The Soft Case for Soft Energy

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Since the 1970s, North American and European governments as well as many policy analysts have believed that fossil fuels will gradually be replaced by "softer" sources of energy--mainly renewable energy sources such as windpower, solar power, biomass, geothermal power, speculative hydrogen power technologies and energy conservation. These soft energy sources have been considered more environmentally benign than coal or oil and nearly as attractive economically Soft energy advocates believe that only a moderate amount of government intervention is necessary to increase the use of soft technologies and the efficiency of the economy.

The state and federal campaigns against fossil fuels, however, have not produced the quick victory that advocates predicted. Instead, they have taken on the characteristics of the Vietnam War. For over 25 years now, between $30 and $40 billion has been spent to force soft energy onto consumers(1) in a campaign employing a dizzying array of federal and state taxes, subsidies, preferences and consumption orders.(2)

Indeed, victory over fossil fuels is nowhere in sight. Renewable energy--wind, solar, geothermal and biomass--comprise only 1.5 percent of the energy market,(3) and revolutionary advances in natural gas technology, not soft energy, are fundamentally reshaping the energy industry. Still, soft energy advocates continue to proclaim that an energy revolution is upon us and that just a few more subsidies and mandates are necessary to bring us into the progressive energy promised land.

Soft energy advocates including Amory Lovins and Christopher Flavin justify their call for governmental intervention in energy markets by relying on four arguments. First, they argue that energy markets are riddled with "market failures" that lead to economic inefficiencies. Second, government is said to have subsidized fossil fuels, artificially tilting the market against soft energy Third, such advocates predict that global warming will inevitably force governments to dramatically restrict the use of fossil fuels, making the advent of a soft energy economy a question not of "if" but "when." Finally, soft energy policy experts assume, if implicitly, that they have superior information and insights that market actors simply lack or choose to ignore. Government intervention, they conclude, is the only way to achieve the "best" use of energy.

This paper briefly examines the economic and environmental rationales behind the ongoing campaign to promote soft energy Those rationales, while superficially attractive, do not hold up well to scrutiny. There is no compelling reason to believe that soft energy will play any larger role in the 21st century than it does today.

HOW BROKEN ARE THE ENERGY MARKETS?

Remarkably few non-economists understand the exact meaning of the terms "market failure" or "efficiency," despite their promiscuous use in public debate. Harvard University professor Steven Kelman, for instance, interviewed staff members of U.S. congressional committees to determine their understanding of the terms and found that neither Republicans nor Democrats understood either concept.(4) Consequently, the charge of market failure is used with little care or precision and is subject to extensive misuse. Nowhere is that more true than in the energy debate.

Market failures result when the marketplace is unable to secure adequately "public goods," defined as those commodities for which it is difficult to restrict the benefits of trade to those who participate in the transaction. A common example is air pollution. If someone brought suit against

a factory's pollution or negotiated a contract with the factory to reduce pollution, the benefits of the suit or contract could not be restricted to the person who filed the charges. The others in the neighborhood, the free riders, would also benefit.(5)

Implicit in the charge of energy market failure, then, is the idea that fossil-fuel markets are characterized by property rights that do not require users to pay for all the costs imposed by their use, and that harmed third parties face public-good problems in organizing a solution. For market-failure arguments to justify government promotion of soft energy, research would have to demonstrate that those "failures" result in fossil fuel prices that are too low and soft energy prices that are too high relative to their "optimal" prices. But as we shall see, research suggests that governmental actions have, by and large, kept petroleum prices above rather than below an unregulated market price.

Unfortunately, most policy activists use the phrase "market failure" as a catch-phrase to identify any sub-optimal economic decisions by consumers (at least, "sub-optimal" as defined by activists). While economists generally believe that free markets are the most efficient means of producing and distributing goods and services--save for when the aforementioned public goods dilemma confronts consumers--the activist definition fundamentally challenges that very premise. While the idea that government planners can generally produce "better" social and economic outcomes than market actors is outside the scope of this paper, suffice it to say that even economists with great faith in government intervention accept that, as long as public goods issues do not arise, markets have proven superior to governmental planning. Indeed, as we will argue, government intervention in the energy economy has proven so dismal a failure that no exception to this rule can be found in our current discussion.

This paper will critically examine four alleged characteristics of energy markets, which give rise to most of the activists' charges of energy market failure:(6)

1. Petroleum is a nonrenewable resource and thus the preferences of future generations are not being properly considered in the decisions of current owners to deplete petroleum stocks.

2. The responsiveness of supply and demand to changes in price is very inelastic in the short run. Thus, small changes in either produce large price changes that damage the economy and thus justify intervention to reduce reliance on foreign oil.

3. Consumers do not find the price of the substantial health and environmental costs of fossil fuel use reflected in energy prices. Thus, pricing signals are distorted, creating inefficiencies in the market.

4. Energy markets are inefficient because consumers are poorly informed; lack adequate incentives to conserve; react sluggishly, if at all, to changes in the price of energy; have an unjustifiably jaundiced view of soft energy; and are unable to locate the installation, maintenance and repair networks to support soft energy investments.

MUST GOVERNMENT ALLOCATE NON-RENEWABLE RESOURCES?

It is sometimes argued that because petroleum is exhaustible, we need to ration production in ways normal market forces would not in order to ensure that supplies exist for future generations. Another version of this argument, instead of emphasizing future generations' access to energy per se, calls for government planning today to mitigate the negative consequences of inevitable future oil shortages--such as energy price hikes, recessions and political struggle--as production declines due to resource depletion.(7)

If fossil fuels were being depleted at an alarming rate (or even at any consequential rate), the data would reflect such trends, but they do not. Consider the data surrounding proven reserves, which are defined as those reserves that are well developed, "online" and can be profitably exploited under present economic conditions. If present consumption levels were to hold steady, today's proven reserves of oil would last 44 years--a reserve 15 times larger than when record keeping began in 1948. Proven reserves of natural gas would last 70 years, a reserve almost five times larger than that of 30 years ago. Proven reserves of coal would last 221 years.(8)

The U.S. Geological Survey did not attract criticism when it calculated 25 years ago that there are enough fossil fuels to last 520 years given projected rates of demand, and 10 years ago that figure was raised by some analysts to 650 years.(9) Today; one prominent study estimates that 6 trillion barrels of recoverable conventional petroleum exist today (a reserve of approximately 231 years given present consumption), and another 15 trillion of unconventional petroleum is recoverable given favorable economics.(10) Given present rates of consumption, that would give us 231 years of conventional petroleum and 808 years of petroleum resources of all kinds.(11)

Reserve estimates only consider petroleum that "can be recovered under present and expected local economic conditions with existing available technology."(12) If fossil fuels were to become more scarce, prices would reflect that fact and create incentives to increase inventories dramatically.(13) In addition, current reserve estimates presume no further advances in extraction technologies, despite the fact that such innovations have made it possible to increase reserves while maintaining current prices, especially recently.(14) Moreover, the world's stock of fossil fuels is far greater than those of traditional oil, natural gas and coal. For example, as energy economist Robert L. Bradley, Jr. has noted, when technological improvements in the mid-1980s made Venezuela's reserves of orimulsion (a thick energy source consisting of 30 percent water and 70 percent bitumen) commercially viable, the tar-like substance became the "fourth fossil fuel." "Venezuela's reserve equivalent of 1.2 trillion barrels," writes Bradley, "exceeds the world's known reserves of crude oil, and other countries' more modest supplies of natural bitumen add to this total."(15) Tar sands and oil shale also promise similar supplies of fuel if world petroleum prices were to surpass $30 per barrel. All those unconventional fossil fuel alternatives can be refined into today's fuel products, given favorable economics.

