The possibility of global climate change has aroused renewed interest in long term energy consumption forecasts. Uncertainty with respect to these forecasts is great — the results of various studies concerning consumption in 2020 vary by a factor of 1.5, or even 2. Strategies aimed at controlling the emission of greenhouse gases can be based on substitution between fossil fuels, on energy production from non-fossil fuels and, especially, on energy conservation. The entire range of energy industries is likely to be affected by measures that respond to the risks of global climate change. The dynamics of international energy markets could be profoundly changed by the desire to limit consumption of certain types of energy sources; depending on the nature of the constraints applied, decreases in international market prices are possible. This paper provides a brief discussion of these prospects in the light of an examination of current oil markets and a retrospective analysis of energy trends and economic development in major regional groupings. (While the papers on these latter two subjects, in Part 5 of Energie Internationale 1989-1990, *are not included in this ESR/EI Co-edition, abstracts of them are found on p.271 below.)*

*La question du changement climatique global renouvelle aujourd'hui l'intérêt pour la prospective des consommations à long terme. L'incertitude dans ce domaine est grande, puisque des études reconnues aboutissent à un écart d'un facteur 1,5 ou 2 pour la consommation mondiale en 2020. Les stratégies de contrôle des émissions de gaz à effet de serre pourront s'appuyer sur la substitution entre sources fossiles, la production d'énergies non fossiles, mais surtout la conservation de l'énergie. Toutes les industries énergétiques sont susceptibles d'être affectées par la prise en compte des risques de changement global. Il en est de même des marchés de l'énergie dont les équilibres pourraient être profondement modifiés par la volonté de limiter la consommation de certaines sources, ce qui d'ailleurs pourrait entrainer la chute de leur prix international. Cet article présente ces perspectives à la lumière d'une analyse rétrospective de tendances économiques et énergétiques dans les différentes régions du monde. (Les articles d'*Energie Internationale 1989-1990 *sur ces derniers sujets n'étant pas inclus dans cette co-edition, leurs résumés apparaissent page 271 ci-dessous.)*

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Trends in World Energy Demand in the Face of Possible Global Climate Change

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The outlook for world energy demand is not only unclear but also, if one considers both the short and long term, somewhat contradictory. Recent changes in demand, particularly within OECD countries, appear to upset the conclusions of various analysts, according to whom consumption in the industrialized world has nearly reached a final levelling-off point. At the same time, the long-term factors contributing to the demand slow-down in industrialized countries — relatively static demographic trends, capital saturation and technical progress — are very real.

On the basis of several simple hypotheses, concerning trends in energy intensities and per capita consumption, we can construct a framework within which to examine long term (20 years) changes in demand. These assumptions lead to an overall growth rate considerably lower than the rates observed over the last few decades. Although energy demand is currently growing, several studies of the causes and consequences of the greenhouse effect associated with the use of fossil fuels conclude that it may be necessary to stabilize global energy consumption in order to limit its impact on world climate. In that event, the challenges to be faced will be great. They will be different for industrialized and developing countries, though equally diffi-

Energy Studies Review Vol. 1, No. 3, 1989 Printed in Canada

cult. This article provides an initial analysis of the potential consequences for energy systems of the emerging concern for global climate change.

1. Demand: From Short Term to Medium and Long Term

Current uncertainty about energy demand is due to the obvious contradictions among present trends, characterized by rapid growth, long term trends that could be more moderate within the industrialized countries and, finally, the possibility of having to control world energy consumption due to environmental constraints.

1.1 Short Term Changes Confirm the "Econometric View" of Energy Demand

World consumption of conventional energy forms grew at an average annual rate of 5.2% between 1960 and 1973 (ENERDATA). This rate then fell considerably between 1973 and 1988, to an average low level of 2%. Between 1975 and 1979, however, it was still at 4% per year and since 1983 it has been nearly 3% per year. Each oil shock has thus slowed down growth in consumption, without ever managing to stop it. In regional terms, annual growth over the last four years has been 2.1% in the OECD, 2.2% in Eastern European countries, 4.0% in developing countries and 6.9% in China.

The trends observed within developing and planned economies are not surprising, given the extent of unsatisfied needs and demographic pressure in the former, and the highly energy-intensive development profile of the latter. Continued growth in the industrialized countries, though weaker, would appear to contradict analyses that have predicted very weak or even zero growth in energy consumption, as a result of the softening of industrial growth, technical progress in energy use and an end to growth in the stock of energy-using household equipment due to market saturation.

