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*This paper explores how emerging environmental issues will affect the nature of energy policy and the research agenda of energy analysts in the near future. The energy policies of the 1970s are described as inadequate in the current context because of the failure of markets to regulate environmental resource use and the imperfect link between energy consumption and environmental degradation. Abatement, structural change, substitution, and conservation are discussed as actions for the mitigation of environmental damages. Greater integration of energy and environmental policy and a shift from standards to market-based policy instruments are stressed as strategies for addressing long-term environmental problems.*

*Dans cet article, l'auteur examine comment les questions environnementales influenceront la nature de la politique énergétique et le programme de recherche des analystes du secteur de l'énergie au cours des prochaines années. Les politiques énergétiques des années 70 sont caractérisées d'inadéquates dans le contexte actuel. L'échec du marché face à l'utilisation des ressources environnementales et le lien imparfait entre la consommation d'énergie et la dégradation environnementale qu'elle occasionne sont les principaux facteurs qui nous mènent à cette conclusion. Dans ce contexte, la réduction d'émissions polluantes, les changements structureaux, la substitution et la maîtrise de l'énergie sont présentés comme des mécanismes possibles d'atténuation des dommages environnementaux. L'accent est mis sur une plus grande intégration de la politique énergétique et de la politique environnementale ainsi que sur un changement de cap quant au choix d'outils d'intervention publique, de la réglementation et des standards vers les instruments économiques, comme stratégies pour aborder les problèmes environnementaux de plus long terme.*

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# Energy and the Environment: The New Case for Conservation

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## 1. Introduction

In response to the oil price increases of the 1970s the governments of oil-importing countries initiated programs aimed at reducing their dependence on foreign sources. The principal goals of these programs were to ensure the security of energy supply, to reduce the negative impact of higher energy prices on economic growth, and to offset the balance of payments effects of higher prices. While these programs had important supply-side aspects, their greatest accomplishments were in improved energy efficiency. This improvement, which was achieved through a combination of technological and behavioral changes, was helped along by government subsidies and regulations. Increases in the prices of all forms of energy were, however, the greatest impetus to change; in many countries changes in taxation and the deregulation of energy markets reinforced these price changes.

Now, 20 years later, real oil prices have fallen far below the levels of the early 1980s. While energy efficiencies embodied in technologies developed during the era of high prices remain with us, the economic incentive for further progress is greatly reduced. The issue of energy security has been further diminished by the end of the cold war. These changing conditions do not mean, however, that the next 20 years will see a reduced interest in energy efficiency. Instead, a new sense of urgency over environmental issues has emerged as the principal motive force

behind conservation.

The purpose of this paper is to explore how the emerging focus on environmental issues will affect the nature of energy policy and the research agenda of energy analysts. A fundamental question is whether policies that were developed to address the adverse effects of energy use on security and economic stability are appropriate and adequate in the current circumstances. There are two reasons why they may not be. First, high energy prices gave all economic agents an incentive to conserve. Since the use of common environmental resources is not now properly governed by price mechanisms, such a direct incentive does not necessarily exist in the present context. Thus the simple, market-oriented policy of deregulation must be replaced by a more complex set of policies, including new regulation and market-based incentives. This is further complicated by the need for international cooperation and by concerns over intergenerational equity. Second, not all technological and behavioral changes that conserve energy have the same level of environmental benefit. Some conservation measures may even increase certain types of emissions. Thus the simple objective of reducing energy consumption must be replaced with a more comprehensive set of goals. This is further complicated by the high degree of uncertainty surrounding the causes and effects of certain emissions.

The discussion begins with a brief review of the energy-environment link, with special reference to the greenhouse effect and the relation between energy efficiency and environmental goals. Section 3 considers four categories of action which may be taken to temper the environmental effects of energy use. Section 4 is devoted to the interaction between energy policy and environmental policy. Threaded through it is a brief survey of the economics of environmental control.

## 2. Energy and the Environment

Concerns over the environmental consequences of energy production and use are not new. The deleterious effects of fuel combustion on air quality and human health in industrial regions, as

well as land degradation and water pollution in regions producing fossil fuels, were already evident in the 19th century. The advent of the automobile-based society in the second half of the 20th century expanded the geographical extent of environmental damage, as fuel burning sources of pollution spread beyond industrial regions to all areas of human settlement in the developed world.

By the 1960s it was generally recognised that the environmental consequences of increasing energy intensity inflicted significant damage on human health and property. However, this damage was viewed as being localized and short lived. By the 1970s advances in research and a heightened public awareness led to a recognition that some forms of environmental damage were more pervasive and irreversible than was once thought. In particular, pollutants were seen to interfere with the workings of complex ecosystems leading to a wide range of indirect and unexpected effects. During the 1980s, attention shifted to environmental problems such as acid precipitation, ozone depletion, and global warming. These new problems are different from those known earlier, firstly because of the non-local character of their impacts, and secondly because of their potentially cataclysmic long-term consequences, which could include widespread loss of aquatic and plant life, large increases in human cancer rates, and desertification and flooding on a global scale. Of these, the greenhouse effect provides the most powerful new imperative for rationalizing energy systems.

### 2.1 Energy and the Greenhouse Effect

The average temperature at the earth's surface is determined not only by the level of solar radiation, but also by the presence of radiatively active gases which help to trap heat in the atmosphere much as glass windows trap heat in a greenhouse. This *greenhouse effect* is intensified by the fact that human activities have increased the rate at which some of these gases — including carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), and chlorofluorocarbons (CFCs) — are produced by an amount sufficient to significantly increase their atmospheric concentrations.

This could lead to a general increase in global temperatures. The Intergovernmental Panel on Climate Change estimates that if current trends persist, there will be an increase of 1°C above the current average temperature by the year 2025, and a 3° increase by the year 2100 (Grubb, 1990, p.8-9). Much larger increases than these can be expected in certain regions, especially in the arctic.<sup>1</sup> While such predictions are the subject of scientific dispute (see for example Linzen, 1993), they identify the potential for massive destruction of ecosystems and dislocation of human settlement patterns.

