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ORNL FOREIGN TRIP REPORT

ORNL/FTR-3860

DATE: January 7, 1991

SUBJECT: Report of Foreign Travel of Stephen F. Rayner, Energy Division

TO: Alvin W. Trivelpiece

FROM: Steve Rayner

PURPOSE: To attend Dahlem Research Conference on Limiting the Greenhouse Effect: Options for Controlling Atmospheric CO_2 Accumulation

SITES VISITED: December 9–14, 1990 Dahlem Research Conference Berlin, FRG

ABSTRACT: Traveler attended the Dahlem Research Conference organized by the Freien Universitat, Berlin. The subject of the conference was *Limiting the Greenhouse Effect: Options for Controlling Atmospheric CO_2 Accumulation*. Like all Dahlem workshops, this was a meeting of scientific experts, although the disciplines represented were broader than usual, ranging across anthropology, economics, international relations, forestry, engineering, and atmospheric chemistry. Participation by scientists from developing countries was limited.

The conference was divided into four multidisciplinary working groups. Traveler acted as moderator for Group 3 which examined the question "What knowledge is required to tackle the principal social and institutional barriers to reducing CO_2 emissions?" The working group rapporteur was Jesse Ausubel of Rockefeller University. Other working groups examined the economic costs, benefits, and technical feasibility of options to reduce emissions per unit of energy service (Group 1); the options for reducing energy use per unit of GNP (Group 2); and the significance of linkage between strategies to reduce CO_2 emissions and other goals (Group 4). Draft reports of the working groups are appended (Appendix A). Overall, the conference identified a number of important research needs in all four areas. It may prove particularly important in bringing the social and institutional research needs relevant to climate change closer to the forefront of the scientific and policy communities than hitherto.

Dahlem Research Conference on Limiting the Greenhouse Effect: Options for Controlling Atmospheric CO_2 Accumulation

The Dahlem Research Conferences (Dahlem Konferenzen) were founded in 1974 to promote international interdisciplinary exchange of scientific information and to stimulate internatio al cooperation in research, and also to test new models conducive to more effective communication among scientists. Each conference follows an established format known internationally as the Dahlem model (see Appendix B). Particularly, the organizers encourage participants to pose questions to their colleagues from disciplines other than their own, in an effort to further interdisciplinary perspectives and cooperation.

Papers are prepared and circulated in advance of the meeting. In this case 20 such papers were written (listed in Appendix C). Another participant is selected in advance to submit written comments on each paper. The traveler was invited to be discussant for the paper by Konrad von Moltke on the topic "International Regimes for Reducing Greenhouse Gas Emissions." Dahlem papers are not presented at the meeting, but are taken as read to provide the context for discussion.

Report of Working Group 3

Working Group 3 (chaired by the traveler) had 10 members including Jesse Ausubel of Rockefeller University (rapporteur) Eric Arrhenius of the World Bank; Richard Benedick (author of the Montreal Protocol); a former German member of parliament, Reinhardt Uerberhorst; and Konrad von Moltke of the Conservation Foundation. This group also had all of the developing and newly industrialized country scientists at the conference; from Korea, India, and Sierra Leone. Since the research questions posed to all of the groups seemed to overlap, Group 3 chose to distinguish itself by focussing on the institutional and broad societal obstacles to CO_2 reductions. We agreed to discuss economic issues only in terms of economic institutions and the discipline of economics itself. Technical considerations also were left for exploration by Groups 2 and 4.

Seven subjects were selected by Group 3 for its deliberations. Each was considered to warrant further attention to increase understanding of social and institutional barriers to reducing CO_2 emissions. In each case a set of priority research questions was identified.

1. Plural rationalities among all types of decision makers;

   Systems level:
   1. Can we describe better and more fully world views and their configuration?
   2. How do diverse world views constrain action at the global level?
   3. At the national level, how do diverse world views influence choice of policy instruments?
   4. At the subnational level, are there ways to invert the tragedy of the commons so that local or community goals favor the global good?

Types of organizations:

5. Where is there need to stimulate the growth of "missing" institutions?
6. What organizations are best adapted for the range of functions required to respond to global change, for example, functions of monitoring and verification of international environmental agreements?

Time horizons:

7. How do diverse world views influence the sense of urgency that different groups hold about global environmental change?
8. How does culture structure the use and perception of time?

Types of action:

9. What environmental goals are best pursued through *explicit* consensus?
10. What environmental goals are best pursued through *informal* agreement?
11. To what extent can environmental and energy technologies be designed around world views?

2. Inadequacy of existing processes for scientific and political consensus formation;

    1. How can processes for consensus formation in the field of environment and technology be enhanced at all levels?
    2. What changes are required in the processes internal to the scientific community to make its work in its roles with a normative orientation more useful?
    3. Should there be more discussion of guidelines or norms of advocacy for scientists to facilitate communication with the political system?
    4. How is communication between science and politics affected by the universalist orientation of science in contrast to orientation of politicians toward the sovereign state?
    5. To what extent is it the case in environmental negotiation that stakeholders facing decisions with highly uncertain outcomes will emphasize a fair process of decision-making rather than gambling for advantage?

3. Variability of institutional time horizons for decision making;

    1. What are the time horizons characteristic of the organizations most important to global environmental change and why?
    2. What are the institutional factors that shape the spectrum of time horizons?
    3. Why are some political systems more open to change and to long-term perspectives?
    4. What is the time required to reach various kinds of international agreements? Does it differ systematically for broad and specific agreements?
    5. How can methods be improved for the conduct of studies that extend decades and generations ahead?
    6. What establishes the calendar of science and are there ways to accelerate the production of usable knowledge from science important for global environment?

4. Institutional distortions of economics of environmental and energy services;

   1. To what extent will provision of better information about environmental costs of energy use change behavior?
   2. How broad a definition of externalities can be functionally applied to current pricing structures?
   3. What are long-run elasticities of energy demand, how high will taxes or charges need to be to exert a sustained influence on behavior, and are these best applied in gradual or abrupt price changes?
   4. What are the strengths and weaknesses, by criteria including fairness and efficiency, of various economic regimes for limitation of carbon emissions (fixed reductions, per capita targets, carbon taxes, tradeable permits, etc.)?
   5. What are the relative benefits of approaches to the energy system as a whole versus approaches focusing only on carbon dioxide?
   6. Why are more costly instruments for economic control often selected by society than the instruments judged superior by economists?
   7. What is the shape of the "supply curve" for carbon reductions for different nations, regions, and the world as a whole?
   8. To what extent will formal action at both the international and national level be needed in order to bring about changes in energy pricing sufficient to achieve major carbon emission reductions?

5. Design of organizations for research, assessment, and evaluation of climatic change, its causes, and efforts for adaptation and prevention;

   1. How can progress in basic environmental research be accelerated to the benefit of many nations? Would a network of international environmental research centers be useful, and if so, how should it be designed?
   2. How can the joint international conduct of scientific assessments be improved? Are there new roles for international nongovernmental scientific organizations in this regard?
   3. How can evaluation of programs and policies designed to achieve reduction of carbon emissions be reliably assured? What combination of existing and new independent organizations might best carry out this function?

6. Technology transfer with developing countries and the possibilities for technological leapfrogging;

   1. Can we understand better the relative importance of various factors affecting response to carbon emission reduction at various levels of development?
   2. Recognizing that in many countries there will be governments that lack leverage over the national economy, how can obstacles to action by developing countries to reduce carbon emissions be overcome most effectively?
   3. What are the possibilities for informal action to reduce carbon emissions in developing countries?
   4. What is the possibility for developing countries to leapfrog in energy and environmental technologies in order to avoid the pattern of development that has traditionally characterized industrialization?

5. How can international arrangements for transfer of technology and intellectual property rights be made into more a positive sum game that also recognizes the assets and needs of LDCs?
6. What can done to improve the weak performance of international organizations with regard to environmental protection in developing countries?
7. What can be done to strength indigenous environmental research capability in developing countries and to strengthen participation of scientists from developing countries in regional and global evaluations of environmental issues?

7. Lifestyle trends and changes related to climate and energy.

1. Where and how will we live? What will be the size and kind of homes and households?
2. Where and how will we work? Can the relationship between transportation and communication be changed?
3. Where and how will we play? Will leisure be energy-intensive or not?
4. What have been the most significant behavioral changes in recent decades that have been favorable for energy efficiency?
5. How can lifestyles and behavior be changed while respecting individual rights? What is the potential of eduction in this regard? How is it best to project notions of needs for lifestyle change so that acceptance may be encouraged?
6. Can market research and consumer psychology be employed more constructively form the perspective of global environment?
7. What are the implications for energy demand of a continuation of recent trends in lifestyle?
8. What are the implications for lifestyle of various goals for carbon emissions reduction?

It was evident to the Working Group that certain proposals for action and change could be made now. However, much more needs to be learned about the barriers to action. Contributions can come from anthropology, demography, development studies, economics, geography, history, market research, organizational behavior, philosophy, political science, psychology, sociology, statistics, and, most importantly, from the integration of all these disciplines. A new kind of science for policy is required to face the issues of potential climate change and other global environmental issues. Over the long term, this will require considerable rethinking of the relationship among scientists, politicians, the private sector, and the people who are affected by all of their actions. The draft report of Working Group 3 was well received at the closing plenary, which is particularly encouraging as it dealt with aspects of the human response to potential climate change that concern many scientists and decision makers, but have yet to get on the front burner for research funding.

Visit to Wissenschaftzentrum (Science Center) Berlin (WZB).

During a free period at the conference, the traveler was invited by Dr Udo Simonis to visit the Science Center. The WZB is part of the Technical University of Berlin. It is housed in an architecturally significant building designed by the contemporary British architect John Sterling based on medieval Italian architectural motifs. The building reflects the willingness of German institutions to put significant resources into the reflexive study of science as a social activity as well as major policy issues of science, technology, and society; all of which tend to be poorly funded in the United

States. Simonis and the traveler have been invited to establish a working group on the Social and Behavioral Aspects of Energy Conversion for the International Social Science Council (ISSC) referred to in Foreign Trip Report ORNL/FTR-3841. This was an opportunity to sketch out preliminary plans for composition and funding of such a group.

Conclusions

The trip was most useful in these respects:

1. The traveler made contact with German researchers investigating the potential for state and local government and non governmental actors (including the private sector and citizens' organizations) to respond to potential climate change. This is a research issue funded at ORNL since FY 1989 by the DOE Office of Environmental Analysis. The contact will enhance our ability to make international comparisons of the options available to actors other than national governments.

2. The trip offered an opportunity to have preliminary discussions with the co-chair of the proposed ISSC Working Group on Energy Conversion.

3. The traveler was able to discuss the direction of ORNL's program and future plans for Policy, Energy, and Human Systems Analysis within the Global Environmental Studies Center with a select group of international experts that is likely to be influential in shaping the international research agenda in human dimensions of global change. Our plans appear to match well with the priorities established by Working Group 3. The challenge is how to capitalize on this consensus to encourage U.S. Government agencies to fund research that they do not yet recognize (as evidenced by the expenditures cited by the Committee on Earth and Environmental Sciences) as having high priority and payoff.

APPENDIX A

DRAFT REPORTS OF WORKING GROUPS

What Are the Economic Costs, Benefits, and Technical Feasibility of Various Options Available to Reduce Greenhouse Potential per Unit of Energy Service?

S.I.Boyle, Rapporteur
W. Fulkerson
I. Mintzer
R. Klingholz
G.I. Pearman
G. Pinchera
J. Reilly
F. Staiß
R.J. Swart
C.-J. Winter

INTRODUCTION

Energy related greenhouse gas emissions are currently estimated to contribute more than 60% of global warming in the 1980s (Ref. IPCC/EPA). Carbon dioxide emissions, of which fossil fuels constitute approximately 75% and biomass emissions 25% (Ref. IPCC I)., contribute half of global warming in the 1980s. It is clear that energy related CO_2 emissions must be a key focus for policy initiatives in reducing the risks of climate-induced impacts.

The Group interpreted its task as adding to the papers produced by Fulkerson, Kane and South, Winter and Reilly, as well as those by Yamaji, Jenney, Ashton and Secrest, Jochem and Schipper. These provide a "state of the art" of a range of technologies and policies which can reduce CO_2 emissions, as well as reflecting a perception of the energy-related aspects of the climate change problem. The emphasis of Group 1 was in identifying important interdisciplinary and methodological issues raised by the papers. Key informational gaps, and recommended new research - which is essential if a) remaining scientific uncertainties are to be resolved and b) policymakers are to be given clear guidance on a range of actions which can reduce emissions provided the focus of most of our discussions.

We thus touched only briefly on specific end-use efficiency or energy supply options and technologies in our discussions. Some of the themes which were thrown up on a regular basis during discussions included the importance of regular interaction between climatologists, energy specialists, and social scientists, and the fact that some of the technologies and policies had multiple benefits. For example, advances in fossil fuel combustion technologies not only reduce CO_2 emissions per unit of electricity generated; they significantly reduce acid emissions and also lessen energy security problems for countries heavily dependent on imports.

TECHNICAL ISSUES

How might one best assess the maximum technical potential of various options including efficiency, renewables, nuclear, fossil fuels, and CO_2 removal?

A clear consensus emerged that there was in principle no technical limitation to significant reductions in CO_2 emissions, on the scale suggested by both IPCC I, and the Scientific Declaration of the Second World Climate Conference. After some discussion on the definition of technical limits, we took this to mean "Appropriate scientific understanding of the ecosystem and climate changes, nor absence of appropriate technical solutions if applied in an integrated fashion, are not the main constraints for achieving an efficient reduction of the wished for disruptive consequences due to GHG buildup in the atmosphere on the medium term. The constraints lie in the absence of appropriate ways to implement this knowledge in the socio-economic sector." This is an important area for additional research. The latter is the area for additional research.

