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Moving Beyond Kyoto

In November 2000, just after the presidential elections in the United States, negotiators will meet in The Hague at the sixth meeting of the Conference of the Parties (COP6) to the United Nations Framework Convention on Climate Change (UNFCCC). By then, it will have been almost three years since the negotiation of the Kyoto Protocol on global climate change at COP3, which was held in Kyoto in December 1997. Intense negotiations over the intervening period have focused on how to implement the Kyoto Protocol. The Kyoto Protocol has been signed by 84 countries but not ratified by any of the key countries, and ratification does not appear to be imminent, especially in the United States, where the Senate has registered its strong opposition.

Why has it been so difficult to take the next step of implementing the Kyoto Protocol? The simple answer is that mechanisms within the Protocol are too complex and require too many new institutional developments to be plausible. The fundamental answer is that the Kyoto Protocol is never going to work because it is the wrong approach to tackling the climate change issue.

The core issue about climate change is how to design a policy response in an environment of considerable uncertainty. There is enough evidence and professional expertise to suggest that climate change could be a serious problem. What is required is an insurance policy against the *possibility* that climate change could be very costly to the planet. The key question is: how much insurance is needed, given the current state of our understanding? The answer is that we don't really know what price we should pay now. We also don't know by how much nations should reduce carbon dioxide emissions or how quickly.

Nonetheless, the Kyoto Protocol consists of a specific set of targeted reductions in emissions: 5.2 percent for Annex I countries, relative to 1990 emissions, between 2008 and 2012. Annex I countries, which are listed in Annex I of the UNFCCC, are essentially industrialized economies and include several countries that were part of the former Soviet Union which are in transition to market economies.

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An Early Action Climate Change

The target was set even though the negotiators had no way of knowing how costly it would be to attain. Understandably, countries are reluctant to implement a policy that could potentially be very costly and whose benefits are uncertain. Although there is some flexibility built into the Protocol to smooth costs across countries, the total cost results from the overall targets.

More importantly, only a subset of countries are part of the agreement and those countries are expected to create new international institutions and laws that can accommodate the various mechanisms at the foundations of the Protocol. The most problematic are international trading of emission permits, which requires a system of monitoring and enforcement that is unlikely to be feasible in the near future, and the Clean Development Mechanism, which requires detailed and costly evaluation of carbon-reducing investment proposals in developing countries on a project by project basis.

Why has it been so difficult to take the next step of implementing the Kyoto Protocol? The simple answer is that mechanisms within the Protocol are too complex and require too many new institutional developments to be plausible.

Solving the Problem

So what can be done? A number of realistic proposals have been made. One, from Resources for the Future, a Washington, D.C.-based environmental research organization, would place a cap on the prices of emission permits that each nation would issue. This would guarantee that the cost of implementing the Protocol would not exceed a set level.

An alternative is the McKibbin-Wilcoxen (MW) Proposal, devised by the author and Peter J. Wilcoxen, a professor of Economics at the University of Texas at Austin. It proposes a fundamental re-thinking of the approach embodied in the Kyoto Protocol—fixed targets and the international trading of emission permits. Both proposals have evolved over time and can be considered "early action policies," while countries still attempt to solve the problems with the Kyoto Protocol. This brief lays out the key features and advantages of the MW proposal and its attractiveness as an early action policy.

The McKibbin-Wilcoxen Proposal

Rather than centralize the process of reducing carbon emissions and creating new international institutions, it is better to coordinate responses across countries (what Richard Cooper of Harvard calls an approach of agreed actions) in an explicit way so that each country would pay the same price for emitting carbon. Furthermore, it is

Policy for All Countries

appropriate at this stage to create property rights over emissions of carbon dioxide from burning fossil fuels only. While it would be nice to include alternative gases and sinks as part of a policy, as in the Kyoto Protocol, it is an administrative nightmare to deal with them in the near term and adds enormous complexity to the task. In the future these could likely be added without compromising the system.

The key innovation of the MW proposal is that it would create *two emissions-related assets* and associated markets for both in each country. The two assets are designed to set a long-term goal for emissions and limit the short-run costs. Fortunately, the two markets also would create a mechanism for managing risks associated with climate change policy within each economy so that little else would need to be done to implement a consistent and simple market-based approach to tackling the climate change issue.

Key Elements of the McKibbin–Wilcoxen Proposal

All countries create two assets:

- an emission permit which is required by fossil fuel industries to supply a unit of carbon annually;
- an emission endowment which gives the owner an emission permit every year forever.

All countries create two domestic markets:

- a domestic emission permit trading system with a fixed price of $US10 per ton of carbon in Annex I countries and a cap price of $US10 in non-Annex I countries;
- a domestic emission endowment trading system with a flexible price.

In 2000, all countries are allowed to make a once-only allocation of emission endowments domestically based on Kyoto targets for Annex I countries and current emissions plus a percentage to be determined for non-Annex I countries. Trading in both markets begins in January 2001.

Permits must be reconciled against production or imports of carbon on an annual basis at the top of the carbon production chain—coal mines, oil refineries, gas refiners. Production that is exported is exempted.

Every decade there is a meeting of the Conference of the Parties to the UNFCCC to evaluate the extent of abatement and the state of climate science, and to negotiate a new price for permits.

The first asset is an *emission permit*. This certificate would entitle its holder to produce one unit of carbon per year. Each permit would have a date stamp and be valid only in the year issued. The second asset is an *emission endowment*, which is a certificate that would permanently entitle the holder to an annual emission permit. The emission endowment is like a

government bond, or like stock in a corporation, while the emission permit is the dividend the corporation pays each year to people who hold the shares. The stock value is the expected value of future dividends.

There is a critical difference between the two asset markets. The endowment market would be one in which the supply of carbon is fixed (the goal of policy) but the price is flexible. The government cannot issue more endowments after the initial allocation but can buy back endowments in future years if the target for emissions is to be tightened. Because the endowment is perpetual, its price would reflect the expected future price of emission permits in each year (which is analogous to the relationship between the stock price and the dividends of a company).

Every ten years, there would be a negotiation between all countries in which the price for emission permits is agreed to and fixed for the next decade.

We treat the market for emission permits—where the price is fixed, but the output of carbon is variable—quite differently because the permit market is directly related to the short-run cost of carbon. Every ten years, there would be a negotiation between all countries in which the price for emission permits is agreed to and fixed for the next decade. The price of permits would be fixed in each economy by governments selling additional permits into the market after the permits generated by the endowments have been fully utilized. Thus, a producer that wants to produce a unit of carbon for domestic use can get a permit in a given year by either having an existing emission endowment, purchasing an emission endowment in the endowment market (sold by another private holder of an endowment), or purchasing an emission permit in the permit market that is either supplied by a private owner of a permit or the government.

We propose that the initial price of the annual permits—which would determine the marginal cost of emitting carbon—be set at $10 (U.S.) per ton of carbon, in 1990 dollars. The price would be the same in all markets in all participating countries, and thus the cost of removing carbon at the margin in each economy would be identical in the short run. No complicated system of international trading in permits or global monitoring would be required—addressing a central flaw in the current Kyoto Protocol. Moreover, the value of permits in the United States would not depend on how permits are generated in other countries.

In contrast, the price of endowments would be flexible, reflecting the outcome of market forces, the period of fixed permit prices in the near future, and the expectations of private actors as to what is likely to happen after the current negotiation period. In making spending and investment decisions, industry and consumers would be expected to respond to both the short-run price signals—which are known for ten-year periods—as well as the long-run price signals, which are market determined. The purpose of separating the endowment market from the emissions market is to ensure

that, over the long run, emissions do not exceed a given limit. The annual emissions permitting process cannot accomplish this objective since it operates on the basis of a fixed price (the emissions fee), not a fixed quantity.

The initial allocation of endowments would be up to each government. We propose giving a significant portion to fossil fuel industries as compensation to shareholders for the capital losses of significant structural change that would result from raising carbon prices, and to galvanize support for the policy. We also would allocate a portion to every person in the economy. The initial allocation of endowments would create a natural constituency supporting climate change policies because the value of the endowments in future years would depend on the commitment of the government to pursue sound environmental policies. This would create a mechanism for enforcement of the agreement that is exclusive to each country.

Overall, the nationally-based emissions permit and endowment program is far more appealing than the Kyoto Protocol.

How Can Developing Countries Be Induced To Participate?

In discussing carbon emission reductions, it is important to distinguish between Annex I countries and developing countries. Failure to do so would unduly inhibit the growth of the developing world and would not attract their support for a global system that is absolutely crucial for a successful policy.

Accordingly, it is appropriate in the case of Annex I countries to use the Kyoto targets as the endowment allocation within each economy. For developing countries, however, it is only reasonable to allow endowments far in excess of current requirements (the precise levels being subject to international negotiation). With endowments greater than requirements for permits over the next several decades, the price of permits in these countries would be zero, and thus there also would be no short-run costs. In contrast, the price of endowments in developing economies would be positive, since the price would reflect the expected future price of permits. Thus, a price signal can be introduced to the developing world that will affect current investment plans without entailing short-run costs.

A developing country can therefore begin to contribute to a reduction in emissions with a firm commitment in the form of endowments. This reduction will be realized, however, only when emissions actually bump up against the endowment limit. The faster a country's economy grows, and thus the faster pace at which emissions are growing, the more rapidly the endowment constraint will become binding.

Meanwhile, carbon intensive industries will have fewer incentives to move from Annex I countries into developing countries in order to avoid the carbon charge in industrial countries, because all countries will be participating in the overall emissions reduction program. The differential endowment system—one for first

world countries, another for developing countries—also would have the added benefit of factoring in the cost of emissions in decisions by foreign private investors when decisions are made about whether to commit funds to developing countries.

Overall, the nationally-based emissions permit and endowment program is far more appealing than the Kyoto Protocol. All institutions would be created and managed within each economy. Breakdowns in the infrastructure of any given market would not spill over to markets in other countries. To be sure, there would be fluctuations in the amount of global emissions, but such variations would be within a downward trend. Furthermore, decentralizing responsibility for taking action to individual countries would make the whole program more sustainable than the Kyoto alternative, which requires participation by all countries in an international permit-trading regime.

The key objective for those interested in promoting responsible climate change policy is to allow each country to run its program without depending on other countries.

Another advantage of the approach proposed here is that the decennial negotiation on the permit price would allow a great deal of flexibility. Monitoring of emissions and the extent of induced abatement activities could be undertaken more easily than in a global program. If information changes, then the price of permits could be changed by international agreement. The endowment market would reflect this information immediately and would enable more rapid but cost-minimizing adjustment, if required.

An Early Action Proposal

The permit and endowment approach can and should be easily implemented in the United States and all other countries as an early action policy. By establishing such a system with a low initial price for permits, all domestic institutions that would be required—if and when the Kyoto Protocol is implemented—would be created in the meantime. To move from the fixed price system that we propose to a flexible price system under the Kyoto Protocol, all that is required is to remove the government intervention from the permit market in 2008 and allow international trading of the permits at the same time. Alternatively, and more likely, countries that implement the MW proposal would find that it works so well in providing price signals to consumers and industry that there will be no need to move to the Kyoto style system in the coming years.

Summary

The key objective for those interested in promoting responsible climate change policy is to allow each country to run its program without depending on other countries but on an overall framework that provides constructive incentives for private actors to control emissions efficiently. The proposal outlined here would accomplish this objective, ensuring sufficient flexibility for private actors, providing incentives for developing countries to commit to the system, and creating constituencies within all

countries to sustain the agreement—all without the need for cross-border intervention.

Finally, raising the price of carbon by a known amount in the short run would establish the insurance premium to be paid for climate change prevention over coming years, while reducing the short-run uncertainty for investment planning and creating a market that accurately prices carbon emissions for long-run planning purposes. Credible price signals can guarantee that emissions of carbon will be lower than otherwise would have been the case. Perhaps emissions will not be low enough as time proceeds and we gain better information and improved climate science. But a flexible system of emissions reduction can deal with this over time.

Starting now with small but significant action is far better than continuing to argue over the Kyoto Protocol and failing to implement policies that could make a meaningful start toward emissions reduction. The current situation generates enormous uncertainty for investment decisions and compounds the cost of climate change.

Additional Reading for this Policy Brief

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- *The Morning after Earth Day: Practical Environmental Politics*
  Mary Graham (1999)
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significantly and the increase in outgassing of the CO_2 from the ocean surface would be minimal.

The cost of sequestering CO_2 on a commercial scale is expected to be about $1.00 per ton of CO_2. The sales price for CO_2 sequestering credits, should they become tradable, should be above $2.00 per ton of CO_2, to include the cost of verification, overhead and profit. It is expected that these credits would be highly valued since they would not suffer from the problems of fire hazard, leakage and additionality the forest projects for CO_2 sequestering face.

While the experimental voyages to date have not had to deal with environmental regulation, the possibility that this could come up during commercialization should be recognized. Two possible regulatory hurdles have been mentioned. The first is Executive Order 12114 of January 4, 1979. This order, signed by President Carter is titled "Environmental Effects Abroad of Major Federal Actions". The purpose of this Executive Order is to enable responsible officials of federal agencies having ultimate responsibility for authorizing and approving actions by the Federal Government to be informed of pertinent environmental considerations and to take them into account along with considerations of national policy in making these decisions. Only actions by the Federal Government are covered, so private ocean fertilization projects are exempt from this order. The second possible regulatory hurdle is the London Convention[13], in which Article III states in part that dumping "...does not include placement of matter for a purpose other than the mere disposal thereof, provided that such placement is not contrary to the aims of this Convention." The protocol further lists the specifically covered pollutants, which include, among others, hydrocarbons, including oil and their waste, radioactive pollutants and agents of chemical and biological warfare, but not include carbohydrates or fertilizers. This means that there are neither UN conventions nor US regulations to limit the sequestration of CO_2 by iron fertilization. Should such limitations arise in the future, fertilization sites in the Pacific island nations could be an alternative.

Expected Impacts

The expected impacts of a successful demonstration of the technology and the measurement of significant sequestration response by the ocean to the planned chelated iron addition could be significant. The costly early actions now being contemplated to counteract possible future impacts of increased CO_2 content of the atmosphere would no longer be needed and instead all responses could be tied to measured consequences, which could then be reversed. This would open new options, avoid the unnecessary use of scarce resources and refocus attention on actual problems rather than seeking to deal with possible future scenarios. Many entities, both governmental and industrial may decide to do very useful things based on these concerns, such as improved energy efficiency and the exploration of new energy resources. This is to the good of society where they make economic sense and should be implemented in any case.

A CO_2 credit system may be instituted that will allow trading of credits to generate the lowest cost. Credits from sequestering CO_2 in the oceans should be a part of this effort so as to take early advantage of this lower cost, environmentally benign, low human impact and robust capacity approach to solving the global warming concerns, should this become necessary.

Conclusion

Many approaches for dealing with the increase in the CO_2 content of the atmosphere have been proposed, but sequestration by ocean fertilization has received little attention. It is new, far away and poorly understood by many. The initial reaction is that not enough is known to warrant attention at this time. While this reaction may have had merit in the past, the last few years have seen a great increase in knowledge about the oceans, especially the equatorial Pacific, where moored and floating buoy systems, research vessel voyages and continuous satellite monitoring have all greatly increased our knowledge and understanding. The last remaining piece of the puzzle is to quantify the response of this HNLC ocean water to iron fertilization, which can be done by the large experiment described here. We now know enough to design and carry out this technology demonstration experiment. This experiment can lead to solving the problem of peoples' concerns rather that just working on them. Therefore, this experiment can save time and costs while greatly reducing the risk of adverse consequences.

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Voyage 2 was carried out in the Gulf of Mexico in early May 1998. One 9 square mile patch was fertilized using the enhanced chelated iron-containing pellets. The ocean conditions were much more benign (no one got seasick) and we were able to follow the patch for six days. The pellets acted as expected, discharging the chelated iron over a period of four days. The result was a bloom of large diatoms that averaged five times background and reached seven times background. Further increase in phytoplankton was restricted by the absence of the next required fertilizing element, probably phosphorous, nitrate or both. However, extrapolating over the increased size to the patch gave an estimated 600 tons of diatoms per ton of fertilizer pellets, or 1,800 tons of diatoms per ton of chelated iron added to the waters. Both voyages in the Gulf of Mexico were in low nutrient, low chlorophyll (LNLC) waters, which are not favorable to the production of large blooms.

A fifth voyage, SOIREE, has been conducted in the Southern Ocean[11] south of New Zealand. Iron sulfate was added to the 20 mi^2 patch on days 1,3,5 and 7 to keep the concentration of dissolved iron at about 1.0 ηmolar versus a background of 0.08 ηmolar. The chlorophyll concentration went up by a factor of six and biomass by a factor of three with a preponderance of diatoms in the bloom. The increase in biomass was slower in these frigid waters than at the equator and the bloom concentration was less. However, the bloom lasted for about one month, as measured by satellite imagery.

These experiments have added greatly to our knowledge of the biodynamics and chemistry of the ocean. Other recent measurements have further increased our understanding. These have included the tethered buoy systems (TAO buoys) as well as the SeaWiFS satellite, instrumented buoys and drifter systems. These systems have, for the first time, provided continuous measurements of the ocean surface as well as at depth, instead of isolated measurements from intermittent ship cruises. This great increase in data has provided enough understanding that we can now design a technology demonstration aimed at proving the CO_2 sequestration potential of ocean fertilization.

Planned Technology Demonstration

All of these previous experimental voyages, while providing a compelling case for iron fertilization in HNLC waters, did not provide a solid basis for evaluating the potential for carbon sequestration. The fertilized patches were all so small that they were all edge; that is, the diffusion in the ocean surface waters is so great that the result of the fertilization, especially the amount of the biomass that sinks below the thermocline, could not be measured. Therefore, we have designed a technology demonstration using the long-lived chelated iron fertilizer in the HNLC waters of the equatorial Pacific Ocean. The fertilized patch will be 5,000 square miles in area and designed to sequester between 600,000 and 2,000,000 tons of CO_2. The patch will be laid by a chemical tanker that will traverse a spiral path[12] starting at a floating buoy that is maintained as the center of the pattern at all times. When the 5,000 square mile (80 miles in diameter) patch has been completed, in approximately four to five days, the commercial ship will return to port. It will leave a patch with an iron concentration of 2 to 4 ηM Fe in the ocean, an increase of about 20 to 40 times background. Based on patch dissipation rates determined from the IronEx studies in the same general Pacific location, the reduction in concentration from diffusion for the center of the patch is expected to be about 2% during the 20 days of the test. A scientific team on a research vessel using the most advanced technology, including direct measurement of the sinking biomass under the patch will measure the response to the fertilization. The research vessel will continuously transact the patch, taking samples to compare with the background measurements made before the patch is laid and, later, outside of the patch. The academic team will measure all relevant environmental impacts until the impacts vanish, which is expected to take about 20 days. The ocean area of the test site is shown in Figure 1.

This area is over 2,000 miles from any reef system and in waters 10,000 to 15,000 feet deep that have high oxygen content. Therefore, anoxia that can occur in shallow waters will not be a problem. Red tide and noxious algae typically occur only in shallow waters so should not be a concern. We will not be adding any new organisms to the ocean, only increasing the numbers of those already there. This controlled experiment will parallel the upwellings that occur off of the coast of Peru in all but the El Niño conditions, so we expect the environmental impacts to be benign.

Possible Commercialization

Should the increasing CO_2 content of the atmosphere be determined to have adverse impacts, the further demonstration of this technology can provide a solution, relieving the concerns regarding the continuous increase of these adverse impacts. CO_2 sequestering could then be carried out in the equatorial Pacific and in other HNLC waters, especially off of Antarctica, the main areas of the oceans that have a high capacity of sequestering CO_2. For instance, if all the CO_2 in the atmosphere were sequestered in the ocean, it would raise the average concentration of CO_2 in the ocean by only about 1.2%. The ocean chemistry would not be altered

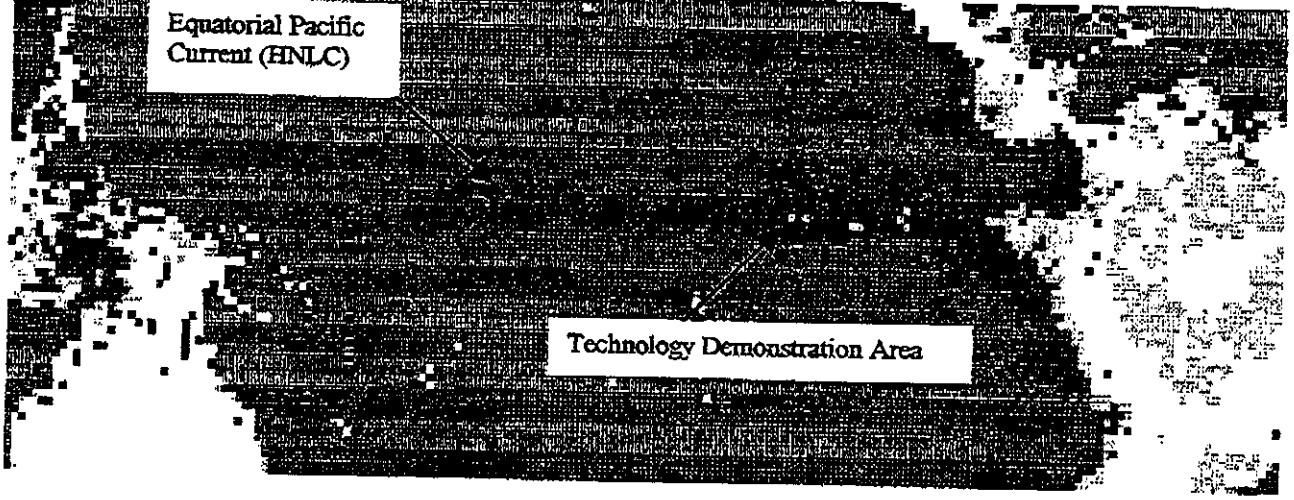

Figure 1. Location of Planned Technology Demonstration

PROPOSED US POLICY ON CONTROL OF CO_2 CONTENT OF THE ATMOSPHERE

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Abstract

Recent articles in *Science* magazine indicate that the US and Canada may be a net sink for CO_2, not a net source. Natural sequestration by agriculture and trees appears to be the cause of the decrease in the atmospheric CO_2 content of the winds as they blow from west to east over North America. This sink is expected to diminish over time so that other sinks will be required. To maintain the balance, perhaps the best additional sink is by means of CO_2 sequestering through surface fertilization of the deep tropical ocean, which can handle the impact of a growing population and economy while removing the future pressure on agriculture land for additional CO_2 sequestration.

Proposed US Policy on Control of CO_2 Content of the Atmosphere

Proposed US Policy on Control of CO_2 Content of the Atmosphere

Executive Summary

The recent increase in the carbon dioxide (CO_2) content of the atmosphere has given rise to concerns of possible adverse effects on climate and a call for early actions to address these concerns. Debate on these matters has centered on the Kyoto Protocol and the subsequent COP-6 meeting. The general tenor of these debates has been that the US, as the producer of 24% of the CO_2 released into the atmosphere from burning fossil fuels, is mainly responsible for the problem and must bear the largest cost of solving it. Such "solution" does not include the major use of sinks to remove the CO_2 from the atmosphere but only the emissions.

This view completely ignores the fact that the US, Canada and Eurasia do not add CO_2 to the atmosphere but, rather, remove it due to the large terrestrial sinks produced by their forestation and agriculture[1]. The most recent study indicates that the wind, blowing from the East Coast of North America out over the Atlantic, has a lower concentration of CO_2 than the wind blowing in over the West Coast, making North America a large terrestrial sink[2,3]. This sink has been modeled but its extent and permanence is controversial.[4,5] Therefore, the US needs to develop and prove, scientifically, technologies that can add to this sink and are low cost, environmentally benign, high capacity and long-lived. Development of sinks, such as sequestration by fertilization of the open ocean surface is an approach that meets these criteria. With new technologies the US can address the concerns of people regarding the CO_2 content of the atmosphere and can welcome other nations to join in this endeavor looking to reduce the net CO_2 production of the world, perhaps to zero, should this prove to be necessary in the future.

Introduction

The CO_2 content of the atmosphere has risen from about 285 ppm to 367 ppm over the past 50 years. This has produced concerns in many people that adverse effects will follow, including global warming, sea level rise, destructive weather patterns, increase in tropical disease and reduced food production worldwide. While there are some positive effects that have been measured, such as increased plant growth and increased nighttime temperature in the Arctic, peoples' concerns remain and must be addressed. This has been done on small scales by increasing the efficiency of energy production and energy use, getting more value from each pound of carbon burned as well as small tree planting and saline aquifer injection projects to produce sinks. Wind and solar energy production has received large incentives. There has also been a large shift from coal to natural gas, which decreases the CO_2 produced per unit of heat or electricity generated but with the increases in natural gas prices, at a considerable cost. In the US there has been an emphasis on increasing the fuel efficiency of cars and several states have mandated that electric utilities decrease the net CO_2 emitted per kilowatt-hour produced. All of this is not

sufficient to take care of peoples' concerns, so an international agreement has been sought to move the process forward.

The Kyoto Protocol

An international meeting was held in December 1997 to seek agreed-upon CO_2 emissions reductions from the developed countries, embodied in the Kyoto Protocol. The agreement sets out goals for developed countries averaging 5.2% below 1990 emissions by 2008 to 2012. This would mean a reduction of about 30% for the US due to our growing economy and population. The agreement mandated reductions that must be verifiable, deliberate (rather that a result of standard practice), permanent and avoid saturation and leakage. They must not include things that would happen anyway and they must "hurt". Trading of CO_2 credits were discouraged, leaving increased efficiency and reduced GNP the methods of choice. Developing countries were excused on the basis that countries like the US were the ones that caused the problem and should feel the pain of the solution. Emerging nations like China and India also had no responsibility and can continue to increase their CO_2 emissions without limit. The European nations expected to reach their goals by increased efficiency and conversion from coal to natural gas and nuclear energy. The basic reasoning was that the US, with 24% of the CO_2 production, is the major cause of the problem and therefore should suffer the major loss in GNP, shifting energy-intensive industries to developing nations.

COP-6

After the Kyoto Protocol was signed a series of meetings were held to iron out problems and set up workable guidelines to reach the intended goals. These culminated in COP-6 in The Hague during November 2000. The meeting was contentious, with the Europeans demanding no CO_2 trading across country boundaries and restrictions of CO_2 credits for sequestration, including soil and trees, with no ocean sequestration included. The US demanded CO_2 credit trading and broad sequestering credits as a part of relief for a growing economy and population. In spite of major concessions by the US the meeting broke up with no agreement, leaving the Kyoto Protocol in limbo. This essentially clears the slate and gives the US an opportunity for a fresh approach to meeting peoples' concerns.

Background for Suggested Approach

A new US policy approach is suggested based on two facts:

1. The US and Canada take out more CO_2 from the atmosphere than they emit, providing a net CO_2 sink, not a source.
2. The harnessing of ingenuity and creativeness can solve the problem previously thought to be intractable by such means as enhanced sinks for CO_2.

Published studies have shown that North America and Eurasia are not net emitters of CO_2 to the atmosphere, but take more CO_2 out of the atmosphere by

agriculture and growing new forest trees than they put in by burning fossil fuels.[1] The US and Canada are also net sinks for CO_2, as reported in the most recent study.[2,3] This is due to the planting of trees in the great plains and increases in agriculture from irrigation and enhanced farming methods. When a new forest is planted it sequesters CO_2 until it matures to the point where the rotting of dead trees emits as much CO_2 as the live trees absorb, a climax forest. While the overall trend for the North American net CO_2 sink appears secure at this time, the variation in the values around this trend are large.[4,5] Significant effort will be needed to continue the net sink for the area, including increasing the efficiency of fossil fuel use and increasing the use of non-carbon energy sources such as nuclear, hydropower and solar-driven devices. The stabilization of the North American net sink can be enhanced by the increase in land productivity in the US from new farming technology which is releasing land to provide for new forest areas, further delaying the return to a balance of emission and sequestration of CO_2 in the US and Canadian land area.[6] The amount of net sink of CO_2, including emissions from fossil fuel burning, is expected to fall slowly in the years ahead. The key is that North America is a part of the solution to peoples' concerns, not the problem. While these studies have been available for several years, they remain controversial. More measurements of CO_2 content of the atmosphere need to be made to characterize the overall CO_2 flux and more modeling must be carried out to decrease the margin of error in the predictions. The key point is that sinks count. The enhancement of sinks should be a cornerstone of the new US policy going forward.

The Impact of New Technology

The inventiveness of mankind will continue to solve problems, including this one. The key is to continue the present trend of diminishing CO_2 emissions per person and per dollar of GNP. While we can expect this trend to continue, and perhaps accelerate, the greatest gains are expected to be in CO_2 sequestration. Several technologies are under investigation but one, sequestration of CO_2 in the deep ocean by fertilization of the ocean surface, appears to have the greatest potential. Here a chelated iron fertilizer of the type that is currently sold in local garden shops is spread on the ocean surface. This produces a bloom of plant life, mostly diatoms, which double or triple every day, using up the fertilizing elements, after which they die and sink through the thermocline at about 75 feet per day and are trapped in the deep ocean. This technology has been tested in five separate iron fertilization voyages, all of which produced a bloom. They were all too small (about 9 to 30 square miles) to allow for measurement of the amount of biomass sequestered. This can be done in a proposed technology demonstration voyage in the equatorial Pacific with a 5,000 square mile fertilized area[7].

The technology to be demonstrated is:

- Low cost, about $2.00 per ton of CO_2 sequestered.
- Environmentally benign since it does just what the ocean does naturally in upwellings, only in a different place.

- Long lasting since the deep ocean waters only come back to the surface through upwellings after an average of about 1600 years.
- High capacity since just the waters of the Pacific Ocean west of the Galapagos Islands could, if necessary, sequester about 400 million tons of CO_2 per year with the continuous fertilization of about 3 million square miles of deep open ocean. This amount of CO_2 sequestered is 20% of the 2000 million tons of CO_2 that the US puts into the atmosphere from burning fossil fuels and making cement.
- Of low ocean impact since 400 million tons is miniscule in comparison to the total CO_2 equivalent content of the ocean, which is 145,000,000 million tons.
- Without problems of additionality since this process does not reduce other sequestration or loss of CO_2 from the atmosphere due to other human interventions.

The US needs to have available a technology of this kind in order to keep its net CO_2 production negative in the future and to have the ability to help to assuage the concerns of people about the impacts of other countries such as India and China as we go forward. To do this the US should carry out continuing demonstrations of the technology including measurement of local atmospheric CO_2 fluxes.

Recommended Policy

The US should take the view that we will continue to help the world to cope with the possible adverse effects of the increase in the CO_2 content of the atmosphere, should they arise. This can be done completely unilaterally and outside the Kyoto Protocol. The US can continue to be a net sink of CO_2 as we have in the past and can take steps to develop technologies that will assure that this will continue after the forest and agriculture sinks balance the fossil fuel CO_2 production in the future.

The US should use these technologies to address the concerns of other nations resulting from the increase in CO_2 content of the atmosphere to reduce the rate of increase, or even to reverse it, if this should become necessary. We should invite other nations to join with us in this endeavor.

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[6] Ausubel, J.H., "The great reversal: nature's chance to restore land and sea", *Technology in Society*, 22 (2000) pp 289-301.

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Davis Stubs Toe On QF Solution

BY TINA DAVIS

Eager to solve a key part of California's energy puzzle, Gov. Gray Davis unveiled a proposal late Tuesday aimed at ensuring payment for power produced by so-called qualifying facilities. But his announcement annoyed utilities and angered QFs.

Davis (D) said he wants to move quickly to resolve the needs of the qualifying facility owners—many of whom have received little or no payment for their power since last year. To that end, the California Public Utilities Commission will vote on Davis' proposal Tuesday, the governor said, in an effort to get payment underway again by April 1.

QFs have become pivotal of late because they have taken up to 3,100 megawatts of power offline in California due to the inability of the state's nearly bankrupt investor-owned utilities to pay for the power. If the state had access to the power, it would not have needed to implement the statewide rolling blackouts that took place Monday and Tuesday this week.

Although most of the facilities are small, altogether QFs produce about 30 percent of California's power, a larger segment than any single power generator in the state, according to the California Energy Commission.

While larger generators have begun selling power to—and receiving payment from—the state's Department of Water Resources, QF owners are locked into long-term contracts with financially ailing Pacific Gas & Electric and Southern California Edison.

The small generators—which have special federal status as qualifying

(Continued on page 2)

NNSA Cuts Funding For Plutonium Disposal Facility

BY GEORGE LOBSENZ

The National Nuclear Security Administration will scrap fiscal year 2002 funding for a planned plutonium vitrification facility in what could signal a major change in U.S. nuclear nonproliferation policy.

NNSA, a semi-autonomous agency within the Energy Department that runs the U.S. nuclear weapons complex, said it would not proceed next year with the design of the so-called immobilization facility, which previously was seen as a key part of DOE's dual-track program to dispose of surplus weapons plutonium.

NNSA indicated the decision was dictated by budget constraints, and suggested the immobilization facility was being delayed, not killed. It also said it is proceeding with the other track of the plutonium disposal program, which calls for converting surplus plutonium into mixed oxide, or MOX, fuel for commercial reactors.

"NNSA and DOE are in the midst of the budget cycle for the new administration," NNSA said in a statement. "The administration is looking at the budget and programs for the next fiscal year and wants to assure the most effective use of monies available.

(Continued on page 4)

Senator Falls Flat In Pushing CO2-Less Multi-Pollutant Plan

BY CHRIS HOLLY

The chairman of the Senate Environment and Public Works Committee Wednesday tried but failed to get environmentalists to sign on to his vision of a multi-pollutant regulatory program that would regulate utility emissions of sulfur dioxide, nitrogen oxides and mercury but make carbon dioxide emissions cuts voluntary.

Sen. Robert Smith (R-N.H.) proposed such a regime at a clean air subcommittee hearing on harmonizing clean air law and the nation's energy needs, but David Hawkins, the clean air guru of the nation's environmental community to whom Smith floated the trial balloon, politely but firmly shot it down.

In particular, Hawkins said emissions trading programs favored by Smith would not work without a firm limit on carbon dioxide.

The exchange focused on legislation Smith is drafting that would integrate regulation of key utility pollutants and extract significant emissions reductions from utilities in exchange for giving the industry a commitment that no new emission reduction requirements would be handed down by the Environmental Protection Agency for a number of years.

