THE ENVIRONMENTAL IMPERATIVE: A Driving Force in the Development and Deployment of Renewable Energy Technologies

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> In 1993, power plants were responsible for 72 percent of all sulfur dioxide emissions in the U.S. They also contributed 33 percent of all nitrogen oxide emissions and 32 percent of all emissions of particulate matter. Of the nation's emission's of mercury, a toxic heavy metal, 23 percent came from power generation in 1993.... Moreover, powerplants represent the source of 36 percent of all [human] 1993 emissions of carbon dioxide, a dominant greenhouse gas.[4]

Significance

Each year, as global population swells, humans worldwide seek to improve their standard of living. Even allowing for steady improvements in energy efficiency, future generations will require enormous quantities of energy. Current trends indicate that they will satisfy most of this demand by burning fossil fuels -- i.e., coal, oil and natural gas. If so, the environmental implications are grave. For several decades, policy-makers and scientists have acknowledged the links between fossil fuels, acid rain, air pollution and human health. Recent medical research indicates that energy-related pollution threatens human health even more than previously suspected. A yet more severe peril arises from the contribution of fossil fuels to the danger of climate change; producing, distributing and using fossil fuels releases voluminous amounts of carbon dioxide (CO_2), the most important of the heat-trapping pollutants known as greenhouse gases.

Energy technologies drawing on renewable energy avoid the severe environmental impacts of the fossil fuel cycle. These technologies, some of which are more mature than others, convert sunlight, wind, flowing water, the heat of the earth and oceans, certain plants and other resources into useful energy. Like all energy technologies, renewables affect their environment to some extent, but most are far more benign than their conventional competitors. An energy market that considered the total cost to society of its energy choices would greatly encourage the deployment of renewable energy technologies. In the following pages, we outline the environmental imperative for accelerating the exploitation of renewable energy sources.

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The "Externality" Cost of Energy Use

As economists, agronomists, biologists and others become aware of the vast environmental consequences of energy choices, they complain that energy markets fail to include the cost of environmental externalities in fuel prices.[5] Such costs are excruciatingly difficult to determine. Estimates from different studies often prove incomparable. Most vexing, some studies reckon the cost of preventing environmental damage, while others attempt to tot up the cost of the damage itself. Often, neither alternative seems quite satisfactory.

Consider the externality value of CO_2, a byproduct of electricity generation. Experts base some attempts to figure the externality value of CO_2 on the cost of planting trees to remove carbon from the atmosphere, even though the true cost of tree-planting on a large scale is unclear. (Massachusetts determined a value of $24 per ton of emitted CO_2 using this technique.) Some economists contend that accurate comparison of carbon-emitting and carbon-free energy sources requires considering the actual cost of the damage. But assigning a dollar amount to the damage due to *the increased risk* of global warming -- let alone that due to the envisioned damage -- is difficult and perhaps impossible. For this and other reasons, the six states (see Table One) that currently consider externalities in their planning processes use the cost of preventing or controlling the damage as a politically-acceptable proxy for the cost of the damage itself. (None of the six actually bill these costs to anyone; rather, the state utility commissions use the figures to rank generating technologies in the planning process.) In general, externalities from energy use remain an extremely contentious subject.[6] Only one thing is clear: policy that assigns externalities a value of zero is wrong.

While new and relicensed power plants far from population centers can be comparatively benign, the environmental effects of older technology still in operation constitute substantial hidden costs. For example, researchers using the New York State Public Service Commission's EXMOD computer model have estimated the environmental cost of running a hypothetical pre-1980 pulverized coal facility at a rural site near Ithaca, NY, at 7.2 cents per kilowatt-hour (Kwh); the damage due to a newer pulverized coal facility at the same site at 6 cents/kWh; and damage due to a

[5] Economists define externalities as byproducts of an economic activity that fall to parties lacking control over the transaction itself. Standard economics contends that markets work efficiently when decision-makers bear all benefits and costs of their actions. Thus, the presence of externalities may justify policy intervention.

