Science, Equity, and the War against Carbon

Sonja Boehmer-Christiansen
Hull University

The scientific evidence is reviewed for claims that a global transition to "green" fuels and technologies by global treaty obligations is needed. The likely equity implications of these efforts are discussed, and it is argued that this evidence remains shaky. Measures based on this contested knowledge cannot be defended on grounds of either environmental effectiveness or equity. Rather, they rely on commercial expectations and promises of secondary (no regret or win-win) benefits usually requiring state intervention. Poorer groups and nations are unlikely to benefit from proposals to redirect energy policies to "combat global warming." The advocated decarbonization of global energy supplies is more likely to increase political instability than prevent climatic change. To support this argument, three areas of knowledge are consulted: controversies about the causation and likely impacts of global warming, advocated technical and fiscal solutions, and the interests of technical, commercial, and political elites.

The claims that the combustion of fossil fuels is endangering the planet, that major emission reductions are needed to prevent planetary warming, and that these reductions are achievable at tolerable economic and political costs are rejected and attributed primarily to the ambitions of bureaucracies funding the "underpinning" research. A climate protection treaty that promises more equity between countries could be devised but only if based on a more skeptical approach to the role and funding of science and technology.

The Issue

Since the mid-1980s, there have been efforts to mitigate climate change, or rather global warming, by reducing the emission of greenhouse gases (ghgs), particularly carbon dioxide (CO_2), generated by the combustion of fossil fuels.[1] The legal basis is the Framework Convention on Climate Change (FCCC) of 1992 and its Kyoto Protocol of 1997. The treaty is in force and aims to stabilize ghg concentrations in the atmosphere at an unspecified

Science, Technology, & Human Values, Vol. 28 No. 1, Winter 2003 69-92
DOI: 10.1177/0162243902238496

but nondangerous level, while the protocol, not yet in force, proposes net emission-reduction targets for industrialized countries only. Problems include how to identify how much—if any—of the predicted warming is attributable to human action and hence amenable to "policy" intervention and what to do about expected future emission increases in developing countries. Big science research continues in a handful of countries, and its findings are summarized for policy makers at convenient intervals by the Intergovernmental Panel on Climate Change (IPCC). Its scientific consensus is said to "underpin" the Kyoto process.

Negotiations based on the assumptions of human attribution and dangerous future increases in ghgs succeeded only in 2001 in making recommendations on how to implement the protocol to the first meeting of the parties to the protocol. This is to take place in 2002 provided that the required conditions are satisfied. The most recent negotiations took place at the Hague in 2000, in Bonn in 2001, and Marrakesh in 2001 and have greatly diluted the objectives sought by environmentalists and the European Union (EU). The United States has withdrawn from the protocol, and developing countries, while seeking aid under the protocol, have not agreed to any emission-reduction obligations (Environmental Data Services 2001). The United States, the largest emitter of ghgs, justifies its position as a principled stand against UN-dominated global governance and with reference to economic unfairness and scientific uncertainty (Bush 2001, 391).[2] In contrast, the EU and the United Kingdom remain wholehearted supporters of the protocol and do so largely with reference to science. What is going on scientifically and politically? Who is likely to gain from emission reduction?

To answer these questions, the climate convention, its protocol, and subsequent negotiations are reviewed, and the logic of these efforts is outlined. A critique follows, outlining the uncertainties and assumptions underlying the hypothesis of anthropogenic causation. The institutional source of this scientific consensus, the IPCC, is explored to understand the sources of its bias and influence. Economic and equity issues arising from the proposed solutions are identified and supported by an outline of bureaucratic responses so far (World Bank, EU, and United Kingdom).

The Theory

While agreeing that social reality and knowledge production are not independent and that natural science cannot be separated from how concrete material interests are defined, this article is a plea against excessive relativism or the view of science as mere social construct. The ideal that truth about nature can be discovered by science should be upheld, if only to protect

science from misuse by vested interests and moralists, environmental ideology included. Allowed to progress without excessive steering by interests, research may lead toward truth. I hope to demonstrate that science can indeed be constructed, if well funded, to serve particular politically determined ends (Proctor 1991). Referring to narratives emerging from science and technology studies about the common production of knowledge, the normative stance adopted here is

> to render more visible the connections and the unseen patterns that modern societies have often taken pains to conceal, often by enlisting the unquestionable forces of the physical world as represented by the voices of scientists-seers or as hardened into obedient machines. (Jasanoff 1996, 413)

The Climate Treaty and Its Kyoto Protocol

Stabilization of global emission at 1990 levels—assuming that these can be known—was the target of the FCCC.[3] In 1997, the Kyoto Protocol, an instrument to implement the convention, proposed emission targets expressed as percentage of total national net emissions measured from a 1990 baseline for developed countries and economies in transition. Developing countries, where the greatest emission growth is expected in the future, have refused to accept emission targets. Organization for Economic Cooperation and Development (OECD) countries and the former USSR agreed, once ratification had taken place, to reduce their net emissions by differentiated amounts between 2008 and 2012 to achieve a global cut of 5.2 percent of CO_2 emissions below 1990 levels. This might be compared to the 60 percent cut advocated by environmentalists and some scientists.[4] The protocol will only become binding if at least fifty-five governments, whose 1990 emissions amount to 55 percent of the world's total, ratify. At the end of 2001, forty-two countries had ratified, but none of these were major industrial countries. The EU ensured that all its members had ratified by July this year, when Japan and Canada also promised to ratify in the future, making the entry into force of the much diluted protocol likely. The United States and Australia, and of course all developing countries, continue to refuse to accept emission reduction obligations. The EU was prepared to make large concessions to achieve this. But from a green perspective, the Kyoto Protocol is now fatally flawed by these concessions. They include the acceptance of carbon "sinks," that is, emissions "sequestered" by assorted land use changes, such as the planting of new forests or forgoing planned land clearance; of large-scale emission trading and aided technology transfer; and the abandonment of strong compliance

rules. The pressure on reducing emissions from energy sectors has been significantly reduced.

