REPP

SPECIAL EARTH DAY REPORT

Renewable Energy Policy Project

April 2000

AN EXECUTIVE SUMMARY OF

THE ENVIRONMENTAL IMPERATIVE FOR RENEWABLE ENERGY: AN UPDATE

by Dr. Adam Serchuk

Every option for generating electricity affects the environment. As this survey makes clear, conventional generating options can damage our air, climate, water, land and wildlife, as well as raising levels of harmful radiation. Renewable technologies are substantially safer. The environmental imperative remains clear: The future must be renewable.

1612 K Street, NW, Suite 202
Washington, DC 20006
202-293-2898
202-293-5857 fax

www.repp.org

Dr. Adam Serchuk is Research Director at REPP-CREST. He can be reached at aserchuk@repp.org, 202-293-0542.

Special thanks to Bridgette Steffan, who assisted in this research, and to reviewers of early drafts: Joseph Chaisson, Stacy Davis, Karl Gawell, Charlie Higley, Kurt Johnson, Steven Kaufman, Alan Miller, Alan Nogee, Richard Ottinger, Christine Real de Azua, Roby Roberts, Rachel Shimshak, Virinder Singh, Randy Swisher, Sam Swanson, and Carl Weinberg. Special thanks to Cindy Folkers of the Nuclear Information and Resource Service (NIRS) for her assistance on Section V of the full report. The positions stated here do not necessarily reflect those of the reviewers, NIRS, REPP-CREST or the REPP-CREST Board of Directors.

THE ENVIRONMENTAL IMPERATIVE FOR RENEWABLE ENERGY:
AN UPDATE

The complete report includes seven tables and over 35 pages of ground-breaking research.

Download free of charge at:

www.repp.org

Or request paper copies from REPP-CREST:

(202) 293-0542 or aserchuk@repp.org.

The Environmental Imperative for Renewable Energy: An Update

by Dr. Adam Serchuk

What is the Environmental Imperative?

In late 1995, the newly formed Renewable Energy Policy Project published *The Environmental Imperative: A Driving Force in the Development and Deployment of Renewable Energy Technologies*. This issue brief by Irving Mintzer, Alan Miller, and Adam Serchuk outlined the environmental rationale for developing renewable sources of electricity. We contended that "global energy systems developed their current appetite for fossil fuel…through an economic sleight of hand which permits energy consumers to ignore the staggering environmental costs of their choices." We went on to conclude that "future energy systems, whether they rely on markets or governmental mandates, must manifest greater economic honesty. Once they do so, we believe the world will turn increasingly toward renewable energy."

The environmental imperative has not changed since 1995: it has become even clearer that renewable energy must play a growing role in our long-term electricity strategy, and that we must also boost energy efficiency and replace coal with cleaner fuels. Taken together, the following issues constitute our environmental imperative:

- **All energy use affects the environment:** Gathering energy for useful purposes alters the natural cycles of planetary ecology. At their most severe, consequences include perturbation of the global climate; threats to endangered species and thereby to biodiversity; health risks through respiratory disease, cancer, and other ailments; irreparable destruction of land; and production of toxic waste.

- **For a given resource (e.g., coal or wind), technology choices and management practices often alter environmental consequences:** For instance, pollution controls can reduce the emissions of combustion-based power plants, and wind turbines can be designed and sited so as not to threaten birds.

- **Renewable energy technologies are, in the vast majority of cases, preferable to conventional ones:** Renewable energy technologies carry their own risks. In general, these are far less than those of conventional competitors.

- **Most conventional energy technologies are ultimately unsustainable:** Some of the impacts of conventional energy production, such as the production of greenhouse gases by coal combustion, land disturbance due to coal mining, and the generation of nuclear waste, seem so intractable as to exclude these technologies from a sustainable energy strategy.

In short, with careful management, we can use renewable energy without disturbing natural ecological activity in a harmful way—although no energy technology has zero environmental cost. By contrast, reliance on conventional energy sources seems by definition to alter the balance of material and energy in the ecosystem in a dangerous manner. For this reason, renewable energy represents a vital element of a sound energy strategy.