In looking at the "outer limits" of various options and the comparative contributions from each, it was noted that energy supply options tended to be slower to implement than demand side options, and that none of the supply side options could really achieve the CO_2 abatement options necessary without an aggressive energy efficiency program.

Though it appeared that there were no real technical limits in reaching high CO_2 abatement levels, analysis on the degree of integration that was required to achieve this is limited. The extent to which the effective penetration levels of the various technologies are potentially much lower under current market and social conditions is a key problem and research question.

There was broad consensus that "technology-fix" approaches alone would not achieve the desired result. It was clear, for example, that the differences in energy intensities between nations (e.g., between Japan and the U.S.A.) were a factor of infrastructures, social aspects, and varying energy systems, and not just the use of less/more efficient technology (Ref. Schipper). A series of measures, including the "technology-fixes," new fuels and associated infrastructures, modifications to planning systems, and changes in lifestyle were just some of the interlocking options. Figure 1 shows such a range of options and some illustrative costs for reducing CO_2 emissions from cars.

Research has suggested that a broad brush appreciation of the scale of improvements in energy efficiency needed to bring specific CO_2 reductions could be ascertained by utilizing the following formula (Holdren et al.) (Reference) (see Fig. 2). This links population, affluence, and energy intensity. For example, one simple analysis by Schipper suggested that in OECD countries, a 20% CO_2 reduction from current levels over the next 15-20 years would require a 34% reduction in energy intensity. Further analysis using this type of approach may be useful for assessing the scale of reductions required and comparing the technical potentials of differing options.

Of the CO_2 abatement options, least was known on both the technical feasibility and costs of CO_2 removal from power station stacks. More research is required to clarify the technical feasibility of CO_2 removal and disposal, the associated efficiency reductions, and costs. Though some analysis suggested that efficiency reductions and the costs could be high, this was by no means certain (references).

How would potential changes in the structure of the energy system, e.g., increasing electrification changes in end-use patterns affect emissions of GHPs per unit of energy service?

Two energy sectors, electricity and transport, were the focus of much discussion. This reflects the relative importance of the sectors in their contribution to CO_2 emissions - 40 to 50 percent of total OECD emissions, the rate of growth of emissions (especially the transport sector), and the complex mix of questions and research needs generated by the problems they throw up.

<u>Electricity Sector</u>

The electrical sector is clearly an important one in that it consumes between 25 and 40% of primary energy, often constitutes the largest single source of CO_2 emissions in a country, and consumes a large proportion of the industrial investment capital available. It was acknowledged that electricity is a powerful symbol for the public, and a number questioned the extent to which there was a mindset on the role of electricity in the overall fuel mix.

A current energy paradigm, which has quite strong support within the energy community, is that increasing electrification in all countries is both inevitable and desirable. (reference) Assessing whether this is a suitable paradigm in relation to future emissions of carbon dioxide is problematical. There has been a lack of evaluation as to the record of utilities worldwide and the related CO_2 emissions, and only limited understanding as to why there is a wide variation in the relative role of electricity in different countries. The results of such analysis may provide understanding of the relative importance of political imperatives.

historical precedents, and technological and environmental issues in the current and future roles of electricity in society.

A number of technical and data issues remain to be solved before the future role of electricity can be assessed. These include increased understanding of the future role of advanced electrical technologies for industries (e.g., electro-arc induction), in increasing electricity demand, and impacting on CO_2 emissions when compared to current nonelectrical technologies. Though conventional power stations remain relatively inefficient, the potential role of technologies which can substantially improve such efficiencies, for example, cogeneration and heat pumps, needs to be assessed against direct fuel use, for example, in gas condensing boilers. As well as comparisons between such differing supply options, the significant potential of electricity efficiency (see Lovins) could allow a major increase in electricity services, with a static or falling electricity demand. The potential future role of electricity in the transport sector may have a significant impact on future electricity demand and consumption levels. Given the importance of energy use in areas such as mining and waste disposal, such analysis should include the total fuel cycle.

A final area of discussion focussed on the future role of electrical utilities. This appears to be in need of redefinition, given that some of the original premises and objectives of the industry no longer hold good in a future where CO_2 restraint is important. Simply responding to increasing electricity demand by building more power stations, or even actively marketing electricity in order to increase demand is no longer a key objective among many US utilities (Gellings, 1990). Key questions here include:

- How to integrate a social role for the utility into the current structure and activities;
- How to turn the utilities into energy service companies, where demand side management (DSM) and pollution reduction are an integral part of their business;
- Should gas and electricity utilities be integrated?

<u>Transport Sector</u>

<u>The Context</u>

Transport is the fastest growing sector for CO_2 emissions in OECD countries, currently increasing at the rate of between 2 and 5% per annum (ref Jenney). Though there is a large potential for improving fuel efficiency, the volume of vehicles and distance travelled will, on the basis of current trends, swallow up any improvements (Ref. Walsh; Jenney). Both developing countries and eastern European countries have the potential to follow the OECD model of transport development, both at local urban and national level. If action to reduce

CO_2 emissions is required, the transport sector needs to be a priority area for new initiatives and a wide range of multidisciplinary research and analysis.

Technology

There are a wide range of technological options available which can reduce CO_2 emissions. These range from improving fuel efficiency in private vehicles, mass transit, and airplanes. to switching to a number of alternative fuels such as hydrogen and electricity.

There is a need to improve basic data in the transport sector, including fuel consumption, vehicle occupancy and usage, and identification of the reasons for the vehicle trip. Though there is wide acceptance of the longer-term potential for significant fuel efficiency improvements in automobiles (Ref. Bleviss), there remains some disagreement on the potential in the shorter-term, taking account of the inertia of car manufacturers, transport systems and vehicle life expectancy (Ref: OTA, Defiglio etc.,).

A wide range of fuels other than the current oil-based ones (gasoline/diesel) exist. These have varying impacts on relative CO_2 emissions (Ref. and Figure from Sperling), and it appears that hydrogen produced from non-fossil fuel sources of electricity, non-fossil fuel sources of electricity, and several of the biomass-based fuels (e.g., ethanol) may offer the potential for significant reductions. It is important when assessing the relative contributions of these fuels to climate change, that greenhouse gases other than CO_2 be assessed. This should include for example, the role of CO, HCs, and O_3. A number of initiatives which have the aim of reducing local air pollution (Ref. SCAQMP) have not assessed the impacts of proposed policy changes on greenhouse gas emissions. Hence, the Southern California initiative to substantially replace gasoline-driven vehicles with methanol (derived from natural gas) over the next decade, is likely to have a minimal effect on reducing CO_2 emissions.

Transport Systems and Structures

Transport and related CO_2 emissions is not simply a technological issue. It is linked to planning, urban design, consumer behavior, income and choice, energy, price, and political philosophy.

Figure 4 shows the strong correlation between vehicle densities and usage, consumer income and fuel prices. An examination of the financial aspects of transport is important, in order to understand the capital flows and sources, such as for infrastructure; and the subsidies provided for private and mass transit. Low fuel prices, linked to a lack of readily available mass transit systems, and generally low density urban development are a feature of the US automobile dominated transport system. The extent to which modifications to pricing structures, for example, through a high carbon tax, or removal of workplace parking spaces and mileage allowances, might alter current transport intensities and modal splits is an interesting area for research. This would lend itself to a range of case studies on different communities, looking at both success stories and failures. Though 75% of the world's vehicles (and associated vehicle kilometers travelled) are associated with the USA, Western Europe and Japan, the growth potential in eastern European and developing countries is significant (Ref.?). The extent to which land zoning, the planning of denser urban settlements in order to allow successful and cost effective mass transit systems, and pricing structures might influence future demand projections is an important focal point for multidisciplinary research.

The issue of market instruments versus more planned policies was raised on a number of occasions. The extent to which city and national authorities might intervene to reverse current trends of congestion and air pollution, is not a purely scientific question. For example, though it is clear that reducing traffic congestion in the short-term should improve the fuel efficiency of vehicles (ref. Jenney), it may be that such efforts encourage additional trips or vehicle owners. In order to influence the behavioral aspects of consumers and encourage them to shift to mass transit or reduce distances and vehicle trips, it might be more appropriate to allow urban congestion to increase. This was just one example of the multifaceted nature of transport.

Given the wide range of research needed to resolve the problem of how to reduce CO_2 emissions in the transport sector, a question remains over the potential funding of this. A significant amount of transport-related research is carried out by vehicle manufacturers, airlines and oil companies. Little is related to the above issues. To what extent can they be encouraged to fund this work in the future?

What information and methods are needed to assess the realistic potential of forestry and soil conservation efforts to reduce CO_2 accumulation?

Non-fossil fuel sources and quantities of anthropogenic carbon emissions are much less certain than fossil fuel related emissions. The focus of the Group's discussion in this area concentrated on forestry and soil conservation, and biomass systems for energy.

Forestry

The present scientific understanding is that around 2GtC/annum (references) are emitted to the atmosphere due to deforestation, and that this could be reduced or stopped by halting deforestation and initiating major reforestation programs (IPCC I). Reference was made to the ambitious target of the 1989 Noordwijk Conference in the Netherlands of planting 12mha/annum of trees by the year 2000. This target has subsequently been criticized as unrealistic at the Second World Climate Conference in Geneva (November 1990).

There are multiple benefits from both halting deforestation and initiating sustainable reforestation programs. These include increasing the economic potential of marginal lands, reducing soil erosion, providing income for local populations, providing a sustainable and local fuel supply, improving biodiversity, and sequestering carbon. Thus forestry conservation cannot be considered in isolation as a CO_2 abatement option (something on feedbacks from Graeme P. to come here).

Estimates of deforestation levels are still poor, and further research to give more accurate figures is needed. A variety of methods are available to achieve this, including soil surveys, remote sensing, ground studies and forestry models. A longer term perspective (50 to 100 years) suggests that the potential from carbon sequestration due to reforestation, is at least an order of magnitude lower than the potential carbon releases from fossil fuels during this period (check with Graeme Pearman for reference). In the next 30 to 50 years, there may be a potential to sequester perhaps as a maximum, some 5 to 10% of total anthropogenic carbon emissions, This requires a great deal of further work to validate (Ref. Tirpak).

Soils

Much less is known about carbon in soils. With a standing mass of c.2000GtC, perhaps an additional 1 GtC/annum could be sequestered in soils. The order of magnitude of the amount of carbon annually circulated through the world's agricultural system is similar to fossil fuel emissions. A large portion of this carbon is not effectively used as food, fiber, fuel or fertilizers. Research is recommended to assess the possibilities to reduce net greenhouse gas emissions by utilizing this resource more effectively in agricultural and urban systems. It will be very difficult to measure and verify whether this had been accomplished or not, however.

Presently large amounts of carbon in soils are being lost due to soil degradation. At the level of farming systems, management changes may actually increase soil carbon. For example, a reduction in deep tilling and fallowing practices should reduce carbon releases. Research is needed to better quantify these options and assess their practical feasibility. Policies directed at protecting or improving soil quality are also useful, even in the absence of climate change.

Recommended Research

A. Information Needs for Forestry

There are [three] high priority information needs that are essential to either a global climate change convention or a free standing international forest agreement. These include the following:

1. Operational Biomass Burning Systems. There is an urgent requirement for annual estimates of CO2 and other trace gas emissions from biomass burning. The estimates are needed at the national level as part of the improvement of knowledge of the biogeochemical cycles of CO_2 and CH_4 in particular, and thus improve the predictability of climate change resulting from the accumulation of these gases, and identify options for intervention in emissions. During the next year a cooperative international effort involving the IGBP and national/regional centers should be established, with actual data analysis beginning in the 1992 calendar year. The initial system could be quite crude, relying on existing satellite platforms and the best available estimates of biomass and emission factors. It is anticipated that the accuracy of such a system could be slowly improved over the next five to ten years as improved information becomes available from laboratory emission tests, small test burns under field conditions, and improved space based platforms. The evolution of such a system fits in closely with the need for a compliance system once any target agreements for forests is agreed.

2. Cost Effective Management Practices. The implementation of forest management plans requires improved information on the cost-effectiveness of agroforestry practices in different parts of the world. An initial first step should include the compilation of existing information in a manual for by planners, policy analysts, research managers, and development assistance funding agencies. This effort activity be complemented by expanded efforts to demonstrate and document agroforestry practices in the field.

3. National Forest Plans. Any future international forest agreement is likely to rely on the development of national forest plans to integrate diverse objectives including, sustainable forest use, biodiversity, increased carbon storage, and economic development. An improved process to develop national plans for the boreal, temperate, and tropical forests is needed. The development of such a process should build on an improved Tropical Forest Action Planning process through the

cooperation of the World Bank, FAO, national governments, and nongovernmental organizations. It would include extensive inventories.

Other informational needs for both forestry and soil conservation include the impact of photochemical and acid pollution on boreal forests and their ability to sequester carbon, and the range of nontechnical issues affecting deforestation. The latter include economic, social and institutional barriers. Though the former area of research is likely to be relatively long term, the latter could be completed within the next few years.

Biomass energy systems have the potential to replace fossil fuels as a fuel source, with no net carbon emissions. In many parts of the world such biomass systems are not being operated in a sustainable manner (Ref. Sao Paolo). In addition, there is a growing tendency for many developing nations to switch from biomass to commercial fossil fuels. There have been a number of attempts to improve the combustion efficiency of biomass systems, for example in the area of woodstoves, but the success rate has been mixed (Ref.). More advanced combustion technology such as gasifiers (Ref. Williams) may help redefine the future role of biomass.

IMPLEMENTATION MECHANISMS FOR CO_2 ABATEMENT OPTIONS

The introduction of appropriate CO_2 abatement options does not just entail technological assessment. Methods of comparing the costs and benefits of technologies and policies are necessary to evaluate optimum strategies involving solutions, appropriate to local, national and international circumstances. In addition, there is a need to facilitate technology transfer, to apply international instruments and develop relevant international organizations for such activities as administering funds, collating data and carrying out research. These issues formed the focus of the Group's discussions on implementation mechanisms for CO_2 abatement options.