Of the "greenhouse gases," the most critical is CO<sub>2</sub>. Current emissions levels of the others can be significantly reduced by making reasonably achievable technological adjustments. CO<sub>2</sub> is, however, the main output of fuel combustion. Thus nothing short of a massive reorientation of current energy production and use will prevent continued increases in anthropogenic CO<sub>2</sub> production, especially in light of expected growth and industrialization in the developing countries. Furthermore, since CO<sub>2</sub> remains in the atmosphere for decades, the effect of emissions on concentration is cumulative. This means that in order to maintain current atmospheric concentration, very large *decreases* in CO<sub>2</sub> production are needed. According to Smil (1989), the only hope of achieving such decreases in the next century lies in major changes in consumption patterns in the rich countries and reductions in the rates of population growth in poor countries.

## *2.2 Energy Efficiency and the Attainment of Environmental Goals*

The link between energy efficiency and the economic and security problems caused by the energy crises of the 1970s was clear. Any measure that reduced the ratio of energy use to GDP also reduced the potential for high energy prices to promote inflation and the fear that supply disruptions would threaten the economic well-being and security of importing nations. While it is

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1/ For example, some atmospheric models predict June temperature increases of almost 7°C for Inuvik in Canada's Northwest Territories (Cohen, 1993, p.27) .

generally true that energy efficiency has positive environmental benefits, it is not necessarily true that it constitutes in itself an adequate strategy for mitigating the environmental damage associated with energy production and use.

As one illustration, improved fuel efficiency in cars does not reduce all categories of harmful tailpipe emissions. While more fuel-efficient cars produce less of most pollutants, including carbon monoxide (CO) and carbon dioxide (CO<sub>2</sub>), they often produce higher levels of nitrogen oxide (NO<sub>x</sub>) (Hassounah and Miller, 1993).<sup>2</sup> In fact, the perverse relationship between energy efficiency and NO<sub>x</sub> appears to apply to other forms of fuel burning. In the case of natural gas combustion, those technologies that reduce CO and hydrocarbons emissions tend to increase NO<sub>x</sub> and vice-versa (Anderson, Kliman, and MacDonald, p.235). Thus, the environmental benefit of certain fuel efficient technologies may depend on the weights given to reductions in various types of emissions.

The link between energy efficiency and environmental benefit becomes more tenuous when a broader definition of environmental quality is employed. Virtually all environmental literature recognises pollution of the air and water and degradation of land as problems. Proponents of sustainable development go beyond this to include such things as resource depletion, the maintenance of biodiversity, and aesthetic values. Some would extend the notion of environmental quality to include a broad range of social and ethical issues. Clearly the definition has to stop somewhere to be useful, but it may be that some problems have been unduly stressed at the expense of others. For example, there has been more attention paid to outdoor air quality than to indoor air quality. Efforts to improve the energy efficiency of buildings by reducing air leakage and infiltration may cut outdoor emissions at the cost of trapping a broad variety of indoor emissions, leading to degraded interior air quality with serious associated health effects. Similarly, reduction in the delivery of indoor light translates into less electricity generation, but it has been connected with the problem of chro-

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2/ NO<sub>x</sub> is an important precursor pollutant to acid precipitation.

nic depression during the winter months (Rosenthal, 1993, p.44). Thus if we define all external factors that may have an adverse effect on human health as environmental problems, some conservation efforts appear to have both positive and negative impacts on the environment.

This is not to suggest abandonment of the basic principle that energy efficiency is good for the environment. In the great majority of cases the net effect of efficiency is positive, and the problems defined above probably can be resolved through technical means. What it does suggest, however, is that environmental problems associated with energy production and use are complex and multidimensional, and that care must be taken to avoid exchanging one problem for another.

### 3. A Taxonomy of Responses

Four categories of actions may be taken in order to mitigate environmental damage associated with the current pattern of energy production and use: abatement, structural change, source substitution, and conservation.<sup>3</sup>

#### 3.1 Abatement

Abatement is the removal of harmful substances in combustion wastes, usually from the exhaust stream as in the cases of catalytic converters on vehicles and scrubbers on smokestacks. The required use of abatement technologies has been one of the main instruments of environmental policy in Western countries. It is estimated that most harmful chemicals, including the precursors of acid precipitation, could be removed via abatement technologies for a cost equivalent to roughly 30% of the cost of the primary fuels (Holdren, 1990). The great attraction of abatement is that it reduces the harmful side effects of energy production and use without decreasing the rate of

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3/ While these four are distinct actions, they may be interrelated. For example, using natural gas in place of petroleum products constitutes an energy source substitution, but if it occurs on a significant scale it results in a shift in the pattern of demand that leads to structural economic change in the energy sector.

delivery of energy services.

Abatement has its limits. It is generally the case that the cost of abatement increases with the percentage of total emissions removed. Thus, while it may be reasonably inexpensive to remove some or even most harmful emissions, removal rates approaching 100% become prohibitively expensive. More importantly, abatement has very limited potential for reducing the threat of climate warming. This is because CO<sub>2</sub>, which is the most abundant of the greenhouse gases, is not just a byproduct, but the primary output of fuel combustion. It is therefore doubtful whether abatement technologies that will make a significant dent in CO<sub>2</sub> emissions will be developed (Grubb, 1990). Environmental strategies that rely heavily on abatement generally do not respond adequately to the greenhouse problem.<sup>4</sup>

#### 3.2 Structural Change

Structural change refers to the reallocation of human, capital, and natural resources to different categories of economic activities. Such shifts are a normal outcome of the process of economic evolution. For example, as regional and national economies develop and grow they tend to shift resources first from agriculture to manufacturing, and then from manufacturing to services. These shifts naturally affect the patterns of energy production and use, and lead to increases or decreases in the energy intensity of economies over time.

Much of the reduction in energy intensity and the associated reduction in harmful emissions that have occurred in the developed world over the past two decades may be attributable to structural change (Huntington, 1989). It is not clear how much of this change was induced by high energy prices and how much was simply a reflection of longer-term trends.

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4/ For example, the Bush administration's National Energy Strategy for the US stressed abatement. According to the Alliance to Save Energy *et al* (1991), it would lead to significant reductions in the output of SO<sub>2</sub> and NO<sub>x</sub> by the year 2030 (52% and 24% respectively), while at the same time allowing an increase of nearly 60% in CO<sub>2</sub> emissions.

Structural change will probably continue to play a role in alleviating the more localized types of environmental problems in the developed world. However, it will not necessarily play a positive role in addressing global problems such as the greenhouse effect. For one thing, it is likely that much of the shift away from energy intensive industries in the OECD countries was achieved by substituting imports for domestic products — thus transferring the energy use and associated pollution across international borders. More importantly, structural change in the developing world is likely to increase rather than decrease energy intensity, as economies shift from labour intensive agriculture into capital intensive agriculture and manufacturing.