Indeed, current movements confirm the "econometric view" of energy demand, according to which incomes and prices remain the principal factors determining consumption. Though the stabilizing factors mentioned above are real, they have been offset in recent years by growth in certain energy-consuming activities (in the transport sector in particular), as well as by a flagging in energy conservation efforts and by a limited but real comeback of some heavy industries.

Which of these two groups of contradictory factors will dominate in the future? The results of most econometric models point to a continuation of present consumption trends within the OECD — at a rate of around 2% — until 1995. Given the existing levels of consumption in the industrialized countries and in developing countries, this growth rate would lead to equal growth in the volumes of energy consumed in the OECD nations on the one hand, and the entire developing world (China included) on the other, despite the fact that the growth rate in the latter group is clearly much higher (Criqui and Kousnetzoff, 1987).

1.2 Long Term Perspectives in the Light of Developments Over the Last Twenty-Five Years

Econometric forecasting methods are appropriate so long as there are no major changes in technological systems, industrial structures or household consumption behavior. In the medium to long term (10-20 years), however, it cannot be assumed that such structural characteristics will remain unchanged, nor that offsetting compensation of the effects of structural changes will occur.

In contrast to the econometric approach, a credible forecast within this long term time scale requires that each of the key variables be considered in an explicit and coherent manner, with allowance for possible changes in the structural framework.

A preliminary approach might involve the analysis of 'energy-economy' profiles of the world's major regions over the last 25 years (See Figure 1 and Coulombs *et al* (1989)). Between 1960 and the first oil shock, energy intensity underwent a considerable increase in the developing countries, while it remained stable or increased only slightly in the OECD countries and

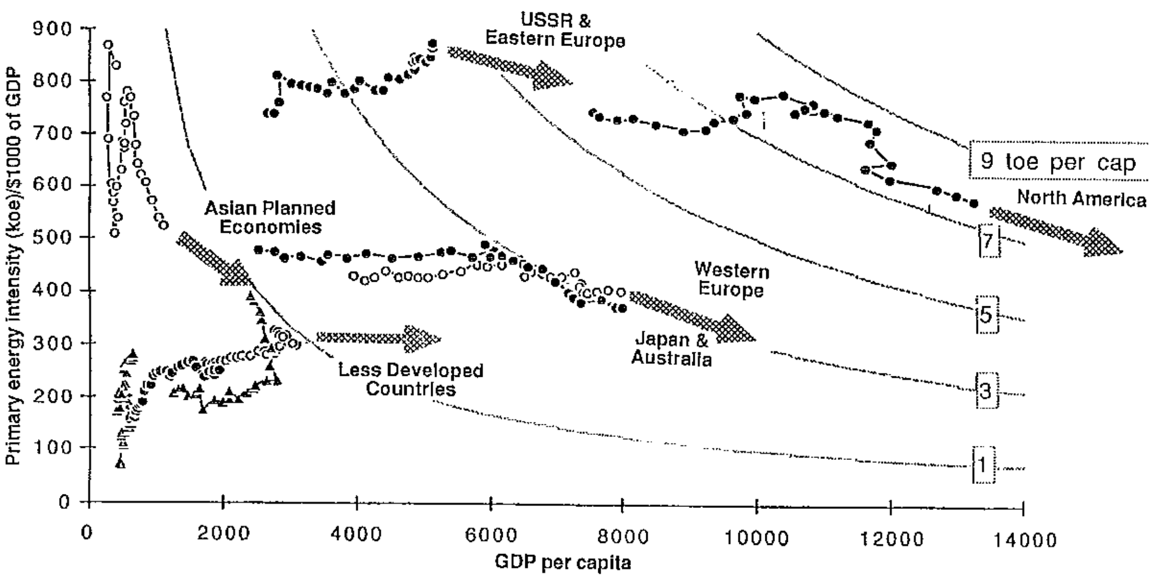

Figure 1: Energy Intensities and Per Capita Income, 1960-86

Clusters of points for each region show observations on regional energy intensities and per-capita income or production for the years 1960 through 1986. Energy intensity is measured in kilograms of oil equivalent (including only commercial energy) per $1000 of Gross Domestic Product. GDP is measured in 1980 US dollars, with exchange rate conversions based on purchasing power parity.