The following table portrays the major environmental impacts of electricity generation. A few words of explanation:

- *Comparability:* The table should be read vertically. That is, it does not attempt to compare the severity of different categories of environmental effects (e.g., air and water pollution). Rather, it contrasts the effect of different generation technologies (e.g., biopower and hydropower) for a given category.

- *Big picture:* The table is qualitative, labeling impacts in order from worst to best as **high**, **moderate**, **low** or **near zero**. The table also indicates important **potential** effects whose presence depends on technology choices. Readers wishing more precision should refer to the full report.

- *Life cycle impacts:* The table includes "life cycle" impacts, based not only on power plant operation but fuel production and transport, waste disposal, and other operations. For this reason, no cell is the table is empty: even very clean energy sources such as wind and solar require energy at some point in their cycle - for instance, for manufacturing - and this energy itself has environmental effects. Whereas most environmental analyses of electricity generation focus on the air impacts at the smoke stack, the lifecycle approach provides a more accurate picture.

Major Life-cycle Environmental Impacts of Energy Sources for Electricity Generation

	Air Pollution	Climate	Land Use and Degradation	Water Use and Quality	Wildlife	Radiation
Coal	**Very high:** • PM, SO_2, NO_X **Moderate:** • Hazardous metal (e.g., mercury) and organic air pollutants	**Very high:** • CO_2 from combustion • Coal-bed CH_4 • Energy to mine and transport coal, and manufacture equipment	**High:** • Land disturbed by mining • Acid mine drainage • Toxic solid waste and sludge • Nitrogen deposition	**High use:** • Coal mining **Moderate** impact on water quality • Nitrogen deposition • Acid rain **Very high** non-consumptive use for once-through cooling systems: • Thermal pollution of rivers, coastal waters **Low** use in closed cooling systems	**High:** • Air pollution • Habitat destruction from acid mine drainage, nitrogen deposition, thermal pollution of river and coastal habitat • Fish and mammal kills in cooling systems **Potentially high:** • Climate change	**Low:** • Uranium, thorium and daughter products in solid waste
Oil	**High:** • SO_2, NO_X and PM **Moderate:** • Hazardous metals (e.g., mercury) and organic air pollutants	**High:** • CO_2 from combustion • CH_4 from drilling and pipelines • Energy to manufacture equipment	**Moderate:** • Drilling and pipelines • Toxic solid waste and sludge	**Moderate** use: • Steam plants **Potentially high** on quality: • Spills	**Moderate:** • Habitat destruction from drilling and pipelines • Air pollution **Potentially high:** • Spills **Potentially high:** Climate change	**Near zero**

	Air Pollution	Climate Change	Land Use and Degradation	Water Use and Quality	Wildlife	Radiation
Natural Gas	**Very low** to **high** depending on vintage: • NO_X, PM	**Moderate** where efficiency high, otherwise **high:** • Combustion **Low:** • Methane from drilling and pipelines • Energy for manufacturing	**Low** to **moderate:** • Drilling and pipelines	**Low** in combined cycle; **near zero** in simple cycle	**Low:** • Habitat destruction from drilling and pipelines • Air pollution **Potentially high** from climate change	**Near zero**
Biomass	**Low** to **moderate** depending on technology and fuel: • NO_X • Hazardous metals, organic pollutants **Near zero** in virgin wood, **potentially higher** in waste wood: • SO_2	**Very low** if growth sustainable; otherwise **high:** • Transport • Fertilizer production • Energy for manufacturing **Potentially high** benefit if avoids open burning and decomposition	**Low** or **near zero** use for urban, forest and crop waste; **high** for plantations **Potentially moderate benefit** if plantations buffer habitat, protect watershed and topsoil, etc.	**High** use, but **very low** impact on water quality **Potentially moderate advantage:** • Watershed protection	**Potentially high** depending on fuel: • Habitat destruction **Low** to **moderate:** • Air pollution **Potential moderate advantage:** • Habitat buffer zones	**Near zero**
Wind	**Near zero**	**Very low:** • Energy for manufacturing	**High** use, but simultaneous farming, ranching	**Near zero**	**Near zero** to **potentially high**, depending on site: • Bird kills	**Near zero**
Photvoltaic	**Near zero**	**Low:** • Energy for manufacturing.	**Very high** use **Potentially moderate** depending on technology: • Heavy metals	**Near zero**	**Near zero**	**Near zero**