[6] See U.S. Department of Energy, *Energy Technologies and the Environment: Environmental Information Handbook*, DOE/EH-0077 (October 1988); Richard L. Ottinger *et al.*, *Environmental Costs of Electricity* (New York: Oceana Publications, Inc., 1990); Frank Muller, "A Methodology for Environmental Analysis of Alternative Energy Scenarios in Vermont," Center for Global Change, College Park, MD (March 1991); U.S. Congress, Office of Technology Assessment, *Studies of the Environmental Costs of Electricity*, OTA-ETI-134 (Washington, DC: U.S. Government Printing Office, September 1994); Olav Hohmeyer and Ottinger (eds.), *Social Costs of Energy: Present Status and Future Trends* (Berlin: Springer-Verlag, 1994), and; Russell Lee, "Externalities Studies: Why Are the Numbers Different?" Oak Ridge National Laboratory, Oak Ridge, TN, prepared for the 3rd International Workshop on Externality Costs in Ladenberg, Germany (27-30 May 1995).

new atmospheric fluidized bed coal combustion plant at only 0.1 cent/kWh.[7] Unfortunately, numerous older coal plants remain in operation. Worse, the Environmental Protection Agency (EPA) and several advocacy groups charge that rules recently proposed by the Federal Energy Regulatory Commission (FERC) to permit utilities to compete in distant markets will postpone the retirement of these older coal-fired plants.[8]

Although many studies consider the environmental impact of smokestack emissions from fossil-fuel powerplants, accumulating research indicates enormous damage resulting from other steps in the fossil fuel cycle. Consider coal, the source of 56% of the electricity generated in the U.S. Despite extensive environmental regulation, ancillary effects of the coal economy include landscapes degraded by mining, air polluted by trucks and trains that transport coal, run-off from storage sites, mounds of waste ash, and costlier health care and health insurance for those who work the mines or breathe the by-products of combustion. Added to these effects is an increased threat of climate change (which may itself raise insurance premiums).[9] These costs are distributed arbitrarily to society as a whole, rather than apportioned among the offending activities. More accurate energy pricing would allow consumers to make sound energy choices by revealing their true cost to society.

Environmental Impacts of Energy Supply and Use

The quality of America's air is improving. Since the mid-1970s, sulfur dioxide (SO_2) emissions (72% of which come from powerplants) have fallen substantially, thanks in part to the novel

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[7] A. Myrick Freeman III and Robert D. Rowe, "Ranking Electric Generating Technologies with External Costs," *The Electricity Journal* 8 (December 1995), p. 50. The authors note that EXMOD sets a default value of $0/kWh for CO_2 emissions; they also consider a value of $1/kWh. The Tellus Institute, which developed the computer code for EXMOD, takes issue with several of the program's assumptions. Aside from the CO_2 issue, Tellus questions EXMOD's neglect of values that resources may have in addition to their commercial worth, the value it assigns to human life, and its treatment of long-term nuclear radiation. Nevertheless, Tellus praises EXMOD for allowing site-specific assessment of powerplant damage costs. See Stephen Bernow *et al.*, "Counting the Costs: Scientific Uncertainty and Valuation Perspective in EXMOD," prepared for Technical Meeting of the International Atomic Energy Agency in Vienna, Austria (December 1995), or contact Tellus in Boston, MA at (617) 266-5400.

[8] EPA, "Promoting Wholesale Competition...." A Harvard study claims that even a 3% increase in the use of such facilities will add 500,000 tons of NO_X to the air, equivalent to 25% of the Clean Air Act's NO_X target, and 43 million tons of CO_2, which is not regulated. Henry Lee and Negeen Darani, "Electricity Restructuring and the Environment," Center for Science and International Affairs at the Kennedy School, Cambridge, MA (1996), telephone (617) 495-1390.