"Flexible mechanisms" are to be employed globally to secure cost-effective reductions, but this will require the participation of developing countries. One instrument still being negotiated is the clean development mechanism (CDM) that is to aid green energy developments. Nuclear power as a solution deserving aid remains excluded. Presumably, nuclear developments and reliance on domestic coal might challenge the competitiveness of aid-giving nations, but the official explanation is environmental. Joint implementation and emission trading, on the other hand, work only between countries with mandatory emission targets. They promise to transfer finance and technology to inefficient energy producers but are accompanied by calls for the abolition of fossil fuel subsidies. More efficient and less carbon-intensive technology is the solution the Kyoto process tries to implement worldwide.[5]

In the rhetoric of the negotiations, OECD countries with high past emissions are treated as villains and had to show willingness to reduce emission growth immediately. Countries such as China and India with low past emissions and low current per capita values but high economic growth rates are the villains of the future. They are under great pressure to forgo conventional technologies and fuels in the future. The likely impacts of this green energy agenda, including more expensive transport systems for poor countries and poorer sectors in all countries and those heavily dependent on coal, have not, to my knowledge, been openly negotiated or well researched. Rather, bodies such as the EU and many individual nations have undertaken domestic energy policy reforms and encourage innovation with reference to their global emission obligations. The measures being tested at various national levels include subsidies and taxes, energy efficiency standards, emission trading, and, most recently, the inclusion of carbon sinks in national carbon accounting. The search for sanctions for noncompliance continues. If implemented globally, these measures would transform energy sectors at enormous cost but unevenly: several percentage points of GNP are usually suggested.[6]

Analysis of national positions in the climate negotiations demonstrates that these were shaped not by any future climate but by concerns over economic futures: development, aid, and trade. The core issue facing negotiators remains how to share burdens fairly and prevent others from benefiting from the pain of losers. To disguise opportunities and present them as pain to be born for the sake of the planet is another strategy creating problems.[7] Equity between states but not people predictably became the major issue as negotiations moved from principles to the instruments of implementation.

The Origin of the Climate Treaty

A more carbon-rich atmosphere was welcomed as enhancing plant growth and fertility when first predicted in the late nineteenth century, and some research groups support this position today (http://www.co2science.org). Research into the subject of increased CO_2 and climate change relates to the development of global climate change models from weather forecasting since the 1960s. The possibility of warming was noted during the 1930s but dismissed as unimportant because of the expected development of nuclear power. In the 1970s, the troubled nuclear industry, followed by researchers into renewable energy technologies and energy efficiency, discovered the threat of future planetary catastrophe and transformed it into opportunities (Boehmer-Christiansen 1997, 1999; Boehmer-Christiansen and Kellow 2002). Their vehicle was the famous Brundtland Report that proposed a climate treaty and global research agendas.

Since the early 1980s, technical experts have argued that alternative fuels could replace coal, oil, and gas as these were running out or becoming too expensive. The same alternatives would soon serve "climate change" mitigation: the warming threat was preventable by measures that would exclude fossil fuels or keep their price high. Alternative energy experts initiated and were part of the IPCC process (see below) from the start—the solution constructed the problem. The World Bank and most other global institutions greened a little later. In 1987, the Toronto Conference called for a 20 percent reduction in ghg emissions though a 60 percent reduction had been discussed. At the 1992 Earth Summit, the climate treaty was signed and some aid made available through the Global Environment Facility (GEF). The "South" remained suspicious.

The decarbonization of energy supply has therefore been a formal objective of international negotiations since the mid-1980s, that is, the period when fossil fuel prices returned to their low pre-1973 values and hence threatened the alternatives developed during the 1970s, including nuclear power. Planetary salvation was to be achieved by the reduction (later net reduction) of emissions of eight gases, primarily CO_2 and methane. The former, assumed to be the main culprit though this remains contested, is a most convenient target for measurements and abatement, with the options ranging from fuel switching and storage in geological formations to sequestration by new forests.

Whether man-made warming is indeed "discernible" remains a subject of dispute. This is a postglacial era subject to considerable natural fluctuations.

It is known that CO_2 concentration has increased since the eighteenth century but also that it has fluctuated considerably and rapidly throughout history and prehistory, without necessarily being accompanied by temperature changes. Surface warming is measurable, if the data sets are believed, only for periods during the past fifty years. Is this a trend or a cycle? Do temperature changes cause these fluctuations or vice versa? Different sciences give different answers, though many groups remain adamant in support of this treaty's assumptions, especially the scientific advisor to the treaty and protocol, the IPCC, as it exists to support the treaty. If these assumptions are untrue, as I believe, why do so many powerful institutions believe in them?

One reason is skillful and biased presentation of evidence, and the other is interests (Boehmer-Christiansen and Kellow 2002). Global research has long been skewed toward discovering the threat. The tools on offer for implementation are very research intensive. Bureaucracies at all levels are now charged with enormous tasks of gathering data on emissions and planning for their abatement. Methodologies for establishing emission baselines for projects are needed, as are limits for emission trading that involve estimating or measuring emissions worldwide. Carbon trading systems with brokers, banks, and risk managers are being set up. Carbon sinks and carbon sequestration need to be included in national carbon budgets and need to be checked by intergovernmental bodies for compliance. Billions of dollars are to change hands, and legal certainty is therefore needed. For developed countries, detailed ghg accounting and liability rules have been devised; in the future, they are also needed for carbon sinks such as forestry, land clearance, and soils. The Europeans had wanted to exclude taking sinks into account in national carbon balances because this would reduce pressure to modernize energy sectors by improving efficiency, but they lost the argument. Developing countries are to be included gradually.

Without a deal as made at Kyoto and Marrakesh, large investments would be lost. Technology seeking new markets and money seeking investment opportunities in sequestering carbon would find it more difficult to obtain subsidies or helpful regulations. While some "carbon-poor" countries, such as Japan and Norway, have incentives to buy carbon credits abroad, the EU with its emphasis on renewables and efficiency also sees opportunities from enhancing its energy security. With the withdrawal of the United States, however, it has lost the opportunity of making energy more expensive for a competitor. The EU opposed the sinks and emissions trading, while Japan and Australia wanted and obtained more of each in order not to have to cut emissions.

The Logic behind the Kyoto Process

The link between the scientific hypothesis selected as ready for action and the solutions proposed can be restated.

- If increasing energy demands in the future were to be met by fossil fuels, a warming climate (on average) and a rising sea level, and other severe environmental dislocations, would affect all nations, but the poorest would be affected the most. The rich must therefore act first.
- An impressive menu of technological options, regulatory and financial instruments for reducing CO_2, is available. These options seek global markets. Replacing carbon-intensive activities is technically feasible, at a cost that also represents investments, or potential debts.
- Energy demand is expected to double in the next fifty years, primarily in industrializing economies that are therefore most attractive to investors. Planetary salvation would lead to income streams moving from South to North and economic growth in both.[8]

However, if noncompliance with treaty obligations were to remain unpunished, the Kyoto process would remain voluntary, restricted to national regulations and in the hands of the private sector. Governments, lawyers, and environmentalists might benefit less. With strong government involvement, the global warming project might gain markets for green technologies and fuels, irrespective of any future "climate protection" effect. Expanded bureaucratic powers would be needed "to make and nurture relationships with the private sector, civil society and Bretton Woods institutions" (United Nations Environment and Development Forum 2000, 8).

The logic of Kyoto reveals not only nonenvironmental economic and political interests but also points to immediate losers: the owners, miners, and users of coal and, to a lesser degree, oil, as well as taxpayers and energy consumers who are charged higher prices or taxes. The phasing out of fossil fuels before market forces or resource endowments demand it depends on public support and is likely to switch public resources from welfare to private gain. As the winners are the politically stronger who fund research, considerable pressures on scientific institutions to provide an authoritative underpinning for this logic can be expected. The observed emergence of a strong scientific consensus may reflect either the "truth" as we can know it today or a selected truth. This requires a closer look at science.