	Air Pollution	Climate Change	Land Use and Degradation	Water Use and Quality	Wildlife	Radiation
Geothermal	**Near zero** to **very low**, depending on technology: • Reservoir emissions	**Very low** to **low**, depending on technology: • Reservoir emissions • Energy in manufacturing	**Very low**	**Near zero**	**Near zero**	**Near zero**
Hydroelectric	**Near zero**	**Potentially very high** in tropical applications, **otherwise low:** • CO_2 and CH_4 from rotting biomass • CO_2 from concrete	**High** Run-of-the-river systems **very low**	**High** on quality: • Pressure • Chemistry **Low** use: • Reservoir evaporation	**Very high** on river and coastal habitat; can be partially mitigated Run-of-river **less harmful**	**Near zero**
Nuclear	**Near zero**	**Very low:** • Producing fuel • CO_2 from concrete • Energy to manufacture equipment	**Very low**	**High** on quality for once-through systems: • Thermal pollution of rivers, coastal waters. Closed cooling systems **low** use and quality	**High** for once-through cooling systems: • Fish and mammal kills in cooling systems • Thermal pollution and water quality impacts	**Moderate** to **high:** • Mining and milling • Routine operaional releases • Spent fuel • "Low level" waste **Potentially very high** from accidents: • Reactors • Waste transportation

SO_2 = sulfur dioxide; NO_X = nitrogen oxides; PM = particulate matter; CO_2 = carbon dioxide; CH_4 = methane

AIR POLLUTION

All combustion releases gases and particles into the air. These can include sulfur and nitrogen oxides, carbon monoxide, and soot particles, as well as smaller quantities of toxic metals, organic molecules, and radioactive isotopes. These pollutants impair human and animal health, degrade habitats, lower water quality, reduce visibility and damage agriculture.

In general, coal combustion presents the greatest risk to air quality. Oil and waste wood also release pollutants when burned. Natural gas and gas obtained from biomass, followed by virgin wood, tend to burn most cleanly, although older gas-fired combustion turbines produce much higher levels of nitrogen oxides than cooler burning, more efficient, modern gas turbines.

Air pollution presents several hazards, including the following:

- Acid rain results from the emission of acidic nitrogen and sulfur compounds, which then fall to earth and damage ecosystems. In 1997, power plants released 64% of national SO_2 emissions and 26% of NO_X emissions.
- The planet's nitrogen cycles between soil, living organisms, water and the atmosphere. Viewed globally, power plants' emissions contribute about 4% of the load added to the natural nitrogen cycle by human activity -- a small but nontrivial stress on the system.
- High atmospheric winds carry air pollution long distances, including to many natural parks. Northeastern cities receive air pollution generated by coal plants in the Midwest; Midwesterners themselves suffer equally from nearby sources of air pollution.
- Shifting energy markets have improved air quality by facilitating a boom in relatively clean natural gas. However, restructuring of the electric system has to some extent withered renewable energy development, and opened the door to increased use of dirty Midwestern coal plants exempt from the most rigorous provisions of the Clean Air Act.

The generation technologies with the lowest air impacts are wind, solar, hydropower and nuclear, with no direct air emissions at all. Some geothermal plants belong in this group; others have very low air emissions. The air impacts of these technologies reflect primarily the energy used in their construction and in obtaining fuel. Biomass combustion may present an air pollution issue, depending on the nature of the fuel and technology used. When burned together with coal ("co-firing"), biomass can actually lower the coal's nitrogen emissions.

CLIMATE CHANGE

To the now-familiar litany of problems associated with conventional air pollution comes the additional threat of global warming and resultant climate change. Because the climate naturally exhibits both statistical variability and long-term patterns of change, it remains difficult to distinguish "natural" from human-caused climate effects. Yet, although we understand climate mechanics only incompletely, few mainstream scientists debate climate change itself. In 1995, the Intergovernmental Panel on Climate Change affirmed that "the balance of evidence suggests a discernible human influence on global climate." In 2000, the National Research Council found evidence that surface temperatures have risen 0.7 to 1.7° over the past century, and concluded that surface warming is "undoubtedly real."