What information and methods are needed to compare the costs and benefits of various strategies to reduce CO_2 accumulation?

There are two main methods of comparing costs and benefits of the various CO_2 abatement strategies. These are:

a) engineering cost accounting, or "bottoms up" analysis, which looks at potential CO_2 reductions in a sector by sector analysis, producing relative and net costs for the various options,

b) a "top down" econometric analysis.

These two disciplines have a different philosophical perspective that contributes to the differences. The engineering approach is a prescriptive one that attempts to find the best solution for a specific problem or individual application. The economic approach is a descriptive approach, holding that individual agents/ consumers know best what the situation is and what solutions to choose. Within the economic approach is the recognition that individuals may/will seek out or react to the prescriptive solutions offered by engineering approaches.

In applying these approaches for estimating the likely future energy use or the costs or benefits of changing fuel use and technologies, each approach has both strengths and weaknesses. Focussing on the weaknesses firstly, the engineering approach, which looks at any technology altering energy use and supply, neglects most characteristics of the technology that is replacing the current one other than direct costs and the technical results of applying it. One concern is whether this approach can evaluate other characteristics (such as x) completely, and under all conditions.

Under the econometric approach, a question often arises as to many zero or near-zero cost opportunities do not get adopted. There is less acceptance in this approach of the many market failures and barriers which are behind the low uptake of the technologies. The econometric approach will also tend to overestimate the costs, because it treats barriers as a permanently higher cost, whereas the cost of the technology may be lower once the barrier is overcome. For example, a high start up cost for a new technology may fall rapidly once large-scale production starts.

Research Gaps, confusions and controversies

How do you carry out a comparison between the two approaches? One important point is in recognizing the different way costs are reported, including the total investment cost, the fuel cost, the net additional cost/benefit relative to existing technology, the annualized levelized cost, the inclusion of environmental costs, and finally, what is the role of the expected prices of the analyst versus the price potential/actual adoption which may be higher or lower?

The question of reconciling both approaches is important. Though it is currently difficult to achieve a consensus on this question, a number of groups are already working together to integrate some aspects of their work (e.g., Stanford/LBL, UNEP, and meetings between the USA and the European Community). Detailed criticism of analysis by Messne and Richels (Refs.) has led to modifications in the original assumptions and a considerable reduction in the range of costs now estimated for CO_2 emission/reductions in the USA (Ref.)

The role of subsidies: - which fuels and efficiency technologies are benefitting and which are penalized; what is the basis of the subsidy; does it address a perceived externality or market failure, or are there other irrational reasons for it?

Modifications to the current models. The econometric models need to be developed to analyze the impacts of policies other than energy/carbon taxes; the "bottom-up" models do not so far incorporate equilibrium effects.

How do costs change with regard to the scale of use or application?

Further Informational needs are outlined in Appendix 1

Two final observations were made by the Group. Part of the difference between the costs in the two approaches may not be a basic difference but only where and how the costs are accounted. The econometric approach, by its very nature, accounts everything as a dollar or money value, whereas the engineering approach only counts certain costs and ascribes the lack of penetration of technologies as due to market barriers, hence needing further information, innovative financing, regulations, standards etc. Putting a value on some of these barriers may help narrow the difference in the estimates.

How can the technical, institutional and social feasibility of various options and strategies be best evaluated?

The methodology for assessing the technical feasibility of a wide range of options has been well established over the past 15 years, and a broad consensus has been reached. There is a major problem in applying the results of such analysis however.

Total fuel cycle costing is a key approach for evaluating the non-economic issues of CO_2 abatements. A great deal of work has been and is being produced on total fuel cycle costs, including the externalities. There appears to be a growing consensus on the externalities of the various CO_2 abatement options within an order of magnitude, at lest for non-nuclear options (Ref. U.F.:). For nuclear power there is still major disagreement however (Ref. Hohmeyer, and FRG alternatives). There remains a problem as to how to actually apply the externalities.

Continuing controversies of where to draw the energy system boundary remain (i.e., does one include the embodied energy in related products, and can one evaluate the overall impacts of a major programme of technology introduction on a country's economy?). The development of extensive input-output tables covering the wide range of possible variables is one possible option for clarifying the issue.

The assessment of the social acceptability of new technologies and policies requires considerable additional analyses. There is still resistance by the public to new technologies, particularly energy supply side options in their local area. Though some evidence is available from the social sciences on how people react to new technologies and systems, these did not always have appropriate variables built in as far as CO_2 abatement is concerned. New research and demonstration programs are needed to evaluate public/consumer reaction to CO_2 abatement options, particularly those which have substantial impacts on lifestyle and social organizations. Work on the importance or not of more democratic and/or participatory decision-making processes in choosing the options and the application of them, is a necessary addition to these demonstrations.

Two large-scale demonstration ideas were strongly supported. The first requires turning a utility into a full energy service company and assessing both the process as the utility changes its modus operandi and the eventual outcome. The second relates to modifying transport systems in several cities in order to influence modal shifts, mobility, travel distance patterns, and new transport technologies. In addition, international comparisons of energy conscious/energy autonomous communities (e.g., Davis (USA), Rottweil (Germany), Milton Keynes (UK) could provide some important lessons for policymakers and other communities.

What can be done in the way of technical transfer to help developing countries and transition economies to reach a low energy, low emission path to sustainable growth?

Though many developing countries are not important CO_2 emitters in the energy sphere at present, they could be in future as a function of a shift to commercial fossil fuels and population growth. Analysis into the energy intensity of a range of countries and country groups shows that developing countries have not yet peaked (see figures). Technology transfer, particularly of efficient and low CO_2 technologies and related changes to systems, structures and societies, thus has a major potential in reducing unnecessary future energy consumption and associated CO_2 emissions.

Discrete country-by-country analysis, and sectorial analysis within each country, is important in understanding the unique characteristics of the potential recipients of technology transfer. Historical, cultural, and social dimensions to this research are as important as current fuel mixes, trends and market conditions, in determining the potential success of the technology in the country.

CO_2 abatement may not be the key criteria in relation to technology transfer for many countries, where current and even future emissions will be low. Where the technology can have multiple benefits, including reductions in relative CO_2 emissions, it should have an added attraction.

In the past, many well-intentioned efforts at technology transfer have failed. Unfortunately many of these programs and efforts have not been analyzed adequately, hence the reasons why good technology in an engineering sense failed are not always clear. However, some of the ingredients are known, which suggests that the failures were a function of many things, including social and cultural issues, lack of adequate training and maintenance, and inappropriate scales of technology and associated institutions. Setting up local energy efficiency, renewable and environmental protection centers was regarded as an important initiative. Reference was made to initiatives by the U.S. EPA/Batelle in Eastern Europe, and Italy in Egypt, which could provide a test-bed for research.

The need to evaluate the success or failure of technology transfer is problematical and requires additional research (see below). One technique which will be helpful to both aid agencies and recipient countries for energy technology, however, is "least cost planning" with associated "Demand Side Management" (DSM) programs evaluation.

The question of developing countries "leapfrogging" or simply closely following industrialized country technologies raises theoretical and practical issues. Though "leapfrogging" has attractions in allowing developing countries to move ahead and reduce relative CO_2 emissions quickly, it may lead to setbacks when unplanned technical hitches and problems occur. The lack of a sophisticated support infrastructure may seriously impair the developing country's ability to keep the advanced technology working at optimum levels. Research is needed into this issue.

Successful technology transfer involving the private sector is essential. There is a clear need to break the current cycle of inefficient and polluting technologies being exported to developing countries. A promising initiative might be to establish a clear Code of Conduct for industrialized countries and companies to follow (on the lines of the Hazardous Waste Code of Conduct which prohibits the exports of such wastes to developing countries). This can only evolve by involving all parties in the technology transfer. Research as to whether this will need to be supplemented with other measures such as compensatory funds to pay for more expensive technology, and trading arrangements through GATT, for example, is important.

A key emphasis for future work is on demonstration, rather than research programs. The areas of work most needed include efficiency technologies and techniques, and evaluations of past and current technology transfers. The latter needs to be honest, transparent, and where possible, carried independently. It will need to highlight both the success stories and failures of technology transfer, and the reasons for this, and the impact of such transfers on local trade and economic growth patterns.

What criteria are appropriate for choosing national and international levels of R,D & D on strategies to reduce accumulation of CO_2?

Much of the Group discussions centered on the role and focus of Research, Demonstration and Development. Notwithstanding the identification of a wide range of new research, a consistent theme to emerge from the discussions was the need for active implementation of technologies and related systems which are already well-understood in a technical sense, but have so far had limited application and use. This is an important message for policymakers, in that CO_2 abatement options can be embarked upon almost immediately, even while additional research is being carried out.

There are three main types of R, D & D; that related to technology, social sciences, and basic/cross-cutting research respectively (Ref. papers 5,6,9 Fulkerson, Winter, Jenney, Yamaji and Fuji). Where capital is limited, a systematic set of criteria for deciding on R,D & D priorities is needed. The following criteria emerged from the Group discussions:

- The size of the potential CO_2 reductions - "the biggest bang (CO_2 reduction) for the buck"- relative to the timescale on which this could be achieved. It is recognized that results would change quite significantly on the timescales of 3-4 years, 15, 50 and 100 years.
- The economic feasibility of the option, including the social costs (e.g., externalities), once again recognizing that this may change over varying planning and time horizons.
- The environmental acceptability of the option, e.g., low or zero carbon intensity.
- The extent to which options are robust, in the sense that they make sense to adopt under a range of conditions (the 'no regrets' policy) or have multiple benefits, e.g., reduces acid emissions CO_2 emissions, and energy security problems.
- The size of the market for the products and services, both domestically and overseas.
- The contingency value of the option as an insurance policy, just in case some of the preferred/more attractive current options fail to achieve the desired objective.
- The extent to which the option lends itself to international cooperation with developing and other nations, and helps to ease international tensions/problems, e.g., a technology which increases the chances of peace.
- The degree of applicability to developing countries.
- The extent to which options not yet known might prove to be important. This called for a certain proportion of the research budget to be for basic research.

To achieve optimum strategies, assessments of success and failure stories in areas such as the inter-action of technology with receiving communities, and evaluations of these, is important. Hence a further criteria should be:

- The extent to which technologies require associated social science research to improve the potential of successful uptake, application, and organization of the technology system. Such research could include for example, the role of disseminating policies that work, the role of institutions in the success or failure of certain technologies, and understanding the social consequences and acceptability of technologies and programmes.

On the crucial question of the amounts or percentages (of GNP or energy system costs), which should be spent on R, D & D, no specific numbers were presented. The emphasis of R,D & D should be on demonstration and implementation, not just research. However, two approaches - one based on budgetary criteria, the other on the opportunity costs and potential benefits (and also the costs of doing nothing) were outlined (see Appendix 2).

Determining which of these is appropriate is a further area of research, and is dependent on national circumstances. One analysis suggests that in OECD countries, a government expenditure of 1% of energy systems costs (as in the USA) was too low, and a figure of at least 3% could be justified. It was noted that in OECD countries, R, D & D levels had generally fallen substantially in real terms, particularly on renewables and energy efficiency since 1984. (see Figure 3 IEA not provided Ref. see Appendix 2, Fulkerson et al; IEA on renewables).

(The majority of the points in this section have been covered by Group 4--hence this section is likely to be deleted).

International policy instruments and institutions

(a) What international instruments are available to facilitate CO2 reductions? What tools are required to monitor the process and maintain compliance?

(b) What roles for international institutions are required to achieve reductions in the rate of accumulation of CO2?

Though the implementation of international agreements is carried out by national organizations, the role of current and potential future international organizations is a crucial area for the successful implementation of CO_2 abatement policies. Some of the main points to emerge from our short discussion were:

1. There are a wide range of organizations currently involved in energy and potential CO_2 abatement issues, including UN agencies, OECD, European Commission, World Bank, GATT, IMF, WHO, G-7 and NGOs.
2. Most of these organizations have either a limited remit, limited resources or other limitations which prevent them from fulfilling a comprehensive role in relation to CO_2 abatement. For example, there is no energy efficiency reference in the Treaty of Rome and its amendments; the OECD/IEA have almost no resources to work on renewable energy, and the IAEA only work on nuclear power. It appears anomalous that no major organization in the energy field has a remit for either energy efficiency or renewable energy. The desirability and possible effectiveness of a new

organization, for example an International Solar Energy Agency attached to the UN, should be assessed.

3. Though past precedents (e.g., ozone depletion, acid rain) are useful in helping us decide on international instruments and organizations, the uniqueness of the CO_2 abatement issue should not be underestimated. Research is needed to clarify the uniqueness of the issue, in order to understand the needs from either a new or modified organization.

4. Research into the key elements of successful organizations needs to be carried out, e.g., the success of UNEP in some areas such as the negotiations of the Montreal Protocol and the Regional Seas Program, may in part be a reflection of its limited size and resources, as its role as a catalyst organization.

5. There is a need for an international organization to verify data and CO_2 statistics to monitor and set ecological targets, to administer funding and technology transfer.

6. Research into the effects of global instruments such as a carbon tax has been of a varying quality, and work on new initiatives and instruments such as a World Resource Tax is needed. This must of practicality recognize the national sovereignty issue, as no country is yet prepared to talk about international taxes.

7. Much greater transparency on data (e.g., national CO_2 emission trends) as well as systematic and consistent data collection are needed. A data gathering organization (or organizations) is required providing, for example, a data base on best available technologies, environmentally sound energy, forestry and agricultural technologies, etc.

8. NGOs have an important role in monitoring, enforcement, consensus-building, setting standards, and consensus-building through media exposure.

9. New organizations may evolve from current ones, e.g., a climate convention and/or funding secretariat, using the precedent of the Montreal Protocol Fund. This may be more likely to gain acceptance than setting up completely new organizations.