Utilities support the concept of integrated regulation because it would give them greater certainty on their long-term regulatory costs. However, the multi-pollutant concept suffered a clear setback when President Bush—breaking a campaign promise—recently announced he was opposed to any carbon limit.

(Continued on page 4)

CO2-Less Multi-Pollutant Plan... (Continued from page one)

Despite Bush's announcement, Smith has remained enthusiastic about the concept, saying he wants to require utilities to cut SO2, NOx and mercury but allow voluntary CO2 cuts.

In that vein, Smith asked Hawkins to assume that greenhouse gas reductions are being made in other sectors through a suite of government policies.

"If we make all those assumptions, why is it necessary to regulate specifically the power plants' emissions of carbon?" Smith asked. "Are you insisting that it be command and control, end-of-pipe, end of power plant emission-controls on carbon?

Hawkins replied that environmentalists don't necessarily like command-and-control regulation any more than industry does, but said if utilities aren't asked to cut CO2 along with SO2, NOx and mercury, the economics of pollution control financing could lead many utilities to adopt emissions abatement strategies that could leave them—and their ratepayers—financially vulnerable to carbon reduction mandates that force them to change fuels or make other expensive changes later in the decade.

"We think that a target for carbon needs to be an integral part of [the] legislation," Hawkins said, noting the success of utilities in cutting SO2 reduction costs under the cap-and-trade Acid Rain Program. By finding emission reduction strategies that account for all four pollutants, utilities will lower the cost of compliance for each pollutant, he said.

Smith asked if it would be enough to give credits to utilities that, in the course of cutting SO2, NOx and mercury, also voluntarily reduce CO2 emissions directly or indirectly, through planting trees, for example.

Hawkins replied: "Well, a credit is useful if there is an obligation that one applies the credit to, but if you don't have any obligation to limit carbon then whether or not you pursue an opportunity to reduce carbon is going to be pretty questionable, because why are you doing it?"

In discussing how to harmonize the Clean Air Act with U.S. energy policy, Linda Stuntz, former deputy Energy secretary and now an attorney with investor-owned utility clients, said Congress must ensure that utilities not be required to phase out their use of coal. Instead, lawmakers must establish policies to ensure that technologies are developed to allow coal to be burned more cleanly and efficiently, she said.

Stuntz, a key player in the enactment of the 1990 Clean Air Act Amendments and the 1992 Energy Policy Act, said the power crisis in California and other Western states is due in some measure to the difficulty generators have had in obtaining NOx offsets for new power plants—particularly in California. She noted that in response to the crisis, Washington Gov. Gary Locke (D) has asked EPA for waivers from federal emissions limits to allow the use of diesel generators to keep his state's lights on.

"These units are far dirtier, by five or six orders of magnitude, than coal-fired plants," Stuntz said.

Plutonium Disposal Facility Funding Cut... (From page one)

"In this particular program we are continuing with the MOX facility design and construction—but are opting to look at other aspects, such as the immobilization facility, in possible future budget cycles."

NNSA officials had no other details on budget considerations, but other sources have said the agency is facing significant cuts in its nonproliferation programs.

However, some sources said the budget cuts could provide a pretext for killing the immobilization program and using existing DOE facilities to dispose of the plutonium materials that are supposed to be vitrified.

That would represent a major departure from DOE's plutonium disposal program, as decided upon by the department several years ago following an exhaustive programmatic review. It also would deviate from the terms of a U.S.-Russian agreement under which both countries agreed to use both MOX fuel and immobilization to get rid of 50 tons of surplus plutonium each.

The immobilization facility, to be built at DOE's Savannah River Site in South Carolina, is supposed to prepare for disposal 17 metric tons of plutonium contained in scrap materials left over from past nuclear weapons production. The materials are to be vitrified into a glassified waste form, poured into cans and then placed inside large canisters of high-level radioactive waste for underground disposal. The vitrification process is aimed at immobilizing the waste in a highly radioactive package so the plutonium cannot leak into the environment or be recovered for weapons use.

The scrap material is considered unsuitable for conversion into MOX fuel because the plutonium would have to undergo expensive purification processes.

In addition, Clinton administration officials said immobilization was needed so the United States could have a dual-track plutonium disposal strategy that assured there would be a viable disposal method if one method or the other were to run into technical problems.

Immobilization also has had strong support from antinuclear groups who are opposed to MOX fuel because it would make commercial use of weapons-usable plutonium, raising proliferation concerns.

Not surprisingly, those groups expressed alarm at NNSA's funding decision.

"We are quite disturbed that they appear to be defunding the immobilization program," said Tom Clements, an official with the Nuclear Control Institute. "It's prudent to keep this track open and operative."

However, immobilization has been viewed with suspicion by some DOE officials who say existing nuclear reprocessing canyons at Savannah River could be used to dispose of plutonium residues without the expense and uncertainty of building the immobilization facility.

Using the canyons could purify plutonium sufficiently for it to be used in MOX fuel—and it would please South Carolina's politically powerful congressional delegation, which wants to keep the aging canyons running to maintain jobs.

Using the canyons also could reduce the cost and complexity of the MOX effort, which is running into difficulty in developing plutonium purification processes.

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Reframing the Climate Change Debate

The United States Should Build A Domestic Market Now for Greenhouse Gas Emissions Reductions

Jon Naimon and Debra S. Knopman

Forget the dead-end debate about whether the Kyoto climate change treaty negotiated in 1997 is too much, too soon, or too little, too late. Even if this particular agreement is never ratified by the Senate, the United States still needs a plan to help stabilize the build-up of greenhouse gases in the atmosphere. The plan proposed here harnesses market forces and rewards businesses, governments, and individuals when they take action to reduce greenhouse gas emissions. Following this course, the United States could begin to address the climate change threat without slowing economic growth.

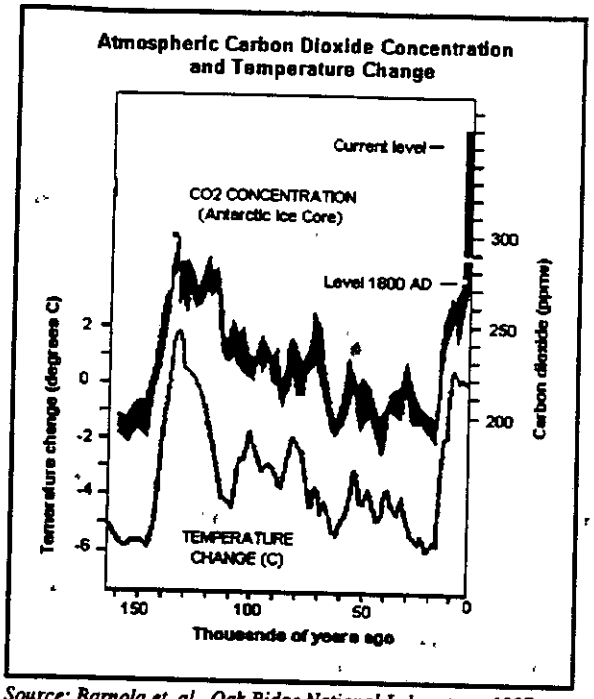
Fossil fuel combustion, forest destruction, and intensive animal agriculture have pumped up atmospheric concentrations of greenhouse gases like carbon dioxide and methane to their highest levels in 160,000 years. By the end of the next century, greenhouse gas concentrations are expected to be twice what they were at the dawn of the industrial age. Studies of past climate, using ice cores from Antarctica, Greenland, and other historical evidence, show a close connection between high concentrations of greenhouse gases and higher global average temperatures. Higher temperatures could raise sea levels and alter current climate patterns. For the United States and other industrialized nations, climate-induced changes in seasonal temperatures, rainfall, storms, drought, and floods could prove costly but ultimately manageable. Many developing countries with weak economies and even shakier social structures will have a much harder time adapting to these changes, particularly if they occur rapidly.[1]

The climate change threat is unlikely to go away any time soon. Based on current science, greenhouse gas-triggered change is likely to happen—but just when, where, and how obvious its effects will be are highly uncertain.[2] The dilemma is how to devise a policy whose benefits won't be seen for generations, yet whose costs will be felt now. The lag time between action and reaction is so long that even if nations immediately cut back on emissions of greenhouse gases, atmospheric concentrations would not decline appreciably for close to a century.[3]

Congress has been polarized and paralyzed by the scientific and economic uncertainties surrounding climate change. For the last two years, Rep. Joe Knollenberg (R-MI) has led the charge in Congress to impose a ban on Administration action to implement the Kyoto treaty except for basic research on climate change.[4] Action on once-promising legislation to grant credits to businesses that take voluntary actions to reduce greenhouse gases has now stalled.

There is a viable, near-term alternative to the false choices of the "Kyoto or Bust" debate. Government, business, and individuals live with uncertainty about bad weather

Figure 1. Trends in atmospheric carbon dioxide concentrations and temperature change over th



Source: Barnola et. al., Oak Ridge National Laboratory, 1997

and economic downturns every day, and have found ways to act prudently. Businesses and consumers buy all sorts of insurance and other financial products to reduce financial risks. Public agencies build dams, reservoirs, and levees to reduce the risks of floods and droughts. Property owners make buildings earthquake-proof and lower risks of physical damage. Businesses diversify their interests and investments to buffer their bottom line from economic downturns.

Congress should get over its Kyoto complex and adopt a "no regrets" market-based policy that deals sensibly with the threat of climate change. The policy has three objectives:

- Put the United States on a path that leads to real reductions in national greenhouse gas emissions;
- Minimize the costs of emission reductions to businesses and taxpayers; and
- Equitably spread the costs and benefits of U.S. climate policy across the economy.

Traditional Regulation Won't Do

The first generation of environmental regulation (so-called "command and control") simply wasn't designed for the greenhouse gas problem. Because of the diversity of greenhouse gas emissions sources and even greater diversity of processes for reducing greenhouse gas emissions, traditional, prescriptive regulation would be impractical, inefficient, and politically unsustainable.[6] Under the first generation approach, Congress decides which industries should be regulated, and government regulators tell businesses which technologies to use to comply with regulation, based on their estimates of corporate

costs of compliance. Then, by setting deadlines for compliance, regulators decide when and how much pain the companies should endure to comply with the rules.[7]

The greenhouse gas challenge presents an opportunity to advance a "second generation" model of market-based incentives and information disclosure that recognizes the significant environmental impact from consumers, consumer products, service industries, and numerous government agencies. In a second generation approach like emissions trading, government sets the environmental goals and rules, but lets the private sector determine optimal ways of achieving the goals under the rules.[8] Some economists still prefer a direct, across-the-board tax on greenhouse gas emissions or on the carbon content of fuels, but a broad, new tax is unlikely to gain public acceptance anytime soon.[9]

Build a Market Now

The single most important action Congress could take is to establish a domestic market for greenhouse gas emission credits. A market would provide a positive economic incentive for companies, public agencies, and consumers to reduce their emissions. A market would encourage those with the lowest incremental costs to make reductions first. Building a market would increase the value of voluntary greenhouse gas reductions taken by many companies. Further, an organized market would reduce speculation about economic effects of climate change policies by demonstrating real-world costs of emissions reductions.[10]

The U.S. pioneering experience with controlling sulfur dioxide emissions shows that a properly designed emissions trading market works. The trading program, established by the Clean Air Amendments of 1990, sets a graduated series of "caps" on total national emissions of sulfur dioxide. The government allocates credits to electric utilities corresponding to the amount of sulfur dioxide emissions permissible under law; these credits can then be traded among the utilities and others. The "cap and trade" program lowered sulfur dioxide emissions below the required levels at a cost of less than $1 billion compared to an estimated $4.5 billion price tag for conventional "command and control" regulation.[11]

Here's how Congress should initiate a market for greenhouse gas emissions:

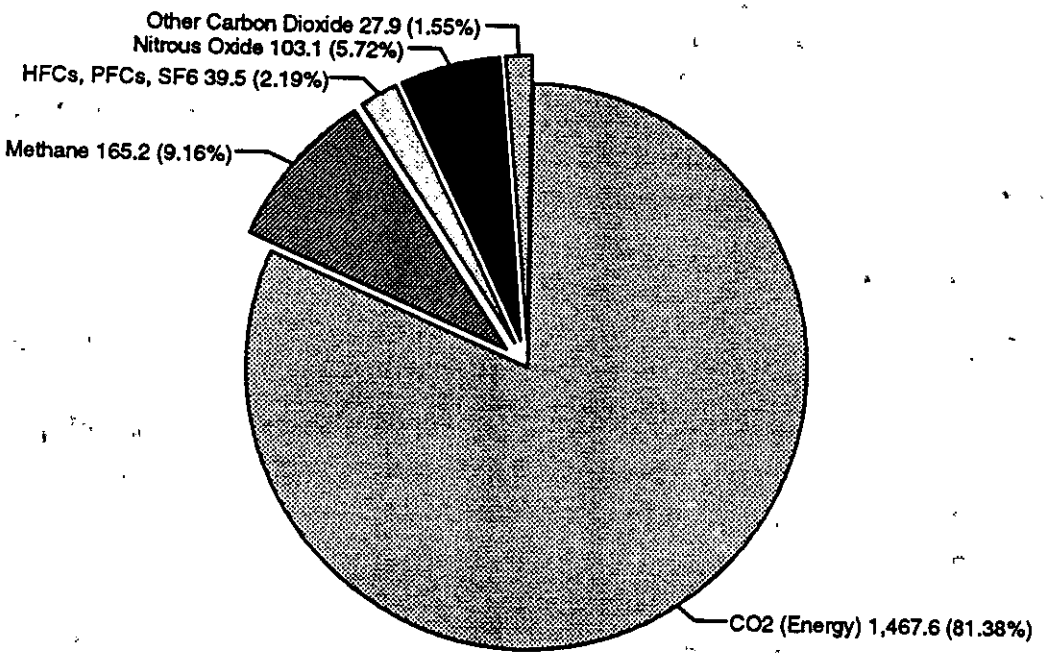
- Authorize a "cap and trade" program that would initially set a limit on overall greenhouse gas emissions corresponding to year 2000 levels;
- Specify initial allocation of credits to existing generators of greenhouse gas emissions, setting aside 5 percent of credits to auction for new market entrants;
- Reduce the overall cap by 1 percent each year;
- Require those who receive initial credits to pass them through to customers who indirectly reduce their greenhouse gas emissions;
- Include government agencies as full market participants with the same responsibilities as companies;
- Push government purchasing toward more energy-efficient and climate-friendly goods and services;

- Implement a greenhouse gas information disclosure program to communicate relevant environmental performance information to the public and financial markets; and
- Phase out the administrative allocation of emission credits over 10 to 15 years and gradually replace with an auction of emissions credits.

With a national cap on total emissions declining by only 1 percent each year and the ability to purchase emissions credits, the potential economic impact of the emissions market on energy-intensive industries would be minimal. Indeed, last year's economy offers hard evidence of this proposition: preliminary numbers from 1998 suggest that emissions barely increased (0.4 percent) as the economy continued to expand (3.9 percent growth).[12]

Getting an emissions trading market up and running would reduce the economic risk that government might require businesses to take abrupt action later. Companies could reduce emissions gradually instead of being required to rapidly retire capital equipment. Further, the market would create economic opportunities for companies and individuals who participate in the trading directly.

Figure 2. U.S. greenhouse gas emissions by gas for 1998 in million metric tons of carbon equivalent. (HFCs are hydrofluorocarbons, PFCs are perfluorocarbons, SF6 is sulfur hexafluoride, and CO2 is carbon dioxide).[13]



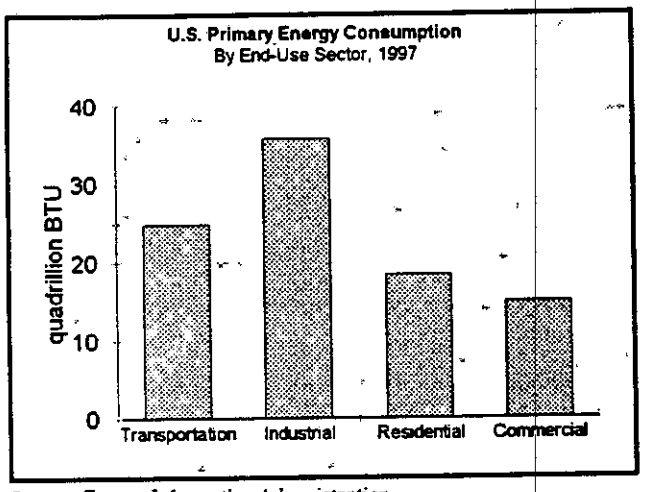
Source: Energy Information Administration, 1999

An Emissions Trading Market Offers Multiple Incentives

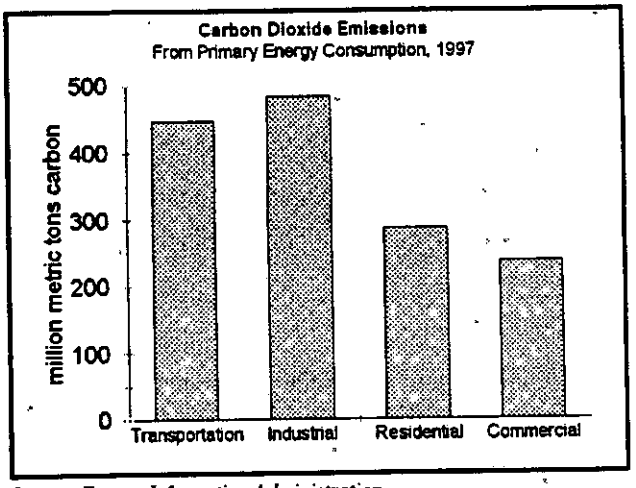
Reducing greenhouse gas emissions means changing sources and efficiency of energy use. Nearly 85 percent of greenhouse gases produced within U.S. borders arise from fossil fuel combustion for energy use; the rest comes from methane from landfills, coal mines, oil and gas operations, and agriculture.

By 2000, the greatest source of demand growth for electricity in the United States may well be home office equipment, not aluminum smelters.[14] This means that a successful greenhouse gas emissions reduction program will need to extend beyond the largest industrial companies, and engage almost every sector of the economy, including commuters. More than 30 percent of U.S. greenhouse gas emissions come from energy used by commercial and residential activities like lighting, heating, and cooling offices and homes, and operating computers and electrical appliances. Driving cars and trucks and other forms of transportation account for another third of total emissions—about the same fraction as industry.

Figure 3: U.S. primary energy consumption and sources of greenhouse gas emissions by economic sector for 1997.[15]



Source: Energy Information Administration



Source: Energy Information Administration

The vast majority of U.S. companies do not yet perceive much value in greenhouse gas emissions reductions in the absence of clearer regulatory policy. As an executive at a large electric utility remarked, "We've done the voluntary program and have the green stamps. Before we do more, we need to know how we can redeem these 'green' stamps."[16] In other words, companies need to know that a broad, viable, and stable national marketplace will develop before undertaking more voluntary activities with uncertain payoffs.

In Europe, Australia, and in the U.S. informal "over-the-counter" (OTC) capital market, companies and governments have been experimenting with greenhouse gas emissions trading.[17] Without a formal market, however, the price of reductions varies widely from trade to trade, and only the companies with the largest emissions participate. For example, in some projects to reduce greenhouse gas emissions and store carbon, prices range

from pennies per ton of carbon dioxide emissions avoided to over $5 per ton avoided. A broader and more transparent market would iron out these inconsistencies in pricing.

Some of the most successful corporations in America (and the world) have already devised long-range greenhouse gas emissions reduction programs.[18] To tap the full power of the marketplace—including the unique skills of financial intermediaries—Congress needs to formally establish U.S. policy, national emission caps, and rules for measurement and enforcement.

Key Features of a Domestic Emissions Trading Market

Congress should direct the President to establish a "cap and trade" emissions credit program modeled on the successful sulfur dioxide emissions program. Credits would be defined in terms of a ton equivalent of CO_2. The sulfur dioxide program covers only a few thousand power plants that are responsible for 70 percent of the domestic sulfur dioxide emissions. In contrast, reduction of greenhouse gas emissions needs to come from virtually all sectors of the economy that contribute to emissions, including consumers of fossil fuel-generated energy.

Table 1. Proposed recipients of initial greenhouse gas emissions allocations, accounting for between 70-80 percent of total U.S. emissions of carbon dioxide.

RECIPIENTS OF INITIAL ALLOCATION CREDITS	APPROX. NUMBER OF ENTITIES
Electric utilities	~1000
Industrial co-generation facilities	~1000s
Industrial direct emitters	~10,000s
Commercial fleets (trucks, planes, and autos)	~10,000s
Public agencies (federal, regional, state, and local)	~1000s
Large organizations with commuters (over 10,000 employees)	~10,000s

Market players in the industrial sector would be allocated credits to cover their emissions in the year 2000. They would then be free to undertake greenhouse gas reduction activities or purchase credits equal to the amount by which their annual greenhouse gas emissions are expected to exceed their allocations. Large greenhouse gas emitters in the non-industrial commercial and transport sectors also would be allocated credits based on year 2000 emissions.

In addition, there would be an important role for third parties like environmental brokerage firms. Brokers who help connect willing buyers and sellers would not receive allocations, but would be allowed to buy and sell credits, aggregating emissions from smaller parties who would otherwise not have the time or money to play in the market. By expanding the community of participants in a regulated market, the incremental burden of the regulation (if any) on an individual economic sector would be lower than if that sector were singled out for attention.

Table 2. Summary of rules for the proposed domestic greenhouse gas emissions trading market.

FEATURE	RULE	RATIONALE
Authority to allocate credits	A federal interagency group	Greenhouse gas emissions credits are public goods transferred to the private and public sectors.
Base year for allocating credits	Year 2000	Market operations should begin from present levels, using the best available information.
Transferability	Fully transferable to third parties	Small businesses and consumers can gain direct economic benefits from reducing greenhouse gas emissions.
Form of allocation credits	Credits for carbon dioxide (CO_2) and other gases (when added to the market) expressed as metric CO_2 tons using international conversion standards.	Other greenhouse gases should be added after the first several years of market operations.
"Pass through" requirements	Direct emitters required to pass along credits for energy efficiency improvements to their customers as a requirement for receiving allocation credits.	Businesses that save energy can obtain greenhouse gas (GHG) emission credits if they reduce their demand for GHG-producing electricity. If companies fail to pass through credits to customers, then they lose their entitlement to "free" credits and instead have to buy credits on auction market.
Third-party allocations	Third parties not provided initial allocations may aggregate savings of customers or other small generators and apply for GHG emissions credits. Organizations receiving initial allocations are required to pass through verifiable credits.	Organizations that build or retrofit energy-efficient buildings should be allowed to obtain GHG credits. Manufacturers that lease energy-efficient computing systems could obtain GHG credits as part of deals with customers who get them from direct emitters, like their power supplier.
Annual reduction in cap on emissions	All GHG allocations reduced by 1 percent per year.	To achieve real reductions in greenhouse gas emissions gradually, the cap on allocations needs to decline in an incremental and predictable way. The "grandfathering" of allocation credits will be phased out over time and replaced by auctioning.

Expanding the scope of a regulated greenhouse gas market can change the political dynamic from "whose ox gets gored" to how different industries can cooperate to identify the least costly solutions for reducing greenhouse gas emissions on a national basis. This provision secures an economic incentive for financiers to support greenhouse gas emission reduction activities. For example, several firms have put together deals that would result in the trading of about 10 million tons of carbon dioxide emissions.[19] These "demonstration" trades were limited, not by corporate economics, but by lack of federal action on establishing an organized market framework.

Table 3. Examples of emissions trading that could occur in the proposed domestic market, assuming the "pass through" requirement.

POTENTIAL SELLER	POTENTIAL BUYER
Owner of power plant converts from coal to natural gas	Owner of coal-fired power plant used for peak loads
Building owner who reconfigures lighting, heating, and air conditioning to gain energy efficiency	Industrial emitter seeking to avoid expensive upgrades of a soon-to-be-retired facility
Parcel delivery service upgrades truck fleet to include very low-emissions vehicles	Regional air quality fund purchases and retires credits
Privately-operated "cash for clunker" program	Conservation organization retires credits

Beginning in 2001, the federal government should begin a process of making market allocations for other greenhouse gases such as methane and nitrogen oxides which have proportionally greater effects than carbon dioxide Over time, other key greenhouse gases should be included. [20] Other specific features of the market are discussed below.

Disclose Emissions Data

Large emitters throughout the economy—including major energy users such as government agencies, the service industry, and transportation companies—should publish estimates of greenhouse gas emissions in a standardized format to be placed on the Internet. The federal government would use these estimates to set allocations. This disclosure would enhance the information base on which market participants can act and also allow the public to incorporate information on greenhouse gas emissions and developments into their private buying decisions.

Information disclosure can be a powerful tool. The Toxic Release Inventory (TRI), created by the 1986 Emergency Planning and Community Right to Know Act, has demonstrated that the mere public disclosure of legal toxic emissions stimulates corporate efforts to reduce emissions substantially. Indeed, if companies misrepresent their emissions in TRI, the government imposes stiff penalties. In the chemical industry alone, emissions per unit of revenue have fallen by over 50 percent in the last five years, although overall emissions in some sectors have risen.[21] Similar requirements to disclose greenhouse gas emissions should lead to high levels of compliance and stronger incentives to improve greenhouse gas emissions estimation methods.[22]

Small emitters of greenhouse gases should have a choice about whether to participate in the market or not. If they choose to not participate, they should be exempt from mandatory reporting and administrative allocations. If they choose to enter the market as a buyer or seller, they should submit to appropriate reporting requirements. In some cases, these smaller players may be able to capture the "low-hanging fruit" of cheap emissions reductions compared to industries that are already intensively working to minimize energy costs.

Companies that purchase energy efficient products should be allowed to buy and sell credits in an emissions trading market. The pass-through provision enables them to get credit for greenhouse gas emissions reductions as a consequence of their actions. Congress should direct the U.S. Environmental Protection Agency (EPA) to expand product information standards such as Energy Star to increase the market pull for products that are more greenhouse gas efficient. The EPA allows companies to use their Energy Star "seal of approval" if the products meet EPA's criteria for energy efficiency. The program takes credit for encouraging gains in the efficiency of over 3,200 products in 25 product categories.[23] The advance has been achieved by thousands of companies who purchase energy-efficient office equipment and other goods, however, even though they are not necessarily direct emitters of greenhouse gases.

Allocate Rights to Emit Now, Auction Later

The heart of the political challenge of establishing a greenhouse gas emissions market is how the government distributes emissions credits to initiate the market. Either the government could hand out the credits for free, called "grandfathering," or it could auction the credits and use the revenue generated from the auction to reduce payroll taxes or pay down the national debt.[24]

In the market proposed here, initial allocations are based on grandfathering existing large sources of greenhouse gas emissions. Grandfathering avoids compelling major greenhouse gas emitters to bid for the "right" to continue their operations. In the early stages of the market, 5 percent of the credits should be set aside for auctioning among new market entrants. Over time, the auction set-aside should be progressively increased.

Company-specific allocations of greenhouse gas emission credits would be granted by the federal government on the basis of a 1 percent per year reduction for the next 10 years, using the year 2000 emissions as a baseline.[25] This level of certainty would be more amenable to companies than other, less predictable schemes to adjust emissions caps.

Energy suppliers and others who receive grandfathered allocations would be required to pass through credits to customers who demonstrate real, net reductions in energy use. This "pass through" requirement is essential to broadening participation in the market to include companies, property owners, and others who adopt more energy-efficient products and processes.

The missing players in the proposed market are personal vehicle owners. (Commercial fleets are included.) There are several approaches that could be taken to deal with their inclusion in the market. The simplest is to build on California's experience with major employers who can earn air quality "credits" from actions to reduce emissions taken

by their employee commuters. In the spirit of this proposal, third parties like cities or environmental groups could organize vehicle owners on a strictly voluntary basis within regions, aggregate their emissions through a certification process, and gain entry to the allocation or auction process. Alternatively, the vehicle emission problem could be dealt with using modified fuel efficiency standards.[26]

Circumscribe the Role of Government

The yearly reduction in allowable greenhouse gas emission credits should be the same for each regulated entity: 1 percent of the previous year's cap. This takes the government out of the controversial role of estimating an individual company's economics and opportunity costs. Neither government nor trade associations have a good record of determining the net costs, if any, of environmental regulations on private firms. An across-the-board reduction leaves the government with a smaller, well-defined role of administering a database of emissions estimates, determining greenhouse gas emission goals on the basis of those estimates, providing a legal forum for trading greenhouse gas credits, assuring the public that goals have been obtained, and adjudicating disputes that may arise.

Regulate Government Agencies as Market Players

Federal and state government agencies should not receive a carte blanche "carve out" from emissions limits, but rather should be required to meet greenhouse gas targets based on estimated 2000 emissions—just like private sector actors. The federal government is the largest energy consumer in the United States. The economic burden on private entities—which may well be more energy-efficient by virtue of their economic incentives—will be reduced if government agencies and nonprofits are also required to shoulder their proportional share of the burden. In fact, President Clinton signed an executive order in June 1999 to push federal agencies toward greater energy efficiency and lower greenhouse gas emissions.[27]

A few states like Oregon and New Jersey are already moving on this front. A pilot program underway in Portland, Oregon, estimates the greenhouse gas emissions of various municipal departments, and provides a model for assessing incremental changes by others in the public sector.[28]

Uncle Sam Can Buy Green Too

In addition to participating in an emissions trading market, federal procurement could generate a very significant market signal to support greenhouse gas efficiency efforts throughout the economy. The federal government is the largest single customer in the United States. If other government entities—for example, states and municipal agencies—are included, the public sector may represent over 5 percent of the buying power in the United States. A federal procurement initiative that encourages agencies to add greenhouse gas emissions per unit of production to their lists of buying criteria could have a tremendous impact on companies supplying goods and services. In the past, federal procurement has

been responsible for the rapid development of solar photovoltaics, wind turbines, aeroderivitive turbines, superconducting transmission, and several other significant contributions to current efforts to reduce atmospheric greenhouse gases.

If public agencies are clever, they may be able to meet their 1 percent emissions reductions per year through better procurement without incurring any incremental costs. If that is not possible, agencies could contract for greenhouse gas emissions reduction services from energy service companies. Stimulated by the June 1999 Executive Order, some federal agencies are already moving toward green procurement, but much more could be done.[29] If agencies still can't meet their annual greenhouse gas reduction targets by either of these means, they could be permitted to purchase credits in the market, subject to limitations on direct conflicts of interest.

Seed a Futures Market

Buyers and sellers in oil, electricity, grain, and other commodity markets limit their exposure to big swings in commodity prices through the use of option and other derivative contracts.[30] Market players in greenhouse gas emissions trading also should be allowed to purchase option contracts to limit their risk of losses when the price of greenhouse gas emissions credits rises or falls. For example, a hedge against an increase in price of a greenhouse gas emissions credits may be the purchase of an option contract that offers the right to purchase 10 million tons at $1.00 per ton. With that hedge, an electric utility could proceed with its less than $1.00 per ton activities, but know that if the market price went to $2.00 a ton, the company's additional costs would be limited if it still had to purchase more credits to meet its requirements.

To price these option contracts, the financial community and buyers and sellers of emissions credits and options need to know that there will be some stability in government-set "rules of the game" for reducing greenhouse gas emissions. For example, as additional greenhouse gases are added to the trading market, the government would need to maintain consistent definitions of trades and other emissions reduction actions allowable under the law. However, the market—not government or think tanks—should set prices for credits and options contracts. Government cannot and should not be in the business of estimating business compliance costs which vary widely among firms and across sectors.

Additional Measures To Strengthen the Domestic Policy

Congress should take other low-cost actions to strengthen the proposed climate change policy such as :

Provide an "early bird" credit for voluntary action on greenhouse gas emissions reductions and storage projects in advance of the domestic market's operation.

Two bills are pending in Congress to do just this.[31] To maximize future flexibility when a

domestic emissions trading market is activated, Congress should place a cap of 2 percent of the U.S. annual greenhouse gas budget that could be allocated to these voluntary actions.

Expand scientific work and field testing of means to measure "carbon sinks," the consumption of carbon by trees, crops, soil, and oceans.

Among the most innovative approaches to reducing greenhouse gas emissions are actions that enhance the uptake of carbon by soils, forests, croplands, and water bodies—called "sequestration." Unfortunately, several practical problems preclude the use of carbon sinks as part of the backbone of a U.S. trading regime over the next several years.[32] For the time being, greenhouse gas sequestration projects should be treated separately from greenhouse gas emissions reduction efforts. The United States should commit to a five year schedule to develop a scientifically acceptable approach to dealing with carbon sinks.[33]

Set the rules to grant credits from investments in developing countries that yield verifiable, net reductions in greenhouse gas emissions.

U.S. negotiators should continue to push for establishing rules to provide credits for investments in developing countries that result in net reductions in greenhouse gas emissions—called "joint implementation" in the United States and the "clean development mechanism" in the Kyoto protocol. Even if the Kyoto treaty fails, these investment rules would still offer some consistency in crediting international actions that would have value under a different climate change treaty. U.S. companies could provide developing countries with the technologies to control greenhouse gas emissions as their economies grow. An international agreement could further stipulate that developing countries would be required to submit large joint implementation projects for competitive bid.[34]

Stimulate research on innovative energy and other technologies.

Research and development of new energy technologies depends on relative prices of energy and on the private sector's perception of consistent federal and state tax and regulatory policies. By developing a market for greenhouse gas reductions and a framework for rewarding companies that figure out ways to achieve reductions, the government would likely spur more development of new technologies than it would by tinkering with the tax code.[35]

Conclusions

A domestic emissions trading market is a model second generation program. The proposed "cap and trade" program for greenhouse gas emissions harnesses market forces and keeps the government out of the business of choosing technologies to accomplish an environmental goal. Further, a wide variety of market actors could actually profit from making climate-

friendly economic choices under the second generation model for greenhouse gas emissions reductions.

This proposal avoids reliance on international organizations and developing countries' actions. At the same time, it would put the United States within striking range of the Kyoto targets within the next decade or so, and serve as a market-oriented model for action by other countries—a necessity for diminishing the climate change threat over the long term.