A Critique of the Scientific Consensus

> Skepticism with regard to global warming is not shrinking but growing. . . . Reliable quantitative estimates of relationships between natural and man-made changes . . . do not exist. . . . The IPCC Reports do not reflect the range of divergence of relevant scientific opinion. (Kondratyev 2000, 365)[9]

Research on climate models, the impacts of climate change (as predicted by models), the provision of technical solutions, and their "delivery" in practice has consumed vast amounts of resources and intelligence since the mid-1980s. Initial research dates back to very few institutions in the United States, Germany, and Sweden in the 1970s.[10] The IPCC provides the scientific consensus that underpins the climate treaty and is negotiated in association with the Kyoto process. It acts as a legitimating authority.

The scientific consensus that underpins Kyoto is relatively new. Only two decades ago, it was argued that mankind might face another ice age (and this remains on the geological agenda). There was little political response. "Our knowledge of the mechanisms of climatic change is at least as fragmentary as our data," conceded the National Academy of Sciences in 1975, when global cooling was generally expected (Matthews 1975).

The IPCC, however, based itself on warming, attracted widespread support, and by the late 1990s had generated a consensus of scientific opinion that is now rarely challenged at the political level, especially in Europe, in spite of numerous attempts by critics to be heard (Kondratyev 1997; Metzner 1998). Coupled with simplified oceanic models and provided with emission scenarios by interested parties (the technologists with the solutions), climate models run on the assumption that CO_2 concentration will double from an eighteenth century baseline some time this century. IPCC users reduce science to three claims that are contested to varying degrees: that global warming is man made, that this will harm the planet in coming decades, and that warming is discernible. Underlying these claims we find more fundamental if contested beliefs: that climate is predictable, that anthropogenic warming can be distinguished from natural change, and that the available models are good enough for policy purposes. This issue of causality is debated in scientific journals and electronic networks but is not an issue for many others, especially those committed to expensive policies or hoping to benefit from emission controls. Opponents in Europe in particular have been denied means of dissemination. They have few natural allies and tend to be condemned as "unethical."[11] IPCC critics tend to be dismissed as "right wing" or in the pay of the coal industry and have clearly lost the argument in the populist media (Leggett 1999). While critical arguments cannot be rehearsed

here in detail, they question the merit of still primitive mathematical models for predictive or even scenario-building purposes and question many of their scientific assumptions (Metzner 1998).

As one influential critic has pointed out, it is often forgotten that the scope of the climate treaty is restricted to anthropogenic impacts. As pointed out by John Zillman (1997), director of the World Meteorological Organization (WMO) and advisor to the Australians, when the IPCC says that

> climate has changed over the past century, it is simply saying the climate now is not the same as it was a century ago (whatever the cause), whereas the FCCC listener will reasonably interpret such a statement as the scientific community affirming that human influence has changed climate over the past century. (P. v)

He advised therefore that any action going beyond "no-regrets" policies would be irresponsible. In other words, governments should only undertake climate-related policies that promised to have other benefits as well. No-regrets policies are of course closely linked to national energy endowments and wealth, though unpopular policies may be green washed by associating them with planetary salvation. Such policies were not easily negotiated at the global level. I argue that it is these non-climate-related policy outcomes sought by the stakeholders locked in negotiations since 1990 that drive the Kyoto process without having been assessed seriously for their equity effects.

While many uncertainties are admitted by IPCC, these exclude the underlying scientific paradigm (radiative forcing of temperature) brought about primarily by the combustion of fossil fuels. Combustion is assumed to increase the concentration of CO_2 by 1 percent per annum, though the observed values are considerably less. Skeptics argue that IPCC scenarios are unrealistic and based on faulty physics.[12] Opposition to the "mainstream" theory comes from many disciplines but is not integrated into a single challenge. These come mainly from the study of solar influences, clouds and aerosols, and past climates (Calder 1999; Soon et al. 2001). Empirical science demonstrates that past climatic changes were similar to recently observed ones, with major variations occurring long before human beings inhabited the earth (Karlen 1998). Geologists point out that the earth was warmer several times during the last interglacial period, and the evidence we have does not indicate that these warm periods were generally disastrous. One solar physicist predicts that this warm period will end in a decade or so, and space physics in general with NASA and the European Space Association in the lead are now the main challengers to IPCC by testing the role of clouds, cosmic rays, and solar phenomena.

Yet even the IPCC, read carefully or in private conversations with leading members, remains uncertain; indeed, without uncertainty research might grind to a halt. Statements about the likely increasing concentration of anthropogenic ghgs having contributed substantially to the observed warming over the past fifty years are balanced by admitting that the influence of the individual external factors continues to be limited. Statements that support the "dangerous, man-made warming" hypothesis are followed by others that emphasize remaining uncertainties (Boehmer-Christiansen 1994a, 1994b). Its full 2001 assessment (Third Assessment Report [TAR]), for example, remains cautious about the causation of the warming as observed in recent decades, but the brief "Policy-Makers' Summary" for the first time referred to human-induced global warming as "fact" rather than as a "discernible" possibility. There have been angry disputes inside the IPCC, leading to major changes in texts. For example, the following transformation occurred in chapter five between April and May 2000. The first draft says of aerosols that "the net forcing of the climate over the last 100 years (and since pre-industrial times) may be close to zero or even negative" (IPCC 2001). In other words, there has been no warming because of complex feedbacks. By May 2001, this had become "our ability to assess the indirect forcing by aerosols has a much larger uncertainty associated with it. The largest values of negative forcing due to the warm-cloud indirect effect may approach or exceed the positive forcing by greenhouse gases" (IPCC 2001).

If man-made aerosols, by causing cooling, were to balance the warming due to CO_2 alone, it would be other gases that needed to be reduced as a priority, as was suggested by later research (Hansen et al. 2000).[13]

Uncertainties in estimates of internal variability and natural and anthropogenic radiative factors, in particular the forcings by anthropogenic radiative factors and the climate response to these factors, remain to be resolved. While it is admitted that what advocates of warming tend to present as predictions are only scenarios based on "story lines" coupled with the precautionary principle, the message remains persuasive. Inadequate and inconclusive empirical data and doubtful "socioeconomic" assumptions can always be justified as the best available or one set of values among many. The choice of the future is then left to the political system.

While the postulated link between feasible emission cuts and the prevention of climate change remains debated, some IPCC supporters, especially those close to the U.K. government, now claim that a cut of 60 percent of current emissions would be necessary to "stabilize" climate by the end of this century. Some doubters argue that if the benefits of reduced population growth and the technological advances over the next fifteen to thirty years

were included in model calculations, they would show that waiting is the only sensible solution.

