Policy Analysis

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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); __
- 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, [49]

and Vermont--as potential sites. 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.

Problems of Other Renewable Options

Why have so many eco-energy planners clung to wind power, a land-intensive, unsightly, noisy, and wildlife-unfriendly source of energy that accounted for only 1/10 of 1 percent of total U.S. power generation in 1995 (3.2 of 3,365 billion kWh) and 1/5 of 1 percent of the total U.S. electricity capacity of 770 GW? [144] The answer is that if wind power joins hydroelectric power (and other troubled renewables) on the no-longer-preferred list of renewable energy sources, there are really few, if any, realistic alternatives to fossil-fuel-fired generation in the foreseeable future. The problems with, and limited choices of, substitute renewables for new generation capacity will be considered next.

Hydroelectricity: The Politically Incorrect Renewable

Of the 386 billion kWh produced from renewable sources in 1995, 308 billion kWh--or 80 percent--were generated from falling water. On a capacity basis, hydro accounts for 79 GW of total U.S. renewable capacity of 95 GW, an 83 percent market share. Hydropower has a 9 percent and a 10 percent share of the total national electricity-generation and capacity markets, respectively.

Hydroelectricity has been downplayed by eco-energy planners as an alternative to fossil fuels for new capacity

investments despite its dominant market share among renewable energies. Reported the *Energy Daily* in 1992,

> A strange thing happened to hydropower on its way to the sustainable energy ball: the party's environmentalist hosts withdrew their invitation. Long a favorite of sustainable energy groups opposed to more traditional fuels . . . in the last 10 years environmentalists have turned on hydropower. . . . Suddenly hydro is being mentioned in the same breath with coal, oil and nuclear--precisely the fuels hydro, touted early on as an environmentally benign energy source, was to replace. Today environmentalists talk of "non-hydro renewables" like wind, solar and biomass. [145]

As far back as 1985, Russell Shay of the Sierra Club testified before a House subcommittee that "fisheries in California and the Pacific Northwest face disastrous effects from the unprecedented numbers of small hydro projects which have been proposed for our Western waterways." [146] New hydroelectric construction was condemned as particularly invasive. [147] In 1987 the Electric Consumers Protection Act declared a moratorium on new hydro designations as "qualifying facilities" under PURPA. [148] Criticism from mainstream environmentalists led the Bush administration to drop incentives to promote hydro in what became the Energy Policy Act of 1992. In 1993 the Sierra Club and Trout Unlimited criticized the Clinton administration for promoting hydro development as a global warming mitigation strategy. [149]

In the Worldwatch Institute's 1994 manifesto on the coming energy revolution, there is excited speculation about new wind and solar farms around the world totaling 1,500 MW, yet there is only vague talk about possible growth of hydro. [150] A joint study by the Alliance to Save Energy, American Gas Association, and Solar Energy Industries Association, with peer review by the Natural Resources Defense Council and Worldwatch Institute, forecasts low growth in hydropower "due to recent concerns regarding the loss of large land and recreational areas to accommodate hydroelectric facilities, the possibly catastrophic effects of potential dam failures and various health and ecological considerations." [151] Another sign that hydro is the "politically incorrect" renewable occurred when, in the 1995 edition of the *Electric Power Annual*, statistics for hydroelectric power were separated from the renewable category for the first time. [152]

The eco-energy planners' lack of interest in hydro is reflected in the Yergin task force's goal "to triple the U.S. *nonhydropower* renewable energy capacity by the year 2000." [153] Hydro is left out of the picture despite having no air emissions and as much as 74 GW of potential capacity, [154] a figure far higher than those for other more favored renewable energy sources. Another DOE study concludes, "[DOE] projects minimal growth for conventional hydropower; however, recent rulings, especially to protect fish, could result in capacity declines." [155] A study by the CEC released in November 1995 lists 14 electricity supply options for the state with pumped storage (at a costly $1,300 per kW) the only water resource. [156] Indeed, hydro's environmental problems mean not only that new projects are not being built but that some existing capacity is being retired and ratepayers are underwriting expensive fish-preservation programs. [157]

Environmental concerns with hydropower--even when it might substitute for coal burning--surfaced with (successful) environmental lobbying for the U.S. Export-Import Bank to deny funding for China's 18,000 MW Three Gorges Project. Global warming concerns were put aside by groups such as Friends of the Earth who were concerned about water quality, endangered species, and population resettlement. [158]

The economics of hydropower will not rescue the king of renewable energy from its no-growth posture in the United States. The domestic hydro industry is mature, with the best sites already exploited (due, in large part, to government subsidies since the 1930s). Up-front capital cost estimates for the remaining undeveloped sites range from $2,000 to $3,700 per kW in today's dollars, [159] figures from three to six times greater than the capital cost of new gas-fired combined-cycle plants.

Hydroelectricity from developed projects is typically the cheapest power in a generation portfolio. Little existing hydropower capacity, therefore, should face retirement, even given the competitive challenges of a restructured industry. The threat to existing capacity is political, not economic. The political conflict surrounds federal licensing of hydro projects, which at the time of renewal gives environmentalist opponents the opportunity to force new waterway investments that create new incremental costs. Such controversies, and the construction of new hydropower facilities, might (and indeed should) be addressed through waterway privatization, which would create true markets to direct water [160]

resources to their highest competing uses.

Solar: The Smaller, the Better

Solar power, along with wind power, is a particularly favored renewable energy resource. If wind fails the bird test as hydropower fails the fish test, or if wind becomes economically unsustainable in the United States, solar power will have to shoulder a greater load. Economic, environmental, and scale problems, however, limit solar's potential as an electric utility power source despite improving tech-nology.

Weighing in at 358 MW nationally, bulk or central-station solar power (power generated at a large-scale centralized location and then transmitted on the power grid to multiple users) represents .05 percent--1/20 of 1 percent--of total U.S. generation capacity. Solar generation of 824 million kWh in 1995 was under 3/100 of 1 percent of national electricity production, one-fourth the size of the tiny wind-power industry (see Appendix, Tables A.2 and A.3). Like wind power's, solar's long-promised commercial viability has not occurred, [161] and potential market share has been grossly overestimated. [162]

Solar power is substantially less economic than wind as a central-station power source, although its cost fell from around 25 cents per kWh in the early 1980s to a claimed 8 cents per kWh a decade later. [163] Unlike wind-power capacity, new solar-power capacity is *triple* the cost of new gas-generated electricity and *quadruple* the cost of surplus power. Solar power, like most other renewables, is geographically limited for the foreseeable future. In the United States, central-station solar power is limited to the desert Southwest and other selected locales and often involves transmission investments that custom-sited gas-fired plants can avoid. States such as California and Nevada are swimming in economy energy at 2 cents per kWh, [164] an insurmountable barrier for cost-effective central-station solar under any conditions. Greater potential may exist abroad where power needs are greater (one-third of the world's population remains without electricity), desert areas are more common, electricity is more scarce, and natural gas is not indigenous. Even then, solar power is only a daytime electricity source, and intermittent at that, unless fossil-fuel generation, pumped storage (very expensive), battery storage, or nuclear power provides back-up reliability.

The environmental problems of solar power center around the production of mirrors and land impacts. Regarding the latter, central-station solar requires between 5 and 17 acres per MW (see below), compared with gas-fired plants that a decade ago required 1/3 acre per MW and today can average as low as 1/25 acre per MW. [165]

The DOE has spent approximately $5.1 billion (in 1996 dollars) on solar energy since FY78, [166] over $12 million per MW. That investment per unit of capacity is some 20 times greater than today's capital cost of modern gas-fired plants. Looking ahead, post-FY94 DOE funding to attempt to commercialize photovoltaics and solar thermal is estimated to be $1.050 billion, triple the estimate for wind power. [167]

The solar power industry can be broken down into thermal solar markets, photovoltaic markets, and micro-solar markets. Each is defined and examined with special attention to economic and environmental issues.

Thermal Solar. Thermal-solar systems receive sunlight that is concentrated in a parabolic dish trough or in a tower and is then converted to electricity by a heat engine and electric generator. A 1978 study found that the materials required for thermal-solar projects were 1,000 times greater than for a similarly sized fossil-fuel facility, creating substantial incremental energy consumption and industrial pollution. [168] An updated study of the total fuel cycle environmental costs of solar energy has been contemplated but not rigorously pursued. The attitude, according to one participant who wished to remain anonymous, is "keep the closet closed so you don't know what is in there." [169] However, an energy specialist at the CEC calculated that the concrete production per 1,000 megawatts of nameplate solar capacity (a proportionally high input) results in carbon emissions equivalent to 10 billion cubic feet of combusted natural gas--approximately a year's worth of fuel for a similarly sized gas-fired plant. [170]

Thermal solar installations have had a disappointing past. Solar One, a 10 MW solar thermal project operated by Southern California Edison for high-demand periods, closed in 1988 after six years of operation. The facility, 80 percent of which was funded by the DOE, was so experimental and expensive that no cost per kWh was publicly revealed. [171] In addition to heavy land requirements, bird deaths ("the birds died primarily from collisions with the picture-like surface of the

heliostats") [172] were as much as 10 times the kill at Altamont Pass per megawatt, although endangered species and other high-profile birds were not at risk. [173]

Solar Two, a $48 million, 10 MW demonstration project cofunded by an industry consortium led by Southern California Edison, the DOE, and the CEC, entered production in 1996. The project uses a receiver tower in place of a parabolic dish where the concentrated heat from the field mirrors (called heliostats) is converted to electricity. Its $4,000 per kW installed cost--which would have been as much as $14,000 more per kW if Solar One's equipment had not been used [174]--is still between 5 and 10 times greater than that of a gas-fired plant with current technology. The plan to generate power at between 7 and 8 cents per kWh [175] will be impossible at this capital-cost level. An annual operating cost of $3 million virtually ensures a shutdown in 1999, the year federal subsidies are scheduled to end.

The 1,900 mirrored panels, each measuring over 100 square yards, are the equivalent of 17 acres per MW of capacity. [176] That is 50 to 100 times greater than a similarly sized gas-fired facility on a nameplate basis but 150 to 300 times greater on an actual generation basis. And, unlike wind power, the land concentration of solar farms is dense.

Those concerns led a Worldwatch Institute study to conclude,

> Solar Two looks good on paper, and it is expected to provide steady baseload electricity as well as late afternoon peaking capacity, but the future of all the central solar generators is in doubt. They are expensive to build, their very scale escalates financial risks--as with nuclear power--and their massive height (in excess of 200 meters) may attract opposition. [177]

The economic plight of central-station thermal solar was revealed with the bankruptcy liquidation of LUZ International in December 1991. LUZ, which was responsible for virtually all solar capacity in California, blamed lower fossil-fuel prices for its plight. [178] A restart company using LUZ technology, heavily subsidized by private and public Israeli interests, hopes to lower thermal-solar costs to 7 to 7.5 cents per kWh after the turn of the century. [179] However, gas-fired technology, the DOE predicts, will cost one-half as much, [180] and this estimate has already been exceeded.

Photovoltaic. Photovoltaic technologies directly convert sunlight to electricity via panels that do not have moving parts. The Yergin task force concluded that "the long-term goal of producing power at 5 to 6 cents per kWh by 2004 is highly achievable." [181]

A proposal by Amoco/Enron Solar Company to sell power at 5.5 cents per kWh from a 100 MW plant (now a 10 MW plant) built in the southern Nevada desert (Nevada Solar Enterprise Zone, sponsored by the Corporation for Solar Technology and Renewable Resources) suggests that this future is coming. The Amoco/Enron project would use a new generation of photovoltaic technology to reduce costs well below those of thermal-solar and previous photovoltaic technologies. However, the project is not close to being economic compared with new gas-fired capacity and particularly compared with surplus purchased power that is widely available in the area for 2 cents per kWh. The 5.5 cent year-one rate escalates at 3 percent per year for the 30-year contract, making the nominal price more than 8 cents per kWh. With the federal tax credit, accelerated depreciation, and tax-free industrial development funds for construction, the real cost balloons above 10 cents per kWh. [182] Finally, the project was equipped with a gas turbine to average down the cost and overcome intermittency. Instead of a solar project, it was really a solar-gas project, which raises the question of why the national media reported the proposed project as a breakthrough, in the words of one journalist, "producing solar power at rates competitive with those of energy generated from oil, gas, and coal." [183]

A major environmental cost of photovoltaic solar energy is toxic chemical pollution (arsenic, gallium, and cadmium) [184] and energy consumption associated with the large-scale manufacture of photovoltaic panels. The installation phase has distinct environmental consequences, given the large land masses required for such solar farms--some 5 to 10 acres per MW of installed capacity. [185] Species such as the desert tortoise and the Mojave ground squirrel are displaced. Radio-tagged desert tortoises, classified as a "threatened species," were killed either at the Kramer Junction Luz thermal solar site or soon after relocation away from the site, [186] a problem for photovoltaic farms as well. Hundreds of stacked mirrors create visual blight, and shading from the solar cells creates micro-climatic impact. [187] Some of those environmental negatives may seem puny, but they cause an "eco-dilemma" for proponents who are trying to justify the

expenditure of millions of involuntary ratepayer and taxpayer dollars for an allegedly benign energy resource.