The proposed market reduces economic costs and dislocations by spreading the burden of domestic greenhouse gas emissions reductions throughout the economy, including consumers, rapidly growing service industries, and government. While industry has been the primary target of the first generation of environmental regulation, it is only responsible for about one third of total U.S. greenhouse gas emissions. Hence, spreading the responsibility for emissions reductions increases fairness and decreases costs for the high greenhouse gas emissions industries, a major concern voiced by organized labor. [36]

The time has come to drop the rancor and mistrust engendered by the Kyoto treaty, and address the threat of climate change without shortchanging the U.S. economy.

Jonathan Naimon is a co-founder of Light Green Advisors (www.lightgreen.com), a Seattle-based investment advisory firm specializing in constructing portfolios of environmental leadership companies. Debra Knopman is director of PPI's Center for Innovation and the Environment. ***The authors wish to thank Megan Susman, PPI policy analyst, for her editorial and research support; and Christopher Murphy, currently assistant to the Financial Attache of the French Embassy, for his insight and guidance on the importance of the Clean Development Mechanism to global U.S.-based firms. The authors also wish to thank Michael Margolick of Global Change Strategies International (GCSI) in Vancouver, Canada for his contributions.***

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4. U.S. Congress, H.R. 2684, the FY2000 VA, HUD and Independent Agencies Appropriations Act. A key provision of this legislation was language proposed by Rep. Knollenberg that prevents the EPA from issuing rules and regulations to implement the Kyoto Treaty on climate change until it has been ratified by the U.S. Senate. According to a September 10, 1999 press release from Rep. Knollenberg: "Our language in this year's VA/HUD bill is even stronger than last year's.... The Administration's backdoor efforts to foist this fatally flawed treaty upon the American people has not gone unnoticed. If the supporters of this treaty want to begin implementation they must first have debate and approval in the U.S. Senate. Unfortunately, they have been unwilling to offer this treaty to the Senate where I am confident it would be dead on arrival."

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24. At $10 per ton, an auction of carbon emissions credits could generate $15 billion in new tax revenue. Leaping immediately to an auction, however, would impose large and uneven costs on greenhouse gas emitters, who would pass those costs to consumers. Unless consumers could immediately receive a tax rebate from their "share" of the auction's revenues, they would likely protest loudly over sudden jumps in energy costs. A full auction should be pursued, but we propose a long-term transition strategy to get there with minimal economic disruption.

25. Under a credit for voluntary action plan, companies that could certify that they achieved real emissions reductions between 1993, when the Administration's Climate Change Action Plan was initiated, and the year

2000, would have their 2000 baseline adjusted accordingly.

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31. Senate Bill S. 547, introduced on March 4, 1999 by Senators John Chafee, Joe Lieberman, Connie Mack, and others; House Bill H.R. 2520, introduced on July 14, 1999 by Congressmen Rick Lazio, Cal Dooley, and others.

32. While sinks exist for other pollutants, there is little regulatory precedent in the United States or elsewhere for allowing air pollutant emitters to cite uptake of pollutants by terrestrial sources as an offset. Applied internationally, activities such as tree planting hold the promise of dramatically reducing the incremental cost of reducing greenhouse gases far below the costs of reducing greenhouse gas emissions by fossil fuel burning activities.

33. A research plan would include: developing a national baseline inventory of terrestrial and aquatic sinks, by ownership type, for all greenhouse gases using standardized measurement protocols; developing technical protocols for determining the magnitude and longevity of greenhouse gas sequestration; developing technical capacity in the public or private sector to certify projects that effectively reduce atmospheric greenhouse gas emissions by enhancement of terrestrial and aquatic sinks; and negotiating international agreements that address concerns about double-counting and other loopholes to guarantee that real net increases in carbon storage are being achieved.

34. U.S. companies have tended to fair poorly in developing country markets for environmental technologies, in part because of aggressive aid packages provided by European and Japanese governments in support of their own companies.

35. Congress should modernize and make permanent the research and development tax credit across the board, not just for energy technologies. For more details, see Robert D. Atkinson, *Boosting Technological Innovation Through the Research and Experimentation Tax Credit*, Policy Briefing, Progressive Policy Institute, Washington, DC, May 1999. More focused tax credits for specific technologies could be distortionary and counterproductive.

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Outside**INFLUENCES**

The Power Elite

By Brody Mullins

■ The nation's largest energy providers and users will launch a broad coalition today to generate support for a new national energy policy. The high-powered coalition, dubbed the Alliance for Energy and Economic Growth, plans a multimillion dollar campaign to persuade members of Congress to back plans to increase U.S. supplies of coal, oil, natural gas and nuclear fuel.

The coalition, to be unveiled at a news conference, will sponsor television and radio commercials, host media events, lobby White House staff and members of Congress and brief House and Senate staff. "The country needs a new energy policy, and there needs to be one group to push the ball forward," said Darrell Henry, director of public affairs for the American Gas Association, who helped organize the group.

The alliance will provide a "united voice in support of a national energy policy, a structure to guide and coordinate an advocacy effort and a vehicle to enlist the support of the American public," said Bruce Josten, the U.S. Chamber of Commerce's executive vice president of government affairs, in a letter sent to 875 trade associations earlier this month.

In recent interviews, lobbyists who helped shape the group said they have patterned the alliance on a string of coalitions designed to support other industry priorities, such as the Tax Relief Coalition and another coalition that backed the congressional repeal of ergonomics regulations. "Before you can pass any major piece of legislation, you need to persuade people that there is real need to act," said one coalition organizer.

The energy coalition will be unveiled today with more than 100 members, but its organizers believe it will soon double or triple in size — making it one of the largest energy coalitions ever assembled. The full coalition hopes to be in place when the White House unveils its national energy policy in two weeks.

The alliance will be led by a full-time executive director — who has yet to be selected from a handful of remaining candidates — and a management committee stacked with K Street heavyweights, including Josten, National Association of Manufacturers Senior Vice President Michael Baroody, American Iron and Steel Institute CEO Andrew Sharkey and American Forest and Paper Association CEO Henson Moore.

The heads of Washington's largest energy trade groups — including David Parker, CEO of the American Gas Association; Red Cavaney, CEO of the American Petroleum Institute; Thomas Kuhn, CEO of the Edison Electric Institute; Barry Russell, president of the Independent Petroleum Association of America; Jerald Halvorsen, president of Interstate National Gas Association; Jack Gerard, CEO of the National Mining Association; and Joe Colvin, CEO of the Nuclear Energy Institute — also hold considerable power in the coalition. Most of the big energy groups were required to pump $100,000 or more into the coalition as an entry fee.

The coalition also will include hundreds of other corporate members, representing virtually every industry involved in the energy sector — from the developers of advanced computer systems that pinpoint energy reserves far below the earth's surface to the companies that pipe, ship and haul fuel to refineries and generators to the commercial and residential consumers who use the final product to power assembly lines, forklifts and cell phones. Some of these members will be required to pay at least $5,000 to sit on a steering committee. But the bulk of the coalition's members will not be required to support the group financially.

■ Nevertheless, some of the energy industry's smaller players have refused to join the Alliance for Energy and Economic Growth because they believe they will be dwarfed. "If I were to participate, I am lucky if I am a small fin on the small fish," said one association head who declined to join. Other lobbyists complain that the coalition will be dominated by energy-producing companies and will ignore consumers.

The coalition also has come under fire for reversing course and deciding to hire an executive director. Some lobbyists complain that it does not make sense to hire a full-time executive. "A lot of companies are saying, 'Why are we hiring a Washington office and paying association dues just to start a new coalition and hire a chief executive?'" asked Don Duncan, vice president of government relations for Phillips Petroleum Co., which will not become a paying member. "In my opinion, it's a waste of the trade association's members' money," he added.

Even so, Duncan may join the Alliance because he believes it will play an important role in putting energy policy on the nation's agenda. Said Duncan, "The coalition has a tremendous value in getting the issue up front and center."

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Mass. Announces Emissions Rules

Updated 5:46 AM ET April 24, 2001

By JOHN McELHENNY, Associated Press Writer

BOSTON (AP) - Massachusetts will become the first state to limit carbon dioxide emissions from power plants under clean-air rules set to go into effect in June.

The new standards unveiled Monday by acting Gov. Jane Swift also will limit mercury emissions and require deep cuts in emissions of sulfur dioxide, which causes acid rain, and smog-causing nitrogen oxide.

The regulations will apply to the state's six dirtiest power plants, which produce 40 percent of the electricity used in Massachusetts.

"This sets the bar for any other state that is doing power plant clean ups," said Conrad Schneider, a spokesman for Clean Air Task Force, a national environmental advocacy group that monitors power plant emissions. "And it sets the bar for the national debate for what the level of reduction should be in federal legislation."

Proposals to limit carbon dioxide emissions surged onto the national scene last month when Swift's fellow Republican, President Bush, reversed a campaign pledge to push for carbon dioxide power plant limits.

"He and I, in this case, came to a different conclusion," Swift said as she announced the new Massachusetts regulations.

AP U.S. News

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* Story has photo

Story has photo

Power plants would be required to cut average carbon dioxide emissions by 10 percent under the new regulations. Many scientists believe such emissions are causing the Earth to warm significantly.

Efforts to cut carbon dioxide emissions have often presented a political challenge for state officials because the reductions have little direct impact locally.

"I know that climate change is a global problem - but that does not mean we should sit around and wait for global solutions," said state Environmental Affairs Secretary Bob Durand.

A spokesman for the Competitive Power Coalition of New England, an industry group, said the strict rules would lead to higher electric rates and increase the risk of outages. Swift dismissed that prediction, noting that several new power plants were planned for the region.

On the Net:

EPA global warming site: http://www.epa.gov/globalwarming

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CLIMATE CHANGE: Entergy to hold C02 emissions at 2000 level
J.L. Laws, Greenwire staff writer, May 4, 2001

Entergy Corp., a power producer which serves some 2.6 million homes and businesses in the Southeast, on Thursday became the first U.S. utility to pledge it will cut emissions of the greenhouse gas carbon dioxide (CO2).

Working with the green group Environmental Defense, New Orleans-based Entergy plans to cut CO2 emissions to its year 2000 level of 50 million tons, even though it plans to increase power generation by 25 percent over the next five years. The company plans to spend $25 million making improvements to its domestic fossil fuel plants, which generate 17,500 megawatts of electricity for its customers in Arkansas, Louisiana, Mississippi and east Texas, said Arthur Wiese, Entergy's vice president for corporate communications. The company does not yet know how much the effort will cost, Wiese said.

One of the main reasons Entergy decided to cut CO2 emissions is the threat its home state faces from a rise in sea levels due to rising global temperatures, Wiese said.

In March, President Bush broke a campaign pledge to regulate utilities' CO2 emissions, saying CO2 is not a pollutant under the Clean Air Act and that such regulations would adversely affect both U.S. energy supplies and the economy. Later that month, Bush rejected the Kyoto Protocol, a 1997 agreement requiring industrialized countries to cut greenhouse gas (GHG) emissions an average 5 percent below 1990 levels no later than 2012, saying it was unfair because it excused developing countries from mandatory GHG cuts.

"We are not taking a pot shot at the Bush administration. We are simply doing what we think is responsible to do, and what we hope other companies will decide to do as well," Wiese said. "We do not need to wait for all of the countries in the world to come up with a plan for us to go ahead and get this done."

A press release from Environmental Defense on the Entergy pledge made no reference to Bush's record. Another environmental group, however, took advantage of a Ford Motor Co. announcement to toss a dart in Bush's direction Thursday.

Ford's corporate citizenship report, released Thursday, announced the creation of an executive team to find ways to fight global warming, prompting Sierra Club lobbyist Dan Becker to say Bush should "give Bill Ford and Jac Nasser a call about the effects of global warming." Ford previously announced it would increase the fuel efficiency of its sport utility vehicles 25 percent by 2005. Ford's report said the team will focus on the automaker's five-year production cycle, "complex economic and social forces" that impact land, vehicle use and fuel prices while trying to maintain value for its shareholders.

Wiese said Entergy's nuclear assets, used to produce electricity sold on the open market, will not be counted toward its CO2 reduction target. The company will work with Environmental Defense to design programs to reach its target, he said.

"Entergy's first priority is to reduce greenhouse gas pollution within our own operations. We expect to achieve at least 80 percent of the reduction in this way," Entergy CEO J. Wayne Leonard said in a written statement. "Entergy also believes that extending our reach outside our walls for ways to reduce greenhouse gas emissions will stimulate innovation and create incentives for finding new ways to aggressively cut pollution in the most practical, cost-effective manner possible."

Environmental Defense Executive Director Fred Krupp said: "As we have learned from past experience, it is possible to cut emissions and still provide products to customers and profits to shareholders. Entergy's leadership in this arena should encourage other electric utilities to take similar steps to reduce pollution."

NEW YORK TIMES
April 1, 2001

A Climate Policy That Works

William K. Reilly

President Bush and Christie Whitman, the administrator of the Environmental Protection Agency, have now definitively abandoned any intention to regulate carbon dioxide from utilities and confirmed that they oppose the Kyoto Protocol, the international treaty to fight global warming.

Many the world over are speculating on the significance of these moves, some countries concluding they can relax their own efforts to reduce greenhouse gas emissions, others despairing that the United States may not lead on the environmental issue of the era.

Is there another way to address the problem of climate change while accommodating the Bush administration's concerns about the science and the costs of a climate policy? Is there a conservative response to global warming?

I believe that a distinctive Bush policy on climate could involve three parts. First, the administration should ask the National Academies of Science and of Engineering to review the scientific evidence on climate change and the availability of energy-efficient technologies -- both issues on which the president has expressed concern. The Intergovernmental Panel on Climate Change has recently concluded that anthropogenic emissions have "contributed substantially" to warming. The National Academies could be asked to review the panel's findings, along with the state of technologies. In this way, President Bush could fulfill his campaign promise to follow the science on climate.

Second, the administration should ask the private sector what it can achieve by way of energy efficiency. What is practical and cost-effective, and how quickly can it be done? It is little known, though quite astonishing, that 11 major companies, eight of them American, have committed to reducing greenhouse gas emissions by a total that exceeds the reductions required of Britain under Kyoto. United Technologies, I.B.M., Baxter, Polaroid and others have committed to improve energy efficiency, or to cut carbon dioxide, by at least 25 percent.

emissions. Fifty percent of the tax would be imposed on energy production (including nuclear power) except renewables; 50% of the tax would be based on carbon emissions. Some European countries have modified their energy taxation to fit the model discussed by the EC.

And those who say these are only commitments should look at DuPont, the nation's largest chemical company, which has already reduced its greenhouse gas emissions by 50 percent and promises to cut them by 65 percent by 2010. It has also pledged that 10 percent of its energy needs will be met by renewable sources by that time.

After consulting carefully with companies, the administration should identify realistic goals for the major sectors of the economy. Auto executives, for example, have indicated that their industry cannot make the substantial changes called for by Kyoto in the next seven years but could achieve major improvements in 10 to 15 years. The president needs to get the automobile companies and other important industries to spell out what they can achieve and then commit to these goals.

Finally, we must realize that very few countries are cutting emissions; most will not come close to equaling the reductions required of the United States by the Kyoto Protocol. Many nations would support the administration if it instead made a convincing commitment to abide by the 1992 international convention to combat global warming -- which President Bush's father signed -- while also agreeing to exceed the goals of Kyoto over a longer period of time. Such commitments would permit a more orderly replacement of capital equipment and put to rest concerns that energy taxes are required or that electricity supplies would be disrupted.

President Bush and many in the Senate have decried the Kyoto Protocol's failure to require cuts in greenhouse gases from developing countries. But the United States must have a cogent, credible policy before it can speak with authority to developing countries.

China, second only to America in its emission of greenhouse gases, has actually reduced its carbon emissions over the past five years. The Chinese, in an effort to curb suffocating air pollution, have reduced coal subsidies, switched to cleaner transportation fuels and converted power plants to natural gas from coal. Helping the Chinese to make further progress could be another distinctive element of the Bush climate policy.

In sum, there is another way: Review the state of science and technology, involve the private sector, set realistic goals and seriously engage developing countries. This is the path toward energy efficiency and progress on the environment.

The Impact of Municipal Solid Waste Management on Greenhouse Gas Emissions in the United States

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ABSTRACT

Technological advancements in United States (U.S.) municipal solid waste (MSW) disposal and a focus on the environmental advantages of integrated MSW management have greatly reduced the environmental impacts of MSW management, including greenhouse gas (GHG) emissions. This study was conducted to track changes in GHG emissions over time from the management of MSW. A baseline 1974 MSW management strategy, consisting of limited recycling and landfills without gas collection, was compared to today's integrated MSW management strategies that include recycling, composting, waste-to-energy combustion, and landfills with gas collection and energy recovery. Included in the analysis are the benefits of materials recycling and energy recovery to the extent that these displace virgin raw materials and fossil fuel electricity production, respectively. The impact of MSW management decisions on carbon sinks is also addressed.

The results show that the actions taken in U.S. communities have significantly reduced potential GHG emissions. GHG emissions from MSW management in 1974 were estimated to be 36 million metric tons carbon equivalents (MMTCE). Yet, even with doubled waste generation today, using modern MSW management techniques has lowered estimated GHG emissions to 10 MMTCE. Without today's MSW management practices, annual GHG emissions would be nearly 51 MMTCE. Thus, more than 41 MMTCE per year are being avoided as compared to potential GHG emissions if 1974 practices were still being used.

INTRODUCTION

One of the most difficult challenges faced by U.S. cities is the management of MSW. Local officials have made difficult decisions for more than a century regarding the proper management, environmental impacts, and costs to collect, recycle, transport, and dispose of MSW. The results of those decisions directly impact residents. Selection of collection, transportation, recycling, treatment, and disposal systems can determine the number of recycling

and carbon taxes. Proposed CO2 ... tradable permit program (similar to the acid rain

bins under a sink or in the backyard, the day people must place their garbage at the curb; the truck routes through residential streets, and the time that people might awake to the sound of garbage trucks rumbling through alleys and streets. Thus, MSW management can be a significant local issue for municipalities.

However, MSW management also is an issue of global significance. The MSW management decisions made by mayors, county executives, and city and county councils and boards can impact the release of GHG emissions that are attributed to global climate change. GHG emissions can trap heat in the atmosphere and lead to warming the planet and changing our weather. According to the U.S. Environmental Protection Agency's (EPA's) latest inventory of GHG emissions,[1] the waste management sector represents about 4% of total U.S. anthropogenic GHG emissions. However, the waste management sector offers broad opportunities for GHG reductions due to linkages to other sectors (e.g., energy, industrial processes, forestry, and land use change). The potential for global climate change due to the release of GHGs is being debated both nationally and internationally and has led to investigating ways to reduce GHG emissions from MSW management.

This study is one such investigation that was conducted for the U.S. Conference of Mayors through funding by the Integrated Waste Services Association. The study examined the effect of local MSW management decisions on GHG emissions during the past 25 years. The scope of the study included all activities that play a role in MSW management from the point at which the waste is collected to its ultimate disposition. The MSW management options included in this study were collection, recycling, composting, waste-to-energy combustion, and landfills (with and without gas collection and energy recovery). The environmental aspects of fuel and electricity consumption were included, as well as the displacement of virgin raw materials through recycling and the displacement of fossil-fuel-based electrical energy through energy recovery from MSW. The GHG emissions studied in this analysis were carbon dioxide (CO_2) and methane (CH_4). Other GHG emissions such as perfluorocarbons (PFCs) and nitrous oxide (N_2O) were not included. The impact of MSW management decisions on carbon sinks was also addressed using EPA's Office of Solid Waste WARM model[2] and is discussed in the sections on carbon sequestration and storage.

The technical analysis for this study was conducted by Research Triangle Institute (RTI) under the direction of EPA's Office of Research and Development using data and a decision support tool developed through a cooperative agreement between EPA's Office of Research and Development and RTI. Representatives from the U.S. EPA, RTI, Integrated Waste Services Association, U.S. Conference of Mayors, Solid Waste Association of North America, Environmental Industry Associations, Waste Management Inc., and ICF Consulting worked cooperatively to review this analysis.

METHODOLOGY

To calculate the GHG emissions from MSW management, a general MSW management strategy used by cities in 1974 was examined as a baseline and compared to today's general strategy. Data from the years 1974 and 1997 were used in this analysis to estimate GHG emissions 25 years ago and today. 1997 is the most recent year for which comprehensive information is available about MSW. However, when more recent data were available for specific assumptions (e.g., 1999 recycling rate), the analysis incorporated such information accordingly. As illustrated in Figure 1, most MSW in 1974 was disposed of in landfills without modern technology (e.g., liners, leachate collection systems, and landfill gas control systems) and with limited recycling. The majority of the world's population still dispose of MSW in this manner. More advanced methods, such as waste-to-energy combustion and landfills with gas collection and energy recovery systems, were not widely used in 1974 and still remain widely unavailable around the world due to their cost and other factors.

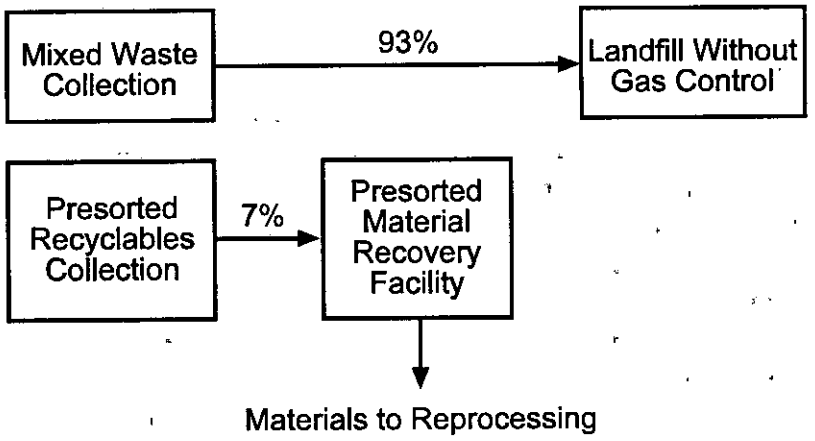


Figure 1. 1974 Waste Management Scenario.

Today's general MSW management strategy is illustrated in Figure 2 and includes an integrated mix of recycling, composting, waste-to-energy combustion, and landfills. Each technology plays an important part in reducing GHG emissions that would otherwise be released into the atmosphere. Figure 3 shows the mix of waste management technologies used in 1974 compared to today. The methodology used for this study is intended to illustrate GHG reductions from integrated solid waste management strategies. Due to changes in waste volume, composition, and rate of emissions per ton of waste, this study was not designed to compare GHG reduction potential between specific MSW management technologies (e.g., recycling versus combustion).

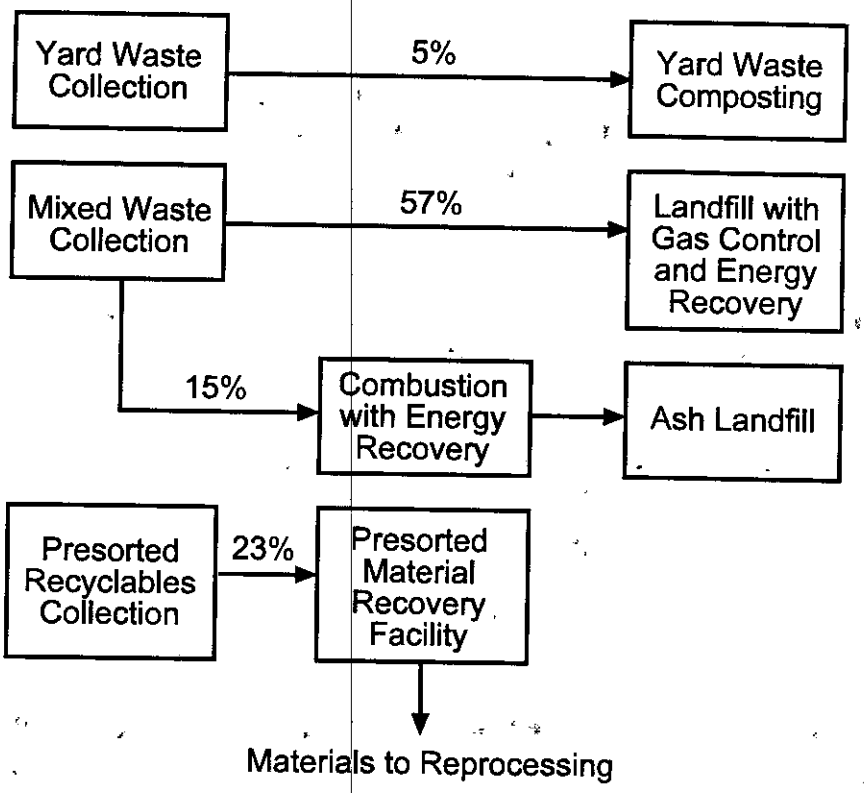


Figure 2. Today's Waste Management Scenario.

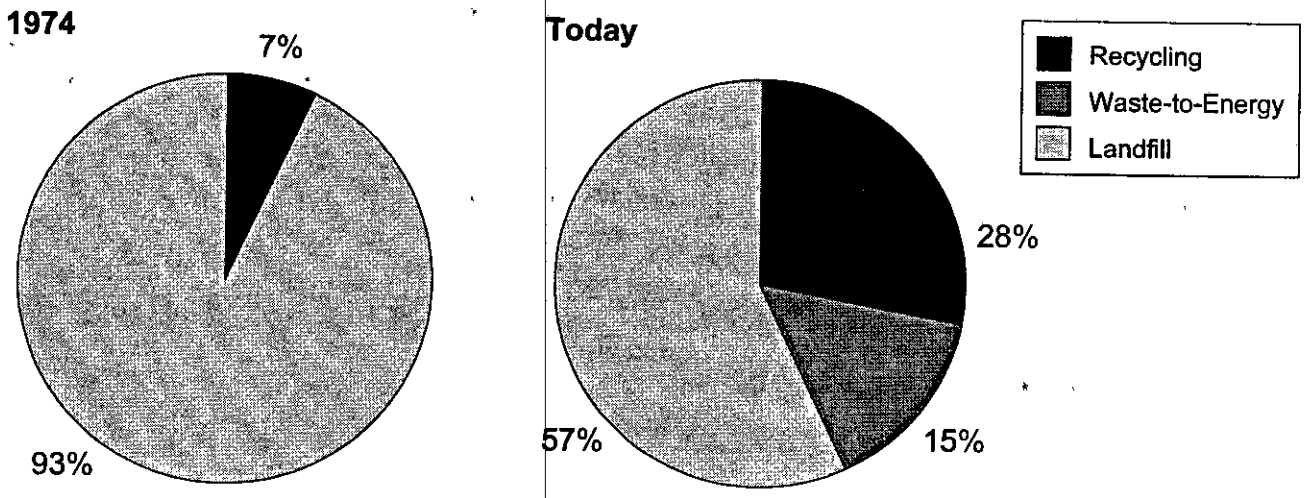


Figure 3. Past and Present Technologies Used to Manage U.S. Waste Generated
(Note: Today's Recycling Level Today Includes Recycling [23%] and Composting [5%]).

The methodology used in this study is based on a holistic approach using life-cycle assessment and full cost accounting. The recently completed decision support tool for North America was used to calculate the GHG emissions resulting from MSW management practices. (The decision support tool and life-cycle inventory database for North America were developed through a cooperative effort between EPA's Office of Research and Development, RTI, and its partners—North Carolina State University, University of Wisconsin-Madison, Franklin Associates, Roy F. Weston, and Five Winds International.) The decision support tool analyzes GHG emissions from waste collection, transport, recycling, composting, combustion, and land disposal. The tool considers the direct GHG emissions from each waste management practice as well as the GHG emissions associated with the production of fuels and electricity consumed by the practice.

Table 1 provides a complete list of GHG emission sources associated with the waste management technologies considered in the study. Data were not available for PFCs and N_2O across all waste management practices. As additional data become available, they can be included in future analyses. Although only GHGs were addressed in this study, the decision support tool provides data for cost, energy consumption, and a variety of additional air emissions and water pollutants.

Approximately 1.5% of the 1974 total waste stream and 5% of the 1997 waste stream included waste constituents that are not addressed by the decision support tool. These constituents include items such as durable goods, other paper and plastic packaging, wood waste, rubber tires, textiles, and lead-acid batteries. To complete the analysis for this study, data for these constituents were obtained from the EPA Office of Solid Waste WARM model.

The energy consumed and environmental releases associated with production of new products as well as those saved by using recycled instead of virgin resources were considered. In addition to considering recycled materials, emission savings were also calculated for MSW management strategies (namely waste-to-energy combustion and landfill) where energy was recovered. In calculating the emission savings associated with energy recovery, the "saved" energy was assumed to result from offsetting the national electric grid. For every kilowatt-hour of electricity produced from MSW, the analysis assumed that a kilowatt-hour of electricity produced from fossil fuels was not generated and therefore these emissions were avoided. In cases where an MSW management practice requires energy, the analysis took into consideration the energy associated with the use and production of that energy as well as the emissions associated with the production of that energy (for example, the production of a gallon of diesel fuel).

Table 1. Sources and Savings of GHG Emissions from MSW Management-Related Technologies Included in the Analysis.

Waste Management Activity or Process	GHG Emissions (CH_4 and CO_2 fossil) Sources
Collection (recyclables and mixed waste)	Combustion of diesel in collection vehicles Production of diesel and electricity (used in garage)
Material Recovery Facilities	Combustion of diesel used for rolling stock (front-end loaders, etc.) Production of diesel and electricity (used in building and for equipment)
Yard Waste Composting Facility	Combustion of diesel used for rolling stock Production of diesel and electricity (used for equipment)
Combustion (waste-to-energy)	Combustion of waste Offsets from electricity produced
Landfill	Decomposition of waste Combustion of diesel used for rolling stock Production of diesel Offsets from electricity produced
Transportation	Combustion of diesel used for vehicles Production of diesel
Reprocessing of Recyclables	Offsets (net gains or decreases) from reprocessing recyclables recovered; offsets include energy- and process-related data

To complete this study, information about MSW generation and composition was needed for 1974 and today. We used three primary data sources to calculate MSW generation and composition:

- U.S. EPA's Municipal Solid Waste Characterization Report for 1998 (providing information about 1997 waste trends, composition, and generation)[3]
- Unpublished waste characterization data for 1974 from Franklin Associates[4]
- U.S. Bureau of the Census historical housing data.[5]

The EPA and Franklin Associates waste characterization studies provide data available for U.S. MSW management practices. The amount of MSW generated in the U.S. increased from 115 million metric tons in 1974 to 197 million metric tons today.[3,4] Waste composition data are shown in Table 2, and waste generation and management data are shown in Table 3.

Table 2. Waste Composition.[3,4]

	Composition (%)[a]			
	1974		Today	
Waste Category	Residential	Commercial	Residential	Commercial
Yard Trimmings, Leaves[b]	13.0		5.0	
Yard Trimmings, Grass[b]	13.0		10.0	
Yard Trimmings, Branches[b]	11.2		15.0	
Newsprint	12.3	2.2	7.5	1.8
Corrugated Cardboard	2.2	20.6	2.4	29.3
Office Paper	1.1	3.3	1.4	5.7
Phone Books			0.2	0.2
Books	3.0		0.7	
Magazines			2.9	
3rd Class Mail			2.5	1.8
HDPE - Translucent[c]			0.5	
HDPE - Pigmented[c]	2.2		1.2	
PET[d]			0.5	0.2
Steel Cans	1.8	5.7	2.0	0.7
Ferrous Metal - Other	0.3			
Aluminum - Food Cans	0.5	0.2	1.0	0.4
Aluminum - Other Cans			0.3	
Aluminum - Foil and Closures	0.6			
Glass - Clear[e]	9.4	2.1	3.8	1.1
Glass - Brown[e]	6.0	1.4	2.4	0.7
Glass - Green[e]	1.7	0.4	0.7	0.2
Paper - Nonrecyclable	10.4		19.7	
Food Waste	11.0		8.8	
Other Organic Materials		29.5		40.2
Plastic - Nonrecyclable			4.3	
Metals - Nonrecyclable	0.3			
Miscellaneous		34.5	17.2	17.7

[a] Numbers may not add up to 100% due to rounding.
[b] Yard waste split between leaves, grass, and branches was assumed to be 35, 35, and 30%, respectively.
[c] HDPE = high-density polyethylene.
[d] PET = polyethylene terephthalate.
[e] Glass composition split between clear, brown, and green was assumed to be 55, 35, and 10%, respectively.

Table 3. Waste Generation and Management (Metric Tons)[3,4]

Waste Flow	1974	Today
Collection of Yard Waste		10,400,000
Collection of Recyclables	6,700,000	35,200,000
Collection of Mixed Waste	108,000,000	151,000,000
Recovery of Recyclables in MRF[a] (material sent to reprocessing)	8,380,000	43,300,000
Composting of Yard Waste		10,400,000
Combustion of Waste with Energy Recovery		29,600,000
Landfilling of Mixed Waste	108,000,000	122,000,000
Landfilling of Ash from Combustion		7,280,000

[a] MRF = mixed recovery facility.

U.S. Census data[5] were used to estimate the number of residential, multifamily, and commercial waste generators. The composition and quantities of materials recycled and composted were set at the levels of recycling reported by the U.S. EPA and Franklin Associates national data sets. The composition of materials that are recycled and composted is presented in Table 4. In evaluating recycling and composting, we assumed a current recycling rate of 23% and a composting rate of 5%.

For this study, the typical waste management technologies used in 1974 and today were modeled. Figure 3 compares the difference in management practices between 1974 and today. In 1974, waste management primarily involved the collection of mixed MSW. About 7% of waste was recycled as commingled material. The remaining 93% of the waste was disposed of in landfills without gas control.

Today's MSW management strategies have changed significantly since 1974. Data[3] showed that about 5% of all waste is collected as yard waste and composted, and about 23% of the waste is collected for recycling. Recycled and composted materials were managed at material recovery and composting facilities, respectively, according to the characterization reports.