The total per capita consumption of primary energy associated with each combination of energy intensity and per capita GDP can be read from the system of isoquant contours shown in the background. Let primary energy consumption be represented by PEC and population by POP. Then PEC/POP = (PEC/GDP) x (GDP/POP) and each isoquant shows all possible combinations of energy intensity and per capita GDP for a constant PEC/POP.

Sources: Commercial primary energy consumption from ENERDATA. Population and GDP from CHELEM.

Eastern Europe. Since 1973, growth in energy intensity has slowed down in some developing regions (Southeast Asia, Latin America) and has been accentuated in others (North Africa and the Middle East). In Western Europe and Japan, energy intensity has fallen as per capita income has risen and per capita consumption has stabilized. This has also been the case in North America since the early 1980s. Asian planned economies have undergone atypical changes throughout this period. These countries have experienced a very rapid reduction in energy intensity since 1978, when economic reforms were introduced.

Given previous trends, a low-range energy consumption scenario in the various country groupings could thus be based on the following hypotheses:

Stabilization of per capita energy consumption in the industrialized countries: This would imply that total energy consumption increases at the same rate as does population (0.4% per year on average). It would also imply that the rate at which energy intensity falls is the same as that of income growth per head of population. Such a change would in fact be an extension of trends observed since 1973 — at least up until the stabilization and subsequent fall of oil prices.[1]

Stabilization of energy intensity in the developing countries: After the earlier quasi-general increase in energy intensity, this would lead to a rate of growth in energy consumption equal to the combination of the rate of population growth (2% per

1/ On average, per capita income in the industrialized countries has increased by 1.5% to 2% per year since 1973, with a proportional reduction in energy intensity. Since 1983, however, the reduction in energy intensity has slowed, particularly in Western Europe.

year) and that of per capita income, which we shall take to be 2% per year on average. We shall thus assume that these countries will not undergo a profound or lasting economic crisis (though none of them will return to the pace of economic growth seen in the 1960s or 1970s).[2]

Growth in energy consumption at most equal to the rate of development of productive capacity in the Planned Economies of Asia and Eastern Europe: Neither of these regions are in a position to become major net energy importers, because of their size and foreign trade constraints.[3] Information on forecasts to the year 2000 suggests an annual increase in energy production capacity of the order of 2% for Eastern Europe (mostly in the Soviet Union) and 3% for China. If this hypothetical energy constraint were to be confirmed, then economic growth would be largely a function of the rate at which energy intensity will be reduced.

In sum, based on these hypotheses for the period covering the next 20 years, energy consumption growth trends would be 0.4% per year in the OECD, 4% in the developing countries, 2% in Eastern Europe, and 3% in the Asian planned economies. Aside from the developing countries, these rates are much lower than those observed in recent years. They would result in growth in world energy consumption of 1.5% per year. In 2005, the planning horizon adopted by the Toronto conference on greenhouse gases, world consumption would thus be of the order of 10.2 gigatonnes of oil equivalent, as compared with 8 Gtoe at present — an increase of nearly 30%. This suggests that the Toronto conference's recommendation that CO_2 emissions should be reduced to 80% of their current level by 2005 will be difficult, if not impossible, to achieve.

A major shift to nuclear power would appear to be out of the question within such a time scale, if the present interruption of programs and the time necessary to put nuclear plants into operation (roughly 10 years) are taken into account (without even looking at social, technical and economic constraints). Fuel substitution can only provide a partial solution since the replacement of coal by natural gas would produce only a limited reduction in CO_2 emission per unit of useful energy (Grubb, 1989).

1.3 Contradictory Long Term Objectives and Trade-offs

Should an international readiness to limit global emissions of CO_2 actually materialize, it would inevitably be in contradiction with the need to increase consumption in the developing countries, a necessity based on the combination of rapidly growing population and presently unsatisfied needs. Improvements in the efficiency of energy utilization and the harnessing of new technical solutions doubtless provide a fair degree of room for manoeuvre — for example, allowing current needs to be better satisfied with the same levels of per capita consumption. But they will not prevent consumption from rising in the developing countries.