In 1993 congressional hearings, the Sierra Club and Wilderness Society testified in favor of maximum acreage to be set aside from commercial development in California's Mojave Desert, one of the prime solar sites in the United States. The rationale for nondevelopment, which implicitly applies to solar as well as other development and recreational uses, was stated by the president of the Wilderness Society:

> The California desert contains some of the most wild and beautiful landscapes in America, but these lands are being continually degraded. The fragile desert soils, scarce water, unique ecosystems, irreplaceable archaeological sites, and spectacular scenic beauty are receiving too little protection in the face of a variety of development pressures. The opportunity to experience what remains of the frontier quality of the region is rapidly disappearing as development spreads. The public has lost much of this priceless heritage already; it is time to save the best of what remains as a lasting gift to future generations. [188]

Another environmentalist has gone so far as to resurrect the nuclear option as an alternative to solar energy under an air-emission-free standard.

> From the standpoint of scenic pollution and the destruction of wildness, there are distinct advantages to the hard energy option. . . . A nuclear plant modifies a relatively small area compared to a large-scale solar installation. [189]

Micro Solar. Unlike small-scale wind-power generation, "hundreds of photovoltaic applications are currently cost-effective for off-grid electric power needs." [190] Common remote-site applications include communications, lighting, and switching. While such micro power is not cheap (a goal is to reduce rates to 12 cents per kWh by 2000), [191] its niche is making power available in remote locations for small energy uses that would be even more costly to connect as grid power. Where there is readily available grid power, micro solar applications, such as by city governments for lighting, represent a misdirection of taxpayer monies.

Rooftop solar energy for heating and cooling buildings competes head-to-head with existing electricity or natural-gas infrastructure in most residential and commercial buildings in the United States. Spurred by federal tax credits, over 1 million hot water systems have been installed. Negative customer experiences over the years and high costs relative to conventional fuels, however, have limited this option on a nonsubsidized basis. [192] Although the DOE has spent $34 million on solar building technologies, the Yergin task force estimated $176 million more would be required beyond FY94 for commercialization. [193]

Biomass: The Air-Emission Renewable

Biomass is shorthand for electricity created from a variety of sources of energy such as wood, wood waste, peat wood, wood sludge, liquors, railroad ties, pitch, municipal solid waste, straw, tires, landfill gases, fish oils, and other waste products. Wood accounts for over 60 percent of those inputs. Biomass generated 59 million kWh in 1995, 1.7 percent of national electric power output and 15 percent of national renewable production (see Appendix, Table A.3).

Biomass is not economic today, and even the projected research and development goal of 4 to 5 cents per kWh [194] is still above the cost of new gas-fired capacity and roughly double the spot price of surplus electricity. In the Worldwatch Institute's *Power Surge*, the authors report that a government-sponsored design competition for a 25-30 MW biomass-fueled gas turbine could cut costs from 8 cents to 5 cents per kWh, "making biomass-fired electricity competitive with conventional coal-fired power plants." [195]

After a decade of liberal subsidies from the federal and state governments, the prospect that biomass will become competitive with coal is not encouraging. Gas-fired combined-cycle capacity is presently 1/2 as expensive to build as a coal plant and has a double-digit percentage levelized cost advantage under a variety of assumptions compared with state-of-the-art coal plants. [196]

Biomass is not environmentally benign from the energy environmentalists' own perspective, as carbon dioxide is released

upon combustion--even more than from coal plants in some applications. [197] Nitrogen oxide and particulates are also emitted. Other environmental problems were stated by Christopher Flavin and Nicholas Lenssen of the Worldwatch Institute:

> Although biomass is a renewable resource, much of it is currently used in ways that are neither renewable nor sustainable. In many parts of the world, firewood is in increasingly short supply as growing populations convert forests to agricultural lands and the remaining trees are burned as fuel. . . . As a result of poor agricultural practices, soils in the U.S. Corn Belt . . . are being eroded 18 times faster than they are being formed. If the contribution of biomass to the world energy economy is to grow, technological innovations will be needed, so that biomass can be converted to usable energy in ways that are more efficient, less polluting, and at least as economical as today's practices. [198]

Although biomass is more akin to fossil fuels than to renewables, mainstream environmentalists have kept biomass on the favored energy renewables list. With hydropower banished, biomass is the only sizable option in the eco-energy planners' portfolio. New capacity will not come cheap, however. The Yergin task force estimates that $930 million in future DOE subsidies will be necessary to enable biomass to approach commercialization. [199]

Geothermal: The Nonrenewable Renewable

Geothermal--steam energy that is generated by the Earth's heated core--is currently produced at 19 sites in four western states (California, Hawaii, Nevada, and Oregon) and accounts for just under 1/2 of 1 percent of national power production and national generation capacity (see Appendix, Tables A.2 and A.3). Production has fallen far short of projections made in the 1980s [200] and is currently in decline because of erratic output from a number of California properties. Nationally, geothermal output in 1995 was 14 percent below 1994, a drop of 2.4 million kWh. [201]

The experience of the world's largest geothermal facility--the 1,672 MW facility known as the Geysers--is emblematic. As Pacific Gas and Electric reported,

> Because of declining geothermal steam supplies, the Company's geothermal units at The Geysers Power Plant are forecast to operate at reduced capacities. The consolidated Geysers capacity factor is forecast to be approximately 33 percent in 1995, which includes forced outages, scheduled overhaul and projected steam shortage curtailments, as compared to the actual Geysers capacity factor of 56 percent in 1994. The Company expects steam supplies at the Geysers to continue to decline. [202]

After reporting a 37 percent performance for 1995 (versus the 33 percent forecast), Pacific Gas and Electric predicted a lower percentage for 1996 due to "economic curtailments, forced outages, scheduled overhauls, and projected steam shortage curtailments." [203]

A number of drawbacks are inhibiting geothermal growth. Geothermal is site specific and may not match customer demand centers. Geothermal sites often are located in protected wilderness areas that environmentalists do not want disturbed. [204] Unique reservoir characteristics and limited historical experience increase investor risk. Depletion occurs where more steam is withdrawn than is naturally recharged or injected, and "inexhaustible" reservoirs can become noncommercial. [205] Alternative water uses or low availability have reduced recharging capacity at the Geysers, for example. Corrosive acids have also destroyed equipment at the facility, and toxic emissions can occur. Promising sites can turn into dry holes upon completion of drilling. [206] Surplus gas-fired generation in California, New Mexico, and Utah also has removed the need for new geothermal capacity. [207] Concluded one journalist conversant with the western U.S. renewable industry,

> By all accounts, the utility-grade geothermal power development business has reached a plateau within the United States. The few dozen viable sites identified and developed in California and Nevada during the 1980s are now entering a mature operational phase. New exploration opportunities--mainly in Oregon and northern California--are sparse due to high cost and perceived "overcapacity" of resources held by utilities. Even expansion of existing plants is limited because of the low avoided-cost energy prices currently available from utilities and the current restrictions on nonutility purchasers. [208]

Is geothermal a renewable resource? One study included the statement that "geothermal is one of the few renewable energy sources that can be a reliable supplier of baseload electricity," yet the same study also noted that "geothermal resources are not strictly *renewable* on a human time scale, but the source is so vast it seems limitless." [209] Flavin and Lenssen told us five years later, "Although geothermal reserves can be depleted if managed incorrectly (and in come cases have been), worldwide resources are sufficiently large for this energy resource to be treated as renewable." [210] Yet the coal supply of the United States combined with the natural gas supply in North America is arguably "so vast it seems limitless" as well. Geothermal cannot be considered a renewable resource, at least in the United States.

Geothermal is not only a scarce, depleting resource, it has negative environmental consequences despite the absence of combustion. In some applications, there can be CO2 emissions, heavy requirements for cooling water (as much as 100,000 gal. per MW per day), hydrogen sulfide emissions, and waste disposal issues with dissolved solids, and even toxic waste. [211] Those problems and the location problem have caused some environmental groups to withhold support for geothermal since the late 1980s. [212]

Negawatts: Our Dirtiest Resource

If the foregoing renewable fuel sources are dismissed, energy efficiency is left as the "renewable" energy resource of consequence. Conservation as a "supply" of energy has been popularized by many writers, including Daniel Yergin, who in the late 1970s spoke of "conservation energy" as "no less an energy alternative than oil, gas, or nuclear." [213] Yergin then argued that a "serious commitment" to conservation in the United States could result in a 30 to 40 percent reduction in energy use with "the same or a higher standard of living" as a result. [214]

Pacific Gas and Electric, one of the largest electricity utilities in the country, in 1990 called energy conservation the "largest, least-costly untapped resource option." [215] The CEC in 1995 estimated that their state alone could displace more than 6,800 MW of capacity by the year 2005 through energy efficiency. [216] Nationally, capacity savings of approximately 11,000 MW is expected between 1995 and 1999. [217]

"Negawatts" (a termed coined by energy conservation guru Amory Lovins to describe the potential of conservation as a resource) in place of megawatts has become a multi-billion-dollar taxpayer- and ratepayer-subsidized industry. Between 1989 and 1995, the nation's utilities spent $15.1 billion on ratepayer-subsidized electricity conservation programs (known in the industry as "demand-side management," or DSM). Adding pre-1989 expenditures (DSM programs began as early as the mid-1970s), the total is above $17 billion. [218] The DOE has spent as much as $8 billion to $9 billion of its total conservation expenditures of $13.3 billion on state and federal electricity usage reduction programs since inception. [219]

California has led the nation with a $3 billion to $4 billion DSM commitment. Pacific Gas and Electric alone has accounted for over $1.5 billion. [220] Those massive subsidies, which have been reevaluated as too much, too soon, [221] have contributed to the state's abnormally high electricity rates and virtually ensure a nonsustainable level of energy conservation investment in the future. The historic Blue Book proposal of CPUC, in fact, substituted a new public policy goal--reducing high rates--for the previous one of lowering total bills through conservation. [222]

Like wind and solar farms, utility demand-side management programs are susceptible to environmental review on a total fuel cycle basis. One electricity planner at a major California electricity provider has called DSM "our dirtiest energy source" because gasoline-powered vehicles traverse the countryside to service the thousands of residential and commercial program participants. [223] Motor gasoline, in effect, is being substituted for natural-gas-fired electricity generation in the provider's service territory.

Energy also is expended to manufacture the new energy-saving appliances marketed by DSM programs, and the disposal of traded-out energy assets (such as refrigerators) is an environmental liability that should be accounted for in the DSM environmental equation from the proponents' own viewpoint.

Environmental tradeoffs aside, economic problems threaten the future of utility-provided, ratepayer-subsidized DSM. The law of diminishing returns suggests that the supply of negawatts is a depletable resource. Declining benefit/cost ratios of

utility DSM programs are a fact of life in California, [224] not to mention other states. The debate is really about how great the cost savings overestimates have been, not about how much cost-effective energy conservation really remains.

Of note are two particularly rigorous studies by the Illinois Commerce Commission and the DOE's Energy Information Administration. [225] The former examined the full costs of state natural gas DSM-type programs from their inception in 1985 through 1994. The commission found that no program showed benefits greater than costs. [226] In fact, most programs demonstrated benefits that were a mere 25 percent of costs.

The second study examined the total costs and benefits of DSM programs nationwide. The Energy Information Administration concluded that, from 1991 to 1995, approximately $12 billion (nominal) was spent on DSM programs that yielded 215.6 billion kWh of energy savings. Yet the cost of DSM programs over that period averaged 5.58 cents per kWh. Over that same period, however, fossil fuels produced electricity at 2.35 cents per kWh. Thus, subsidized energy conservation was twice as expensive as generated power, much of which came from facilities with unused available capacity (such as in California). [227]

If there were ever an economic honeymoon period for ratepayer-subsidized energy efficiency (and most academic and many professional economists doubt that there was ever an efficient phase of DSM based on empirical investigation and the pure logic of consumer choice), [228] those days have passed.

The impending industry restructuring, which will deliver to the market excess generating capacity and cause rates to drop significantly absent a new round of reregulation, will likely make the "production" of negawatts as unnecessary as the construction of new wind, solar, biomass, and geothermal energy capacity. In fact, increased electricity consumption to better use underperforming (often gas-fired) power plants will be a key strategy to bring average costs down toward the marginal costs of generation in states like California that are trying to be competitive with other jurisdictions.