About 15% of the U.S. MSW was used to generate electricity at 102 waste-to-energy facilities nationwide. Emissions from waste-to-energy facilities were based on actual emissions test results provided to the U.S. EPA and individual state environmental agencies.[6]

Table 4. Recovery Rates of Materials.[3,4]

	Recovery of Materials (%)[a]			
	1974		Today	
Waste Category	Residential	Commercial	Residential	Commercial
Yard Trimmings, Leaves			46.0	
Yard Trimmings, Grass			46.0	
Yard Trimmings, Branches			46.0	
Newsprint	29.3	4.9	64.3	10.7
Corrugated Cardboard	3.1	29.6	7.6	73.9
Office Paper	0.9	31.2	2.0	67.3
Phone Books				18.6
Books	13.1		78.1	
Magazines			47.8	
3rd Class Mail				28.0
HDPE - Translucent[b]			31.3	
HDPE - Pigmented[b]			9.7	
PET[c]			49.5	22.0
Steel Cans	4.2	2.8	64.0	50.4
Ferrous Metal - Other	0.5		13.3	
Aluminum Cans	27.2	16.2	58.3	49.6
Aluminum - Foil and Closures			7.4	
Glass - Clear	2.8	3.2	24.5	27.5
Glass - Brown	2.8	3.2	23.1	25.9
Glass - Green	2.8	3.2	53.8	60.5

[a] Recovery of materials is defined as the percentage of a material generated that is recycled. Where appropriate, materials that were recycled based on U.S. EPA data were combined into a similar waste category for which reprocessing data were available. For example, 3rd Class Mail and Phone Books recycled in 1997 were combined into the Books category. This assumption makes some recovery numbers appear high.

[b] HDPE = high-density polyethylene.

[c] PET = polyethylene terephthalate.

For this study, we assumed that 50% of MSW is landfilled at sites equipped with landfill gas collection, and at those facilities, half of the gas was flared and half was used for energy recovery. A landfill gas collection efficiency of 75% was used in this analysis and a CH_4 oxidation rate of 20% was used. These assumptions were verified through communication with industry groups.

Role of Carbon Sequestration and Storage

When CO_2 is removed from the atmosphere by photosynthesis or other processes and stored in sinks (like forests or soil), it is sequestered. One of the more controversial issues with accounting for GHG emissions from MSW management is associated with whether carbon sinks should be considered. There is no current consensus on methodology or data for carbon storage in forests, soils, and landfills. During the series of peer reviews conducted on the methodology developed for the decision support tool, the recommendation from the peer reviewers was that carbon sequestration should not be considered unless a full product life cycle was being analyzed. Therefore, the current version of the decision support tool does not account for carbon sinks resulting from forests, soils, and landfills.

EPA's Office of Solid Waste used a different methodology in a report that was released in 1998[7] to support its voluntary partnership program on climate change and MSW management. This methodology tracks carbon storage related to waste processes and tracks carbon associated with fossil fuel and nonenergy GHGs such as PFCs and N_2O. The principal carbon storage mechanisms addressed are changes in forest carbon stocks related to paper and wood recycling, long-term storage of carbon in landfills, and accumulation of carbon in soils resulting from compost application. Carbon storage from combustion ash residue was also studied and was estimated to be negligible. Although carbon storage in forests, soils, and landfills clearly has a strong influence on net GHG emissions, the exact accounting methods that should be used to quantify them are still a matter of spirited debate since many scientific and policy questions remain to be resolved. However, the U.S. EPA currently includes estimates of carbon storage from landfills and forests in its national GHG inventory.[1]

To help illustrate the difference in estimates of GHG emissions when carbon storage is taken into account, EPA's Office of Solid Waste and ICF Consulting provided data and used the EPA WARM model to perform comparisons. Table 5 shows the potential carbon storage for the three scenarios that were evaluated for this study. The negative values in the table indicate that the storage is, in effect, a negative emission. In both scenarios where waste is managed according to 1974 technology, substantial carbon storage is associated with landfills. In the scenario with today's technology, the balance shifts—the large volume of paper recycling results in substantial benefits in the form of forest carbon storage, and there are some soil carbon benefits from composting as well.

Table 5. Carbon Storage Potentials for 1974 and Today's Waste Management Strategies (Mmtce/year).

Scenario	Recycling (includes compost)	Landfill	Total
1974	-6.1	-16	-22
Today	-29	-19	-48
Today with 1974 Technology	-9.4	-31	-40

RESULTS

Table 6 compares net GHG emissions from today's MSW management strategies with net GHG emissions in 1974, providing an overall view of GHG emissions savings. Figure 4 illustrates the trend in GHG emissions from the 1974 MSW management strategy pathway versus the actual integrated MSW management pathway employed. The following sections discuss the net contributions of GHGs from recycling and composting, waste-to-energy combustion, landfills, and collection and transportation practices. In addition, the effects of carbon storage on the net total GHG emissions are discussed.

Table 6. GHG Emissions From U.S. Waste Management (MMTCE/year).

	GHG Equivalents			
Waste Management Technology	1974 (A)	Today (B)	Today with 1974 Technology (C)	Avoided GHG Emissions (C-B)
Collection/Transportation	0.5	1	1	0
Recycling	-1	-7	-3	4
Waste-to-Energy Combustion		-5		5[a]
Landfilling	36	21	53	32
Total	35	10	51	41

[a]If avoided landfill GHG emissions are also included in the analysis, then the total avoided GHG emissions from waste-to-energy combustion would be approximately 11 MMTCE.

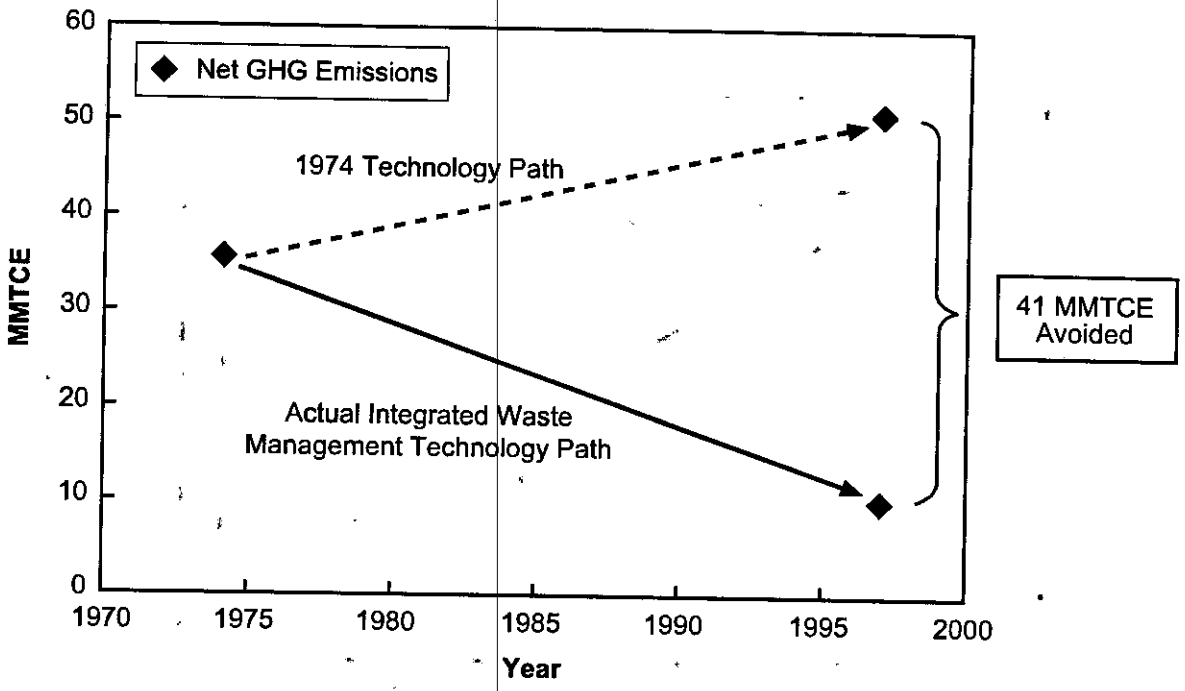


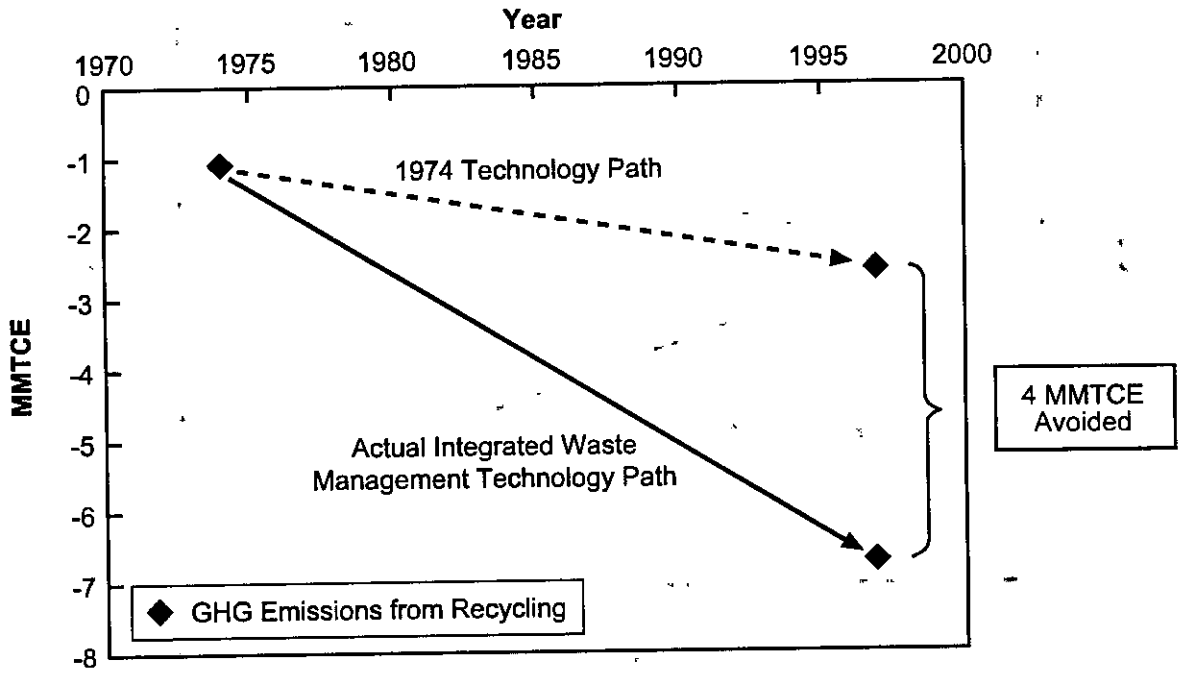
Figure 4. Comparison of Net GHG Emissions for MSW Management.

Recycling and Composting

Recycling contributes to the reduction of GHG emissions by displacing virgin raw materials and thereby avoiding environmental releases associated with raw materials extraction and materials production. In addition, recycling and composting avoids GHG releases (i.e., methane) by diverting the disposal of organic materials in landfill. As shown in Figure 5, increasing recycling and composting from about 8 million metric tons, or 7% in 1974, to more than 53 million metric tons, or 28% today, avoided the release of more than 4 MMTCE annually. Recycling data presented in this document include GHG emissions from materials separation and reprocessing as well as composting activities.

Waste-to-Energy Combustion

Waste-to-energy facilities reduce GHG in two ways. First, combustion of MSW with electrical energy production displaces electricity generated by fossil-fuel-fired power generators. Second, MSW that otherwise would produce methane as it decomposes in a landfill is instead diverted from the landfill and combusted to produce electricity. The GHG emissions resulting from the combustion process are far less than those that otherwise would be produced by fossil fuel power generation and landfilling.



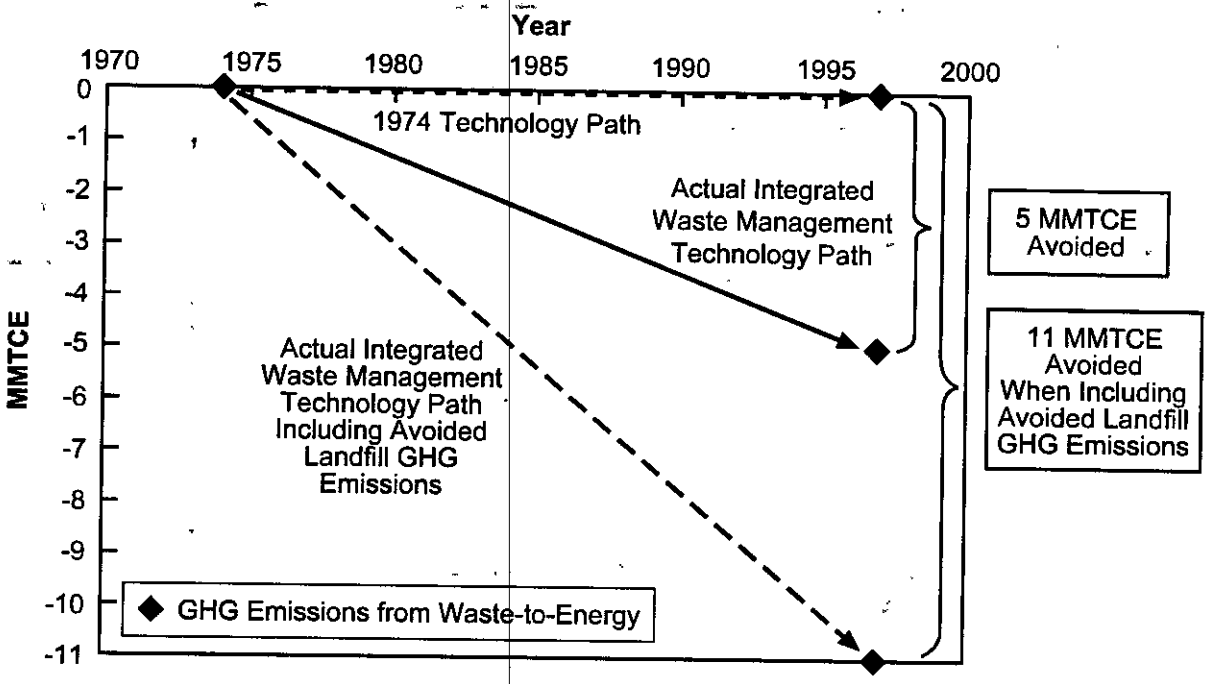
Note: Negative emissions indicate "savings" in emissions due to energy recovery.

Figure 5. Comparison of Net GHG Emissions Avoided from Recycling and Composting.

About 29 million metric tons of MSW, representing about 15% of U.S. MSW is managed today by waste-to-energy combustion, resulting in a net decrease of GHG emissions of about 5 MMTCE as shown in Figure 6. Note that Figure 6 includes only the net decrease of emissions attributable to displacement of electricity and does not include the GHG emissions avoided from land disposal. If the avoided landfill GHG emissions are also included in the analysis, an additional 6 MMTCE is saved by virtue of combusting versus landfilling the 29 million metric tons in a landfill without gas collection. This raises the total amount of GHG emissions savings through waste-to-energy combustion from 5 to 11 MMTCE.

Landfills

The U.S. currently landfills about 129 million metric tons of MSW and combustion ash, representing 57% of its MSW generated. In 1974, 108 million metric tons of MSW were landfilled. Landfills with gas collection systems reduce the release of GHG emissions associated with the decomposition of waste. For instance, if the CH_4 gas is collected and utilized to create energy, the energy produced displaces energy that otherwise would have been generated by fossil fuel sources. Due to the growth of landfill gas collection projects from zero in 1974 to nearly 300 landfill gas-to-energy projects today,[8] Clean Air Act requirements, and improvements in landfill design and management, there has been a substantial reduction of GHG emissions



Note: Negative emissions indicate "savings" in emissions due to energy recovery.

Figure 6. Comparison of Net GHG Emissions Avoided from Waste-to-Energy Combustion.

associated with MSW landfills. For this analysis, we assumed that 1974 landfills had no gas collection or energy recovery. In analyzing landfills today, we assumed that 50% of the MSW being landfilled is managed at sites with gas collection. Of the gas collected, 50% was assumed to be flared and 50% was assumed to be used for energy recovery, using recent statistics of the distribution of energy recovery projects (internal combustion engines, direct gas use, gas turbines, etc.).[8] The GHG emissions associated with fossil-fuel-based electrical energy that was displaced by the use of landfill gas was included in the calculations.

The results, as illustrated in Figure 7, indicated that modern landfills today avoid the release of 32 MMTCE of GHG emissions. This level of avoided GHG emissions is achieved through the use of gas collection and control systems as well as the diversion of MSW from landfills by using of recycling, composting, and waste-to-energy combustion technologies. Note that the GHG emissions from landfills are the total quantity of gas released over 100 years for the quantity of MSW landfilled in a year. For all other waste management processes, the GHG emissions are released instantaneously; but for landfills, waste decomposes over several decades, and the GHG numbers in this analysis are the total emissions over 100 years of decomposition from the waste landfilled in 1974 and today.

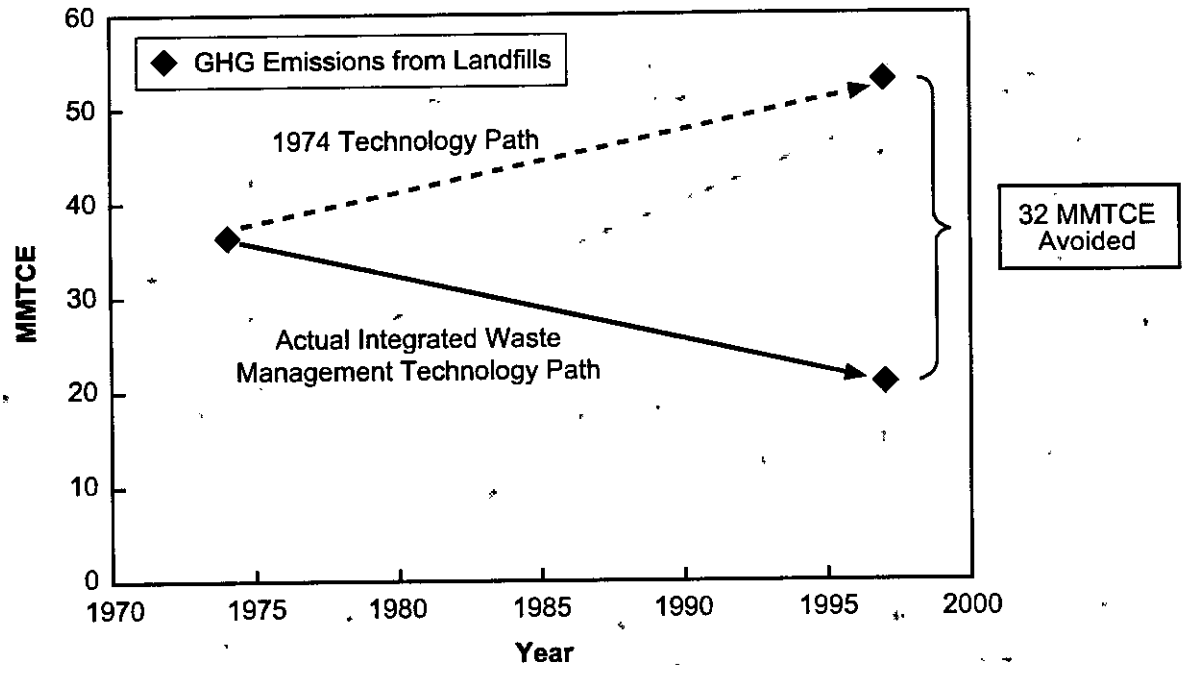


Figure 7. Comparison of Net GHGEmission Reductions from Landfills.

Collection and Transportation

Collection and transportation of MSW and recyclables accounted for about 0.5 and 0.9 MMTCE in 1974 and today, respectively. More GHG emissions are emitted today from collection and transportation due to the doubling of the amount of MSW generated and collected since 1974. In addition to increases in GHG emissions from collection and transportation, increases in other local pollutants (such as sulfur oxides, nitrogen oxides, carbon monoxide, ozone, and particulates) should also be considered, particularly in regions that are classified as nonattainment areas with respect to the National Ambient Air Quality Standards.

Carbon Sequestration and Storage

The magnitude of carbon storage relative to the magnitude of emissions is shown in Table 7. Considering carbon storage in the calculations dramatically offsets all of the energy and landfill emissions. If carbon sequestration is considered in this analysis, then net GHG emissions avoided are still about a factor of 5. Overall, the basic findings remain the same: improvements in management have dramatically reduced net GHG emissions from the waste sector.

Table 7. Net GHG Emissions Including the Effects of Carbon Sequestration for 1974 and Today (Mmtce/year).

Scenario	Estimated Amount of Carbon Sequestered	Estimated GHG Emissions	Total Net GHG Emissions
1974	-22	35	13
Today	-48	10	-38
Today with 1974 Technology	-40	51	11

CONCLUSIONS

America's cities are avoiding the annual release of 41 MMTCE of GHG emissions each year through the use of modern MSW management practices. The total quantity of GHG emissions from MSW management was reduced by a factor of 5 (51 to 10 MMTCE) from what it otherwise would have been, despite a doubling in the rate of MSW generation. This reduction is a result of several key factors:

- Increasing recycling and composting efforts from 7 to 28% resulted in savings of 4 MMTCE from avoiding use of virgin materials.
- Producing electricity in waste-to-energy facilities avoids 5 MMTCE that would otherwise have been produced by fossil fuel electrical energy generation and avoids 6 MMTCE of GHG emissions that would be produced if the MSW was landfilled.
- Increasing diversion of MSW from landfills by using recycling, composting, and waste-to-energy combustion.
- Increasing landfill gas collection and energy recovery technology avoids 32 MMTCE that would otherwise have been produced by older landfills and by fossil fuel electrical energy generation.

This study illustrates that there has been a positive impact on GHG emissions as a result of actions taken by local governments in managing MSW. Although MSW has more than doubled since 1974, more than 41 MMTCE of GHG emissions per year are being avoided based on actions taken in U.S. communities. There are additional opportunities for decreases in GHG emissions as well as improvement in other environmental co-benefits through improved materials and energy recovery from MSW management.

For more information about the decision support tool, please contact either Susan Thorneloe, EPA Senior Project Officer, at Thorneloe.Susan@epa.gov (or 919/541-2709) or Keith Weitz at RTI at kaw@rti.org (or 919-541-6973). Also, information is available through the project web site.[9] This World Wide Web site will be updated as the final project documents are completed and the details for the release of the decision support tool are finalized.

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The New York Times ON THE WEB

February 10, 2001

New Report Backs Planting More Trees to Fight Warming

By ANDREW C. REVKIN

An influential panel of scientists is preparing to endorse two strategies for curtailing global warming that have been major points of contention between the United States and Europe in efforts to complete a climate treaty.

In a report scheduled for next month, the panel concludes that by protecting existing forests and planting new ones, countries could blunt warming by sopping up 10 to 20 percent of the heat-trapping carbon dioxide that is expected to be released by smokestacks and tailpipes over the next 50 years.

It also says the cost to industrialized countries of a global climate plan could be cut in half if they were allowed to buy and sell credits earned by those that make the deepest reductions in carbon dioxide and other so-called greenhouse gases.

The conclusions could bolster the position of the United States when negotiations over details of the treaty resume this summer. But some experts involved in the talks stressed that a scientific analysis of untested climate-control strategies says little about whether such efforts would prove effective.

"The big question is whether real programs in the real world will work," said Dr. Daniel A. Lashof, a senior scientist at the Natural Resources Defense Council, a private environmental group. "The devil's in the details."

The report was written by a working group within the Intergovernmental Panel on Climate Change, a network of hundreds of scientists who advise governments on climate issues under the auspices of the United Nations. The group plans to release it at a meeting in Ghana.

A final draft was recently sent to governments for comment, and a copy was given to The New York Times by an American official.

The panel's findings are closely watched by governments as a barometer of mainstream scientific thinking on global warming.

A report by another working group last month concluded that the burning of fossil fuels and other human activities are responsible for most of a one-degree rise in average global temperatures measured in the last 50 years. This was the first time the 12-year-old panel found that human actions were the dominant

force behind the recent warming.

The climate treaty, the 1997 Kyoto Protocol, would require 38 industrial countries to cut emissions of greenhouse gases by 2012 to 5 percent below emission levels in 1990. It has been signed by more than 100 countries but lacks fine print and has not yet been ratified.

Negotiations over details broke down at a tumultuous meeting in November in The Hague when the European Union rejected an American proposal calling for trading in credits for emissions reductions and granting credit for planting forests and crops.

The report lends some new credence to the American positions. According to the panel, "Forests, agricultural lands and other terrestrial ecosystems offer significant, if often temporary, mitigation potential."

Even if the carbon taken from atmospheric carbon dioxide is eventually released again from plants or soil, the report said, "conservation and sequestration allow time for other options to be further developed and implemented."

The scientists added that if the rules for such living carbon reservoirs were right, they could also preserve endangered species and improve water quality.

The European Union and some private environmental groups have opposed giving credit for forest planting, saying it could take the pressure off industrial countries to cut emissions from the source: vehicles, power plants and industry.

In The Hague, the United States scaled back the amount of credit it sought for farm and forest changes, but American negotiators and many representatives in Congress say this remains an essential component of the final Kyoto treaty.

Trading of emissions credits is equally contentious. Such trading is a way of encouraging the greatest cuts in pollution where they can be done most cheaply. In theory, under such a program the United States or another wealthy country — either directly or indirectly — could get credit toward greenhouse-gas targets by investing in new, efficient power plants in, say, Eastern Europe.

The new plants would represent a big leap in performance over old, pollution-belching plants there, proponents of trading say. Building similar plants in the United States would cost more and would result in a smaller improvement in emissions.

According to the new report, a variety of economic models predict that a climate plan without trading among industrialized countries would result in a range of losses to their gross domestic products of anywhere from two-tenths of 1 percent to 2.2 percent. Under a climate plan with emissions trading, the range of losses could be cut in half.

Over all, the report says, even in the middle of this range of possible losses, costs of adjusting power plants and other sources of greenhouse emissions would be small enough that no substantial economic harm would result. On one point, the scientific panel, some environmental groups and some industry officials all agree: To make emissions trading work, there must be clear, enforced rules and an accurate way of measuring changes in gas emissions.

"If you don't have a system that's legitimate and verifiable, there's tremendous potential for gaming the system," said Dale E. Heydlauff, senior vice president for environmental affairs of American Electric Power, a $12-billion-a-year energy company that supports trading under the climate treaty.

But some environmental groups insist that there is a moral obligation for countries to make a significant amount of their emissions reductions at home.

"From the European perspective, we think that should be a priority," said Frances MacGuire, the climate change policy director in the London office of Friends of the Earth. "There is a place for trading, but it shouldn't be without limit."

Dirty new warming secret

STEVEN MILLOY

Global warming pushers should be choking on soot this week. Instead the global warming-friendly media is choking a potentially devastating story.

"Soot may be responsible for 15 percent to 30 percent of global warming, yet it's not even considered in any of the discussions about controlling climate change," says Stanford University professor Mark Jacobson.

The familiar black residue coating fireplaces and darkening truck exhaust is second in importance only to carbon dioxide as a cause of global warming, according to Mr. Jacobson's new study published this week in the prestigious journal Nature.

Though Nature added a news story and media release to spotlight the study, no major media outlet reported it — not the Associated Press, The Washington Post or New York Times, all of which typically miss no opportunity to trumpet gloom-and-doom stories about global warming.

But that's the problem. Mr. Jacobson's study raises serious questions about the theory that humans are measurably changing global climate.

Mr. Jacobson ironically offers the study as a reason to accelerate efforts to control global warming. But his study actually illustrates the utter folly of the Kyoto protocol — the 1997 treaty not yet ratified by the U.S. Senate, which calls for drastic reductions in carbon dioxide emissions (read "energy use") among developed nations in hopes of avoiding predicted climate-related calamities.

Global warming alarmists claim humans are raising global temperatures by burning oil, gas and coal. Such combustion releases carbon dioxide into the atmosphere. The added "greenhouse gas" absorbs solar radiation, thereby "unnaturally" warming the atmosphere.

Unchecked carbon dioxide emissions will cause global temperatures to rise by as much as 10.4 degrees Fahrenheit over the next 100 years, according to the alarmist United Nations' Intergovernmental Panel on Climate Change (IPCC). This temperature increase is predicted to cause all sorts of problems from severe weather-related events to higher sea levels to the spread of infectious diseases.

The predicted rise in global temperature is not based on scientific evidence, but rather on mathematical models that rely on crude assumptions about the numerous and complex factors that affect global climate

The IPCC explicitly admits a lack of knowledge about climate factors, stating there is "low" or "very low" scientific understanding for 9 of the 12 factors thought to affect global climate. For two factors, there is "medium" understanding. The IPCC says there is a "high" level of understanding only for the greenhouses gases, such as carbon dioxide, methane and nitrous oxide.

Enter soot.

The IPCC acknowledges soot may affect climate but downplays it anyway. The IPCC classifies soot in the "very low" category of scientific understanding and says that soot isn't a very potent trapper of solar radiation.

But Mr. Jacobson says soot combines in the atmosphere with dust, sea spray, atmospheric aerosols and chemicals. The resultant particles, call them "soot-plus," absorb much more solar radiation than plain soot.

The IPCC hypothesizes carbon dioxide is the most important global warming factor, trapping solar radiation at a rate of 1.56 watts per square meter. Methane is rated second by the IPCC at 0.47 watts per square meter. Jacobson estimates the rating for soot-plus is an astounding 0.55 watts per square meter.

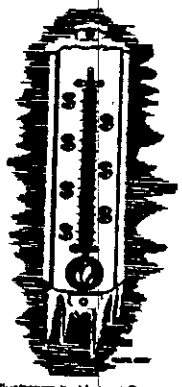

Illustration by Michael Osbun/ Los Angeles Times Syndicate

Here's how soot-plus is a show-stopper.

There is general agreement that global temperatures warmed from 1910 to 1940 and cooled from 1940 to 1975. Temperature changes since 1975 are hotly disputed. The IPCC says global temperatures have warmed. But this claim is based on surface temperature records that are biased upward by temperature readings from urban areas whose concrete and asphalt absorb heat.

Other climatologists point to satellite and balloon temperature measurements that are unaffected by the so-called "urban heat island effect" and that report no significant warming global warming since 1979.

So despite the steady increase in atmospheric greenhouse gases all during the 20th century, there has been significant no warming trend since 1940.

The IPCC tries to account for this discrepancy by saying an increase in atmospheric aerosols — dust from volcanic eruptions and sulfates from fossil fuel that reflect solar radiation — masked the post-1940 warming effect of the greenhouse gases by providing a cooling force in the atmosphere.

Accepting the IPCC's explanation for the sake of argument, the heretofore ignored existence of soot-plus exactly offsets the cooling effect of the aerosols — and the IPCC is back to needing an explanation for why global temperatures aren't rising with greenhouse gas concentrations.

So the IPCC models that assume global climate is very sensitive to greenhouse gases and predict a 2.5- to 10.4-degree increase in temperature over the next 100 years remain seriously flawed.

University of Virginia climatologist Pat Michaels says Mr. Jacobson's study bolsters his prediction of only a 2.5 degree Fahrenheit increase over the next 100 years. Atmospheric physicist S. Fred Singer says the predicted temperature increase is likely to be even less.

The larger question, though, is how much confidence should be placed in IPCC forecasts completely overlooking possibly the second-most important manmade impact on climate?

Under the Kyoto protocol, carbon dioxide emissions would be reduced to 1990 levels by 2010 — what could amount to a 30 percent reduction in energy use. Should we reduce energy use and risk harming the economy based on a predictions of global warming that are so lacking in understanding?

Certainly more research is needed to confirm soot is the dirty secret that undoes global warming hysteria. Meanwhile, the soot-plus hypothesis should bar the rush-to-judgment the global warming pushers wants us to make — if only the media would tell someone.

Steven Milloy is publisher of Junkscience.com and an adjunct scholar at the Cato Institute.

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The Washington Post

FEB 20 2001

Circ: 852,262

U.N. Report Forecasts Crises Brought On by Global Warming

Poor Countries Would Bear Brunt of Climate Consequences

By Eric Pianin
Washington Post Staff Writer AP

Rising global temperatures already responsible for shrinking glaciers and vanishing permafrost eventually could touch off climate changes that would literally alter ocean currents, wipe away huge portions of Alpine snowcaps and aid the spread of cholera and malaria, according to a study released yesterday.

In the most comprehensive look yet at the existing and long-term effects of global warming, the report by a United Nations panel warned of the potential for large-scale and irreversible climate changes—including large reductions in the Greenland and West Antarctic ice sheets and a substantial slowing of the circulation of warm water in the North Atlantic.

The report also warns of devastating droughts, floods, violent storms and the spread of cholera and malaria. It concluded that poor countries in Africa, Asia and Latin America with limited resources would bear the brunt of the most extreme climate changes.

The report said that economic losses from natural catastrophes increased from about $4 billion a year in the 1950s to $40 billion in 1999, with about a quarter of the losses occurring in developing countries.

"Most of the Earth's people will be on the losing side," said Harvard University environmental scientist James J. McCarthy, who co-chaired the U.N.'s Intergovernmental Panel on Climate Change, which issued the report in Geneva.

Dire Warning

Findings of the latest report on global warming by the Intergovernmental Panel on Climate Change:

- **Recent regional climate changes already have had adverse effects,** from shrinkage of glaciers and thawing of permafrost to unusually early breakup of ice on rivers and lakes and the decline of some plant and animal populations.
- **Long-term dangers worldwide include** reduction in crop yields, decreased availability of water for populations in drought-prone regions, increase in the number of people exposed to cholera and malaria and widespread risk of flooding in populous areas.
- **Natural systems are at risk,** including glaciers, coral reefs and atolls, alpine ecosystems and prairie wetlands.
- **Global warming left unabated** could unleash large-scale and possibly irreversible changes in Earth's ecosystem, from a significant slowing of the ocean circulation that transports warm water to the North Atlantic to large reductions in the Greenland and West Antarctic ice sheets.
- **Poor countries would bear the brunt** of devastating changes as a result of global warming, but wealthier countries including the United States would likely be lashed by storms and rising sea levels.

THE WASHINGTON POST

The 1,000-page report follows the group's warning in January that Earth's average temperature could rise by as much as 10.4 degrees over the next 100 years—the most rapid change in 10 millennia and more than 60 percent higher than the same group predicted less than six years ago.

Taken together, the two studies provide the strongest evidence yet that most of the global warming in the past 50 years has been caused by human activities, primarily the burning of oil, gasoline and coal, which produces carbon dioxide and other gases that trap heat in the atmosphere.

While some scientists disagree over the panel's methodology and findings, the release of the latest report is likely to put added pressure on the Bush administration to develop a policy to address the mounting threat of global warming.

President Bush and his advisers have made increased domestic energy production a top priority, but have had little to say about the related issue of cleaning up the environment. At the administration's request, United Nations officials agreed last week to delay the next round of formal global warming treaty negotiations, set for May, until this summer.