[9] For a conceptual outline of the environmental consequences of the coal cycle, see U.S. Department of Energy, Energy Information Administration, "Electricity Generation and Environmental Externalities: Case Studies," DOE/EIA-0598 (September 1995), figures 1a-c. While the oil and natural gas cycles avoid the harshest land impacts of coal mining, they pose their own threats. For instance, natural gas pipelines leak large amounts of methane, a major greenhouse gas, and transoceanic oil tankers regularly spill their cargo into sensitive ecological areas.

system of tradable emissions allowances established by the Clean Air Act Amendments of 1990.[10] A combination of factors has successfully reduced use of high-sulfur coal (at the expense of Appalachian mining communities) and encouraged the use of scrubbers for the smokestacks of new power plants. During the same period, national nitrogen oxide (NO_X) emissions (about one-third of which come from powerplants) have fallen slightly as well, although the United States remains the world's greatest nitrogen polluter. The EPA claims substantial reductions in American air pollution since 1970, a period during which gross domestic product rose by 77%, population by 25% and vehicle-miles by 111%.[11]

Still, America's progress toward clean air must be judged partial. The EPA reports that 90 million citizens (down from 140 million in 1990) still breathe air below minimum quality standards. Thirty-three areas exceed federal smog standards.[12] More troubling, recent research indicates that airborne pollution impairs human health in concentrations well below federal standards. For instance, doctors attribute 50,000 American deaths per year to airborne particulate matter, about one-third of which comes from powerplants. Powerplants also account for 23% of America's emissions of the toxic metal mercury. Such data do not conceptually invalidate federal pollution law; in framing the Clean Air Act of 1970, policy-makers did not posit a "pollution threshold," but sought pragmatically to protect specific populations against disease. But new medical evidence indicates in a disturbing fashion that politically acceptable air pollution causes substantial health impairment and death.[13]

Developing countries use far less energy per capita than industrialized nations. The average American consumes as much energy as six Mexicans, 25 Egyptians, or over 100 Kenyans. But because economic and social development require ample energy, energy use in the developing world is growing rapidly. For example, electricity provides light, powers fertilizer factories and runs refrigerators for vaccination programs. Since developing countries have high rates of population growth, development experts anticipate burgeoning demand for energy in coming decades. Increased energy use already has increased pollution; China, for instance, emits as much sulfur as the United States, largely because of weaker environmental requirements. Fossil fuel use

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[10] SO_2 allowances now trade for far less than originally expected, demonstrating that apt policies can combine environmental progress and economic efficiency. Jeff Bailey, "Electric Utilities Are Overcomplying With Clean Air Act," *The Wall Street Journal* (15 November 1995), p. B-8; Dallas Burtraw, "Trading Emissions to Clean the Air: Exchanges Few but Savings Many," *Resources*, no. 122 (Winter 1996), pp. 3-6. For more information on this source, contact Resources for the Future in Washington, DC at (202) 328-5000.

[11] U.S. EPA, "Implementation Strategy for the Clean Air Act Amendments of 1990: Update," EPA 410-K-95-001 (November 1995), p. 1. Figures for powerplant emissions noted above refer to 1993. See EPA Comments to the FERC, p. 7.

[12] *Ibid.*

[13] Curtis A. Moore, *Life and Death: Protecting Health Under the Clean Air Act*, prepared for the American Lung Association (July 1995). See p. 7 for particulate matter. For information on this source, call the ALA in Washington, DC, at (202) 785-3355. For more on air pollution, contact the World Resources Institute in Washington, DC, at (202) 638-6300, or see their *World Resources 1994-95* (New York: Oxford University Press, 1994), pp. 197-212.

in the developing world occasions the same occupational and public health effects that industrial nations have encountered, including intense episodes of urban pollution. The high cost or scarcity of imported fossil fuels has in some areas led to depleted firewood stocks and desertification. Acid rain caused by energy use has damaged millions of hectares of forest worldwide.

The phenomenon of global warming must now be added to this litany of "conventional" environmental effects. Scientists have long known that heat-trapping gases in the Earth's atmosphere held the warmth that first permitted life to thrive. It is also generally agreed that the fossil fuel cycle releases gases that are physically capable of augmenting such a "greenhouse" effect. Chief among these gases is CO_2; in 1993, powerplants generated 36% of the CO_2 produced by human activity worldwide. Methane from coal mines and natural gas pipelines, as well as nitrogen compounds and ozone precursors from combustion, also contribute to the greenhouse effect. (These gases have other sources unrelated to fossil fuels.) Agreement on the relationship among human activity, climate change and danger to future generations has come more slowly, but some consensus has emerged. In 1995, over 300 scientists and economists representing 120 governments on the Intergovernmental Panel on Climate Change (IPCC) agreed that "the balance of evidence... suggests a discernible human influence on global climate" through the production of greenhouse emissions.[14] The IPCC forecasts a rise in global temperature of between 1.8 and 6.3 degrees Fahrenheit by 2100 due to the greenhouse effect.