But large-scale overall emission reduction may not be what proponents seek most, that is, under the win-win label. What is now advocated as a set of solutions to global warming existed in laboratories and on drawing boards, or in practice, before the climate models predicted catastrophe or were interpreted to do so. Renewables, nuclear power, and energy efficiency, initially at least, were responses to high oil prices.[14] Energy R&D in particular had long relied on public funding and on government for help. For example, in a report to the U.S. president written in the late 1970s, it was assumed that oil prices would continue to rise and that many countries would soon have difficulties in meeting their energy needs, and research bodies claimed that "vigorous changes in public policy around the world are needed to avoid or minimize these problems before they become unmanageable" (Global 2000, 392).

A huge research agenda was presented to President Carter in which it was stated that "atmospheric concentration of carbon dioxide and ozone-depleting chemicals are expected to increase at rates that *could* alter the world's climate" (Global 2000 1982, 3). Moderate global warming and cooling were briefly discussed, but the U.S. Department of Energy admitted that energy projections could not be made and that the environmental impacts of energy consumption beyond 1990 could not be commented on. The climate models would soon change this. Until these were ready to make global prediction, energy challenges remained national, and large investments were sunk, in some countries, into nuclear and solar power, as well as energy efficiency.

Oil price rises in the 1970s led to the heaviest investments in energy-poor continental Europe and Japan. Only in still fossil fuel–rich countries such as the United States, Australia, and United Kingdom did efficiency increase–albeit little. After the mid-1980s oil price collapse, (to levels lower in real terms than in the 1960s) pressures to protect sunk investments increased to different degrees. Global warming proved a welcome message for it justified interventions to protect "clean" energy. Converts to a new ideology—that carbon was a pollutant endangering life on Earth—were easy to find. When oil prices briefly trebled in 2000, there were immediate impacts on petrol prices, growth, and investments that contributed to the current recession.

Without the assertion of scientific support for the view that the burning of fossil fuels was initiating the climate threat, the global techno-economic governance strategy in support of clean energy and energy efficiency would lack authority. Before looking at policy and hence equity implications more closely, the institutional role of the IPCC is outlined to understand the sources of its influence and bias.

The IPCC: Negotiating Consensus and Advising on Energy Options

The IPCC was set up formally in 1987, after oil prices had slumped, and was listened to immediately. By 1992, the FCCC had been agreed. IPCC does not itself fund research but helps to promote "policy-relevant" global research at the national level and in UN bodies, often in close association with the International Council of Scientific Unions (ICSU). More directly related to climate science were the World Climate Research Programme of WMO and the International Geosphere Biosphere Programme of ICSU. Both were in need of funding by national governments (Boehmer-Christiansen 1993, 1994a, 1995). IPCC science leaders were well connected to both. The Geneva-based IPCC Bureau soon selected or approved scientists to participate and thus significantly influenced IPCC membership, recommendations, and drafting.[15] This process produced the famous scientific consensus reports of 1990, 1995 (Second Assessment Report), and 2001 (TAR) (IPCC 1995, 2001). On the research side, the institutional beneficiaries that emerged included national meteorological offices, the big national science laboratories in the United States and Australia, the research councils of the United Kingdom, the Max-Planck Society of Germany, many research-based nongovernmental organizations, as well as UN agencies. All became major IPCC supporters (Boehmer-Christiansen 1993). Their research efforts provided IPCC lead authors with new "findings," authors and reviewers who needed national approval, and the whole enterprise with powerful gatekeepers.

Starting in the early 1980s, the global research agendas mentioned above, while based on earlier efforts, have always made astonishing claims to policy relevance.[16] The IPCC thus emerged in close association with research on one side and with environmental bureaucracies on the other, also a fairly new development. Both had strong interests in atmospheric modeling and space technology. A shared objective of both "independent" and governmental research was to obtain national support for the rapidly expanding IPCC "community." In the United Kingdom, asserting policy relevance became the name of the research game.

IPCC decisions relating to its procedures and publications are taken in close collaboration with civil servants. Policy and policy-related statements are left to IPCC group leaders and leading authors. Three groups were set up at the start and have been but slightly reorganized since. They work more or less independently of each other, with Working Group (WG) I concerned with scientific assessment, providing the baseline for the research of the other two, dealing with impacts and response options. The groups report to govern-

ments, the United Nations Environment Program, and WMO and are now trying to synthesize their findings. Social scientists have become increasingly involved, but concern for human equality—that is, equity inside states as distinct from equity between them—unsurprisingly perhaps, is not part of current research agendas.

WG I reports on the state of scientific knowledge and relies for this, excessively in my view, on the climate-modeling community found in a handful of large research laboratories often associated with meteorological offices. The group is managed from within the Hadley Centre of the U.K. Meteorological Office and funded by the former U.K. Department of the Environment (Boehmer-Christiansen 1995). The U.K. Meteorological Office's research capacity was upgraded by world-class computer facilities to study global warming, an idea that appealed greatly to Margaret Thatcher and British environmentalists and that has remained virtually unchallenged in the United Kingdom.

Mathematical experiments with general circulation models are the tool of climate change predictions. They consist of highly parameterized sets of equations plotting weather onto a global grid that links the atmosphere to a highly simplified ocean system. Fed into the models are emission scenarios provided by WG III, which envisage the CO_2 content doubling by various dates depending on assumptions made about population growth, fuel mix, and wealth. Authority is claimed with reference to numbers of papers cited, for example, "25 lead authors from 11 countries based on 120 contributing authors from 15 countries and 230 reviewers from 31 countries" (IPCC 1994, 2). The third scientific assessment (TAR) was published after the Hague meeting, but the most scary scenarios—up to six degrees Celsius warming on average—were leaked in advance. The danger from climate change as popularized appeared to increase with the approach of Bonn, while the science, in my judgment, had become less certain (IPCC 2001).

WG II considers possible biological and socioeconomic (never political) impacts of climate change. Included are possible impacts on human health, agriculture, energy demand, and transport, with findings based on the worst-case scenarios released by WG I but generated with supplied emission scenarios. Some of these findings can be monetarized to provide global economic cost estimates, and there can be speculations about social and legal changes. Social scientists and epidemiologists could join the IPCC project on the basis of "what-if" research and have generally predicted harmful outcomes that served to justify more interventions. These are designed by WG III (mentioned above), which advocates response strategies and options for governments to consider (Rayner and Malone 1998). Technologists and

energy interests from industry, governments, and nongovernmental organizations meet here and have now created their own research community external to the inner IPCC (Grubb, Vrolijk, and Brack 1999).