The analysis of world energy prospects in the very long term illustrates this prospect and at the same time highlights the problem of how to find a new world equilibrium for energy consumption. Extrapolation scenarios in which no limits are placed on consumption show it doubling in the developing countries (including China) by the year 2020 and they show an increase of 50% in the industrialized countries (including Eastern Europe) (see Figure 2). This is the case particularly in the low-profile scenario contained in the ATRE Report of the World Energy Conference in 1986 (Frisch, 1986).

On the other hand, limiting total consumption to somewhere near current levels would imply a reduction of consumption in industrialized countries. This was demonstrated in the normative scenario in *Energy for a Sustainable World*, based on a maximum mobilization of energy-ef-

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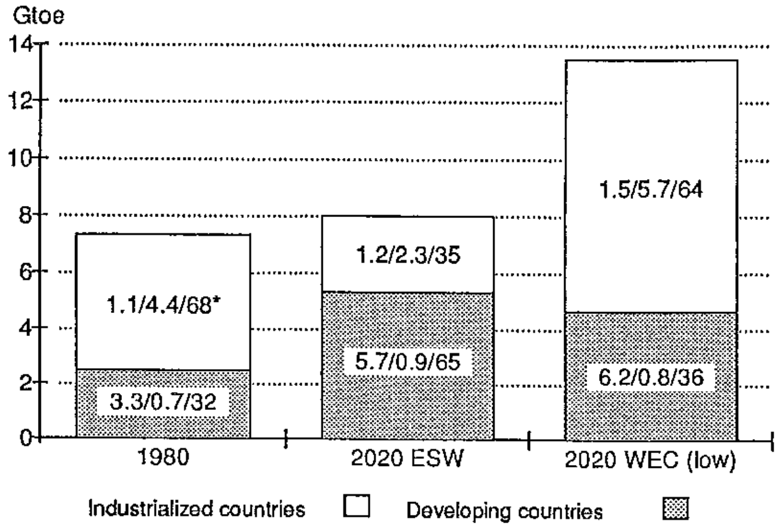
2/ The increase in per capita income in the developing countries between 1960 and 1973 was: 3% in Latin America, 4% in the Middle East/North Africa, and 1.5% in Africa (excluding North Africa and the South African Republic). Between 1960 and 1986 it was: 4% in South-East Asia, 1.2% in Southern Asia (though this included 3.3% between 1979 and 1986) (ENERDATA).

3/ See Locatelli (1987) for the Soviet Union and the COMECON countries and Coulombs *et al* (1989) for China.



*Population (billions)/per capita consumption (toe)/share in total consumption (%)

Figure 2: World Energy Consumption With and Without Constraints
Source: Goldemberg *et al* (1988).

ficient techniques (Goldemberg *et al*, 1988). It exhibits a new balance between the industrialized and the developing world in which developing countries increase their consumption while total world energy consumption is constrained.

At present it seems that if there were to be an overall constraint on energy growth, it would probably be the result of environmental factors rather than of resource limitations. In this case, one of the lessons to be learned from the diverse results of very long term forecasts is that industrialized and developing countries would be faced with quite different (but no doubt equally difficult) challenges: that of reducing fossil fuel consumption in the industrialized world; and that of limiting its growth in the developing world in a context in which energy needs are rapidly growing.

2. The Threat of Global Climate Change and Its Possible Effects

In the late 1980s, concern over global climate change became a major preoccupation for the scientific community, international organizations, political decision-makers and the general public. Are they overreacting? It will doubtless be necessary to wait another few years, quite possibly a decade or more, for research results and measurements to make it possible to evaluate the extent of the phenomenon and its potential consequences (Walsh, 1988). However, the current consensus among climatologists and meteorologists is that a warming process is indeed underway and likely to accelerate. Assuming that this consensus is accurate, the intention here is to examine possible consequences for the energy system and for the evolution of policies aimed at preserving the world environment. We shall try to do this, first, by describing the main types of technical solutions currently envisaged and, second, by analyzing their potential impacts on energy industries and on the dynamics of energy markets.

2.1 Towards a Strategy to Limit Greenhouse Gas Emissions

The desire to limit emissions of greenhouse gases

Inset: Energy and Global Climate Change: A Major Challenge?

The environmental impact of energy use cannot be reduced to the greenhouse effect, for local atmospheric pollution, deforestation and the management of nuclear waste are, or will become, major environmental preoccupations as well.