Although many mechanisms of global climate remain murky to scientists, most agree that the effects of rapid climate change, should it occur, could be quite harsh. Rising sea levels could inundate coastal regions and island nations. Temperature shifts could spread tropical diseases such as malaria. Higher summer temperatures could increase conventional air pollution. Severe weather events such as floods, droughts and hurricanes could multiply. These dangers might not materialize for decades. They may develop so gradually as to be initially indistinguishable from normal, short-term fluctuations -- or they may manifest themselves with unforeseen turbulence. Scientists remain uncomfortably aware that complex systems such as the global climate behave in unpredictable, non-linear ways; the ozone depletion crisis has demonstrated that the continuous application of small stresses to the climate can initiate sudden shifts -- in any direction -- out of proportion to the most recent "nudge." Most important, the effects of climate change may first appear when it is too late to forestall their extreme consequences. Unlike conventional pollutants, CO_2 lingers in the atmosphere for many decades, meaning that actions taken to diminish the risks of climate change will take effect several years after their introduction.[15]

In sum, the threat of climate change adds to an extensive list of environmental rationales to develop substitutes for conventional energy technologies. Notable among these substitutes are renewable energy technologies. Contemporary advocates of renewable energy carefully note that no energy technology poses zero environmental cost. Technologies designed to tap diffuse renewable

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[14] IPCC Working Group I, "1995 Summary for Policy-makers," Geneva (1995). Summaries of the IPCC Working Group Reports are currently available on the World Wide Web at *http://www.unep.ch/ipcc/ipcc-0.html*. The IPCC Secretariat can be reached at 41-22-730-8215. See also Jessica Mathews, "Global Warming: No Longer in Doubt," *The Washington Post* (26 December 1995), p. A24.

[15] Scientists estimate that stabilizing *concentrations* of greenhouse gases in the atmosphere immediately would require reducing fossil fuel *emissions* by 60%. For more on climate change, see the IPCC's *Climate Change 1995*, a compendium of climate science, policy and economics forthcoming in April of 1996 from Cambridge University Press (telephone 44-1223-325970).

resources on a large scale can require broad areas of land and significant volumes of fresh water. Hydropower can have profound ecosystem impacts, and in America may threaten plants and animals protected by the Endangered Species Act. Biomass power can pose the same questions of sustainability as any other intensive crop production. Spinning wind turbines occasionally kill soaring raptors, which, like wind energy developers, prize the gusts blowing through mountain passes. In addition, the manufacture, construction and operation of renewable energy technologies can raise occupational risks for workers and public health risks for others in the region of deployment. Responsible promoters of renewable energy advocate community-based decision-making to assess the trade-offs between energy supply, social impact and environmental effect.

Nonetheless, shifting a significant fraction of global energy demand from carbon-intensive fossil fuels to modern biomass and other advanced renewable energy technologies is likely to have many important environmental benefits. The most important advantages may be reduced impacts on human health locally, declining risk of acid deposition and land degradation regionally, and decreased risk of rapid climate change globally.

Future Patterns of Energy Use and Their Environmental Impacts

The oil shortages of the 1970s proved to startled energy planners that Americans indeed use less energy when its price rises, and that national productivity can increase faster than energy consumption. Since then, planners have appreciably refined the craft of modeling interactions between energy, the environment and the economy. Yet, plausible scenarios of the world's environmental future still diverge widely. For example, a literature survey performed by the Intergovernmental Panel of Climate Change notes that, due to different assumptions regarding global population, changes in energy intensity and economic growth, estimates of annual emissions of CO_2 have ranged from 1.2 to 60 gigatonnes per year by 2100.[16]

Modelling activities have produced a few areas of agreement. Energy use is likely to spiral upwards. Economic growth in the developing world will drive much of that increase. In the absence of policy measures, future generations will use fossil fuels, principally coal, to meet their energy needs. No fossil fuel economy is capable of stabilizing concentrations of greenhouse gas in the atmosphere at safe levels -- a primary goal of the Framework Convention on Climate Change, an international treaty ratified as of early 1996 by over 130 countries.