In the United States, the electricity sector for accounts for 36% of manmade greenhouse gas emissions. Energy-related activity in general accounts for 86%. Fossil fuel combustion is the primary culprit; coal is the most carbon-intense of the fossil fuels. Petroleum and natural gas contain respectively about 75% and 55% as much carbon per unit of energy as coal; the higher efficiency of gas-burning technology (and fuel cells, described below) enhances the greenhouse advantage of natural gas. Nevertheless, where gas generation meets new demand, or replaces zero-emission technology, it will contribute substantially to our greenhouse problem.

Fuel cells combine hydrogen and oxygen chemically to generate electric power without combustion. For that reason, this attractive emerging technology releases no greenhouse gases directly. If the hydrogen is produced with zero-emission energy, the fuel cell may indeed be greenhouse-neutral on a lifecycle basis. However, most fuel cells will presumably derive their hydrogen from natural gas in the near future; other potential sources include gasoline and methanol. In such cases, fuel cells' greenhouse impact will depend on their efficiency, currently not too far from that of a combined-cycle natural gas turbine. Of course, whatever the hydrogen source, fuel cells also emit little or no conventional air pollution.

As in the case of air emissions, the life-cycle greenhouse gas emissions of most renewables reflect the energy used in their manufacture. In the case of biopower, carbon dioxide released from burning sustainably grown biomass was previously absorbed during the plants' growth cycle. As result, the life-cycle greenhouse impact of biopower primarily reflects the energy needed to cultivate and transport fuel. Moreover, the overall greenhouse impact of biopower may be *positive* where burning biomass for energy production can avoid methane-producing decomposition in landfills or on forest floors. Flashed-steam geothermal plants release small volumes of carbon dioxide from underground reservoirs. Binary geothermal plants have no emissions at all. Hydropower can have a very high greenhouse profile in cases where large, oxygen-poor reservoirs submerge large areas of tropical biomass; decomposition over a facility's first decades of operation may release as much carbon dioxide and methane as a fossil plant of comparable capacity.

Land

Coal mining contributes the most severe land-use impacts of the electricity sector, through pit and shaft mining, mountaintop removal, and acid mine drainage caused by exposing iron-bearing rock to water. Waste from uranium mines and milling operations constitutes the largest source of low-level radiation in the country; a disproportionately large fraction of these wastes reside on Indian lands. While wind farms and biomass plantations can require large areas, these activities can coexist with other land uses, such as ranching, farming and forests. Biomass production can provide ecosystem benefits, including watershed and topsoil protection, or buffer zones around biodiversity preserves.

Solid waste represents another electricity-related issue. While some ash and sludge can be used for productive purposes, most is landfilled. Whereas biomass ash is relatively clean and therefore represents primarily a management issue, coal and oil plants produce waste that is toxic, due to concentrations of heavy metal and radionuclides. Currently, however, hazardous waste regulation exempts most coal and oil waste.

Water Use and Quality

The cooling systems of nuclear and coal plants require water. Plants with open systems draw very large quantities from rivers or coastal waters; closed-system plants require only enough water to replace that lost through evaporation. Once-through systems return the huge majority of the water to the source after passage through the system, but in so doing introduce substantial thermal pollution to the receiving ecosystems. Hydroelectric facilities also return water to the ecosystem in an altered state (e.g., pressure, chemical characteristics, etc.). Water loss occurs primarily through surface evaporation at reservoirs.

Coal combustion leads to the acidification of lakes and streams through acid precipitation. Coal mining itself requires very large quantities of water, and, by exposing iron-bearing rock, mining can damage nearby water bodies through "acid mine drainage." Biomass cultivation also requires large amounts of water, but generally without serious ecological impacts (although fertilizer runoff may in some cases prove a hazard). In fact, biomass cultivation can improve local water quality by providing watershed protection services.

Wildlife

Any development activity may threaten wildlife habitat. Often, careful siting and technology choices can minimize these impacts. For example, wind developers can reduce the danger posed by wind farms to local birds by burying transmission lines, choosing no-perch towers, siting facilities away from migration paths, etc.