The interactions and networking of a range of organizations is an important dimension to the success of international actions. Research into this, for example, looking at the respective roles of the World Bank, UNEP, GATT, OECD, etc., or the potential of a new network of research organizations, particularly in the developing world, would be valuable as the world enters a phase of negotiations on a Climate Change Convention and possible protocols on CO_2 emissions, forestry for example.

APPENDIX 1

INFORMATION GAPS

- Costs in the Industrial Sector
- Successful Policies in the Industrial Sector
- Remaining disagreements on the cost-effectiveness of fuel efficiency improvements in vehicles
- The ancillary benefits of reducing fossil fuel use, e.g., reductions in methane emissions from coal mine
- The costs of new infrastructure, for example in Eastern Europe with the dissemination and production of energy efficiency equipment (controls, insulation etc)
- The synergies of energy efficiency investments at a macro economic level, e.g., reducing the need for steel in coal mines, hence freeing up scarce capital
- The relative costs of efficiency and other CO_2 abatement strategies in different countries and regions, e.g., OECD, Eastern Europe and developing countries
- Full fuel cycle analysis for a range of options
- The lack of quantification of market failures and barriers
- Understanding the sociological and marketing aspects of consumer choices in technology, reflecting the non-rational (in a pure economic sense) aspects of such choices
- The validity or otherwise of baseline scenarios

Appendix 2

CRITERIA FOR CHOOSING R, D & D INVESTMENT LEVELS

Top Down

Look at R, D & D Investments relative to total energy expenditures

For the US Energy Expenditures	$\approx 400 \times 10^9/a$
Public R, D & D	$\approx 3 \times 10^9/a$
Private Sector R, D & D is unknown but probably comparable to public	$\approx 3 \times 10^9/a$
Total R, D & D	$= 6 \times 10^9/a \approx 1.5\%$ of total energy expenditure

Mature businesses spend 2-3% on R,D & D

We could argue another 3 to $6 \times 10^9/a$ are warranted given magnitude of changes to energy system necessary to reduce CO2 emissions

What about other countries?
What is their level of investment?

Bottom Up

What technologies are most promising? What institutional-social issues most need to be researched?

Given these R,D & D targets, how much would it cost to make progress more rapidly?

The Group suggested criteria which might be used to construct a figure of merit for evaluating (crudely) the opportunity for R,D & D investment. These are:

1. Potential for reducing CO_2 emissions: near term; intermediate; ultimately; energy potential X reduction/unit of energy
2. Potential for reducing other environmental stresses
3. Relative economic improvement (reducing costs)
4. Societal consequences of adoption
5. Societal acceptance
6. Potential for attaining other goals such as energy security
7. Attractiveness of developing /or tansition economics
8. Relevance to international stability
9. Balance consideration

Similarly, for considering R & D investment on institutional and social issues researchable questions should be posed and ranked such as:

Appendix 2 cont.

1. How can the rate of adoption of better technologies (with lower social costs) be accelerated in different countries?

2. What structural changes could be effective?

3. How can collaborative research be more productive - international; public/private sector, etc.

Finally, investment in R & D should be made to develop totally new options unimagined or far out, including R & D on materials, instruments, etc.

All of these R & D opportunities should be costed to determine a bottom up estimate of needed investment level.

At ORNL we did this three years ago and determined that about 81X109/a more was needed because of the greenhouse issue. This is probably too small.

Energy technology R & D: what could make a difference?
Part 1 Synthesis Report
ORNL - 65 & 1 V1
May, 1989

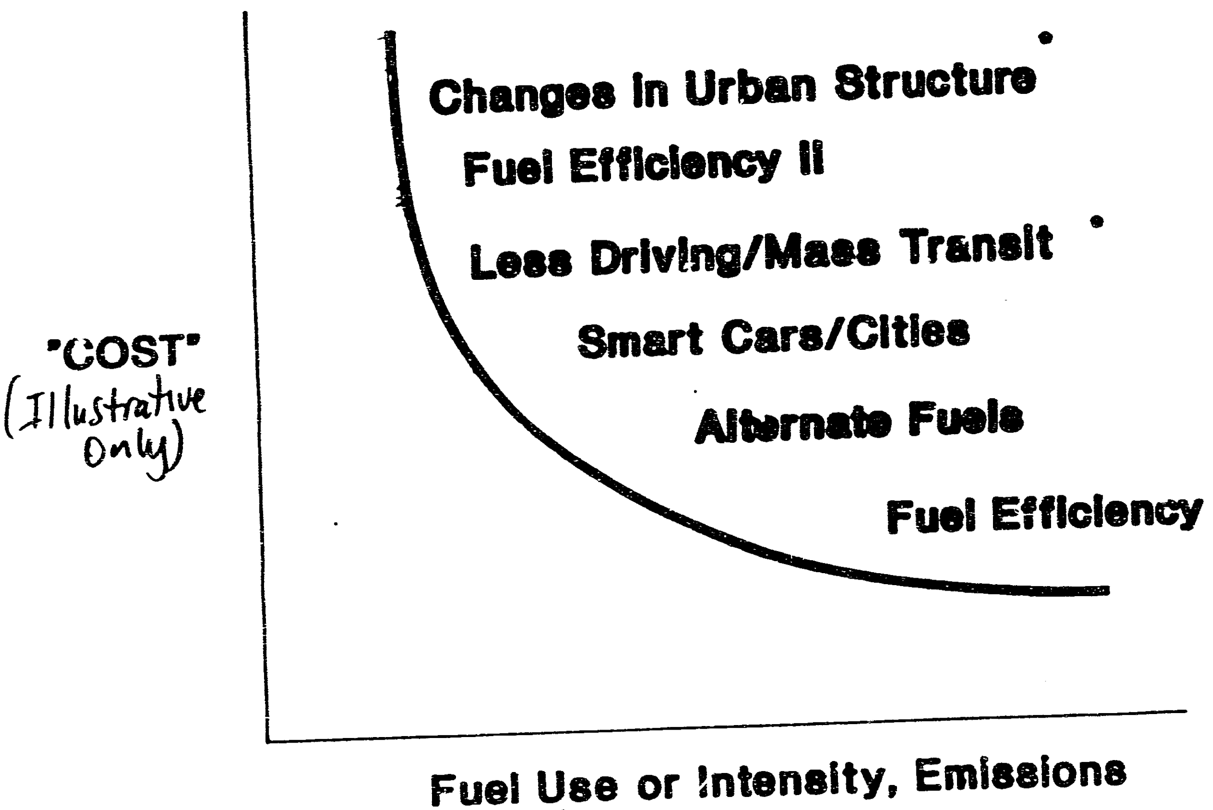
See attached Table.

Then, bottom up and top down estimates can be reconciled.

FIGURE 1

REDUCING FUEL USE AND CO_2 EMISSIONS

Conceptual Cost Curve



• [Demand Side Reduction] options

FIG. 2 — Relationship between population, consumption levels, durability of products, efficiency of resource use, and specific impacts (emission factors).

Energy-related environmental impact =

population × affluence × impact =

$$\text{population} \times \left[\frac{\text{stock}}{\text{person}} \times \frac{\text{throughput}}{\text{stock}} \right] \times \left[\frac{\text{energy}}{\text{throughput}} \times \frac{\text{impact}}{\text{energy}} \right]$$

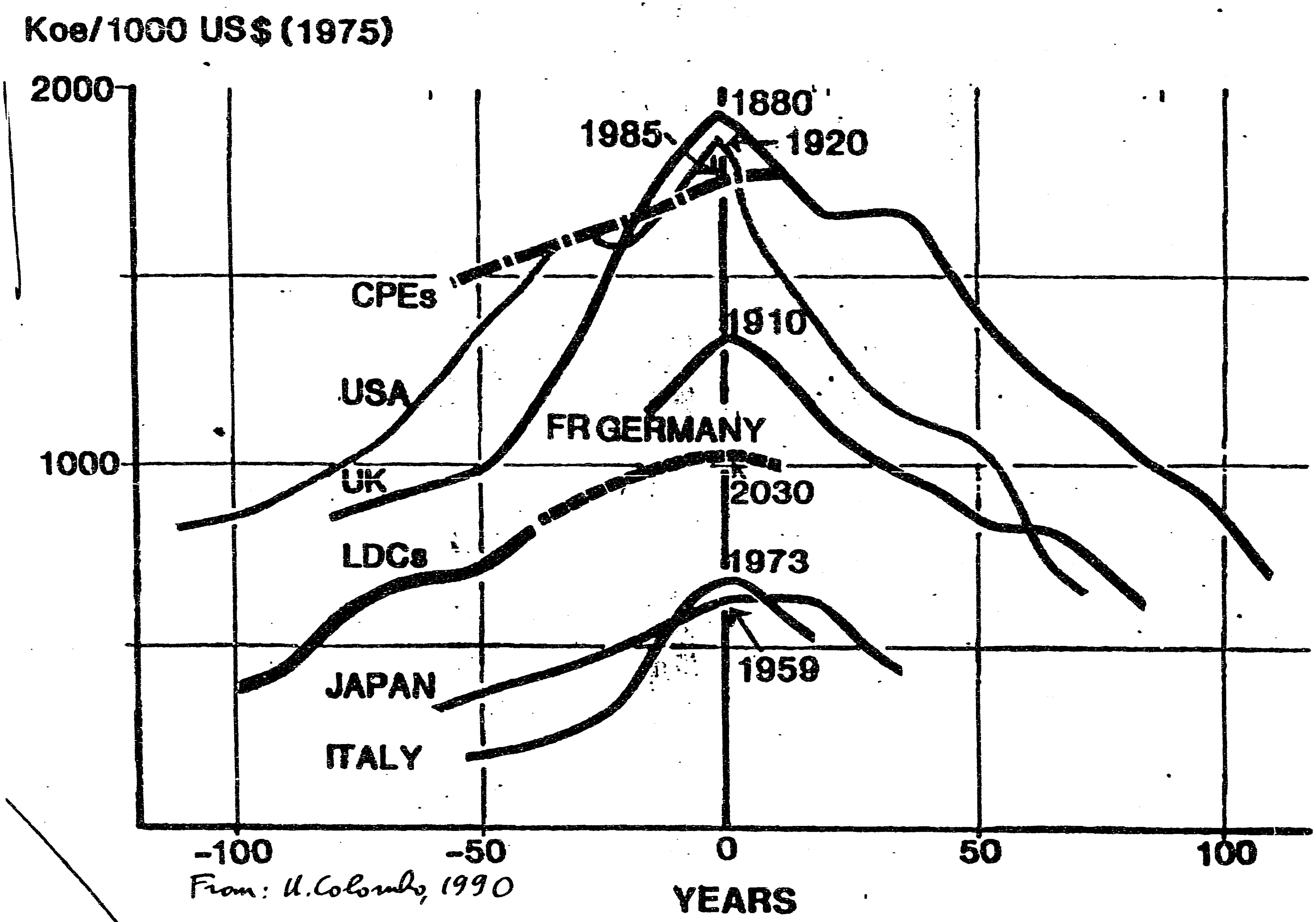
<u>Timescale of major change</u>

~ 50-100 y ~ 0-50 y ~ 0-20 y ~ 0-30 y ~ 0-50 y

Source: Holdren, Lovins

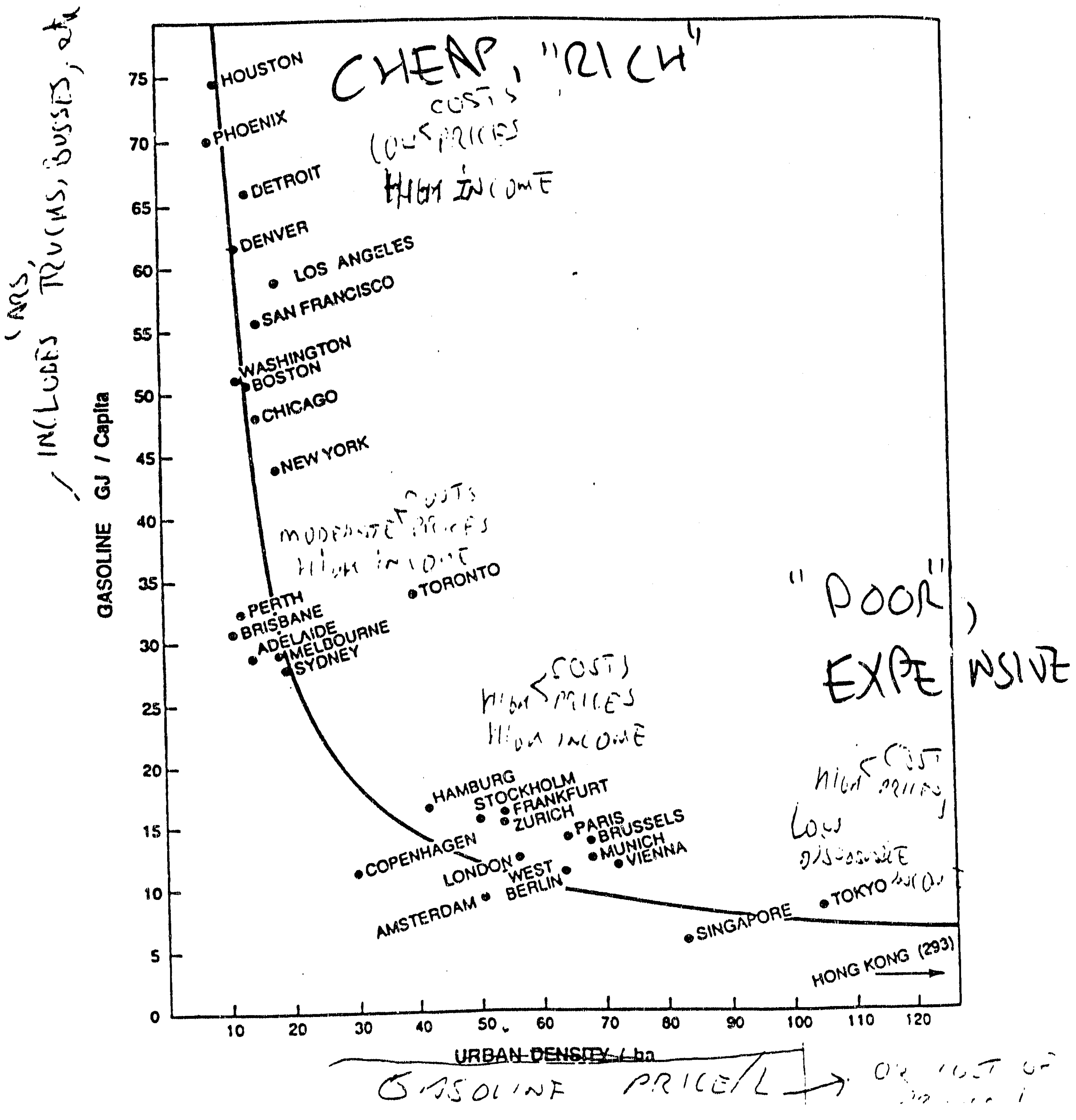
PATTERNS OF ENERGY INTENSITY DURING THE DEVELOPMENT PROCESS

1



GASOLINE USE VS COST

SOURCE: P. W.G. Newman, J. R. Kenworthy, & T.J. Lyons, "Transport Energy Conservation Policies for Australian Cities," NERDDC #836 (Envtl. Science, Murdoch University), August 1987.