Ever-increasing petroleum production has steadily driven down prices over time. For instance, the February 1998 domestic average price of $12.15 for a barrel of crude oil was about the same as the real price of oil in the 1966-1973 period, the lowest price during the post-Second World War era. Coal prices are lower now in real terms than they were in the late 1950s.(16)

If and when the futures market suggests that petroleum is difficult to find at the current price, the price of futures will rise. This increase, in turn, will induce consumers to substitute away from petroleum-based fuels to other less expensive (hence, less scarce) fuels, and suppliers will have strong incentives to find alternatives. No one needs to decide centrally through government action whether or how this transition will take place.

PETROLEUM SUPPLY SHOCKS: JUSTIFICATION FOR SUBSIDY?

Another characteristic of petroleum markets that generates discussion of market failure is the inflexibility of petroleum supply and demand in the short run. This inflexibility implies that small

changes in supply or demand have very large effects on prices.(17) This may be so in the short term, but over a longer time period of several years, both supply and demand are in fact very responsive to prices. The price increases of the 1970s, for example, were followed by a 50 percent reduction in real oil prices after 1985.(18) Energy scholars have found through empirical research that for every 1 percent increase in energy prices, energy use over the long run will decrease by about 1 percent.(19)

The inflexibility of petroleum supply and demand in the short run is not a market failure. Rather, it is merely a characteristic of oil markets that many find unpleasant because it leads to large transfers of wealth from consumers to firms when supply decreases (as in the Saudi and Texas booms of the 1970s) and firms to consumers when supply increases (as in the Saudi and Texas busts of the 1980s). Both consumers and firms attempt to enlist the assistance of government to prevent these wealth transfers.

Most economists, however, are of the opinion that the interventions enacted by the United States after the Organization of Petroleum Exporting Countries (OPEC) embargo in 1973 exacerbated the energy crisis and did not aid consumers in general. The gasoline shortages experienced in 1973 and 1979, for example, came about because of the peculiar incentives created by U.S. price and distribution controls. In 1973 the system of oil price controls originally imposed by President Nixon applied only to large petroleum companies, which supplied most of the gasoline to independent gasoline stations. Because the large companies could not raise prices to cover the increased costs of imports, they reduced supplies to such stations, creating a shortage at many independent stations. In addition, even though the energy regulations of the 1970s were enacted allegedly to aid consumers, economists have concluded that of the $50 billion in profits denied crude oil producers in 1980 by the price control system, $32 billion went to refiners, only $14 billion to consumers and $4 billion represented efficiency losses to the economy.(20)

The 1990 Iraqi oil shock illustrates how oil markets behave if the government does nothing. After the Iraqi invasion of Kuwait in August 1990, the world market suffered a shortfall of about 4.5 million barrels a day (b/d) out of a total world supply of crude oil of approximately 61 million b/d.(21) Prices jumped from $16 per barrel in June 1990 to $30 in September. The shortfall in supply in this case was about 7.4 percent. While prices increased by 85 percent, by the next year prices had returned to pre-shock levels.

The Gulf War oil shock was not without economic consequences, but the effects were much less than the effects of the shocks of the 1970s. This is particularly striking since the shortfall generated in 1990 was larger than those generated in 1973 or 1979 (3 percent and 6 percent respectively).(22) The main difference was that the U.S. government did not create an elaborate price-control system to take away the profits that came from the sudden increase in value of inventories. Once owners realized that the price-control policies of the 1970s would not be reenacted, they sold inventory to the market and made money from the 85 percent price hike.(23) The marketplace worked efficiently and both producers and consumers were thus better off than they had been when government encumbered the forces of supply and demand in the 1970s.

Soft-energy subsidies are also justified as a method for reducing our use of imported oil, which, in turn, will reduce our vulnerability to the effects of oil shocks. Reducing dependence on imported oil may sound like a strategy to reduce the effect of oil shocks on the U.S. economy, but such beliefs do not have an economic basis. Changes in oil supplies anywhere in the world affect oil prices everywhere as long as oil is freely traded in markets. The United States would have to isolate itself from world petroleum markets to eliminate the price effects of supply shocks elsewhere, regardless of how much oil it imports.(24)

Even if a decrease in U.S. oil imports would not greatly reduce the impact of reductions in world supply on U.S. prices, wouldn't the subsidized availability of soft energy make petroleum shocks easier to cope with if they occur? The answer, of course, is yes, but the question is whether the

subsidy required to effect this change is worth the cost, and whether political judgments about the future are better than market judgments. The possibility of profits for oil substitutes provides incentives for entrepreneurs to develop those substitutes. If entrepreneurs do not think that future profits warrant the development of a technology, why should governments second-guess that judgment? Certainly the ability of experts in the 1970s to predict energy prices in the 1990s was not very good.(25)

Likewise, the internationalization of the oil trade ensures that the United States will always have access to Persian Gulf oil whether OPEC members like it or not. As Thomas Lee, Ben Ball, Jr. and Richard Tabors observed about the 1973 embargo:

[I]t was no more possible for OPEC to keep its oil out of U.S. supply lines than it was for the United States to keep its embargoed grain out of Soviet silos several years later. Simple rerouting through the international system circumvented the embargo. The significance of the embargo lay in its symbolism.... [While] there were short term supply disruptions ... the only tangible effect of the embargo was to increase some transportation costs slightly, because of the diversions, reroutings, and transshipments necessitated.(26)

MUST SOFT ENERGY BE PROMOTED TO PROTECT THE ENVIRONMENT?

The argument that fossil fuel extraction and combustion foul the environment in ways that are incompatible with property rights and markets has some merit.(27) Air and water resources have been, and still are, treated like a public commons rather than like private property. Soft energy advocates argue that the air and water exhibit classic market failure; fossil fuel consumers have not had to directly indemnify anyone for the environmental consequences of their consumption and thus prices for fossil fuels are lower than their "true" prices. Consequently, society consumes "too much" fossil fuel. Soft energy subsidies, it is alleged, would reduce fossil fuel consumption, increase economic efficiency and, ultimately, produce greater economic wealth.

The idea that micromanaging the energy marketplace is the best way to control pollution is certainly compelling on paper. But the government ought to address the problem of air pollution by focusing on goals, not on the means to arrive at those goals. As Adam Smith explained in The Wealth of Nations, when consumers seek various goods in the marketplace, market agents arrange themselves to deliver those goods at the lowest possible price. We seek various outputs at the lowest prices, and we let entrepreneurs, interacting spontaneously, worry about the inputs. As economists Daniel Klein and Pia Maria Koskenoja note:

When we go into a restaurant, for example, and order a crock of French onion soup, we specify only the desired output. We do not tell the chef how to slice the onions, grind the pepper, or grate the cheese. We do not tell the restaurant manager where to get the ingredients, how to store them, or how to train the employees. Customers merely specify the outputs, and, as Smith explained, entrepreneurs in the market attend to the inputs. Successful entrepreneurs are experts on local opportunities for effectively combining inputs, and they compete for customers by seeking to produce the outputs that customers desire.(28)

Thus, if technology permits, the government ought to address the problem of air pollution by focusing on goals, not on the means to arrive at those goals. This could be achieved most efficiently either by pollution taxes or emission trading regimes. As Adam Smith wrote, every individual can "in his local situation, judge much better than any statesman" what inputs are most appropriate to producing his desired output. "The statesman, who should attempt to direct private people ... would ... load himself with a most unnecessary attention."(29) Thus, even if soft energy advocates are correct about the need for further efforts against air pollution, their proposed remedy is not necessarily the proper prescription.