Rather, scenarios of environmentally sustainable economic development require maturation and deployment of low-emission fuel sources.[17] This technological shift will require nuclear power or renewables. The United States, the former Soviet Union and Japan have each experienced significant nuclear accidents, and physical and political barriers continue to stymie safe, long-term disposal of radioactive waste. In both the developed and developing world, the prospects remain dim for a nuclear fission regime free of meltdowns, thefts of radioactive material, weapons

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[16] IPCC, *Climate Change 1994: Radiative Forcing of Climate Change and An Evaluation of the IPCC IS92 Emissions Scenarios* (Cambridge: Cambridge University Press, 1995), p. 252.

[17] See, for example, *Energy for Tomorrow's World* (New York: St. Martin's Press, 1993), pp. 28-30.

proliferation and unsolvable waste disposal issues.[18] Nuclear fusion remains out of reach. Thus, hedging against environmental disaster while pursuing reasonable economic growth seems to require increased exploitation of renewable energy.

The lesson of energy modeling is that renewable energy must make substantial contributions to the next century's energy system in order to make economic growth environmentally sound. Unfortunately, renewable energy faces declining support among some American citizens and policy-makers, who repudiate public policy mechanisms that integrate economic and environmental goals. Instead, they lobby for an electric system in which individual households and businesses select their preferred electricity supplier. Such a system would leave environmentally sound energy decisions to the discretion of each consumer. At the same time, many polls indicate swelling American support for policies that promote renewables[19] and the environment generally.[20] Many renewable energy advocates reconcile these apparently contradictory cultural trends by recommending policies that exploit the natural tendency of markets and rejecting those that function through command and control mechanisms. Economic efficiency and environmental prudence require that market-based energy policies consider the degradation of environmental resources in addition to the short-term cost of fuel and equipment.

Conclusion: Economic Honesty Will Push Us Toward Renewable Energy

Expanding energy use has played a huge role in improving living conditions for most humans worldwide, and will continue to do so. The use of fossil fuels for electricity generation has played an equally large part in our growing environmental predicament. Specific problems include immediate local effects on human health, regional crises such as acid rain, and global risks centering on climate change. In contrast to conventional energy options, renewable energy technologies exploit a far more vast resource and pose far fewer environmental risks. However, technological progress for renewables still lags behind, although it has been steady and rapid.

In order to deploy renewable technologies on a large scale, the time has come for decisive action. The rationale for such action is clear: global energy systems developed their current appetite for fossil fuels only through an economic sleight of hand which permits energy consumers to ignore the staggering environmental costs of their choices. Future energy systems, whether they rely on markets or governmental mandates, must manifest greater economic honesty. Once they do so, we believe that the world will turn increasingly to renewable energy.

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[18] Alan Miller and Irving Mintzer, "Global Warming: No Nuclear Quick Fix," ***Bulletin of Atomic Scientists*** **46 (June 1990), pp. 30-34.**

[19] See, for example, Barbara Farhar, "Trends in US Public Perceptions and Preferences on Energy and Environmental Policy," ***Annual Review of Energy and the Environment*** **20 (1995), pp. 28-32, and "Americ Out on Energy: A Survey of Voters' Attitudes on Sustainable Energy Issues," Sustainable Energy Bud Takoma Park, MD (December 1995), telephone (301) 270-2258.**

[20] Dennis Farney and Timothy Noah, "Environmental Stands Alienate Some Backers of the GOP's Agenda," ***The Wall Street Journal*** **(5 March 1996), pp. A1, A8.**

APPENDIX
Possible Issues for Further Research

Both long-term strategic and targeted research is needed to advance the cause of renewable energy. Below, we list several avenues of research that would strengthen the case for renewables. We urge authors interested in undertaking these or other related research projects to contact the Renewable Energy Policy Project.