The new era of constrained electricity conservation has already begun. Soon after CPUC's Blue Book proposal, two of the nation's and California's largest demand-side management utilities announced $206 million in DSM cutbacks for the following year (1995). Consumer groups in the state that were signatories to accelerating DSM investments in 1990 testified against further ratepayer cross-subsidies. The coalition put environmental groups in the awkward position of arguing that DSM spending was good for consumers whether their self-styled consumer representatives knew it or not. [229] In an article in *Environmental Action*, David Lapp also noticed

> the emerging conflict between environmentalists and ratepayer advocates, particularly those representing low-income consumers. Although advocates for low-income ratepayers support energy conservation programs, many are raising questions about who benefits from the programs, how much they cost, and how those costs are distributed. [230]

The ongoing restructuring of the electricity industry removes the traditional rationales for ratepayer-subsidized conservation. First, the utility's incentive to invest in electricity generation so long as the allowed rate of return is greater than its cost of capital will be removed. In a restructured industry, future generation will compete in an open, competitive market and not be artificially encouraged by automatic cost recovery (or "stranded cost" compensation after the fact). [231] Second, flat rates capped at embedded cost, which in peak periods have failed to regulate consumption, will give way to market pricing in a restructured electricity industry. Real-time pricing and other "peaking rate" innovations will spontaneously prevent unnecessary consumption and the generation capacity needed to serve it. With the introduction of real-time pricing, interactive computer technologies controlling "smart appliances" and for-profit energy service companies promise to institutionalize market conservation as an alternative to political conservation in a restructured industry where for-profit opportunities really exist. [232]

In summary, the market is poised to replace both demand- and supply-side planning. As a Sierra Club representative concluded, "DSM as we have known it cannot function in a reasonably competitive marketplace because DSM is a fix to a flawed regulatory system, which competition is intended to replace." [233]

Eco-Energy Planning in a Competitive Electricity Industry

The electricity utility industry is one of America's last bastions of monopoly privilege. Heeding Samuel Insull's call for politicized electricity near the turn of the century, industry leaders successfully lobbied state legislatures to establish commissions to implement cost-plus rate regulation and franchise protection. [234] The predictable result of decades of the "regulatory covenant" is a high-cost, conservative, standardized industry ripe for restructuring. The investor-owned utilities estimate their collective uneconomic generation costs at between $50 billion and $300 billion versus a net worth of $175 billion--a colossally bad economic investment. [235]

The Downside of Lower Rates for Eco-Energy Planning

Following the "open-access" natural-gas model--which contributed to a 40 percent real decline in end-user rates in the 1985-95 period--states (and even some foreign countries) are now debating whether to allow end users to shop around for the cheapest power and turn to the utility for transmission and related services only. That economic model is called direct access, or mandatory retail wheeling. Driving the campaign for mandatory retail wheeling is the sizable gap between the (lower) marginal cost of generation and the (higher) average cost that consumers and marketers wish to force out of the system.

The consumers' gain would be eco-energy planning's loss in a retail wheeling world. Lower prices (and estimates are that deregulation could deliver electricity prices between 30 and 40 percent lower than those of today) [236] would

- increase electricity consumption and accordingly increase the utilization rate of idle fossil-fuel capacity;
- arrest DSM conservation programs by lengthening the payout period for energy-saving investments;
- lower generation costs to make renewable generation technologies less competitive and even cause near-term retirements of uneconomic renewable capacity with high operating costs; and
- incite utilities to resist incurring new uneconomic costs with renewables and conservation that could be "stranded" rather than passed through to the consumer as before. [237]

The restructuring would also likely

- unbundle rates to itemize surcharges such as those for DSM to facilitate consumer scrutiny and challenge;
- incite greater integration of geographically dispersed generation and transmission systems and thus remove the need for new electricity-generation capacity (including favored renewables) for some time;
- replace average-cost pricing by utility providers (where higher cost renewable generation is averaged down by lower cost generation) with stand-alone economic evaluation for each generation source; and
- introduce time-of-day pricing to value wind power and solar power as intermittent resources at (lower) off-peak rates to the extent that their power generation is noncoincident with demand peaks. [238]

Not surprisingly, sophisticated eco-energy planners did all they could to block interest in mandatory retail wheeling and the lower rates and economic efficiencies that would come with it. Ralph Cavanagh of the Natural Resources Defense Council led a national crusade with a Joint Declaration on the Electric Utility Industry, signed by some 50 groups, to dissuade state officials from even investigating mandatory retail wheeling. [239] Customer choice was described as "a great illusion," a paper shell game reallocating costs from more favored, larger end users to smaller, less favored end users with no overall economic gain. Cavanagh urged states to "go on saying no to retail wheeling in order to be able to create something better: regulatory reforms that align utility and societal interests in pursuing a least-cost energy future." [240] The quasi-reforms urged by Cavanagh were competition in the bulk power market (wholesale wheeling) and performance-based ratemaking for utilities. Monopoly utility service to end users would remain to allow the status quo of renewable and efficiency subsidies via integrated resource planning to continue. The alliance between high-cost utilities and pro-high-rate environmentalists was in clear evidence.

Electricity restructuring is no longer "if" but "when" and "in what form." [241] At the close of 1996, 10 states had either enacted legislation or issued commission orders setting timetables for universal retail wheeling: Arizona, California, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont. Debate also is under way in virtually all of the other lower 48 states. [242]

The California Crisis and Restructuring Proposal

The opening salvo in the electricity restructuring debate was the Blue Book proposal of CPUC, released in April 1994. [243] The ironic but predictable result of the commission's dramatic about-face was that the rate crisis occurred in the very state proclaiming to be the world's leader in renewable energy and subsidized energy efficiency. Table 1 gives an overview of California's commitment to high-cost renewables (as of 1996) and conservation (as of 1994) compared with that of the nation as a whole.

With electricity prices at 150 percent of the national average and nearly double those of neighboring states, rates and total bills rising faster than the national average, and prospective stranded costs potentially greater than the net worth of the state's investor-owned utilities, California's energy diversity and energy-efficiency programs can be called a failure. [244]

Table 1
California's Renewable Capacity versus That of the United States as a Whole (megawatts as of 1995-96)

Source	*California*	*United States*	*Percentage*
Wind	1,459	1,731	84
Solar	386	390[a]	99
Geothermal	851	3,042	28
Biomass	925	10,914	9
Demand-side management[b]	11,562	25,001	46

Source: California Energy Commission, Department of Energy.
a. Estimated in light of the new California figure.
b. As of 1994.

A Restructured PURPA: Closing the Renewable Window?

PURPA required utilities to purchase power from independent "qualifying facilities" at the utilities' "avoided cost" of self-generation or self-procurement. So-called QF contracts have given small energy projects a long subsidy run and literally spawned the nonhydropower renewables industry.

While achieving its purposes of promoting independent power and renewable generation, PURPA significantly contributed to overcapacity in the electricity-generation market and higher electricity rates overall. [245] Utilities, while concerned about increasing rates, acquiesced so long as state commissions allowed them to pass through qualifying facility costs to consumers and so long as their customers could not bypass the system. With electricity utility restructuring raising the specter of "stranded costs" that might not be recoverable, utility concern turned into legal challenge.

In California, PURPA capital of the nation with nearly 10,000 MW of operational capacity subscribed between 1982 and 1986, [246] two of the state's three largest utilities--Southern California Edison and San Diego Gas & Electric--petitioned FERC to void a 1993 California PURPA auction. The companies claimed that the capacity of the winning bids they had to accept was not needed, priced above their true avoided cost, and subject to recovery risk as stranded costs. Indeed, CPUC had forced the utilities to accept several hundred megawatts of renewable energy (geothermal and wind) priced at above 6 cents per kWh, compared with available new gas-fired capacity at less than 4 cents per kWh--a 35 to 40 percent premium. [247]

In a landmark decision issued in February 1995, FERC agreed with the utilities that, given the emerging competitive landscape, avoided cost determinations had to be open to all sellers to accurately measure the utility's avoided cost. FERC summarized:

> It is incumbent upon regulators, federal and state, to avoid the creation of transition costs where possible. California's decision to consider a major restructuring of its retail electricity market significantly heightens our concern with stranded costs arising from above avoided-cost rates. We believe it is inconsistent with our

> obligation under PURPA to ensure just and reasonable rates, and our goals to encourage development of competitive bulk power markets, to permit the use of PURPA to create new contracts that do not reflect market conditions for new bulk power supplies. [248]

In its rehearing order upholding its previous decision, FERC added that "in promoting greater fuel diversity . . . Congress was not asking utilities and utility ratepayers to pay more than they otherwise would have paid for power." [249] Rejecting the charge that their decision would ruin the renewables industry, the commission reminded CPUC and eco-energy planners that renewable energy goals could be met outside of PURPA through tax incentives and capacity mandates. Still, the high-cost power industry, led by renewable interests, was stunned. Complained Randall Swisher of the American Wind Energy Association,

> FERC has turned PURPA on its head. Legislation that was intended to encourage renewables has instead been used to throttle the domestic market for wind and other renewables. . . . This decision effectively closes the door to domestic markets for renewable energy. [250]

The early returns of the marketplace reflected the concerns of renewable interests. PURPA auctions are on hold, and a DOE forecast of electricity generation by fuel source to the year 2015 eliminated 927 MW of new wind-generating capacity, citing FERC's PURPA decision. [251] The economic consulting firm National Economic Research Associates similarly concluded, "A growing realization that expensive 'alternative energy' schemes cannot survive in a competitive environment suggests that electricity generation using renewable energy will increase slowly during the next 10 years." [252]

Joining FERC's reality check on state commissions has been congressional interest in repealing PURPA. Even if the law is not repealed, it faces a de facto demise due to a restructured industry where electricity generation from all sources, utility and independent, will be deregulated to compete on a variable-cost basis. An emerging forward market in "black-box" capacity commitments was another indication that, absent a new round of government intervention, a generation-blind electricity market would make PURPA and renewable quotas obsolete. [253]

Table 2
California's QF Renewable Energy Portfolio (in megawatts)

At-Risk Capacity	*Total Capacity at Risk*	*Percentage Exp. Date*	*Contract*
650	1,459	45	2001
571	925	62	2000
183	386	47	2000
638	851	75	2000
Total 2,042	3,621	56	-

Source: California Energy Commission.

With PURPA's future in limbo, existing PURPA contracts are running their course toward expiration. Table 2 compares California's at-risk QF renewable capacity with total renewable capacity.

As the clock ticks, renegotiations and contract buyouts of uneconomic qualifying facilities' contracts are occurring, [254] and the CEC is allocating a new round of subsidies to at-risk renewable projects. [255]

Has Natural Gas Made Renewable Energy Subsidies Obsolete?

Economic and technological advances in the natural gas industry (the fuel of choice for new power plants across the country) have direct implications for the debate over fuel use and the environment. Natural gas, in fact, has emerged as a fierce competitor, if not the victor (in both an economic and an environmental sense, as will be discussed) over both subsidized renewable generation and subsidized electricity conservation under present technologies. This is in spite of

heavy government support of natural gas's competitors. Renewables' tax credits, as mentioned, swamp wellhead tax deductions. [256] And cumulative DOE subsidies for natural gas of $787 million through FY95 are swamped by over $10 billion given to nonhydropower renewables in the same period. [257]

Renewable energy remains stubbornly uneconomic, not because of past or current federal subsides for rival fuels, but because of the relative scarcity of resources necessary to deliver renewable energy to consumers at a competitive price. The DOE's Energy Information Administration reports that federal energy subsidies in 1990 totaling between $5 billion and $10 billion amounted to only about 1 to 2 percent of the total value of energy production. [258] Energy subsidies alone, in other words, cannot account for the dramatic differences in price between renewable and nonrenewable fuels. [259] Indeed, even the pro-renewable energy Alliance to Save Energy concedes that energy subsidies are responsible for no more than half a cent of every dollar spent on natural gas. [260]

It cannot be said that natural gas has been more heavily advantaged by past subsidies than have renewable fuels. According to Management Information Services, Inc. (an economic consulting firm in Washington, D.C.), total subsidies to renewable energy sources over the past four decades totaled $75 billion, while natural gas was subsidized with $58 billion over that same period of time. Because Management Information Services accepted many of the dubious definitions of subsidy marshaled by the Alliance to Save Energy, the $58 billion is heavily inflated. For example, $51 billion of the total four-decade subsidy credited to natural gas stems from special exemptions, allowances, deductions, and credits occasionally found in the tax code that partially offset double (and sometimes even triple) taxation of capital and capital returns. [261]

In fact, natural gas on net has been *victimized* by government intervention, not subsidized by it. Long-standing federal wellhead price regulation of natural gas, exacerbated by public utility regulation of interstate gas pipelines and local distribution companies, caused shortages and service moratoriums in interstate markets during the 1970s. [262] Eco-energy planners, like the political establishment, put the blame on nature and not bad public policy. It was believed that rapidly depleting natural gas supplies were insensitive to price and therefore consumption should be phased out of "low-priority" boiler and power plant uses and redirected to "high-priority" residential and commercial uses. [263] The result was the Powerplant and Industrial Fuel Use Act of 1978 and other legislation that further subsidized coal, nuclear, conservation, and renewables at the expense of natural gas.

The Energy Information Administration has concluded that regulatory interventions such as those discussed above are far more likely to unbalance the energy playing field than are direct subsidies.

> It is regulation and not subsidization that has the greatest impact on energy markets. . . . The economic impact of just those energy regulatory programs considered in this [pre-1992 Energy Policy Act] report total at least 5 times that amount [of direct fiscal subsidy]. [264]

A decade of deregulation and restructuring later, natural gas has emerged as economically and environmentally a different fuel and a preferred choice for new capacity additions in the United States and, increasingly, abroad. Major developments in the past decade (1985-95) under open-access competition include significant price reductions from the wellhead to the burner tip, system reliability under even abnormal peak-demand conditions, dramatically improved energy-efficiency factors, major emission reductions, and new risk-management practices. As we head toward the new millennium, those developments directly challenge the case for renewable and energy-conservation subsidies.

The Open-Endedness of Natural Gas Supply

Over the last decade, wellhead natural gas prices, after adjusting for inflation, have fallen by one-half, while end-user prices have fallen by 40 percent. The price of natural gas delivered to powerplants fell nearly 60 percent in the same period. [265] In response, gas consumption has increased by 26 percent since the mid-1980s.