Thus, environmental sciences have tended to base research on the worst-case scenarios from WG I and to propose technological mitigation policies based on the precautionary principle rather than win-win strategies. This requires a stronger rather than weaker climate threat, especially when fossil fuel prices are low. Social scientists and engineers provide the emission scenarios for WG I and advocate technology options. Advice for policy makers seeking no-regret or win-win opportunities is constructed in WG III with investments in ecological modernization, improved energy efficiency, and less wasteful technologies as proposed solutions. Adaptation, an alternative strategy, has only recently crept into research agendas. WG III is therefore of major policy importance but keeps a very low profile. Major interventions in energy policy, agriculture, and forestry are being researched for their effect on cost-effective ghg mitigation. Resource efficiency, new sources of revenue income, stimuli to innovation, and investment are advocated. Governments were advised to look for such *synergy* (the TAR term for win-win and no-regret) in their policies, that is, expect short-term benefits from the Kyoto process while hoping for climate benefits later. As a global strategy, this has created major equity issues that help to explain the long delays and weak outcome.

Economy, Equity, and Human Equality

Equity between states is a major issue in the Kyoto process, dominated by concerns over the impact of the proposed instruments and targets on national economies. Neither equity nor equality between human groups is negotiated in any depth, intergenerational equity being an exception: it justifies pain today for the sake of the future. However, neither term appears in the glossary of the technical summary of TAR WG III, although the section on decision frameworks refers to "equitable burden-sharing" between countries as a means to encourage participation. Equity here tends to mean preserving the economic status quo. Like the negotiations themselves, the summary deals primarily with national economic impacts, promises and strategies from experts that emphasize technological change, and emission trading with politically allocated national emission targets or allowances as a foundation.

The overriding aim of global climate policy therefore is cost efficiency not equity, that is, cutting emissions at the lowest possible cost to industry worldwide in a policy framework that maximizes the opportunities for the trans-

ition to low-carbon economies. Synergy, experts promise, will enhance competitiveness. Drawing on IPCC and other evidence, it is therefore concluded that technologies related to combating global warming offer capital-intensive solutions for application in the North and aided exports to the South. The precise nature of new inequalities and debts that this strategy may create only the future will tell, but warnings can be heard from many quarters. One claim is that every ton of CO_2 above an arbitrarily international set limit will cost its emitter about U.S.$140, a sum used in scenarios of the U.S. Department of Energy and about 3.5 times the import price of coal in Western Europe. Whatever the precise numbers, considerable cost increases in energy-intensive production (cement, fertilizer, ceramics, steel, aluminum) would be unavoidable, hitting developing countries and coal-based economies such as China and Australia hardest. "Carbon leakage" might follow, that is, the shift of such industries to countries not required to reduce their emissions. Deindustrialized economies with strong service sectors, such as the United Kingdom, but also relatively energy-inefficient ones, would suffer less or might even gain. But burden sharing is not easy when the burdens are so uncertain. So the Kyoto process depends for its persuasiveness on assertions of future benefit and appeals to the pursuit of intergenerational equity wrapped up in the dubious promise that by protecting the atmosphere and its natural resources now, "we" shall become much wealthier in the future (Weizsäcker and Lovins 1997).

TAR WG III gives one important insight relating to equity and equality problems. For climate mitigation, it is argued in the technical summary, sectoral losers are easily identified for their losses are likely to be immediate, concentrated, and certain. The opposite is true for the potential gainers, that is, groups that are therefore appealing to the public purse for the sake of future equity. State support for renewables is now available in most OECD countries in the hope that lucrative markets will emerge. However, virtually all emission reduction achieved so far by the "market" has been due to industrial collapse (USSR, East German) or a one-off switch from coal to natural gas or nuclear power. The market will not deliver new technologies and fuels until fossil fuel prices are very high, possibly facing mankind with energy shortages more dangerous than climate change. Major technological transitions do not come cheap, and costs will differ greatly between countries, hence the deep concern over impacts on competitiveness apparent in the negotiations. Here, the importance of the fuel prices (and volatility) and taxes cannot be overemphasized and with it the importance of emission regulation on energy policy. Both have a major influence on economic growth. Strong pressure is already being exerted in favor of switching subsidies from fossil fuels to even more expensive energy irrespective of social impacts and location.

National differentiation, allowing for very different national emission targets, was therefore eventually accepted at Kyoto (Boehmer-Christiansen 2000). Even then, concessions made over national emission-reduction targets may merely conceal the attraction of climate protection policies to sectoral and political interests. Global warming provides a more dramatic and insurable explanation for floods and storms than natural climatic variability or poor land use management. Foreigners can be blamed for current problems or policy failures. All states would therefore have some stake in a positive outcome, though the cost-benefit balance would differ between them, hence the accepted principle of differentiation. For example, in the EU, the decarbonization agenda promises investments today, more energy efficiency and security in the medium term, as well as increased revenue from green energy taxes. However, the link between energy efficiency and aggregate emission reduction remains tenuous.[17] Historically, improved efficiency in electricity generation has been accompanied by increased consumption of energy in transport and by private households. There is also the opportunity for protecting nuclear investments and supporting nonproliferation policies by converting weapons-grade plutonium into reactor fuel (Moniz 1999) and the promise that green exports may enhance trade balances and that green investment aid returns profits home.

Even assuming that ghg mitigation will deliver the promised synergies, whether these benefits would improve human equality would still depend on domestic policies on health, education, welfare, and, above all, income and its taxation. Increased energy prices will hit lower income groups hardest. The *Financial Times* (4 July 2001, 4) in a report from the University of Westminster Transport Unit concluded that petrol duty and other anti-car-use policies fall more heavily on low-income groups than "previously thought." The poorest groups spend between a fifth and a quarter of all household expenditure on running a car compared to 16 percent to 18 percent for other groups. Tax redistribution in favor of poorer groups could alter this, but this is not part of the Kyoto agenda. Switching to green (and more expensive) energy will not benefit poorer sections of society. While eventual equality between countries' per capita emissions is occasionally advocated, poverty reduction would only follow if energy consumption taxes were to be lowered, and such proposals are not included in either the global or national climate policies, as it is inconsistent with the emission-reduction instruments. Some advocate emission equality in a system in which rich individuals would have to buy their carbon allowances or credits from the poor, but this idea seems wildly utopian.[18]

The losers from climate protection policies as proposed are not only coal miners but all interests related to carbon-based fuels—investors, managers,

experts—and energy-intensive industries in general. The Organization of Petroleum Exporting Countries (OPEC) is extremely worried and has demanded international compensation for its losses. Large workforces, especially in developing countries, will not find ready reemployment unless governments, or rapid economic growth, provide alternatives. Most important, perhaps, development priorities will be biased toward decarbonization when education and health might be more relevant at the national level. Developing countries' governments (including Russia) remain worried that northern firms will pick off their cheapest options and leave them with high emission-reduction costs in the future. Oil producers and exporters of coal, or electricity generators depending on coal, such as the United States, Australia, China, and India, remain deeply worried and are not likely to accept emission- reduction targets in the foreseeable future. Apart from seeking delay, they have therefore come to support the sink idea as well as the flexible mechanisms that encourage exchanges between North and South.[19] Regulating or subsidizing industry to become more eco-efficient in the context of the current political consensus against higher income taxes would seem to require switching tax revenue from welfare to economic growth.