The United States and other industrialized countries have declined so far to ratify the so-called Kyoto Protocol, an agreement first negotiated in 1997 that would require about three dozen developed nations to cut combined emissions of greenhouse gases to 5 percent below their 1990 levels by 2012.

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The New York Times

Circ: 1,187,950

FEB 19 2001

A Message in Eroding Glacial Ice: Humans Are Turning Up the Heat

A1

By ANDREW C. REVKIN

The icecap atop Mount Kilimanjaro, which for thousands of years has floated like a cool beacon over the shimmering plain of Tanzania, is retreating at such a pace that it will disappear in less than 15 years, according to new studies.

The vanishing of the seemingly perpetual snows of Kilimanjaro that inspired Ernest Hemingway, echoed by similar trends on ice-capped peaks from Peru to Tibet, is one of the clearest signs that a global warming trend in the last 50 years may have exceeded typical climate shifts and is at least partly caused by gases released by human activities, a variety of scientists say.

Measurements taken over the last year on Kilimanjaro show that its glaciers are not only retreating but also rapidly thinning, with one spot having lost a yard of thickness since last February, said Dr. Lonnie G. Thompson, a senior research scientist at the Byrd Polar Research Center of Ohio State University.

Altogether, he said, the mountain has lost 82 percent of the icecap it had when it was first carefully surveyed, in 1912.

Given that the retreat started a century ago, Dr. Thompson said, it is likely that some natural changes were affecting the glacier before it felt any effect from the large, recent rise in carbon dioxide and other heat-trapping greenhouse gases from smokestacks and tailpipes. And, he noted, glaciers have grown and retreated in pulses for tens of thousands of years.

But the pace of change measured now goes beyond anything in recent centuries.

"There may be a natural part of it, but there's something else being superimposed on top of it," Dr. Thompson said. "And it matches so many other lines of evidence of warming. Whether you're talking about borehole temperatures, shrinking Arctic sea ice, or glaciers, they're telling the same story."

Dr. Thompson presented the fresh data yesterday at the annual meeting of the American Association for the Advancement of Science in San Francisco.

Other recent reports of changes under way in the natural world, like gaps in sea ice at the North Pole or shifts in animal populations, can still be ascribed to other factors, many scientists say, but many add that having such a rapid erosion of glaciers in so many places is harder to explain except by global warming.

The retreat of mountain glaciers has been seen from Montana to Mount Everest to the Swiss Alps In the Alps, scientists have estimated that by 2025 glaciers will have lost 90 percent of the volume of ice that was there a century ago. (Only Scandinavia seems to be bucking the trend, apparently because shifting storm tracks in Europe are dumping more snow there.)

But the melting is generally quickest in and near the tropics, Dr. Thompson said, with some ancient glaciers in the Andes — and the ice on Kilimanjaro — melting fastest of all.

Separate studies of air temperature in the tropics, made using high-flying balloons, have shown a steady rise of about 15 feet a year in the altitude at which air routinely stays below the freezing point. Dr. Thompson said that other changes could also be contributing to the glacial shrinkage, but the rising warm zone is probably the biggest influence.

Trying to stay ahead of the widespread melting, Dr. Thompson and a team of scientists have been hurriedly traveling around the tropics to extract cores of ice from a variety of glaciers containing a record of thousands of years of climate shifts The data may help predict future trends.

The four-inch-thick ice cylinders are being stored in a deep-frozen archive at Ohio State, he said, so that as new technologies are developed for reading chemical clues in bubbles and water in ancient ice, there will still be something to examine.

The sad fact, he said, is that in a matter of years, anyone wanting to study the glaciers of Africa or Peru will probably have to travel to Columbus, Ohio, to do so.

Dr Richard B. Alley, a professor of geosciences at Pennsylvania State University, said the melting trend and the link — at least partly — to human influence is "depressing," not only because of the loss of data but also because of the remarkable changes under way to such familiar landscapes.

"What is a snowcap worth to us?" he said. "I don't know about you, but I like the snows of Kilimanjaro."

The accelerating loss of mountain glaciers is also described in a scientific report on the impact of global warming, which is being released today in Geneva by the Intergovernmental Panel on Climate Change, an influential network of scientists advising world governments under the auspices of the United Nations. The melting is likely to threaten water supplies in places like Peru and Nepal, the report says, and could also lead to devastating flash floods.

Kilimanjaro, the highest point in Africa, may provide the most vivid image of the change in glaciers, but, Dr. Thompson said, the rate of retreat is far faster along the spine of the Andes, and the consequences more significant. For 25 years, he has been tracking a particular Peruvian glacier, Qori Kalis, where the pace of shrinkage has accelerated enormously just in the last three years.

From 1998 to 2000, the glacier pulled back 508 feet a year, he said. "That's 33 times faster than the rate in the first measurement period," he said, referring to a study from 1963 to 1978.

In the short run, this means the hydroelectric dams and reservoirs downstream will be flush with water, he said, but in the long run the source will run dry.

"The whole country right now, for its hydropower, is cashing in on a

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USA TODAY

FEB 19 2001

Circ: 1,557,171

U.N. study: Global warming has effects now

By Traci Watson
USA TODAY 5A

Global warming is already having clear effects on animals, birds, glaciers and other features of the natural world, says a report out today from a U.N.-sponsored panel of scientists and other technical experts.

The evidence shows "there is high confidence" that the recent rise in the Earth's temperature has had "discernable impacts on many physical and biological systems," the scientists wrote. "High confidence" means there's a 67% to 95% chance the statement is true.

Changes noted in the USA:

▶ Tree swallows are building nests earlier in the year.

▶ A western species of butterfly is moving farther up the West Coast and higher up mountainsides.

▶ Flowers in Wisconsin are budding earlier in the spring.

As the planet warms even more, the report says, humans, too, are likely to feel the heat. Countries in southern Africa are likely to have even less fresh water. Farming in the Midwestern USA will probably suffer. Higher sea levels and more intense cyclones are likely to displace millions of people in Asia.

A report released in January by the same panel said the average surface temperature of the Earth rose 1 degree during the 20th century and could rise 2.6 to 10.4 degrees from 1990 to 2100.

The January report said it's likely that "most" of the warming since the 1950s is "due to the increase in greenhouse gas concentrations."

Greenhouse gases, which have built up to unnaturally high levels in the Earth's atmosphere, trap heat. They include carbon dioxide, which is emitted when fossil fuels are burned, and other gases produced by human activity.

The sponsor of both reports, the United Nation's Intergovernmental Panel on Climate Change, carries enormous weight with governments around the world. Previous editions of the report, which is produced every five years, have often been cited at the international negotiations over a treaty to control global warming.

More than 160 nations agreed to such a treaty, called the Kyoto Protocol, in 1997. However, talks over the treaty collapsed in December.

Those talks are to resume this summer, but President Bush said on the campaign trail that he opposes the Kyoto Protocol. His administration has yet to fill positions key to directing global-warming policy.

Environmentalists hope the new findings will coax the White House into taking a strong stance on global warming. "I hope they really study this report," said Jennifer Morgan of the World Wildlife Fund.

Some scientists argue the planet may be warming naturally. The new report doesn't touch on that argument, nor does it explicitly tie the changes in natural patterns to warming caused by humans.

However, several scientists said it's not hard to connect the dots.

Others criticized the newer report for relying on what they say are simplistic estimates of how much the Earth will warm.

"No one says we can predict the weather next year," says Roger Pielke Sr., an atmospheric scientist at Colorado State University. "So why do we think we have better skills for 50 years in the future?"

The Washington Times APR 25 2001

Measure aims to preserve rain forests

Brownback bill meets Bush criteria

By Patrice Hill
THE WASHINGTON TIMES

A leading Senate Republican yesterday introduced legislation creating tax incentives for U.S. companies to work with developing countries to stop the destruction of tropical rain forests.

The bill, offered by Sen. Sam Brownback of Kansas, was touted by environmentalists and industry groups alike as an example of what the United States can do to curb a major source of greenhouse gases that currently is not covered by the global warming treaty rejected by President Bush.

The Bush administration, which has shown interest in the proposal, is seeking ways to involve developing countries in the quest to reduce the carbon dioxide emissions thought to be warming the Earth's atmosphere. It also wants to achieve such cuts without harming the U.S. economy

The bill would address both of Mr. Bush's concerns, since the slashing and burning of forests, mostly in tropical regions of the Third World, is responsible for one-fifth of the carbon released into the atmosphere each year. And U.S. businesses would benefit modestly from the $200 million a year in tax breaks in the bill.

Mr. Brownback said he wants to "contribute to the solution on climate change and help to reshape the way we view environmental problems."

The Senate, like Mr. Bush, has overwhelmingly rejected terms of the Kyoto treaty that could impose harsh constraints on U.S. economic growth while exempting developing countries from having to curb their greenhouse gases.

"We should move forward," Mr. Brownback said, "by engaging developing nations rather than cutting them out of the process."

Environmentalists say the proposal would enable the United States to achieve about 10 percent of the cuts in carbon dioxide called for under the global warming treaty drafted in Kyoto, Japan, in 1997 though the treaty as written would prohibit the United States from getting credit for such forest-saving measures.

The bill also addresses other serious environmental problems associated with clear-cutting, including the rapid disappearance of thousands of species of plants and animals that reside in the tropics, some of which may hold the keys to solving medical problems.

The bill's tax credits would be given to companies that invest in projects in Brazil, Bolivia and other Third World countries that prevent further deforestation of their rain forests or replant areas that have been cleared. A panel of energy and environmental experts would determine which projects get credits.

The bill has attracted the support of an unusual coalition of environmental and industry groups, including Environmental Defense, the National Environmental Trust, the Nature Conservancy and the American Electric Institute.

Environmentalists said they also are working with Senate Republicans on ways to encourage American farmers and ranchers to use land management and conservation techniques that absorb carbon dioxide in the atmosphere and help curb global warming.

"There is a way to chip away at environmental challenges, rather than demagoging an 'all-or-nothing' stance," said Mr. Brownback in addressing a group of students who traveled to Washington to push for the legislation.

"This is the way Washington is supposed to work," said Kevin Curtis, vice president of the National Environmental Trust. "Instead of going for headlines and posturing about Kyoto, we've moving toward solutions."

Robert Bonnie, an economist with Environmental Defense, noted that the huge contribution to global warming caused by deforestation has been largely ignored in the international negotiations over the Kyoto treaty.

The United States and a few allies, notably Australia and Canada, have tried to include deforestation remedies in the treaty, but their efforts have been spurned by the 15-nation European Union and Third World countries.

Brazil, which has the largest rain forest, the Amazon, is opposed to measures that would penalize clear-cutting. It wants the treaty to include only measures that encourage the replanting of cleared areas.

A compromise proposal drafted this month by Jan Pronk, a Dutch minister who currently is the president of the U.N. climate change conference, follows Brazil's wishes. It would allow the United States to take credit for the carbon-dioxide-absorbing powers of its own forests, but it specifically bars businesses from getting any credit for protecting rain forests, Mr. Bonnie said.

GLOBAL WARMING

John, Bob
FYI
_Marcus

Oh no, Kyoto

WASHINGTON, DC

George Bush has thrown the decade-long effort to finalise the UN treaty on climate change into chaos. Can the treaty survive—and should it?

THE Kyoto Protocol, which binds industrialised countries to cut their emissions of greenhouse gases, was signed with much fanfare in 1997. For the United States, the deal was done by Vice-President Al Gore, who could fairly claim to have been one of the first public figures to focus attention on the dangers of global warming. Now, three years on, nearly a decade after the first UN treaty on global warming was signed, the protocol seems to have been dealt a lethal blow—and it was wielded by the man who defeated Mr Gore for the American presidency, George Bush.

In truth, the protocol was already in deep trouble even before Mr Bush took office. The most recent round of negotiations over the implementation of Kyoto, held in The Hague last November, ended in disarray. The EU had refused to accept the American arguments that the Kyoto targets should be met through the use of more flexible mechanisms, notably the free trading of emission rights (including trading between countries) and the claiming of credit for forest and agricultural "sinks" that absorb carbon dioxide, the principal greenhouse gas. Some European ministers made it clear that they wanted Americans to feel some economic pain more than they wanted a workable agreement. Unsurprisingly, the Americans made it equally clear that they could not possibly implement Kyoto as it stood, for the cuts it required would be far too swingeing.

Mr Bush has now dropped two big bombshells, which may conceivably kill Kyoto altogether. Last month, to the embarrassment of Christie Whitman, head of the Environmental Protection Agency, and other top officials, he abruptly announced a U-turn on a crucial aspect of his domestic policy on climate change: a campaign pledge to regulate CO_2 through domestic environmental laws. And last week, he made it clear that his long-stated opposition to the Kyoto targets was not open to post-election persuasion. Some of his aides have flatly declared that the Kyoto agreement is dead.

Mr Bush's actions sparked a ferocious storm of criticism from every corner of the world, from Europe to Japan, and from Canada to China. Much of this was mere posturing, with environment ministers claiming to be shocked, shocked by a state of affairs they already understood. In addition, admittedly, there was a layer of genuine surprise at the administration's clumsy handling of it all. One American energy boss, a veteran observer of climate-change diplomacy, said he was amazed by "the manner and tone of how all this has been handled: it was inexperienced and immature."

Get used to it

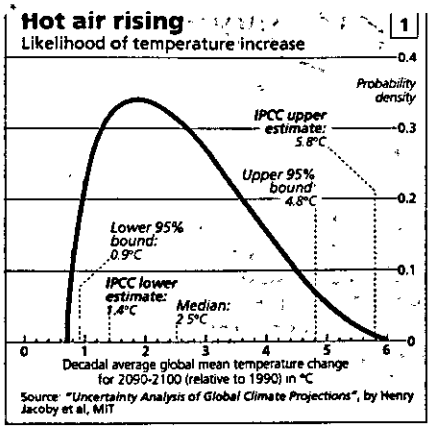
The Europeans were only too happy to take the moral high ground. Yet, as their blindly rigid approach in The Hague showed, their position was hardly more tenable than that of the Americans. Quite fortuitously, two EU member countries are reasonably close to their Kyoto targets—Britain, thanks to its dash to gas in electricity generation, and Germany, thanks to the closure of much of East Germany's polluting industries. But the rest of the EU is hardly more likely to meet the Kyoto targets than is America. Mr Bush's apparent torpedoing of the deal could well have let hypocritical Europeans off the hook.

The dialogue between the EU and the Americans remains highly strained. After a curt reception of a delegation led by Margaret Wallstrom, the European environment commissioner, this week, Ms Whitman issued a curious statement that captures the Kafkaesque quality of current American thinking. She starts on a seemingly cheerful note: "I continue to be as optimistic as the president." She then goes on to reiterate Mr Bush's hard line: "the Kyoto Protocol is unfair to the United States and to other industrialised nations because it exempts 80% of the world from compliance. That is why the United States Senate voted 95-0, to warn against sending the Senate a treaty that could damage the economy." But she concludes by offering some hope: "Global climate change is a serious issue that this administration is committed to addressing by working closely with our friends and allies."

Clear as mud

This statement has left everybody concerned with climate change scratching their heads and wondering whether the Kyoto treaty is really dead or not. There is a still more profound issue at stake, argues Maurice Strong, an environmentalist who was in charge of the earth summit in Rio de Janeiro in 1992. It was at that gathering that the then American president, Mr Bush's father, signed the Framework Convention on Climate Change, the landmark treaty that launched the process that led to Kyoto.

Mr Strong argues that the younger Mr Bush's attack on Kyoto could mean one of two things. Perhaps the president rejects the entire Rio process of international engagement on climate change. Alternatively, Mr Bush may object chiefly to the details of the Kyoto blueprint—the specific bundle of emissions targets and timetables agreed in 1997 in that Japanese city. If what Mr Bush opposes is the first, Mr Strong thinks that this "will be not just a setback, but an immense tragedy." But if Mr Bush means the second, and if he comes up with some innovative counter-proposals, then the president might



have provided a much-needed shock that revives the troubled treaty.

Working out what Mr Bush really means, and whether he will be the scourge or the saviour of the global environment, depends greatly on understanding the reasons for his opposition to Kyoto. This would be an easier task if Mr Bush had announced his policy in, say, a thoughtful speech on the matter. He has not, and his aides say that he will not do so until a cabinet-level panel completes an exhaustive review of the options.

However, the administration has already cited several arguments for opposing proposed action on climate change. It cites uncertainties about the science, the lack of participation of poor countries, the economic burden imposed on the United States and the political impossibility of getting the Kyoto treaty ratified in the Senate. All four of these warrant a closer look.

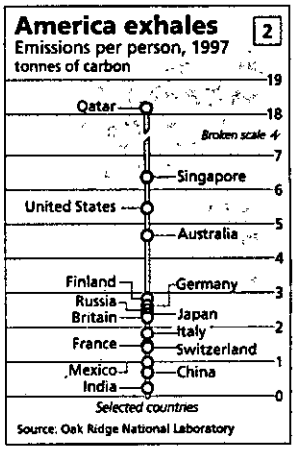
The alleged uncertainties of climate science are not a justification for Mr Bush's actions. It is notable that even such heavyweight companies as Ford, BP and Royal Dutch/Shell, all of which opposed Kyoto, have since shifted their positions towards supporting its general aims, if not its specific targets. This is because they recognise that the overwhelming consensus among the climate scientists is that global warming is real, that its effects will eventually be damaging or even catastrophic, and that the evidence of man's role in it is strong enough to warrant some action now.

The chief authority on this matter is the UN's Inter-governmental Panel on Climate Change, which includes most of the world's leading climate scientists. In the group's latest and most alarming assessment, it said that the earth could warm up by between 1.4°C and 5.8°C over the next century. Sceptics have tried to rubbish this prediction, pointing out that the IPCC gives no indication of relative probabilities for that range. Now, a team of (comparatively sceptical) experts at the Massachusetts Institute of Technology led by Henry Jacoby has completed that elaborate number-crunching exercise (see chart 1). By their reckoning, the median rise in temperature that the world can expect, if

The second argument put forth by Mr Bush's team is that developing countries such as India and China are not required to cut emissions, and so get a free ride while America suffers economic hardship. Under the Kyoto pact, only industrialised countries are required to cut their emissions of greenhouse gases during the first "commitment period", to an average of about 5% below their 1990 levels by the end of this decade.

But does this mean that poor countries are getting off scot-free? It is true that China and India are already big emitters of greenhouse gases, and in a few decades may even be the world's biggest. Today, however, their contribution pales besides America's (see chart 2). It was the rich world that created today's problem by emitting greenhouse gases while industrialising over the past century; it is only fair, goes the argument, that rich countries act first to curb emissions. The Kyoto process envisages that poor countries will take on targets at a later stage.

That Mr Bush is challenging Kyoto on this point troubles many, because it suggests that he may have deeper philosophical problems with the Rio approach to climate change. His revelation that the poor are getting off scot-free rings hollow, for the notion of "common but differentiated" responsibilities is enshrined in the Rio treaty, which Mr Bush's father signed and which passed the American Senate unanimously. Even Republican insiders in the Senate say that there is room for compromise on this point—perhaps along the lines of a firmer commitment by developing countries that they will indeed sign up to Kyoto targets at a later stage.



A third objection from the new administration concerns cost. Some of this, too, is posturing. Claims by Mr Bush that America's "energy crisis" prevents it from taking action to curb emissions are bogus. There is no energy crisis in America, just a botched deregulation of electricity in California. Even so, the question of cost is paramount—and on this the Americans are more in the right than the Europeans.

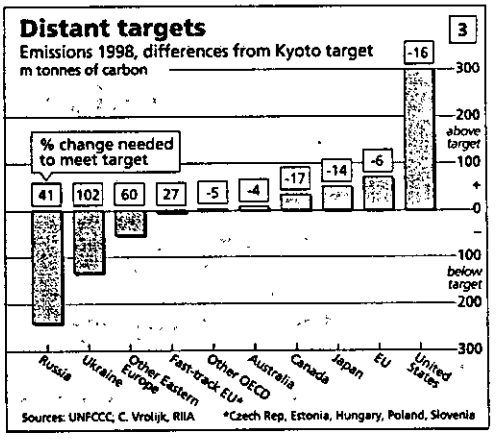
The costs of the Kyoto Protocol, as with everything else involving climate change, are not known with any precision. Economic analyses range from zero or even net gain to staggeringly high. The IPCC reckons that a modestly flexible treaty would reduce global GDP by between 0.1% and 1.1% in 2010. But most economists agree that, if the treaty is implemented in a more flexible way, to allow market forces more play and encourage innovation and investment in clean technologies, the cost can be substantially reduced. Such provisions are envisaged in the language of the Kyoto pact, and were the starting-point for the Clinton team negotiating in The Hague. But they fell foul of the Europeans' suspicions of the market. The EU delegation insisted on a variety of measures, such as restrictions on emissions trading, that would have made the deal more rigid and more costly than it had been to begin with.

As for the fourth point, about congressional politics, there is no doubt that the Senate was never going to ratify Kyoto as it stood. But it did ratify Rio, and Mr Bush may now be underestimating the degree of public concern about global warming.

Fixing Kyoto

The game has moved on, however, and if there is now to be any chance of rescuing and improving Kyoto, some big changes must be made to its provisions. Chief among these are targets and timetables, which are key determinants of the treaty's economic cost. That is because one of the chief attractions of Kyoto to the environmental lobby is also its biggest drawback: the fact that it calls for sharp reductions in emissions over a relatively short period of time. That was meant to have the pleasing effect of galvanising politicians, and jump-starting the century-long process of dealing with climate change seriously.

The trouble is that front-loading deep cuts makes them much more expensive to implement. And that problem has only become worse as the American economy has churned out emissions over the past decade of growth. As a result, America's emissions are already well above their baseline of 1990, and higher by an even greater margin than



the target set for the end of the decade (see chart 3 on previous page). Many European countries also have a tough road ahead—which some have no real intention of travelling—but for most the required cuts are not as savage as America's.

Though few politicians on either side of the Atlantic pay attention, economists argue that there is a better way to reduce the economic burden of Kyoto: to introduce a "safety valve". David Victor of the Council on Foreign Relations, a think-tank in New York, worries that governments will learn the wrong lessons from the Kyoto saga: that the demise of the treaty is due merely to the ambition of its targets and lack of will in the United States. In a timely new book, "The Collapse of the Kyoto Protocol" (Princeton University Press, $19.99), he argues that, while those factors are undeniable, the real cause of the treaty's collapse is the architecture of a pure "cap and trade" system, which allows ambitious targets but puts no limits on compliance costs.

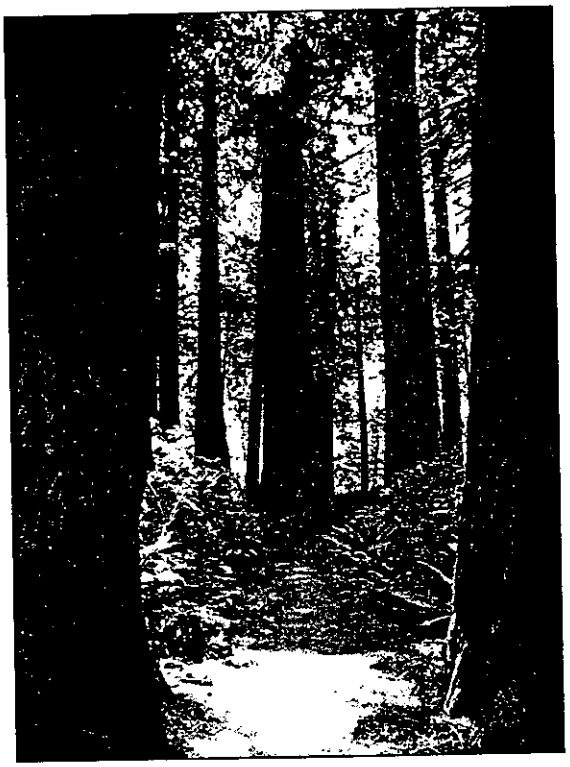
A number of like-minded boffins agree that, since global warming is caused by the growing stock of greenhouse gases in the atmosphere (rather than any one year's level of emissions), strict caps in the short term make little sense. The cost of meeting a specific emission target can be astronomical if, say, firms do not have enough time to adjust or if they have long-lived capital assets. Mr Victor argues that Kyoto must be amended with some safety valves (such as extra credits that a country could issue if costs of compliance skyrocket in a given year), to ensure the economic burden is supportable.

The end game

Will the shock that Mr Bush has given to the Kyoto deal result in the adoption of any such sensible proposals? Since even Mr Bush's administration does not seem to know its own position on global warming, it is hard to say. The next few months will bring several opportunities for America and Europe to clash on this matter. Talks among several dozen environmental ministers are due later in April in New York. For that meeting, Jan Pronk (the Dutch environment minister who chaired the failed talks in The Hague last November) is preparing a robust new proposal that he hopes will bridge the ever-wider gulf between the EU and America. The Bush administration has also said America will still participate in the next round of the Kyoto process, due to be held in Bonn in mid-July. However, it is not clear that the taskforce now developing a new climate change policy will be finished by July—or what poor Ms Whitman will say in Bonn.

Given all this, several outcomes are possible. First, it is plausible that the entire Kyoto process may fall apart completely. This could happen suddenly at the Bonn gathering, or in painfully slow fashion thereafter. If the Europeans maintain their hostility to market approaches and continue their hypocritical attacks on Mr Bush, they could well push the talks off the rails.

Even more deadly, though, would be the revelation that Mr Bush's opposition to Kyoto extends beyond targets and timetables to the entire Rio process. However, such a derailment seems unlikely, as public support for action on global warming is strong in both Europe and—say some recent opinion polls—even in America. There are signs that Mr Bush's stridency on the Kyoto pact and his desire to open Alaska to oil exploration may be provoking a broader green backlash that could rally support in Congress for action on global warming.



A tree-lined sink

Another possibility is that Europe forges ahead with the Kyoto treaty while America dawdles. Comments from Mr Bush's national security adviser and others suggest the White House believes that Kyoto will die without the United States. Not so fast, say various outraged European officials. Sweden's environment minister, Kjell Larsson, insists that "the Kyoto Protocol will not fail just because the United States doesn't join."

Technically, he is right: the treaty can come into force if 55 of the signatories ratify it, including a big share of the polluters. In practice, that means the EU must persuade Russia and Japan to sign. Realistically, however, he might be talking nonsense. After all, any treaty that purports to address global warming without the support of the country with the biggest emissions, which also happens to be the world's biggest polluter, is surely a farce.

Not necessarily, argues Michael Grubb of Britain's Imperial College. He reckons that the only salvation for the process will come from bold, but measured, steps taken by the EU. He argues that Russia will ratify the treaty since it has much to gain from the sale of its plentiful stock of unused emissions. Japan is trickier, since it is even less likely to meet its targets than Europe; that is why the Japanese are as keen on market mechanisms and trading as was the previous American administration. In the end, though, Mr Grubb argues that Japan will not allow its refusal to ratify to provide the nail in the coffin for a treaty bearing the name Kyoto. By the time the next earth summit takes place, in September 2002, in Johannesburg, he reckons it may be in force, even without America.

The key, he argues, is for Europe to do this not with bitterness, and certainly not in the rigid, moralistic and ultimately costly tone that it adopted in The Hague. Rather, he argues for Europe to pursue as flexible an interpretation as possible, so that Kyoto becomes potentially attractive to the United States. By forging ahead, he notes that Europe would also show that it is not merely posturing over Kyoto. This may help persuade poor countries to commit voluntarily to targets in future, which in turn may lure America back to the table.

The last option, of course, is that Mr Bush surprises everybody and comes up with a credible set of proposals that revives the Kyoto negotiations, either by the Bonn meeting, or more likely some time thereafter. To do that, however, he will probably need to come up with some serious domestic initiatives on climate change, so as to claw back some of the credibility and goodwill he has lost on this issue in recent weeks.

Such an outcome seems less fanciful when one considers that it is not only green groups, or even the ordinary punter, that wants action on climate change. Many of America's biggest businesses, ranging from DuPont to United Technologies, and even to coal-fired utilities like AEP, support action on climate change and want regulatory certainty on the question of carbon. Those are the sorts of voices that Mr Bush should heed. One of Mr Bush's top lieutenants this week even insisted that his boss would be a world leader on this issue. The ultimate irony of the past two weeks' coruscating attacks on the American president is that he could yet turn out to be Kyoto's saviour after all.

The New York Times

Apr. 8 2001

Circ: 1,187,950

Bush's Moves to Assure Right Ignite Storm on Left

By RICHARD W. STEVENSON

WASHINGTON, April 7 — On issue after issue in his first few months in office, President Bush has heartened and reassured conservatives.

But in pleasing the right, Mr. Bush has infuriated many liberals. And in doing so, he has helped re-energize some of his most vocal political opponents and provided a rallying cry for those politically active Democrats who were already fuming over how the presidential campaign ended.

Environmental groups, labor unions, abortion rights organizations and other powerful Democratic constituencies said that in dealing them some harsh early setbacks, Mr. Bush had given them a chance to motivate their supporters at the grass-roots level, to raise money and to challenge any claim the new president had to being a moderate.

"What Bush has done since the election is affronted and slapped in the face every major activist constituency," said Roger Hickey, co-director of the Campaign for America's Future, a liberal advocacy group. "They've attacked labor. They've undermined regulations the environmentalists care about. They've outraged women. They've given each constituency a reason to say to its troops, let's change this equation."

Some of the ire among liberals stems from personnel choices made by Mr. Bush, particularly his selection of John Ashcroft, a strong opponent of abortion rights, as attorney general. And some stems from a flurry of policy decisions by Mr. Bush, including his moves to reverse or suspend regulatory actions and executive orders issued by former President Bill Clinton in the waning days of the last administration.

Unions have been upset by the new administration's decision to roll back workplace safety rules and end preferences granted to unionized companies in bidding for government-financed building programs.

Environmentalists have bitterly protested Mr. Bush's decision not to seek limits on carbon dioxide emissions or otherwise support an international agreement seeking to limit climate change, and to undo new limits on arsenic in drinking water.

Supporters of abortion rights were angered by Mr. Bush's decision to end federal financing for international family planning groups that support abortion.

"Not since Clarence Thomas was nominated to the Supreme Court have I seen such a spontaneous and strong reaction from people at the grass roots," said Kate Michelman, president of the National Abortion and Reproductive Rights Action League. "They hit the phones, the faxes and the e-mails even before we got ourselves focused on exactly what we would do."

White House officials say much of the criticism from liberal groups is unfair, asserting that Mr. Bush, for example, has supported some of the Clinton administration's environmental actions, like limiting diesel emissions. They say many of the groups are more focused on playing politics than on addressing issues.

"Their actions also are indications that the previous administration tilted the playing field toward groups that oppose the president," said Ari Fleischer, the White House spokesman. "The president is restoring the balance and the middle ground."

Some Democrats said Mr. Bush had stepped into a trap left by Mr. Clinton, whose last-minute actions forced the new administration to grapple immediately with many charged issues it might otherwise have delayed, especially those involving labor and the environment.

Aides to Mr. Clinton said the regulations had been in the pipeline long before the election was resolved. But they said they knew as they left office that Mr. Bush would pay a political price if he reversed actions they believed had strong support.

"Bush has really lit a fire, especially on the environmental issues," said John D. Podesta, who was Mr. Clinton's chief of staff. "People are really angry about it, and incredulous that on decision after decision he has sided with the special interests."

The liberal advocacy groups say that Mr. Bush's actions have helped them raise money and recruit members, and that they have been able to flood the White House and the offices of lawmakers with messages from their supporters.

Still, it is unclear whether the liberal groups will be able to harness the strong feelings among their supporters to practical political effect.

Although they have taken heart from the difficulty Mr. Bush has had getting his budget through the evenly divided Senate, they have had little success in blocking or reversing any of Mr. Bush's other initiatives. And it is too early to say whether Mr. Bush will be able to maintain some claim to the political center as his term progresses, and what role the left-right clash might have in the mid-term elections next year.

But it seems clear that whatever other effects it will have, Mr. Bush's move to the right and the reaction from the left will make it hard for him to "change the tone" of intense partisanship in Washington, as he frequently pledges to do.

Steve Cochran, director of strategic communications for Environmental Defense, said some environmental groups, including his, had been optimistic about working with Mr. Bush to find common ground and compromises. Now, he said, liberals were starting to have the same kind of visceral negative reaction to Mr. Bush that conservatives had to anything associated with Mr. Clinton.

"These decisions — both the content and the style in which they were announced — have further polarized the situation and made people dig in more rather than relax," Mr. Cochran said.

Steve Rosenthal, the political director of the A.F.L.-C.I.O., said the labor federation's president, John J. Sweeney, had recently directed union officials to go to "war footing."

Mr. Rosenthal said organized labor was developing a campaign to shape public perceptions of Mr. Bush. He said the campaign would seek to pressure Republican lawmakers from states where Al Gore did well in the 2000 presidential race.

"We will begin to get out information on exactly who George W. Bush is and what so-called compassionate conservatism is in terms of wrecking workers' rights and workplace protections," Mr. Rosenthal said. "It's a great opportunity for us to define George W. Bush."

science & technology

Transcribed Monday, February 26, 2001

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Politics foils objective U.N. Climate Change Report -- again

By: Kenneth Green, Director of Environmental Program, Reason Public Policy Institute

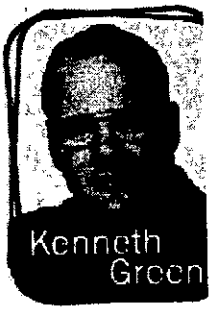
Once again, climate change is in the news, as the United Nations Intergovernmental Panel on Climate Change (IPCC) has released a "Summary for Policymakers" based on the massive second volume of its "Third Assessment Report" on climate change.

IPCC Volume 2 picks up where the Volume 1 left off, asking how temperature increases predicted in Volume 1 might lead to climate changes in the future. The new Volume 2 Summary (all that's been released to date) raises the specter of coastal inundation; violent weather; droughts; increased spread of mosquito-borne illnesses; crop failures; and more.

In fact, there is evidence that the Earth's atmosphere has been heating up a bit for the past 150 years, and there is good reason for people to be concerned about a changing climate -- so far as a changing climate can produce such extreme conditions -- delicate ecosystems, agriculture, transportation systems, coastal structures could face additional risk.

But for environmental policies to provide the best return on investment, they have to be prioritized against all the other environmental concerns facing individuals and society, and that prioritization requires scientifically rigorous risk characterization. Unfortunately, the 19-page Volume 2 Summary fails several tests of scientific rigor, such as substantiating assumptions, using sound statistics to indicate certainty, and using meaningful peer-review. Unlike the 1,000 page underlying report, the Summary was written by only a few governmental officials; was reviewed only by a small selection of the original authors, and was not subject to expert review.