Continual reserve replacement and falling gas prices from the wellhead to the burner tip suggest that natural gas is not a nonrenewable resource in a policy-operative sense. As one industry executive explained,

> Domestic supply has increased as fast as it has been consumed--and at a lower cost. Approximately 185

> [trillion cubic feet] of gas was consumed in the United States between 1985 and 1994, yet proven reserves in the lower 48 states remain virtually the same today as they were a decade ago. Natural gas may be a finite, depletable resource under wellhead price regulation, but under market incentives, supply is proving to be open-ended. [266]

The natural gas supply situation in Canada, centered in Alberta, is even more dramatic than in the lower 48 states. Reserves have increased over 5 percent since 1982 despite record production and consumption in the same period. [267] Canadian exports to the United States have almost tripled in the last decade and now account for approximately 13 percent of U.S. consumption. [268] Although uneconomic at present, natural gas reserves from the Alaskan North Slope--estimated at 26 trillion cubic feet, [269] more than a one-year supply for the entire United States at present consumption rates--await a price economical enough to justify pipeline construction through Canada to the lower 48.

Concerns over the size of the U.S. and North American gas resource base were addressed by a major 1992 study by a National Petroleum Council task force. In addition to near-term inventory (proven reserves) of 160 trillion cubic feet (TCF) as of January 1, 1991--a 10-year supply at prevailing consumption rates--conventional supply was estimated at 616 TCF and nonconventional supply at 519 TCF. Together, the nearly 1,295 TCF lower-48 resource estimate represented more than a 60-year supply for the United States. [270]

In addition to the abundant resource base, there is the question of whether at least some methane deposits are classically depletable. The DOE-appointed Yergin task force speculates that some oil and gas deposits are steady-state rather than depletable because of evidence of upward migration from fossil fuels from deeper sources. [271] This view, however, is secondary to the more important one: improving technology literally *creates* commercial supply where there was none before, and this process is open-ended. [272]

Not only gas supply but pipeline capacity to reach end-use markets is abundant. Ironically, the market with the most surplus natural gas capacity is California, the renewable energy capital of the nation. Between 1.5 billion cubic feet and 2 billion cubic feet per day of surplus natural gas capacity exists in the state, a 25 percent average-day surplus. Whereas regulatory delays in the construction of new pipeline capacity led to natural gas curtailments and oil burning in the state in the 1980s, the long-awaited arrival of three pipeline expansions and one new pipeline in 1992-93 portends surplus capacity well into the next century. [273]

Is Fuel Diversity Obsolete?

In 1992 the CEC held a policy debate on fuel diversity. Supporters of renewable energy lobbied for a fuel diversity penalty on natural gas in the integrated resource planning process to make planned gas-fired capacity additions more expensive relative to renewables. Their rationale was that natural gas had a price risk that renewables, without an energy input cost, did not. In response, the American Gas Association argued that "[energy] cost is only one form of risk, and fuel is only one of the three primary cost components." [274] The association explained,

> The argument for fuel diversity is based on concerns with respect to volatility in fuel prices and supplies. But risk to the ratepayer depends on many other variables--environmental and permitting risk, financial risk, the risk of new versus proven technologies and the risk of operating reliability. All of these risk categories will be translated into ratepayer risk, and gas-fired combined-cycle plants measure up extremely well on each of these measures--as proven by the fact that project developers have moved so strongly toward this technology. [275]

Enron Corp. testified that available long-term, fixed-priced gas contracts, futures hedging, and storage could mitigate or entirely remove price risk. [276] Thus analogies between natural gas and "crack cocaine," [277] insinuating that today's "low" gas prices are fostering unhealthy dependencies should prices spike, are irrelevant. A variety of financial products offers end users the ability to lock in their financial "high" for as long as 20 years. [278] Shorter term hedging can be done on the 18-month futures market. Market institutions have literally made yesterday's fuel diversity concerns obsolete for the sophisticated buyer. [279]

In nonhedged situations, price risk in the short run and the long run is *symmetrical*. There is no theoretical or empirical

reason why the future price of natural gas (like that of other "depletable" resources) must be higher than the present price adjusted for inflation. In the shorter run, market processes continually work to arbitrage intertemporal and geographical prices through drilling, storage, and transmission investments, although surprises always have the market playing catch-up.

Concerns still linger about fuel diversity despite the aforementioned theoretical arguments and new market institutions. FERC commissioner William Massey, in his PURPA decision dissent (June 1995), raised the concern that

> If the only costs cognizable under PURPA are quantifiable costs actually incurred by the utility, how would the PURPA process reflect the value of fuel diversity? If a utility today owns only gas-fired generation and places a high value on diversifying its fuel mix by making its next capacity addition something other than gas-fired, does today's order require the avoided cost determination nonetheless to include gas-fired generation? If so, would PURPA prohibit even cost adders to the gas bids to reflect the lower relative value to the utility of gas-fired generation? . . . The majority's order moves perilously close to a rule that PURPA requires selection of the cheapest power regardless of the value of fuel diversity. [280]

The CEC, in a report released in November 1995, cited the "substantial success" of California's having "one of the most diverse electricity systems in the world" and warned that "there is a legitimate concern that if nothing but gas-fired plants are constructed then someday the state may face a situation like the oil embargoes of the 1970s, or another unforeseeable crisis that will send electricity prices skyrocketing." [281]

Such concerns should not be a public policy issue, particularly in a restructured industry where market participants have a variety of risk-mitigating choices and must either make the right choices or be penalized. Without government price and allocation regulation, over a century of experience suggests that a buyers' market will be the rule and a sellers' market the exception for fossil fuels. [282]

The Increasing Environmentalism of Natural Gas

Natural gas has increasingly displaced fuel oil in dual-fuel electricity plants. Whereas electricity generated from natural gas accounted for less than half the dual-fuel power plant market as recently as 1976, it now has more than 80 percent of this market relative to fuel oil. [283] Fuel oil consumption in power plants in 1995 was 82 percent below 1973 (a 458 million barrel drop) and 62 percent below 1989 (a 162 million barrel reduction). [284] Coal, nuclear, and hydropower generation, accounting for approximately 80 percent of electricity generation, is typically baseloaded rather than dispatched because of lower variable costs. Consequently, renewable energy and conservation, traditionally justified as displacing coal and fuel oil emissions from power plants, must now justify displacing a much cleaner burning fuel, natural gas.

Decreased air pollution from existing and new natural-gas-powered plants is as significant a development as the fall in delivered gas prices and the improvement of combined-cycle turbine technology. While carbon dioxide emissions from all fossil-fuel power plants increased 15 percent between 1985 and 1993, CO2 emissions from gas plants decreased 16 percent. While nitrogen oxide (NOx) emissions fell 20 percent for the general power plant population, gas plants registered a 36 percent decrease in the same period. [285] Serving the Los Angeles region, Southern California Edison Company reported a 61 percent reduction in average NOx emissions and a 96 percent reduction in average SO2 emissions in its oil/gas plants between 1990 and 1995. [286]

New power-plant technologies can reduce NOx emissions, the major pollutant from natural gas combustion, by more than 90 percent from the uncontrolled-burn levels of the 1970s (from more than one pound per million Btu to under .1 pound per million Btu). [287] The emission reductions of gas combined-cycle plants are compared with those of coal and fuel oil under present technology in Table 3.

Table 3
Natural Gas Emissions versus Those of Clean Coal and Residual Fuel Oil in New Power Plants (% reduction using gas)

Emission	*Natural Gas versus Oil*[a]	*Natural Gas versus Clean Coal*

Sulfur dioxide	99	99
Nitrogen oxides	75	81
Carbon dioxide	43	58
Particulates	95	95
Solid waste	100	100

Sources: ICF Kaiser Study for Enron Corp., September 1995;
Applied Automated Engineering Study for Enron Corp., September 1995.

a. 2.7 percent sulfur.

Other studies have found similar advantages for gas. A 1994 estimate by the Worldwatch Institute, for example, was that gas-fired combined-cycle plants emitted 92 percent less

NOx, 100 percent less SO2, and 61 percent less CO2 than a pulverized-coal-fired steam plant with scrubbers. [288]

Existing gas power plants have been required to reduce NOx emissions under Clean Air Act requirements, and this situation will continue as new emission reduction targets take effect. New facilities in southern California must either acquire emissions offsets or obtain trading permits. The same California utilities that have led the nation (and the world) in wind and solar development and DSM expenditures have proclaimed that their gas power plants have internalized environmental externalities. As Pacific Gas and Electric testified before the CEC in 1994,

> Before addressing *how* to internalize externalities from powerplants, it is first worth examining *whether* to internalize them. In the late 1980s, when internalization requirements were added to the Public Resources Code and Public Utilities Code, utility powerplants accounted for 3-5 percent of statewide NOx emissions. Many plants did not have advanced NOx control equipment, such as Selective Catalytic Reduction (SCR). Since then, air quality regulators have imposed "Best Available Retrofit Control Technology" requirements and other regulations that will drastically reduce NOx emissions. In effect, NOx emissions from utility powerplants are being internalized, at a cost of hundreds of millions of dollars. Given these changes, it is not clear whether an additional layer of regulation to internalize externalities from utility powerplants would produce a net benefit to society. [289]

Increased efficiency factors of natural gas, where the same unit of gas combustion produces more electricity, also have resulted in effective reductions in gas power plant emissions. The energy-efficiency factor for gas, as stated earlier, has increased 40 percent since the early 1980s. [290]

Improving gas-fired electricity generation, FERC concluded, "has been made possible by the development of more efficient gas turbines, shorter construction lead times, lower capital costs, increased reliability, and relatively minimal environmental impacts." [291] Given that natural gas is abundant, reliable, contractually price certain, and relatively clean, the question must be asked: why should the economic failure and environmental drawbacks of renewables be overlooked?

Eco-energy planners, while welcoming gas as the most environmentally benign of the three fossil fuels, [292] have been slow to redefine the opportunity cost of conservation and renewable energy not in terms of fuel oil or coal but of natural gas. [293] Testimony by the Natural Resources Defense Council in the California electricity restructuring proceedings warned against increased coal and fuel oil burning, for example, never once mentioning that relatively clean-burning natural gas was now the dominant fuel for California's electricity market. [294]

In contrast to Worldwatch, Greenpeace has urged the phaseout of gas-fired generation. [295] Instead of envisioning natural gas as the bridge fuel to renewables, Greenpeace sees gas as displacing renewables. Stated Jason Salzman,

> There will be a new generation of gas-fired powerplants emitting pollutants for another 20 to 40 years that will be built in lieu of, rather than as a bridge to, renewables. We think that gas is undercutting the market for renewables, that the renewable market will hardly grow worldwide, and that our children will face a world in

climate crisis. [296]

A Greenpeace world would have little energy generation or production, and what little was produced--from solar and wind, primarily--would occur during only parts of the day. A modern society would have difficulty functioning under this scenario, to say the least.

"Greening" Electricity Prices: Renewables Again Fall Short

If current environmental standards governing power plant emissions are considered appropriate, or the entire exercise of defining externalities is considered too unscientific a basis for public policy, or both, [297] the externalities of fossil-fuel generation can be considered internalized. State and federal subsidies for favored renewables (and energy efficiency) are unnecessary, and existing tax credits, in fact, can be challenged as overcompensating qualifying renewables.

Yet assuming that fossil plants must be more stringently regulated to address such problems as ozone formation and global climate change, renewable subsidies may still be a poor use of the environmental dollar. The reasons are that

- ∑ subsidies are very expensive for renewable technologies that are a very small part of the electricity-generation market;
- ∑ natural gas, not coal or fuel oil, is the "opportunity cost" of renewables with existing and new capacity in California and other regions of the country; and
- ∑ more effective alternatives exist for air-emission abatement with the same expenditure.

In a September 1996 report, the Natural Resources Defense Council estimated that carbon dioxide emission costs for a coal plant were approximately 2 cents per kWh ($20 per ton) and 1 cent per kWh for a gas-fired facility. Carbon costs at new gas facilities were estimated to be lower still because of more efficient conversion rates. [298] This not only identifies coal plants as the most important target for the environmental dollar, it gives natural gas an environmental value that the renewables premium cannot exceed.