What Are the Options Available for Reducing Energy Use per Unit of GNP?

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INTRODUCTION

Between 1973-87, falling energy intensity[1] reduced overall U.S., Japanese, and West German energy demand by 19, 21, and 18 percent, respectively. (Source: Schipper et al. 1991, Schipper, Howarth, and Geller 1990). The ratio of energy to GDP in these countries fell by 26 percent, 34 percent, and 19 percent respectively, suggesting that for Japan and the U.S., changes in the mix of goods and services also had a significant effect on the overall ratio of energy use to GDP.

The United States increased its GDP by more than one-third between 1973-85 while holding energy demand virtually constant. The significance of this experience, which can be expressed as a rate of reduction in the energy to GDP ratio of 2-2.5 percent per year--is evident in that the United States also held carbon dioxide emissions steady over the same period. To be sure, the oil price increases took a multibillion dollar toll on most of the worlds' economies, but improvements in energy efficiency reduced this damage considerably.

What were the driving forces behind this decoupling of energy and economic output? What will be their impact in the future? Can they be accelerated and, if so, at what cost?

UNDERSTANDING THE POTENTIAL FOR ENERGY EFFICIENCY

The terms energy efficiency and energy conservation must be carefully specified in order to avoid misunderstanding. Energy conservation has been defined as embodying four concepts:

1. reduction in the use of energy services;
2. fuel switching to conserve scarce or otherwise valuable fuels;
3. shifts in the mix of goods and services produced with the use of energy, and
4. reduction in the energy required to produce a given level of goods and services.

energy intensity per unit of activity in 20 sectors

Item 4 is synonymous with energy efficiency, and items 3 and 4 control strongly the potential for energy intensity reduction per unit of GDP.

The future potential for energy efficiency may be characterized by five aspects--or cases--of the system that delivers energy services:

1. the reference case;
2. the reference case with market imperfections removed;
3. the reference case with market imperfections removed and with the external costs of energy use incorporated, thus stimulating further efficiency;
4. the reference case without any regard for the cost of saving energy (that is, the application of the best available technology regardless of its cost-effectiveness); and
5. the reference case with the application of all feasible technology, without regard to its commercial availability or even, in an extreme case, its existence (see Figure 1).

The reference case or business-as-usual projection is an essential first step in any estimate of future energy savings potential. The reference case projection of energy demand, the first aspect of this characterization, indicates the expected level of energy efficiency for a given date projected into the future, assuming that market barriers are not overcome. This projection requires a variety of assumptions, including future energy price levels and expected consumer price response. The reference case incorporates prevailing obstacles and market imperfections that hinder the full application of the potential for energy efficiency. This case yields the least energy efficiency and the highest energy demand of those considered here.

The second aspect, the "no market imperfections case," represents the additional energy efficiency which may be added to the reference case by removing all of the various impediments to energy efficiency. The common examples include: average pricing of electricity (as opposed to marginal pricing); lack of price signals (no meters in Moscow flats, for example); and split incentives, exemplified by the classic tenant-landlord situation where the person who could invest in energy-saving measures has no incentive to do so because the renter pays the energy bills. Common examples of this potential include: refurbishing the existing building and equipment stock; increasing the application of cogeneration in industry; and increasing the use of district heating. In this aspect, cost-effective energy efficiency technology is assumed to penetrate the market to its fullest extent, and cost-effectiveness is defined by applying social--not the much higher private--discount rates.

The third aspect, or case, builds on the second by adding to the cost of energy all of the external costs of using energy. Common examples of external costs are the military or national security costs of energy dependence from imported oil, or the health, environmental, and welfare effects from energy-related air pollution.

The fourth aspect takes case three and applies all commercially available technology for saving energy, regardless of its cost.

The fifth aspect is the theoretical maximum potential case. This case refers to the energy which analysts think could be saved if ideas for energy-saving measures could be moved from their heads onto drawing boards, into laboratories, and into commercial application. Examples range from improved exergy efficiences in heat transformers, high temperature fuel cells, through innumerable reductions in demand for "useful" energy due to improved insulation, catalysts, materials, biotechnology techniques, to the substitution of low-energy for energy-intensive materials.

OVERCOMING BARRIERS TO MORE-EFFICIENT ENERGY USE

The current debate over the potential for energy efficiency improvements is centered around the cost and benefits of moving from case 1 to case 2. Barriers to energy efficiency include price distortion, lack of infrastructure, disparity between private and social discount rates, promotional practices among energy suppliers, split incentives, lack of markets in saved energy, and inadequate consumer information. A vast literature has identified and described these difficulties, but has been less successful in prescribing solutions. Solutions have nevertheless been documented in successful regulatory, incentive, and information programs. New research in the social sciences could greatly improve our understanding of how to overcome these barriers and resistance to change by suppliers and consumers (see Table 1). This research work deserves the highest priority.

Energy analysts believe that changes in energy prices were responsible for at least two-thirds of the energy efficiency improvements attained in the developed market economies in the period following the oil shocks of the seventies and early eighties. Though market pricing is an important mechanism for achieving efficiency, price distortion remains common throughout the world. Many countries, particularly planned and developing nations, price energy at a small fraction of its market value. In the United States, electric power is often priced at less than replacement cost. Coal in Poland and China and natural gas in the Soviet Union have until recently been sold at less than half their value on open export markets. A related problem extends to state-owned enterprises in some countries which have received subsidies to offset rising energy prices in order to maintain output of critical goods for consumption or export. Price reform--and making prices matter--must provide the motivation for enterprise managers to renovate and replace equipment.

A problem arises in this context because the planned and post-planned economies must also develop the capability to manufacture energy-efficient materials and equipment before efficiency opportunities can be captured. Lack of this infrastructure compounds pricing problems. The almost complete lack of measurement of domestic heat and hot water consumption at the household level in the Soviet Union, for example, means that price reform could well have little positive effect in that sector--individual consumers would be unable to reduce their energy costs by increasing the efficiency with which they use energy. Lack of banking systems to finance investment, lack of communications equipment for gathering information and conducting business, and lack of high quality, reliable of energy supplies, particularly for electricity, are also infrastructure problems which constrain progress in energy efficiency in much of the world. Given time and resources, these problems can be overcome.

Problems with electric power reliability in developing countries complicates the use of advanced equipment and controls. Transferring energy-efficiency technology to developing and post-planned countries requires removing barriers necessary to facilitate development itself.

A common infrastructure problem in western developed countries is the lack of suitably sized lamp shade holders for use with highly efficient light bulbs. Such problems can easily be solved through minor changes in manufacturing, but only when the problem becomes a priority for manufacturers and retailers of lighting equipment.

Capital replacement is a problem in all economies, but particularly in the recently planned ones. For example, the current rate of capital replacement in the Soviet Union is only 2-3 percent per year, while a rate of 7-8 percent could be justified. Because capital replacement usually means the replacement of outmoded, energy inefficient technology with much more efficient products and processes, stalled economies impede improvement in the energy to GDP ratio in many countries.

Tax incentives have sometimes been proposed as a means to overcome investment barriers, but there is no evidence that tax credits for home or industrial energy efficiency investment in the United States have been worth their cost. However, some U.S. utilities have sponsored incentive plans that have worked quickly. In 1983-84, when Southern California Edison Co.

experienced a 14 GW peak load, it reduced the 10 year forward peak by 1.2 GW per year. About 45 percent of this savings came from the utility's own programs, which saved energy at a cost of 0.3 cents per kilowatt hour, or $32 per kilowatt. Fifty-five percent came from state programs, at roughly no cost. The total average cost of savings was 0.1 to 0.2 cents per kWh. Other utilities have recently captured up to 90 percent of selected demand-side markets in just 1-2 years or even in a few months. Recent regulatory reforms, chiefly in the United States, seek to conserve and reward efficient utility behavior, for example by decoupling profits from sales and by letting utilities keep as extra profits part of what they save their customers.

Regulatory standards can effectively promote energy efficiency where there are clear market failures or where discount rates are unusually high. The level of fuel economy in private automobiles illustrates this effectiveness. Research and experience suggest that car-buyers will be indifferent to fuel economy over a broad range. While levels even double the current new car average would yield net savings to consumers, the savings would be quite small and can be ignored from the buyer's point of view. Evidence of the constant increase in average U.S. fuel economy over the last 15 years despite wildly fluctuating gasoline prices presents a strong case for the effectiveness of standards.

Regulatory policy, however, can fail unless continually evaluated and revised. For example, the fleet of light trucks in the United States has grown rapidly in part because they were treated differently from cars in the corporate average fuel economy standards. These vehicles today are generally used not as trucks per se, but as automobiles. They generally are more powerful than cars, use far more fuel per unit distance, and remain in use longer. This fact suggests that a combination of policies might be required to accomplish a given objective. For example, U.S. appliance policy was crafted from a combination of efficiency labelling, regulatory standards, utility incentive programs for the purchase of efficiency models, and rising energy prices. A hypothetical example of such as policy in the transport sector combines fuel economy regulation with meaningful gasoline taxes, and information programs designed to appeal to consumer self-interest.

We do not know the relative contribution of each of the above barriers to reducing energy efficiency. We do know that small and large businesses alike often achieve savings far below the economic potential. This raises the question of how policies can be combined to effectively overcome the barriers to energy efficiency. Many regions will need cooperation in creating a system of energy efficiency regulation.

MODELLING THE POTENTIAL

These complex variables are usually understood best in the context of models that interrelate energy-using behavior and technology. Valid models must be reproducible, transparent, and based on valid principles and assumptions. Recently, strong debate has revolved around the validity of the modelling tools themselves as well as the assumptions used in them. Strikingly different projections of future energy demand--and carbon dioxide emissions--can result from the modeller's choice of both models and inputs.

Confusion can arise from differences in modelling tools, particularly between the "top down" and the "bottom up" approaches. The former type of model is driven primarily by economic growth, modified by econometrically estimated income- and price-elasticities of energy demand. These models may also include parameters that modify energy demand projections based on estimates of technological change, but they typically have very little detail on end-use activities or technologies.

End-use or bottom-up modelling efforts also are driven by economic growth, but they permit more detailed investigation of non-price-induced technical and policy changes. For example, automobile fuel economy or appliance efficiency standards can be assumed in an end-use or bottom-up model, while such a change can only be crudely approximated in a top-down, principally economic model. End-use models can thus reveal additional detail for understanding past and future energy demand.

If the elements affecting demand are studied over time, the relative impact of changes in total activity, the structure of activity, and the intensity of each activity on total energy use can be seen. The forces driving changes in each of these components--changes in energy and other prices, income, technologies, energy and related policies, and demographic changes--can then be linked to changes in energy use. From such analysis, we can identify the most important behavioral and technological components and causes of energy saving in the past, and thus estimate how they can be amplified in the future.

End-use or "bottom-up" models are handicapped, however, by their inability to provide equilibrium solutions. That is, economic theory suggests that reducing energy demand through regulatory policy should also lower energy prices somewhat. Depending on the magnitude of the price reduction, energy demand could be stimulated and thus offset some of the savings. Similarly, energy savings could have the effect of increasing the net income of consumers, and thus increase energy demand. A macroeconomic model would capture this effect, but the energy end-use models in use today often do not. On the other hand, the end-use models may better represent saturation of energy services.

In principle, there is no reason why the strengths of the two approaches, top-down and bottom-up, cannot be merged. Efforts to develop and validate such an approach could have a significant payoff. Relatively small projects are underway in one or two laboratories to create models based on such an approach. This work plus related research efforts needed to improve the basic art of energy-economic modelling should be very high priorities (see Table 1).

There is wide disagreement in estimates of energy efficiency potential, even applying the same types of models (that is, among analysts using bottom-up modelling characterized as the second case, above). This disparity can be attributed to several analytical differences, for example:

1. Assumed technological vintage or "modernity": The best electricity-saving technologies have been available for less than 1 year. Lower estimates of efficiency potential use older data.
2. Extent of technological characterization: Analysts, for example, may consider only two of 10 measured savings mechanisms for electronic ballasts; or they omit savings from correcting oversizing of motors.
3. Extent of disaggregation of energy-using devices and activities: The sum of many small savings can be large.
4. Consideration of system effects: Multiple individual improvements, when combined in a system, are not always additive and, conversely, there may be multiple benefits from single improvements.
5. Differences in methodology: Whether reduced maintenance costs are included sometimes makes large differences in estimated savings.
6. Differences in cost valuation, particularly choice of discount rate.