Soft energy advocates might not even be correct about the need for further efforts to control pollution. Environmental regulation since the 1970s has imposed large costs on firms, particularly steel and coal-burning utilities, that probably have been passed on to consumers. Thus, in a sense, energy consumers have had to pay a premium for the environmental consequences of the fossil fuels they consume. In fact in the United States, the costs of compliance with the Clean Air Act through the 1970s and 1980s (the "environmental tax" on fossil fuels) have been about $25 to $35 billion annually.(30) The relevant questions, then, is whether the $25 to $35 billion paid annually by consumers already cover the environmental cost of fossil fuel consumption?(31)

Economic efficiency--the explicit goal of soft energy advocates who cite market failure as a rationale for government intervention--requires that the additional benefits obtained from pollution abatement expenditures exceed the additional costs. Subsidies to soft energy sources are necessary to correct for the costs of air pollution if and only if incremental net benefits would arise from reduced pollution relative to the current status quo. And even then an economically justified subsidy would equal only the difference between the existing prices of fossil fuels (which include the cost of existing pollution controls as well as some taxes) and a price that included all pollution damages.(32) Because the prices of some fossil fuels, such as gasoline, are already taxed, pollution policies already control emissions,(33) and a reasonable interpretation of the evidence suggests that the additional cost of further exposure reduction exceeds the additional health benefits.(34) Hence the economically efficient subsidy of alternative power sources is probably zero.

Even if current regulatory costs are insufficiently reflective of true environmental costs, they are not so far off the mark to significantly affect consumer decision-making. For instance, when the U.S. General Accounting Office considered the issue as it relates to the electricity industry, it reported that:

The consideration of externalities in the planning process for electricity has generally had no effect on the selection or acquisition of renewable energy sources [because] electricity from renewable energy usually costs so much more than electricity from fossil fuels that externality considerations do not overcome the difference.(35)

ARE CONSUMERS INCOMPETENT?

The conservation lobby has succeeded in convincing policymakers that energy consumers are either too ignorant or too incompetent to make efficient energy consumption decisions. Individuals and corporations, it is argued, demand tremendous cost savings from energy-efficient appliances and equipment before they will invest in those technologies. Economists refer to those sorts of consumers as having "high discount rates," meaning that such consumers highly discount the value of dollars in the future compared to the value of dollars in the present. The charge is that consumers for some reason pass up significant energy cost savings in the marketplace and thus government agents can improve upon the overall efficiency of the energy economy by either mandating such purchases or subsidizing them in whole or part.

Most economists are deeply skeptical about such arguments.(36) First, they argue that studies of consumer behavior that involve home heating and cooling rather than appliances such as refrigerators find that the implicit rates of return used by consumers in making energy conservation investment decisions are consistent with returns available on other investments.(37)

Second, the variance in energy prices over time creates uncertainty about the return on energy conservation investments. Because such investments are irreversible and much more illiquid than other investments, consumers rationally demand high returns on home conservation investments to compensate for the uncertainty that they face.(38)

Third, the estimates of alleged energy savings that consumers pass up are based on engineering estimates rather than actual changes in use. A study based on changes in actual use of electricity, rather than engineering estimates, concluded that consumers actually choose conservation investments rationally in light of the cost of capital and the returns on alternative investments.(39)

Finally, it is alleged that industrial buyers, writers of product specifications, architects, engineers and builders have little incentive to provide energy efficiency since they are not paying the full life-cycle cost of inefficiency. Yet if consumers truly demanded energy efficiency in products or homes, suppliers would have every incentive to provide it, and they would loudly advertise the energy-efficient attributes of their goods and services.(40) The fact that this is not happening to the extent desired by the conservationists indicates that there is little demand for the kind of energy efficiencies preferred by the conservation lobby, not that there exists a market failure.(41)

ARE SOFT ENERGY SUBSIDIES NECESSARY TO "LEVEL THE PLAYING FIELD"?

A variation of the argument that soft energy sources should be subsidized because of market failures is the argument that subsidies to fossil fuels justify subsidies to alternatives to "level the playing field."(42) This argument assumes that fossil fuel industries are favored by government policy. Let's consider the major subsidies alleged to exist for conventional fuels.

Tax Subsidies

Soft energy advocates allege that there are a plethora of preferences in the tax code that unfairly subsidize the fossil fuel industry. While past and present government interventions have certainly distorted the marketplace,(43) they are scarcely responsible for the major differences in prices and technological maturity between fossil fuel energy and soft energy alternatives.

Most of the tax preferences decried by the soft energy community are special exemptions, allowances, deductions and credits designed to partially offset double--and sometimes triple--taxation of capital and capital returns. It is scarcely an unwarranted "preference" to relieve industry generally from onerous and excessive taxation.(44) Of the $58 billion of subsidies that one recent study assigned to the natural gas industry over the last four decades, $51 billion were comprised of that sort of tax relief.(45)

Most importantly, however, is the fact that the alleged size of the preferences are miniscule in relation to the energy industry as a whole. The U.S. Energy Information Administration reported that energy subsidies in 1990 totaled between $5 and $10 billion, only about 1 to 2 percent of the total energy economy.(46) Even the most liberal accounting of tax preferences, compiled by the Alliance to Save Energy (ASE), finds only about $17 billion in energy subsidies, a figure that is still very small relative to total expenditures on energy.(47)

Obsession with the tax code tends to blind analysts to the countervailing regulatory interventions that affect prices far more dramatically than do preferences or subsidies. The Energy Information Administration, for instance, concludes that regulatory interventions 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].(48)

The oil industry tax preferences most often discussed--the percentage depletion allowance and the expensing of intangible drilling costs--illustrate the lack of importance of tax preferences. While the now largely-defunct depletion allowances did encourage more investment in petroleum production than was optimal, the restrictions on petroleum production enforced by the Texas

Railroad Commission restricted output and raised domestic petroleum prices above what they would have been absent the government-enforced cartel, more than offsetting the countervailing production incentives provided by the depletion allowance.(49) Moreover, in 1990, Congress enacted excise taxes on gasoline that for the first time went to general revenues rather than transportation-related trust funds.(50) These taxes were estimated to be 10 times the value of the remaining tax subsidies to the oil industry in fiscal year 1992.(51)

Thus, tax subsidies of the oil industry over the last 70 years have not led to sub-optimal petroleum prices. In fact, the net effect of government policies has been to place a net tax--rather than subsidy--on oil on the order of $2 to $3 billion per year as of fiscal year 1992.(52) Put simply, government intervention has made oil too expensive, not too cheap.

R&D Subsidies

In the United States, research and development (R&D) subsidies for energy sources started with nuclear energy in the 1940s and 1950s. Coal interests argued that such subsidies unfairly subsidized a competitor. Congress responded not by terminating nuclear subsidies but by funding coal research and development, particularly research that would reduce coal pollution and allow it to compete as a clean fuel.

The practice of accommodating political opposition from other fuels by including them in the pork barrel game continued during the 1970s energy crisis, when Congress initiated funding for soft energy. Over the past 20 years, soft energy technologies have received in inflation-adjusted 1996 dollars $24.2 billion in federal R&D subsidies. Nuclear energy received $20.1 billion and fossil fuels received only $15.5 billion.(53)

Clearly, there is little to the argument that federal R&D programs have unbalanced the marketplace by shifting research dollars away from soft energy sources. To the extent that nuclear power has received heavy favor from government, the primary victims have been oil, gas and coal--not soft energy.