For the sake of argument, an "externality adder" for natural gas can be assigned to see if renewables are justified from an eco-energy perspective. The CEC calculated a "damage function" adder of 1.39 cents per kWh for gas plants located in the Los Angeles basin, the ozone capital of the nation. [299] An externality assignment for a gas plant located in better air-quality areas would be half as much. [300] Yet even the high side of this estimate appears to have been "internalized" already by the existing federal tax credit for qualifying renewables versus gas (now 1.7 cents per kWh), accelerated depreciation, [301] and the aforementioned negative externalities of renewables. Therefore, from a traditional environmentalist perspective, the substantial economic advantage of natural gas over renewables appears to be little disturbed even when externalities are internalized. Concluded the CEC after its painstaking externality exercise,

> In the last several [*Electricity Reports*], our assessments have consistently found that gas-fired plants were the least-cost resource choice. . . . Even in the social cost case, which valued damages from residual emissions, new geothermal and wind plants did not become cost-effective until around 2010, past the end of the twelve-year forecast period. Baseload coal, solar thermal and pumped storage never entered the mix of cost-effective choices, even during a twenty-year assessment. [302]

The externality internalization exercise not only falls short of justifying government mandates, it turns into a double-edged sword for qualifying renewable energy resources, particularly wind and solar energy. Adding DOE subsidies as a "social cost" to the private cost of wind and solar, the externality penalty assigned to natural gas is not only negated but reversed. [303] Dividing the cumulative DOE subsidy to wind power by total U.S. wind output since 1977, roughly estimated to be 30 billion kWh, yields a "social cost" of over 2 cents per kWh--the price of today's spot electricity. The same calculation with solar output, estimated at 10 billion kWh, yields an astronomical "social cost" of several dollars per kWh. Geothermal, in contrast, with cumulative production since 1977 of 192 billion kWh, almost five times the combined output of wind and solar, has a DOE "social cost" of under 1 cent per kWh. [304] Given the retirement of older wind and solar facilities and the need for further subsidy for new generations of technology, the social costs are not likely to be recouped

or even significantly lowered with future production.

Should a carbon tax or carbon trading system be implemented to "correctly" value the social cost of fossil fuels, renewable energy subsidies would become obsolete, and the unfavorable economics or pure environmental costs, or both, of renewables would be controlling. But if the preponderance of evidence today suggests that an imputed externality or social cost for natural gas still leaves such alternatives as wind and solar energy uneconomic, the same verdict should be rendered, and the environmental dollar should be spent elsewhere (if at all). Natural gas should be free to expand its market share against both its more polluting fossil-fuel rivals and its less air-emitting rivals as incentives dictate.

Cofiring or repowering coal plants with natural gas, or substituting cleaner burning subbituminous coal for bituminous coal, are alternatives for the renewable-subsidy dollar. [305] Tax incentives used to reduce SO2 emissions at coal plants can be employed to repower coal plants with natural gas. [306] Environmental initiatives in the transportation sector are another "opportunity cost" of renewable subsidies. The failure of eco-energy planners to consider the opportunity cost of renewable subsidies, instead favoring a "get all the reduction you can get wherever you can get it" mentality, is an intellectual failing and policy convenience that should no longer be accepted.

Public Policy Implications

This analysis can be employed now in the public policy debate to answer such questions as whether there has been too little or too much renewable energy investment to date, whether renewable and conservation subsidies should continue, and what the role of renewables and conservation in a restructured electricity industry might be.

Reconsidering the rationale of eco-energy planning opens the door to market-based energy policy. State-level energy agencies lose a key rationale, and some of the most significant civilian programs of the DOE can be eliminated. [307] Air-emission regulation under the Clean Air Act would continue with revisions based on the best available information; ad hoc eco-energy planning programs would not.

Renewables: Underinvestment or Overinvestment?

The DOE-appointed Yergin task force, formed to evaluate the nation's energy research and development effort, concluded in 1995 that "there is growing evidence of a brewing 'R&D' crisis in the United States--the result of the cutbacks and refocusing in private-sector R&D and reductions in federal R&D." [308] This "depletion of our R&D resource" was presented in stark terms:

> The loss of our "inventiveness"--that is, our store of human intellectual capital--would change America's future. It would reduce economic growth, damage the U.S. standard of living and America's international competitiveness--and erode America's leadership and . . . our "national power in the modern world." [309]

The verdict, that a continued or enlarged federal effort was needed to subsidize energy technologies on both the demand and the supply side, is undermined by the major findings of the present analysis. The problem has been not market failure but government failure (and analytic failure). The economic and environmental shortcomings of renewable energies point to a stark historical fact: a multibillion-dollar public-sector "malinvestment" has taken place. The fuel of choice for electricity generation has turned out to be the fuel that the DOE did not feature in its R&D portfolio--natural gas. Of the $60 billion (1996 dollars) expended by the DOE from FY78 through FY96, only 1 percent ($787 million) was spent on natural gas, while 99 percent was spent on conservation ($13.3 billion), civilian nuclear energy ($20.1 billion), coal ($13.3 billion), solar energy ($5.1 billion), geothermal energy ($1.8 billion), wind power ($900 million), other renewable energy sources ($2.8 billion), oil ($1.4 billion), and hydropower ($193 million). [310]

The lesson from the past is a warning for the future. One caution about a governmental R&D silver bullet has come from Gipe:

> Whenever renewables seem stymied, environmentalists, regulators, and politicians respond that more R&D is needed. This cry arises from an outmoded belief that technological and social innovations spring from the womb of large centralized organizations. This model of innovation no longer produces results either in government or commerce. The call for more R&D diverts attention from what is needed most, structural

change in the market. [311]

Ending Renewable Energy Subsidies

The policy implication of the present analysis is, *stop throwing good money after bad*. All renewable energy subsidies from all levels of government should cease. Once again, the lesson has been learned the hard way that government invariably picks losers, the market picks winners, and "infant industries" requiring government favor have trouble growing up. The history of subsidized renewable output also provides another case study of the unintended consequences of even well-intentioned government intervention in the marketplace. The unnecessary demise of members of endangered species populations and controversial unnecessary development in environmentally sensitive areas are unintended consequences of the eco-energy planners' energy agenda that they must openly and honestly confront.

The end of renewable and conservation subsidies translates into a number of specific public policy reforms. One is to end state-level integrated resource planning, a central planning exercise by utilities and regulators to determine "optimal" demand- and supply-side strategies. The end of IRP would entail repealing sections 111 and 115 of the Energy Policy Act of 1992. [312] Iowa would need to repeal its 1983 Alternate Energy Production Law. California would need to repeal sections 701.1 and 701.3 of the California Public Utility Code to end the requirement for energy diversity and renewable set-asides. [313]

Another policy revision on the state level is no longer to condition utility mergers on environmental commitments that lower the wealth of either ratepayers or shareholders. In what Ralph Cavanagh of the Natural Resources Defense Council called a model for future merger proceedings, 13 special-interest groups required the acquiring company in a particular merger to purchase a minimum amount of wind and geothermal resources regardless of cost. [314] Ratepayers also were required to fund energy-efficiency programs, among other things, through a nonbypassable transmission charge ("wires charge").

Deregulate, Do Not Reregulate

Electricity restructuring is gaining momentum at both the state and federal level. Many of the reforms being proposed and adopted still suffer from an unthinking reliance on the paradigm of eco-energy planning and thus threaten to negate some, if not much, of the rate savings possible from increased industry competition.

CPUC's about-face on the matter of eco-energy planning has been a disappointment to those welcoming the prospect of lower electricity rates and a free-market industry structure. Despite the commission's initial hostility toward the range of expensive subsidies for renewable energy and energy conservation programs, heavy pressure from eco-energy planners and welfare-seeking corporations led the commission ultimately to endorse maintaining, if not enlarging, renewable subsidies. [315] On the other hand, the CEC began to reconsider the need for renewable quotas to achieve fuel diversity given available market instruments to do the same. [316]

Twenty-nine months after the restructuring debate began, the California legislature settled the issue with a resounding victory for eco-energy planning. Fully $2 billion in ratepayer money is to be dedicated to propping up the eternally uneconomic renewable and conservation energy market. For the 1998-2001 period, the investor-owned utilities were instructed to commit $872 million to energy efficiency, $540 million to qualifying renewable generation (existing and new), and $350 million to research and development. Public power entities in the state would allocate approximately $400 million more to these areas. [317] In addition, "green pricing" programs were sanctioned under which consumers could contract to pay a premium for renewable energy, and qualifying renewable portfolios of at least 50 percent were allowed open access on the opening day of the program, January 1, 1998.

Allocating the $540 million for renewable projects was a central planning exercise by the CEC despite instructions in AB 1890 to employ "market-based mechanisms." The choices were among seven or more qualifying fuels; among existing, new, and emerging technologies; and among the four years 1998-2001. The final allocation was 45 percent for existing technologies ($243 million), 30 percent for new technologies ($162 million), 10 percent for emerging technologies ($54 million), and 15 percent for customer-side accounts ($81 million). Of the existing technology account, 56 percent went to biomass and solar thermal ($135 million); 29 percent went to wind power ($70.2 million); and 15 percent went to geothermal, small hydro (under 30 MW), digester gas, municipal solid waste, and landfill gas ($37.8 million). The

allocation of monies for new and emerging technologies was by bid and request, respectively, and the consumer-side allocation was divided between customer credits for renewable purchases ($75.6 million) and customer information ($5.4 million). [318]

The $243 million allocation to exiting technologies, 5 percent more than was required by the legislation, represented a bailout of existing renewable facilities threatened by the end of PURPA contracts and marginal-cost competition in a restructured industry. Solar power was the big winner, given its highly uncompetitive state as a central power station generator, while wind projects hit the jackpot since "the best way to reduce high operating and maintenance costs on older turbines is to largely or completely replace them with new equipment via retrofitting or repowering." [319] Confirming the environmental problems of new wind siting, the CEC determined that "repowers are preferable to green field development from an environmental standpoint." [320] Yet left standing was wind power's notorious killing field--Altamont Pass. The hard question must be asked: Where were the "environmentalists?"

Reflexively throwing another billion or two dollars at unproven technology and exhausted opportunity after two decades of failure will not achieve "fuel diversity," "job creation," "export commercialization," "clean air," and other panaceas any more than before. It will only exacerbate a public policy failure by having a renewables industry in competitive disarray compete against an overbuilt, utility-dominated, energy-efficiency industry in a state plagued by excess capacity, high rates, and low marginal costs. [321]

Two states besides California have already moved ahead toward restructuring in ways that protect renewable energy and energy conservation programs from the competitive forces of the marketplace. Only one state passing legislation (thus far) has resisted the temptation.

- Rhode Island, on August 7, 1996, became the first state in the country to enact electricity restructuring, requiring each distribution company to include a 0.25 cent per kWh charge to fund demand-side management and renewable programs.
- Pennsylvania specified ratepayer subsidization of conservation programs but did not specify a renewables program.
- New Hampshire simply stated that customers should be allowed the opportunity to choose to pay a premium for renewable energy.

In Arizona, a restructuring order from the state public utility commission established a set-aside for solar power of a half percent by 1999 and 1 percent by 2002. Commission orders in Maine, Massachusetts, and Vermont are also tending toward renewable portfolio requirements.

In other states, mandated environmental expenditure is proving to be too much for some parties to agree to industry restructuring. In Texas, for example, the industrial-user Coalition for Competitive Electricity complained that a proposed $1.5 billion ratepayer commitment for renewables and energy efficiency was unaffordable. [322]

Industry restructuring at the federal level also provides challenges. The proposed Electric Consumers' Power to Choose Act of 1997 (H.R. 655), introduced by Rep. Dan Schaefer (R-Colo.), would require that each state's power generators submit credits to FERC for qualifying renewables (organic waste biomass, dedicated energy crops, landfill gas, geothermal energy, solar energy, and wind power) in the following percentages of total generation: 2 percent in 2004; 3 percent in 2005-2009, and 4 percent for 2010 forward. [323] States with less than those percentages would be required to purchase credits from generators in states with extra qualifying renewables.

The renewable provision would not only force technology on markets whether or not it was economically or environmentally desirable, it would create unequal wealth effects favoring states with existing renewable infrastructure or more attractive renewable sites at the expense of other states with less renewable energy activity or fewer prospects. California, in particular, would enjoy a windfall at the expense of the dozens of states with little qualifying renewable activity. The federal setaside, unlike the California law itself, continues the quota for an indefinite period.

The provision contradicts the intention of the restructuring bill to lower electricity rates for consumers. Coming on top of the generous federal tax credit and promises of "green pricing," the quota mandate reveals the economic plight of a two-decade-old subsidized industry that the U.S. market would naturally reject.

A competing electricity restructuring bill (H.R. 1230) by Rep. Tom DeLay (R-Tex.), reintroduced on April 8, 1997, does not specify a renewables or energy conservation program but leaves such matters to the states. A bill (S. 237) introduced by Sen. Dale Bumpers (D-Ark.) adopts the same renewable quotas as does Representative Schaefer's bill with higher percentages to include hydroelectricity; but it has a sunset date of 2019.

Fuel-Neutral, Free-Market Energy Policy

Changes in consumer demand and technology can make what is uneconomic today economic in the future. If central-station power from wind, solar, or other renewables becomes economic on its own merits, there will be no complaint from free-market quarters. In fact, free-market advocates will likely be defending those resources from zero-tolerance environmentalists who will condemn even air-emission-free energy for its other environmental costs. For now, the harsh environmental opposition to hydroelectric power, the only meaningful alternative to fossil fuels in the renewable portfolio, should be reconsidered. A public policy initiative to repeal licensing requirements and privatize waterways to allow market decisionmaking about existing and new hydropower facilities is long overdue to replace the current political conflict over these now "public" resources.

The chance that market verdicts may change with such resources as wind and solar energy in central-station electricity generation cannot be a rationale for government to pick winners and losers before the market does. The evolutionary market process is theoretically and empirically the best way to allocate scarce resources amid uncertainty--a conclusion buttressed not only by theory but by the history of market and government forces in energy markets. [324]

It is possible that the primary source of energy in 50 or 100 years will be renewables, as a study by Shell International predicts. [325] Then again, present trends may continue to make wind and solar backstop fuels, as synthetic oil and synthetic gas are today, while fossil fuels, and even nuclear power, continue to be abundant and increasingly nonpolluting as a result of technological change through the 21st century. Government planners and the eco-energy planning intelligentsia cannot know if a transformation to preferred renewables will occur or what its specific parameters might be if it were to occur. The results of a complex, evolving market discovery process cannot be known ahead of time.