For each of these reasons, it is not surprising that well-informed analysts can reach quite different conclusions. But the differences in estimates may be unimportant: the savings potential may be so large that society may not need it all to address the climate problem. The real question is whether society can effectively capture the available savings through the policy process.

TRANSFERRING TECHNOLOGY FOR ENERGY EFFICIENCY

Technology transfer is broadly accepted as an important means of improving energy efficiency, particularly in developing and post-planned economies. Although the term is ill-defined, the process must transfer not just machines, products, or processes, but the systems of knowledge and services that go with them, and must be mindful of the inevitable concomitant transfer of cultural assumptions and attitudes.

Financial, institutional, cultural, and technical problems must be overcome to make available the most efficient energy technology for all nations. Debt is a major constraint for technology transfer, and is an obstacle that should be considered in addressing both modelling and policy. There is a particular institutional constraint in nations such as the Soviet Union where people do not own or control their flats. Occupants cannot make changes even if they desire them. There are cultural constraints for preferences for types of energy services--level of heating, acceleration of cars, and willingness to accept given policies and practices.

Key questions include, How can we avoid the transfer of outmoded technology? One example of this problem is in China, where one western company recently transferred the most modern technology to make a product for export, and an outmoded facility to make the same product for domestic consumption. Both developed and developing countries export very inefficient energy-using equipment, chiefly to developing countries, and that equipment's huge indirect cost in energy supply infrastructure often hobbles development. Commerce in such apparently cheap but actually costly devices cannot be restrained without better inventories, labelling, and standards. The extent of this problem is not known but appears to be very large.

Valuable research could be organized as case studies--success stories--for specific transfer activities in industrial as well as developing countries. That is, we need to identify "what works" in transferring technology. Case studies of failures in technology transfer can also be constructive.

Several proposed solutions have been offered to ameliorate the institutional difficulties in technology transfer. One proposal is to create institutions for transferring funds from large financial organizations such as the World Bank to small investment projects. "Energy conservation banks" in the target countries could receive funds in large blocks. These institutions could thus overcome the inability of the World Bank to make loans of the relatively small magnitude appropriate for energy efficiency.

Another proposal would provide resources for developing and transition economies to organize their own skills to solve technical and policy problems, rather than the common practice of sending western consultants to do that work in the targeted country--an expensive approach which usually transfers little technology. The energy efficiency center concept was proposed as an alternative. Such centers can provide resources for local development of policy and technology expertise, the development of joint ventures with foreign firms possessing needed technology, development of energy efficiency measurement protocols essential for the development of efficiency labels and standards, and basic data as well as public education campaigns. Several observers also urge the creation of mechanisms for transferring technology from developing to developed countries.

COMMUNICATING OPPORTUNITIES FOR ENERGY-EFFICIENCY

Despite the overwhelming benefits of energy efficiency that can be demonstrated, there remains an enormous amount of energy efficiency to be achieved. Understanding of this potential must be communicated at individual as well as national levels.

The extraordinary range of cultural, economic, and political differences around the world presents an obstacle to effective communication. Using efficiency to curb emissions would be an acceptable argument in Germany, but not in some other countries. Another problem in effective communication is finding the right people with whom to communicate. In many countries, we could work with the currently responsible people, but people who may soon be out of power.

Five broad categories of policies and activities can be used to communicate energy efficiency activities. The first is market mechanisms. Prices may be the most effective way of communicating to consumers the need to conserve, as evidenced by the post-oil shock experience. Incentives such as fees on inefficient equipment and rebates on purchases which beat the minimum performance standards by a specific amount provide strong signals for changing consumer choices.

Second, information feedback to consumers would also help modify behavior. Appliance efficiency labeling helps consumers make proper choices. Clearly understandable monthly energy bills are needed, and real-time metering for behavioral feedback would be ideal for households, autos, and industry alike.

Third, new institutions such as energy efficiency centers offer opportunities for communicating energy efficiency. They can provide guidance on the purchase of efficient equipment, educational tools, and media campaigns to effectively reach the larger public as well as policy makers. Fourth is demonstration projects. The actual demonstration of successful ideas is necessary to convince consumers and investors that new ideas will really work.

Fifth, new tools are needed for improving energy education and our ability to communicate the concepts of energy efficiency. We do not have adequate educational facilities in this field, and we need to develop university departments, centers, and institutes to train experts--and trainers--in efficiency. At the same time, we need to develop tools for teaching. From simple verbal comparisons (for example, a car produces its own weight in carbon each year) to computer games would help make the subject come alive. We also need mechanisms such as expert systems to help train people faster.

In the end, it is neither physical nor economic potential for energy saving that limits its contribution to reducing carbon dioxide emissions. Reserves of energy efficiency are truly enormous. Instead, it is social and institutional barriers that limits this contribution and creates uncertainty. Uncertainty leads to an important strategic question: how much energy saving will be realized?

The continuing evolution of human behavior--lifestyles--holds an important sway over future energy demand. In the west, lifestyles have become increasingly more comfort and travel intensive, raising energy use. In much of the east and Third World, by contrast, comfort and mobility lie at very low levels, but rising. These important trends will raise energy use and intensity by an uncertain amount. Thus, the strategic question, "how much energy saving can be counted on?" must be supplemented by another, "How much efficiency will be needed?"

TABLE OF RESEARCH PRIORITIES

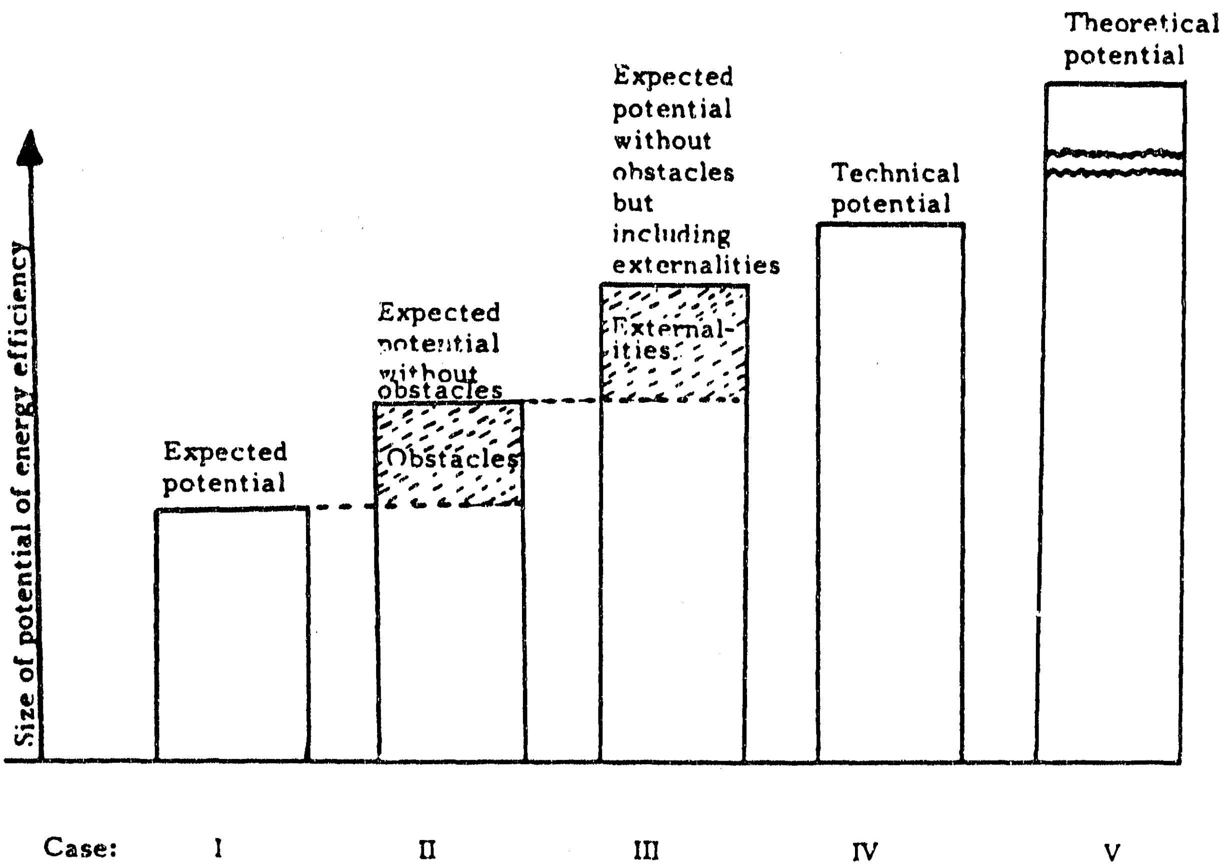
I. Behavior and Policy:

1. What are the causes that are prompting changes in the modes of energy using activities?
2. What are the energy efficiency improvements of modal shifts?
3. What role should government play in effecting energy efficiency improvements?
4. What are the different discount rates that must be applied for decision-making? What factors determine the discount rates, and what factors could decrease them?
5. What are the causes that initiate additional activity in the transportation sector?

II. Economic Tools: Understanding Demand and Barriers

1. How can we explain past energy demand elasticities in terms of bottom-up models?
2. How can we understand the energy implications of land use and materials policy?
3. What kind of factors influence AEEI, for example expenditures on R&D funds? Energy security considerations might prompt such investments and yield efficiency improvements?
4. How useful are historical data in energy use in trying to predict future consumption?
5. What are the aspects of the historical problem that need to be used to understand fuel mix?
6. What are the causal relationships in the efficiency and safety of light vehicles?

1 **FIGURE 1: SCHEMATIC OF ENERGY MODELLING CASES**



What Knowledge is Required to Tackle the Principal Social and Institutional Barriers to Reducing CO_2 Emissions?

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SUMMARY

Seven subjects warrant special attention to increase understanding of ways to reduce social and institutional barriers to reduction of CO_2 emissions. These are:

1. Plural rationalities;
2. Processes for consensus formation;
3. Time horizons for social decision-making and action;
4. Economic distortions of environmental and energy services;
5. Design of organizations for research, assessment, and evaluation regarding climatic change, its causes, and efforts for adaptation and prevention;
6. Diffusion of relevant environmental technology in developing countries and the possibility of technological leapfrogging;
7. Lifestyle trends and changes related to climate and energy.

INTRODUCTION

Seven questions were defined to structure the work of the group.
For most of the questions, it was found useful to explore the following dimensions:

1. *System levels*, i.e., international, national, subnational;
2. *Organizational types*, i.e., intergovernmental, governmental, nongovernmental (including corporate);
3. *Time horizons*, i.e., less than 15 years, 15-50 years, 50 years and beyond;
4. *Types of action*, i.e., formal (such as laws and conventions) and informal (such as social norms and markets).

I.

What are the limitations of different views of nature, approaches to rationality, risk management, and framing of information, and how can these be turned to advantage?

The climate change issue provides ample evidence that there are abiding and sometimes contradictory views of nature and philosophies of risk management, in short PLURAL RATIONALITIES. For some hazards, risk can be adequately defined by multiplying the probability of an event times its magnitude. For problems in which there is precision in measurement of the risk and for which the stakes are largely local, few difficulties arise. When risks become more difficult to quantify, when assessment relies on less developed methods, and when the spatial extent of risk enlarges, understanding of underlying views of nature assumes greater significance.

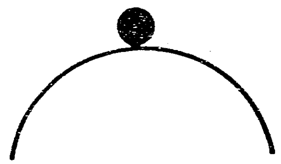
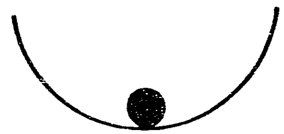
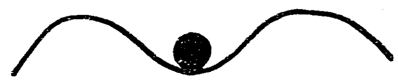
One perspective on views of nature is provided by "cultural theory" as developed in anthropology (Mary Douglas). Cultural theory suggests that there are four primary "nature myths". These are that nature is either fragile, robust, resilient, or capricious. As shown in Table 1, where nature is represented as a ball on a differently shaped surface, each of the myths leads to a particular moral imperative, preference in response strategy, and type of social organization. This typology is a heuristic device, defining pure or ideal types that are rarely found in practice. Individuals and organizations are in fact likely to be hybrids of these views and characteristics.

The approach does, nevertheless, suggest the extent to which notions of trust, liability, and consent are integral to the definition of risk. As suggested in Table 2, each form of social organization is likely to have preferences in regard to how trust is established, how liability is characterized, and how consent is obtained. The existence of plural rationalities creates structural obstacles to social learning, because it is hard for individuals and groups, dwelling primarily in one or another paradigm, to interact.

The diversity of views is also a resource. It provides society in the large with sources of warning and with explorers, as well as with more stable organizations that can take a longer view. It also creates some ambiguity about the role of expertise. From the viewpoint of cultural theory, every social group has its own experts and its own characteristic demands for information. Because experts may hold fundamentally different views of nature, their views may remain in conflict both about what facts are and whether the facts make an argument.

Understanding more about plural rationalities could have several benefits with regard to CO_2 reduction. It could help in design of more viable and customized implementation strategies.