### 3.3 Substitution

Substitution among primary energy sources has figured prominently in the post-1973 energy strategies of oil-importing nations. We can distinguish between three types of substitution strategies: substitution among conventional fossil fuels, substitution of nuclear energy for fossil fuels, and substitution of renewables for non-renewable fuels. In the 1970s, the goal was primarily to displace oil with any source that was plentiful, secure, and relatively cheap. In the future this goal will shift to displacing energy sources with high emissions or other environmental disadvantages to more environmentally benign sources.

Interfuel substitution has been a key strategy allowing firms and consumers to switch from expensive oil to cheaper coal and natural gas. Especially in North America, the great abundance of coal led some to believe that massive substitution of coal for oil was the answer to the energy problems of the 1970s.<sup>5</sup> Coal, however, has a number of practical drawbacks. It is much more difficult to transport than oil, and it must be transformed to a liquid or gaseous state before it is useful in many economic applications. Most importantly, coal burning has more damaging environmental consequences than burning oil.

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5/ See Horwath (1979) for a discussion of the role accorded coal in US energy policy and the practical limitations on its use.

While some of these consequences can be mitigated by abatement or transformation technologies, little can be done to offset the production of CO<sub>2</sub> from coal burning. Thus in the case of coal, rationales for substitution based on economic and security concerns are in conflict with environmental goals.

Interfuel substitution may play an important role in addressing the problem of climate warming, at least over the short run. The ratio of carbon to energy content for coal/oil/gas is roughly 100/77/56. Thus, for example, if the generation of electricity were shifted from coal-based thermal stations to gas-based thermal stations, the emissions of CO<sub>2</sub> would be reduced by almost half. Such a shift would also reduce emissions of SO<sub>2</sub>, particulates and other pollutants. In general, substitution of natural gas for other fossil fuels results in a reduction in environmental damage. However, while gas may cause less environmental damage at the point of end use, there are still significant environmental impacts associated with its production, and there is some question as to the adequacy of reserves.<sup>6</sup>

In principle, nuclear energy provides an opportunity to greatly reduce the emissions associated with combustion of fossil fuels, at least in the generation of electricity. Massive nuclear expansion could obviate the need for any fossil fuel combustion if electric technologies for the production of heat and mechanical energy were to replace all existing technologies. Despite this potential, hopes for a nuclear future have diminished in most countries.<sup>7</sup> One reason is that the capital, maintenance, regulatory, and operational costs associated with nuclear technologies have exceeded expectations, making nuclear a relatively expensive generation option. Still, in some countries with inadequate domestic fossil fuel resources, it remains economically viable (Banks, 1993). The most important limiting factors, how-

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6/ For example, it has been estimated that if gas were to displace all coal use in the US, current reserves would last only 18 years (Fulkerson, Judkins, and Sanghvi, 1990.) However, current reserve estimates underestimate the amount of gas that could be produced given improved technology and higher prices.

7/ See Damian (1994) below in this feature.

ever, are the uncertainties surrounding the issues of reactor safety, waste disposal, and nuclear proliferation. The Chernobyl accident, the difficulty of siting a waste disposal facility in the US, and the recent concern over potential production of weapons grade materials in Iraq and North Korea have all brought the problems of nuclear energy, rather than its benefits, into the forefront of public debate.<sup>8</sup> Despite these problems, growing concern over the environmental consequences of fossil fuel burning provides an argument for "keeping the nuclear option open" (Committee for Economic Development, 1993).

In the longer term, the most important substitution strategy will probably be the replacement of fossil fuel and nuclear energy with renewable energy sources. Renewable sources include hydroelectricity, solar, wind, geothermal, and ocean thermal energy, all of which are non-polluting, and biomass (plant matter) energy, which is CO<sub>2</sub> neutral. Hydroelectricity already makes an important contribution to the overall energy budget. However the fact that many of the best available sites have been used up, and the increasing recognition that new sites which involve impoundment of water have their own environmental and social drawbacks, limit the future growth of hydro power. Recent studies indicate an enormous potential for other renewables, especially biomass. A comprehensive analysis commissioned by the United Nations (Johansson *et al*, 1993) provides one of the most optimistic assessments yet, concluding that renewables have the potential to provide 60% of the world's electricity supply, and 40% of its direct supply of fuels by the middle of the next century at costs that are equivalent to or below those of conventional sources.

Even if some analysts may find the argument for renewables to be compelling, it is important to recognize that their integration into energy systems will require institutional as well as technological change. While they may be economically competitive, they are not likely to be so much

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8/ Häfele (1990) has suggested that in order to permit expansion of nuclear generation it may be necessary to place all nuclear materials under the control of a single international agency.

cheaper than energy firms and utilities will scrap their centralized production systems in favour of decentralized systems based on renewables without some public sector initiatives such as tax credits and research and development subsidies. Increased use of renewables will also require some changes that are outside the traditional scope of energy policy. For example, the scenarios in Johansson *et al* (1993) assume that millions of hectares of marginal agricultural land can be recommitted to biomass production. This will require fundamental changes in land use regulations and in the attitudes of farmers.

### 3.4 Three Mechanisms of Conservation

In contrast to substitution, whereby one type of energy input is replaced with another, conservation refers to a reduction in the amount of energy consumed. This can be achieved by three quite distinct mechanisms. The first is an improvement in the efficiency at which input energy, such as a fuel or electricity, is transformed into useful energy, such as heat, light, or mechanical energy. By this mechanism, energy is conserved even though the delivery of useful energy remains constant. The second is an improvement in the efficiency at which useful energy is transformed into an energy service. The third mechanism is a reduction in the demand for energy services.<sup>9</sup>

A simple example is provided by the heating of a home. The first mechanism refers to the efficiency with which fuel is transformed into heat, which depends upon the design of the furnace. The second mechanism refers to the efficiency with which the heat (useful energy) is transformed into interior temperature (an energy service), which depends upon the characteristics of the structure being heated, including insulation, window design, etc. The third mechanism refers to the decision by the residents of the house as to what interior temperature they want. Thus, energy may be conserved by installing a more efficient furnace, by adding insulation to the house, and by turning down the thermostat.