Air pollution affects wildlife health as it does humans. Researchers observe biological effects in wildlife at or below the air pollution levels set by regulatory standards for SO_2, ozone and particulates. Alteration of habitat by mining, acid mine drainage, thermal pollution of rivers and coastal waters, oil spills and other electricity-related activity has equally deleterious consequences. For instance, hydropower in the Northwest is largely or primarily responsible for drastic population decreases, and even extinction, of several fish species. The cooling water intakes of coastal nuclear facilities in California regularly sweep up and kill endangered marine mammals.

Radiation

Commercial nuclear power produces only a small fraction of the radiation experienced by the U.S. population. For instance, one report estimates that New York's six nuclear power plants cause approximately 0.5 to 1.5 statistical cancer deaths per year, and a comparable number of survivable cancers. Extrapolated very roughly to the U.S. as a whole, these data imply between 8 and 30 annual statistical deaths, and comparable survivable cancers. These risks are highly concentrated among individuals exposed regularly to the nuclear fuel cycle, for example uranium miners or power plant workers.

Nuclear plants produce highly radioactive spent fuel, the disposal of which represents a vexing political problem. It is not clear that the proposed Yucca Mountain repository would provide adequate long-term containment, and the possibility of truck and rail accidents while transporting waste to the site from reactors around the country alarms many communities. Meanwhile, every disposal site ever used for so-called "low-level" waste has leaked. In fact, this term may mislead, as some types of low-level waste can be more radioactive than high-level waste.

Finally, because uranium, thorium and their radioactive daughter products occur naturally in coal, some analysts contend that coal plants expose nearby residents to higher radiation doses than nuclear plants meeting federal regulations.

Conclusion

In conclusion, all energy generation options levy environmental costs. Some of these can be mitigated through careful planning and appropriate technology configurations. However, the impacts of several resources, notably coal and nuclear, seem incompatible with an environmentally sustainable electricity sector. By contrast, renewable energy -- augmented by increased energy efficiency and the substitution of natural gas for coal -- provides a reasonable way forward.

Facts on Electricity and the Environment

FACT: Power plants burning coal, oil and natural gas produce 64% of the United States' sulfur dioxide (SO_2) emissions; 33% of mercury; and 26% of nitrogen oxides (NO_X).

FACT: The poverty rate of communities located within one mile of coal-fired power plants is almost double that of the general population.

FACT: While overall tonnage of major air pollutants has fallen since 1970, NO_X emissions have risen 11%; NO_X from coal plants has risen 44%.

FACT: Several studies correlate air pollution to increased mortality rates, hospital stays, and emergency room visits. Particulate pollution kills 64,000 Americans per year through heart and lung disease; inhabitants of polluted cities run substantially higher risks.

FACT: Families with annual incomes below $10,000 suffer over twice the asthma incidence of families with incomes over $35,000, making them more susceptible to pollution-related illness.

FACT: Despite reductions in SO_2 emissions, acidity continues to trouble large regions of North America—rising emissions of NO_X may be equally to blame.

FACT: Power plants deposit 11-15% of the nitrogen in the Chesapeake Bay, thought to have contributed to the rapid growth of toxic organisms in recent years.

FACT: Electricity use accounts for 36% of America's greenhouse gas emissions.

FACT: The coal, oil and natural gas that we can economically recover today may lead to a doubling of pre-industrial carbon concentrations in the 21st century.

FACT: Coalmines supplying American power plants disturb about 1.7 million acres of American land.

FACT: Coal mining accounts for about 95% of acidic mine drainage, a potent threat to streams, wildlife and vegetation.

FACT: Scientists at Oak Ridge National Lab hold federal hydroelectric dams primarily responsible for reducing Northwest salmon from 16 million to 300,000 wild fish per year.

FACT: According to the Congressional Research Service, transporting nuclear waste to the proposed Yucca Mountain storage facility could result in 154 truck and 18 rail accidents per year, a small number of which might release radioactivity.

FACT: State and federal documents indicate that every dump ever used to store low-level nuclear waste—a total of six—has leaked.

The full version of this paper provides references and explanations for these facts.

www.repp.org