The failed coercive model of eco-energy planning should be replaced with a *market energy model* predicated on private property, competition, market pricing, profit/loss signals, technological improvement, and growing real wealth and philanthropy. This paradigm shift should be welcomed by environmentalists who

- prefer voluntary negotiation to coercion (civil society to political society),
- recognize the unintended negative consequences of government intervention and the unintended positive consequences of market transactions, and
- understand the positive correlation between private economic wealth and improving technology on one hand and ecological sensitivity and progress on the other.

To this end, the failed ad hoc program of eco-energy planning should be terminated. Such a public policy initiative would end the present era of energy intervention, facilitate the abolition of the DOE and state-level energy bureaucracies, and contribute to increased energy abundance and true sustainability.

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.

[144]. All statistics for renewable and nonrenewable generation and capacity are from the DOE's Energy Information Administration and can be found in Appendix, Tables A.2 and A.3.

[145]. Daniel Kaplan, "Is the Green Promise of Hydro Fading to Brown?" Energy Daily, December 7, 1992, p. 1.

[146]. Russell Shay, Testimony, Hydroelectric Relicensing: Hearings before the Subcommittee on Energy Conservation and Power of the House Committee on Energy and Commerce, 99th Cong., 1st sess. (Washington: Government Printing Office, 1985), p. 124.

[147]. "Approximately 2 to 3 percent of the power capacity of small power-producing projects and cogenerators that is represented by new dams on natural water courses is responsible for at least 90 percent of the environmental problems and environmental controversies associated with that whole range of [PURPA] projects." Ibid.

[148]. Public Law 99-495, 100 Stat. 1243 (1987).

[149]. Margaret Kriz, "Dueling over Dams," National Journal, December 11, 1993, pp. 2935-37; "Environmentalists Fault Clinton Promotion of Hydropower," Water Policy Report, October 27, 1993, p. 30.

[150]. "[Hydro] would grow in the next few decades in our sustainable future, but . . . growth would be constrained by resource limitations," Flavin and Lenssen, Power Surge,p. 286. Elsewhere they characterize hydro as "essentially static" (p. 41).

[151]. Alliance to Save Energy, American Gas Association, and Solar Energy Industries Association, An Alternative Energy Future, April 1992, p. 3:5. For a summary of environmental concerns with hydropower, see José Moreira and Alan Douglas Poole, "Hydropower and Its Constraints," in Renewable Energy, pp. 94-107.

[152]. Energy Information Administration, Electric Power Annual, 1995, vol. 1, Table 10.

[153]. DOE Task Force Study, Annexes 2-4, p. 183; emphasis added.

[154]. Ibid., Annex 1, p. 68.

[155]. Energy Information Administration, Annual Energy Outlook, 1996, p. 31.

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

[157]. The hydro system of the Bonneville Power Administration (BPA) was downrated from 9,918 MW to 9,258 MW in 1995, a 660 MW (7 percent) decline, to account for increased environmental (nonpower) management of river flows. Conversation with Perry Gruber, BPA spokesperson, February 12, 1996. BPA has charged its ratepayers an estimated $450 million per year for its fish programs. Lon Peters, "Power, Politics, and Salmon--Restructuring the Northwest Power Industry," Cascade Policy Institute, February 1996, p. 6. Under a new federal arrangement, salmon recovery will be capped at $435 million annually, but BPA is obligated to spend $1.5 billion on river restoration over six years and set aside another $352 million in a contingency fund. Portland Oregonian, September 13, 1996, p. 1. Meanwhile, a glut of salmon in Alaska has reduced their wholesale price to 5 cents per pound. Bill Richards, "Fishermen in Alaska, Awash in Salmon, Strive to Stay Afloat," Wall Street Journal, September 4, 1996,p. A1.

[158]. John Cushman, "Ex-Im Bank Refuses to Back Big China Dam," New York Times, May 31, 1996, pp. C1, C6; HeleneCooper, "Ex-Im Bank Snubs Chinese Dam Project," Wall Street Journal, May 31, 1996, p. A3.

[159]. The DOE estimate of between $1,850 and $2,180 (1991 dollars) per kW was provided by Perry Lindstrom, economist with the Energy Information Administration's Office of Integrated Analysis and Forecasting, on February 7,

1996. The estimate from the California Energy Commission (1991 dollars) of between $1,700 and $3,400 per kW was provided by Tom Tanton, adviser to Commissioner David Rohy, on February 7, 1996. The dated estimates reflect the absence of actual data on new projects.

[160]. See Terry Anderson and Pamela Snyder, Water Markets: Priming the Invisible Pump (Washington: Cato Institute, 1997), pp. 109-31.

[161]. In 1987 congressional hearings an executive with the nation's largest solar firm testified, "Increasing the size of solar facilities . . . to 80 megawatts . . . is the key to making solar thermal electric generation competitive in the immediate future." Patrick Francois, executive vice-president, LUZ International Limited, Testimony, Solar Power: Hearing before the Subcommittee on Energy and Power of the House Committee on Energy and Commerce, 100th Cong., 1st sess. (Washington: Government Printing Office, 1988),p. 12.

[162]. "The consensus as far as I can see is [that] after the year 2000, somewhere between 10 and 20 percent of our energy could come from solar technologies quite easily." Statement of Scott Sklar, executive director, Solar Energy Industries Association, ibid., p. 26.

[163]. Scott Sklar, "Solar Industry Appears Poised to Contribute," Forum for Applied Research and Public Policy, Summer 1992, p. 84.

[164]. See earlier subsection, Unfavorable Economics. See also Nevada Power Company, 1995 Annual Report, pp. 3, 6, 10.

[165]. Black & Veach, Assessment of New Utility Power Plants: Final Report, September 1986, pp. 15-5, 19-3. The 1,875 MW Teesside gas plant in England was built on 23 acres.

[166]. See Appendix, Table A.1.

[167]. DOE Task Force Study, Annex 1, pp. 57-61.

[168]. Referring to a 1978 study by K. A. Lawrence of the Solar Research Institute, Beckmann states, "To construct a 1,000 MW solar plant needs an excessive amount of materials: 35,000 tons of aluminum, 2 million tons of concrete, 7,500 tons of copper, 600,000 tons of steel, 75,000 tons of glass, 1,500 tons of chromium and titanium, and other materials. . . . The energy that goes into the construction of a solar thermal-electric plant is, in fact, so large that it raises serious questions of whether the energy will ever be paid back." Petr Beckmann, Why "Soft" Technology Will Not Be America's Energy Salvation (Boulder, Colo.: Golem, 1979),p. 6.

[169]. For a methodological overview of total fuel cycle environmental impacts, see National Renewable Energy Laboratory, Summary and Recommendation: Total Fuel Cycle Assessment Workshop (Golden, Colo.: NREL, 1995). The "upstream" environmental problems of solar would presumably have to be revealed and addressed in the "extended product responsibility" proposal of the President's Council on Sustainable Development. See PCSD, Sustainable America: A New Consensus (Washington: Government Printing Office, 1996), pp. 38-43.

[170]. Communication from Tom Tanton to Rob Bradley, December 29, 1995. Another source of incremental CO2 emissions is the production of soda glass for mirrors, although that was not quantified by Tanton.

[171]. Conversation with Mark Skowronski, former project director, Solar One Project, Southern California Edison, January 19, 1996.

[172]. Gipe, p. 351.

[173]. Ibid.

[174]. Linda Kanamine, "Experimental California Solar Plant 'Bottles' Energy for Later Use," USA Today, June 4, 1996,p. 2A.

[175]. Silverman and Worthman, "The Future of Renewable Energy Industries," p. 25.

[176]. Kanamine, p. 2A.

[177]. Flavin and Lenssen, Power Surge, p. 143.

[178]. Lotker, p. 94. LUZ's bankruptcy has left Southern California Edison ratepayers with a $5.8 million liability for an unfinished transmission project. See J. A. Savage, "CPUC Lets CalEnergy Off Kramer Substation Hook," California Energy Markets, September 6, 1996, p. 11.

[179]. Elaine Fletcher, "Can Solar Shine Again?" San Francisco Examiner, February 21, 1996, p. B1.

[180]. Energy Information Administration, Annual Energy Outlook, 1996, p. 32.

[181]. DOE Task Force Study, Annex 1, p. 60.

[182]. Allen Myerson, "Solar Power, for Earthly Prices," New York Times, November 15, 1994, pp. C1-C2. For a review of the special tax and subsidy treatment under consideration for the Nevada Solar Enterprise Zone, see Libby Brydolf, "Solar Power Proponents to Form Independent Power Authority in Solar-Energy Effort," California Energy Markets, December 9, 1994, pp. 17-18.

[183]. Myerson, "Solar Power, for Earthly Prices."

[184]. DOE Task Force Study, Annex 1, p. 58.

[185]. Ibid. The California Energy Commission puts the estimate at 9 acres per MW. Gipe, p. 406.

[186]. Communication from Ray Bransfield, wildlife biologist, U.S. Fish and Wildlife Service, Ventura, California, January 29, 1996.

[187]. Deroy Murdock, "Eco-Dilemmas: How 'Green' Policies Hurt Mother Nature," National Minority Politics, October 1995, p. 27.

[188]. Karin Sheldon, president, Wilderness Society, Prepared statement, California Desert Protection Act of 1993: Hearings before the Subcommittee on Public Lands, National Parks, and Forests of the Senate Committee on Energy and Natural Resources, 103d Cong., 1st sess. (Washington: Government Printing Office, 1993), p. 208. An extreme position of nonuse has been forwarded by Paul Ehrlich: "In a country like the United States, there is not the slightest excuse for developing one more square inch of undisturbed land." Quoted in Jonathan Adler, Environmentalism at the Crossroads (Washington: Capital Research Center, 1995), p. 116.

[189]. Roderick Nash, quoted in Gipe, p. 257. See also ibid., p. 444.

[190]. DOE Task Force Study, Annex 1, p. 57.

[191]. Ibid.

[192]. Bradley, Energy Choices and Market Decision-Making,pp. 19-20.

[193]. DOE Task Force Study, Annex 1, p. 73.

[194]. Ibid., p. 63.

[195]. Flavin and Lenssen, Power Surge, p. 180.

[196]. ICF Kaiser Study. For coal-fired plants to be competitive, very high gas prices and very low gas-fired generation capacity factors must be assumed. See, for example, Energy Venture Analysis, "Fuel Choice for New Electric Generating Capacity: Coal or Natural Gas?" Study for Center for Energy and Economic Development, Washington, 1994.

[197]. Christopher Flavin, Slowing Global Warming: A Worldwide Strategy (Washington: Worldwatch Institute, October

1989), p. 41.

[198]. Flavin and Lenssen, Power Surge, pp. 176-77.

[199]. DOE Task Force Study, Annex 1, p. 63.

[200]. In 1989 Flavin predicted that year-2000 geothermal capacity would be between 4,200 MW and 18,700 MW. Flavin, Slowing Global Warming, p. 39. Capacity today is around 3,000 MW with little growth anticipated.

[201]. Energy Information Administration, Electric Power Annual, 1995, vol. 2, Table 1.

[202]. Pacific Gas and Electric, Securities and Exchange Commission Form 10-K for the Year Ended December 31, 1994, p. 21.

[203]. Pacific Gas and Electric, Securities and Exchange Commission Form 10-K for the Year Ended December 31, 1995, p. 28.

[204]. "Many of the most promising geothermal resources are located in or near protected areas such as national parks, national monuments, and wilderness, recreation, and scenic areas." Energy Information Administration, Renewable Energy Annual, 1995, p. 79.

[205]. "The steam-powered Coldwater Creek Geothermal Plant, hailed as a source of 'inexhaustible' clean energy at its opening eight years ago, may soon be shut down." Kimberly May, "SMUD Plans to Shut Down Steam Plant," Sacramento Bee, June 21, 1996, p. 1B.

[206]. "In a 'stunning blow' to supporters of geothermal energy, California Energy Company has 'mothballed' drilling operations at the Newberry National Volcanic Monument in Oregon, because it did not find enough superheated water at shallow depths." Mike Freeman, "Failure to Find Geothermal Hot Spot Puts 'Green' Energy Project at Risk," Seattle Daily Journal of Commerce Online, October 22, 1996.

[207]. These points are taken from DOE Task Force Study, Annex 1, p. 70. See also Energy Information Administration, "Geothermal Energy in the Western U.S. and Hawaii: Resources and Projected Generation Supplies," September 1991; Silverman and Worthman, "The Future of Renewable Energy Industries," pp. 17-20.

[208]. Arthur O'Donnell, "A Geyser of Ill Will, Part II," California Energy Markets, November 3, 1995, p. 8.

[209]. Christopher Flavin and Rick Piltz, Sustainable Energy (New York: Renew America, 1989), p. 30.

[210]. Flavin and Lenssen, Power Surge, p. 191.