Emission-reduction policies are not likely to serve human equality, though they can be designed to improve equity between states. As envisaged in the Kyoto process so far, the transition into a greener world will not be possible without increased government spending on economic growth accompanied by reduced investments in other social priorities, with taxpayers bearing the burden. What policies are currently being pursued?

Bureaucratic Opportunities

Bureaucracies in most OECD countries, recently deprived of direct control of the energy sector in many countries by deregulation and privatization, have found promising new tasks in environmental regulation and have already emerged as major winners. Civil servants and offices dedicated to climate change are expanding in numbers. Are there signs that they can use their increased powers to reduce inequalities at home and seek global equity?

The solution on offer to developing countries from the World Bank is assisted technology transfer as part of an economic and financial globalization agenda dedicated to privatization and national deregulation. Improved "eco-efficiency" usually means capital-intensive development with increased debts. More equal national quotas are likely to increase inequalities in its client states as emerging middle classes strive for their share of the good life in the global economy (Boehmer-Christiansen 1999). The World Bank was

early attracted to "the seriousness of the threat of climate change" because of the opportunity to lend money for "clean technology" directly or via the GEF, for upgrading energy and forestry projects. Emission reductions thus achieved are equated with global environmental benefit, while projects by definition contribute to development, clearly a "win-win" strategy. Bank economists believe that developing countries can reduce ghg emissions from five to fifteen dollars per ton of carbon compared to fifty dollars in industrialized nations, persuading the World Bank to become involved in emission trading.[20] If Kyoto fails, investors will be out of money but have lots of emission permit certificates. In the meantime, the World Bank's traditional support for the construction of fossil fuel power plants has ground to a halt in spite of clients' wishes. China would like to have nuclear power funded through the CDM, but this is not permitted. Will inequality in developing countries decline thanks to Kyoto?

The CDM has not yet started functioning, but it "might generate capital flows of $10 billion per year" (Sandor 2000, xix) providing, the GEF has claimed, markets in developing nations with power plants, cars, appliances, and other products worth millions. The question is whether these transfers are what the countries concerned need most. Evidence so far from the GEF and CDM raises some doubts. The CDM with its certified emission reductions—to start accumulating from 2000 for use from 2008—has remained under the control of the parties, with the World Bank having started a separate carbon fund. The developing countries must agree to emission trading and joint implementation in return for the CDM aid: clients are to achieve sustainable development and developed countries compliance with their quantified emission limits. The private sector may earn reduction units as credits for their countries by investing in permitted cleaner technologies in developing countries. Firms may invest in or buy less efficient producers of electricity abroad, earning credits measured in tons of carbon equivalent.

For the EU, climate negotiations have not only been a major growth opportunity for the European Community's Environmental Protection Directorate but for the EU as a whole in its attempt to advance political integration (Sbragia 1999). While committed to an 8 percent reduction of emissions between 1990 and 2008 to 2012, its environment commissioner has claimed that without action, emissions would increase by 8 percent, numbers that will be very difficult to confirm. Most member states are not on track for reaching their allotted targets. The EU commission set out its final policies and measures in March 2000 without any reference to equity or equality. The strategy "aims to reinforce" agreed policies, including voluntary agreements to reduce vehicle emissions and the "development of energy markets . . . incorporating environmental considerations." Further initiatives include a

directive to promote renewable energy and a paper on integrating sustainable development into enterprise policy, as well as continuing support for nuclear power. The commission also foresees transport pricing and economic instruments in aviation, a fiscal framework for reducing CO_2 from cars, improvements in energy efficiency standards, and CO_2 capture in underground reservoirs. State aid rules are to be changed to reduce their climate impact. EU energy taxation is not listed in the proposals, but complaints are aired that progress would have been "far more pronounced" had ministers "more actively pursued" the idea. An EU-wide ghg emissions trading scheme is planned to provide experience before global rules are introduced.[21] A bonanza for bureaucratic intervention in national economies is outlined, with the commission trying to protect its win-win strategy from international threats to the competitiveness of its energy-intensive industries. "We won't allow sinks [to be used] in such a way that they create a big loophole," the environment commissioner had said before Bonn. Persuading industry to accept these proposals remains a task for the future.[22]

At the national level, for example in the United Kingdom, taxing energy, especially when prices are low, has long been an important source of revenue. Most of the costs of petrol in Europe moves into treasuries, and climate levies are now adding to this.[23] Climate levies or taxes on energy use by business also exist in several countries and are raised in the United Kingdom, though resistance persists. The United Kingdom is a special case as it is but one of two countries that have reduced ghg emissions since 1990. This has given the former "dirty man of Europe" a better image at little or no cost—because gas was then very cheap—and with expected future benefits. The public now needs to be persuaded to pay for further investments needed to replace coal and possibly nuclear power within a few decades. The application of a carbon tax to fossil fuel use can therefore have four distinct goals: reduce CO_2 emissions, preserve oil deposits for future generations, provide a cushion against oil shocks that are possible under an oil supply market once again dominated by OPEC, and raise revenue for governments. None of these has inevitable implications for wealth distribution, though any may affect overall wealth. Blair and his deputy recently met business leaders (the EU environment commissioner attended) to discuss the challenges ahead and the potential benefits of moving to a low-carbon economy. According to the environment ministry, the economic opportunities of moving to what is also to be an energy-efficient economy were discussed, and U.K. support for domestic emissions trading schemes was reiterated. The U.K. government hoped to benefit financially from emission trading by selling "spare" carbon credits (Jepma 2000, 13). Business leaders, however, have since called for reductions in the climate levy or corporation tax exemptions. The leader of the advisory committee on

business and the environment is reported to have said, "There has to be an incentive for companies to put themselves on the block by agreeing (emission) targets. Without incentives, it will be very hard to get the system going" (House of Commons 2001, 11; see www.parliament.uk/commons/selcom/eahome.htm; for information on the low-carbon economy, see U.K. Environment Ministry, http://www.detr.gov.uk).

