The Greenhouse Effect: Challenge & Opportunity

By F. Douglas Muschett

The magnitude of the "greenhouse effect" may be uncertain at this time, but it is definitely becoming a factor in international environmental and energy policy discussions. The debate gives the alternative energy and cogeneration industry an opportunity to present its case.

The year 1988 may well be remembered in history as a year of global environmental awareness. Certainly it is becoming difficult to read a professional journal or even the daily newspaper without seeing some reference to the "greenhouse effect" —the projected warming of the earth's atmosphere due to increased emissions of carbon dioxide and other gases. Predictably, as with every other important environmental issue during the past twenty years, battle lines are already being drawn for influence in national legislation and policy: those who say that the stakes are too high to avoid waiting to act versus those who say that the situation is still too uncertain to bear the costs and inconveniences of acting prematurely.

The hot summers and warmer climate during the 1980s may or may not be related to the greenhouse effect, and the complete magnitude of the greenhouse effect and the magnitude and scope of its global societal impacts are clearly uncertain at the present time —and may well remain so. However, in "Global Climate Change: Towards A Greenhouse Policy" (1), Jessica Mathews observes that there is increasingly strong scientific evidence that an overall global warming of about one degree Fahrenheit has occurred during the 20th century, roughly in line with theoretical predictions of the greenhouse effect. As a result, it is becoming increasingly likely that there will be international co-operation and a major national thrust of policy initiatives and strategies concerning the greenhouse effect. A desire to limit the growth in carbon dioxide (and methane) emissions presents a variety of challenges and opportunities for the further development of alternate sources of energy and independent sources of power. In this article we will analyze the greenhouse effect and argue that it is time to develop an "agenda" By getting involved in these policy discussions and presenting an agenda, proponents for the development of alternative sources of energy can play a major role in national and international policy initiatives, for both the short and the long term.

Drawing Conclusions

Two provocative international workshops held during 1987 helped focus attention on the global implications of the greenhouse effect and the need for international policy strategy responses and treaties. The first workshop in Villach, Austria included about 50 international scientists and technical experts, who examined how climatic warming from the increasing atmospheric concentrations of "greenhouse gases" (e.g. carbon dioxide, CFCs, and methane) could affect various regions of the earth during the next century. The second group, meeting in Bellagio, Italy used the findings of the Villach workshop as a backdrop for examining policy steps and institutional arrangements (2). Both conferences were summarized by J. Jager in the September 1988 issue of Environment magazine (3).

It is generally recognized that any attempt to project global scale changes in temperature (and other climatic variables) over the next several decades as a result of a greenhouse effect is fraught with many uncertainties. The amount of gaseous emissions is dependent upon rates of population and economic growth in the industrialized and developing countries, the energy "mix" of fossil and non-fossil energy sources, and, to a lesser extent, land use and agricultural practices which release carbon dioxide to the atmosphere. After partial assimilation by "sinks" such as plant biomass or ocean uptake, these gaseous emissions result in an increased atmospheric concentration of carbon dioxide and other gases. Dependent upon the assumptions used, there is a range of "low" to "high" emissions scenarios. And, dependent upon the exact climate model used, there is also a projected range of climatic sensitivity and temperature increase. When the emissions range is combined with the climatic sensitivity range from both scenarios, there is a very large possible range in resultant temperature increases from the greenhouse effect. The Villach group used three scenarios for global temperature increase: upper scenario (0.8 degree C per decade), middle scenario (0.3 degree C per decade) and low scenario (0.06 degree C per decade).