[211]. "Carbon dioxide is released in direct steam and flash systems at a typical rate of 55.5 metric tons per gigawatt hour, or at approximately 11 percent of the rate for gas-fired steam electric plants." Energy Information Administration, Renewable Energy Annual, 1995, p. 78.

[212]. Complained Sen. Conrad Burns (R-Mont.) to a representative of the Natural Resources Defense Council in congressional hearings in 1989, "Now we have environmental concerns about geothermal energy. In other words, just about the time we want to use them, somebody comes along and says well, do not change the pattern of everything under the ground. And so we have to leave that alone." Arctic Coastal Plain Competitive Oil and Gas Leasing Act, p. 140.

[213]. Daniel Yergin, "Conservation: The Key Energy Resource," in Energy Future: Report of the Energy Project at the Harvard Business School, ed. Robert Stobaugh and Daniel Yergin (New York: Random House, 1979), p. 136.

[214]. Ibid. The father of modern energy conservation is Amory Lovins, whose article "Energy Strategy: The Road Not Taken," Foreign Affairs 55, no. 1 (October 1976): 65-96, popularized "soft energy" (conservation) as an alternative to "hard energy" (new megawatt capacity).

[215]. Quoted in Ralph Cavanagh, The Great "Retail Wheeling" Illusion--And More Productive Energy Futures (Boulder,

Colo.: E Source, 1994), p. 8.

[216]. California Energy Commission, 1994 Electricity Report, p. 40.

[217]. Energy Information Administration, Electric Power Annual, 1994, vol. 2, p. 82.

[218]. Energy Information Administration, Electric Power Annual, 1993 (Washington: Government Printing Office, 1994), p. 108; Energy Information Administration, Electric Power Annual, 1995, vol. 2, p. 77. DSM expenditures for 1995 are conservatively estimated at one-half of 1994 levels, or $1.36 billion. Pre-1989 data for the United States are not available, but California's 1980-88 expenditure of $1.5 billion is included in this estimate. All estimates are restated in 1995 dollars.

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

[220]. Pacific Gas and Electric, Form 10-K for the Fiscal Year Ending December 31, 1994, p. 14.

[221]. Two principals of the consulting firm Barakat & Chamberlin, who were instrumental in creating the analytical framework used to implement California's record DSM commitment, recently stated, "It is now clear that the industry led itself astray regarding the value and appropriateness of DSM activities; the erroneous views that developed regarding the source of the value of DSM came about at least in part because of the way in which the standard tests were applied." John Chamberlin and Patricia Herman, "The Energy Efficiency Challenge: Save the Baby, Throw Out the Bathwater," Electricity Journal, December 1995, p. 39. While those authors estimate the loss from understated costs and overstated benefits in the "millions of dollars"(p. 45), Herman elsewhere has estimated the national cost in the "hundreds of millions of dollars." Patricia Herman, "Reforming Demand-Side Management for the Competitive Power Era," Paper delivered at the conference on New Horizons in Electric Power Deregulation, Cato Institute, March 2, 1995.

[222]. For a discussion of the CPUC reversal of April 1994, see Robert Bradley Jr., "The Electric Restructuring Debate in California," in Restructuring California's Electric Industry: Lessons for the Other Forty-Nine States, ed. Robert Michaels (Houston: Institute for Energy Research, 1996), pp. 11-15.

[223]. The source of this inside joke wished to remain anonymous.

[224]. Seymour Goldstein, "California Utility DSM at the Crossroads," California Energy Commission, January 1995, p. 3.

[225]. Ruth K. Kretschmer, commissioner, Illinois Commerce Commission, Personal communication with Paul Ballonoff, 1996; Energy Information Administration, Electric Power Annual, 1994, vol. 2, Tables 50, 48, 13. Both studies were brought to the author's attention by the manuscript of Paul Ballonoff, Energy: Ending the Never-Ending Energy Crisis (Washington: Cato Institute, forthcoming).

[226]. Personal communication between Illinois Commerce Commissioner Ruth Kretschmer and Paul Ballonoff, 1995. Cited in ibid.

[227]. See Energy Information Administration, Electric Power Annual, 1995, vol. 2, Table 43, p. 77, for DSM program costs and savings and Table 13, p. 35, for the relative costs of the fuel use presumably avoided.

[228]. For various criticisms of DSM from academic and professional economists, see Alfred Kahn, "An Economically Rational Approach to Least-Cost Planning," Electricity Journal, June 1991, pp. 11-20; Paul Joskow and Donald Marron, "What Does a Negawatt Really Cost? Evidence from Utility Conservation Programs," Energy Journal 13, no. 4 (1992): 47-74; Albert Nichols, "How Much Energy Do DSM Programs Save? Engineering Estimates and Free Riders," National Economic Research Associates, Cambridge, Mass., 1993; Albert Nichols, "Estimating the Net Benefits of Demand-Side Management Programs Based on Limited Information," National Economic Research Associates, Cambridge, Mass., 1993; Albert Nichols, "How Well Do Market Failures Support the Need for Demand Side Management?" National Economic Research Associates, Cambridge, Mass., 1992; Ronald Sutherland, "Market Barriers to Energy Efficiency Investments, Energy Journal 12, no. 3 (1991): 15-33; Ronald Sutherland, "Income Distribution Effects of Electric Utility DSM Programs," Energy Journal 15, no. 4 (1994): 1-15; Ronald Sutherland, "Economic Efficiency, IRPs, and Long Term Contracts," Presented to the Western Economics Association, June 12, 1993; Larry Ruff, "Equity vs. Efficiency: Getting DSM Pricing Right," Electricity Journal, November 1992, pp. 24-35; Douglas Houston, Demand-Side Management: Ratepayers Beware (Houston: Institute for Energy Research, 1993); Bernard Black and Richard Pierce Jr., "The Choice

between Markets and Central Planning in Regulating the U.S. Electricity Industry," Columbia Law Review 93 (October 1993): 1339-44; Andrew Rudin, "DSM: An Exorbitant Free Ride into an Unsustainable Future," Presented to the Great Lakes Conference of Public Utility Commissioners, July 13, 1992.

[229]. On these points, see Robert L. Bradley Jr., "California DSM: A Pyrrhic Victory for Energy Efficiency?" Public Utilities Fortnightly, October 1, 1995, p. 44.

[230]. David Lapp, "The Demanding Side of Utility Conservation Programs," Environmental Action, Summer 1994, p. 27.

[231]. "The regulated monopoly structure [of] . . . utilities . . . has more often than not led to an exacerbation rather than diminution of environmental problems. Investors need to be free to succeed or fail in the marketplace without recourse to the safety net of cost recovery if we are to efficiently match energy investments with demand." Environmental Defense Fund, Statement before the House Subcommittee on Energy and Power Resources Concerning Electric Regulation: A Vision for the Future, May 15, 1996, p. 1.

[232]. For a discussion of some of these issues, see Lee and Darani, pp. II, 12-15, 24-25.

[233]. Ned Ford, "What Role for DSM Now?" Electricity Journal, March 1996, p. 87.

[234]. For a brief review of the early industry's drive to trade franchise protection for rate regulation, see Marvin Olasky, Corporate Public Relations: A New Historical Perspective (Hillsdale, N.J.: Lawrence Erlbaum Associates, 1987), pp. 33-43. For a longer review, see Robert L. Bradley Jr., "The Origins of Political Electricity: Market Failure or Political Opportunism?" Energy Law Journal 17, no. 1 (1996): 59-102.

[235]. James Rhodes, Statement on behalf of Edison Electric Institute before the House Subcommittee on Energy and Power Resources Concerning Electricity Regulation: A Vision for the Future, May 15, 1996.

[236]. Michael Maloney and Robert McCormick, Customer Choice, Consumer Value: An Analysis of Retail Competition in America's Electric Industry (Washington: Citizens for a Sound Economy, 1996); Robert Crandall and Jerry Ellig, Economic Deregulation and Customer Choice: Lessons for the Electric Industry (Fairfax, Va.: Center for Market Processes, 1997).

[237]. This led directly to the political pressure to suspend PURPA auctions described in the later subsection, A Restructured PURPA.

[238]. Wind, for example, often peaks in the early evening, whereas the demand peak occurs in midafternoon. See Cavallo et al., p. 151.

[239]. The declaration and signatories are reprinted in Ralph Cavanagh, The Great "Retail Wheeling" Illusion, pp. 25-28.

[240]. Ibid., p. 3. See also Ralph Cavanagh, "Electricity Shopping Can Be a Bad Deal," New York Times, June 12, 1994, p. 11. A study by the Worldwatch Institute similarly complained that the "mirage" of retail wheeling "would severely undermine the long-term planning that has been so vital to the evolution of an efficient, environmentally sound electricity market." Christopher Flavin and Nicholas Lenssen, "Powering the Future: Blueprint for a Sustainable Electricity Industry," Worldwatch Paper no. 199, Worldwatch, Washington, June 1994, p. 46.

[241]. One report states that environmentalists have conceded as much, finding solace in the fact that competitive restructuring could hasten the phaseout of the nuclear industry and accelerate "green pricing" to help renewables compete. James Ridgeway, "The Green Movement's Shock Treatment," Village Voice, May 28, 1996, p. 22.

[242]. Rhodes, p. 10.

[243]. For a summary of the first year of the Blue Book debate, see Restructuring California's Electric Industry.

[244]. See generally, Bradley, "The Electric Restructuring Debate in California," and Bradley, "California DSM," pp. 41-47. A sign of the times is that a leading architect of California's central planning failure with electricity, Ralph Cavanagh of the NRDC, received the 1996 Heinz Award in Public Policy as "the most influential figure in Western energy policy."

"Cavanagh Wins Congratulations and Cash for Bringing People Together," California Energy Markets, December 13, 1996, p. 2.

[245]. The Edison Electric Institute has estimated above-market PURPA-related costs of "at least" $38 billion. Edison Electric Institute, Statement, p. 11.

[246]. California Energy Commission, "QF-Self Generation LTBA Database," no date, copy in author's files.

[247]. Federal Energy Regulatory Commission, "Order on Petitions for Enforcement Action Pursuant to Secton 210(h) of PURPA," 70 FERC 61666 at 61667, 61672 (1995).

[248]. Ibid. at 61676.

[249]. Federal Energy Regulatory Commission, "Order on Requests for Reconsideration," 71 FERC 62074 at 62079.

[250]. Quoted in Craig Cano, "IPPs Stunned, State Miffed--Just Another Day on the PURPA Front," Inside F.E.R.C., February 27, 1995, p. 14.

[251]. Energy Information Administration, Annual Energy Outlook, 1996, p. 36. DOE also mentioned the "further uncertainty" of Congress's proposed elimination of the 1.5 cent per kWh tax credit. Ibid.

[252]. "NERA Energy Outlook," December 21, 1995, p. 1.

[253]. See, for example, Dennis Wamsted, "TVA Charts New Course, Takes Option on Enron Power," Energy Daily, January 2, 1996, pp. 1, 3.

[254]. See, for example, Arthur O'Donnell, "Edison Files QF Buyout Pact, Seeks Confidentiality of Provisions," California Energy Markets, September 1, 1995, p. 11.

[255]. See later subsection, Deregulate, Do Not Reregulate.

[256]. See earlier subsection, Unfavorable Economics. The depletion allowance was eliminated for integrated oil companies in the Tax Reduction Act of 1975 and significantly reduced for nonintegrated oil and gas production companies in the Tax Reform Act of 1976. The intangible drilling cost deduction was significantly scaled back in the same 1976 law and the Tax Equity and Fiscal Responsibility Act of 1982. See Robert L. Bradley Jr., Oil, Gas, and Government: The U.S. Experience (Lanham, Md.: Rowman & Littlefield, 1996), pp. 337-42.

[257]. See Appendix, Table A.1.

[258]. Energy Information Administration, "Federal Energy Subsidies: Direct and Indirect Interventions in Energy Markets," November 1992, p. x.

[259]. The Alliance to Save Energy calculates that energy subsidies in 1989 totaled $36 billion (about four times larger than the figure calculated by the DOE's EIA), but even this number is relatively inconsequential, in comparison with the total size of the U.S. energy industry (about 6 percent). Still, there are several serious problems with ASE's calculations. First, $11.6 billion of subsidies (almost a third of the total) stems from two programs--accelerated depreciation of capital stock and the generation investment tax credit--that have been repealed. Another $12 billion of the subsidies is not energy subsidies but tax provisions generally available to capital investments. Although ASE argues that those provisions artificially advantage capital investments over less capital-intensive alternatives (such as energy efficiency investments), a truly neutral tax code would not tax capital investments at all, since capital returns are invariably taxed a second time at the point of consumption whereas noncapital consumption is taxed only once. Thus, the "subsidies" castigated by ASE simply help offset the unfair treatment of capital via the corporate income tax and the capital gains tax. Finally, other ASE categories are a stretch, such as the Strategic Petroleum Reserve, considered to be a $2.1 billion annual subsidy to the oil industry. With SPR injections suspended and withdrawals becoming more regular, the subsidy has turned negative. Douglas Koplow, "Federal Energy Subsidies: Energy, Environmental, and Fiscal Impacts," Alliance to Save Energy, April 1993.

[260]. Ibid., p. 20.