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9/ These three mechanisms are defined in line with Gardner and Robinson's (1993) model of the energy end-use process.

Recognising the distinctions between these three mechanisms should prove useful in defining the environmental benefits associated with energy conservation. As was mentioned above, improvements in transformation efficiencies may reduce some emissions while increasing others. Thus conservation actions in the first category need to be examined carefully to determine their net environmental benefit. Actions in the second category are more likely to have positive net benefits, although they may have unwanted side effects such as interior air quality problems. Conservation actions that fall into the third category are certain to reduce all environmental emissions involved, although taken to extremes they could have adverse effects on the efficiency of production or on human health.

The first two mechanisms depend not only on the availability of conservation technologies, but also on the factors that enter the decisions of firms or households to purchase capital goods that incorporate those technologies. The efficiency with which input energy is transformed to useful energy depends on the technologies embodied in a relatively small number of transformation devices. In the transformation of useful energy into energy services, efficiency depends on the purchase, installation, and maintenance of a larger number of devices in homes and businesses. Thus it involves more separate decisions, with the marginal benefit of each decision being smaller. For this reason, this type of efficiency is more likely to be underachieved. The third mechanism depends entirely on the amount of service people wish to consume, and is therefore independent of the choice of technology.

A recurrent theme in the energy literature is that technologies already exist that could provide very significant energy conservation, and that the capital costs of these technologies are such that they provide lower life cycle costs than conventional technologies when energy savings are factored in. Thus the first two mechanisms described above are by far and away the cheapest way to increase the supply of energy services (Anderson *et al*, 1993, Yergin, 1979). The question is why such a small proportion of this conservation potential ever gets achieved. Authors who have addressed this "efficiency gap" cite lack of

information, risk aversion, unreasonable payback requirements, limited access to capital, and lack of attention to relatively minor cost differentials, as well as an array of institutional factors such as taxes and regulations that prevent decision makers from reaping the benefits of efficiency gains (Grubb, 1990, pp.114-17; Pearce *et al*, 1989, p.69). All this suggests that greater emphasis needs to be placed on individual behaviour, including the range of institutional factors that affect decision making, if the full potential of conservation is to be achieved.

### 3.5 Combined Strategies

Any strategy to address environmental problems associated with energy production and use will involve some role for the four types of responses described above — abatement, structural change, substitution, and conservation. This can be illustrated for the case of CO<sub>2</sub> production. In order to reduce emissions while maintaining a reasonable rate of economic growth, it will be necessary to reduce the CO<sub>2</sub> intensity, defined as the ratio of CO<sub>2</sub> to GDP. Following Criqui (1989), this ratio can be decomposed as follows:

$$\frac{CO_2}{GDP} = \frac{CO_2}{FFI} \cdot \frac{FFI}{TEI} \cdot \frac{TEI}{GDP}$$

where FFI is fossil fuels input and TEI is total energy input. Reduction of any of the three ratios on the right-hand-side will result in a reduction in CO<sub>2</sub> intensity. Reduction of the first ratio can be achieved by abatement or by substitution among fossil fuels, such as gas for coal. Reduction of the second ratio can be achieved by substitution between fossil fuels and renewables or nuclear. Reduction of the third ratio can be achieved by structural change such that the share of energy intensive sectors in GDP are reduced, or by conservation whereby the total energy input used to produce the level of energy services necessary to attain a certain level of GDP is reduced.

While combined strategies are important, it is prudent to have policies that stress conservation relative to the other three categories of actions. There are four reasons for this.

1) The potential for conservation is enormous. Gaps between actual and potential efficiencies are still very large, and can be significantly closed in an economically efficient manner. These gaps probably exceed those associated with abatement technologies because so much abatement has already been done.

2) A broad range of technologies for conservation is already available. A theme that often emerges from conferences and workshops on energy and the environment is that it is institutional rather than technological constraints that currently prevent rapid progress in conservation.

3) The effects of and potential for conservation are already well understood, as compared with nuclear and renewables.

4) Conservation is probably the most politically tractable of the four categories of actions. In most countries the public has lost faith with nuclear energy, and it is difficult for politicians to justify expenditures on uncertain long-term prospects such as fusion and some renewables.

These four reasons taken together indicate that major conservation efforts can begin now, and do not have to wait for further research, though whether or not such efforts are seen as economically viable depends on a variety of factors that we have not yet considered.

#### 4. Energy Policy and Environmental Policy

The fact that energy production and use are the main causes of many of the most pressing environmental problems indicates that energy policy and environmental policy should not be viewed in isolation.<sup>10</sup> However, the way these two areas of policy have evolved in some countries implies that integration of the two will not be easy. Taking the UK as an example, Pearce (1989) observes that energy policy has been largely market oriented, using instruments such as deregulation and tax codes to provide incentives for private firms to bring about desirable outcomes by way of their private choices. By contrast, environmental policy has been interventionist, relying

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10/ For a discussion of energy policy since 1973, see Finon (1994), immediately preceding this article.

on regulations rather than incentives. This probably reflects the fact that energy policy was developed largely in response to economic concerns, while environmental policy was developed to address problems that do not invite the application of cold economic analysis, such as effects on human health.<sup>11</sup>

In recent years there have increasingly been attempts to incorporate environmental considerations into energy policy design, although it may be that such attempts are "tacked on" rather late in the policy development process, at a point where the relevant options have already been defined.<sup>12</sup> At the same time, there are also moves underway to incorporate into the realm of environmental policy the more market-oriented types of instruments which have been employed for energy policy. This involves a shift from command and control regulation to an approach in which price signals are manipulated so as to incorporate environmental costs and benefits into the determination of market outcomes.

This section discusses some basic issues that must be considered in order to formulate energy policy that addresses environmental concerns. The main argument is that in order to reduce the rate of environmental degradation, the costs of externalities must be more fully reflected in the costs of energy production and use. This raises the question of whether energy cost increases of the magnitudes necessary would cause such severe economic damage as to be impossible to sell. After brief discussions of how the choice of policy instruments affects the costs of reaching environmental goals, and of the potential economic impacts of environmental policy, the section concludes with a discussion of how some aspects of the current environmental dilemma are leading policy makers into a journey in uncharted waters.

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11/ In the US, environmental legislation has in some cases gone so far as to explicitly ban any consideration of costs and benefits in establishing environmental standards (Portney, 1990).

