THE 1995 INTERNATIONAL ENERGY WORKSHOP: THE POLL RESULTS AND A REVIEW OF PAPERS

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RR-96-8
June 1996

Reprinted from *OPEC Review*, Vol. XX, No. 1, March 1996.

INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS
Laxenburg, Austria

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Printed by Novographic, Vienna, Austria.

Foreword

The International Energy Workshop (IEW) has been organized over the past 15 years by IIASA and Stanford University. The Workshop offers a unique forum for researchers working on energy perspectives to compare their scenarios and projections on future crude oil prices, economic growth, primary energy consumption and production, and energy trade patterns among world regions. The data for the comparisons are derived from standardized polls, which are published annually prior to the Workshop. The polls provide material for assessing reasons for similarities and differences among scenarios and projections during the annual IEW meetings. In addition to the presentation of poll results and analyses, the IEW meetings feature plenary and parallel sessions dedicated to timely topics on a wide range of energy issues, such as climate change. IEW participants include researchers and representatives from national and international energy organizations and industries.

This report summarizes the highlights of the 1995 IEW meeting held at the IIASA Conference Center in Laxenburg, Austria. It gives an overview of the poll results and presents two issues discussed at the meeting. The first focused on global and regional energy markets with a particular emphasis on the situation in countries undergoing economic transition in Eastern Europe and the former Soviet Union; the second topic concentrated on energy-related environmental issues with emphasis on climate change. This report illustrates the usefulness of the IEW as a forum for establishing a consensus and assessing the divergence within the energy research community concerning likely future developments. The medians of the poll results represent the "conventional wisdom" about possible future trends of oil prices, primary energy consumption, and carbon dioxide emissions. The standard deviation is also presented in this report for future developments, and shows the degree of dissension within the research community. For some analyses, it is also useful to know the "extreme" views about the future within the research community, and these are given in the poll results that fall outside of the standard deviation.

This paper analyzes how the poll results have evolved over the past 15 years, and presents some of the salient reasons for the consensuses and disagreements concerning future energy-related developments. The activities of this unique forum continue; the next IEW meeting will be held in 1996, for the first time in Japan, at the Osaka Convention Center.

Nebojša Nakićenović
Project Leader
Environmentally Compatible Energy Strategies

The 1995 International Energy Workshop: the poll results and a review of papers

Leo Schrattenholzer and Keith Marchant

FORECASTING OIL prices can don the mantle of either an art form or a science. Although both require a thorough grounding in energy economics, the art form requires a vivid, creative imagination while the science utilises rigorous analytical procedures! Sadly, however, over the years, neither mantle has successfully and consistently matched the singular profile of the international oil market. Examples of "bad fits" are plentiful across the fabric of the industry's long and chequered history. In the context of early meetings of the International Energy Workshop, projections made just a decade and a half ago — at a time when the spot market price of Arabian Light, OPEC's former marker crude, had penetrated the $40 per barrel barrier — suggested a price of around $100/b by the year 2000; yet, with less than five years to run until the start of the new millenium, those projections exceed by more than five times the current spot price of the same crude, and command a much higher multiple when expressed in real terms.

This is not to cast doubt on the outstanding capabilities of colleagues and associates in the precarious art, or science, of oil price forecasting. Such activity, however, takes place in the most volatile sector of energy economics. Oil's central role in the global energy mix subjects analysis of its dynamics to a wide array of political, strategic and other macro considerations, in addition to basic market economics, and these hamper even the most skilled efforts at forecasting oil prices.

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Since 1981, in the wake of the second series of large price rises at the turn of the decade, an annual workshop has been held, in either Austria or the United States, with the specific purpose of collating forecasts from a network of accomplished energy analysts from many different parts of the world. Organised jointly by the International Institute for Applied Systems Analysis and Stanford University, the declared aims of the International Energy Workshop are to compare energy projections and to understand the reasons for diverging views of future developments. From its earliest days, there has been a strong emphasis on the exchange of research information between "East" and "West". This has been due, in particular, to the Workshop's close association with IIASA, which, since its establishment in 1972, has been envisaged as having a special role as an "East-West think tank" — the importance and the relevance of this international body during the latter stages of the "Soviet era" needs no elaboration.

The main activity of the IEW is the iterative polling of crude oil prices, economic growth, primary energy consumption and production, energy trade, electricity generation, and carbon emissions. The poll results are discussed at the annual meetings, which are held in June, alternately at the IIASA headquarters in Laxenburg, just south of Vienna, Austria, as in 1995, and at different locations in the US, home to Stanford University. In 1996, the Workshop will branch out to a new continent, when the "US" meeting is held in Osaka, Japan, jointly with the Japan Society of Energy and Resources.

The early IEW meetings focused mainly on oil, but, as new issues came to the fore in the mid-to-late 1980s, the scope broadened. Two principal areas of interest rose high on the agenda — the former Soviet Union (FSU) and environmental issues.

The dissolution of the Soviet Union and the dismantling of its longstanding special relationship with the countries of Eastern Europe had a rapid, substantial impact on world energy supply and demand. The time-worn concept of "excluding centrally planned economies" soon became redundant and the rulebooks of energy economic analysis had to be revised. A huge geographical area, which previously had been little more than an extraterritorial black box to many conventional, Western-oriented observers, had to be integrated into now-fully-global energy analysis, even though relatively little was understood about that area at the time — even today, there remain many mysteries. The significance of the area could not be overlooked, because, almost up to its dissolution, the Soviet Union, as a collective entity, was the world's leading oil producer. There was a pressing case, therefore, for this region to merit special attention at the IEW, when the edifice collapsed. As noted above, the IEW already had a much closer association with this area than other international research bodies. The new, enhanced level of attention that came about continues to the present day. At this year's two-and-a-half-day Workshop, an entire morning's plenary session and an entire afternoon's parallel session were devoted to the FSU and Eastern Europe.

The other substantial change to the Workshop's programme concerns an issue which was virtually non-existent on the international political agenda in 1981, and

yet now is an integral component of every major energy seminar and conference — the environment, especially the purported "greenhouse" effect and related issues. This has a much longer term profile than conventional energy analysis, with some projections stretching as far forward as the year 2200. In the light of such a large time-span, modelling on this topic could be said to be still in its infancy. Modellers' efforts are impeded by the considerable uncertainty about the true nature of the problem. In addition, there is a host of new political, strategic, social and cultural issues involved. While environmental issues featured, either directly or indirectly, in most presentations at this year's Workshop, the final morning's plenary session was devoted to "Greenhouse policy: regional distribution of costs and benefits", rounding off with a panel discussion on "World regional studies on greenhouse gas mitigation and their implications for international negotiations".