Conclusions

The global warming threat was constructed in the 1980s by a coalition of interested parties offering expertise and technologies to solve the problem. The climate threat, like the limits to growth scare beforehand, offered new opportunities to environmental bureaucracies and professionals who found the proposed solutions empowering. A belief system was provided by environmental religiosity, while science, engineering, and economics provided the rationalizations from which global and selected national bureaucracies would derive authority for promoting technological change, "greenmailing" opponents, and raising revenue. Negotiations have continued for more than a decade in a major experiment in global lawmaking in support of globalizing energy markets. The objective is a faster transition to a less carbon but a more information- and capital-intensive energy supply than would happen if left to market forces, that is, to rising fossil fuel prices. Taxpayers, recipients of public welfare, and consumers have for several decades funded research and bureaucratic interventions. Yet fossil fuels remain abundant, cheap, and widely distributed. They do not attract the available capital and knowledge. Issues of more immediate human needs tend to be ignored as the present generation of taxpayers and consumers rather than investors will have to pay for the market to be "rigged" to favor new fuels and technologies. Given the fundamental importance of energy prices, this scenario creates its own political dangers. Southern elites attracted to the issue by promises of aid remain fearful about northern motives and the implications for their economies. Private corporations may be joining the bandwagon but only if given "incentives" and advantageous regulations. Immediate benefits accrue primarily to elites wherever they live, while the costs fall disproportionately on the majority of consumers and taxpayers. Increases in national public spending on renewables and new regulations, while assisting in the expansion of global corporations, may undermine human welfare and weaken the credibility of science, especially in developing countries. Higher energy prices and taxes may sharpen inequalities in developed economies. Government-controlled research has not constructed a more equitable global energy policy. For this to happen, govern-

ments themselves would have to change their political priorities. More equality between human groups is not on the political agenda. Bureaucracy and research are the winners of the Kyoto process.

Notes

1. Coal is more readily substituted than oil, least likely to be depleted, and widely distributed. Gas generates much less carbon dioxide (CO_2) per unit electricity than coal or oil. Nuclear power is almost carbon free.

2. President Bush's (2001) letter to the Senate refers to the "incomplete state of scientific knowledge of the causes of, and solutions." Hugh Ellsaesser (Lawrence Livermore National Laboratory) had written to him:

> If it is true [that there is a solar triggering mechanism starting ice ages], then some higher level of carbon dioxide could very possibly nullify the trigger and allow us to escape the next Glacial which is geologically imminent. I cannot think of anything more dangerous than something which returns it to the conditions of the Last Glacial. (Email Skeptics Network)

3. The likely effect of the Kyoto Protocol's emission reduction targets, accepting the IPCC, on calculated global average temperature would be a fall of 0.02 °C.

4. The European Union (EU) agreed to propose emissions cuts overall by 8 percent, United States by 7 percent, Iceland may increase by 10 percent, Australia by 8 percent, and Portugal by 27 percent. Fiercely opposed to differentiation globally, the EU is practicing it at home: France's target is 0; United Kingdom, 12.5 percent; and Germany, 21 percent.

5. The literature here is vast. It can be found in Intergovernmental Panel on Climate Change (IPCC) reports (IPCC 1992, 1995, 2001) and in journals, for example, *Energy Policy*, *Energy & Environment*, and *Environmental Finance*. For debates, see climatesceptics@yahoogroups.com.

6. The protocol is likely to cost at least $150 billion a year. Just $70 to $80 billion a year could give all Third World inhabitants access to the basics, such as health, education, water, and sanitation (*The Guardian* 16 August 2001).

7. A clear statement of opportunities is veiled by the "ethical" claims of environmentalism that hinder rather than advance negotiations.

8. Northern energy demand has become decoupled from economic growth. In Russia, it has collapsed, releasing much "hot air" (permitted CO_2 not emitted) for sale. Developing countries demand investments in conventional energy.

9. Kondratyev is an expert on aerosols, nuclear winter, and radiation at the Research Centre for Ecological Safety, St. Petersburg.

10. U.S. investment in climate change research alone is estimated at $5 billion per annum. The Global Environment Facility was given $6 billion over three years.

11. In the mid-1990s, several conferences were held (Leipzig and Bonn) where thousands of scientists signed declarations against the climate threat as presented by the IPCC. All failed to "outshout" environmentalist voices or impress growing environmental bureaucracies. IPCC critics have been published since the early 1990s in *Energy & Environment* and include Soon, Lindzen, Singer, Courtney, Calder, Sharp, Volz, Jelbring, Barrett, Gray, and Ahlbeck. All agree that the empirical basis of current claims to "discernable warming" is suspect and that uncertainties were removed from policy statements. Academic think tanks (Marshall Institute, United States; the Institute for Economic Affairs, United Kingdom; and the European Science and Environment Forum) have supported these voices on scientific and often ideological grounds.

12. Solar theorist Langenscheidt (personal communication, April 2001) said,

> Models are an excellent research tool to find out whether special physical processes, based on complex concepts, agree with reality. I appreciate the endeavour of scientists who are old hands at such work. I only disagree when models which are unable to represent the utterly complex climate system are taken to project what will be in a hundred years.

Readers may want to inspect the following Web pages: http://www.marshall.prg/Williecomments onDMI.htm, www.sepp.org/weekwas/2000/answer.html, and http://www.Vision.net.au/~daly.

13. Hansen also made a major submission to the U.S. Senate in early 2000 that suggested directing abatement efforts away from CO_2 to aerosols and other gases.

14. Oil prices have a major effect on fuel competition and technology choice. Between 1971 and 1973, they rose sixfold and rose again steeply at the end of the 1970s, to decline sharply between mid-1980s (except for the brief Gulf War period) and mid-1999.

15. Its leaders, including John Houghton (United Kingdom), Bert Bolin (Sweden), and Robert Watson (United Kingdom/United States/World Bank), have used their scientific status to act as policy advocates. Watson addressed the opening of the Hague conference with "we can't afford to delay" technology responses and used worst-case "projected increases" in temperatures to outline threats to agriculture, water supply, nature, and human health. In 1998, Watson addressed the Uranium Institute to ask this industry for support in their mutual interest.

16. See the following newsletters: for the International Council of Scientific Unions, *IGBP: Global Change Newsletter*, Royal Swedish Academy (lisa@igbp.kva.se), and for the Human Dimensions Programme on Global Environmental Change, *Update*, from Bonn University (www.ihdp.org).

17. "How Green Is Energy Efficiency?" a special issue of *Energy & Environment* (Herring 2000), published the articles from an Open University conference on this subject, all highly skeptical that efficiency improvement alone will reduce emissions.

18. "Seeking Support for Equitable Global Climate Policy," by the Global Commons Institute, calls for emission equity because greenhouse gases are "causing death and destruction year after year" (http://www.gciorg.uk).

19. Methods of emission trading are of interest to policy designers. All require public intervention and supervision, create disputes over power sharing, and involve large transaction costs requiring complex contracts between firms and governments (Jepma 1999).

20. The following have invested in the World Bank's carbon trading fund: BP Amoco, Statoil, Norsk Hydro, Deutsche Bank, Gaz de France, and four governments (*UKen Newsletter* 4, 3 June 2000, www.ukenvironment.com). Also, from Fred Singer, *Newsletter* (28 January) and *Joint Implementation Quarterly* (Jepma 2000).

21. An economic analysis done for the commission shows that EU-wide trading would cut euro 2 billion off the Kyoto Protocol implementation costs of euro 9 billion annually.