The biggest failing of the Volume 2 Summary is its tendency to exaggerate the scientific certainty of the predictions it makes. Though specific words meant to convey certainty are paired with numerical estimates of certainty (high confidence, for example, is supposed to imply greater than 95 percent certainty), the assignment of these "confidence" terms and numbers is an exercise



in nearly pure subjectivity. The Volume 2 Summary describes how terms like "very high confidence" are derived as follows: "In this Summary for Policymakers, the following words have been used where appropriate to indicate judgmental estimates of confidence (based upon the collective judgment of the authors using the observational evidence, modeling results, and theory that they have examined..."

The Volume 2 also fails to explain that its predictions are based on highly criticized modeling of dubious worst-case scenarios. The predictions made in the new report are not based on independent observation and extrapolation of real-world trends, but are based upon an estimated range of predicted warming from the Volume 1 report – a controversial and dubious estimate that itself is based on questionable assumptions from a third report. Even were it not for these pre-existing problems, the computer models used in the Volume 2 effort are of questionable value. According to a Science news brief from June 2000, Jerry Mahlman, director of NOAA's Geophysical Fluid Dynamics Laboratory, observes that when regional climate models such as those used in the new IPCC report try to incorporate external factors such as population and economic growth rates, "the details of future climate recede toward unintelligibility." Climate modeler Filippo Giorgi, of the Abdus Salam International Center for Theoretical Physics, observes that regional climate models of the sort used by the WGII authors are of limited value: "For the most part, these sorts of models give a warning, but they tend to give very different predictions, especially at the regional level, and there's no way to say one should be believed over another."

Finally, the Volume 2 Summary lumps all possible types and causes of climate change together, whether it is of human origin, solar origin; whether it is warming, or whether it is cooling. But current understanding in the mainstream scientific literature only ascribes half of the observed warming since the 1970s to human activity – a critical distinction for policymaking. Without specifying how much of which impacts are predicted to be of human origin, the Volume 2 Summary deprives policymakers of information needed to determine appropriate action.

While everyone is rightly concerned about prospective changes in climate, the devil is in the details. With finite resources available to use in the human search for safety, some basic ranking of investments is imperative to be sure we get the best return on investment. In the realm of climate-change policy, such ranking becomes impossible when politicized portrayals of the state of scientific knowledge are passed off as the best that science has to offer. The latest IPCC report Summary continues a pattern of publishing Summary reports that distort more than they reveal, and will misinform policymakers more than it will inform them.

Information on the IPCC reports can be found at (http://www.ipcc.ch/).

Transcribed Monday, February 12, 2001

Climate-Change Scientists Confront an Ancient Elephant

By: Kenneth Green, Director of Environmental Program
Reason Public Policy Institute

Sometimes, reality enacts a great folktale with stunning clarity. That's what happened at a Rice University-James Baker Institute conference on climate change a few months ago, when six reputable scientists brought the story of the blind men and the elephant to life in a spectacular fashion.

For those unfamiliar with the story of the six blind men asked to identify an elephant, here's how it goes. A certain Raja called for six blind men and had them led to different parts of an elephant, asking them to explain what an elephant is like. One man feels the elephant's trunk, and says, "It's a giant snake." Another touches the elephant's flank, and says, "It's a wall." A third blind man touches a leg, and says, "It's a tree." The other blind men pronounce that the elephant is like a spear, a rope, or a fan, touching the elephant's tusk, or tail, or ear. In their dispute, the blind men take to railing at one another, to the Raja's great amusement.

The climate change conference enactment of this folktale began when Dr. Theodor Landscheidt from the Schroeter Institute for Research in Cycles of Solar Activity in Nova Scotia took the podium. Dr. Landscheidt put up many impressive charts, and argued that his research strongly suggests that the cause of the warming observed in the 20th Century was not greenhouse gases, but clearly results from an increase in the output of radiation from the sun.

But immediately after Dr. Landscheidt finished, Dr. Judith Lean, a research physicist with the Naval Research Laboratory, presented her most recent findings, arguing that whatever the cause of 20th Century warming was, it was not an increase in solar radiation. Dr. Lean's charts suggested that net solar output simply hadn't changed as much as the temperature had, and so changes in solar output could not be the sole cause of observed 20th Century warming.

Next on the podium was Dr. Willie Soon, an astrophysicist with Harvard University. Dr. Soon showed many charts suggesting that changes in the Earth's average temperature correlate with the

frequency of sunspots. Dr. Soon's conclusion was that the likely cause of 20th Century warming was not increased solar radiation, but rather, was due to increased cosmic ray activity and its impacts on cloud formation.

Shortly after Dr. Soon finished, however, Dr. James Kennett with the University of California at Santa Barbara presented his findings. Dr. Kennett's research led him to argue that the cause of 20th Century warming was not solar radiation, nor cosmic rays, nor the traditional greenhouse gas such as carbon dioxide, but was due largely to the release of methane from deep-ocean pockets of methane hydrate.

Finally, Dr. Thomas Crowley of Texas A&M University took the podium with equally impressive charts and argued that his research strongly suggested that the warming of the 20th Century could indeed be blamed on the traditional greenhouse gases, carbon dioxide, methane, chlorofluorocarbons, and the like.

But Dr. Crowley's claims were clearly at odds with those made on the previous day by Dr. James Hansen, sometimes called the Father of Climate Change. Dr. Hansen, whose congressional testimony in the 1980s galvanized political interest in climate change, argued that the main cause of 20th Century warming was not the traditional greenhouse gases, as he'd argued for nearly 20 years. Rather, Dr. Hansen suggested that his latest research indicates that the cause of observed 20th Century warming is actually soot and other urban air pollutants, including methane.

It goes without saying that these six credible, reputable scientists, who all subject their work to scientific peer-review and publication, can't be equally right. It's also obvious that the policy prescriptions that would flow from believing any one of them to be right would do little to produce a positive outcome should any of the others turn out to be correct instead.

Advocates of rapid action on climate change like to portray the science as a done deal, and suggest that scientific understanding of climate change is sufficient to guide policy action. But a Western version of the elephant folktale better characterizes the situation. As poet Geoffrey Saxe explains: "So, oft in theologic wars, the disputants, I ween, tread on in utter ignorance, of what each other mean, and prate about the elephant, not one of them has seen!"

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Mopping up After a Leak: Setting the Record Straight on the "New" Findings of the Intergovernmental Panel on Climate Change (IPCC)

e-brief #105

Dr. Kenneth Green
Director of Environmental Program
Reason Public Policy Institute

October 29, 2000

Every five years, the Intergovernmental Panel on Climate Change publishes a massive report on global climate change. These "Assessment Reports" become the central touchstone of the debate over climate change, laying out a consensus version of what is known, what is still uncertain, and how various actions might or might not cause changes in future climate conditions.

The last such publication was the IPCC's "Second Assessment Report (SAR),"published in 1995. The 1995 SAR argued that the Earth's climate was changing in ways that seemed unlikely to be of non-human origin, and that the weight of evidence suggested a "discernable" human impact upon the climate. Predicted future temperatures in the SAR ranged from 1 °C to 3.5 °C (1.8 °F to 6.5 °F) degrees centigrade by 2100, and sea level increases of 15 to 95 cm in the same timeframe.

The 1995 report is about to be supplanted by the IPCC "Third Assessment Report, or TAR, to be published early in 2001. The first volume of the TAR, the product of IPCC's Working Group 1 (WG1) reviews the massive body of climate change literature, and attempts to present a consensus view of the current understanding of climate change. This report was reviewed by a panel of experts in late 1999, was subsequently reviewed by governmental entities, was revised according to feedback, and is now undergoing "final government review." After a last round of revisions based on the final government review (which, theoretically will not alter any of the scientific conclusions of the report as it emerged from expert review), the TAR will be published in early 2001.

When the IPCC publishes a new major report, it also publishes a derivative document called the "Summary for Policymakers" (or Summary). These summaries attempt to condense the contents of the IPCC's full Assessment Report, and express findings in a language suitable for moderately educated readers.

Less than two weeks before the U.S. Presidential elections, copies of the draft Summary for Policymakers based on the Third Assessment Report were leaked to the Associated Press and other media commentators. The draft Summary became an instant issue in the election.

Working from more extreme 'worst-case' estimates than previous IPCC reports, the Summary suggests a higher range of potential warming by 2100, and higher sea-level rise as well. Global average temperature in the new Summary is modeled to increase from 1.5 to 6.0 degrees Centigrade by 2100 (2.7 to 10.4 degrees Fahrenheit). Predicted sea-level increases under the new scenarios range from 14 to 80 cm by 2100.

But media coverage of the Summary lacks contextual information needed to allow people to decide whether the report was credible. The genesis of the Summary was not explained, and the "findings were not put in context with regard to either the previous assessment report, or the main body of the more scientifically rigorous and more carefully qualified Third Assessment Report.

Climate change is a concern worthy of serious attention, and the best quality scientific research that humanity can muster. It is an issue of great complexity, in which fine details of interpretation, and underlying assumptions are indispensable if sound policy is to be derived from sound use of scientific information.

The purpose of this document is to add some context and balance to the discussion, and to correct some of the mistaken impressions that recent news coverage of the leaked IPCC draft Summary for Policymakers may have created.

1. Predictions of future changes rest upon speculative scenarios that were not reviewed by technical reviewers of the main report.

The claims regarding the potential increase in global average temperatures and sea levels in the year 2100 are based upon "scenarios" about the future that enfold a panoply of assumptions about global development patterns, population growth, energy sources, economic development, technological change, and so on:

- It is the addition of more pessimistic scenarios to those used in previous IPCC reports that produces greater estimated future temperatures, more than changes in understanding of past or present climate processes, or theoretical understanding of the relationship between human activity and climate;
- Future temperature and sea-level predictions are not modeled with state-of-the-art computer models, but use "simple" computer models that are "calibrated" to the more accurate models. No mention is made of the fact that such simple models imitate their high-powered cousins poorly; have many well-known weaknesses that make them

of limited use; and are of limited reliability even for modeling current climate trends;

- Only the Summary of the report delineating scenario assumptions is currently available for download which limits analysis, but the new "worst case" scenario assumes that:
  - There are no mid-course programs implemented between now and 2100;
  - Population peaks at 8.7 billion in 2050, and declines to 7 billion by 2100;
  - Global deforestation is not abated;
  - The developing world will reach similar levels of development as developed countries;
  - World GDP will increase 10 times by 2100;
  - Most energy production will be from carbon-based fuels;
  - Carbon dioxide emissions will nearly quadruple by 2100;
  - Methane emissions will more than double by 2100;
  - Carbon monoxide emissions will nearly triple by 2100;
  - Volatile organic carbon emissions will nearly triple by 2100; and
  - Fluorocarbon levels will rise dramatically by 2100, in some cases by two orders of magnitude.
- The assumptions used in these "scenarios" were only published in the Spring of 2000, more than six months after the actual "expert review" cycle was completed; and
- Economic and population parameters are not published as part of the peer-reviewed Third Assessment Report, and must be retrieved from another report. This makes simultaneous comparison difficult for experts with access to the full reports, and nearly impossible for others who have only the Summary.

2. The Summary for Policymakers presents findings devoid of vital contextual information.

When discussing the findings of how the Earth's climate has changed in recent years, the Summary for Policymakers presents hard evidence regarding temperature readings, rain measurements, snow measurements, and so on. But the Summary presents this information without vitally important contextual and qualifying information found in the body of the IPCC report:

- Increases in temperature are presented without pointing out that:
  - The majority of physically observed warming since 1860 happened from 1910-1945, and the majority of that early warming is attributed to non-human climate forces in the body of the report;
  - The warming observed since 1860 was not continuous, but happened in two bursts;
  - Twice as much of the observed warming since 1860 appears as warming of nighttime low temperatures in the coldest parts of the Earth, rather than increases of daytime highs in the warmer

parts of the Earth;
  - The difference between ground-level temperature readings and high-altitude readings from balloons and satellites reveals a critical weakness of the climate models used to predict future impacts discussed later in the Summary; and
  - Estimated increases in temperature for the last 1000 years, are based on disputed climate reconstructions rather than observed data. No mention is made that evidence documents sharper temperature shifts in the climate record from before humans existed, suggesting that recent changes could be of non-human origin.

- Decreases in global ice extent (glaciers, icebergs, etc) and snowfall trends are presented without explaining that:
  - Measurements of historical snow depth and extent are extremely limited;
  - Glaciers in some regions are growing, not shrinking;
  - Reductions in snow and ice are not happening in the seasons where increased warmth has actually been observed;
  - Estimates of Arctic sea ice thickness show a wide range, from 1 to 4 centimeters of shrinkage per year because the sampling of evidence is too small to be conclusive; and
  - Antarctic sea ice has been stable or shows what seems to be a slight **increase** in extent since the 1970s.

- Evidence of sea level rise of 0.1 to 0.2 meters during the 20th Century is presented without reference to the fact that:
  - Sea level has been rising for nearly 20,000 years, by about 120 meters since the last glacial maximum;
  - The rate of sea level rise is not steady, but fluctuates;
  - Sea level rise did not speed up during the 20th Century, though theoretically, global average temperatures were increasing; and
  - While sea level rose between one-tenth and two-tenths of a meter during the 20th Century, the body of the report attributes only two-hundredths to six-hundredths of a meter to human activity from 1910 to 1990.

- The claim that human activities "continue to alter the atmosphere in ways that affect the climate system" is made without mentioning that:
  - This conclusion, unlike those regarding actual climate changes, are purely based on still-developing theories and highly uncertain computer modeling, not on any measurable cause-and-effect relationship between any particular activity and global climate;
  - Greenhouse gases including both carbon dioxide and methane rose and fell along with global average temperatures before human beings were around to influence their concentrations;
  - At least two of these human activities expected to contribute to

greater warming in the future are pollution reduction initiatives to reduce sulfur aerosols, and to eliminate the use of ozone-destroying chlorofluorocarbons;
  - While computer models agree that human activities have some role in observed 20th Century warming, individual models give very different estimates for the extent of the human role;
  - Uncertainties are still large in key modeling areas that underpin the entire claim of human causality in observed changes. These uncertainties involve the role of water vapor, cloud formation, and aerosol impacts in climate regulation.

3. The leaked "Summary for Policymakers" is not peer-reviewed, the author is anonymous, the document is created independently of the actual Assessment Report, and the Summary is so short that issues are overly simplified.

- Unlike the main body of the IPCC Third Assessment Report which represents an herculean effort to assess the current state of knowledge about climate change, and which speaks with great credibility because of extensive peer-review, the leaked Summary for Policymakers ***is not reviewed by the main body of IPCC experts*** and thus lacks the credibility of the technical reports they claim to summarize.
- The author of the summary is not identified, and there is no explanation of the process that generated the Summary, nor specifies whether it was or was not reviewed by the main authors, contributing authors, or expert reviewers that vetted the body of the Third Assessment report.
- The Summary for Policymakers is 12 pages long, and theoretically summarizes the Working Group I report (which) is over 1000 pages long as well as parts of the not-yet-finalized Working Group II report, which will probably be over 1000 pages.

SUMMARY

News coverage of the recently leaked "Summary for Policymakers" from the pending Third Assessment Report of the Intergovernmental Panel on Climate Change lacks information vital to putting the leaked document in meaningful perspective.

Specifically, the leaked report:

- Does not explain that increases in predicted future temperatures from the last IPCC report are due to added worst-case scenarios generated outside the careful, peer-reviewed publication process of the Third Assessment Report rather than changes in gathered evidence or empirically documented trends in climate, energy use, or greenhouse gas production;
- Does not spell out how extreme the worst-case scenarios are;
- Does not explain that predictions of future climate were generated

not with state-of-the-art models, but with simple climate models that cannot reliably reproduce known temperature changes of recent years.

- Does not provide the contextualizing information needed to accurately communicate what scientists have learned about past climate changes, current climate function, or future climate expectations;
- Does not mention that observed climate changes are only partially due to human activity; and
- Was not peer-reviewed by the same experts who reviewed the technical reports from which it is ostensibly extracted.

The forthcoming Third Assessment Report of the Intergovernmental Panel on Climate Change will serve as the central touchstone of climate change debate for the next five years. Climate change is a serious and important subject, and concerns about rapid changes in climate – whatever the cause might be – should not be treated lightly. Accuracy in the understanding of the underlying science is equally critical, and should not be misrepresented or politicized by partisans of any particular control approach.

Activities which weaken the credibility of the TAR impede not only the search for knowledge, but insure greater divisiveness in the debate over whether the report represents a scientific consensus, or is a document biased by political forces outside of the scientific process of discovery.

The leak of the Summary report of the IPCC Third Assessment Report may be seen, by some, as a way of creating a short-term ripple in the political landscape of the United States Presidential campaign. But in the long term, this leak can only harm the search for a consensus statement of knowledge, and the search for appropriate responses to the risks posed by climate change.

Related Publications:

Plain English Guide 3: Exploring the Science of Climate Change
Questions People Ask About Climate Change
Climate Change Policy Options and Impacts: Perspectives on Risk Reduction, Emissions Trading, and Carbon Taxes
Evaluating the Kyoto Approach to Climate Change

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For Immediate Release,
January 23, 2001

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New UN Global Warming Report is not New—Predictions Derived from Extreme Worst-case 'Future Scenarios'

Dr. Kenneth Green
Director of Environmental Program
Reason Public Policy Institute

January 23, 2001

Media outlets are reporting that the United Nations Intergovernmental Panel on Climate Change (IPCC) has released a new report suggesting that the Earth's atmosphere is likely to warm faster than previously predicted. Blame for this predicted warming is laid firmly at the feet of humanity, attributed to the release of potentially heat-trapping "greenhouse" gases into the atmosphere.

But the report approved in Shanghai is not "new"—it is the same report that was leaked during the recent presidential elections. Only the wording was changed from the version leaked last year – the predictions are the same.

Unfortunately, media reporting is failing to cover important information within the underlying technical report, and are taking politicized "summary" documents and press releases at face value. While emphasizing the dramatic predictions of future warming and sea-level rise, many reports entirely fail to explain where these predictions come from, or how credible they are.

1. While many reports trumpet the scary predictions of extreme warming by 2100, they often fail to explain that the temperatures increases predicted in the report (and accompanying rises in sea level) are not based on observed trends in temperature or sea level at all, and were not the product of the most modern computerized climate models. Rather, speculative (and in some cases, extremely pessimistic) scenarios about the future were run through simple computer models with known flaws.

2. Though the "science of climate change" is portrayed as being increasingly settled, few media reports explain the many radical changes that have occurred only in the past four years, since publication of the Second Assessment Report in 1996. The Third Assessment Report

contains changes from the previous report that show dramatic and continuing change in the fundamental understanding of climate processes. Aerosols, discounted as a global cooling force only a few years ago was first acknowledged to be a potent climate forcing, then discounted due to reducing aerosol levels – all in a few years. The same rapid changes in understanding hold true for most warming or cooling forces, including solar output, dark particulate "soot," methane compounds, chlorofluorocarbons, and so on. With papers battling back and forth every week in journals like science and nature, portraying climate science as either settled or a "done deal" is clearly misleading.

3. The new IPCC Third Assessment Report is portrayed as the result of a scientific process of discovery by highly esteemed scientists, but media reports do not explain the extensive political involvement that takes place at all stages of report generation, from conception of the outline, to recruiting of the lead authors by governmental representatives, to review and approval of final language by governmental representatives. While the underlying 1,000-page report is full of caveats and the cautious prose of scientists and probably does come closest to being a scientific "consensus" document about how the climate works, summaries derived from the full report omit vital contextual information and often fail to reflect the uncertainties discussed in the report they purport to summarize.

3. While many media reports quotes ranking members of the IPCC who suggest that certainty has improved over time in both predicted climate changes and attribution of human cause, many reports fail to explain that the models used in making predictions, and the futuristic "scenarios" still contain many questionable assumptions about how the climate works, and about what the future will look like. Nor is it made clear that the "scenarios" were not reviewed by the full panel of experts that give the underlying "science" report its credibility. Questionable assumptions from the worst-case scenario that produced the high-end predictions for temperature and sea-level rise include:

- No mid-course programs will be implemented between now and 2100, even in the face of what are predicted to be extreme climate changes;
- Global deforestation is not abated;
- The developing world will reach similar levels of development as developed countries;
- World GDP will increase 10 times by 2100;
- Most energy production will be from carbon-based fuels, with limited technology growth;
- Carbon dioxide emissions will nearly quadruple by 2100;
- Methane emissions will more than double by 2100;
- Carbon monoxide emissions will nearly triple by 2100;
- Volatile organic carbon emissions will nearly triple by 2100; and
- Fluorocarbon levels will rise dramatically by 2100, in some cases by two orders of magnitude.

Climate change will continue to be an important environmental issue for decades to come, and proposed policy responses could have significant impacts on national economies, technological development, and individual lifestyles. People are naturally concerned about threats of possibly radical environmental change and the IPCC reports, which constitute the common 'touchstone' of debate over climate change are too important to be so badly mischaracterized through politicized summaries and simplistic media reporting.

Related Publications

- E-brief 105: Mopping up After a Leak: Setting the Record Straight on the "New" Findings of the Intergovernmental Panel on Climate Change (IPCC)
- Mopping up After a Leak: Setting the Record Straight on the "New" Findings of the Intergovernmental Panel on Climate Change (IPCC)
- Plain English Guide 3: Exploring the Science of Climate Change
- Questions People Ask about Climate Change
- Climate Change Policy Options and Impacts: Perspectives on Risk Reduction, Emissions Trading, and Carbon Taxes
- Evaluating the Kyoto Approach to Climate Change

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Park Description
Project Summary
FAN Background
Park Protection
Ecotourism
Local Communities
Canopy Botanicals
Carbon Monitoring
Bolivian Gov't Support
Maps of The Park
E-LAB
Photo Tour of Park
Contact Us
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Site in Spanish

American Electric Power
BP Amoco
FAN: Friends of Nature Foundation
Government of Bolivia
The Nature Conservancy
Pacificorp

Noel Kempff Mercado Climate Action Project

Project Summary

At the Noel Kempff Mercado National Park, a unique partnership was forged between the Government of Bolivia, Friends of Nature Foundation (FAN) (a non-profit conservation organization headquartered in Santa Cruz, Bolivia), The Nature Conservancy (the world's largest conservation organization headquartered in Arlington, VA), American Electric Power, (an electric utility company headquartered in Columbus, OH), BP Amoco (a major petroleum company headquartered in London) and PacifiCorp (an electric utility company headquartered in Portland, OR) in 1997 to protect nearly four million acres of threatened tropical forests in the Department of Santa Cruz, Bolivia for at least 30 years. The primary purpose of the project is to sequester (capture) carbon dioxide and store carbon that would have been released as a result of logging activities in the area. At the same time, the project preserves one of the richest and most biologically diverse ecosystems in the world and fosters sustainable development in local communities. It is the largest project of its kind in the world and serves as a showcase for an innovative and cost-effective approach to abating greenhouse gas emissions. These emissions are increasing rapidly and accumulating in the atmosphere and may trigger adverse global climatic changes.

The NKMCAP is projected to avoid emissions of 7-10 millions tons of carbon or 25-36 million tons of carbon dioxide during its 30-year life. The project has been

approved by the governments of the United States and Bolivia. Prior to the project, the Park was under imminent and demonstrable threat from logging and conversion to agriculture. The project consists of numerous components: park expansion and protection activities; ecotourism; local communities sustainable development; a for-project venture to generate revenues for the Park (Canopy Botanicals) and monitoring & verification activities; and support to the Government of Bolivia's climate change program.

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FOR IMMEDIATE RELEASE

Impact of Climate Change on Human Health Remains 'Highly Uncertain'

WASHINGTON -- Even though it is understood that changes in climate and weather may factor into some disease outbreaks, it is not yet possible to determine whether global warming will actually cause diseases to spread, says a new report from the National Academies' National Research Council. While some studies have shown an association between short-term climate variability, such as that caused by El Nino, and a higher incidence of certain illnesses, numerous other factors must be considered to fully account for the spread of infectious diseases, said the committee that wrote the report.

"The potential exists for scientists one day to be able to predict the impact of global climate change on disease, but that day is not yet here," said committee chair Donald Burke, professor of international health and epidemiology, Johns Hopkins School of Public Health, Baltimore. "To help scientists and policy-makers gain a better understanding, our committee recommends strong support from the federal government for interdisciplinary efforts to analyze climate-disease relationships. The critical capabilities that must be strengthened and brought together include epidemiological surveillance, field ecology, computer modeling and simulation, and evaluation of public health interventions."

Since the time of Hippocrates, scientists have understood that weather can influence where and when some epidemics occur. For instance, mosquito-borne diseases such as dengue, malaria, and yellow fever are generally associated with warm weather, while influenza epidemics usually occur during cold weather, and outbreaks of intestinal illnesses caused by cryptosporidiosis are linked to heavy rainfall. In recent years, as research has confirmed the likelihood of a long-term global warming trend, questions have been posed as to what effect this might have on infectious disease patterns around the world, prompting numerous studies of climate-disease linkages.

Some of these studies have shown that climate variation from one season or year to the next can affect the life cycle of many pathogens and disease-carrying insects, potentially affecting the timing and intensity of disease outbreaks. A number of computer models have been developed as well to simulate the effects of climate change on disease incidence, but estimates of the extent to which diseases will potentially spread have varied significantly among some of the models. In addition,

observational and modeling studies generally are not able to consider complex social factors -- such as sanitation and public health services, population density, and travel patterns -- that also play important roles in disease dynamics. Because of this, the results of such studies must be interpreted with caution, especially when used to develop scenarios of the potential health effects of future climate change, the committee said.

Indeed, the highly uncertain impact of long-term climate change on the spread of disease and on the evolution and emergence of new pathogens stems largely from the confounding influences of human behavioral adaptations and public health interventions. For instance, basic public health protections such as adequate housing and sanitation, as well as the availability of vaccines and drugs, can limit the geographic distribution of diseases regardless of climate. One example of this is along the border between the United States and Mexico, where dengue fever outbreaks are common just south of the Rio Grande river in Mexico, but are rarely seen in neighboring regions just north of the river in the United States, mainly because of differences in socio-economic conditions.

The report also notes that there are potential pitfalls in extrapolating climate and disease relationships from one time scale to another. For example, the ecological effects of short-term climate events, such as El Niño, may be significantly different from the ecological effects and social adaptations expected under long-term climate change.

Research to understand the relationship between climate and infectious disease is in its infancy and needs to be strengthened, the committee said. Interdisciplinary research centers should be established to foster collaboration between scientists in fields such as epidemiology, climatology, and ecology. And federal health agencies such as the Centers for Disease Control and Prevention and the National Institute of Allergy and Infectious Disease should become actively involved in the U.S. Global Change Research Program, an organization that coordinates climate research among federal agencies.

Recent technological advances, such as gene-sequencing techniques for studying the molecular biology of disease-causing pathogens and satellite-based remote sensing of ecological conditions, should be used to aid research efforts, the committee added. In addition, to overcome the existing lack of high-quality epidemiological data for most diseases, a concerted global effort should be made to collect long-term disease surveillance information, along with the appropriate meteorological and ecological observations, and store it in centralized, accessible databases.

As the potential linkages between climate and disease become better understood, it may be possible to provide early warnings to help prevent disease outbreaks, the committee said. To do this, climate forecasts will have to be complemented by ongoing meteorological, ecological, and epidemiological surveillance systems. Together, this information could be used to issue a "watch" for regions at risk and subsequent "warnings" as surveillance data confirm earlier projections.

The committee emphasized, however, that early warning systems should not take the place of proven public health measures since there will always be some element of unpredictability in climate variations and disease outbreaks. Officials should continue to place a high priority on reducing people's overall vulnerability to infectious disease through vaccination programs, mosquito-control efforts, and water-treatment systems, it said.

The report was sponsored by the U.S. Environmental Protection Agency, Centers for Disease Control and Prevention, National Science Foundation, NASA, National Oceanographic and Atmospheric Administration, U.S. Geological Survey, U.S. Global Change Research Program, and the Electric Power Research Institute. The National Research Council is the principal operating arm of the National Academy of Sciences and National Academy of Engineering. It is a private, nonprofit institution that provides scientific and technical advice under a congressional charter.

Copies of **Under the Weather: Climate, Ecosystems, and Infectious Disease** will be available this summer from the National Academy Press at the mailing address in the letterhead; tel. (202) 334-3313 or 1-800-624-6242. Reporters may obtain a pre-publication copy from the Office of News and Public Information at the letterhead address (contacts listed above).

NATIONAL RESEARCH COUNCIL
Division on Earth and Life Studies
Board on Atmospheric Sciences and Climate

Committee on Climate, Ecosystems, Infectious Disease, and Human Health

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Remarks by Paul O'Neill
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Alcoa

SCIENCE, POLITICS & GLOBAL CLIMATE CHANGE

"THE ISSUE OF GLOBAL CLIMATE CHANGE AND THE POTENTIAL OF GLOBAL WARMING... DESERVE A SPECIAL APPROACH AND WAY OF THINKING ABOUT THEM — ONE THAT STARTS FROM A PERSPECTIVE OF STANDING OUTSIDE THE WORLD."

Reprint of an address on global climate change given by Paul O'Neill to the Spring Meeting of The Aluminum Association, Washington, D.C., March 6, 1998.

HOW I THINK ABOUT THE ISSUE OF GLOBAL CLIMATE CHANGE is significantly influenced by the ten years that I spent in the Executive Office of the President.

What I intend by that is this: I think there are certain issues that are different—issues that transcend individual companies and individual industries and individual countries. There are two that rise to a special level of consideration and concern. One is nuclear holocaust and the danger of renegade states having available to them nuclear weapons of mass destruction. The second is environmental: specifically, the issue of global climate change and the potential of global warming. These issues deserve a special approach and way of thinking about them—one that starts from a perspective of standing outside the world.

Why do I say this is affected by the ten years that I spent in the Executive Office of the President?

For some of you who live in this town, you know something about the Office of Management and Budget and what it is now, and some of you will know what it was in the past. In the time that I was there, I felt my responsibility was to make sure that the President of the United States—

"THE QUESTION IS: IF YOU WERE THE PRESIDENT, AND YOU WERE PRESENTED WITH SOME FACTS THAT SUGGESTED OUR BIOSPHERE MIGHT BE IN DANGER, WHAT WOULD YOU DO?"

and I served under Kennedy, Johnson, Nixon and Ford—had in front of him, for every issue that he had to deal with, the best information that the mind of man could distill.

Our job was the fact side. It was up to others to spoon in the political considerations which we, from our objective, rationalist, fact-based perspective, abhorred. We couldn't understand why anybody wouldn't just simply do what the facts said was the right thing. I tell you all of that to help you understand the cast of mind that I bring to this proposition. The question is: if you were the President, and you were presented with some facts that suggested our biosphere might be in danger, what would you do?

Defining the Issues

To begin, I think you would ask, what are the facts? What do we know?

On this issue we know one thing for sure. We know, without dispute, that the people of the world have been emitting so-called "greenhouse gases," most importantly carbon dioxide, into the atmosphere as we have developed our world economy, to a point that concentration levels of greenhouse gases over the last hundred years have increased very substantially.

There is no doubt that there are much higher levels of CO_2 in the atmosphere than existed a hundred years ago. It's also not disputable that CO_2 has a half-life of about one hundred years. This means that of the emissions we put in the atmosphere today, in the year 2098, 50% of them

will still be there. For those of you who are mathematically inclined, you'll understand that this means we have a growing level of concentrations, and they're building up if we don't do anything. There is no doubt about this issue.

There is another fact we can probably be sure about. The world's average temperature has increased maybe a half a degree over the last hundred years. Now, I say maybe we know it. But in a long-run analysis, we can't be sure.

One and a Half Facts

Now, after we say those two things, we don't know much more that we can really call a fact. That may be a surprise to you, because some of you may have seen comments made by some of our political leaders about storms in South Dakota and California being related to global climate change. I'm here to tell you, as one who investigates everything I can look at and read from academic journals, I don't think you can make those ties. I don't think there is a scientist who can say, "One plus one equals two, and here's a direct cause and effect relationship."

And so, I'm concerned that what we have are what I would call one and a half facts, and then we have conjecture, speculation, theory. That is not to say we should just dismiss it out of hand, but I think it's important to know what you do know and to be very clear about what you don't know in these issues, because if you're wrong, as distinguished from most things that we as human beings deal with, you don't get a second chance.

"IT'S IMPORTANT TO KNOW WHAT YOU DO KNOW AND TO BE VERY CLEAR ABOUT WHAT YOU DON'T KNOW IN THESE ISSUES, BECAUSE IF YOU'RE WRONG...YOU DON'T GET A SECOND CHANCE."

If you get welfare reform wrong, you get a second chance. Now, I have to say, even in social policy areas where we theorize and speculate and intervene, when we get it wrong, lots of individuals may suffer as a consequence. But civilization doesn't go down the drain. Regimes and politicians and the rest of us get second chances to deal with most of these things. For these two issues—nuclear holocaust and global climate change—we may not get a second chance. So I think we shouldn't dismiss the climate question out of hand. We should pay a lot of attention to it.

The Population Factor

Thinking about this issue the way those of you who are in the business community would think about an issue, you would make an inclusive analysis of the subject. In doing that, one of the first things you would

"YOU'VE NOT HEARD ANYTHING FROM ANY MAJOR POLITICIAN ABOUT A POPULATION QUESTION RELATED TO THIS. WHY NOT? IT'S A NASTY ISSUE. NOBODY WANTS TO TALK ABOUT HOW WE KEEP POPULATION FROM BECOMING THE MAJOR DRIVER OF ENERGY CONSUMPTION AND EMISSIONS."

encounter is this simple fact: human beings are major consumers of energy, and the better we are at economic development and the more highly developed we become, the more energy we use and the more emissions we put into the atmosphere. Now, why is that important? It's important because it says energy consumption and emissions are a function of population.

Today, we've got six-plus billion people in the world. And if you look at the models on which a lot of the conjecture, speculation and theory are based, they assume that in one hundred years we're going to have 11-plus billion people in the world. Now, again, as a rationalist, you don't just assume that that's the way it's going to be and we have to accept it, at least not if you're interested in dealing with all of the possible ways that you might cope with a problem of a global climate change and the prospect of global warming.