The sudden interest in the risks of global climate change due to the increasing concentration of greenhouse gases, can be explained by a combination of two factors:

- The nature of the potential effects, which range from lasting change in regional climates, through flooding of coastal areas, deltas and estuaries, to disturbances in the balance of the Earth's climate.
- The uncertainty that surrounds the extent of the changes currently taking place, given the possibility of positive or negative feedback effects.

These factors help to give the problem an apocalyptic dimension which often hinders rational analysis. Nevertheless, it appears that specialists in the various disciplines involved (essentially climatology and meteorology) agree on several points (Houghton and Woodwell, 1989):

(1) Analyses of borings from glaciers, which make it possible to trace back 160,000 years, show a correlation between the concentration of certain gases (including CO_2) and the surface temperature of the Earth.

(2) The current overall CO_2 balance corresponds to a net output of 3 Gt per year. Human activity produces 7 Gt per year (5 Gt by combustion of fossil fuels and 2 Gt by deforestation). The net balance of natural flows is -4 Gt per year (+50 Gt due to plant respiration, +50 Gt by the ground, -100 Gt by photosynthesis, and +100 and -104 Gt by physico-chemical processes on the surface of the oceans).

(3) The proportion of greenhouse gases in the atmosphere has been rising since the beginning of the century. It has risen from 280 to 345 ppm in the case of carbon dioxide, and from 1 to 1.6 ppm for methane (which has a greenhouse effect 25 times greater than that of CO_2).

(4) Average world temperature has risen by about 0.5% since the end of the last century. If greenhouse gases were to double between now and 2025-50, the average temperature increase would be of the order of 2-5°C, depending on the model considered.

Carbon dioxide accounts for only 54% of greenhouse gases, chlorofluorocarbons (CFCs) accounting for 24%, methane for 14% and nitrous oxides 6% (*Energy Economist*, 1989). CFCs are also held to be responsible for the destruction of the ozone layer at the poles, though it would be technically easy to take steps to replace them by the year 2000, or even earlier in the industrialized countries.

Emissions of methane, nitrous oxides and especially CO_2 are inherent in the use of fossil fuels. However, different fuels produce different quantities of gas. In terms of carbon content per toe, natural gas accounts for only 56% of coal, whereas the figure for oil is 78%. If the other greenhouse gases are taken into account, and if the calculation is made in terms of final consumption (thereby taking conversion losses into account), then gas' advantage over coal is slightly reduced, whereas oil's advantage is increased. One final toe of gas then produces 60% of the equivalent emission of coal, and one toe of oil 74% (Grubb, 1989).

without calling into question economic growth[4] will no doubt lead to more widespread use of a new indicator analogous to energy intensity, namely, tonnes of CO_2 released per unit of GDP (CO_2/GDP). However strange a ratio linking greenhouse gas emissions with a measure of economic activity might seem, such a measure will make it easier to understand certain questions, particularly those concerning the overall measurement of the efficiency or inefficiency of different economic systems from an environmental point of view.

4/ See, in particular, the analysis of the double imperative — growth-and-environment — by the Norwegian Prime Minister, Mrs. G.H. Brundtland (1989).

Breaking down this indicator into its constituent parts makes it possible to highlight what could, under various circumstances, be the main strategic orientations for the control of CO_2 emissions.[5] Letting CO_2 represent the quantity of carbon dioxide emitted (in tonnes),[6] PFC — primary fossil fuel consumption and PEC — total primary energy consumption (in Mtoe or GJ), then:

$$CO_2/GDP = (CO_2/PFC) \times (PFC/PEC) \times (PEC/GDP)$$

- CO_2/PFC is the emission rate per tonne of fossil fuel used. Since the total amount of gas emitted cannot be measured, this ratio can only be an overall estimate, which might be arrived at by taking account of the main technical features of the energy systems involved. The ratio will depend, above all, on the fuel mix, bearing in mind that, in relation to greenhouse gases, natural gas is the cleanest fuel and coal is the dirtiest.
- PFC/PEC is the share of fossil fuels in total energy consumption. Conversely it allows us to measure the contribution made by energies that do not directly produce CO_2 (such as nuclear power or renewable energies) and energies whose net emission is zero (as in the case of cultivated biomass where the emitted CO_2 has first of all to be extracted from the atmosphere by photosynthesis).
- PEC/GDP is the energy intensity of GDP. Since the oil shocks, it has been a key indicator in the analysis of strategies aimed at adaptation to the new energy situation.