22. The EU's position at the Hague conference was that industrialized countries should meet at least half of their reduction commitments through domestic action, the clean development mechanism should in its early stages exclude nuclear power, strong economic sanctions should apply to countries not in compliance, the use of carbon sinks to soak up emissions should be deferred for at least a decade, and developing countries should not be forced to contemplate binding cuts later. Most of these had to be given up in Bonn or Marrakesh.

23. Note the headline in the *The Guardian*: "UK Leads World in Carbon Dioxide Cut—Switch from Coal and Fulfilment of Manifesto Pledge for 20% Reduction in ghg for 2010 Will Pay Off with £100m 'Carbon Credit' " (2000).

References

Boehmer-Christiansen, S. A. 1993. Science policy, the IPCC and the climate convention: The codification of a global research agenda. *Energy & Environment* 4 (4): 362-408.

———. 1994a. Global climate protection policy: The limits of scientific advice—Parts I and II. *Global Environmental Change* 4 (2/3): 140-56.

———. 1994b. A scientific agenda for climate policy? *Nature*, p. 372.

———. 1995. Britain and the Intergovernmental Panel on Climate Change: The impacts of scientific advice on global warming: Integrated policy analysis and the global dimension. *Environmental Politics* 4 (1): 1-18.

———. 1997. A winning coalition of advocacy: Climate research, bureaucracy and "alternative" fuels. *Energy Policy* 25 (4): 439-44.

———. 1999. Climate change and the World Bank: Opportunity for global governance. *Energy & Environment* 10 (1): 27-50.

———. 2000. Differentiation since Kyoto: An exploration of Australian climate policy in comparison to Europe/UK. *Energy & Environment* 11 (3): 343-53.

Boehmer-Christiansen, S. A., and A. Kellow. 2002. *The making of international environment policy: Interests and the failure of the Kyoto process*. Cheltenham, UK: Elgar.

Bush, G. W. 2001. Letter from the president to Senators Hagel, Helms, Craig and Robers. *Energy & Environment* 12 (4): 391-92.

Calder, N. 1999. The carbon dioxide thermometer and the cause of global warming. *Energy & Environment* 10 (1): 1-18.

Environmental Data Services. 2001. *London. Kyoto Protocol rules finalised* (No. 322:53). London: Environmental Data Services.

Global 2000. 1982. *Report to the president*. London: Penguin.

Grubb, M., C. Vrolijk, and D. Brack. 1999. *The Kyoto Protocol: A guide and assessment. The Royal Institute of International Affairs*. London: Earthscan.

Hansen, James, Makiko Sato, Reto Ruedy, Andrew Lacis, and Valdar Oinas. 2000. Global warming in the twenty-first century: An alternative scenario. *Proceedings of the National Academy of Sciences USA* 97:9875-80.

Herring, Horace. 2000. How green is energy efficiency? Special issue. *Energy & Environment* 11 (5).

Intergovernmental Panel on Climate Change. 1990. *Climate change 1990. The IPCC scientific assessment*. First assessment report. Cambridge, UK: Cambridge University Press.

———. 1992. *Climate change 1992. Contribution of working group 1 to the first assessment report of the IPCC*. First assessment report. Cambridge, UK: Cambridge University Press.

———. 1994. *Radiative forcing of climate change. Report of the Scientific Assessment Working Group, summary for policymakers*. Bracknell: U.K. Meteorological Office. Available from http://www.meto.gov.uk/sec5/CR_div/ipcc/wg1.

———. 1995. *Climate change 1995. The IPCC scientific assessment*. Second assessment report. Cambridge, UK: Cambridge University Press.

———. 2001. *Climate change 2001, 3 vols: I (scientific basis), II (impacts, adaptation, and vulnerability), and III (mitigation)*. Third assessment reports. Cambridge, UK: Cambridge University Press. Available from www.cip.cam.ac.uk/cais.

Jasanoff, S. 1996. Beyond epistemology: Relativism and engagement in the politics of science. *Social Studies of Science* 26 (2): 393-417.

Jepma, Catrinus. 1999. Magazine on the Kyoto mechanisms. *Magazine on Joint Implementation*, September.

———. 2000. Editorial. *Joint Implementation Quarterly* 6 (2): 13.
Karlen, W. 1998. Long-term solar forcing of the holocence climate. *Energy & Environment* 9 (6): 741-44.
Kondratyev, K. Ya. 1997. Key issues of global change. *Energy & Environment* 8 (4): 279-83.
———. 2000. Letter to the Royal Meteorological Society UK. *Energy & Environment* 11 (3): 365-66.
Leggett, J. 1999. *The carbon war: Global warming at the end of the oil era*. London: Penguin.
Matthews, Samuel W. 1975. What's happening to our climate? *National Geographic*, 28 April, 576-615.
Metzner, H., ed. 1998. The misinterpreted greenhouse effect [Special issue]. *Energy & Environment* 9 (6).
Moniz, E. J. 1999. Shaping the nuclear future. *Energy & Environment* 11 (6): 639-46.
Proctor, R. 1991. *Value free science? Purity and power in modern knowledge*. Cambridge, MA: Harvard University Press.
Rayner, S., and E. L. Malone. 1998. *Human choices and climate change*. Vol. 4. Columbus, OH: Battelle Press.
Sandor, R. 2000. CDM-simplicity is the key. *Environmental Finance: Supplement—The Carbon Challenge*, October, xix.
Sbragia, A. M. 1999. The changing role of the European Union in international environmental politics: Institution building and the politics of climate change. *Environment and Planning C: Government and Policy* 17:53-68.
Soon, W., S. Baliunas, S. B. Idso, K. Kondratvev, and E. Posmetier. 2001. *Modeling climatic effects of anthropogenic carbon dioxide emissions: Unknowns and uncertainties*. Preprint for Climate Research, January. Cambridge, MA: Harvard-Smithsonian Center for Astrophysics.
UK leads world in carbon dioxide cut—Switch from coal and fulfilment of manifesto pledge for 20% reduction in ghg for 2010 will pay off with £100m "carbon credit." 2000. *The Guardian*, 10 March, p. 11.
United Nations Environment and Development Forum, United Kingdom. 2000. UNDP business plan. *Connections*, May-July, 8.
Weizsäcker, E., and Amory Lovins. 1997. *Factor four: Doubling wealth, halving resource use*. Report from the Club of Rome. London: Earthscan.
Zillman, J. W. 1997. *IPCC and the science policy interface*. Proceedings. Melbourne, Australia: Royal Society of Victoria.

Sonja Boehmer-Christiansen is a reader in environmental politics and management, Department of Geography, Hull University, United Kingdom, and the editor of Energy & Environment. *She was formerly a senior research fellow at the Science Policy Research Unit, University of Sussex. She has published three books and more than ninety articles on international environmental politics with an emphasis on energy.*