Military Expenditures in the Persian Gulf

Some policy analysts have argued that the costs of U.S. Persian Gulf military and foreign aid activity are a subsidy for the use of petroleum and should be included in any accounting exercise that determines whether conventional fuels have received policy advantages relative to alternative fuels.(54) If these costs are added to the price of Mideast oil on a per barrel basis, the cost is about $60 a barrel, making the price of a barrel of Saudi oil $75 instead of $15. At such a price, numerous other alternatives become financially viable. In this view, sound public policy requires that Middle East-related military costs be added to the cost of imports and used as a rationale for establishing subsidies for domestic alternatives.

From an economic perspective, a key question to ask is whether a reduction in U.S. military and foreign aid expenditures would result in an increase in the price of oil. To be sure, if the termination of U.S. assistance implied the termination of all military services in the region, petroleum extraction investments would become more risky. But remember that oil companies in the region are largely creatures of government. The question thus is really whether Middle East governments would produce less oil if the United States ended its military and foreign aid--or would they provide or pay others to provide their own military services?

Saudi Arabia and Kuwait paid for about 55 percent of the Gulf War.(55) Certainly, one could argue that the size and scope of the U.S. operation was excessive and that the war could have been won at a much lower cost. Thus it seems quite possible for the Mideast oil kingdoms to pay for the defense of their own oil production facilities.

Yet even if oil regimes paid for their own military protection and the protection of their own shipping lanes, would U.S. military expenditures in the Mideast really decrease? The answer might very well be no for two very different reasons. First, the U.S. military presence in the Mideast stems from its commitment to defend Israel as well as the oil kingdoms, and would not end simply if the Arab oil regimes suddenly defended themselves. Second, bureaucratic and congressional inertia might leave military expenditures constant regardless of Israeli or petroleum defense needs because of the pork barrel aspects of defense expenditures. In this admittedly cynical view, the importance of defense is not its security role but its role as a provider of jobs and a purchaser of goods and services in congressional districts.

Thus, U.S. Persian Gulf expenditures should not be viewed as a subsidy that lowers oil prices below what they otherwise would be. Instead, the expenditures should be thought of as a transfer or a gift that has wealth effects--making U.S. taxpayers poorer and oil-regime and Israeli governments richer--rather than efficiency effects (namely, making oil prices "too low").

THE ECONOMIC TRUTHS ABOUT SOFT ENERGY

Thus far, we have reviewed the case for government intervention in the energy economy and found it wanting. Still, a lingering belief exists that solar power, wind power and energy efficient technology--the main technologies that comprise soft energy--are nearly competitive with fossil fuel alternatives and are far more environmentally benign than oil, coal or natural gas.

Although renewable energy is often thought of as an "infant industry" facing an uphill and unfair struggle against "Big Oil," the truth is that the largest corporate conglomerates in America have long devoted themselves to making renewable energy markets a reality. Starting in the mid-1970s, Exxon, Shell, Mobil, ARCO, Amoco, General Electric, General Motors, Texas Instruments and Grumman have all invested aggressively in renewable energy research and development projects.(56) While many of those projects went bust due to the unfavorable economics of renewable energy, the most aggressive renewable energy development initiatives today continue to be undertaken by Shell (the world's second largest energy company), British Petroleum (one of Europe s largest energy companies), Bechtel (one of the world's largest construction firms), Enron (the world's largest integrated natural gas company) and Amoco.

To soft energy advocates, heavy corporate investment in renewable energy technologies is evidence of the potential competitiveness of alternative fuels in the near future. But some perspective is necessary Total private-sector investment in solar, wind and biomass in 1995, the most recent year in which data are available, was less than 1 percent of total world energy investments.(57) Shell's highly-publicized plan to spend $500 million over five years on renewable energy, for instance, is only half its budget for developing three deepwater off-shore oil rigs in the Gulf of Mexico.(58)

Most renewable energies have similar common denominators: extremely high capital costs,(59) spotty power output,(60) environmental complications,(61) serious NIMBY opposition (the "Not In My Back Yard" phenomenon) and struggling economics. Indeed, even the most cost-effective soft energy sources are three times more expensive on the spot market than the least-costly fossil fuels, even before adjusting for government subsidies.(62)

Most importantly, renewable energy is competing against continuously plunging fossil fuel prices and rapidly advancing technologies--primarily natural gas turbines--that result in electricity costs of 2 to 3 cents per kilowatt-hour if the waste heat from the natural gas turbines is also used for heating and cooling.(63) According to projections by the U.S. Energy Information Administration, almost all the growth in new electricity capacity over the next 15 years will come from natural gas turbines.(64)

So why have sophisticated companies wasted their money? The existence of explicit as well as tax-code subsidies has meant that taxpayers rather than shareholders have paid for these investments. In addition, from a political economy perspective, it is rational for large corporations to curry favor with governments and constituencies by looking "green" as long as the costs to shareholders are not too high. And the existence of government appropriations and tax-code features may very well mean profits for shareholders.(65)

This brief review of the facts about the leading soft energy technologies reveals that economic faith in soft energy is akin to the old adage about a second marriage: the triumph of hope over experience.(66)

THE LOST HOPE OF SOLAR POWER

In 1987 Scott Sklar, executive director of the Solar Industries Association and the United States' leading proponent of solar power, told a congressional subcommittee that the "consensus" among energy analysts was that solar power would provide between 10 and 20 percent of America's energy needs by the year 2000 "quite easily."(67) As we approach that date, solar provides but one-twentieth of 1 percent of America's energy needs, but Sklar and his colleagues Continue to peddle the same "solar's around the corner" message to congressional appropriators and the public.(68)

The main problem for all solar technologies is cost.(69) Generating electricity via solar power from thermal or photovoltaic (PV) sources, or from micro-applications, costs between 11 and 12 cents per kilowatt hour,(70) at least quadruple the cost of its main competitor today--combined-cycle natural gas--and quadruple the cost of surplus gas-fired electricity in the marketplace.(71) Even those cost figures, however, are understated. According to Solarex, a subsidiary of a partnership between Amoco and Enron and the largest U.S. manufacturer and marketer of PV systems, "using typical borrowing costs and equipment life, the life-cycle cost of PV generated energy generally ranges from 30 cents to $1 per kilowatt hour."(72) Those high solar costs, according to the California Energy Commission, are related to "problems such as high materials costs, fabrication cost, corrosion, erosion, fatigue, and thermal stress."(73)

Perhaps the greatest economic obstacle to solar power is the problem referred to in the industry as "intermittency"--the fact that the sun doesn't always shine and thus solar plants are not reliable sources of electricity. In fact, a typical plant only operates at 13 percent of its theoretical capacity over a given year.(74)

WIND POWER: THE LAST, BEST HOPE FOR RENEWABLES?

Wind power's economic potential has long beguiled policymakers and environmental activists. In 1976, the U.S. Department of Energy estimated that wind power could supply about 20 percent of the country's electricity needs by 1995, a projection echoed by the American Wind Energy Association in congressional hearings in 1984.(75) In 1985 an executive of the American Wind Energy Association told a congressional hearing that an "achievable goal" for the industry was for wind power to be "the lowest-cost source of electricity, along with hydro, available to a utility by 1990."(76)

Today, such projections look patently ridiculous. Wind power is only slightly less of an economic white elephant than solar, costing about 7 cents per kilowatt hour once subsidies are factored out of the picture(77) and responsible for only one-fifth of 1 percent of America's electricity generation.(78) Wind-driven electricity generation from the very best locations is still twice as expensive as combined-cycle natural gas units and triple the price of existing underutilized fossil fuel generation.(79)

A conservative estimate of the total federal subsidy for wind power totals $1,200 per installed kilowatt hour of generation capacity.(80) That's even greater than the direct capital cost of wind power at around $860 per kilowatt hour and far more than installed capacity of fossil fuel generated electricity, such as gas-fired combined cycle plants that cost only $580 per installed kilowatt hour to build.(81) If one converts those numbers to subsidy per kilowatt hour consumed, the aggregated, real price of wind generated power is 10 cents per kilowatt hour.(82)

Wind energy's problems are akin to those found in solar energy production. The wind does not blow around the clock, much less at peak speeds, which means that wind power facilities only operate at about 23 percent maximum capacity even at prime locations.(83) This intermittency problem is a serious obstacle to wind power ever becoming a primary source of electricity.