This paper is divided into two sections. The first section, prepared by Schrattenholzer, presents and analyses the latest poll results, along the lines of discussion at the Workshop and accommodating additional information and points raised there. The second section, compiled by Marchant, reviews a selection of papers presented at the meeting, categorised as world and regional energy markets and environmental issues. The aim of the review is to acquaint readers with issues of special concern to academics at the present time in the field of energy economics, and the directions in which research is heading.

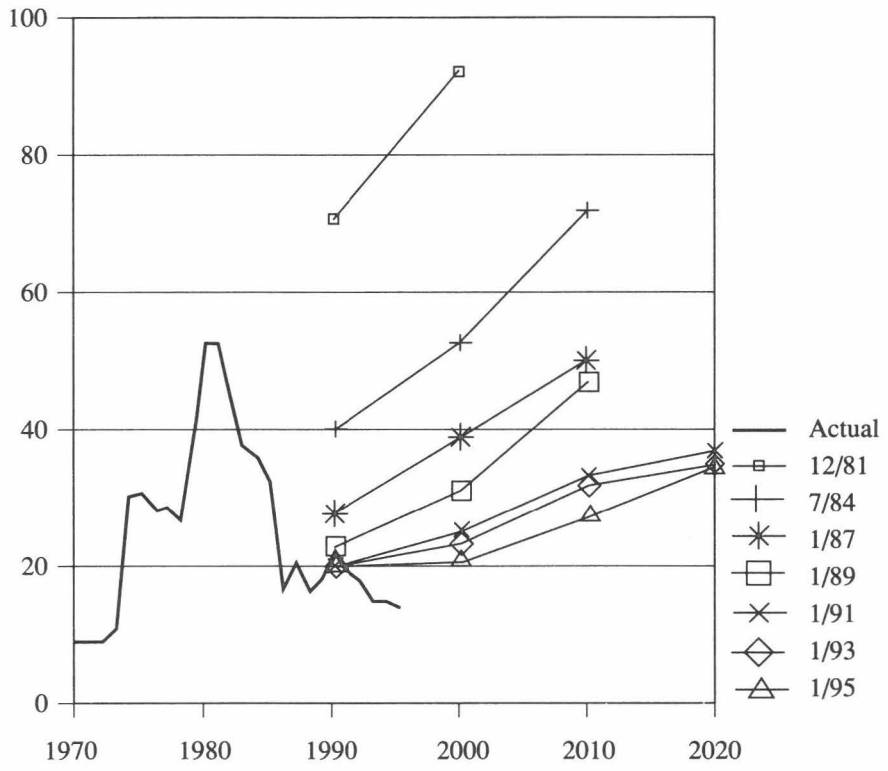
Finally, copies of many of the presentations referred to in the text and listed at the end of this paper, can be obtained from Schrattenholzer, at the International Institute for Applied Systems Analysis, A-2361 Laxenburg, Austria.

1. Recent IEW poll results

We begin the presentation of IEW poll results with a summary of the historical development of the international oil price — and its projections (**figure 1**). For the oil price development between 1970 and 1995, we have taken official US import prices, measured in constant US dollars of 1990 purchasing power. The curve of the historical oil price movements shows the familiar rises of 1973 and 1980, where it reached its record high point. The first IEW meeting was held in late 1981, and oil price projections, here presented as medians,[1] clearly reflected the expectation of a continuation, albeit at a slower pace, of significantly increasing oil prices. By the year 2000, according to the 1981 median, the oil price was expected to be close to $100 per barrel. After 1981, the current oil price dropped precipitously, and with it the oil price projections. Since the 1991 poll, projections have begun to stabilise on paths that are near an average annual increase of two per cent between 1990 and 2020. Since 1995's oil price is in the neighbourhood of $15/b, the implicitly projected average increase is in excess of three per cent per year for the next 25 years.

1. The median is the "middle" projection, that is, the projection that has an equal number of projections above and below it.

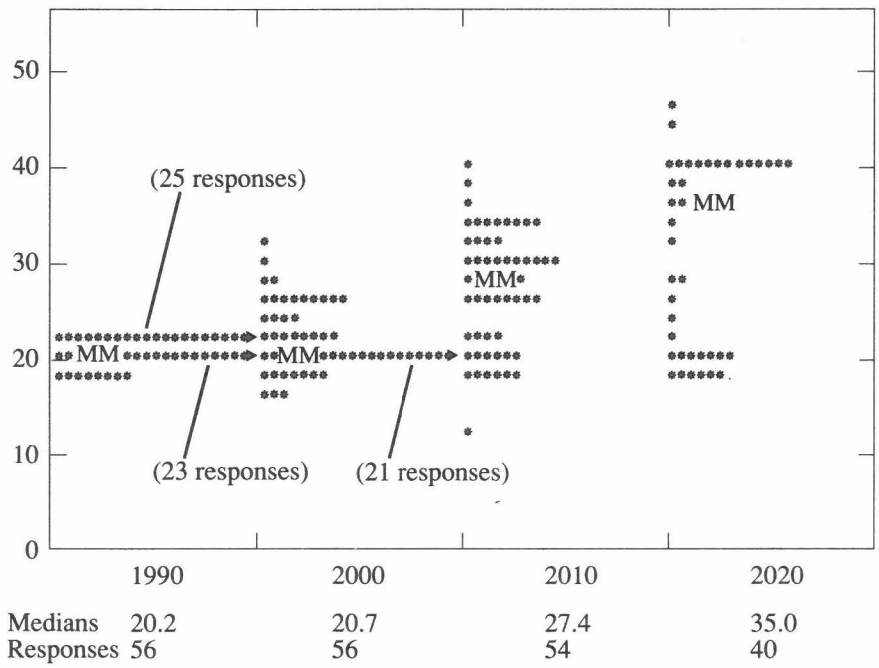
Figure 1
Crude oil prices —
actual and successive IEW polls
(US 1990) dollars per barrel



It would appear rational to adapt expectations on the basis of actual developments, but the question might arise as to why such an actual development was not foreseen by the participants in the IEW poll. One answer to this question is that much information is lost by reporting medians only. Indeed, as early as 1983, individual poll responses projected a decline of the sort that actually occurred in the second half of the 1980s. To give an idea of the full range of recent projections, we show all the projections carrying dates 1992, 1993 and 1994 in **figure 2**. The wide range of projections displayed here is another indicator of the difficulty of projecting future oil prices.

