems Analysis, Inc., Wind Turbine Effects on Avian Activity, Habitat Use, and Mortality in Altamont Pass and Solano County Wind Resource Areas: 1989-91 (Sacramento: California Energy Commission, 1992), p. xi; Elissa Wolfson, "Who Owns the Wind?" E Magazine, May-June 1993, p. 19.

[89]. The Valdez kill was estimated to be 200 out of a total bald eagle population of 40,000, a percentage of .5. Alexander Volokh, "Punitive Damages and Environmental Law," Reason Foundation Policy Study no. 213, September 1996,p. 52.

[90]. Jan Beyea, "Birds, Windpower and Energy Futures," Presented to Audubon's Asilomar Conference, March 27, 1994,p. 1. Copy of speech in author's files.

[91]. Jan Beyea, "Avian Issues in Wind Development," Presented to the 1995 Annual Meeting of the American Wind Energy Association, March 1995, p. 2. Copy of speech in author's files.

[92]. Ibid., p. 5.

[93]. "Never Again," Windpower Monthly, February 1994, p. 4. This editorial in the organ of the wind-power community went on to say, "The situation should never have arisen and the industry ought to be kicking itself."

[94]. Ibid., p. 14.

[95]. Ibid., p. 4. For a revealing look at the internal debate among the pro-wind community on whether to expose the Tarifa bird death problem, see Arthur O'Donnell, "Wind Turbines, Dead Birds and Bad News," California Energy Markets, February 18, 1994, p. 5.

[96]. For a history of bird research at wind farms, see LGL Ltd., Proceedings of National Avian-Wind Power Planning Meeting (Washington: LGL, Ltd. 1995), pp. 33-52.

[97]. See Jonathan Weisman, "Two Dead Eagles Fuel Altamont Debate," Tri-Valley Herald, September 12, 1995, p. A1; "CEC Awards Grant Money for Bird Research," California Energy Markets, December 19, 1996, p. 2.

[98]. Quoted in Arthur O'Donnell, "Energy Commission Studies Bird Deaths at Wind Farms," California Energy Markets, May 8, 1992, p. 16. For claimed progress with the problem, see Colleen Wilder, "Kenetech Reports Bird Progress," California Energy Markets, June 2, 1995, p. 2.

[99]. Allen Myerson, "Enron Wins Pact to Supply Power from Wind Turbines," New York Times, March 20, 1997, p. C2.

[100]. Ralph Cavanagh, "Opening Comments of the Natural Resources Defense Council and Comments on Balancing Public Policy Objectives in a Competitive Environment," California Public Utilities Commission Hearings on Restructuring California's Electric Services Industry and Reforming Regulation, June 7, 1994, p. 14.

[101]. Christopher Flavin, "The Bridge to Clean Energy," World Watch, July-August 1992, p. 12. Flavin on the same page mentions that "no energy source is ecologically pure" but provides no follow-up analysis of the environmental problems of wind and solar, much less a possible monetary value.

[102]. "To some who drive through the Alameda County, California, site, Altamont is a visual blight. Acre after acre of 100-foot-tall turbines in long curved rows line the softly rolling hills. . . . Altamont is where neighbors complain--loudly and with media coverage--that the noise from the turbines is unbearable." Carlotta Collette, "Wind's Eastern Front," Northwest Energy News, July-August 1992, p. 14.

[103]. Quoted in Gipe, p. 258.

[104]. This has been called the "machines in the garden" problem. Ibid., p. 255.

[105]. "When heavy rains struck, runoff surged along roadcuts to cascade down steep slopes, gouging deep gullies into the mountainsides and leaving some wind turbines standing precariously on exposed foundations." Ibid., p. 414. See also ibid., p. 317.

[106]. Ibid., p. 417.

[107]. "Such flashing lights are particularly annoying at night, as is the bright 'security' lighting common at wind plant substations in California." Ibid., p. 320.

[108]. "California wind developers say wide roads speed construction by enabling two-way traffic of heavy vehicles to move at high speed. These roads met the need of the frantic year-end construction schedules typical of California's tax-credit era." Ibid., p. 411. See also ibid., pp. 322-23.

[109]. Ibid., p. 342.

[110]. Ibid., p. 444.

[111]. "Unfortunately, there are hundreds, if not thousands, of wind turbines in California that are less reliable, less well maintained, and less well sited. . . . Some simply do not work." Ibid., p. 302.

[112]. Ibid., p. 324.

[113]. Paul Gipe, letter to Charles Imbrecht, chairman, California Energy Commission, Document File 96-RDD-1890, October 15, 1996.

[114]. Gipe, p. 454.

[115]. LGL Ltd., p. 5. The aforementioned West Texas wind-power project evoked this reaction from an official of the Guadalupe Mountains National Park: "I've got a lot of mixed feelings. I understand that wind power is supposed to be clean, yet I don't look just at the visual intrusion. We're tearing up a lot of country putting up those wind towers." Quoted in Diane Jennings, "Wind Power Gets a Turn," Dallas Morning News, September 24, 1995, p. 49A.

[116]. James Bruggers, "Stirring Ill Winds, San Ramon Valley Times, May 14, 1995, p. A1. Explains Paul Gipe, "There are many ways in which a wind turbine can ignite a wildfire. Electrical short circuits, an overheated bearing, downed electrical cables, welding splatter from technicians servicing the turbines, or even the catalytic converter on service vehicles can start a conflagration." Gipe, p. 370.

[117]. Flavin and Lenssen, Power Surge, p. 294.

[118]. Gipe, p. 396.

[119]. CEED Study, pp. 2-12. A land-use estimate by EPRI is near the low end of this range. LGL Ltd., p. 11.

[120]. Christopher Flavin, "Power Shock: The Next Energy Revolution," World Watch, January-February 1996, p. 15.