1. Renewable Energy Scenarios: Recent analyses by the IPCC, the World Renewable Energy Congress and others highlight the potential of policy to minimize the risks of global environmental damage by changing the way people produce and consume energy. The rapid deployment of renewable energy technologies may be critical to avoiding the worst risks. However, none of these projects assesses the role of renewable energy technologies as its main task. Researchers might construct a set of energy scenarios designed to reduce global environmental damage from energy supply and use. Such scenarios should meet the dual objectives of the Framework Convention on Climate Change: stabilizing concentrations of greenhouse gases in the atmosphere and promoting sustainable economic development. These scenarios also could also be analyzed for environmental implications beyond the risks of global climate change.

2. Renewables and Natural Gas: Determining the future of renewable energy technologies requires an examination of the role of natural gas in the future energy system. Some energy analysts contend that sustainable development and environmental security can best be achieved by switching from coal and oil to gas. They note that a state-of-the-art, gas-burning plant operated as a cogenerator (i.e., producing both electricity and heat for industrial processes or residential heating) is tremendously efficient. Such a plant is free enough of conventional pollutants to operate in an urban setting and may emit less than 20% of the CO_2 released by a comparable coal plant. While some members of the renewable energy community see the advent of cheap natural gas as a threat, other environmentalists argue that any technology able to replace old, dirty coal plants and nuclear power stations merits support.[21]

Many renewable energy advocates support a triple energy strategy of renewables, increased efficiency and natural gas; they also suggest that gas and renewables may act synergistically. For example, natural gas turbines could provide clean, easily dispatchable back-up power for facilities dependent on intermittent renewable resources such as sunlight or wind. Gas also may constitute an ideal transition fuel to a hydrogen economy, which some visionaries foresee as an environmentally-ideal endpoint. The same technologies that allow the efficient burning of natural gas may lend themselves to gas produced from biomass, a technology now being tested in Brazil and elsewhere. Rapidly developing countries such as China, India and Brazil may lack sufficient natural gas reserves to power their burgeoning economies; renewables could help make up the difference in an environmentally benign manner. In industrial countries, both natural gas and renewable energy would benefit from broad policy shifts, such as the inclusion of environmental costs in energy prices.[22]

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[21] For example, Christopher Flavin and Nicholas Lenssen, *Power Surge: Guide to the Coming Energy Revolution* (New York: W.W. Norton & Co., 1994), especially Chapter 5, "Prince of the Hydrocarbons."

[22] While natural gas facilities generate cheaper power than new coal plants, some gas companies fear that existing coal plants remain cheaper still. Such concerns might motivate a strategic alliance between gas interests, environmentalists and the renewable energy community. But gas firms may eschew such a partnership should it threaten to slow electric industry restructuring. "Producers looking harder at FERC electric ruling," *Gas Daily* (19 March 1996), pp. 1, 4; "Environmental concerns delay electric rule," *Gas Daily* 20 (March 1996), pp. 1, 4.

On the other hand, an economy overly dependent on natural gas may be as vulnerable as an economy overdependent on oil. Natural gas wells and pipelines leak methane, a shorter lived but more potent greenhouse gas than CO_2. Even highly efficient gas combustion emits CO_2 in quantities which, while substantially less than those from coal and oil combustion, are not insignificant. Researchers might analyze how realistic the hopes of natural gas boosters might be by considering the size, quality, distribution and costs of gas reserves, as well as the environmental impacts of widespread use and their capacity to fit expected patterns of future energy demand.

3. Externalities: A third area of research is the development and application of "environmental externalities" -- i.e., quantitative or qualitative adjustments to fuel prices used by regulatory agencies as the basis for electric system planning. By applying externalities, regulators hope to correct for differences in environmental costs not addressed by cost-of-service regulation. While roughly half the states use such adjustments, the ongoing restructuring of the industry, which emphasizes competition and cost reduction, may stunt the technique's further development.

NOTE: The authors thank Curtis Moore for sharing research undertaken for the American Lung Association. This issue paper incorporates research conducted by Mintzer for the Synthesis Panel of the IPCC.