In contrast to the volatility displayed by oil price projections over time, projections of quantities have proven more stable. Take, for example, projections of

Figure 2
International price of crude oil, all years
(US 1990) dollars per barrel



energy consumption and economic output for the OECD region. **Figure 3** shows IEW poll medians of projections, for the year 2000, of total primary energy consumption (TPE) and of GDP growth. The figure shows that median projections for the year 2000 of these two variables have been remarkably constant over 12 years of the IEW poll.

Before jumping to the conclusion that quantities are always easier to project than prices, let us have a look at the corresponding picture of energy consumption and economic development for the reforming economies in Eastern Europe and the former Soviet Union (**figure 4**). For this region, expectations of energy consumption in the year 2000 were reduced by 29 per cent between 1983 and 1995. This may seem modest in comparison with the fluctuation in the oil price projections discussed above, but the IEW poll medians of projected economic growth between 1990 and 2000 mirror the turbulent developments in the region in the past ten years. Shortly after the announcement of "glasnost" and "perestroika", vigorous growth was expected to take place in the formerly planned economies. The fact

Figure 3
Energy consumption and GDP growth
OECD, poll medians, 1983–95

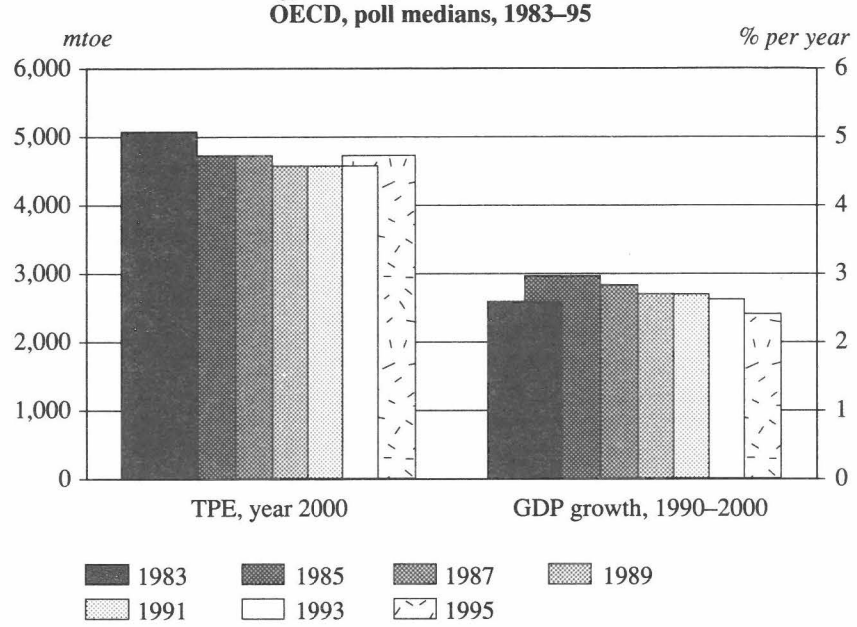
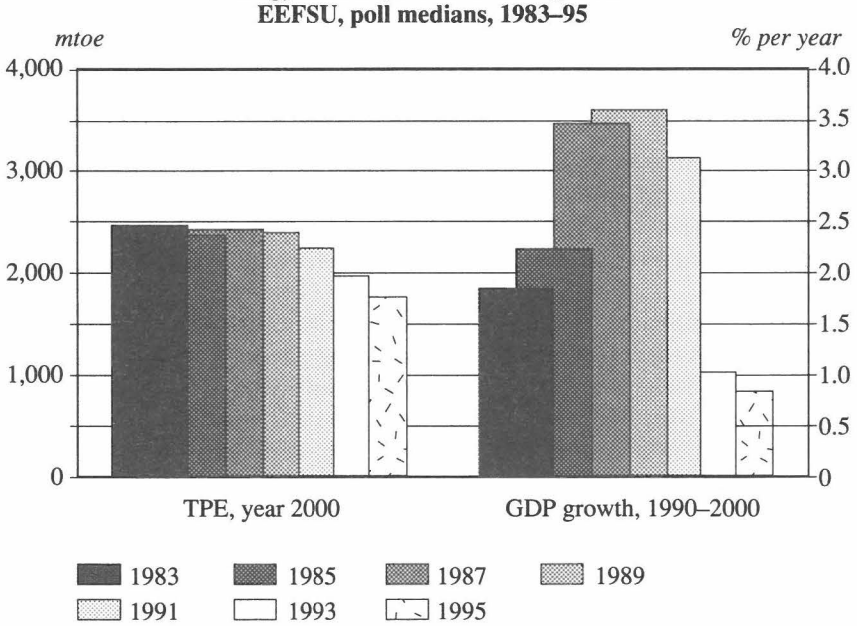


Figure 4
Energy consumption and GDP growth
EEFSU, poll medians, 1983–95



that this was not to happen is again clearly reflected in the IEW poll, and the most recent median, that projects average growth during the present decade, seems to be on the optimistic side.

The environmental impact of energy conversion is summarised in the IEW poll by an item reporting projected energy-related carbon emissions. The idea behind collecting information about carbon emissions is rooted in the concern about adverse global climate change as a consequence of increased atmospheric concentrations of carbon dioxide. The study of carbon emissions was under focus in the CHALLENGE[2] project which, mainly during 1992 and 1993, was carried out in parallel with IEW activities. Today, with CHALLENGE activities declining, two more items on the IEW poll are visibly left behind — total carbon emissions and marginal costs of carbon reductions. The latter item is the main characterization of the reduction efforts' carbon abatement scenarios. In many models that analyse the economics of carbon emission reductions, the marginal cost of carbon emission reductions is reflected in a carbon tax.