[121]. Grubb and Meyer, p. 173.

[122]. The "footprint" argument for ANWR drilling was made against the Sierra Club to no avail by the Bush administration's Department of Energy. Stated the DOE, "Full development in the Arctic National Wildlife Refuge (ANWR) would directly impact only 13,000 acres, an extremely small portion (less than 1 percent) of the 1.5 million acre coastal plain where leasing would occur. The coastal plain, in turn, is a small portion of ANWR itself, which totals 19 million acres." Letter from the Department of Energy to the Sierra Club, reprinted in Committee on Energy and Natural Resources, Legislative History of the Energy Policy Act of 1992, 6 vols. (Washington: Government Printing Office, November 1994), vol. 2, p. 1459.

[123]. Grubb and Meyer, p. 174.

[124]. American Wind Energy Association, The U.S. Wind Industry, February 1995, p. 4. The jobs argument is used to support subsidization of other favored renewable energies. Stated the Union of Concerned Scientists on California's proposal to restructure California's electric industry: "Investments within California for geothermal development have totaled about $5 billion, wind development about $3 billion, biomass-electric development about $2 billion, solar thermal-electric development about $1.5 billion, and solar domestic and pool heating about $1.5 billion, totaling somewhere around $13 billion, or more than a 2:1 ratio in favor of capital investment in California's economy vs. ratepayer subsidies." Union of Concerned Scientists, "Comments on the Commission's Proposal Governing Electric Services Industry Restructuring," June 18, 1994, p. 17.

[125]. Percy Greaves, Mises Made Easier (Dobbs Ferry, N.Y.: Free Market Books, 1974), p. 37. For an explanation of "opportunity cost," see, generally, Henry Hazlitt, Economics in One Lesson (1946; New York: Arlington House, 1979).

[126]. "European countries are maintaining or increasing government-sponsored funding and continue to dominate wind energy research, development, and demonstration, which totals about $140 million annually worldwide." DOE Task Force Study, Annex 1, p. 61.

[127]. Christopher Flavin, "Wind Power Soars," in Vital Signs, 1995, ed. Lester Brown, Nicholas Lenssen, and Hal Kane (New York: W.W. Norton, 1995), p. 54.

[128]. DOE Task Force Study, Annex 1, p. 61.

[129]. Ibid., Annexes 2-4, p. 183.

[130]. "After spending 15 years and investing millions of dollars, America's alternative-energy industry is selling out to Japanese and European concerns--just as some experts believe alternative technologies may be about to pay off." Bill Paul, "U.S. Falls Behind in Alternative Energy," Wall Street Journal, August 15, 1989, p. A6.

[131]. Energy Daily, January 31, 1996, p. 4.

[132]. Total U.S. exports in 1994 were approximately $833 billion. U.S. Department of Commerce, Statistical Abstract of the United States, 1995 (Washington: U.S. Department of Commerce, 1995), p. 802. Solar exports are currently estimated to be $300 million per year. Julie Halpert, "Harnessing the Sun and Selling It Abroad," New York Times, June 5, 1996, p. C1.

[133]. "AWEA's growth reflects the fairly broad interest of American industry in a technology which a 1976 Department of Energy study estimated could supply nearly one-fifth of all U.S. electric power demand by the year 1995." DOE's Fiscal Year 1985 Budget: Hearings before the Subcommittee on Energy Conservation and Power and the Subcommittee on Fossil and Synthetic Fuels of the House Committee on Energy and Commerce, 98th Cong., 2d sess., (Washington: Government Printing Office, 1984), p. 810. More recently, an estimate was made that wind could supply 20 percent of world electricity demand "even when environmental, land use, and systems constraints are taken into account." Grubb and Meyer,p. 157.

[134]. Wind Project Performance, p. 1.

[135]. Quoted in Bruggers, p. 1.

[136]. Wind Project Performance, p. 1. See also the later section, Has Natural Gas Made Renewable Energy Subsidies Obsolete?

[137]. The concern over retirements suggests that operating cost estimates of only 1 cent per kWh are too low. In addition to periodic maintenance and repair, landowner royalties of between 2 percent and 5 percent of revenue and property taxes are paid. Gipe, pp. 233, 403.

[138]. Cyril Penn, "Kenetech's Altamont Pass Repower May Be Blown Away as Congress Threatens Renewable Tax Credit Wipe Out," California Energy Markets, September 22, 1995, pp. 11-12; Charles McCoy, "Kenetech Chooses Saunders as CEO, Explores Options to Increase Its Value," Wall Street Journal, December 13, 1995, p. B6.

[139]. Staff report, Wall Street Journal, May 30, 1996, p. B4.

[140]. Llana DeBare, "Twisting in the Wind," Sacramento Bee, February 18, 1996, p. D1.; Arthur O'Donnell, "Heads Roll at Kenetech: Annual Report Delayed by Red Ink," California Energy Markets, April 5, 1996, p. 2; Arthur O'Donnell, "Kenetech Still Bleeding," California Energy Markets, May 17, 1996, p. 3.

[141]. The $45 million, 45 MW project, expanding a 5 MW project that became operational in 1994, was terminated because of "gearbox oil leakage and blade delamination." Ted Rieger, "SMUD Cancels SEPCO Cogen Project and Kenetech Wind Expansion," California Energy Markets, May 17, 1996, p. 12.

[142]. It is telling that "[environmental organizations'] hesitancy [to endorse natural gas] is reinforced by the beating some took when they mistakenly endorsed nuclear power in the 1960s." Flavin, "The Bridge to Clean Energy," p. 17.

[143]. Arthur O'Donnell, "Enron Acquires Zond, Forms Renewables Unit," California Energy Markets, January 10, 1997, p. 13.