TABLE 1: NATURE MYTHS

FRAGILE	ROBUST	RESILIENT	CAPRICIOUS
			
DON'T MESS WITH NATURE	DON'T CURB GROWTH	PRESERVE CHOICE	DON'T TREAD ON ME
PREVENTION	ADAPTATION	SUSTAINABLE DEVELOPMENT	FATALISM / DENIAL
"GREEN" ENVIRONMENTAL GROUPS	MARKETS	BUREAUCRACIES	NIMBYS* *Not In My Backyard

CHARACTERIZATION OF TRUST, LIABILITY, & CONSENT BY VARIOUS SOCIAL [illegible]

	"GREEN" ENVIRONMENTAL GROUPS	MARKETS	BUREAUCRACIES	NIMBYS
TRUST	PARTICIPATION	SUCCESSFUL INDIVIDUALS	INSTITUTIONS	DUMB LUCK
LIABILITY	STRICT	INSURANCE	DEEP POCKETS	AVOIDANCE
CONSENT	EXPLICIT	REVEALED PREFERENCES	HYPOTHETICAL (REPRESENTATIVE)	VETO

It could help to facilitate communication between groups and to recognize where communication or synthesis will never be achieved. It argues for the preservation of cultural diversity as a resource from which behavioral and technological solutions may arise. Finally, it helps explain where it may be useful to catalyze the formation of new organizations. For example, some societies may be particularly deficient in market organizations, others in small, critical nongovernmental organizations, and others in stable and effective bureaucracies.

Among the salient research questions are:

Systems level:
1. Can we describe better and more fully world views and their configuration?
2. How do diverse world views constrain action at the global level?
3. At the national level, how do diverse world views influence choice of policy instruments?
4. At the subnational level, are there ways to invert the tragedy of the commons so that local or community goals favor the global good?

Types of organizations:
5. Where is there a need to stimulate the growth of "missing" institutions?
6. What organizations are best adapted for the range of functions required to respond to global change, for example, functions of monitoring and verification of international environmental agreements?

Time horizons:
7. How do diverse world views influence the sense of urgency that different groups hold about global environmental change?
8. How does culture structure the use and perception of time?

Types of action:
9. What environmental goals are best pursued through *explicit* consensus?
10. What environmental goals are best pursued through *informal* agreement?
11. To what extent can environmental and energy technologies be designed around world views?

II.

What are the barriers to collective action arising from knowledge and ignorance, trust, self-interest, political motivation and consent, at the levels from local to global decision-making?

The existence of competing and differing world views rises to great importance in the PROCESS OF CONSENSUS FORMATION. In facing challenges such as reduction of carbon emissions, it becomes desirable not only for the views to interact but also in key situations to arrive at a common view, or at least a view that is sufficiently widely shared for widespread social action to take place. In this context, it also becomes necessary to ask which world views are superior from the point of view of political feasibility or action.

Barriers to collective action may arise because of deficits in knowledge with regard to underlying scientific questions, or with regard to motivations, attitudes, and willingness to act in the larger society of which the scientific community forms one element. The traditional model of "science advising" addresses only the production of knowledge by the scientific community for an external "receptor". It is increasingly necessary to consider new roles of the scientific community as all fields of human action become pervaded with technical questions and the more embracing question of the interaction of the scientific community with other groups.

In many instances, work from the scientific community has been judged too narrow to be of use in politics. In politics it is often a mistake to isolate certain aspects of a question (for example, to consider only alternatives to gasoline without considering other changes in transport systems). Scenarios developed internally to science often have heuristic power, but do not represent sufficient or socially urgent viewpoints. A key in politics is provision of alternatives, particularly in terms of what can be accepted by the public. There is a need to develop institutions that can engage in cooperative conceptualization of complex processes in such a way that social learning by all groups participating is enhanced. As long as there is a lack of a "common problematique" between the political system and the scientific community, proposals worked out in the scientific community will be of little use.

The essence of the situation is that many contemporary problems can only be defined with the help of scientists but cannot be solved by them. Solutions rest with intercommunitarian processes, and in particular normative consensus formation. This requires a movement toward the center of society by scientists, changing roles for experts, and recognition that qualities of work by scientists can themselves be barriers to action. It also implies that sometimes consensus is more important than selection of a particular strategy, that the greatest need can be to create an action coalition to implement at least one of several reasonable strategies.

The situation is further complicated by the differing orientations of science and politics. Politics remains oriented primarily to decisions and concerns within the nation-state, although notions and limits of national sovereignty are changing, largely because of technology (ref. George Shultz). The values of science tend to be "universalistic". Many nongovernmental environmental organizations share this universalist viewpoint, sometimes irking governments, as in Brazil (ref. Hans Binswanger).

The challenge in the situation is to preserve the rights of science and the rules of democratic decision-making, while recognizing that traditional argumentation rules used by society are not sufficient. It is necessary to develop processes that encourage the ability to work out views in detail, especially minority views, for those who may lack certain argumentation skills. It is desirable to work out alternative policies in a high quality way that does not rely on bringing every issue to a vote or a court trial. It is important to have a process that represents both the middle and the tails of the distribution of opinion fairly.

One interesting example of a mechanism of this type has been the Enquete-Kommission (E-K) of the German Parliament on protection of the atmosphere. Parliaments can serve as a mediating link between scientists and the general public. Through public hearings and published results, parliaments can provide a means for translating scientific findings into policy-relevant concepts and policy options.

The E-K broke new ground in the scope of its hearings and the balance of membership involving both scientists and politicians as full participants. Although primarily aimed at an audience of German decision-makers, the E-K made considerable efforts to broaden its influence. It invited witnesses on an international scale, and designed a comprehensive report that was not limited to the German perspective but adopted a global viewpoint. The international significance of the E-K's process and work was reflected in the decision to translate the report into foreign languages and its use and citation by German political leaders, not only as the basis for German national policy but explicitly to serve as an example to other industrialized nations.

Specific research questions:

1. How can processes for consensus formation in the environmental field be enhanced at all levels?

2. What changes are required in the processes internal to the scientific community to make its work in its roles with a normative orientation more useful?

3. Should there be more discussion of guidelines or norms of advocacy for scientists to facilitate communication with the political system?

4. How is communication between science and politics affected by the universalist orientation of science in contrast to orientation of politicians toward the sovereign state?

5. To what extent is it the case in environmental negotiation that stakeholders facing decisions with highly uncertain outcomes will emphasize a fair process of decision-making rather than gambling for advantage? (ref. John Rawls)

III.

What opportunities and constraints on collective action arise from differing planning and decision cycles among institutions, including parts of government, private firms, nongovernmental organizations, and the media?

The relevance of the issue of TIME HORIZONS originates in the fact that many of the costs associated with reducing carbon emissions may appear in the short term, while benefits emerge over the longer run. The high level of uncertainty about both costs and benefits further creates a preference in many organizations and groups for a myopic strategy and for a search for "no regrets" policies.

Various time horizons characterize parts of government, consumers and voters, and industry, as well as science itself. Some parts of government, especially elected officials, tend to have relatively short-term perspectives. Many politicians will avoid taking decisions on sensitive or volatile issues during their term of office. Factors that influence the time horizons of elected officials include the power of narrow special interests and the costs of campaigns. But there are other quite different factors that also lead toward short-term horizons. One is the failure of much central planning, which often sought to have a longer-range character through 5-year plans and other programs. Another is competition among priorities. Many governments, especially in developing countries, face immediate issues of survival of such large dimensions that there is little or no room on the political agenda for the long term.

It is important to note that there are instances of far-sighted decisions of governments, for example to establish national systems of agricultural research and to build infrastructure for water supply, wastewater treatment, and transportation. There have also been long-range studies, such as the "Global 2000" project of the U.S. government in the late 1970s, which sought to encourage all departments of government to look forward to the issues that they would need to address more than 20 years in the future.

Consumers and voters also often opt for the near term. The tremendous expansion of consumer debt in all countries is one indicator of the desire for short-term gratification. The experience of the public with changes in scientific knowledge also leads to a certain skepticism about long-term commitments.

In industry, time horizons are determined in large part by the depreciation structure of capital stock, tax rules, and features of financial markets that favor optimizing for periods that are often less than two years and rarely extend for more than 7-10 years. Businesses face the very real risk of bankruptcy and thus must take decisions in the interest of survival.

At the same time, some sectors of industry demonstrate long-term horizons. Decisions to develop entirely new products in such sectors as pharmaceuticals, to build automobile factories, to develop a mine, or to plant timber resources imply horizons of a decade or more. At the highest levels of industry, there may often be more long-term vision about what is best for an enterprise, which involves not only short-term financial results, but a long-term flow of products and a positive public image.

Nongovernmental organizations appear to span a range of time horizons. Some follow fads and fashions and can sustain themselves only by fund-raising strategies that require abandoning an issue if it will not attract contributions, dues, and membership. Others are explicitly oriented toward long-term considerations and may be insulated by endowments or stable memberships. There are also organizations like churches and universities that have displayed longevity measured in many centuries despite taking many short-run decisions that appear uneconomic.

At the international level, the United Nations system has sought to provide long-range perspectives and has designed many decadal programs. However, in practice, unreliable UN budgets have meant that many more programs are announced than carried through. Moreover, there is just as much mistrust of centralized management and planning at the global level as there is on the national level.

The scientific community is unusual in its comfort with long-term considerations. A period of one or two hundred years is short compared to the time horizons of disciplines such as cosmology, geology, or ecology, and scientific agendas are routinely pursued over decades. However, science is always uncertain about what constitutes usable knowledge for today.

Specific research questions:

1. What are the time horizons characteristic of the organizations most important to global environmental change and why?
2. What are the institutional factors that shape the spectrum of time horizons?
3. Why are some political systems more open to change and to long-term perspectives?
4. What is the time required to reach various kinds of international agreements? Does it differ systematically for broad and specific agreements?
5. How can methods be improved for the conduct of studies that extend decades and generations ahead?
6. What establishes the calendar of science and are there ways to accelerate the production of usable knowledge from science important for global environment?

IV.

What changes in pricing resources and decision-making for research and development should be given priority? "Economics" itself may be a major barrier

Important aspects of environmental protection and natural resource management are hindered by reliance on an antiquated and flawed economics. At the same time, economic instruments can be powerful tools for environmental protection and for harmonizing goals for energy, environment, and growth. Reducing ECONOMIC DISTORTIONS and shifting the economic system to better reflect current, shared values about environment would be an important instrument for substantially reducing carbon emissions.

The problem for environment of the evaluation of time within the discipline of economics has been widely discussed for 20 years. The practice of discounting, which correctly reflects that for many economic decisions a dollar today is worth less than the same dollar held at a time in the future, systematically diminishes the value of environmental assets. To take the extreme case, a profitable activity today that would destroy the environment 100 years from now would still be assessed favorably in narrow economic terms, as any positive discount rate applied to an asset 100 years in the future would render it trivial.

Some current natural resources are also undervalued by the systems of accounting generally used in national economic planning and in business decisions. Partly the reason is that some environmental goods that can be assessed in monetary terms with reasonable accuracy have not been internalized into economic analyses. Partly it is because some environmental goods, like genetic diversity or the assimilative capacity of the environment for wastes, are difficult to monetize at all.

The result is a set of energy prices that are particularly distorted from an environmental point of view. Prices have not reflected true *internal* cost whether in Central and Eastern Europe, the Soviet Union, North America, Western Europe, or less developed countries. They have also not included *external* environmental costs. This is true not only for threats to climate, but also for effects of energy sources on human health, materials and the built environment, and ecology. The unrealistically low monetary price of energy is associated with high levels of energy consumption.

The distortions affect not only overall consumption of energy, but also the allocation within energy sources. Subsidies have tended to favor coal, oil, and nuclear energy over natural gas, solar energy, and energy efficiency, the latter all more favorable from an environmental perspective. It is important to note that subsidies to maintain employment in the coal industry or to insure against hazards of nuclear accidents were social choices of the same kind that are now needed to favor protection of the environment. It is also important to recognize that the structure of subsidies and incentives pervades not only energy use but also energy research and exploration. Thus, we may tend to develop the wrong fuels for the future, as well as use the wrong ones today.

The difficulty is that while there is agreement on the heavily distorted pricing structure of the present system, there is much less agreement on how to improve it. There is general agreement on the need to internalize more environmental costs and there is general agreement that changing prices can beneficially effect both the sources of supply and the level of demand. However, it will be useful to provide much more insight into the potential of various economic instruments and incentives.

Pricing structures on energy are also strongly influenced by a tendency to use energy pricing for other goals than social welfare. The difficulty of separating social and economic criteria in practice in a single pricing structure has led to a dominance of social goals.

The economic system must also be adapted to the functions of resilient ecosystems. The risk for sudden irreversible events in such resilient systems places an increased value on early action. The absence of efficient economic evaluation systems considering abrupt humaninduced changes, and associated economic tools giving a bonus for early action, is a constraint in greenhouse gas management.

In adapting to greater instability and increased change in ecosystems under climate change, there is also a need for great flexibility in future infrastructure establishment. Efficient economic tools for stimulating such flexibility must be developed.

Specific research needs:

1. To what extent will provision of better information about environmental costs of energy use change behavior?
2. How broad a definition of externalities can be functionally applied to current pricing structures?
3. What are long-run elasticities of energy demand, how high will taxes or charges need to be to exert a sustained influence on behavior, and are these best applied in gradual or abrupt price changes?
4. What are the strengths and weaknesses, by criteria including fairness and efficiency, of various economic regimes for limitation of carbon emissions (fixed reductions, per capita targets, carbon taxes, tradable permits, etc.)?
5. What are the relative benefits of approaches to the energy system as a whole versus approaches focusing only on carbon dioxide?
6. Why are more costly instruments for economic control often selected by society than the instruments judged superior by economists?
7. What is the shape of the "supply curve" for carbon reductions for different nations, regions, and the world as a whole?
8. To what extent will formal action at both the international and national level be needed in order to bring about changes in energy pricing sufficient to achieve major carbon emission reductions?

V.

What is the relation of science and policy in the design and evaluation of instruments for reducing emissions?

The effectiveness of the relation between science and policy depends critically on ORGANIZATIONAL DESIGN for research, assessment, and evaluation regarding climatic change, its causes, and efforts for prevention and adaptation. The importance of design of organizations and decision-making processes has been highlighted by the creation of the Intergovernmental Panel on Climate Change (IPCC), whose results have been widely accepted as authoritative. Of course, structural aspects of decision-making processes cannot be separated from substantive aspects and performance. The relation between science and policy is determined not only by the vehicles for interaction but also by the quality, relevance, and timeliness of results, which along with the process employed contribute to credibility and legitimacy.