As a summary of three years of IEW poll responses on carbon emissions, we show **figure 5**, ranges of carbon intensities of TPE. Ranges are defined here as intervals around the mean, two sample variances wide. The carbon intensity of TPE has been calculated from the IEW poll results and normalised to an index number, with 1990 as a base. In this way, all responses that included the appropriate information could be used for this graph. It turns out that the curve connecting the averages is almost identical to the curve that extrapolates the long-term trend — that is, a "decarbonisation" of the energy supply system proceeding at 0.3 per cent per year.

One result of the CHALLENGE activities mentioned above is a wealth of carbon emission reduction scenarios with a cut-off point of $200 per ton of carbon. To illustrate, this number is roughly equivalent to 50 US cents per gallon of gasoline. In **figure 6**, we show how much carbon reduction is achieved by such an effort. The achievement is measured by comparing the reduction cases with reference cases in which no particular efforts aimed at carbon emission reductions ("do nothing" cases) are undertaken. The results suggest that, on average, $200/ton of carbon as the marginal cost of carbon abatement leads to approximately 40 per cent lower carbon emissions in 2020, compared with "do nothing" cases. This average reduction is surrounded by considerable uncertainty, however. One-third of the results (i.e. those outside the ranges depicted in figure 6) show reductions that are either less than 20 per cent or more than 60 per cent by the year 2020.

The United Nations Framework Convention on Climate Change (FCCC) requires its signatories to stabilise greenhouse gas concentrations in the atmosphere

2. *For a description of the CHALLENGE project, see, for example, Manne, Alan, and Leo Schrattenholzer, 1993, Global Scenarios for Carbon Dioxide Emissions, Energy, 18(12):1207–1222.*

Figure 5
Carbon intensities of TPE
Historical trend and poll ranges, 1995

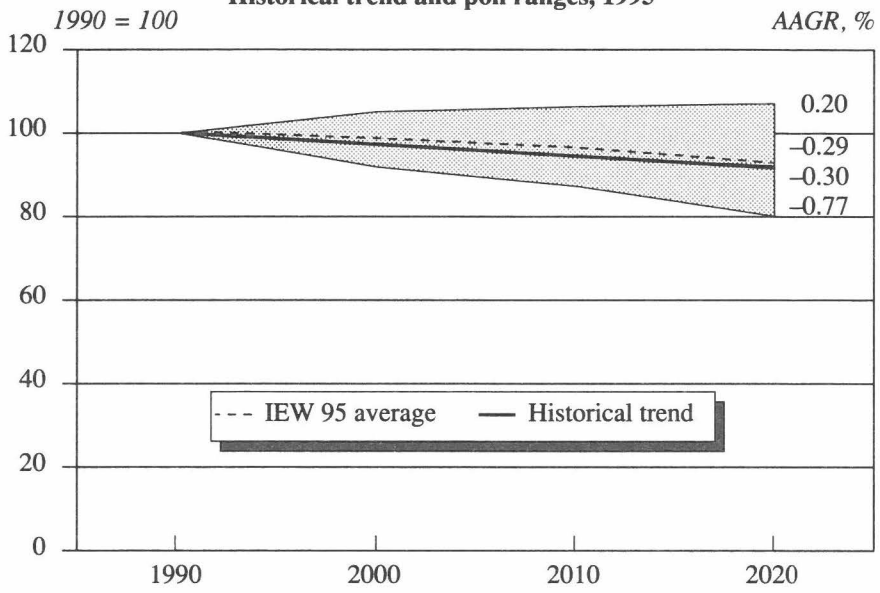


Figure 6
Carbon emissions relative to reference
IEW/CHALLENGE95, carbon tax cases

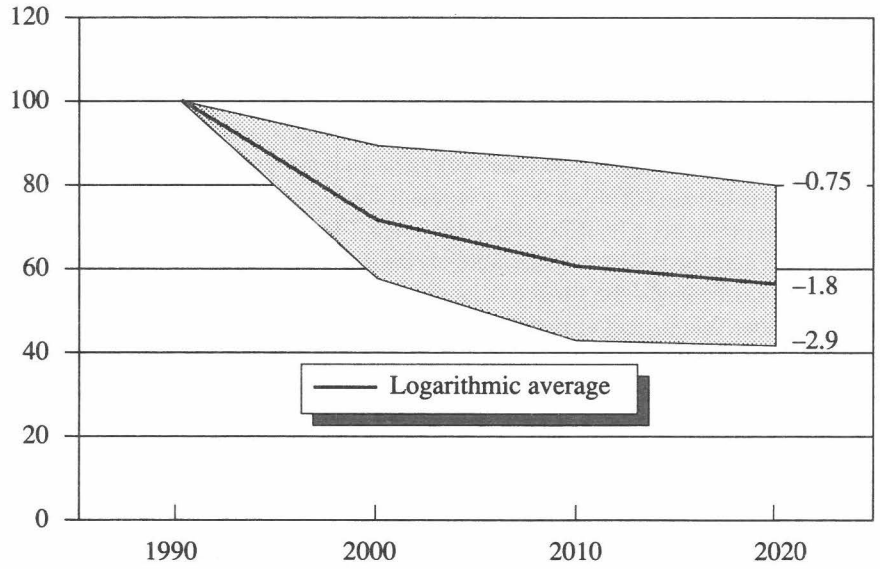
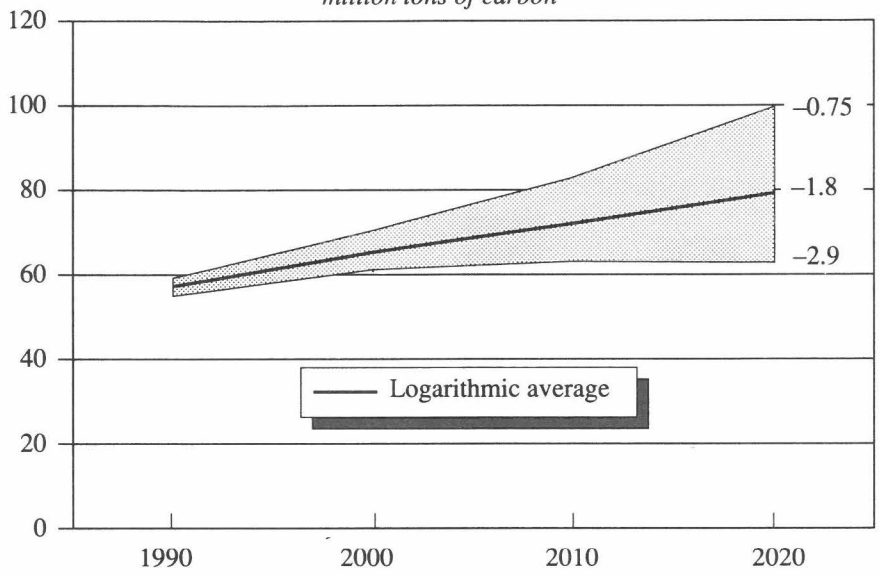