ENERGY EFFICIENCY: THE NONSENSE OF "NEGAWATTS"

In the late 1970s, energy analyst Daniel Yergin popularized the argument that conservation energy was "no less an energy alternative than oil, gas, or nuclear."(84) Reductions in the use of energy through investment in high tech appliances, insulation, lighting fixtures and building design have become known as "negawatts"--as opposed to the kilowatts of conventional electricity supply. Negawatts are perhaps America's most heavily subsidized soft energy resource. State governments have spent approximately $17 billion to subsidize the reduction of demand for electricity, while the federal government has shelled out $8 to $9 billion in support.(85)

The supply of negawatts is alleged to be between 22 and 64 percent of current electricity consumption; in other words, if the economy made use of the most efficient technology on the market today, electricity consumption could be cut by 22 to 64 percent, depending on who's doing the counting.(86) But if such calculations are made by comparing the current use of electricity with a hypothetical scenario in which the same consumption occurs but with the most energy-efficient technology available, rigorous adoption of economically worthwhile energy-efficient technologies would reduce electricity consumption by less than 3.1 percent.(87)

In addition, negawatts are alleged to be environmentally superior to conventional energy because energy conservation is a "pollution-free" energy source. As argued earlier, a first-best pollution reduction policy would use charges or tradeable emission rights for all emissions and not just those from electric utilities. Negawatts are not an effective substitute for first-best explicit pollution policies because conservation programs simply subsidize the installation of various capital items that use less energy. Because these new "toys" lower the marginal costs of additional electricity use, consumers respond by using more electricity in what is known as the "snapback" or "rebound" effect.(88)

The main vehicle for the public exploitation of negawatts in the United States are utility-run programs known as "Demand-Side Management" (DSM). Typically, the utility pays for some or all of the costs of energy auditing and subsidizes the purchase of energy-efficient technologies by its ratepayers in the belief that it costs the utility less to do so than it would to produce more energy.(89)

As with the alleged need for other renewable sources of power, the rationale for DSM has a quasi-economic basis. During the 1970s, the regulation of electric utility prices resulted in consumers receiving incorrect information about the true costs of power. Under such circumstances utilities lost money on every marginal increase in electricity supply and therefore would undertake conservation investments on their own as long as regulation permitted them to do so. The supposed "market failure" was due to the rate controls that prevented utilities from pricing at marginal cost, not to any inherent defect in an unregulated electric utility market. The first-best policy would have been to remove rate controls.

DSM can thus be seen as a second-best policy necessitated by the political difficulty of eliminating or at least significantly reforming rate regulation. In any event, the current pricing problem of utilities is the opposite of the situation in the 1970s that prompted the initiatives for utility-directed energy conservation. In the 1990s, marginal costs are lower than average costs because of an excess supply of electric generation capacity. Under these circumstances, economic efficiency requires that electricity consumption increase rather than decrease. This is particularly true if energy can be substituted easily for capital, labor or other resource inputs. If energy costs are lower than the cost of other resources, then it is economically efficient to consume more energy and conserve other, scarcer resources.

Evaluations of the net costs and benefits of DSM programs have not been kind,(90) although DSM advocates predictably dispute those findings.(91) The official cost estimate of DSM programs appears to average 5.55 cents per kilowatt hour, according to a report from the U.S. Energy Information Administration.(92) Subsidized energy conservation, then, is about twice as expensive as generated energy at the margin--which is generally available at between 2 to 2.5 cents per kilowatt hour--and thus cannot be economically efficient.(93) Moreover, studies indicate that there are diminishing returns to DSM and that the cheapest negawatts have already been harvested.(94)

MUST GLOBAL CLIMATE CHANGE EQUAL GLOBAL ENERGY CHANGE?

Will the threat of global warming prove to be the policy wild card that leads nation-states to provide the massive dose of taxes and subsidies necessary for soft energy to supplant conventional energy sources in the 21st century? While space does not permit a thorough review of the scientific disputes surrounding global climate change,(95) a scientific consensus has yet to emerge about whether anthropogenic greenhouse gases will have a significantly deleterious effect on either the economy or the environment. The 2nd Assessment Report of the Intergovernmental Panel on Climate Change--the most recent such report available--contains two pointed statements about the issue:

Although these global mean results suggest that there is some anthropogenic component in the observed temperature record, they cannot be considered as compelling evidence of clear cause-and-effect link between anthropogenic forcing and changes in Earth's surface temperature.... Finally, we come to the difficult question of when the detection and attribution of human-induced climate change is likely to occur. The answer to this question must be subjective, particularly in the light of the large signal and noise uncertainties.(96)

Ultimately, additional policies to discourage the use of fossil fuels will be adopted if the perceived climate benefits of such policies exceed the costs. As of now, the U. S. Senate does not share that perception, which is why most political analysts believe that the Kyoto Protocol, a treaty that binds most of the developed world to strict greenhouse gas reductions, will not be ratified in the foreseeable future. Speculation about political perceptions even a few years down the road--much less decades--is little more than sheer guess work.

Moreover, even if the scientific "alarmists" are correct about the causes and effects of anthropogenic greenhouse gas emissions, we are not convinced that the benefits of restricting fossil fuel consumption outweigh the costs.(97) Given the large margin by which costs outweigh benefits given mean projections of future warming, it is hard to envision a scenario in which that calculation would change.(98) Thus, in our judgment, it is doubtful that governmental action will occur anytime soon to drive fossil fuels out of the energy marketplace.

CONCLUSION: THE PERILS OF PROGNOSTICATION

Will a technological breakthrough make some soft energy sources suddenly competitive with conventional energy? Will catastrophic global warming compel nations to adopt strict policies to end our reliance on fossil fuels? Will advances in conventional energy technologies suddenly grind to a halt? Will conventional energy reserves suddenly run dry? Such events are unlikely, but they are theoretically possible.

Policy analysts should be warned that, in the game of dueling predictions about the nature of the 21st century energy economy, clues about the veracity of the opposing analyses can be gleaned by examining both the economic foundations of the arguments and the track record of the various parties pertaining to past predictions. We find that the arguments marshaled to support the hypothesis that a transition to a soft energy economy is inevitable are riddled with economic errors and are thus less than compelling. Moreover, we can't help but note that past predictions by soft energy advocates about the future of the energy economy have proven wildly incorrect.(99)

As of 1990, the United States used 55 percent less energy per $1,000 of GNP than it did in 1929.(100) The fact that those gains have occurred steadily through time suggests that market forces and autonomous technological change--rather than governmental efficiency mandates--are the cause. Clearly, government's record of success when it intervenes in energy markets has left much to be desired. Thomas Lee, Ben Ball, Jr. and Richard Tabors argue that "the experience of the 1970s and 1980s taught us that if a technology is commercially viable, then government support is not needed; and if a technology is not commercially viable, no amount of government support will make it so."(101) Heeding that lesson will serve us well as we enter the 21st century.