You've not heard anything from any major politician about a population question related to this. Why not? It's a nasty issue. Nobody wants to talk about how we keep population from becoming the major driver of energy consumption and emissions. And I say this to you because if you just sweep that issue away, you've swept away a major potential contributor to helping contain the global climate change problem.

Science and Politics

The next place to go with this issue is to the question of how much concentration of atmospheric gases we can stand. Interestingly enough, the President, in the program that he laid down over the last several months, has asked the National Academy of Sciences in Washington to develop an analysis and a position that we can all use to address this question of how much concentration of gases we can stand. To me, it's a very important question. I am very glad the President has asked the National Academy to do this.

But if you think about the logic of it, if you don't know what acceptable levels of concentration should be, how do you know what the targets for emission reduction should be? Well, the fact that we don't know the concentration levels didn't have any impact at all on what happened at the Global Climate Conference in Kyoto.

There, the developed nations, in the treaty that they laid down, agreed country by country how much emission reduction should take place in the period between the years 2008 and 2012. And so, there is the prospect of a commitment of the developed nations, including our own, to targets that are very specific and very precise in terms of what emissions would be permitted, and yet we don't know what the acceptable levels of concentration are; and I would say to you that this really puts the lie to the notion that we know what we're doing.

"IN KYOTO...THE DEVELOPED NATIONS AGREED... TO TARGETS THAT ARE VERY SPECIFIC AND VERY PRECISE IN TERMS OF WHAT EMISSIONS WOULD BE PERMITTED, AND YET WE DON'T KNOW WHAT THE ACCEPTABLE LEVELS OF CONCENTRATION ARE."

Dangerous Delays

What we got in Kyoto, by my reckoning, was a political accommodation, and let me say to you from a political point of view, one might argue that we have proceeded brilliantly. We've satisfied—although, for the people who are far out on this issue, there is no satisfaction short of stopping economic activity altogether and stopping energy consumption completely—but with that parenthetical, I would say we've accommodated those who are most concerned about this issue by establishing targets that are very aggressive, I think; and for those who think we don't know enough yet, we've given them satisfaction because there's no bite in any of this until 2008, if then.

So what was done in Kyoto has taken the issue off the front burner.

I believe a real danger to civilization is that, as a consequence of this "brilliant" political process, we don't do anything for ten years. That would not be a good idea, in my judgment, because I do think that global climate change may be a substantial issue that we need to deal with, and we should do it now.

Last August, I was invited to a meeting with the President and the Vice President and Bob Rubin, Secretary of the Treasury, and Janet Yellen, Chair of the Council of Economic Advisors, and the important people in the Administration working on this issue of global climate change. There were ten industrialists there, and we had the usual meeting you have in the Cabinet Room. We went around the table and everybody said what they had to say about these issues, and I said to the President and the Vice President, even more sharply than I've said to you, these same things. On the way out the President said, "If you have other thoughts and ideas, write me a note." So I did.

Leading by Educating

And what I said to him is something I continue to believe is correct. Number one, issues such as this one should not be dealt with in the usual political way. What do I mean by that? If you look at the way we deal with important, substantive issues, it's very hard to distinguish from how we sell soap powder and cereal. Which is to say, political leadership more and more doesn't accept the burden of educating. They proceed on a basis of indoctrination.

"I BELIEVE A REAL DANGER TO CIVILIZATION IS THAT, AS A CONSEQUENCE OF THIS 'BRILLIANT' POLITICAL PROCESS, WE DON'T DO ANYTHING FOR TEN YEARS. THAT WOULD NOT BE A GOOD IDEA."

"ONE OF THE THINGS THAT DISTINGUISHES THIS ISSUE OF GLOBAL CLIMATE CHANGE... IS THAT IT IS A SUBJECT THAT CAN BE ADDRESSED FROM A HARD SCIENCE PERSPECTIVE— NOT POLITICAL SCIENCE."

I believe this issue is so important that political leadership should educate, and by "educate" I mean tell the people what we do know and also tell them what we don't know. Doing so would be so unique that people would say, "This must really be a serious issue, the President is telling us things of uncertainty, that maybe there are things we don't know, and treating us like mature adults." That would certainly be novel.

First of all, the President could do a great good thing for this society by telling us the unvarnished truth about what we know and what we don't know about the dangers of not doing anything for the next ten years. We should then proceed as intelligent citizens and, in our own spheres of activity, to look for ways that we can make a contribution to energy conservation and emission reduction, without the overhanging threat of a government pounding us into submission or bribing us to do things that we ought to do anyway.

Step One: A Foundation of Facts

In my letter I said, "What I would do, what I would suggest that you do is, first of all, assign to a scientific body—I nominated the National Academy of Sciences (another place would be the Heinz Center for Science, Economics and the Environment)—the task of doing a primer for the American people." The primer would do a much more thorough job than what I've tried to do for you this morning in laying down, in clear, lay terms, what we know and what we don't know, clearly differentiating between facts and theory—and speculation and conjecture—so that everyone has the same starting set of facts and uncertainties to work with.

As I have said, in lots of things that political systems deal with, the propositions are arguable. How do you reduce the potential and the reality of drug abuse and drug addiction? The subject is wrapped up with complex issues of genetics and human behavior and social environmental considerations—really arguable propositions. One of the things that distinguishes this issue of global climate change and the prospect of global warming is that, to a significant degree, it is a subject that can be addressed from a hard science perspective—not political science. Parenthetically, some of what I've seen from hard scientists on this subject is amazing, because they are practicing political science—not basic, fundamental science.

Step Two: Reduce the Uncertainties

In any event, the first proposition for me is to get the facts straight. Let's know what we know and clearly identify what we don't know, and then I would urge the National Academy of Sciences to lay out very carefully those things that we don't know that could be clarified by a Manhattan Project level of intensive investment and massing of resources in order to reduce the uncertainties about the connection between concentrations of atmospheric gases and the dangers of global warming. There are a host of them.

Some of you who follow the issue closely have seen the comments from the Administration that we're spending $1.8 billion on this problem, and actually we've raised the amount in this new year's budget. But unless you're an old budget official, you probably never got the documents out to figure out what we're actually spending the money on.

The truth is, of the $1.8 billion in last year's budget, $1.2 billion was an allocation for satellites and the associated software to put up detection monitors that will help us better understand the concentrations—which, by deduction, means this great country last year spent $600 million on the larger non-satellite aspects of this question.

To put that amount in context, what we're talking about here—if we take the strongest medicine that's been recommended to reduce the levels of concentration—is an impact on the world economy going forward of maybe $3 trillion a year. So I say, I look in this hand and

"I LOOK IN THIS HAND AND I SEE $600 MILLION INVESTED IN SCIENTIFIC UNDERSTANDING, AND I LOOK OVER HERE AND SEE $3 TRILLION A YEAR OF IMPACT ON THE WORLD ECONOMY. I SAY THERE'S SOMETHING WRONG WITH THE BALANCE."

"IF YOU WANT TO KNOW WHO PAYS, IT'S LIKE EVERYTHING ELSE IN LIFE—PEOPLE WITH MONEY PAY. PEOPLE WHO DON'T HAVE MONEY DON'T PAY. IT'S A FAIRLY SIMPLE PROPOSITION. WE'RE GOING TO PAY, AND WE OUGHT TO. THIS IS A SERIOUS ISSUE."

I see $600 million invested in scientific understanding, and I look over here and see $3 trillion a year of impact on the world economy. I say there's something wrong with the balance. We're not investing nearly enough to reduce the uncertainty around the scientific principles related to this issue. We should be doing more.

Investing in Research

Now, how should we organize this? I think we should put together a whole smorgasbord list of unknown scientific propositions. Then we should ask how much would it cost to go after this issue? How long would it take to accumulate some new insights and knowledge? And, what is the probability of success after you put in the time and the expected cost? Then we can make some rank-order priority decisions on where we spend our money.

We shouldn't fool ourselves; a lot of it won't pay off. We all know research and development is an uncertain proposition. Nevertheless, I think we should be prepared to spend a lot more money on direct scientific investigation of the cause and effect relationships. We ought to do that in an organized, orderly way, and we ought to lead the world on it.

I'm amused to see the conversations people are having about who's going to pay for this. The developed countries say, "Well, we're not going to do this unless the developing countries do their part." I think it's true that the developing countries need to play a part in emission reduction and control, but if you want to know who pays, it's like everything else in life—people with money pay. People who don't have money don't pay. It's a fairly simple proposition. At the end of the day, we're going to pay, folks, believe it or not. We're going to pay, and we ought to. This is a serious issue. We ought to be prepared to pay and God knows, in a $1.7 trillion budget, we ought to be able to find enough money to do a massive, concentrated effort on this problem.

Industry Initiatives

Now, there is a second set of issues that should be put to this committee, having to do with a series of questions that touch on the aluminum industry.

There are many current uses of energy and consequent emissions that are significantly higher than they might be. In the normal course of our businesses we pay a lot of attention already to energy efficiency in

smelting, and we pay a lot of attention to the emissions that we're producing, especially the chlorofluorocarbon gases that have a major impact, much greater than the CO_2.

We're already paying a lot of attention to those issues. And other industries have the same kind of ongoing productivity improvement activities. Those things all flow naturally. We're all going to continue to work on those things, and I don't believe that the government ought to pay us money—let me say it this way—I don't believe the government ought to give us back some of our own money to get us to do things that we're going to do anyway.

One of the problems with lots of government interventions is that before they have any effect at the margin they have to buy up the base, and one of the things that's wrong with some of these tax credit ideas and grant programs that are part of this Administration's initiatives is that they don't actually accomplish anything except change the tax incidence. They don't have a significant effect on fundamental behavior or performance as compared with what it would have been anyway. So I'm not in favor of giving "we the people's" money back to us, including Alcoa, for something we're going to do anyway.

A Place for Partnerships

I am in favor of the government using "we the people's" money to do things that are not likely to be done otherwise. Let me then give you an example from our industry.

"WE PAY A LOT OF ATTENTION TO ENERGY EFFICIENCY IN SMELTING AND TO THE EMISSIONS THAT WE'RE PRODUCING...I DON'T BELIEVE THE GOVERNMENT OUGHT TO GIVE US BACK SOME OF OUR OWN MONEY TO GET US TO DO THINGS THAT WE'RE GOING TO DO ANYWAY."

"THERE IS A CLASS OF THINGS THAT COULD FUNDAMENTALLY ALTER THE ENERGY AND EMISSIONS EQUATIONS IF WE HAD THE MONEY TO GO WORK ON THEM WITH CLARITY ABOUT HOW MUCH IT MIGHT COST... HOW MUCH TIME IT WOULD TAKE... AND THE PROBABILITY OF SUCCESS."

If you look at the inherent energy efficiency of smelting as we do it today, about 50% of the energy we use in smelting aluminum actually gets stored as energy in the produced aluminum. The other 50% is wasted. Why is it wasted? Because of the nature of the design of the process and the way that it cools itself, so that a lot of energy value simply gets put into the atmosphere.

Now that suggests a huge opportunity. If you would let your mind roam a little and look at what's being done in some other industries with some other metals, you begin to think maybe there's a way, scientifically, that we could do direct reduction of bauxite. Those of you who are scientists will say, "Oh, my God, that's way out on the edge," but these are the kinds of things I think "we the people" and the government ought to entertain as scientific developmental projects that could make a big difference. This is one example from our industry.

There are other examples in other industries. The work being done credibly by the Department of Energy and others in the Administration, working with our companies, identifying things that might be done, is mostly incremental. It is mostly stuck with the proposition of improving things as they are.

What I'm suggesting is that there is a class of things that could fundamentally alter the energy and emissions equations if we had the money to go work on them with clarity about how much it might cost, with clarity about how much time it would take to see whether different ideas work, and clarity about the probability of success. Again, as a civilization, we would have a smorgasbord that we could invest in collectively to help with this issue.

Alternative Technologies

Now, an area that is really underdeveloped from a scientific point of view is looking at a different aspect of this whole question. Most of what you're told about this issue relates to energy conservation and emission reduction. Very little work has been done in looking scientifically at how we might deal with the emissions after they're emissions, which is to say going beyond the idea of forests as a carbon sink.

You have heard the outcry about cutting down the Brazilian rain forest and how the cutting contributes to global climate change because those forests represent a sink and the carbon goes back into the fiber cycle. So people are saying, "Well, we'll grow a lot of trees and that'll help."

If we cover the whole land mass with trees it would make a noticeable difference; but the oceans are also a big sink, and there has been some scientific work done that suggests if we could put collections of iron dust into isolated portions of the ocean—or we could grow a special kind of organism in the oceans—they could be carbon sinks that would make a huge difference in how much we have to worry about emissions because we'll have a new way of dealing with them.

A "further out" idea is salting the atmosphere with something that contributes to the reduction of greenhouse gases. These are areas that are largely unexplored. I believe we should induce and pay the scientific community and the engineering community, of which many of us are a part, to work in a more deliberate way on these things.

Needed: A Voice of Authority

I hope some of these ideas will see the light of day. I also said in my letter to—actually, I sent it to Erskine Bowles because, knowing how the White House operates, I figured if I send it directly to the President, it goes to the correspondence group; and they send you a nice note saying, "Thank you very much for your letter to the President. He's really glad you like his programs..."

But if you send it to Erskine Bowles, he actually gets the mail, or at least somebody close to the Oval Office gets the mail, so I sent it to Erskine. In this letter I also said to him, "I really think this issue would be helped a lot by the appointment of a person that everyone in the country can

believe in, someone who is so respected and apolitical that he or she can become an educating force and a voice of authority with some continuity as Administrations change in dealing with this issue."

The two people that I nominated in my letter were Bill Perry, the former Secretary of Defense, who is also a scientist, and Harold Brown, a former Secretary of Defense and a scientist who, incidentally, got his Ph.D. from Columbia when he was 21. The guy is a flaming genius and a great, public-spirited person.

Often organizational devices play an important part in whether or not you can really make progress on an issue. Bill Ruckelshaus is another example of the kind of person who could bring a new stature to this issue by dealing with it in the apolitical way that I've suggested to you. So I think those are important things we might do.

Looking at Aluminum

Let me talk more directly to our industry.

There are important things that we can do as an industry. Many of you are involved in or know about the work that George Haymaker has gotten started at the International Primary Aluminium Institute, where we've agreed that we will work on life cycle analysis. One of the things we need to do now as an industry is to be clear about our own facts.

We need to create a scientific base that enables us all to say, "These are the facts. As best the mind of man is able to do it, this captures the

"THIS IS GOING TO BECOME A MORE SERIOUS ISSUE. WE NEED TO GET OUT IN FRONT OF IT. WE NEED TO CREATE A FACT BASE THAT WE ALL BELIEVE IN—THAT WE CAN SHARE—THAT IS IN FACT BULLETPROOF. WE MAY NOT LIKE SOME OF WHAT WE FIND, BUT WE SHOULD DO IT."

situation for products in our industry." Eventually, there are going to be challenges, as between products. There have been some guerrilla skirmishes around these issues over the last 20 or 30 years. This is going to become a more serious issue. We need to get out in front of it. We need to create a fact base that we all believe in—that we can share—that is, in fact, bulletproof. We may not like some of what we find, but we should do it, and we shouldn't wait for the government to pay us to do it. We shouldn't argue about it; we ought to just get on with it. We're doing that.

Within Alcoa, we have created a committee of people representing our worldwide activities. We're going at this issue directly in terms of our own operations, looking at energy efficiencies, what else might we do, and trying to identify other things like the smelting example that I've given to you, so that we can contribute ideas to the broader community about things that deserve to be on the agenda.

Energy and the Product Cycle

One more thing I'll share with you: we've got to look at products. I'll give you an example and you can make up your own cases. If you look at energy efficiency from a product point of view—let me use wing planks for Boeing or other structural parts for aircraft as an example—if you look from the beginning of a bauxite mine through the whole process to that final piece of material that goes on a Boeing aircraft, the amount of energy that's consumed through that whole cycle that ends up on the plane is about 10%. It is true of a lot of the products that we all make.

"THIS IS AN ISSUE THAT IS POTENTIALLY SO IMPORTANT THAT I THINK INTELLIGENT CITIZENS NEED TO BECOME INFORMED AND NEED TO STAY INFORMED AND NEED TO TAKE THEIR OWN ACTION."

In thinking about this problem, we're going to have to go outside our own company thought process and think in a different way with the people who are consuming or incorporating our materials about how, together, we can make a major contribution to energy efficiency. If we could line up all these activities and think about them from the point of view of conservation of materials and energy, we might get a different answer. We would do something that is much closer to near net shapes. Right now, there is enormous waste because of the way society is organized to produce goods.

I encourage you at the end to say to yourself, "This is a different class of issue." There are some things about which you probably ought to say, "I'm not going to worry about this because it's outside my area of specialization and, in a world of Adam Smith economics, I'm going to concentrate on what I'm good at and let somebody else work on the

other things." This is an issue that is potentially so important that I think intelligent citizens need to become informed and need to stay informed and need to take their own action.

A Positive Approach

I'd make one final plea to you. And I'd example it by something that's now happening that I think is terrific. More and more, if we want a better life and a better economic situation and better living conditions around the world, the answer won't be found in the government. What we do in our individual lives and responsibilities matters, and the global climate change issue is one where I think those of us in positions of responsibility, if we're going to pretend to be leaders, need to actually lead and not wait for somebody to hammer us into submission.

In that regard, I can't tell you how delighted I am to see the actions that are now being taken by the U.S. automotive industry because they are now leading. They have decided, individually and collectively, that they're going to stop arguing about government intervention, and they're going to get themselves into a position—this is my prediction now—where they're going to have a defensible base to say: "We're doing everything we can do, we're working hard on it, we're producing more and more energy efficient vehicles, we're proud of what we're doing, and we're prepared to argue with anybody who would burden us with something else, when we're already doing all the right things." I think that's the condition we as an industry should be in—that we're taking the lead,

we're showing the way, we're identifying where the future should go.

Now, one more thing—this idea of trading emission limits is not a bad idea. But we need to test it in a way that is consistent with the enormity of the notion of applying this idea to the world economy. We really don't know how to answer a lot of the questions about emissions trading.

As an example, most of the emission trading schemes start with a proposition that says, "Everyone should reduce emissions." Now, if you think about it, Norway is a place that has enormous undeveloped hydropower resource potential, and they've got enormous gas reserves that have not yet been tapped.

I would nominate Norway as a place where emissions ought to go up. If you think about our industry now: where should our industry, especially the energy-intensive part of it, be located in the next century in the context of global climate change? As a basic principle, we ought to be using hydro-power where there are not great pressures from dense population. Now, it won't all be there, but that is where it ought to be heading, which says Norway ought to be a major smelting country in the next century.

I do urge you to be citizens of the world on this issue and get outside the envelope of your individual responsibilities. Thank you very much.

"WHAT WE DO IN OUR INDIVIDUAL LIVES AND RESPONSIBILITIES MATTERS, AND THE GLOBAL CLIMATE CHANGE ISSUE IS ONE WHERE I THINK THOSE OF US IN POSITIONS OF RESPONSIBILITY, IF WE'RE GOING TO PRETEND TO BE LEADERS, NEED TO ACTUALLY LEAD AND NOT WAIT FOR SOMEBODY TO HAMMER US INTO SUBMISSION."

Global warming in the twenty-first century: An alternative scenario

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Contributed by James Hansen, June 16, 2000

A common view is that the current global warming rate will continue or accelerate. But we argue that rapid warming in recent decades has been driven mainly by non-CO_2 greenhouse gases (GHGs), such as chlorofluorocarbons, CH_4, and N_2O, not by the products of fossil fuel burning, CO_2 and aerosols, the positive and negative climate forcings of which are partially offsetting. The growth rate of non-CO_2 GHGs has declined in the past decade. If sources of CH_4 and O_3 precursors were reduced in the future, the change in climate forcing by non-CO_2 GHGs in the next 50 years could be near zero. Combined with a reduction of black carbon emissions and plausible success in slowing CO_2 emissions, this reduction of non-CO_2 GHGs could lead to a decline in the rate of global warming, reducing the danger of dramatic climate change. Such a focus on air pollution has practical benefits that unite the interests of developed and developing countries. However, assessment of ongoing and future climate change requires composition-specific long-term global monitoring of aerosol properties.

climate change | greenhouse gases | aerosols | air pollution

The global surface temperature has increased by about 0.5°C since 1975 (1, 2), a burst of warming that has taken the global temperature to its highest level in the past millennium (3). There is a growing consensus (4) that the warming is at least in part a consequence of increasing anthropogenic greenhouse gases (GHGs).

GHGs cause a global climate forcing, i.e., an imposed perturbation of the Earth's energy balance with space (5). There are many competing natural and anthropogenic climate forcings, but increasing GHGs are estimated to be the largest forcing and to result in a net positive forcing, especially during the past few decades (4, 6). Evidence supporting this interpretation is provided by observed heat storage in the ocean (7), which is positive and of the magnitude of the energy imbalance estimated from climate forcings for recent decades (8).

The Intergovernmental Panel on Climate Change (IPCC) (4) has considered a range of scenarios for future GHGs, which is further expanded in its *Special Report on Emissions Scenarios* (9). Yet global warming simulations have focused on "business as usual" scenarios with rapidly increasing GHGs. These scenarios yield a steep, relentless increase in global temperature throughout the twenty-first century (4, 10) with warming of several degrees Celsius by 2100, if climate sensitivity is 2–4°C for doubled CO_2, as climate models suggest (4, 11–13). These figures can give the impression that curtailment of global warming is almost hopeless. The 1997 Kyoto Protocol, which calls for industrialized nations to reduce their CO_2 emissions to 95% of 1990 levels by 2012 (14), is itself considered a difficult target to achieve. Yet the climate simulations lead to the conclusion that the Kyoto reductions will have little effect in the twenty-first century (15), and "30 Kyotos" may be needed to reduce warming to an acceptable level (16).

We suggest equal emphasis on an alternative, more optimistic, scenario. This scenario focuses on reducing non-CO_2 GHGs and black carbon during the next 50 years. Our estimates of global climate forcings indicate that it is the non-CO_2 GHGs that have caused most observed global warming. This interpretation does not alter the desirability of limiting CO_2 emissions, because the future balance of forcings is likely to shift toward dominance of CO_2 over aerosols. However, we suggest that it is more practical to slow global warming than is sometimes assumed.

Climate Forcings in the Industrial Era

Fig. 1 shows graphs of estimated climate forcings since 1850, which are similar to previous presentations (4, 6). Forcings for specific GHGs differ by as much as several percent from values we estimated earlier: CO_2 (−1%), CH_4 (+2%), N_2O (−3%), chlorofluorocarbon 11 (CFC-11) (+6%), and CFC-12 (+8%). Our prior results, used by the IPCC (4), were analytic fits to calculations with a one-dimensional radiative-convective model (17). The present results (Table 1) are based on calculations of adjusted radiative forcing (5), using the SI2000 version of the Goddard Institute for Space Studies three-dimensional climate model (8, 13), with the absorption coefficients fit to line-by-line radiative transfer calculations, using current HITRAN (18) absorption line data. Thus the present results are improved in several ways.

Estimated Forcings. We separate CO_2, CH_4, and CFCs in Fig. 1 because they are produced by different processes and have different growth rates. We associate with CH_4 its indirect effects on tropospheric O_3 and stratospheric H_2O to make clear the importance of CH_4 as a climate forcing. We assume that one-fourth of the 0.4 W/m^2 climate forcing due to increasing tropospheric O_3 is caused by increasing CH_4 (chapter 2 in ref. 4; ref. 19). We calculate an indirect effect of 0.1 W/m^2 for CH_4 oxidized to H_2O in the stratosphere (20). The recent trend of stratospheric H_2O (20, 21) is even larger than CH_4 could cause, but part of the observed trend may be a result of transport from the troposphere.

The estimated negative forcing due to stratospheric O_3 depletion, −0.1 W/m^2, is smaller than the −0.2 W/m^2 that we used earlier (6) because of changes in the vertical profile of O_3 depletion estimated from observations. O_3 trends recommended by the World Meteorological Organization (22) have less depletion in the tropopause region (where O_3 loss causes surface cooling) and greater loss in the middle stratosphere (where O_3 loss causes surface warming) compared with the O_3 changes that we used previously (5, 6).

Climate forcing by CO_2 is the largest forcing, but it does not dwarf the others (Fig. 1). Forcing by CH_4 (0.7 W/m^2) is half as large as that of CO_2, and the total forcing by non-CO_2 GHGs (1.4 W/m^2) equals that of CO_2. Moreover, in comparing forcings

Abbreviations: GHGs, greenhouse gases; CFCs, chlorofluorocarbons; IPCC, Intergovernmental Panel on Climate Change.

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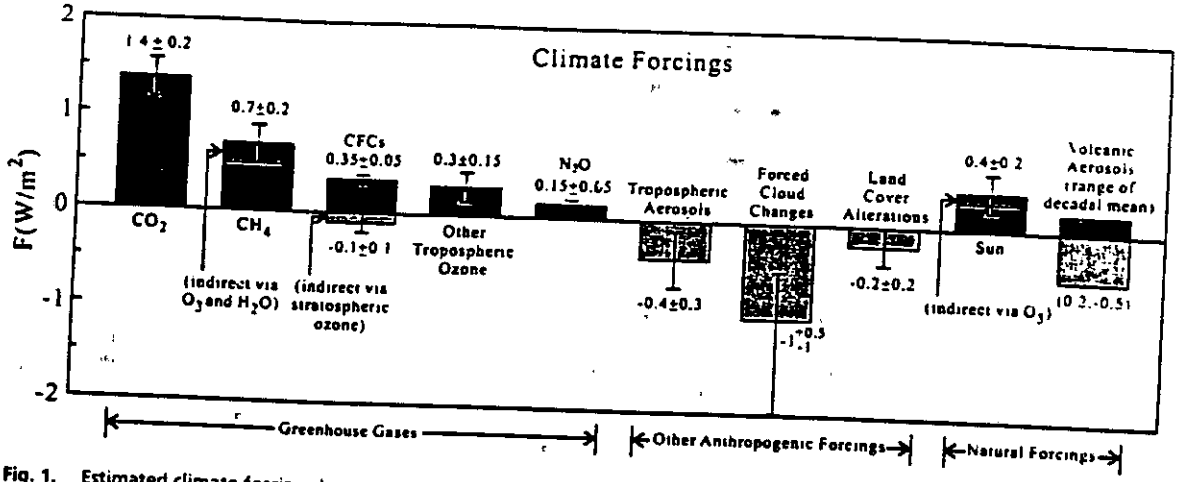

Fig. 1. Estimated climate forcings between 1850 and 2000.

due to different activities, we must note that the fossil fuels producing most of the CO_2 are also the main source of aerosols, especially sulfates, black carbon, and organic aerosols (4, 23). Fossil fuels contribute only a minor part of the non-CO_2 GHG growth via emissions that are not essential to energy production.

Aerosols cause a climate forcing directly by reflecting sunlight and indirectly by modifying cloud properties. The indirect effect includes increased cloud brightness, as aerosols lead to a larger number and smaller size of cloud droplets (24), and increased cloud cover, as smaller droplets inhibit rainfall and increase cloud lifetime (25). Absorbing aerosols cause a semidirect forcing by heating the atmosphere, thus reducing large-scale cloud cover (5). In addition, absorbing aerosols within cloud drops and in interstitial air decrease cloud brightness.

Forcing by atmospheric aerosols is uncertain, but research of the past decade indicates that it is substantial (4, 26–28). The aerosol forcing that we estimate (6) has the same magnitude (1.4 W/m^2) but a sign that is opposite that of the CO_2 forcing. Fossil fuel use is the main source of both CO_2 and aerosols, with land conversion and biomass burning also contributing to both forcings. Although fossil fuels contribute to growth of some of the other GHGs, it follows that the net global climate forcing due to processes that produced CO_2 in the past century probably is much less than 1.4 W/m^2. This partial offsetting of aerosol and greenhouse forcings has been discussed (29–31). Offsetting of global mean forcings does not imply that climate effects are negligible.

A corollary following from Fig. 1 is that climate forcing by non-CO_2 GHGs (1.4 W/m^2) is nearly equal to the net value of all known forcings for the period 1850–2000 (1.6 W/m^2). Thus, assuming only that our estimates are approximately correct, we assert that the processes producing the non-CO_2 GHGs have been the primary drive for climate change in the past century.

Table 1. Greenhouse gas radiative forcings

Gas	Radiative forcing
CO_2	$F = f(c) - f(c_o)$, where $f(c) = 4.996 \ln (c + 0.0005c^2)$
CH_4	$F = 0.0406(\sqrt{m} - \sqrt{m_o}) - [g(m, n_o) - g(m_o, n_o)]$
N_2O	$F = 0.136(\sqrt{n} - \sqrt{n_o}) - [g(m_o, n) - g(m_o, n_o)]$, where $g(m, n) = 0.5 \ln [1 + 2 \times 10^{-5}(mn)^{0.75}]$
CFC-11	$F = 0.264(x - x_o)$
CFC-12	$F = 0.323(y - y_o)$

c, CO_2 (ppm); m, CH_4 (ppb); n, N_2O (ppb); x/y, CFC-11/12 (ppb)

Consistency Checks. Two empirical pieces of information are consistent with our estimated net climate forcing: (*i*) global warming of the past century and (*ii*) observed heat storage in the ocean. The second of these is direct and fundamental.

Paleoclimate data (13, 32, 33) imply that the equilibrium global climate sensitivity for doubled CO_2 (a forcing of about 4 W/m^2) is 3 ± 1°C (thus ¾ ± ¼°C per W/m^2). This figure is similar to the sensitivity derived from climate models (4, 12), but it has a higher precision and confidence level. This climate sensitivity implies a thermal response time of the ocean surface of 50–100 years (32, 34). One implication of this ocean response time is that the observed global warming of ½°C since the late 1800s is consistent with the equilibrium warming of 1.2°C that a forcing of 1.6 W/m^2 implies, because about 70% of the forcing was introduced in the last 50 years (6, 35). The remaining global warming of 0.4–0.5°C that is "in the pipeline" is consistent with the present planetary energy imbalance of 0.6 ± 0.1 W/m^2 (8).

The ocean is the only place that the energy from a planetary radiation imbalance can accumulate, because of the low thermal conductivity of land and the limit on ice melting implicit in the observed sea level rise (36). Thus observed ocean heat storage requires a planetary energy imbalance of the same magnitude. Analyses of global ocean data (7) reveal that ocean heat content increased by 2×10^{23} joules between the mid-1950s and the mid-1990s. This heat storage could be a natural dynamical fluctuation. But the simplest interpretation is that the change in ocean heat content and the implied planetary energy imbalance are a reflection of the net global climate forcing. Observed heat storage between the mid-1950s and mid-1990s yields a mean heating of 0.3 W/m^2 averaged over the Earth's surface for that period (7). This finding is consistent with the ocean heat storage simulated in global climate models that use the forcings of Fig. 1; the heat storage in the models increases from near zero in the 1950s to a mean of 0.5 W/m^2 in the 1990s (8, 35). Thus observed ocean heat storage provides empirical evidence for the sign and approximate magnitude of the net climate forcing of Fig. 1.

Greenhouse Gas Growth Rates

Atmospheric amounts of the principal human-influenced GHGs have been monitored in recent years and extracted for earlier times from bubbles of air trapped in polar ice sheets (37). Gases that cause the largest climate forcings, CO_2 and CH_4, are shown in Fig. 2. IPCC IS92 scenarios (chapter 2 in ref. 4) for the next 50 years are also shown in Fig. 2. IS92a, at least so far, has been the most popular scenario for climate model simulations.

These climate forcing projections involve many assumptions and are very uncertain. The IS92a forcing for all well-mixed

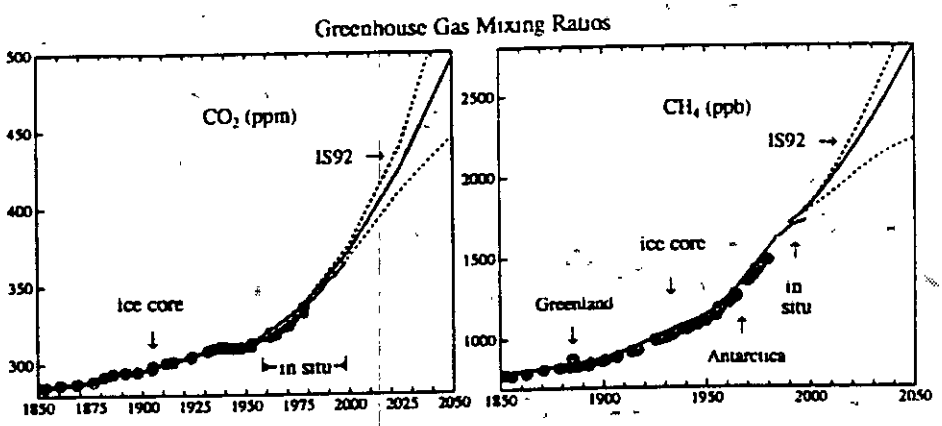

Fig. 2. Atmospheric CO_2 and CH_4 observations and range of IS92 scenarios (the solid red line is IS92a).

GHGs, including CFCs, was already a 15% reduction from the principal 1990 IPCC scenario (38). The observed increase in CH_4 in the 1990s falls below the lowest IS92 scenario, whereas CO_2 falls on the lowest IS92 scenario.

Trends of the climate forcings are revealed better by their annual growth rates, as shown in Fig. 3 for anthropogenic GHGs. The forcings are calculated from the equations of Table 1. The CO_2 and CH_4 amounts for 1999 were kindly provided by Ed Dlugokencky and Tom Conway of the National Oceanic and Atmospheric Administration Climate Monitoring and Diagnostics Laboratory (personal communication).

Carbon Dioxide. The growth rate of forcing by CO_2 doubled between the 1950s and the 1970s (Fig. 3*A*) but was flat from the late 1970s until the late 1990s, despite a 30% increase in fossil fuel use (39). This finding implies a recent increase in terrestrial and/or oceanic sinks for CO_2, which may be temporary. The largest annual increase of CO_2, 2.7 ppm, occurred in 1998. The annual increase was 2.1 ppm in 1999, although the growth rate had decreased to 1.3 ppm/year by the end of the year.

Methane. A dramatic growth rate change has occurred for CH_4 (Fig. 3*B*). The small interannual variability of CH_4 before 1982 reflects smoothing inherent in ice core data (37). Factors that may have slowed the CH_4 growth rate are recognized, as discussed below, but most of them are not accurately quantified.