12/ According to Bregha(1992), this results in inadequate consideration of conservation as an alternative to the development of new supply.



#### 4.1 Market Prices and Externalities

From the mid 1970s to the mid 1980s both Canada and the US achieved roughly 40% growth in GDP while at the same time experiencing almost no growth in energy consumption (Robinson, 1990; Alliance to Save Energy, 1991). The most plausible explanation for why the long term correlation between growth in energy use and economic growth broke down is that energy price increases provided incentives for conservation and energy-saving structural change. These increases were largely the outcome of trends in international markets, but they were reinforced by deregulation of domestic markets in both countries and fuel taxes in Canada. The question that arises now is whether the shift to a declining trend in real energy prices will mean the end of progress on energy efficiency, with its associated environmental benefits. Evidence from the late 1980s indicates a slowdown in the rate of decline of energy intensity in a number of countries (Martin, 1989). More recent data are difficult to interpret, however, because of the effect of the recent recession.

According to an analysis of energy trends in five OECD countries (Howarth, Schipper and Andersson, 1993), the slowdown in energy growth was not due to a decline in the demand for energy services, but rather it was largely due to improvements in transformation efficiencies. Since such technical improvements are unlikely to be reversed, there is no reason to expect a surge in energy demand as a result of lower prices. However, as the incentives to invest in improved transformation technologies decline,<sup>13</sup> it is likely that the demand for input energy will be more closely linked to the demand for energy services (Walker and Wirl, 1993). A return to modest growth in energy use is therefore a reasonable expectation.

In light of the priorities of energy policy in

the 1970s, a return to cheap energy with moderate demand growth might have been viewed as a positive development. In the 1990s, however, it is a disturbing trend. When environmental impacts are taken into account, market prices are not good indicators of the social cost of energy use. Thus energy policy based solely on the allocative efficiency of markets will be inadequate in the absence of a much greater effort to account for externality costs.

The market fails to prevent wanton damage to the environment when polluters who inflict costs on the consumers of environmental resources are not required to compensate them for these costs and therefore have no incentive to refrain from polluting. The textbook solution is to require the polluter to compensate everyone up to the point where they are as well off as they would have been in the absence of the pollution. The polluter then chooses to reduce the output of pollution or pay the compensation, whichever is cheaper. In theory this results in a Pareto optimal level of pollution generation.

The theoretical resolution of the externality problem leaves two questions unanswered. The first is how to determine the appropriate level of compensation — the "externality cost" — and the second is by what mechanism this compensation is to be made. The assessment of externality costs is controversial because some people recoil from the idea that damage to the environment can be translated into monetary terms. However, without a common measure of environmental damage it is difficult to determine which types of externalities are most in need of correction. If this question of philosophical principle can be overcome, there remains the difficult practical problem of how to assign dollar values to various types of environmental damages. While there is no single answer that deals with the wide variety of practical hurdles, considerable progress is being made in the development of novel methods for such valuations.<sup>14</sup>

The question of how to provide mechanisms for compensation is a major concern in policy design. In theory, if property rights are fully

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13/ The average transformation efficiency of the energy-using capital stock will probably continue to improve as old, inefficient capital is retired and replaced with newer technologies. The rate of improvement in new technologies, however, may well slow down.

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14/ For a discussion of externality valuation methods see Pearce, Makandya, and Barbier (1989).

protected in law, when the cost of externalities are determined individuals and firms can make claims against polluters to collect their compensations. Practice is not that simple. Making such claims would involve enormous transactions costs. Furthermore, it would seldom be the case that anyone affected by a given type of pollution could attribute it to a single polluter. To take this to the extreme, if a piece of property is flooded because of global warming, is the owner of that property to be compensated by every firm and individual that produces CO<sub>2</sub>? A practical resolution is to initiate a tax equal to the cost of the externality. This provides firms with an incentive to reduce pollution and thereby avoid the tax. The proceeds for such a tax can be used to repair environmental damage, thus improving the lot of consumers of environmental resources as a group, rather than through individual compensations. Practical concerns about the implementation of such a tax, and alternatives to it, are discussed further below.

#### 4.2 Efficient Policy

Until the 1990s environmental policy in most countries was based on a system of command-and-control regulations, including emissions standards with complementary fuel efficiency standards, and outright prohibition of some activities and substances because of their environmental dangers. While these standards have had positive impacts, especially with respect to emissions from vehicles and industrial sites, they have come under increasing criticism as an outmoded and inefficient approach to addressing environmental problems (Portney, 1990).

#### CONTROL THROUGH STANDARDS

Typically, an environmental standard requires all firms or individuals within a broad category to move to the same lower level of emission or fuel consumption, without taking account of the fact that the cost of making that reduction may vary depending upon who is making it. If the overall goal is, say, to reduce the SO<sub>2</sub> emissions of a group of firms by a million tonnes, and there are some firms within the group that can make

reductions more cheaply than others, then the total cost of reaching the goal is less if the firms who can do it most cheaply make all of the reduction, while the rest continue to emit as before. The problem, of course, is that no regulator could justify compelling some firms to reduce their emissions, while others are allowed to carry on polluting.

Standards may also provide incentives for some behaviours that are inimical to environmental goals. For example many standards, such as emissions standards on cars, apply only to new equipment. In such cases, assuming that application of the standard involves some cost to the purchaser of the new equipment, they provide an incentive to make do with the old for a longer time, thus delaying the penetration of cleaner technologies (Cairncross, 1992). Furthermore, in the case of energy efficiency standards it has been suggested that there may be some "rebound effect" whereby, for example, drivers of fuel efficient cars have an incentive to drive more because of the reduced per kilometre costs.<sup>15</sup> One point on which there is now broad agreement is that if standards are to be applied, they should be defined in terms of some permissible level of emission or fuel consumption, and not on "best technology" specifications, which may lock in old technologies and retard the development of new ones (Grubb, 1990).

#### MARKET-BASED INSTRUMENTS

Given the drawbacks of command-and-control regulation, there is an increasing shift toward policy instruments designed so as to promote the attainment of environmental goals at the lowest possible cost. These instruments are intended to integrate the costs of environmental damages into the market — in essence, to internalize the externality. While economists have long supported their use, only recently have such instruments come to the forefront on policy agendas, and they have as yet had only limited application.