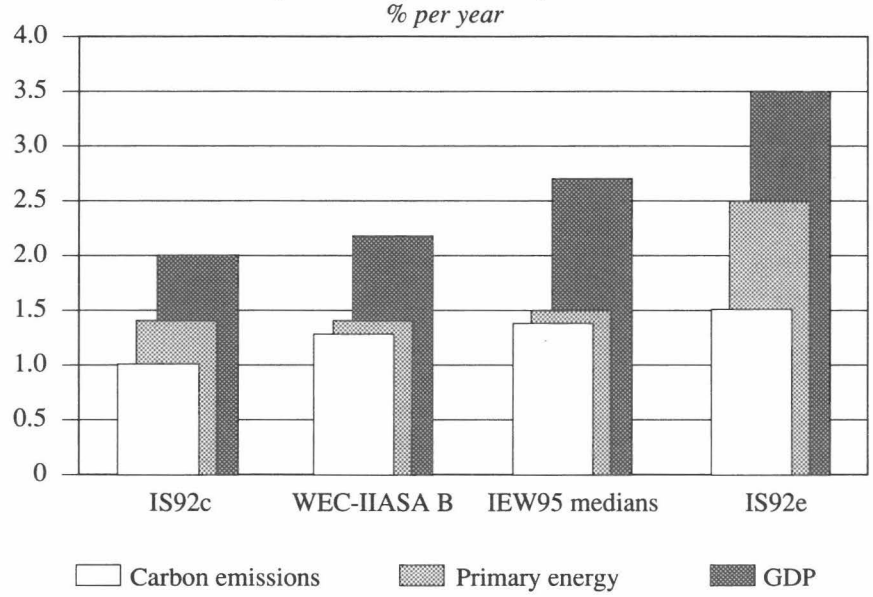
Figure 7
OECD carbon emissions
IEW poll95 averages and ranges
million tons of carbon



at a level that would prevent dangerous anthropogenic interference with the climate system. A practical consequence of this requirement is that countries must aim to reduce energy-related carbon emissions. One of the most quoted reduction goals is for the OECD countries to limit their carbon emissions in the year 2000 to 1990 levels. Let us look at this goal through IEW poll results (**figure 7**). Again, we show ranges. In this case, the first important observation is that the ranges are comparatively narrow, in particular given apparent measurement problems, manifested as a range for 1990. The emissions reduction goal of no increase between 1990 and 2000 seems elusive: it is below the lower bound of the IEW range. This means that it is not expected to come about under reference conditions. Since time is passing, every year in which no new efforts are made to reach this goal will reduce the probability of its occurrence even further, and it will be increasingly difficult to agree on tighter targets if this one is missed.

Finally, in this section, we compare IEW medians and prominent scenarios. **Figure 8** shows average annual growth rates, between 1990 and 2020, of global carbon emissions, TPE and global economic output for two Intergovernmental Panel on Climate Change scenarios (IS92c and IS92e — the highest and the lowest emission scenarios described in IPCC, 1992), the IIASA-WEC95 "Middle Course"

Figure 8
Global carbon emissions, TPE and GDP
Comparison of growth rates, 1990–2020
% per year



(B) case,[3] and IEW medians. It confirms that IEW medians are, indeed, in the "middle of the road" of global projections of energy, economic growth and carbon emissions. Note that, for global projections, the decarbonisation implied by the medians is less (0.08 per cent per year or approximately one quarter of the average rate displayed in figure 5 above). There is no reason why the two should be identical (they are based on different samples, and "inconsistencies" of this kind are a natural consequence of the way the numbers have been derived). They confirm that projections are intrinsically uncertain. In this particular case, however, we think that the difference tells us something, i.e. that global projections have a tendency to be less optimistic than national projections.

2. A review of papers

This review of papers has been prepared with the aim of enlightening readers on the main areas of discussion at the 1995 Workshop, and the directions in which associated research is heading. The review has been divided into three fields of

3. For more information on the IIASA-WEC scenarios, see the paper by Nakicenovic and Rogner, entitled "Financing global energy perspectives to 2050", which appears elsewhere in this issue of the OPEC Review.

emphasis — the world energy market, regional energy markets and environmental issues. There are two bibliographies at the end of the paper. The first refers to the 1995 presentations which can be obtained from IIASA, regardless of whether they have been referred to in this review. The second relates to papers featured in this review, but which were not directly available to readers when this review was prepared.

World energy market

Several papers presented at the IEW focused on the supply and demand situation in the world energy market, for the years leading up to the new millenium and beyond.

Rodekohr stayed close to the central theme of the Workshop when he delivered a comprehensive review of mid-term, international oil market projections. His paper was based on projections from the US Department of Energy's Energy Information Administration carried out between 1978 and 1992, for the years 1985, 1990 and 1995. Rodekohr concluded that, while the projections for 1985 had contained serious errors, those for 1990 and 1995 improved dramatically, with error rates for many supply and demand regions falling noticeably. Since the oil price collapse of 1986, accuracy had increased considerably, this being attributed to the loss of OPEC pricing control. While his analysis concluded that one should be able to predict world oil consumption to plus or minus eight per cent, it contended that there had been a tendency to under-predict for production, as a result of enhanced technology and political factors, particularly affecting the North Sea. Predictions had been fairly accurate for OPEC production, however.

Difficulties in making projections and the shortcomings of the information on which such projections are based also featured in ***O'Dell's*** paper, which provided forecasts from the recently published 1995 edition of the International Energy Agency's World Energy Outlook and a companion study, entitled Oil, Gas and Coal Supply Outlook. Three areas of difficulty, for the forecasting period up to 2010, were identified in the World Energy Outlook. First, there was the very poor understanding of the amount and use of biomass, which makes an important though unquantified contribution to world energy supply. Secondly, there was a need to better comprehend the issue of relocation of major energy-intensive industries, and the technologies they use, due to the fact that industry consumes more than a third of the world's final energy. And thirdly, the potential for technology to improve the efficiency with which energy is used also required much further study and analysis.