It should be emphasized that these are rough global estimates of "first order" effects. There is some scientific dissent as to whether radiative processes are the sole mechanism by which the earth's heat is lost, or whether convective currents in storms play an important role (in which case there could be much greater dissipation of the atmospheric warmup). Although these numbers may appear modest, as rates of change over a prolonged period of time, the medium to high scenarios overwhelm the kinds of changes experienced in the natural order in modern history. Most scientists, as well as critics, recognize that there are probably important "feedback" effects (such as evaporation and cloudiness, changes in general circulation and storms), which could either enhance or reduce the greenhouse effect. Similarly, notwithstanding the cover story in Newsweek last summer, it is generally acknowledged to be impossible to quantitatively model and calculate regional estimates of temperature increases in a meaningful way, due to the scientific uncertainties of modeling a complete atmospheric "system" and the many atmospheric processes which occur at varying geographic scales.

Nevertheless, the Villach group attempted to draw some inferences as to the potential physical and ecological effects which would result from temperature increases in the earth's

TABLE 1 - Carbon Dioxide Generation for Various Fuels (1)

Fuel Type	Higher Heating (BTU/lb)	CO_2 Generated (lb CO_2/lb fuel)	CO_2 Generated (lb CO_2/1000 btu)	Energy Generated (2) (kWh/lb CO_2 generated)
Bituminous Coal	12,700	2.5	.20	.55 (3)
Fuel Oil & Gasoline	19,600	3.14	.16	.70
Methanol (Wood Alcohol)	10,000	1.38	.14	
Methanol (Syn. from Coal)	10,000	3.3	.33	.34
Natural Gas	24,000	2.75	.115	.97
SNG from Coal Gasification	24,000	7.9	.33	.34
Non-fossil Energy (Hydro, Solar, Nuclear, Geothermal-Electrolytic)		0	0	

(1) Table is adapted from M. Steinberg and A.S. Albanese, "Environmental Control Technology for Atmospheric Carbon Dioxide," in Interactions of Energy and Climate, W. Bach, J. Pankrath J. Williams, Editors, Boston: Kluwer Publishing Company, 1980, p. 527.

(2) Assuming a power plant efficiency of 38%.

(3) For a power plant with FGC, assuming power plant efficiency is reduced from 38% to 35%, the kWh (e)/lb. CO_2 generated is reduced to 0.50.

major latitudinal regions. Among the most far-reaching would be a greatly accelerated rise in sea level (as a consequence of greatly enhanced polar temperature increase and polar icecap melting) with serious and costly flooding in the coastal zone throughout the world. The ability of forests, and many species and ecosystems to adapt to the mid-to-upper range temperature increases is seriously in doubt. An increase in both subtropical severe cyclones and drought are major concerns, as are major shifts in vegetation zones and soil productivity and water resources.

Evaluating Emissions

Presently, it is generally estimated that about 50 percent of "greenhouse effect" is due to carbon dioxide; methane, fluorocarbons and other gases contribute roughly 15 to 20 percent each. (4) Although the primary focus is presently upon carbon dioxide as a contributor, attention should also be given —particularly from the point of view of the alternative energy industry— towards methane which is thought to have a twenty times greater impact per unit of emissions.

Some of the significant differences among energy sources with respect to heating valves and the emissions of carbon dioxide per BTU and per unit of electrical generation are summarized in Table 1. Natural gas produces less than one-half the carbon dioxide emissions per unit energy compared to coal, and synthetic liquid and gaseous fuels have considerably greater carbon dioxide emissions than the regular fossil fuels do. On the other hand, methanol, as derived as a wood alcohol, has relatively lower emissions of carbon dioxide. Other forms of biomass (wood, cellulose) have relatively high emissions of carbon dioxide in relation to the BTU content. Other forms of alternate energy, including hydropower, wind and solar, of course, do not produce emissions of carbon dioxide. Geothermal energy produces minute amounts of carbon dioxide. Nuclear energy, in its end use, does not produce emissions of carbon dioxide. However, it is often overlooked that nuclear energy (as well as the synthetic fossil fuels) requires large indirect energy inputs as part of intermediate processing during the nuclear fuel cycle and results in significant indirect emissions of carbon dioxide. This could have some important implications for the development of an agenda for alternate sources of energy and independent power.