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(1) Robert L. Bradley, Jr., "Renewable Energy: Not Cheap, Not `Green,'" CATO Policy Analysis, 280 (27 August 1997) p. 5.

(2) ibid., pp. 4-5.

(3) U.S. Department of Energy (U.S. DOE), Energy Information Administration, International Energy Outlook 1998 (Washington, DC: U.S. DOE, 1998) p. 135.

(4) Steven Kelman, *What Price Incentives?* (Boston: Auburn House, 1981) chap. 3.

(5) If the factory, however, was isolated and only affected a few neighbors, then any pollution remedy would not have spillover benefits and would not have beneficiaries who would benefit without payment. In such situations involving a small number of people, parties could resolve the externality themselves through contract or common law. Under those circumstances, air quality would not be considered a "public good" and a market failure would not exist. See Ronald Coase, "The Problem of Social Cost," *Journal of Law and Economics*, 3 (October 1960) pp. 1-44.

(6) Efficient outcomes make at least one person better off and no one worse off. Choices that make some better off without making others worse off are described as having gains from trade and are labeled Pareto optimal or just optimal. Neoclassical economic theory argues that, under most circumstances, a system of property rights and markets produces efficient outcomes. But this system is efficient only if all the effects of choices are included in market prices. If prices do not incorporate all these effects, such situations are described as inefficient and as constituting a market failure. Three market-failure issues not discussed in this article are the problem of "capture" in petroleum reservoirs, vertical integration in the oil industry and natural monopoly issues in oil and gas pipelines. The problem of capture is of historical rather than current significance, while the other two result in prices higher rather than lower than efficient oil prices, the opposite of the current policy concern.

(7) The arguments come mainly from geologists. See Colin J. Campbell and Jean H. Laherrere, "The End of Cheap Oil," *Scientific American* (March 1998) pp. 78-83.

(8) U.S. DOE, Energy Information Administration, International Energy Annual 1996 (Washington, DC: U.S. DOE, 1997) pp. 3, 109 and 111; U.S. DOE, Energy Information Administration (1998) pp. 35, 50; Enron Corporation, 1997 Energy Outlook (Houston: Enron Corp., 1997) p. 11; World Energy Council, 1995 *Survey of Energy Resources* (London: World Energy Council, 1995) pp. 32-35, all cited in Robert L. Bradley, Jr., "The Increasing Sustainability of Conventional Energy," in *Advances in the Economics of Energy & Resources*, ed. John Moroney (Greenwich, CT: JAI Press, 1999).

(9) William Nordhous, "Resources as Constraint on Growth?" *American Economic Review* (May 1974) pp. 22-26; and "Energy and the Environment: A Power for Good, A Power for Ill,"*Economist* (31 August 1991) p. 4.

(10) *Michael Lynch, Facing the Elephant: Oil Market Evolution and Future Oil Crises* (Boulder, CO: IRCEED, 1998) p. 2, cited in Bradley (1999) p. 13.

(11) Figures calculated from U.S. DOE, Energy Information Administration (1997) Table 1.1, p. 3.

(12) U.S. DOE, Energy Information Administration (1997) p. 111.

(13) For a good discussion of the real economic meaning of "proven reserves," see Paul Ballonoff, *Energy: Ending the Never-Ending Crisis* (Washington, DC: Cato Institute, 1997) pp. 7-8, 17-22. Although soft energy advocates may believe that prices will not reflect adequately the diminishing supply because of imperfect markets, the historical evidence shows that the slightest change in expectations about the balance between future supply and demand results in large changes in petroleum prices because the short-run elasticity of demand is -0.1. In other words, a 1 percent change in expectations about supply results in a 10 percent change in price. See note 17.

(14) For a discussion of the impact of technological advance on petroleum supplies, see Peter Coy, Gary McWilliams and John Rossant, "The New Economics of Oil," *Business Week* (3 November 1997) pp. 140-44; Gary McWilliams, "Technology is What's Driving This Business,"*Business Week* (3 November 1997) pp. 146-148; Allanna Sullivan, "Prudhoe Bay Field Isn't Dying After All, Thanks to Technology," Wall Street Journal, 25 October 1995, p. B1; Daniel Southerland, "Getting a Leg Up: In Gulf of Mexico's Depths, Shell Finds Lots of Oil--And a Way to Restructure," *Washington Post*, 31 March 1996, p. H1; Ballonoff, pp. 7-22; and Roger Anderson, "Oil Production in the 21st Century," *Scientific American* (March 1998) pp. 86-91.

(15) Bradley (1999) pp. 15-16.

(16) See U.S. DOE, Energy Information Administration (1997) Tables 5.16, 6.8 and 7.8.

(17) In the short run a 1 percent decrease in petroleum supplies results in a price increase of 10 percent. In the long run a 1 percent decrease in petroleum supplies results in a price increase of only 1 percent. See M.A. Adelman, *The Genie Out of the Bottle: World Oil Since 1970*(Cambridge, MA: MIT Press, 1995) pp. 190-191.

(18) U.S. DOE, Energy Information Administration (1996) Table 5.16.

(19) Richard Pindyck, "Inter-fuel Substitution and the Industrial Demand for Energy: An International Comparison," *Review of Economics and Statistics* (May 1979) pp. 169-179.

(20) Peter VanDoren, *Politics, Markets, and Congressional Policy Choices* (Ann Arbor, MI: University of Michigan Press, 1991) pp. 39-44; and Joseph P. Kalt, *The Economics and Politics of Oil Price Regulation* (Cambridge, MA: MIT Press, 1981) pp. 43-44, 187.

(21) Peter Passell, "The Oil Reserve: Big Is Beautiful," *New York Times*, 29 August 1990, p. D2; and Matthew L. Wald, "Sanctions Starting To Pinch Iraq Economy, U.S. Aides Say; UN's Diplomacy Welcomed," *New York Times*, 27 August 1990, p. A1. Oil price and supply data come from U.S. DOE, *Historical Monthly Energy Review* 973-1992, Tables 9.1 and 10.1b; and Adelman, pp. 292-297.

(22) U.S. House Subcommittee on Government Reform and Oversight, Committee on Government Reform and Oversight, "Restructuring the Department of Energy," testimony by Jerry Taylor, 104th Cong., 1st sess., 16 May 1995, p. 3.

(23) Philip Verleger has argued that the management of market expectations is crucial during an oil shock. The holders of inventory need to be convinced that their largest profit opportunities lie in selling inventory sooner rather than later, so that they supply oil and thus dampen the shock--rather than withhold oil in the hopes of making more money later. In an ideal world governments would precommit to a stiff and predictably declining tax on oil imports during actual supply reductions to give the holders of domestic inventory incentive to put oil on the market sooner rather than later. See Philip Verleger, Jr., *Oil Markets In Turmoil: An Economic Analysis* (Cambridge, MA: Ballinger, 1982).

(24) Douglas Bohi, "Thinking Through Energy Security Issues," *American Enterprise*(September/October 1991) p. 33.

(25) Typical was the Ford Foundation Study, *Energy: The Next Twenty Years* (Cambridge, MA: Ballinger, 1979) p. 19, which used a doubling of real (inflation-adjusted) oil prices from 1979 to 2000 in its models. The actual price of Saudi oil in real dollars in September 1997 was only 47 percent of the 1979 price. A comprehensive examination of energy price forecast failures is found in Mark P. Mills, *Getting It Wrong: Energy Forecasts and the End-of-Technology Mindset*(Washington, DC: Competitive Enterprise Institute, May 1999).

(26) Thomas Lee, Ben Ball, Jr. and Richard Tabors, *Energy Aftermath* (Boston: Harvard Business School Press, 1990) pp. 17, 30.