The projections came from two scenarios, in which the growth in energy demand was more modest than in recent years: a 'Capacity constraints" case, in which energy prices were assumed to increase, in order to dampen underlying demand pressures: and an "Energy savings" case, in which the rate of introduction and market acceptance of more energy-efficient technologies were significantly greater than in the recent past. As a result of the analysis, primary energy demand was projected to increase over 1992 levels by between 35 and 45 per cent by 2010.

There were other noteworthy implications from the analysis. The global energy system was likely to remain overwhelmingly based on the consumption of fossil fuels, with almost a 90 per cent share of the market. Within fossil fuels, while oil's share of the world energy mix would continue to decline, the volume of oil consumed would continue to rise. Six OPEC Member Countries — the Islamic Republic of Iran, Iraq, Kuwait, Saudi Arabia, the United Arab Emirates and Venezuela — might be called upon to provide more than 50 per cent of the world's oil by 2010. By that time, the OECD would consume half or less of the world's energy and oil, with the dynamic economies of East Asia and China accounting for a greater increase in annual oil demand than the whole of the OECD between 1992 and 2010. Technological and environmental factors, as well as the restructuring now under way in the energy industry, were likely to lead to a significant increase in the use of gas, especially as a power generation fuel. This would lead to a sharp expansion in the gas trade, both by pipeline and by ship as liquefied natural gas. Gas and coal — the coal trade was projected to double by 2010 — would have a greater effect on world energy prices.

Odell concentrated on the oil market, and posited that the world was running into oil and not out of it. Global oil reserves had doubled since the 1973 oil crisis, and now guaranteed supply for at least the next 44 years, at current production rates and real price levels — in spite of cumulative production of almost 500 billion barrels over the last 22 years. Average annual additions to Middle East reserves had almost matched average annual global use of oil, at just over 20 bn b. Therefore, this region alone continued to find enough oil on average each year to cover everyone's current annual needs on Earth. Even without discoveries of new reserves, one could expect, at current output levels, Middle East oil to last about another 100 years.

However, in the period 1973–95, the discovery and development of reserves in other areas, such as the North Sea, offshore Mexico, Egypt, southern Brazil and parts of Australasia, as well as the growing importance of indigenous and regional production, had led to a decline in dependence on Middle East reserves. Although two-thirds of world reserves were in the Middle East, 85 per cent of them were irrelevant to global production levels to 2010, when viewed in narrow economic terms, given the potential in OECD and non-OPEC developing countries and the maintenance of the current oil price. Effectively, much of the Middle East's proven oil reserves had no net present value.

Odell foresaw a situation where "the stage would be set for a potential regionalisation of the global oil industry based on a perception of mutual economic and political interests between contiguous or proximate exporters and importers." The most important elements of this would be the adherence of the non-Middle East major oil-exporting countries to energy-trading blocs, regionalised around three sets of OECD countries, in North America, Western Europe and Japan/Australasia. "Precursors to such a regionalisation ... already exist in the more general politico-economic policies which are already at work in the development of such regional geographical linkages," such as the North American Free Trade Area, the European Energy Charter and the Association of South-East Asian Nations. As a result, the

Middle East would have difficulty in attempting to increase its market share, without running the risk of countervailing developments, based on the ability of most of the rest of the world to continue to secure the greater part of the energy it needed, without recourse to more oil from the Middle East.

Regional energy markets

Still attracting considerable at the IEW was the unfolding energy situation in the former Soviet Union (FSU). Three papers covered this topic in depth.

Nekrasov stated that the switch of the Russian economy from a centrally planned system to a market-oriented one had unearthed contradictions in the consumption and production of energy resources in the FSU. In the present economic crisis, the Russian energy sector performed two very different functions. On the one hand, it kept the Russian economy from disintegration, by supplying it with energy resources and by providing most of the foreign currency flow, due mainly to primary energy exports. On the other hand, rising prices and distortions in the price structure for energy resources and other goods, as well as the preservation of excessive energy consumption by industry, had a negative effect on the stabilisation process. The decline in investment looked especially dangerous for economic development, particularly with regard to the energy sector, since it could seriously impede the social and economic revival of the country.

The destiny of Russia's energy sector depended upon government policy. In this regard, the paper looked at two scenarios. The first scenario resulted from the currently implemented, anti-inflationary policy characterised by the extrapolated adaptation of the economy to hard budgetary and monetary constraints. This scenario implied the conservation of the economic structure, dominated by basic energy-intensive industries, and a further decline in industrial output, with the rate of decline falling gradually and a subsequent slow recovery. The second scenario was based on a drastic change of economic policy, in the direction of a stimulation of industrial output, particularly in those sectors with lower energy-consumption rates. This scenario implied the possibility of economic growth by the end of 1995. Throughout, it was clear that economic development would be determined for a long time by the level of technology and structural factors that Russia inherited from the Soviet Union.

Nikolajew examined selected macroeconomic indicators of the economic development of the FSU and Eastern Europe and their energy aspects. He noted that, in the sixth year of transformation of the former centrally planned economies, the record of achievements had been modest, and awareness was growing that many things could have been different if the transformation, from the very beginning, had been perceived as a common regional economic problem for Eastern and Central European countries, including the FSU. With regard to future prospects, three basic scenarios could be investigated, in relation to energy and environmental problems.

The first was "mutual mistrust", a scenario accompanied by friction, ethnic conflict and instability in the region. Energy demand would at first decline, then,

by 2010, it would begin to rise. The environmental impacts could be devastating. The second option was a "good neighbourhood" one, with the countries in the region trying to resolve problems and conflicts by peaceful means; this option could be suitable for capitalising on self-recovery forces in the region, raising energy consumption and having subsequent favourable ecological consequences, although environmental issues were "not on top of the agenda ... The ecological situation may rather deteriorate, due to increased energy consumption." The third option, a "Marshall Plan", could provide both an efficient economic recovery and an abatement of the environmental consequences, from which Eastern and Western partners benefit equally. "What seems to be important," this paper said, "is strategic thinking in terms of the region as a whole, spearheading a higher level of coordination of the common effort, a solid information base to cover the process, and systems approaches to deal with the challenges."