If strategies adapted to new conditions are to be implemented, they should not be the result of attempts to minimize each component of the CO_2/GDP ratio separately. In fact, some strategies will have a simultaneous effect on more than one of these indicators. This multiple- indicator approach appears to provide a useful overall framework for retrospective analysis and cross-sectional comparisons, as well as for forecasting and policy-making.

Consider now the room for manoeuvre provided by the following three main lines of action.
(1) Substitution between fossil energy sources appears to provide a limited solution. Within the existing world fuel mix (35% coal, 43% oil and 22% gas), the extreme and unrealistic hypothesis in which natural gas totally replaces coal and oil only reduces emissions by about 17%.[7]
(2) Similarly, an acceleration of nuclear programs would not only run into its own special obstacles, but would also merely provide a partial response. If we take account of existing nuclear power stations and those under construction, we arrive at a reasonably reliable forecast of available capacity in 2000 of 475 gigawatts of electrical power. Depending on whether the creation of new capacity is undertaken at a rate of 10 GWe or 20 GWe (excluding renewals) between 1990 and 2010,[8] capacity in 2020 will be 675 or 875 GWe, i.e., 1 or 1.3 Gtoe in terms of fuel equivalent, or 8-10% of a total world consumption of 12 Gtoe.[9]
(3) Turning to demand management, demand forecasts offer radically differing estimates for the year 2020, with divergences up to 100%. Of course, the degree of uncertainty is above all a reflection of the inherent limitations of long-term forecasting techniques. But these margins of forecasting uncertainty should not be confused with the margins for action, which are probably more limited. It remains, however, that controlling demand now appears to be the most promising area for a strategy aimed at limiting emissions of CO_2.

The introduction of new techniques, or whole technical systems, is the key to each of the strategic approaches identified above. Most of the techniques likely to play an important role over

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5/ This technique has been used for, among other things, an analysis of successive structural adaptations to the oil shocks. See, for example, Bourgeois *et al* (1986).

6/ Using appropriate transformation ratios, the analysis that follows could also be done in relation to the emissions of all of the greenhouse gases, expressed as tonnes of CO_2 equivalent. See Grubb (1989).

7/ Using the equivalence coefficients tCO_2/toe calculated by Grubb (1989).

8/ Growth in capacity between 1990 and 2000 should be 13 GWe/year on average.

9/ For a detailed analysis, see Keepin and Kats (1988).

the next 50 years are already known or are at the prototype stage (Dessus, 1989). However, the problem lies in analyzing the real technical, economic and social conditions under which they will spread. That is, it is only by finding solutions that are technically viable, economically effective and socially acceptable, and by taking account of the time scales which they impose, that suitable strategies will be developed.

2.2 *Consequences for Energy Industries and Markets*

Assuming that policies will be adopted to limit greenhouse gas emissions, it is important to envisage the consequences for energy industries and energy markets.

A NEW SHUFFLE FOR THE ENERGY INDUSTRIES?

The handicaps of coal would undoubtedly be increased within such a context. Current clean coal technologies (improvements in boilers, dust and sulphur removal from smoke, fluidized-bed boilers, relocation of electricity production, etc.) are aimed at reducing the impact of pollution at a local level. However, CO_2 production is inherent in all coal-based forms of energy production and its impact is necessarily global. Oil and gas are subject to the same constraints, but the fact that CO_2 emission is lower per unit of energy produced gives oil (and, even more so, gas) a relative advantage. Of all the fossil energy forms, the natural gas industry is likely to benefit the most from the energy-environment challenge.

Nuclear power and renewable energies will have an absolute advantage. Since they do not produce greenhouse gases, their use could be speeded up. However, they will remain handicapped — by barriers of social acceptability in the case of nuclear power and by technico-economic limits in the case of renewable energies. Among the latter, the use of biomass has to be considered separately since it emits CO_2. But, as already pointed out, CO_2 is necessarily extracted from the atmosphere beforehand. The effect of biomass use (like nuclear power and the other renewable energies) is thus roughly zero in terms of CO_2 — so long as it involves cultivated or reforested biomass and does not result in a net deforestation. It could even have advantages in terms of the exploitation of fallow land (Chartier *et al*, 1989).