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

(28) Daniel Klien and Pia Maria Koskenoja, "The Smog-Reduction Road: Remote Sensing vs. The Clean Air Act," CATO Policy Analysis, no. 248 (7 February 1996) p. 6.

(29) Adam Smith, *The Wealth of Nations* (1776), ed. Edwin Cannan (New York: Modern Library, 1937) p. 423.

(30) Between 1970 and 1990 in the United States, Clean Air Act direct compliance expenditures are estimated to have been $500 billion. In 1978 Clean Air Act direct compliance expenditures are estimated to have been $35 billion annually. See J. Clarence Davies and Jan Mazurek,*Pollution Control in the United States: Evaluating the System* (Washington, DC: Resources for the Future, 1998) pp. 128-130.

(31) In a recent example of such an accounting exercise, the authors conclude that diesel fuel, wood and coal are undertaxed relative to their external costs; natural gas is substantially overtaxed; and gasoline is taxed correctly. See W. Kip Viscusi, Wesley A. Magat, Alan Carlin and Mark K. Dreyfus, "Environmentally Responsible Energy Pricing," *Energy Journal*, 15, no. 2 (1994) pp. 23-42.

(32) Albert Nichols, *How Well Do Market Failures Support The Need For Demand Side Management?* (Cambridge, MA: National Economic Research Associates, 1992) p. 9.

(33) Viscusi et al., p. 26. The authors consider only the relationship between optimal pollution taxes and current explicit general taxes not dedicated to a trust fund. They do not consider the cost of existing pollution regulations already embedded in fuel prices.

(34) The 1990 Clean Air Act amendments probably will result in additional costs that are twice the additional benefits. See Paul R. Portney, "Economics and the Clean Air Act," *The Journal of Economic Perspectives*, 4 (Fall 1990) pp. 173-181.

(35) U.S. General Accounting Office, "Electricity Supply: Consideration of Environmental Costs in Selecting Fuel Resources," (19 May 1995) p. 2, cited in Ballonoff, p. 55.

(36) For an overview of the debate see Energy Policy, 22, no. 10 (October 1994), which is entirely devoted to the controversy; and "Markets for Energy Efficiency," A Report of the Stanford Energy Modeling Forum, Report 13, 1 (Palo Alto, CA: Stanford University Energy Modeling Forum, 1996).

(37) Nichols, pp. 22-24.

(38) Kevin Hassett and Gilbert Metcalf, "Energy Conservation Investment: Do Consumers Discount the Future Correctly?" Energy Policy, 21 (June 1993) pp. 710-716. Gilbert Metcalf, "Economics and Rational Conservation Policy," *Energy Policy*, 22 (October 1994) pp. 819-825.

(39) Nichols, pp. 24-25; and Ruth Johnson and David Kaserman, "Housing Market Capitalization of Energy-Saving Durable Good Investments," *Economic Inquiry*, 21 (1983) pp. 374-386.

(40) This holds true even for rental markets that are, according to conservationists, less likely to reflect energy efficiency in rents, which in turn leads to underinvestment in energy efficiency. Nichols, pp. 26-29.

(41) Matthew Wald, "Saving Energy: Still a Tough Sell," *New York Times*, 30 March 1991, p. A25; and Nichols, p. 30.

(42) The details about subsidies come from U.S. DOE, Energy Information Administration, Federal Energy Subsidies: Direct and Indirect Interventions in Energy Markets (Washington, DC: U.S. DOE, November 1992). Some analysts describe the Overseas Private Investment Corporation (OPIC) and the foreign tax credit as subsidizing oil production; see Citizen Action,*Subsidizing Big Oil's Foreign Investments: Importing Oil, Exporting Jobs, and Making War*(Washington, DC: Citizen Action, September 1996). We will not discuss these policies because they are available to all corporations. However, the government provision of risk insurance for overseas investment does violate market principles.

(43) See, for example, Robert L. Bradley, Jr., *Oil, Gas & Government: The U.S. Experience*, 1 & 2 (Lanham, MD: Rowman & Littlefield, 1996); and VanDoren (1991).

(44) 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.

(45) Federal Government Subsidies and Incentives for U.S. Energy Industries (Washington, DC: Management Information Services, Inc., May 1993) p. 35.

(46) U.S. DOE, Energy Information Administration (1992) p. x.

(47) Douglas Koplow, "Federal Energy Subsidies: Energy, Environmental, and Fiscal Impacts" (Washington, DC: The Alliance to Save Energy, April 1993) p. ii.

(48) U.S. DOE, Energy Information Administration (1992) p. x.

(49) VanDoren (1991) pp. 37-39; and Stephen McDonald, Petroleum Conservation in the U.S. (Baltimore, MD: Johns Hopkins University Press, 1971) p. 189.

(50) The revenues in fiscal year 1992 amounted to $3.1 billion. See U.S. DOE, Energy Information Administration (1992) pp. 7, 40.

(51) ibid., p. 7.

(52) Gas and coal receive net subsidies of $1 billion and $300 million, respectively. See Energy Information Administration (1992) p. 7.

(53) Data from the U.S. DOE reported by Bradley (1997) p. 63.

(54) Alan Tonelson and Andrew K. Hurd, "The Real Cost of Middle-East Oil," *New York Times*, 4 September 1990, p. A17.

(55) Saudi Arabia and Kuwait paid approximately $33 billion (55 percent) toward the total cost of Desert Storm and Desert Shield, which was $60 billion. The U.S. share was only $6 billion (10 percent). Defense Department Press Release 125-M, "Gulf War Pledges Fulfilled" (5 May 1992).

(56) Bradley (1999) p. 6.

(57) Martin Daniel, "Finance for Energy," FT Energy News (Summer 1997); U.S. DOE, Energy Information Administration (1998) p. 20.

(58) Shell International Limited Press Release, "Shell Invests US$0.5 Billion in Renewables" (16 October 1997); Sam Fletcher, "Shell to Spend $1 Billion on 3 Deep Gulf Fields," *Oil Daily*, 20 March 1998, p. 1, cited in Bradley (1999) pp. 6-7.

(59) California Energy Commission, 1996 Energy Technology Status Report, Report P500-96-006 (Sacramento, CA: California Energy Commission, 1997) p. 27.

(60) ibid.

(61) For a review of the environmental issues surrounding soft energy, see Bradley (1997) and Bradley (1999).

(62) Bradley (1997) pp. 7-12.

(63) Agis Salpukas, "70's Dreams, 90's Realities: Soft Energy: A Luxury Now. A Necessity Later?" *New York Times*, 11 April 1995, p. C1; Michael T. Maloney, Robert E. McCormick and Raymond D. Sauer, Customer Choice, Consumer Value: An Analysis of Retail Competition In America's Electric Industry (Washington, DC: Citizens For A Sound Economy Foundation, 1996) p. 38; and Michael K. Block and Thomas M. Lenard, *Creating Competitive Markets in Electric Energy* (Washington, DC: The Progress and Freedom Foundation, 1997) pp. 1-1. Block and Lenard report that if the waste heat from the turbines is used for heating, the cost is reduced to 2 to 3 cents per kilowatt hour.

(64) U.S. DOE, Energy Information Administration, Annual Energy Outlook 1996, cited in "Energy Security Analysis Inc., Electricity & Climate Change: Estimating The Effects of Compliance With The Kyoto Treaty," ESAI Power Market Analysis (Winter 1997-1998) pp. 2, 13 and Table 6.

(65) See Bruce Yandle, "Bootleggers and Baptists: The Education of a Regulatory Economist,"*Regulation*, 7, no. 3 (May/June 1983) p. 12.