Acting In The Face Of Uncertainty

A complete understanding of the greenhouse effect and the magnitude and scope of its potential global societal impacts are clearly not available at the present time. Most agree that extensive research should be undertaken to try to learn as much as possible about the greenhouse effect and its potential impacts. At the same time, there are compelling arguments why it does not follow that no action should be taken until "all the facts are in".

For example, in the latter part of the 1960s, the U.S. began an extensive research program in relation to understanding the causes and effects of photochemical smog, sometimes referred to as the "ozone" problem. Now, some twenty years later, debate is still ongoing as to the relative importance of hydrocarbons and nitrogen oxides in the formation of ozone, and as to the "allowable" concentration to protect against health effects. Somewhat analogously, about five years ago the Reagan Administration promoted an increased research program and "good science" as a cornerstone before developing an acid precipitation policy initiative. Although more extensive scientific investigations have improved knowledge in specialized areas, it is highly debatable as to what has been learned to help develop a set of acid precipitation policy initiatives that was not known five years ago. Thus the point is that there is no guarantee that additional scientific research will yield useful information for setting policy initiatives within an adequate timeframe for addressing meaningful responses to the threats posed by the greenhouse effect. (Scientifically speaking, these other environmental issues are relatively simple compared to all of the scientific processes which affect global climate change.)

In response to a greenhouse effect, it is apparent that a large continuum of societal responses are possible, including both adaptation strategies to cope with the effects and limitation strategies to reduce the magnitude of the greenhouse effects. Despite the fact that analysis is preliminary, it has been estimated that partial adaptation strategies would cost on the order of tens to hundreds of billions of dollars and that, despite such expenditures there are still likely to be devastating ecological and human impacts. Therefore there is increasing interest in "limitation" strategies, aimed at reducing the magnitude of the greenhouse effect, slowing the rate of climatic changes, and allowing for easier adaptation to changes by human and natural environments.

Mathews has presented several arguments as to why a "limitation" strategy is necessary, not the least of which is that eventually adaptation would become impossible if the greenhouse effect were to continue indefinitely; and a limitation approach would be required anyway. The Bellagio conference concluded that a coordinated international response is inevitable. More recently, scientists and policymakers from 48 countries attending the International Conference on the Changing Atmosphere held in Toronto in June 1988 released a 22-point "Call for Action" which is summarized in Table 2.

Although the policy debate is in its early stages, the points on which there seem to be general agreement are: (1) that an international response will have to be negotiated among the developed countries and the developing countries, (2) that a global response will have to allow room for developing countries to increase their emissions of carbon dioxide in order to support improved economic growth and an improved standard of living, and (3) that the cornerstone of efforts to reduce emissions and slow the growth of emissions in both developed and developing countries must be improved energy efficiency and alternate sources of energy.

At the same time, very little of substantive, comprehensive policy analysis has been undertaken and published that can demonstrate how the various components and technologies of energy conservation and alternative sources of energy can blend together to meet such policy objectives. This is no small task, given that highly specialized government bureaucracies are often highly specialized and may

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TABLE 2 - TOWARDS GLOBAL PROTECTION OF THE ATMOSPHERE (1)

■ In order to reduce the risk of future global warming, energy policies must be designed to reduce emissions of carbon dioxide and other trace gases. Stabilizing atmospheric concentrations of carbon dioxide is an imperative goal - currently estimated to require reductions of more than 50 percent from present emission levels.

■ An initial global goal should be to reduce carbon dioxide emissions by approximately 20 percent of 1988 levels by the year 2005. About one-half of this reduction would be sought from energy-efficiency improvements and the other half from modification in energy supplies. Clearly, the industrialized nations have a responsibility to lead the way, through both their national energy policies and their bilateral and multilateral assistance arrangements. Negotiations of ways to achieve this reduction should be initiated now.