[261]. "Federal Government Subsidies and Incentives for U.S. Energy Industries," Management Information Services, Inc., Washington, May 1993.

[262]. See Robert L. Bradley Jr. "The Distortions and Dynamics of Gas Regulation," in New Horizons in Natural Gas Deregulation, ed. Jerry Ellig and Joseph Kalt (Westport, Conn.: Praeger, 1996), pp. 12-14.

[263]. "Th[e] imbalance between [oil and gas] reserves and consumption should be corrected by shifting industrial and utility consumption from oil and gas to coal and other abundant energy sources. . . . By 1990 [under this plan], virtually no utilities would be permitted to burn natural gas." Executive Office of the President, The National Energy Plan (Washington: Government Printing Office, 1977), pp. xii, xix.

[264]. "Federal Energy Subsidies: Direct and Indirect Interventions in Energy Markets," p. x.

[265]. See also the later subsection, The Increasing Environmentalism of Natural Gas.

[266]. Kenneth Lay, "Electric Restructuring: A New Opportunity for Natural Gas," American Oil & Gas Reporter, December 1995, p. 43. For an explanation of the "resource pyramid concept" in place of the "finite volume model" to introduce the dynamic driver of improving technology, see The 1995 Enron Outlook (Houston, Tex.: Enron Corp., 1995), p. 8.

[267]. International Energy Statistics Sourcebook (Tulsa, Okla.: PennWell, 1994), p. 202.

[268]. Energy Information Administration, Natural Gas Annual, 1993, p. 211; Energy Information Administration, Natural Gas Monthly, December 1995, p. 10.

[269]. American Gas Association, 1993 Gas Facts (Arlington, Va.: AGA, 1993), p. 6.

[270]. National Petroleum Council, The Potential for Natural Gas in the United States (Washington: NPC, December 1992), Executive Summary, pp. 5-6.

[271]. DOE Task Force Study, p. 45. Also see Malcolm Browne, "Geochemist Says Oil Fields May Be Refilled Naturally," New York Times, September 26, 1995, p. B5.

[272]. See Ballonoff.

[273]. Robert L. Bradley Jr., "Deregulatory Dynamics: Bypass and Reckoning in the California Natural Gas Market," Presented to the DOE-NARUC Conference, New Orleans, April 27, 1993.

[274]. American Gas Association, "Comments in the Matter of: Preparation of the 1992 Electricity Report (ER92)," Docket no. 90-ER-92, January 24, 1992, p. 6.

[275]. Ibid., p. 3.

[276]. "Natural gas dependence does not create special risks for the prudent buyer over the long term. Widespread decisions to depend on natural gas should not be considered a 'market failure' but a vindication of the economic and environmental advantages of this fuel over its rivals." Trans-western Pipeline Company (Enron Corp.), "Natural Gas and a Potential Fuel Diversity Penalty," Testimony on fuel diversity before the California Energy Commission, Re: Docket 90-ER-92, January 24, 1992, p. 3.

[277]. "Natural gas [is] such a cheap high that it's referred to these days as the crack cocaine of the industry." Linn, "Whirly Birds," p. 12. See also Gipe, p. 478.

[278]. Enron Corp., The Natural Gas Advantage, p. 16.

[279]. For a description of the four stages in the evolution of the natural gas commodity business as of 1992, see

Catherine Good Abbott, "The Expanding Domain of the Nonjurisdictional Gas Industry," in New Horizons in Natural Gas Deregulation, pp. 190-92.

[280]. 71 FERC 62074 at 62081.

[281]. California Energy Commission, 1994 Electricity Report, pp. 44, 47. The CEC went on to say that diversity does not appear to be a problem "at this time . . . [to] allow us to see how the market will respond" (p. 47). The report also moves away from renewables-as-diversity (p. 48).

[282]. For a historical review of shortages during regulated periods and "overproduction" during free-market periods in the U.S. oil and gas experience, see Robert L. Bradley Jr., The Mirage of Oil Protection (Lanham, Md.: University Press of America, 1989), pp. 129-39.

[283]. Energy Information Administration, Monthly Energy Review, March 1996, p. 95.

[284]. Ibid., p. 99.

[285]. Energy Information Administration, Annual Energy Review, 1994 (Washington: Government Printing Office, 1995), p. 341.

[286]. Communication from Southern California Edison Company to author, July 15, 1996. Part of the reduction came from eliminating fuel oil burning in favor of natural gas for economic and environmental reasons.

[287]. Natural Gas Council, "New Directions: Natural Gas, Energy and the Environment," May 1993, p. 10; Conversation with Paul Wilkinson, vice-president, American Gas Association, January 24, 1996.

[288]. Flavin and Lenssen, Power Surge, p. 101.

[289]. Mark Meldgim and Curtis Hatton, Pacific Gas and Electric, Testimony before the California Energy Commission on "Internalizing Externalities," Preparation of the 1994 Electricity Report (Docket 93-ER-94), October 20, 1994, p. 1. The 3-5 percent estimate for California compares to a national NOx contribution from gas power in 1994 of 2.5 percent. Environmental Protection Agency, National Air Pollutant Emission Trends, 1900-1994 (Washington: EPA, October 1995), pp. ES-8, A-6.

[290]. Gajewski, 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. See also "Comments of the American Gas Association," CPUC Blue Book Hearings, July 21, 1994, pp. 12-13.

[291]. 60 Federal Register, 17669.

[292]. Flavin and Lenssen, Power Surge, call natural gas the "prince of hydrocarbons" (p. 91) and add "growing signs suggest that the world is already in the early stages of a natural gas boom that could profoundly shape our energy future. . . . This relatively clean and versatile hydrocarbon could replace large amounts of oil and coal" (p. 92). For a collaborative modeling study between the natural gas industry and eco-energy planners where natural gas displaces fuel oil and coal in electric generation to help achieve aggressive emission reduction goals, see Alliance to Save Energy, American Gas Association, and Solar Energy Industries Association.

[293]. Gipe (pp. 242, 324, 351, 394-95, 426, and 459) is also guilty of this, although he does properly focus on natural gas at the end of his book (pp. 476-79).

[294]. See Bradley, "California DSM," p. 45.

[295]. "We are calling for a moratorium on construction of all fossil-fired power plants, including those that burn gas, oil, and coal, and for a phaseout of all existing power plants burning fossil fuels." Jason Salzman, "The Role of Environmental Externalities in Utility Regulation: Comment," in Opportunities and Challenges for Natural Gas (Washington: Department of Energy/NARUC, 1996), p. 866.

[296]. Ibid., p. 867. Greenpeace criticizes environmental groups such as Worldwatch for participating in "the natural gas greenwash." See Carol Alexander, "Natural Gas: Bridging Fuel or Roadblock to Clean Energy?" Greenpeace, January 1993, pp. iv, 42.

[297]. "At the present time, it is not possible to either develop accurate damage values using the [Air Quality Valuation Model] or assess the accuracy of the damage values derived from the AQVM. This is due to the use of inadequate air quality models and the lack of complete data for health impacts from long-term exposure to air pollutants." California Air Resources Board, In the Matter of: Preparation of the 1994 Electricity Report, August 12, 1994, p. 1.

[298]. Natural Resources Defense Council, "Risky Business: Hidden Environmental Liabilities of Power Plant Ownership," September 1996, p. 6.

[299]. The ER-94 externality adders total 1.39 cents per kWh as follows: NOx (.30 cents), PM (.59 cents), CO2 (.47 cents), SOx (.03 cents), and ROG (.002 cents). California Energy Commission, 1994 Electricity Report, appendix A, part II, section A, pp. 104-5. Another addition can be made for methane leakage, estimated to be 1.4 percent of total gas production. Staff Report, "Gas Is green, EPA, GRI, Industry Study Finds," Gas Daily, November 18, 1996, p. 2. However, such a complete penalty for gas would require a total fuel cycle analysis for renewable energy projects, which would reduce if not reverse the gas adder on a net basis.

[300]. Conversation with Tom Tanton, California Energy Commission, March 4, 1997.

[301]. See earlier subsection, Ratepayer and Taxpayer Subsidies.

[302]. California Energy Commission, 1994 Electricity Report, p. 117. Added former CEC commissioner Richard Bilas, "When we did our integrated resource plans, it didn't matter whether we used cost of control or damage functions [to determine externalities]. And for all practical purposes, it didn't matter what the cost of control was. If it was out of sight, it didn't matter, because the only resources that ever won were gas-fired combined cycles. They won all the time." Richard Bilas, "The Role of Environmental Externalities in Utility Regulation: Comment," in Opportunities and Challenges for Natural Gas: Record of Proceedings of the Fourth Annual DOE-NARUC Natural Gas Conference,p. 864.

[303]. DOE subsidies to both wind and solar are more than $1 million per installed megawatt, which on a levelized basis is close to 8 cents per kWh using a calculation relied upon by Paul Gipe. See Gipe, pp. 238-39. DOE subsidies to gas, on the other hand, are virtually negligible, particularly given that gas-fired electricity output in 1995 was more than 125 times greater than the combined output of wind and solar generation. See Appendix, Table A.1.

[304]. For the cumulative renewable output for the United States per source and by year, see Energy Information Administration, Annual Energy Review, 1995, vol. 1, Table 10.9. Financial figures for DOE subsidies are given in Appendix, Table A.1.

[305]. The $5.8 billion spent by the Department of Energy on wind and solar subsidies over the last 20 years is the financial equivalent of replacing between 5,000 and 10,000 MW of the nation's dirtiest coal capacity with gas-fired combined-cycle units, which would have reduced carbon dioxide emissions between one-third and two-thirds. In contrast, the 2,100 MW of U.S. wind and solar capacity present today, which equates to around 700 MW on a dependable capacity basis, has displaced far less CO2 emissions. Simple mathematics shows that a one-third reduction in CO2 emissions for 5,000 to 10,000 MW is from three to four times greater than even a hypothetical 100 percent reduction in CO2 emissions for 700 MW.

[306]. See, for example, Erin Van Bronkhorst, "Coal Plant in Plan to Clean the Air," Journal of Commerce, December 5, 1996, p. B5.

[307]. The case for abolishing DOE includes two public policy issues not addressed in this essay: renouncing the agency's "energy security" role and privatizing DOE's power marketing administrations.

[308]. DOE Task Force Study, p. 3.

[309]. Ibid. Romm and Curtis similarly warn that a diminished federal research and development role in energy and related technologies would be "a blunder of . . . potentially historic proportions" (p. 74).

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

[311]. Gipe, p. 90.

[312]. Public Law 102-486, 106 Stat. 2776 at 2795-96, 2803-05.

[313]. Section 701.3 of the California Public Utilities Code states, "Until the [CPUC] completes an electric generation procurement methodology that values the environmental and diversity costs associated with various technologies, the [CPUC] shall direct that a specific portion of future electrical generating capacity needed for California be reserved or set aside for renewable resources." Quoted in California Energy Commission, 1994 Electricity Report, p. 48.

[314]. "Portland General, Enron Turn Around Opponents to Mega-Merger," Electric Power Alert, January 15, 1997, p. 18.

[315]. Both the majority and minority decisions in the December 1995 reversal stated, "We are committed to establishing restructuring policies which maintain California's resource diversity for existing resources as well as encourage development of new renewable resources." "OIR/OII on the Commission's Proposed Policies Governing Restructuring California's Electric Services Industry and Reforming Regulation," December 20, 1995, majority decision, p. 146; minority decision, p. 143.

[316]. "The Commission supports a policy of maintaining the current benefits from renewable resources to the state's electricity system. . . . The [California] Legislature should allow customers more options toward managing their own risk. The modifications should also expand emphasis beyond renewables alone to include other opportunity technologies . . . as well as financial instruments." California Energy Commission, 1994 Electricity Report, pp. 48; California Energy Commission, Final Adoption Order, November 1, 1995, amending p. 119 of the original that erroneously had "the Commission supports a policy of maintaining the current contribution of renewable resources." Emphasis added.

[317]. For a summary of AB 1890, signed by Governor Wilson on September 23, 1996, see Aldyn Hoekstra and Gary Simon, "Sweetening the Deal: The California Legislature Takes on Electric Restructuring," Cambridge Energy Research Associates, November 1996; Dan Richard and Melissa Lavinson, "Something for Everyone: The Politics of California's New Law on Electric Restructuring," Public Utilities Fortnightly, November 15, 1996, pp. 37-41.

[318]. California Energy Commission, Policy Report on AB 1890 Renewables Funding (Sacramento: CEC, 1997), p. ES-5.

[319]. Ibid., p. A-2.

[320]. Ibid.

[321]. For an example of the tension between renewable and energy efficiency proponents in California, see Geothermal Resources Association, "Demand-Side Management Uncertainty," Testimony before the California Energy Commission, in the Matter of 1992 Electricity Report (ER 92), February 3, 1992.

[322]. "Texas Choice Bill May Not Have Consumers' Support," Megawatt Daily, January 30, 1997, pp. 1-2.

[323]. The bill was reprinted in Electric Power Alert, July 17, 1996.

[324]. See, generally, Bradley, Oil, Gas, and Government.

[325]. Shell International, "The Evolution of the World's Energy System: 1860-2060," December 1995, p. 11. For a view that natural gas will be the "bridge" or "transition" fuel to a renewables future, see Flavin and Lenssen, Power Surge, chap. 5.