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15/ Econometric analyses by Green (1992) and Jones (1993) suggest that this effect, if it exists, is relatively small.

Theoretically, the ideal market instruments would be emissions fees or externality prices that are set equal to the environmental cost incurred by a particular emission or product. If such costs can be accurately defined, there is no need to predefine environmental goals, as the allocative mechanism of the market can be relied upon to produce socially optimal levels of pollution. Under a system of emissions fees there is no legal limit on the amount a firm (or individual) may pollute, but it must pay a tax on each tonne it discharges. Thus, those firms who can reduce their emissions for a cost that is less than the fee will make the reduction, and the rest will not,<sup>16</sup> the total cost of the reduction achieved in this way is less than if everyone were required to reduce their emissions to the same level.

Ideally the fees would be set equal to the social cost of the pollution. In practice, however, it is doubtful whether such costs could be defined in a way that would be widely accepted. Thus it may be that it is still necessary to predefine some emissions target, and set the fees high enough to achieve it. While there is no assurance that this target level will be socially optimal, it will at least be attained at the lowest possible cost.

If emissions targets are to be set, an alternative market-based instrument is a system of tradable permits. Here firms are issued permits to produce a certain amount of pollution, such that permitted emissions sum across firms to the target level. If the firms are allowed to trade the permits among themselves, those that can reduce pollution most cheaply will have an incentive to sell their permits, while those for whom the cost of reduction is highest have an incentive to buy them. Once again, the target is achieved at the lowest possible cost.

While permits and fees both achieve the same end, each has its advantages in practice. Assuming that there is sufficient monitoring and enforcement, permits ensure that the target emissions level is met. Fees, by contrast, will only achieve the target if they are set at precisely the

right level. Since there is no way to be sure of this level in advance, there may be a significant "breaking in" period during which the fees are adjusted until the target is met. Such frequent adjustment would cause significant uncertainty among firms. The main disadvantages of permits are that the regulating agency must make a prior assignment of permits to firms, which may be difficult to justify, and there may be significant transactions costs in achieving an optimal set of trades. Thus, for example, Grubb (1990) argues that permits are not a viable strategy for reducing CO<sub>2</sub> because it has so many sources that the issuance of such a large number of permits would be prohibitively expensive. In general, permits are preferred in circumstances where there are a small number of large polluters, and fees are preferable where there are a large number of small polluters (Haites, 1991).

For those emissions that are principally due to fuel combustion, and for which the potential for abatement is limited, it may be easier to attach a tax to the fuel itself, rather than charging a fee on the emissions. Since CO<sub>2</sub> is such an emission, there have been widespread calls for the institution of a carbon tax. The tax would be proportional to the ratio of carbon to energy in the fuel, thus it would be highest on coal, somewhat lower on oil, and lower still on gas. Since biomass fuels are carbon neutral, which means that the amount of CO<sub>2</sub> released in their combustion is equivalent to the amount taken in during their production, no carbon tax would be charged against them. Such a tax would promote a reduction in CO<sub>2</sub> both through conservation and source substitution. The main problem with the carbon tax is the same as with emissions fees: there is considerable uncertainty as to the level at which it should be set.<sup>17</sup> This is complicated by the fact that energy markets may act to blunt the effect of such a tax. For example, massive application of a carbon tax would depress oil prices, thus reducing its effective impact on consumption behaviour (Criqui, 1989). Also, since the carbon tax falls disproportionately on certain

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16/ If the marginal cost of emissions reduction is increasing, it will cut emissions up the point where the marginal cost is equal to the fee.

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17/ For a discussion of debates surrounding the required level of carbon tax and its market effects see Grubb (1990), pp.87-100.

sectors and regions, its implementation will be opposed on the argument that it is unfair to those who pay the most. This was made abundantly clear in the US when the idea of a carbon-based energy tax was floated during the early months of the Clinton administration.

In those cases where the technology embodied in capital has a major effect on energy consumption and associated emissions, market instruments that influence capital choices by firms and individuals may be most appropriate. Of particular interest are "feebate" programs, whereby the revenue from a tax charged on the purchase of inefficient capital is used to fund a subsidy on the purchase of efficient capital. Programs of this type are already in force in a number of jurisdictions — the "gas guzzler" tax on automobiles. Plourde (1991) proposes a comprehensive strategy to reduce carbon emissions from automobiles that includes a gas guzzler tax, a gas guzzler licence fee to encourage turnover of older cars, and a tax on gasoline to prevent the "rebound effect" from more efficient cars.

#### UTILITIES AND DEMAND-SIDE MANAGEMENT

Electric utilities must figure prominently in the development of more environmentally-oriented energy policy: they are important consumers of primary energy and sellers of secondary energy, and as major consumers of coal, they participate in causing acid precipitation and massive CO<sub>2</sub> emissions. Furthermore, because utilities are generally state-owned enterprises or regulated monopolies and because they make planning decisions involving extraordinarily long time horizons, they are often singled out as having a special responsibility to address environmental issues (Ottinger, 1991).

There is a broad consensus that the fundamental problem with utilities has been that they operate under institutional arrangements whereby they have strong incentives to generate more electricity because their revenues are directly proportional to the number of kilowatt hours they deliver. Since the best hydro sites are often used up and the nuclear option has become less attractive, increasing the generation of electricity often means building new coal fired stations. In

recent years, these institutional arrangements have been changing in ways designed to encourage utilities to carry on demand side management (DSM).

DSM involves strategies through which a utility eliminates the necessity for new generating capacity by improving the efficiency at which electricity as an input energy is transformed into energy services (heat, light, mechanical energy). Such an approach is justified on economic grounds, as it is usually cheaper to promote conservation than it is to build new generating capacity. Thus in some cases, DSM might actually lead to a reduction in the delivered price of electricity. However, the main objective of DSM is to reduce the cost of energy services to the consumer, including the costs of electricity, transformation, and end-use technologies (Hirst, 1992). When the costs of environmental damage are taken into account, the economic case for DSM versus business-as-usual is all the more compelling.

From a practical perspective, DSM implies a number of changes in the way the utility does business. The utility achieves DSM indirectly by encouraging its customers to conserve. This requires a shift of emphasis from engineering to customer relations, which in turn requires changes in the organizational culture of some utilities. Most importantly, regulatory rules must change to provide an incentive for the utility to produce less rather than more electricity (Cairncross, 1992; and Nadel, Reid and Wolcott, 1992).