■ Targets for energy-efficiency and energy-supply improvements should be made. Challenging targets would be a 10 percent improvement in both areas by the year 2005. A detailed study of the system implications of these targets should also be made. Systems must be initiated to encourage, review and approve major new projects for energy efficiency.

■ Contributions toward achieving the energy-efficiency goal will vary from region to region; some countries have already demonstrated a capability for increasing efficiency by more than 2 percent a year for over a decade.

■ The desired reduction in carbon dioxide will also require switching to fuels that emit less carbon dioxide; reviewing strategies for the implementation of renewable energy, especially advanced biomass conversion technologies; and revisiting the nuclear power option. If safety, radioactive waste, and nuclear weapons proliferation problems can be solved, nuclear power could play a role in lower emissions of carbon dioxide.

■ There must be vigorous application of existing technologies to reduce emissions of acidifying substances, other substances that are precursors of tropospheric ozone, and greenhouse gases other than carbon dioxide.

■ Funding for research, development, and the transfer of information on renewable energy should be significantly increased and technology transfer should be extended with particular emphasis on the needs of developing countries.

(1) These statements are adapted from the 22-point "Call for Action" issued by scientists and policymakers at the International Conference on the Changing Atmosphere: Implications for Global Security, Toronto, Canada, June 27-30, 1988.

champion a single energy source or technology.

Developing An Agenda

The greenhouse effect issue is gathering strong momentum in many areas, and it seems likely that it will be a factor in energy and environmental policy debates. Furthermore, the greenhouse effect provides an important opportunity for the nation to refocus and further develop and implement a myriad of technologies and applications that should be done anyway for other reasons even if there were no greenhouse effect. The debate provides an opportunity to promote economic efficiency through improved energy efficiency; by reducing trade deficits by both reducing oil imports; and by developing exports of capital goods and services related to alternative energy and cogeneration technologies. It also can offer opportunities to mitigate other environmental concerns, such as air quality and acid rain by effecting cleaner fuels (such as natural gas and wood alcohol) and by effecting more energy-efficient technologies (such as cogeneration).

It is not possible to offer a neat, well-defined set of answers at this time, but it is possible to formulate a set of issues to be addressed and to begin considering mechanisms for obtaining consensus to help advance the role of alternate sources of energy in meeting the challenges raised by the greenhouse effect. The issues which could be considered are as follows:

—Determining the "highest" and "best" uses of different alternative energy technologies. All too often, it seems that references to alternative sources of energy are prefaced by a remark that they will begin to have an important impact in another 20 years or so, while overlooking opportunities in the "here and now". Questions which policy makers need to hear answers on are: Which technologies are best-suited to which kinds of applications, sizes and locations? Which technologies and applications are cost-effective at the present, and which are expected to become cost-effective at particular "thresholds" in the future? What constraints and obstacles have to be overcome?

For example, the solar photovoltaics industry has made significant economic and technological strides in the last year. Meanwhile, nuclear power is now being proposed by some as the "preferred" alternative for meeting the world's energy needs without increasing carbon emissions. It is important to determine what kind of short term incentives and subsidies may be needed to bring down manufacturing costs for a technology such as photovoltaics, and to compare these with the R&D, tax advantages and subsidies afforded nuclear power throughout the nuclear fuel cycle.

—Examining additional, creative opportunities to develop cogeneration. Although "energy efficiency" has become an important buzzword and there is rightly much discussion being devoted to such issues as appliance efficiency standards, industrial process conservation, and consumer incentives, there has been very little connection drawn in public policy discussions between energy efficiency and cogeneration as a major cornerstone of national energy efficiency. The industry itself recognizes that there are major opportunities in the commercial and institutional areas, including both larger and smaller cogeneration systems, and numerous "inside the fence" opportunities for manufacturing process and institutional facilities. There can also be opportunities to utilize relatively high carbon content energy sources in cogeneration applications so as to make these sources more energy-efficient per unit of carbon dioxide emission.