Siniak took a similar, although less broadly international, approach, in maintaining that success in political and economic transformation depended strongly upon the mutual cooperation of the newly independent states in energy issues, with energy imports and exports remaining "a major priority". He presented three long-term energy scenarios with different geopolitical goals and reactions to global environmental concerns. There was: an "unfavourable" scenario, with isolationism and protectionism, weak international cooperation and no strong policy option; a "reference" one, with dynamics-as-usual, modest international cooperation and slow changes in lifestyle philosophy; and a "preferred" one, with enhanced cooperation and assistance, a strong environmentally oriented policy, and economic convergence.

The main emphasis of all three scenarios was on energy savings and efficiency improvements and carbon dioxide emissions reductions. Major changes would have to be introduced to the FSU's energy system if it were to contribute its share to the goal of globally stabilising CO_2 concentrations by the year 2100. A set of measures was discussed on how to facilitate the required changes in the energy system, especially during the most difficult period of economic recovery. These measures were categorised as government actions (including privatisation, demilitarisation of industrial production, and energy policy), economic measures (including an energy-pricing system), technology policy, research and development priorities, an institutional framework and public policy.

Siniak believed economic recovery would start in 1996/97, and the 1990 level of national wealth would be reached again only by 2010/15. Fifty per cent of present energy consumption could be reduced by the introduction of the latest technology, he maintained. But there were serious problems with demand-side management, the most acute of which was investment, with the "now catastrophic ageing of all energy equipment" Natural gas would dominate the energy balance for several decades and large expectations were held for a new generation of "safe, economic and politically acceptable" nuclear reactors, although these would not be realisable before 2015–20.

Other papers presented on the former CPEs covered post-independence transition problems in Eastern Europe, particularly the Czech Republic, Hungary and

Poland. ***Michna and Krawczynski's*** joint paper focused on the external impediments to the formulation of economic and energy policies in countries in a state of post-CPE transition to market economies. Foreign cooperation in the transition period had included a large number of ineffective (and even harmful) factors with respect to resolving transitional period phenomena. "The fundamental impediment to the most effective direction of the transition period, which became apparent almost immediately after this process began," wrote the authors, "was an imprecise opinion on the part of decision-makers in highly developed countries about how Eastern European countries operate." In Poland, for example, proposals were formulated as if a market economy were already fully operational and operated similarly to systems in highly developed countries. "The transitional countries' economies were not prepared to consume the capital for economic development offered on developed countries' terms." The privatisation of state-owned assets, for example, had made certain people and institutions very wealthy, which, "according to society, do not deserve what they have received."

Switching to the other side of Europe, ***Pellekaan and van Oostvoom*** presented a paper depicting two extreme energy scenarios. One represented on-going integration (IS) in Western Europe, while the other described fragmentation (FS). They were arrived at through the Sectoral European Energy Model, which had been developed to project primary energy demand per country in the industry, services, household and transport sectors. In order to cover almost all primary energy demand, the electricity production sector was also included.

Resulting long-run (2020) primary energy demand for both scenarios differed substantially, with an increase, relative to 1991, of about 65 per cent for IS and 40 per cent for FS. Total energy demand for the former was about 20 per cent higher than that for the latter, due to higher economic growth and lower prices, in spite of a higher rate of technological improvement. Decreasing oil and gas prices in IS resulted in demand increases mainly for these two energy sources, while the rising oil and gas prices in FS were exploited by coal and nuclear power. The substantial increase in energy demand in each scenario resulted in steep rises in CO_2 emissions, which would have to be offset by carbon taxes to meet emissions targets.

For elsewhere in the world, papers were presented on energy development, with a particular emphasis on greenhouse gas emissions, in China (including, separately, Taiwan) and India. There was also a presentation on the energy outlook for the Association of South-East Asian Nations, applying the EFOM-ENV model of the European Commission, with the necessary modifications to reflect the situation in south-east Asia.

Environmental issues

In the context of the energy industry, the principal environmental issues on the international political agenda relate to the "greenhouse effect", and encompass such concepts as climate change, global warming, carbon emissions and energy taxes. Most of the papers already referred to in this review have accommodated

these issues in some way or other and to varying degrees, but as a subsidiary rather than principal part of their analysis. Many presentations, however, were centred around this topic, ranging from the highly theoretical, based upon intensive econometric analysis, to the more practical, aimed at the provision of feasible measures in the not-too-distant future.

Current status of debate

Before reviewing some of the presentations, let us see how Nordhaus outlined the current status of the debate on the greenhouse effect, when he addressed the official press conference on the final morning of the Workshop.

He told journalists that there was great uncertainty about the extent and pace of global warming, but the climate appeared to be heading outside the range experienced during the period of human civilizations. The extent of uncertainty posed deep problems for analysts and policy-makers alike. This uncertainty was the first of five insights that were apparent to him at the 1995 IEW.

The second was that many of the "dire catastrophes", which had received wide publicity, appeared to have been exaggerated, according to economists. Human society could adapt to impacts in a relatively low-cost manner. Nobody was talking about a decline in the standard of living "back to the Stone Age".

Thirdly, there was the question of a "sensible approach" for economists to adopt and this would require a portfolio of strategies. This had four aspects to it. The most important short-term one would be to improve knowledge and understanding of the problem, with "better science, climatology, ecology and social sciences." Enhanced levels of investment in researching low-carbon or no-carbon fuels was the second aspect. Then there had to be the development of such fuels, with, for example, a form of nuclear power that was both safe and recognised as safe, as well as being proliferation-proof. Finally, there had to be adaptation and prevention.

Fourthly, there had to be general recognition that global warming was indeed a global problem, and that it was at this level that the most effective measures had to be taken, with nations being prepared to cooperate with each other. It was not cost-effective for individual nations to act alone in trying to stabilise emissions at 1990 levels.

And fifthly, authorities needed a "robust, adaptable approach" to tackle this problem, which was long-term in nature.