The future of the electricity industry could be troubled in numerous countries. Given the size of coal reserves, heat production from coal rapidly came to be seen as an alternative long term response to oil shocks and the difficulties encountered by most nuclear programs. This has been particularly true in the large countries: the US, China and India (the Soviet Union was less affected because of its immense natural gas resources). But it was also the case for most energy-importing countries. The constraints imposed on electricity producers could thus be particularly severe. While it is not yet possible to see the consequences clearly, one can expect an attempt to maximize performance (reduction at a micro-economic level of the ratio of CO_2 to produced energy), possibly with the use of medium-sized, decentralized total energy systems integrating the latest information technologies.[10]

ENVIRONMENTAL CONSTRAINTS AND MARKET FORCES

Environmental constraints could bring about permanent changes in the evolution of energy demand, in terms of both total volume and structure. What are the likely consequences for international energy markets?

Without either underrating the role of the various agents involved, or overestimating the importance of market mechanisms, for the moment fossil fuel markets are still regulated through prices. Far from perfect or instantaneously effective, market processes can sometimes create shocks within cycles, in particular because the short-term equilibrium does not guarantee a balancing of supply and demand in the medium term.[11] Nevertheless, accumulated market tensions are expressed through structural price rises and overcapacity through falling prices. Wider

10/ Such as those identified by the Japanese Ministry of Trade and Industry (MITI, 1987).

11/ For a discussion of this issue, see Petroleum Finance Company (1988).

recognition of the strength of the market phenomenon in resource markets has played a role in reducing fears of physical shortages.

The self-regulatory function of markets can, however, bring about special problems in a situation in which government policy is imposed; for example, if environmental policies were to limit demand for some or all fossil energies. The international prices of those energies would then be subject to downward pressure due to excess supply. This would occur even if the environmental policy involved the application of a tax. It is necessary to distinguish between the final-user price (including taxes) and the international market or seller's price. A carbon tax on a given fuel would, for instance, increase its price to users, thus depressing the quantity demanded and the seller-price. With a lower seller's price the user's tax-inclusive price would fall below its original level and some of the reduction in demand would be eliminated, unless a higher tax-rate is fixed. A similar perverse effect might occur in the case of interfuel competition: if, for instance, coal consumption were to be discouraged, its seller-price would fall, while that of gas, the use of which is encouraged, would rise.[12]

Thus a major potential difficulty in establishing energy-environment policies then becomes obvious: the application of external constraints to an autoregulated system leads to negative feedback effects, which interfere with the functioning of the constraints.

More generally, there are several new questions to be faced in the economic analysis of energy, including the following.

Is it possible to implement energy-environment policies without accepting new increases in energy prices for consumers — increases that would correspond to the internalization of real environmental costs? If price increases are to be used, who should then benefit from the rent corresponding to the increasing gap between end-use prices and international market prices of energy and how should it be used?

In forecasting terms, the relations between these two different kinds of dynamics (those in energy markets and those based on policy responses motivated by environmental objectives) could be very complex. In particular, assuming the existence of energy cycles, one can hypothesize a structural change in them: the implementation of permanent environmental policies could reduce the amplitude of the cycles, then in turn be themselves made more stringent as a result of the price falls which they had themselves brought about.... And so on. Within this perspective, new trajectories and more complex dynamics for the world energy system would still have to be discovered.

. . .

The prospect of environmental constraints on the consumption of fossil fuels casts an entirely new light on the outlook for energy markets and long term energy demand. An excessively catastrophic view should doubtless be avoided until such time as climatologists have gathered and processed sufficient information for the risks to be properly evaluated. At the same time, it would be just as dangerous to ignore the problem as to be hasty in undertaking any action.

In this initial look at the issue, we have mentioned some of the new questions facing energy economists, including the impact of policies limiting CO_2 emissions on energy prices and markets. The central question over the next decade will be the nature of the trade-offs involved in two major tensions:

- between today's major consumers (the industrialized countries) and those of tomorrow (the countries of the Third World); and
- between the benefits obtained from current consumption of fossil energy and the state in which the planet will be left for the 'third generation' (Davis, 1989), i.e., the children who will be born in the years to come.

12/ This type of phenomenon appears clearly in the low energy scenarios simulated by Edmonds and Reilly (1985), which result in a forecasted fossil fuel demand much higher than the targetted one simply because of price-effects.

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