—Examining opportunities to reduce methane emissions from landfills and agricultural wastes. Because methane is believed to be up to twenty times more potent per unit volume than carbon dioxide in effecting climatic warming, it is important to develop and implement measures which can prevent methane emissions. There are a host of biomass conversion techniques which, in principle, could be used for different types of agricultural and biomass wastes. And the "mining" of landfill gases for waste-to-energy projects is a large improvement despite the resultant emissions of carbon dioxide! It is important to determine what level of methane improvement could be obtained in relation to existing sources, and the feasibility and methods for effecting implementation. The question becomes, what changes in energy planning, regulation and regulatory sign and developmental planning process are required to help affect these opportunities?

The Global Context

From a worldwide perspective, the situation becomes even more complicated by a wide spectrum of circumstances ranging from developed countries, such as in Europe, Japan and the Soviet Union; to intensely-developing countries, such as China, Korea, Brazil; to relatively undeveloped countries, such as Pakistan, and the Sudan. Energy policies are influenced by strong preferences imposed by the presence of indigenous resources (or lack thereof) and culture and constraints offered by geography and infrastructure. It becomes a more difficult task to evaluate the "highest and best uses" of technologies and their feasibilities. Hence any study evaluating global opportunities must include input from not only industry representatives, policy researchers and technical experts, but also the perspectives from other countries and developmental planners familiar with the diffusion of technology in a variety of settings. Some specific issues include:

❒ Evaluating niche opportunities for the development of solar and wind energy. Many such opportunities have been identified, such as communications, solar cookers, irrigation pumping and rural electrification, but a comprehensive evaluation is needed of the appropriate technology for the circumstances in individual countries.

❒ Examining opportunities for development of cogeneration. Certainly in countries which are heavily dependent upon coal for electrical generation and industrial process energy, the development of cogeneration is an important tool for limiting carbon dioxide emissions, and can also promote economic efficiency. In countries which require substantial imports of fossil fuels for electrical generation, cogeneration will also have particular benefits upon the balance of payments. Generally, in other countries the fact that there is often a greater degree of government and developmental planning provides opportunities to co-develop and site electrical generation and industrial and residential users for thermal energy.

❒ Evaluating opportunities for improving the energy-efficiency of indigenous biomass fuels. In most of the developing world, biomass is the most commonly used fuel and is often the only indigenous resource. Biomass tends to result in relatively high emissions of carbon dioxide and (methane under some circumstances) per unit of energy. In some countries, the production of alcohol fuels is prevalent. If the energy-efficiency of the production, conversion and use of biomass fuels can be improved, the environmental benefits will be twofold: a slower growth in carbon dioxide emissions and a greater retention of the forest biomass "sink" for carbon dioxide.

As international governments begin to consider environmental policies concerning the greenhouse effect, it is important to show the positive contribution that alternative energy and independent power can make. If the industry could develop a general consensus on these issues through workshops and other means, the resulting statements could be presented to relevant policy makers. Similarly, after consideration of the role of alternate energy in a global context, recommendations can be developed for consideration by international agreements and additional policy research needs can be identified.

References:

1. Jessica Mathews, "Global Climate Change: Towards a Greenhouse Policy", Issues in Science and Policy, Spring 1987, pp. 67-68.

2. The workshops were initiated by the Beijer Institute, the Environmental Defense Fund and the Woods Hole Research Center, and were sponsored by the United Nations Environment Programme and several foundations and government ministries. Discussions and recommendations from the workshops are summarized by J. Jager, "Developing Policies for Responding to Global Change," WCIP-1, WMO/TD-No. 225 (World Climate Programme Impact Studies, World Meteorological Organization, Geneva, April 1988).

3. J. Jager, "Anticipating Climatic Change: Priorities for Action," Environment, Sept. 1988, 8 pp.

4. James Hansen et al, Journal of Geophysical Research, Aug. 20, 1988, pp. 9341-64. ■

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