TABLE ONE
Environmental Externality Costs in 1992 Dollars Per Ton Emitted

State (Rows 1-7) or **Site** (Rows 8-10)	**Pollutant**					
	SO_2	NO_X	TSP or PM10	VOCs	CO_2	CO
California	4486	9120	4608	4236	9	NVS
Massachusetts	1700	7200	4400	5900	24	960
Minnesota (interim figures)	150	850	1274	1190	9.8	NVS
Nevada	1716	7480	4598	1012	24	1012
New York	1437	1897	333	NVS	1	NVS
Oregon	0	3500	3000	NVS	25	NVS
Wisconsin	NVS	NVS	NVS	NVS	15	NVS
EXMOD: Urban NY NGCC	1200	-1100	43800	NVS	NVS	NVS
EXMOD: Suburban NY NGCC	800	900	7700	NVS	NVS	NVS
EXMOD: Rural NY NGCC	700	900	3200	NVS	NVS	NVS

SO_2: Sulfur dioxide
NO_X: Nitrogen oxides
TSP: Total suspended particulate matter
PM10: Particulate matter under ten microns in diameter
VOCs: Volatile organic compounds
CO_2: Carbon dioxide
CO: Carbon monoxide
NVS: No value stipulated
NGCC: Natural gas combined-cycle turbine

Rows 1 to 7
Approximately half the state utility commissions consider externalities in their planning process. Of these, the states listed in rows 1 to 7 set monetary values on specific emissions, although Massachusetts no longer does so. Where states set a range, the table lists the mean value. *States that do not consider externalities have by default assessed the cost of environmental damage at zero.* Data from U.S. Department of Energy, Energy Information Administration, "Electricity Generation and Environmental Externalities: Case Studies," DOE/EIA-0598 (September 1995), p. 72.

Rows 8 to 10

The New York Public Service Commission's EXMOD calculates the cost of environmental damage from various generating options. Since EXMOD is programmed to consider emissions from state-of-the art technology, NGCC technology proves cheapest in almost all cases. In addition, EXMOD generates environmental damage costs that depend strongly on plant location; the program produces almost negligible damage figures for rural plants. (Due to ozone scavenging, EXMOD figures a net benefit for NO_X emissions at the urban site.) EXMOD assigns no value to damage due to CO_2. But set near $5/ton of CO_2, the damage from a rural powerplant may be substantial. In addition, such a stipulation can make non-combustion technologies such as windpower leapfrog even NGCC plants in the rankings. Note that the six states besides New York in Table One stipulate CO_2 costs well over $5/ton.

The urban reference site is near Kennedy Airport in Queens, NY; the suburban site in Albany's Capital District, and the rural site in Sterling, NY. Data from A. Myrick Freemen III and Robert D. Rowe, "Ranking Electric Generating Technologies with External Costs," *The Electricity Journal* 8 (December 1995), p. 51.

<u>Recent Minnesota figures</u>

On March 22, 1996, the Minnesota Public Service Commission received a recommendation from the State Office of Administrative Hearings that it use the following figures in future resource plans. The PUC has not yet announced whether it will accept or modify the recommendation.

TABLE TWO
Recommended Environmental Externality Costs for Minnesota
in 1993 Dollars Per Ton Emitted

Type of Site	**Pollutant**						
	SO_2 before/after 2000		NO_X with ozone	PM10	Lead	CO_2	CO
Rural	9-24	0	17-96	530-806	379-422	0.28-2.92	.20-.39
Urban fringe	43-104	0	132-251	1873-2720	1557-1881	0.28-2.92	.72-1.26
Urban	106-178	0	350-922	4206-6054	2951-3653	0.28-2.92	1.00-2.14

Data from State of Minnesota Office of Administrative Hearings, prepared for the Minnesota Public Utilities Commission, "In the Matter of the Quantification of Environmental Costs Pursuant to Laws of Minnesota 1993, Chapter 356, Section 3" (22 March 1996), p. 46. The full text of the Administrative Law Judge's decision is available on the World Wide Web site of Minnesotans for an Energy Efficient-Economy (telephone 612-225-1177) at *http://www.me3.org.projects/costs/kleinfof.html*.