Presentations

Nordhaus and Yang presented a regional dynamic general equilibrium model of optimal climate change policy, RICE (regional integrated model of climate and the economy). This was a regionalised version of the earlier DICE model, which was a globally aggregated model integrating a general equilibrium model of the global economy, emissions, concentrations, climate change, impacts and optimal policy. Nordhaus and Yang's paper stated that globally aggregated models, like the DICE model, had the shortcoming of losing much of the interesting and important

details of different regions. It continued: "Perhaps the most important shortcoming, however, is that global models ignore the fact that policy decisions to reduce greenhouse gas emissions through taxes or regulations are primarily taken at the national level. It is single nations — not the United Nations — that make decisions, so any grand design to slow global warming must be translated into national measures. The purpose of the present study is to improve the realism of integrated assessments by lodging policy-making at the appropriate national levels. This involves introducing a number of regions of the world and considering different degrees of cooperation among nations."

The major results, which the authors stressed were "tentative and subject to revision", were that, first, the RICE model produced slightly higher projections of output, CO_2 emissions and concentrations than many other integrated models. Secondly, the cooperative policy showed much higher levels of emissions reductions and carbon taxes than did a nationalistic strategy, and, indeed, nationalistic strategies differed very little from no controls at all. Thirdly, there were substantial differences in the level of controls in both the cooperative and the nationalistic policies of different countries. And finally, the pattern of gains and losses across regions showed that the US lost from a cooperative policy, while the developing countries were the major gainers.

The paper closed as follows: "In sum, the results ... emphasise the fact that, while climate change is a global externality, the decision-makers are national and relatively small. This implies that the long time horizons involved in global warming, and the requirement to undertake planning over a horizon of a century or more, are compounded by the dispersed nature of the decisions and the strong tendency for free riding by non-participants in any global agreement. Countries may be triply persuaded not to undertake costly efforts today — first, because the benefits are so conjectural; secondly, because they occur so far in the future; and, thirdly, because no individual country can have a significant impact upon the pace of global warming. The present study indicates that the third of these, the dispersed nature of the decision-making and the consequent diluted incentives to act, is a powerful hindrance to setting efficient climate change policies."

Manne and Richels used the MERGE-2 (model for evaluating the regional and global effects of greenhouse gas reduction policies) to focus on the issue of hedging strategies. They contended that the challenge facing today's policy-makers was to arrive at a "prudent hedging strategy" that balanced the risks of waiting with those of premature action. There were those who believed that, until there was a better understanding of the impacts of global warming, any response should be limited to "no regrets" policies. Others maintained that the stakes were so high that emissions had to be controlled at all costs — "to act otherwise, would be to court ecological disasters." In-between, however, there was a third school of thought, which believed that both costs and damages were important: "We are a society of of limited resources. We cannot guard against all conceivable environmental threats. Cost-benefit analysis is a logical way to ensure that society's resources are allocated wisely."

Their analysis had highlighted some important considerations. With regard to mitigation costs, there were strong reasons for preferring emissions strategies involving modest reductions in the near term, followed by sharper reductions later. Early mitigation would require costly measures to accelerate the replacement of existing capital stock, low-cost substitutes were apt to be in more plentiful supply in the future, and, even if the cost of removing a tonne of carbon was the same in all periods, a positive discount rate would still favour deferred reductions.

The picture was much cloudier on the benefits side of the analysis, with two critical issues — the magnitude of damages and their timing. Conventional wisdom was that damages would be low in the early years and rise as a function of temperature change. Much of the published literature placed damages at 1–2 per cent of gross world product for a doubling of atmospheric CO_2 concentrations. Under such a scenario, impacts would remain modest until the second half of the next century. If one adopted a benefit-cost perspective, there would be ample time for an economic transition to less carbon-intensive fuels and for developing low-cost substitutes. "On the other hand," the paper continued, "if one believes that high damages are likely in the next 50 years, an immediate departure from the business-as-usual emissions path may make sense." Costly near-term measures would then be justified. Fortunately, however, policy-makers did not have to commit themselves today to a global emissions path for the next 100 years; there would be ample opportunity for learning and mid-course corrections.

Edmonds examined the potential regional costs and benefits of participation in a set of hypothetical protocols to control fossil fuel carbon emissions. The construct of a stabilisation agreement could greatly influence the potential acceptability and stability of that agreement, he claimed. Several alternative agreement structures were studied, including those which involved trade and those which did not and, for those involving trade, a variety of emissions rights, including those based on equity, income and history. The principal conclusion of the study was that any agreement to control fossil fuel carbon emissions, no matter how skilfully crafted, would require a process of constant revision in the terms of participation, because the economic needs of its participants would be evolving.

Chapuis, Duong and Grubb explored the implications for climate policy of inertia and adaptability in energy systems, using a discrete-time numerical optimisation model called GreenHouse Cost. Their paper stated that, to date, quantitative studies had sought to balance the damages associated with rising greenhouse gas levels with the cost of limiting emissions, given a fixed abatement-cost curve or a menu of technical options. Implicitly, it was often assumed that the list of techniques available for lowering emissions and their costs were independent of the policies or incentives adopted. However, the opposite appeared to be the case. Energy systems would adapt, and so abatement costs could be shared between the permanent loss of economic efficiency and the transitory cost of switching the direction of technological progress and accelerating renewal of industrial equipment. If energy systems were to a large degree adaptive, the required short-term controls might be stronger, the reachable long-term reduction of CO_2 would be

significantly more than what previous models had suggested, and procrastination would be dearer.

Walker made a comparative assessment of carbon/energy taxation versus joint implementation, from an OPEC perspective. This was in the context of the United Nations Framework Convention on Climate Change, which stated that "the Parties shall give full consideration to the specific needs and concerns of developing countries, whose economies are highly dependent on income generated from the production, processing and export, and/or consumption of fossil fuels." On the basis of empirical results, he concluded that joint implementation was a more tolerable option for oil-exporting, developing countries than carbon/energy taxation. However, this did not mean that these countries would benefit from it; it was the lesser of two evils, as they saw it. Joint implementation would depress oil demand mainly in the electricity-generating sector, where oil had already experienced a loss in share. Generally, for any climate change policy to succeed, it would have to accommodate the interests of both developed and developing countries.

Less theoretical environmental issues discussed at the Workshop included optimal land allocation and bio-fuel supply, nuclear energy, wind energy, alternative automobile fuels, transportation initiatives, external costs of fuel cycles, and electricity generation by renewable energy.

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