Despite the negative images of many utilities in relation to environmental issues, through DSM many of them are already playing progressive roles in reforming the current energy system. For example, utilities in California have managed for over a decade without adding any nuclear or thermal generation facilities, and regulatory boards in California, Nevada, New York, and Massachusetts have assigned social costs to emissions of CO, CO<sub>2</sub>, and SO<sub>2</sub> which must be used in planning decisions (Chernick and Caverhill, 1990). This optimistic assessment is reinforced by the recent appointment of people with strong credentials in relation to environmental management to leadership roles in Ontario Hydro and the New York State Power Commission.

### 4.3 Economic Impacts of Policy Initiatives

If the environmental problems associated with energy are to be reduced, it is not possible to avoid increases in the effective prices of producing and consuming input energy — they will rise either directly, where externalities are taxed, or indirectly, where technological standards bring about increases in the cost of real capital. The question is then whether such price increases will cause economic disruptions that are viewed as being worse than the environmental problems they seek to alleviate.

An important point in this debate is that it is the price of *input* energy that must rise, rather than the price of energy *services*. Thus, after some period of adjustment during which conservation strategies are put in place on a massive scale, economic prospects may not incur any long term damage. The real issue is what types of economic impacts might occur during such a period of adjustment. While a complete discussion of the issue is beyond the scope of this paper, two questions will be addressed briefly: (1) whether policies designed to reduce environmental damage are necessarily a drag on the economy over the relatively short run; and (2) whether unilateral action on the environment in regional and national economies subjects them to competitive disadvantages.

The argument that aggressive environmental policy will have dire economic consequences is often made by referring back to the energy crisis of the 1970s, when rising energy prices set off an international recession. The proponents of this argument ask why, for example, a price increase due to a carbon tax or other environmental tax would not have the same effect. The environmental editor of *The Economist*, a magazine that is hardly inclined to promote unnecessary disruptions of markets, has argued against this position on the grounds that it was not so much the magnitude as the suddenness of the price increases that caused economic havoc in the 1970s. A carbon tax could be phased in gradually to allow firms and individuals to make the necessary adjustments, just as they did during periods of high prices in the late 1970s and early 1980s. Furthermore, unlike the OPEC price increases,

which for importing countries constituted a transfer of income abroad, a carbon tax could be used domestically for purposes that would have positive economic impacts (Cairncross, 1992).

Empirical studies in the US indicate that the economic impact of air pollution policy has so far been minimal, despite the fact that it was based largely on command-and-control mechanisms that are generally believed to be inefficient (Portney, 1990). Furthermore, recent simulations indicate that policy instruments designed to produce a significant reduction in CO<sub>2</sub> emissions, including a carbon tax, oil import fee, and gas guzzler tax, would have very minor impacts on the US economy (Miles-McLean, Haltmaier, and Shelby, 1993). Allowing for the possibility that more draconian measures could have severe economic impacts, the empirical evidence suggests that moderate but effective measures could be taken without major economic disruption.

One argument against aggressive action on the environment is that, even if some policy such as a carbon tax would be beneficial if it were applied universally, any jurisdiction that applies it unilaterally will be placed at a significant economic disadvantage.<sup>18</sup> While there is sense to this argument, it should be kept in mind that there may also be economic stimulus associated with adjusting to such a tax. For example, Jaccard and Sims (1991) have projected that a utility demand-side management program, which would be a probable response to a carbon tax, has greater employment generating potential than an equivalent expansion of generating capacity, and would create supply-side benefits by increasing energy efficiency. Furthermore, setting environmental policy to a level that other jurisdictions will attain at some later date provides a head start on the development of "green" technologies, renewable energy, etc. For example, by setting extraordinarily high environmental standards for itself, the State of California has developed important export industries in the fields of energy conservation and renewables (Anderson *et al*, 1992).

In regard to measuring the impacts of envi-

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18/ The Committee for Economic Development (1993), an industry group, opposes the carbon tax on this basis, and on the basis that more research is needed.

ronmental controls on the economy, it is important to note that conventional national accounting methods routinely undervalue the environment by failing to adjust for environmental degradation and resource depletion in the same way that they adjust for the depreciation of capital. Thus an analysis of the effect of environmental policy on Domestic Product contains an implicit negative bias. New methods of national accounting that make these adjustments could give a more balanced picture (see Pearce *et al*, 1989, Chapter 4).

The general tenor of much of the literature on the energy/environment link is that a rational and efficient policy regime may be created by weighing the costs and benefits of actions taken to mitigate environmental damage, and that such a regime need not have a negative impact on economic progress. This represents a change from earlier polarized positions stating, on the one hand, that economic growth must cease if the environment is to be saved, and on the other that environmental regulations are unwarranted impediments to growth. Consistent with this new view is an emphasis on economic analysis, including the valuation of externalities, in all environmental policy initiatives. Thus the objective is to pursue environmental objectives in an economically efficient manner.

#### 4.4 *Uncharted Waters*

While conventional theories that apply to other public policy issues are useful in devising efficient strategies for energy and the environment, some of the problems that must be addressed involve markedly new challenges for policy analysis. This is especially true of the global climate warming issue. This problem is distinguished in two ways from any policy problem that has been addressed in the past: (1) the long time scale over which it is defined, which brings up profound issues of uncertainty and intergenerational equity; and (2) the fact that nothing short of a fully international policy strategy will be adequate to the task of correcting it.

In the past, environmental policy has been primarily reactive, responding to environmental problems as they emerge (Pearce, 1989). This ap-

proach is both inefficient and efficient: inefficient because it is generally cheaper to prevent environmental damage than to repair it after it occurs; efficient because it avoids taking action on problems that may never occur. However, when we consider a problem such as the greenhouse effect, it is clear that reactive policies are inadequate. Because CO<sub>2</sub> remains in the atmosphere for such a long time, if reductions in anthropogenic emissions are left until serious damage occurs via global warming, it could take decades or even centuries before the damage is repaired. Thus a proactive approach is called for, whereby action is taken today to prevent the problem in the future. But what is an appropriate proactive policy when there is still debate over whether the problem will ever emerge? And even if we accept that the problem is imminent, to what extent should people in the current generation make sacrifices to prevent a problem that will probably only affect future generations?