CFCs. The growth rate of the two principal CFCs is near zero (Fig. 3*C*) and will be negative in the future as a result of production restrictions imposed by the Montreal Protocol (40). Other CFCs together cause a climate forcing that may approach that of CFC-12 early in the twenty-first century (4, 41). But most of these are being phased out, and, assuming compliance with production agreements (42), the net change in CFC climate forcing in the next 50 years will be small, as discussed below.

The Three Largest Climate Forcings

The largest anthropogenic climate forcings, by CO_2, CH_4, and aerosols (Fig. 1), pose the greatest uncertainties in attempts to project future climate change.

Carbon Dioxide. Coal and oil are now about equal sources of CO_2 emissions (Fig. 4). Coal is the source of potentially large future emissions, as its known resources are an order of magnitude greater than those of either oil or gas (43). Coal use has declined in much of the world, but it has been increasing in the United States and China (39, 43).

The increase in atmospheric CO_2 in recent decades (Fig. 2) represents about half of the emissions from fossil fuels and changes in tropical land use; the remaining CO_2 from these sources is taken up by the ocean, terrestrial biosphere, and soils. The flat growth rate of CO_2 forcing, despite increased emissions, is at least in part a reflection of increased terrestrial sequestration of carbon in the 1990s (44). The slowing growth rate of emissions may itself allow a higher proportion of CO_2 emissions to be sequestered. Thus the prognosis for future sequestration is uncertain, but maintenance of a flat growth rate of CO_2 forcing surely requires a flattening of the growth rate of fossil fuel emissions, which have grown 1.2%/year since 1975 (Fig. 4).

Methane. The decline in the CH_4 growth rate (Fig. 3*B*) probably is caused in part by changes of chemical emissions (such as CO and NO_4) that affect OH, the primary sink for CH_4 (19, 45, 46). However, a reduced growth rate of CH_4 sources also may be involved (37, 47). The short lifetime of CH_4, about 8 years, means that a reduction of several percent in a major source could have

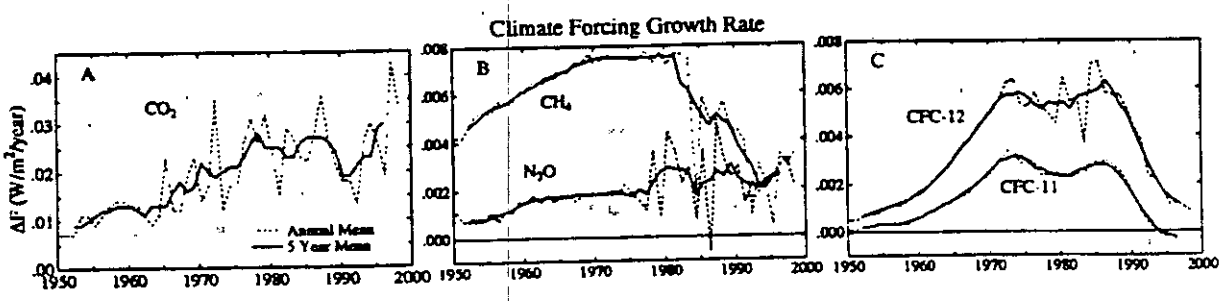

Fig. 3. Growth rates of climate forcings by individual GHGs—CO_2 (*A*), CH_4 and N_2O (*B*), and CFC-11 and CFC-12 (*C*)—based on trace gas data available from the National Oceanic and Atmospheric Administration Climate Monitoring and Diagnostics Laboratory.

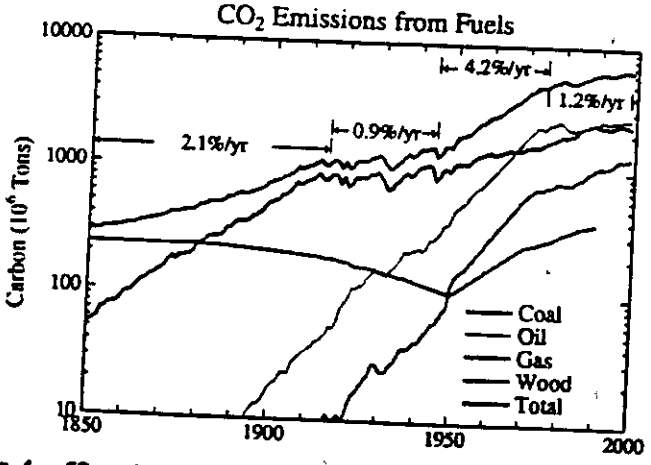

Fig. 4. CO_2 emissions from fuel use (40). The estimate for wood is by N. Makarova (The Rockefeller University; personal communication).

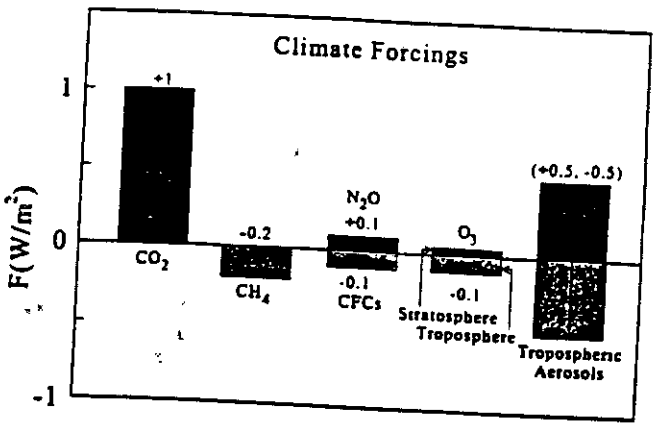

Fig. 5. A scenario for additional climate forcings between 2000 and 2050. Reduction of black carbon moves the aerosol forcing to lower values.

caused the reduced growth rate of CH_4. Sources and sinks of CH_4 are not known to that accuracy (19, 45, 48).

The primary natural source of CH_4 is microbial decay of organic matter under anoxic conditions in wetlands (45, 49). Anthropogenic sources, which in sum may be twice as great as the natural source (45), include rice cultivation, domestic ruminants, bacterial decay in landfills and sewage, leakage during the mining of fossil fuels, leakage from natural gas pipelines, and biomass burning. Global warming could cause the natural wetland source to increase (49), but if warming causes a drying of wetlands, it might reduce the CH_4 source.

Aerosols. Climate forcing by anthropogenic aerosols may be the largest source of uncertainty about future climate change. The approximate global balancing of aerosol and CO_2 forcings in the past (Fig. 1) cannot continue indefinitely. As long-lived CO_2 accumulates, continued balancing requires a greater and greater aerosol load. Such a solution, we have argued (30), would be a Faustian bargain. Detrimental effects of aerosols, including acid rain and health impacts, will eventually limit the permissible atmospheric aerosol amount and thus expose latent greenhouse warming.

We do not even know the sign of the current trend of aerosol forcing, because such information would require knowledge of the trends of different aerosol compositions. Direct aerosol forcing depends on aerosol single scattering albedo (5, 50) and thus on the amount of absorbing constituents. Indirect aerosol forcing also depends on aerosol absorption, through the semi-direct effect on cloud cover (5) and the cloud particle single scattering albedo. Calculations for cloud particles with imbedded black carbon cores (51) suggest an effect on cloud albedo at distances up to 1,000 km from the carbon aerosol source.

An Alternative Scenario

Let us propose a climate forcing scenario for the next 50 years that adds little forcing (Fig. 5), less than or about 1 W/m^2, and then ask whether the elements of the scenario are plausible. The next 50 years is the most difficult time to affect CO_2 emissions, because of the inertia of global energy systems, as evidenced by Fig. 4. The essence of the strategy is to halt and even reverse the growth of non-CO_2 GHGs and to reduce black carbon emissions. Such a strategy would mitigate an inevitable, even if slowing, growth of CO_2. By midcentury improved energy efficiency and advanced technologies, perhaps including hydrogen-powered fuel cells, should allow policy options with reduced reliance on fossil fuels and, if necessary, CO_2 sequestration.

Carbon Dioxide. This scenario calls for the mean CO_2 growth rate in the next 50 years to be about the same as in the past two decades. The additional forcing in 50 years is about 1 W/m^2 for an average annual CO_2 increment of 1.5 ppm.

Is such a CO_2 growth rate plausible? We note that the CO_2 growth rate increased little in the past 20 years, while much of the developing world had rapid economic growth. The United States also had strong growth with little emphasis on energy efficiency, indeed with increasing use of energy-inefficient sports utility vehicles. This fact suggests that there are opportunities to achieve reduced emissions consistent with strong economic growth. Limiting CO_2 growth to 75 ppm in the next 50 years probably requires a moderate decrease in CO_2 emission rates, as continuation of high terrestrial sequestration of CO_2 is uncertain.

In the near term (2000–2025) this scenario can be achieved by improved energy efficiency and a continued trend toward decarbonization of energy sources, e.g., increased use of gas instead of coal. Technologies for improved efficiency exist (ref. 52; available at www.natcap.org), and implementation can be driven by economic self-interest, but governments need to remove barriers that discourage buying of energy efficiency (53). Business-as-usual scenarios often understate a long-term trend toward decarbonization of the energy supply (figure 8 in ref. 54), but the IPCC *Special Report on Emissions Scenarios* (9) includes a subset that is consistent with our CO_2 scenario.

In the longer term (2025–2050) attainment of a decreasing CO_2 growth rate will require greater use of energy sources that produce little or no CO_2. Some renewable energy systems will be developed without concern for climate. But if such systems are to play a substantial role by the second quarter of the century, it is important to foster research and development investments now in generic technologies at the interface between energy supply and end use—e.g., gas turbines, fuel cells, and photovoltaics (43).

Methane. Our scenario aims for a forcing of −0.2 W/m^2 for CH_4 change in the next 50 years. This goal requires the reduction of anthropogenic CH_4 sources by about 30%. Most CH_4 sources are susceptible to reductions, many in ways that are otherwise beneficial (55, 56). Reduction of CH_4 would have the added benefit of increasing atmospheric OH and reducing tropospheric O_3, a pollutant that is harmful to human health and agriculture (57).

The amount of CH_4 produced by rice cultivation, perhaps the largest anthropogenic source, depends on cultivar choice (58), irrigation management (59), and fertilization (60). Mitigation strategies that maintain yields include intermittent irrigation

(61), with the added advantage of reducing plant pests and malaria-carrying mosquitoes. Ruminants offer substantial potential for emission reduction via dietary adjustments (62), as the farmer's objective is to produce meat, milk, or power from the carbon in their feed, not CH_4. CH_4 losses from leaky natural gas distribution lines could be reduced, especially in the former Soviet Union, which is served by an old system that was built without financial incentives to reduce losses (63). Similarly, CH_4 escaping from landfills, coal mining and oil drilling sites, and anaerobic waste management lagoons can be reduced or captured, with economic benefits that partially or totally offset the costs (56).

The economic benefits of CH_4 capture probably are insufficient to bring about the 30% CH_4 reduction that we suggest. But with additional incentives—e.g., as part of multigas strategies for limiting GHG climate forcing (64)—a 30% reduction in CH_4 sources seems reasonable. In addition, it will be necessary to avoid new large CH_4 sources. For example, in new pipeline distribution systems in Asia it will be important to use technology that minimizes losses.

The pollutant carbon monoxide (CO) contributes to increased CH_4 and O_3 through its effect on OH (65, 66). A small downward trend in atmospheric CO has occurred in recent years, apparently as a result of pollution control in Western countries (67). More widespread use of advanced technologies that reduce CO emissions will help achieve CH_4 and O_3 reductions.

CFCs. The Montreal Protocol is aimed at reversing stratospheric ozone depletion. A secondary benefit is reduction of climate forcing by the controlled gases. If production phase-out follows the current plan (40), the forcing by controlled gases will be about 0.15 W/m^2 less in 2050 than at present, primarily because of declining amounts of CFC-12 and CFC-11. Uncontrolled gases, some of which are substitutes for ozone-depleting chemicals, are likely to increase and cause a positive forcing of about that same magnitude in the next 50 years; the largest contributor to this forcing is HFC-134a (chapter 2 of ref. 4).

Verification of the CFC phase-out requires continuing attention and atmospheric monitoring (42), but overall the protocol has been a model of international environmental cooperation. The Protocol's Multilateral Fund recently approved $150 million for China and $82 million for India, the two largest remaining producers, for complete phase-out of their CFC production (40). The cost of the fund over a decade was about $1 billion (40).

At present the net change in climate forcing by these gases over the next 50 years is expected to be about zero. If the phase-out were extended to include additional gases, such as HFC-134a, and destruction of the accessible bank of CFC-12, a negative forcing change of -0.1 W/m^2 would seem possible.

Tropospheric Ozone. Climate forcing by anthropogenic tropospheric O_3 is now 0.4 ± 0.15 W/m^2 (4, 6). Principal precursor emissions are volatile organic compounds and nitrogen oxides (NO_x) (57, 68). Primary sources of the precursors are transportation vehicles, power plants, and industrial processes (57). Business-as-usual scenarios have O_3 continuing to increase in the future (4, 68). Because O_3 in the free troposphere can have a lifetime of weeks, tropospheric O_3 is a global problem; e.g., emissions in Asia are projected to have a significant effect on air quality in the United States. High levels of O_3 have adverse health and ecosystem effects. Annual costs of the impacts on human health and crop productivity are each estimated to be on the order of $10 billion/year in the United States alone.

Despite limited success of past attempts to reduce O_3 (57), the human and ecological costs of this pollutant suggest that it should be a target for international cooperation in the next half-century. Air pollution in some Asian regions is already extreme, with high ecological and health costs. Unlike the Kyoto negotiations on CO_2 emissions, which cast the developed and developing worlds as adversaries, all parties should have congruent objectives regarding O_3. Analogous to the approach to CFCs, sharing of technology may have mutual environmental and economic benefits.

Tropospheric O_3 is decreasing downwind of regions such as Western Europe, where NO_x emissions are controlled (67), but increasing downwind of East Asia (69). There is a clear potential for cleaner energy sources and improved combustion technology to achieve an O_3 reduction. Our scenario assumes that a small reduction of tropospheric O_3 forcing, at least sufficient to balance the expected rebound of stratospheric O_3, is plausible by 2050.

Aerosols. Aerosols, unlike GHGs, are not monitored to an accuracy defining their global forcing and its temporal change. It is often assumed (4) that aerosol forcing will become more negative in the future, which would be true if all aerosols were to increase in present proportions. However, it is just as likely that aerosol forcing will become less negative. Such an outcome is possible, e.g., if nonabsorbing sulfates decrease because of regulations aimed at reducing acid rain.

Black carbon reduces aerosol albedo, causes a semidirect reduction of cloud cover, and reduces cloud particle albedo. All of these effects cause warming. Conceivably a reduction of climate forcing by 0.5 W/m^2 or more could be obtained by reducing black carbon emissions from diesel fuel and coal. This reduction might become easier in the future, with more energy provided via electricity grids from power plants (43). But a quantitative understanding of the role of absorbing aerosol in climate change is required to formulate reliable policy recommendations.

Aerosols have to be monitored globally, thus by satellite, because of their heterogeneity. Measurements must yield precise aerosol optical depth, size distribution, and composition to define the direct forcing and provide data to analyze indirect effects. Such measurements are possible with precision multispectral (UV to infrared) polarimetry, with each region viewed over a wide range of angles (70). These data should be accompanied by visible imaging for scene definition and infrared interferometry to yield a temperature profile and cloud properties. Simultaneous lidar data could provide precise vertical profiles of the aerosols.

Summary

Business-as-usual scenarios provide a useful warning about the potential for human-made climate change. Our analysis of climate forcings suggests, as a strategy to slow global warming, an alternative scenario focused on reducing non-CO_2 GHGs and black carbon (soot) aerosols. Investments in technology to improve energy efficiency and develop nonfossil energy sources are also needed to slow the growth of CO_2 emissions and expand future policy options.

A key feature of this strategy is its focus on air pollution, especially aerosols and tropospheric ozone, which have human health and ecological impacts. If the World Bank were to support investments in modern technology and air quality control in India and China, for example, the reductions in tropospheric ozone and black carbon would not only improve local health and agricultural productivity but also benefit global climate and air quality.

Non-CO_2 GHGs. These gases are probably the main cause of observed global warming, with CH_4 causing the largest net climate forcing. There are economic incentives to reduce or capture CH_4 emissions, but global implementation of appropriate practices requires international cooperation. Definition of

appropriate policies requires better understanding of the CH_4 cycle, especially CH_4 sources.

Climate forcing by CFCs and related chemicals is still growing today, but if Montreal Protocol restrictions are adhered to, there should be no net growth in this forcing over the next 50 years. A small decrease from today's forcing level is possible, at least comparable in magnitude to the expected small rebound in stratospheric O_3 forcing.

Tropospheric O_3 increases in business-as-usual scenarios, which assume that CH_4 increases and that there is no global effort to control O_3 precursors. Despite limited success in past efforts to reduce O_3, the human health and ecological impacts of O_3 are so great that it represents an opportunity for international cooperation. At least it should be possible to prevent tropospheric O_3 forcing in 2050 from exceeding that of today.

Carbon Dioxide. CO_2 will become the dominant climate forcing, if its emissions continue to increase and aerosol effects level off. Business-as-usual scenarios understate the potential for CO_2 emission reductions from improved energy efficiency and decarbonization of fuels. Based on this potential and current CO_2 growth trends, we argue that limiting the CO_2 forcing increase to 1 W/m^2 in the next 50 years is plausible.

Indeed, CO_2 emissions from fossil fuel use declined slightly in 1998 and again in 1999 (71), while the global economy grew. However, achieving the level of emissions needed to slow climate change significantly is likely to require policies that encourage technological developments to accelerate energy efficiency and decarbonization trends.

Aerosols. Climate forcing due to aerosol changes is a wild card. Current trends, even the sign of the effect, are uncertain. Unless climate forcings by all aerosols are precisely monitored, it will be difficult to define optimum policies.

We argue that black carbon aerosols, by means of several effects, contribute significantly to global warming. This conclusion suggests one antidote to global warming, if it becomes a major problem. As electricity plays an increasing role in future energy systems, it should be relatively easy to strip black carbon emissions at fossil fuel power plants. Stripping and disposal of CO_2, although more challenging, provide an effective backup strategy.

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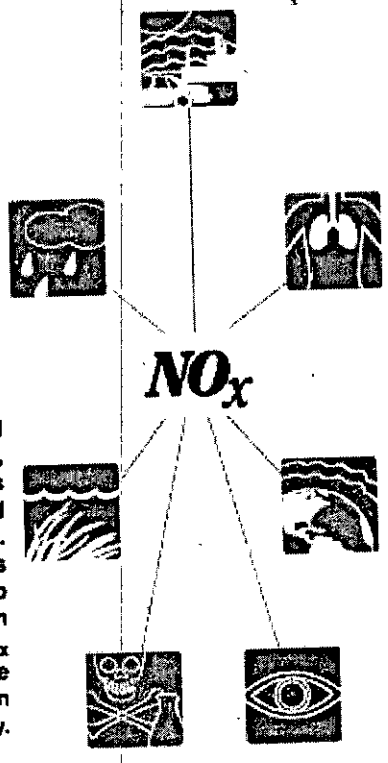
EPA Office of Air Quality Planning and Standards

NOx - How Nitrogen Oxides affect the way we live & breathe

Health and Environmental Impacts of NOx

NOx causes a wide variety of health and environmental impacts because of various compounds and derivatives in the family of nitrogen oxides, including nitrogen dioxide, nitric acid, nitrous oxide, nitrates, and nitric oxide.

Ground-level Ozone (Smog) - is formed when NO_x and volatile organic compounds (VOCs) react in the presence of heat and sunlight. Children, people with lung diseases such as asthma, and people who work or exercise outside are susceptible to adverse effects such as damage to lung tissue and reduction in lung function. Ozone can be transported by wind currents and cause health impacts far from the original sources. Millions of Americans live in areas that do not meet the health standards for ozone. Other impacts from ozone include damaged vegetation and reduced crop yields.



Acid Rain - NO_x and sulfur dioxide react with other substances in the air to form acids which fall to earth as rain, fog, snow, or dry particles. Some may be carried by the wind for hundreds of miles. Acid rain damages forests; causes deterioration of cars, buildings, and historical monuments; and causes lakes and streams to become acidic and unsuitable for many fish.

Particles - NO_x react with ammonia, moisture, and other compounds to form nitric acid vapor and related particles. Human health concerns include effects on breathing and the respiratory system, damage to lung tissue, and premature death. Small particles penetrate deeply into sensitive parts of the lungs and can cause or worsen respiratory disease, such as emphysema and bronchitis, and aggravate existing heart disease.

Water Quality Deterioration - Increased nitrogen loading in water bodies, particularly coastal estuaries, upsets the chemical balance of nutrients used by aquatic plants and animals. Additional nitrogen accelerates "eutrophication," which leads to oxygen depletion and reduces fish and shellfish populations. NO_x emissions in the air are one of the largest sources of nitrogen pollution to the Chesapeake Bay.

Global Warming - One member of the NO_x family, nitrous oxide, is a greenhouse gas. It accumulates in the atmosphere with other greenhouse gases causing a gradual rise in the earth's temperature. This will lead to increased risks to human health, a rise in the sea level, and other adverse changes to plant and animal habitat.

Toxic Chemicals - In the air, NO_x reacts readily with common organic chemicals, and even ozone, to form a wide variety of toxic products, some of which may cause

Visibility Impairment - Nitrate particles and nitrogen dioxide can block the transmission of light, reducing visibility in

FAX

Date	4/30/01	**Number of pages including cover sheet**	10
TO:	*John Howard* *CEQ*	**FROM:**	*Dr. Michael Markels, Jr.* *GreeenSea Venture, Inc* *6850 Versar Center* *Springfield, VA 22151*
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Subject: CO_2 Sequestering in the Deep Ocean by Fertilization

Remarks:

Following are two papers. The first was presented at a recent American Chemical Society meeting in San Diego. The second is a personal proposed policy paper idea that I thought you might find interesting. I will call you later in the week in the hope that we might meet for further discussions.

SEQUESTRATION OF CARBON DIOXIDE BY OCEAN FERTILIZATION

Michael Markels, Jr.and Richard T. Barber
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Abstract

Sequestration of carbon dioxide to the deep ocean by the fertilization of high nutrient, low chlorophyll (HNLC) ocean waters can be an answer to the concerns arising from the increasing carbon dioxide content of the atmosphere. This approach has the potential to sequester carbon dioxide for 1000 to 2000 years for a cost of about $2.00/ton of carbon dioxide. A technology demonstration is planned to fertilize an area of 5,000 square miles of the equatorial Pacific that is expected to sequester between 600,000 and 2,000,000 tons of carbon dioxide in a period of 20 days. The ecological changes expected consist of the increase in diatoms, which double or triple each day until the limiting fertilizing element is used up. No adverse changes are expected, since this is exactly what happens naturally when episodic fertilization occurs in the open ocean. The concept is that fertilization of HNLC waters with chelated iron will cause a bloom of phytoplankton that sink below the thermocline into deep water due to their high density after they die. The experiment, while large by land comparisons, is small in terms of ocean area, about one square degree at the equator. The demonstration protocol will include measurements of the amount of carbon dioxide that is removed from the surface layer and the amount of organic carbon that is produced and exported to the ocean depths as well as other effects in the water column over a period of 20 days. After this time no further effects of iron fertilization are expected to take place because macronutrient elements (N, P and Si) are depleted to limiting concentrations. Since the iron enrichment is transient, no steady-state modification of the food web will occur. The experiment will be carried out outside the EEZ of any nation, as were the previous five experimental voyages, so, like them, no permits will be required. The five recent ocean experiments observed iron stimulation of phytoplankton growth, but the effects were difficult to quantify in the 9 to 28 square mile experiments since eddy diffusion along the edges of the patch diluted the bloom. This problem will be minimized in the planned technology demonstration because its larger area restricts the diffusion from the center of the patch to less than 2% of the concentration over the 20 day period of the test.

Introduction

The CO_2 content of the atmosphere has increased from about 280 ppm to about 365 ppm during the last 60 years[1]. During the 1980's the rate of increase of CO_2 in the atmosphere, in terms of carbon metric tons, was about 3.3 gigatons of carbon per year (GtC/yr). Fossil fuel emissions were about 5.5 GtC/yr (20 Gt CO_2/yr*) and terrestrial emissions were about 1.1 GtC/yr during that period, so about 3.3 GtC/yr, 60% of fossil fuel emissions, were sequestered naturally. Of this, about 2.0 GtC/yr was absorbed by the oceans and 1.3 GtC/yr by the land.[2] The remaining 40%, 2.2 GtC (8.1 $GtCO_2$)/yr, contributed to the increasing atmospheric CO_2 concentration. This increase in the CO_2 content of the atmosphere has led to concerns that this increase will result in global climate change, which, over time, can have adverse effects on weather, sea level and human survival. This concern has led to the 1992 Rio Treaty, the IPCC Working Group[3] and the Kyoto Protocol of 1997, which call for a reduction of emissions of 34% by 2050 and a reduction of 70% from the then-expected emissions by 2100[4]. These reductions, if put into effect, would have serious adverse effects on the economy of the United states, causing loss of jobs, decrease in our standard of living and a reduction in the life span of our citizens. These required reductions would not address the concerns that demand an approach to permit the reversal of atmospheric CO_2 increase, should this become necessary.

Current Approach To Sequestration

The current approach to the problem of atmospheric CO_2 increase is to take specific actions now to reduce the risk of adverse consequences in the future. These actions are to increase the efficiency of energy production and use and to change our standard of living to reduce our dependence on energy in our lives. Energy efficiency can often be increased, but we have been doing this for over 200 years, so there is not a lot of gain remaining before we run into thermodynamic barriers. Even at 100% efficiency we still release CO_2 to the atmosphere, so this can never address peoples' concerns. We can also address the other side of the problem, which is to increase the rate at which CO_2 is removed from the atmosphere. If we could increase this enough we could bring the net increase in CO_2 emissions to zero, providing a solution to the problem of peoples' concerns. The availability of this solution will permit us to avoid precipitous actions and await the proven requirement to take steps to lower the atmospheric CO_2 level as may be prudent.

CO_2 is removed from the atmosphere by plants using the Sun's energy to convert it to biomass. This biomass may be used as food by bacteria, fungi and animals that obtain energy by reacting it with oxygen from the air and respiring CO_2 back to the atmosphere. Over time, a portion of the biomass formed has been sequestered in the earth and in the ocean bottom, forming fossil fuels that we burn to obtain energy to support our standard of living. Numerous projects have been undertaken to increase tree growth in the tropics, which reduces the CO_2 content of the atmosphere. These projects suffer from a short lifetime, generally 20 to 50 years, and the difficulty of assuring that forest fires, poaching, etc., will not result in an early recycling of the carbon to the atmosphere. Other CO_2 sequestering technologies have been proposed, including injection of liquid CO_2 into geological formations or into the deep ocean.

The injection of CO_2 into coal seams and natural gas producing formations to increase methane production has been well proven and is commercially viable where relatively pure CO_2 is available. This is the case where natural gas wells produce a mix of CO_2 and methane, which is separated leaving a CO_2-rich stream at no additional cost. These CO_2-rich streams can also be disposed of in deep saline aquifers such as is being done in the North Sea. The capacity of these alternatives is low since not much pure CO_2 is available near disposal sites. A larger capacity alternative is to separate the CO_2 from flue gas at electric power plants, liquefy and transport it to a location where it can be transferred to a ship for transport to the deep ocean. There, the ship will lower a two-mile long injection pipe and pump the liquid CO_2 to the ocean floor. Each of these steps is expensive and energy intensive, with the result that the approach is expected to cost in the range of $300 per ton of carbon or $80 per ton of CO_2 sequestered.

There are environmental concerns since we would be adding a new chemical to the ocean floor, liquid CO_2, which may produce hydrates and other chemicals over time. The permanence of the technology appears favorable since the ^{14}C to ^{12}C ratio of upwelling of deep ocean water indicates an average of about 1600

* 1GtC = 3.67 Gt CO_2

years[5]. This will vary depending on the deep ocean current involved and its distance from an upwelling site.

Ocean Fertilization

Another approach is to sequester CO_2 to the deep ocean by causing a bloom of plant life that then sinks to the deep waters where it remains for about 1600 years. This process is possible because large areas of the oceans have excess, unused plant nutrients and much less than expected phytoplankton biomass, the so-called HNLC waters. The difference is that the HNLC waters are deficient in one or more of the micronutrients required for plants to grow. While several essential metals may be involved in the limitation of growth in HNLC areas, iron has been shown to be the major micronutrient. Generally, 100,000 moles of carbon biomass require 16,000 moles of fixed nitrogen, 1,000 moles of soluble phosphorous and one mole of available iron. The main difficulty is the iron. Since surface ocean waters are highly oxygenated, any soluble iron is converted to Fe^{+++} with a half-life of about one hour and precipitates as $Fe(OH)_3$. A shovel full of earth is about 5.6% iron on the average. The ocean, on the other hand, has 0.0000000001 or less moles of iron per liter. The first problem, then, is how to add iron to the ocean so that it will be available to the phytoplankton (plants). The phytoplankton themselves exude organic chelating compounds into the ocean that protect the iron that is there from precipitation. Adding iron in the form of a chelate so that it does not precipitate but remains available for plant fertilization can mimic this natural process.[6] An essential element that may be in short supply in nutrient-depleted, tropical ocean waters is phosphorous. Most phosphates are soluble and can be added directly to the ocean. Since the phosphate may attack the iron chelate, it may be necessary to keep the concentrations of both fertilizers low. This can be done by adding them to the ocean separately in the form of small floating pellets that release the fertilizing element slowly over a period of days.[7] This process has been tested in the Gulf of Mexico with good results. The remaining required essential element is fixed nitrogen. Bluegreen algae or, as they are more properly called, cyanobacteria, have the ability to fix nitrogen, so inducing a bloom of nitrogen fixers might supply this requirement.

When the fertilizer mixed with water is added to the tropical ocean surface it mixes rapidly in the warm waters (the mixed layer) and starts the phytoplankton bloom. The plants, mostly diatoms, multiply rapidly, increasing their numbers by two to three times per day, until they run out of one of the required nutrients. They then cease growing, lose the ability to maintain buoyancy and presumably sink through the thermocline. The sinking biomass is trapped in the cold, dense waters where it is eaten by animal life and bacteria. This slowly converts the biomass back to CO_2 in the deep waters. Where high concentrations of biomass are generated and reach the ocean floor they are covered by mud and debris, leading to anoxic digestion. The methane produced is converted to methane hydrates by the high pressure of the deep ocean. It has been estimated that there is twice as much carbon in the methane hydrates of the deep ocean floor than all the terrestrial fossil fuels combined. It is worth noting that the addition of CO_2 in this low concentration-natural process is not expected to have any adverse environmental impact on the ocean, which now has about 85 times as much dissolved inorganic carbon as the atmosphere.

Since our objective is to sequester CO_2 to the deep ocean it is important that we minimize the proportion of the biomass produced that is processed by animal life and bacteria in the mixing layer above the thermocline. This can be done by fertilizing in pulses, so that the slower-growing animal life cannot multiply effectively before the diatoms have bloomed, died and gone below the thermocline, a period of less than 20 days.[8] The fraction of the biomass produced that is sequestered below the thermocline has been measured. It depends principally on the amount of animal life available to eat the biomass and convert it back into CO_2 in the highly oxygenated surface waters. Where the ecosystem is in balance with large amounts of animal life the sequestered carbon is about 10% of primary production and consists mainly of animal parts, scales, bones and fecal pellets. Where animal life is absent the ratio may go as high as 80% sequestered. Measurements made in the tropical Pacific Ocean produced a ratio of 53% sequestered beneath the thermocline[9]. We have used this measurement in our calculations. We must also test the waters we intend to fertilize in order to add the correct amount and mix to produce the optimum result. To achieve this we select the waters for fertilization to include a strong, shallow thermocline, tropical sunshine and high nutrient, low chlorophyll (HNLC) conditions. These waters can be found in the tropical Pacific near the equator west of the Galapagos Islands. The cool wind-driven currents go directly to the west before reaching the Line Islands of Polynesia. These HNLC waters can sequester about 0.4 $GtCO_2$/yr., a significant proportion of the 8.1 $GtCO_2$/yr. from fossil fuels that is not sequestered naturally.

Technology Experiments To Date

The technology of ocean fertilization as a means of CO_2 sequestration is still in its infancy. Accurate estimates of the results of ocean fertilization cannot be obtained from bottle experiments. The iron tends to stick to the walls, increasing the response by as much as 100 times. Therefore, ocean voyages were started in 1993 to determine the response. The first voyage in the equatorial Pacific, IronEx I, spread 880 lbs. of Fe as $FeSO_4$ on a 25 square mile patch resulting in an increase in phytoplankton, but no measurable decrease in the CO_2 content of the water. This was due to the sinking of the patch under an intrusion of barren warmer water. A second voyage in the same area of the equatorial Pacific, IronEx II, spread 990 lbs. of Fe as $FeSO_4$ on 28 square miles of the ocean surface.[10] In order to mitigate the effect of iron precipitation, the iron was added in three infusions, half on day zero, one-fourth on day three and one-fourth on day seven. This resulted in a bloom of diatoms. The chlorophyll increased by a factor of 27 times, while the CO_2 partial pressure was reduced by 90 µatm in the patch.

Ocean Farming, Inc., now GreenSea Venture, Inc., has undertaken two voyages in the nutrient-depleted tropical waters of the Gulf of Mexico. Voyage 1 was carried out in the Gulf of Mexico in early January 1998. Three, 9 square mile, patches were fertilized: one with iron, only; one with iron and 6.35 times the molar ratio of phosphorous to iron; and one with iron and 63.5 times the molar ratio of phosphorous to iron. The iron was in the form of a chelate to protect it from precipitation and the phosphorous was in the form of phosphoric acid. The ocean and weather conditions, including a very deep thermocline and high winds, caused the fertilizer to mix much more rapidly, both vertically and horizontally, than planned. The result was a bloom of large diatoms to 4.3 times their initial concentration in a little over one day. After that, the mixing diluted the signal to about 1.5 times the initial chlorophyll concentration. These results, while giving a positive indication of a large bloom were not definitive and did not provide a verifiable measure of phytoplankton increase over the period of the expected bloom of about two weeks.