(66) For a discussion of biomass and geothermal energy, technologies that are a long way from serious commercialization, see Bradley (1997) pp. 33-36.

(67) U.S. House Subcommittee on Energy and Power, Committee on Energy and Commerce, statement by Scott Sklar, 100th Cong., 1st sess., 1988, p. 26, cited in ibid., p. 29.

(68) ibid., p. 28.

(69) There are three subcategories of solar power: thermal solar systems that collect sunlight on a parabolic dish trough or in a tower, which is then converted to electricity; photovoltaic solar systems that convert sunlight to electricity via massive panels; and small-scale technologies that use micro-photovoltaic systems to power specific applications for communications, lighting and switching (one example is the batteryless standard pocket calculator).

(70) California Energy Commission (1997) p. 57.

(71) Bradley (1997) p. 29.

(72) "Everything You Always Wanted to Know About Solar Power," Solarex brochure 6121-6 (March 1997) p. 3.

(73) California Energy Commission (1997) p. 27.

(74) Solarex, p. 11.

(75) U.S. House Subcommittee on Energy Conservation and Power and the Subcommittee on Fossil and Synthetic Fuels of the House Committee on Energy and Commerce, Hearings on DOE's Fiscal Year 1985 Budget, 98th Cong., 2d sess. (Washington, DC: Government Printing Office, 1984) p. 810, cited in Bradley (1997) p. 24.

(76) U.S. House Subcommittee on Energy Conservation and Power, Committee on Energy and Commerce, statement by Angus Duncan, American Wind Energy Assoc., 99th Cong., 2d sess., 1985, pp. 189-190, cited in Bradley (1997) p. 14.

(77) California Energy Commission (1997) p. 57. For a review of the various subsidies and preferences affecting the prices consumers pay for wind power, see Bradley (1997) pp. 8-10.

(78) ibid., p. 24.

(79) ibid., pp. 7-8 and Bradley (1999) p. 9.

(80) California Energy Commission, 1994 Electricity Report (November 1995) p. 104, cited in Bradley (1997) p. 14.

(81) ibid.; and ICF Kaiser Study, "Subsidies to Renewable Energy," prepared for Enron Corp. (September 1995), cited in Bradley (1997) p. 14.

(82) Bradley (1997) p. 15.

(83) California Energy Commission, Wind Project Performance: 1994 Summary (August 1995) p. 1, cited in Bradley (1997) p. 7.

(84) 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, cited in Bradley (1997) pp. 36-37.

(85) Bradley (1997) p. 37.

(86) David Kline et al., "The Role of Renewable Energy in U.S. Climate Strategies," conference proceedings from the 18th Annual North American Conference of the International Association for Energy Economics, published in International Energy Markets, Competition and Policy (Cleveland, OH: United States Association for Energy Economics, 1997) p. 499.

(87) Mikael Togeby and Anders Larsen, "The Potential for Electricity Conservation in Industry: From Theory to Practice," conference proceedings from the 18th International Association For Energy Economics International Conference, published in Into the 21st Century: Harmonizing Energy Policy, Environment, and Sustainable Economic Growth (Cleveland, OH: International Association for Energy Economics, 1995) pp. 48-55.

(88) See J.D. Khazzoom, "Economic Implications of Mandated Efficiency Standards," *The Energy Journal*, 1, no. 4 (1980) pp. 21-39; "Energy Savings Resulting from the Adoption of More Efficient Appliances," *The Energy Journal*, 8, no. 4 (1987) pp. 85-89; H.D. Saunders, "The Khazzoom-Brooks Postulate and Neoclassical Growth," *The Energy Journal*, 13, no. 4 (1992) pp. 131-148; F.P. Sioshansi, "Do Diminishing Returns Apply to DSM?" Electricity Journal, 7, no. 4 (May 1994) pp. 70-79; Nichols (1992) p. 17; and Paul Joskow, "Utility-Subsidized Energy-Efficiency Programs," *Annual Review of Energy and the Environment*, 20 (1995) pp. 526-534, cited in David Kline et al., p. 499. Robert W. Crandall, "Corporate Average Fuel Economy Standards," *Journal Of Economic Perspectives*, 6 (Spring 1992) pp. 171-180, examines the same phenomenon in the context of regulations that mandate that cars use less gasoline per mile.

(89) See Nichols (1992) pp. 7-9, 12-13.

(90) Paul L. Joskow and Donald B. Marron, "What Does a Negawatt Really Cost?" *Energy Journal*, 13, issue 4 (1992) pp. 1-34; Albert L. Nichols, "Demand-side Management: Overcoming Market Barriers or Obscuring Real Costs?," Energy Policy, 22 (October 1994) pp. 840-847; and Franz Wirl, *The Economics of Conservation Programs* (Boston, MA: Kluwer Academic Publishers, 1997).

(91) Mark D. Levine and Richard Sonnenblick, "On the Assessment of Utility Demand-Side Management Programs," *Energy Policy*, 22 (October 1994) pp. 848-856. Interlaboratory Working Group, Scenarios of U.S. Carbon Reductions: Potential Impact of Energy Technologies by 2010 and Beyond (Washington, DC: U.S. Department of Energy, Office of Energy Efficiency and Soft Technologies, September 1997).

(92) U.S. DOE, Energy Information Administration, Electric Power Annual 1995, 2 (Washington, DC: U.S. DOE, 1995) Table 43, p. 77.

(93) ibid., Table 13, p. 35.

(94) David Kline et al., p. 500.

(95) For a brief overview of the scientific disputes, see Patrick Michaels, "Long Hot Year: Latest Science Debunks Global Warming Hysteria," CATO Policy Analysis, no. 32 (31 December 1998); and Jerry Taylor, "Clouds Over Kyoto: The Debate Over Global Warming," Regulation, 21, no. 1 (Winter 1998) pp. 57-63.

(96) Intergovernmental Panel on Climate Change, Climate Change 1995, Impacts, Adaptations, and Mitigation of Climate Change: Scientific-Technical Analyses (Cambridge, MA: Cambridge University Press, 1996) pp. 411, 439. For a thorough review of the scientific uncertainties acknowledged in the 1995 report of the Intergovernmental Panel on Climate Change, see Kenneth Green, "A Plain English Guide to the Science of Climate Change," Policy Study no. 237 (Los Angeles: Reason Public Policy Institute, December 1997).

(97) For a review of the cost-benefit arguments, see Thomas Gale Moore, Climate of Fear: Why We Shouldn't Worry About Global Warming (Washington, DC: Cato Institute, 1998).

(98) Even accepting alarmist beliefs about the cost of greenhouse gas emissions, incorporating those cost estimates into energy prices would not make renewables competitive with conventional energy and would not lead to an increase in soft energy's market share. See Bradley (1997) pp. 53-55.

(99) For a brief review of the erroneous predictions about the imminent depletion of fossil fuel reserves, see Adelman, pp. 101-105, 163-166, 177-178, 189-190, 205-208, 211-213, 217, 220-222, 249, 253, 273, 283-284.

(100) See Mikhail Bernstam, The Wealth of Nations and the Environment, Occasional Paper no. 45 (London: Institute for Economic Affairs, January 1991) p. 27. See Richard G. Newell, Adam B. Jaffe and Robert N. Stavins, "The Induced Innovation Hypothesis and Energy-Saving Technological Change," Quarterly Journal of Economics (forthcoming 1999) for data on the role that conservation mandates have played in the reduction in electricity use by home air conditioners.

(101) Lee, Balls and Tabors, p. 167. Emphasis is in the original.