In the present context, a proactive strategy for the greenhouse effect involves two categories of action: "no regrets" and "insurance" actions (Holdren, 1990). The former are steps that will be beneficial in an economic or environmental sense even if the problem never comes about. These may include all categories of abatement, structural change, substitution and conservation that have positive net benefits. The notion of a no regrets strategy has some appeal in that it is at least more proactive than a repeated call for further research, and it uses the threat of global warming as an incentive to take action on the environmental problems that are already well known. However, starting from the position that those problems should be addressed anyway, it could be interpreted as a decision to take no specific action on the greenhouse effect. Furthermore, it is far from clear what actions fall into the no-regrets category. For example Holdren (1990) includes a tax on carbon emissions as a no-regrets option, while the Committee for Economic Development (1993) sees such a step as very premature. Thus a clear definition of a no regrets strategy awaits the resolution of a wide range of technical debates.

The analogy to an insurance policy plays up the fact that it is quite normal for firms and indi-

viduals to incur expenses for actions against the possibility of uncertain and undesirable future events. In the case of the greenhouse effect, the major action to be taken as insurance is a reduction in the emissions of CO<sub>2</sub> beyond what would be justifiable for the purpose of mitigating other environmental problems, such as acid precipitation or urban smog. The key here is that a no-regrets approach addresses CO<sub>2</sub> only indirectly, because it happens to be emitted in conjunction with other emissions such as SO<sub>2</sub>, NO<sub>x</sub>, and CO which cause those shorter-term problems. An insurance strategy will focus directly on CO<sub>2</sub>. This implies that, for reasons described above, it will be made up primarily of conservation efforts rather than abatement efforts.<sup>19</sup> Another insurance strategy that falls short of a direct attack on CO<sub>2</sub> emissions is the establishment of a contingency plan, including predefined policies and international agreements, that would make it possible to implement massive CO<sub>2</sub> reductions quickly when and if new information warrants it (Holdren, 1990).

The question of intergenerational equity complicates policy analysis at the methodological level, and also at the ethical level. It is standard practice to apply a discount rate in benefit-cost analysis to make benefits and costs occurring at different times commensurate in the final summary calculation. When we compare the costs of preventing global warming to the costs of letting it occur, we are comparing costs incurred by different people at different times. From an ethical perspective, proponents of sustainable development argue that each generation should take responsibility for passing on a constant stock of environmental resources to future generations. This is often used as an argument for taking early action on global warming. However, there is little consensus on what constitutes a constant stock of environmental resources or exactly how global warming would affect that stock.

The fact that the greenhouse effect does not respect international borders is equally daunting. The difficulty of reaching international agree-

ments on acid precipitation in North America and in Europe are well known. Since acidic damage is caused by precursor pollutants that may come from point and mobile sources hundreds or even thousands of kilometres away, it is not easy to match sources with damages, nor is it possible for any one country to resolve the problem on its own. The international negotiations that will be necessary if anything is to be done about the greenhouse effect will be even more difficult for a number of reasons. First, unlike acid precipitation, the greenhouse effect is the result of pollutants that are fully mixed in the atmosphere, meaning that every country suffers from the problem, and no country can blame its suffering on a single neighbour. Furthermore, since CO<sub>2</sub> is such a pervasive emission, no country can count itself completely innocent. What this means is that the problem can only be addressed by all the countries of the world. In themselves, regional negotiations between countries that are accustomed to dealing with one another, such as the US and Canada, will not do much good. If we look to trade relations for an analogy, we find that regional trade agreements, such as the ones in force for NAFTA, ASEAN, and the EC have generally been more comprehensive and easier to negotiate than global agreements such as the GATT.

International cooperation on the greenhouse effect will be additionally difficult because the effect of anthropomorphic CO<sub>2</sub> emissions is cumulative: the amount of damage that has already been done by various countries will become an issue. For example, less developed countries may argue that an arrangement whereby all countries are required to reduce emissions by a common proportion is unfair to them because the developed countries were not bound by such restrictions during their industrialization periods. Developed countries such as Denmark and Japan that are already energy efficient will also object to such an arrangement because it effectively punishes them for having set a good example for the rest of the world (Schneider, 1993). However, the alternative to across-the-board cuts is a set of more specific limitations that may take decades to negotiate.

The successful negotiation of the Montreal

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19/ See Alliance to Save Energy *et al* (1991) for a policy strategy that features CO<sub>2</sub> reduction as a central, rather than ancillary, goal.

Protocol limiting CFCs, which now has over 65 signatory nations, provides some cause for optimism. As Cairncross (1992) points out, however, there are a number of reasons why an international protocol on greenhouse gas emissions will be more difficult. The first is that by the time the Montreal Protocol was signed in 1987 there was almost universal scientific agreement about the thinning of the ozone layer and its impacts on human health. There is much more uncertainty at this point about global climate warming, and even those who accept its inevitability may argue that people can adapt to it. Furthermore, CFC emissions are exclusively anthropogenic, while there is still some debate over the contribution of human activity to total CO<sub>2</sub> emissions. As well, there are a large number of substitutes for CFCs. There are substitutes for some of the greenhouse gasses (CFCs being a case in point), but there is no easy substitute for the generation of CO<sub>2</sub> through fuel combustion.

## 5. Concluding Comments

The theme of this paper is that environmental issues are defining an agenda for energy research and policy that is in many ways different from the one that was defined by the oil price shock of the 1970s. Energy conservation remains a crucial policy goal, but for different reasons and with a somewhat different emphasis.

In order to meet the challenge of this new agenda, policy makers have to develop their understanding of some new sorts of problems. As was true when energy security was the primary problem, a great deal of scientific work on energy processes is needed. Equally important, however, is the need for behavioral and institutional research. In the case of energy conservation, it appears to be a lack of understanding about decision making by individuals and institutions, rather than a shortage of technology, that retards progress. The need to make meaningful valuation of environmental resources will require rapid progress in fields of social science research, such as experimental economics, which are still relatively new. Understanding the necessary conditions for an international agreement on greenhouse gasses provides a new challenge for

political scientists and the development of theories for making rational decisions under the risks and uncertainties associated with energy systems will require the expertise of management scientists and psychologists. Geographers and planners must consider the development of more efficient patterns of human settlement and interaction. Most importantly, the walls between scientists, social scientists, and engineers must be lowered in order to address a set of complex issues that no discipline can hope to resolve on its own.

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