There are many functions requiring scientific or analytic skills that need to be fulfilled with regard to climatic change and carbon emission reduction. These include basic research, monitoring, assessment, policy design and implementation, verification and compliance, and policy evaluation. We highlight three gaps in the organizational landscape.

The probability of international agreement and action on climate change will likely be increased if scientists from many nations have the opportunity to participate in basic research related to global environment. However, most nations lack sufficient financial, technical, and human resources at the national level to develop autonomous research programs at the frontiers of environmental science. Equally important, it is necessary for the scientific community of nations and regions to be able to understand local and regional implications of global analyses. Ultimately, global issues are local problems, such as drought.

Already there are several useful programs, such as the World Climate Program, that coordinate national research efforts to achieve larger goals. A powerful means to achieve scientific advance and greater participation may be the establishment of a network of international environmental research centers. These centers would be governed internationally and have scientific staff members from many countries. In some ways, the network would be a "Green" version of the Consultative Group on International Agricultural Research (CGIAR). The centers would be responsible for both research and advanced training and would be located in both developing and developed countries. They should seek to strengthen national systems of environmental research, as well as to perform regional and global analyses in order to fill gaps likely to remain from national systems. Recommendations for centers of this kind have been made as part of the International Geosphere-Biosphere Program and by the Second World Climate Conference. However, as yet, little careful thought has been given to how the network might most usefully be designed, taking into account not only the goals of the scientific community but other communities as well.

While a network of centers might generate and diffuse new knowledge and strengthen the human resource base in environmental sciences for many regions, the question remains how to synthesize what is known at the international level. National efforts such as the Enquete-

Kommission are unlikely to touch the full spectrum of issues and people concerned. Although the IPCC was a remarkable step forward in this regard, the IPCC reports leave many questions unanswered, especially with regard to impacts of climate and mitigation strategies for emissions. The IPCC analyses also say little at the regional level. The IPCC is likely to continue in some form. Nevertheless, to establish a more consistent and comprehensive capability, it might also be useful for several international scientific organizations to explore and develop their potential to perform similar assessments. Joint international assessments are integral to the process of consensus formation discussed in section II.

Among the organizations that might play a stronger role in international scientific assessments are the International Council of Scientific Unions (ICSU), which embraces more than 40 national academies of sciences; the International Social Science Council (the counterpart of ICSU) the Council of Academies of Engineering and Technological Sciences, whose membership includes most national academies of technology; the Third World Academy of Sciences; and the African Academy of Sciences. Such organizations need to clarify the processes that they would use to assure high quality, credible, and independent results, as well as their relationships to governments and intergovernmental organizations in their role as conveners of experts to carry out assessments.

The third function, evaluation, is one that is often neglected. Most organizations and sponsors prefer planning and making promises to evaluation. The need for evaluation is great for the larger society to accelerate social learning.

Historically there has been a rather weak connection between cause and effect in broadly defined formal social policy. This has been evident in areas such as urban policy, migration, and energy itself. There have been many perverse and unexpected outcomes of policy interventions. It is important to have realistic expectations about our ability to create alternatives for human societies and move deliberately toward them. There has probably been a gradual increase in the ability to do so and there may be a need for a great increase in this ability, not only because of climate change, but because of needs in development, population, health, and other areas. As we consider substantial escalation of policy interventions to achieve policy goals in environment, it is necessary concurrently to put in place mechanisms at the national and international levels to assess the efficacy of programs and policies and how it might be improved.

Specific research questions include:

1. How can progress in basic environmental research be accelerated to the benefit of many nations? Would a network of international environmental research centers be useful, and if so, how should it be designed?
2. How can the joint international conduct of scientific assessments be improved? Are there new roles for international nongovernmental scientific organizations in this regard?
3. How can evaluation of programs and policies designed to achieve reduction of carbon emissions be reliably assured? What combination of existing and new independent organizations might best carry out this function?

VI.

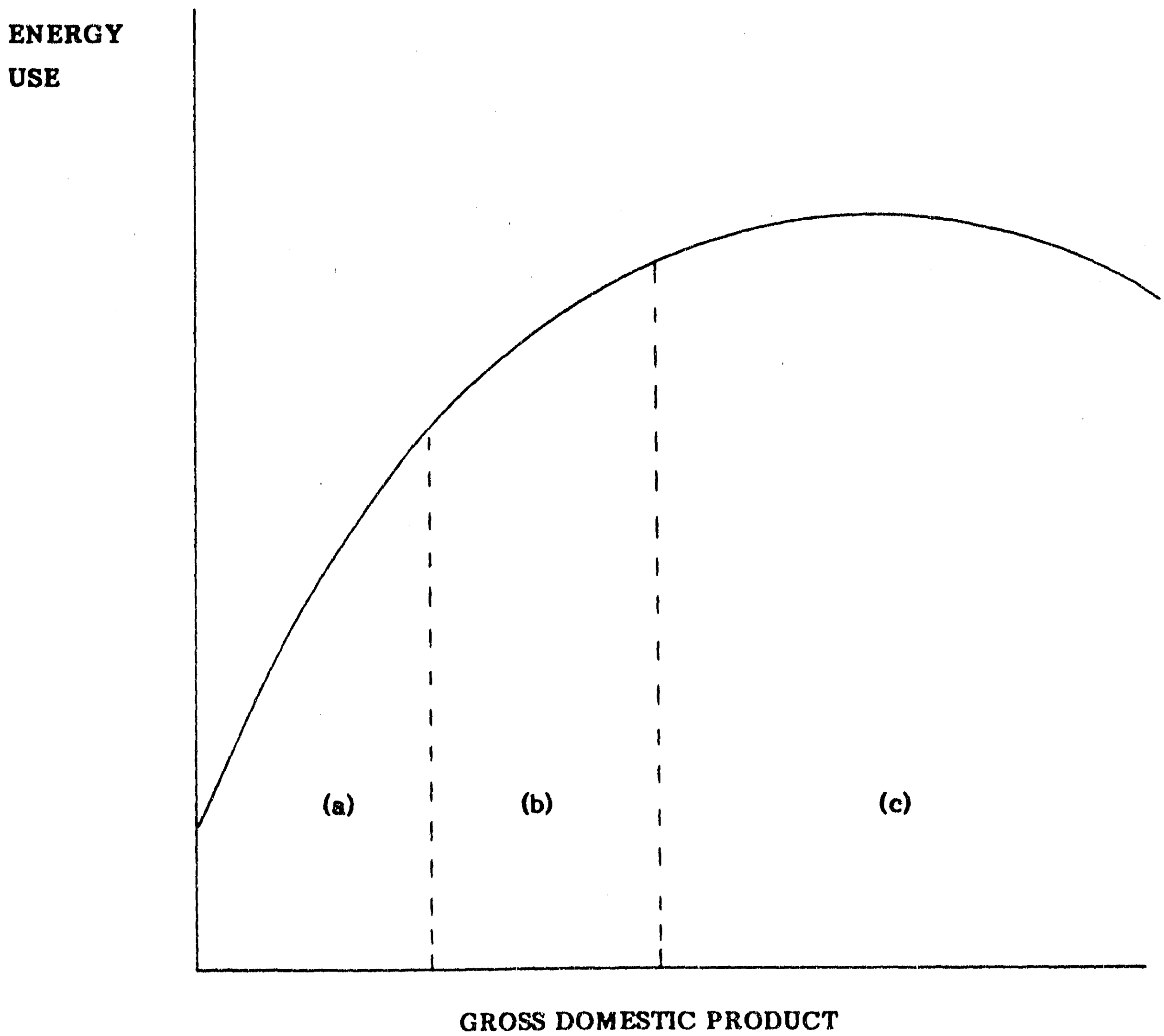
How do different levels of development, our understanding of development processes, and transfer of information and technology constrain CO_2 reduction?

The ability of 80% of the global population to develop in a way that generates low levels of carbon emissions will depend in large part on DIFFUSION OF TECHNOLOGY and the possibility of TECHNOLOGICAL LEAPFROGGING. It is obvious that if the bulk of the developing world repeats the 20th century pattern of the advanced industrialized nations with their reliance on fossil fuels, and motorization and electrification based on these fuels, the atmospheric burden of CO_2 will grow substantially.

In general, countries of the world can be analyzed in three groups: (a) developing countries, those countries using energy for survival; (b) newly industrialized countries, those using energy for development and industrialization; and (c) those using energy to sustain an industrialized lifestyle (Figure 1). Each type of country needs a new growth strategy in light of concern about carbon emissions and is likely to have a different response to the challenge to reduce emissions.

The countries tend to differ in orientation to system levels. For many developing countries, subnational units are very important; for newly industrializing countries, there is often a very strong emphasis on national interest; the industrialized nations are most integrated into a global economy and participate most fully in regional blocs and international governance. The strength and abundance of organizational types also tend to vary with development. Government is often very weak in developing countries, and in many newly industrializing countries there are still few independent nongovernmental organizations. The time horizons of the poorest nations tend to be short, while the industrialized nations can usually afford to look further into the future. Moreover, informal links and decisions are often dominant in developing countries, while the industrialized nations tend to make the most explicit and formal decisions.

Figure 1. Generic Energy/Economy Relationship



(a) developing countries

(b) newly industrializing countries

(c) industrialized countries

For countries of type (c), the challenge is to harvest the many technological opportunities that appear to exist. In many cases, the potential for efficiency has begun to be better utilized in the past 10-15 years. Countries of type (b) have tended to equate growth in energy use with economic growth. For these countries, it may be hard to change paths because of the recently installed capital infrastructure. However, their carbon emission growth is likely to be incremental.

In many ways countries of type (a) present the greatest challenge. They need new energy sources the most and also need to make the clearest choices about paths to follow and organizational structures to foster them. There is often little political means to do much. The processes that can bring about more rapid growth are not well understood. In addition, there are many barriers to diffusion of technologies that might be most helpful to a more carbon-friendly pattern of development.

A significant barrier rests in the current status of intellectual property rights. Such rights are necessary to create and maintain incentives for innovation. However, the current system, or absence of system, may simultaneously harm industrialized countries and developing countries. The lack of rules in some LDCs discourages technology transfer and development of markets. However, simply expanding the present system of the developed nations may place excessive hurdles on LDCs and also undervalue some of their assets, for example, in biological resources and traditional knowledge. The London Ozone Convention is an illustration of an innovative approach to technology transfer in the environment field. Consideration needs to be given to appropriate mechanisms for joint ventures between countries of North and South in energy and environment. The role of international development organizations, which have only recently become concerned with global environment, also needs to be considered in this regard.

A further important barrier is the difficulty of interaction between science and government in many LDCs. The traditions and mechanisms of constructive relations between the communities are at an early stage. Establishment of national research councils, strengthening of the independence of universities, and strengthening of regional organizations such as the African Academy of Sciences can be valuable ways to lessen this barrier.

Specific research questions include:

1. Can we understand better the relative importance of various factors affecting response to carbon emission reduction at various levels of development?
2. Recognizing that in many countries there will be governments that lack leverage over the national economy, how can obstacles to action by developing countries to reduce carbon emission be overcome most effectively?
3. What are the possibilities for informal action to reduce carbon emissions in developing countries?
4. What is the possibility for developing countries to leapfrog in energy and environmental technologies in order to avoid the pattern of development that has traditionally characterized industrialization?
5. How can international arrangements for transfer of technology and intellectual property rights be made into more of a positive sum game that also recognizes the assets and needs of LDCs?
6. What can be done to improve the weak performance of international organizations with regard to environmental protection in developing countries?
7. What can be done to strengthen indigenous environmental research capability in developing countries and to strengthen participation of scientists from developing countries in regional and global evaluations of environmental issues?

VII.

What do we understand about the potential for changes in consumption patterns and social behavior over different time horizons?

Quantitative analysis (ref. Lee Schipper) shows that differences in LIFESTYLE account for differences in final energy consumption and patterns of energy use at least as large as those caused by the technologies employed. Because habits define energy demand to such a great extent, it is necessary to consider their flexibility. It is also not unreasonable for individuals to be concerned that efforts to reduce carbon emissions will have impacts on preferred behavior in such fundamental areas as diet, movement, living area, and reproduction.

Although economic factors may heavily influence energy consumption, it is also important to recognize the limits of these factors. For most individuals, firms, and countries, expenditures on energy require only about 10% of income. Thus, in many circumstances even large increases in energy costs can be absorbed without major disruption of overall consumption. For a few activities, such as production of aluminum, energy costs constitute such a large proportion of total budget that the conduct of the activity is highly sensitive to economic factors. There is evidence that over the past couple of decades lifestyle preference has overridden several major price shocks to the energy system.

Most lifestyle changes appear to be moving in the wrong direction from the point of view of carbon emissions. For example, people in many societies have been spending somewhat more time traveling, and often in ways that demand more energy. On average, time spent in travel consumes about ten times as much energy as time spent in a stable location, whether in work or leisure. The increase in mobility during the past decades has roughly canceled gains from greater efficiency of vehicles. Moreover, trends are moving toward fewer passengers per vehicle, larger vehicles, and kinds of vehicles that consume more energy, such as aircraft and cars.

Changes in population profile are also tending to increase energy demand. Along with population increase itself, the shrinking of households and the aging of the population tend to raise energy demand. Two households with three persons each will consume considerably more energy than one household of six. In industrialized societies, a significant and growing fraction of the population may now live on pension for a period of 20 years or more. This older segment of the population has a historically unprecedented amount of time and income to travel and to maintain residences. Moreover, the population that is aging now is the first population in which possession of driver's licenses is prevalent.

A central question is the extent to which leisure activities will prove to be energy-intensive. With people in the industrialized societies living longer and steadily spending fewer lifehours at work, the question of how non-work time is used throughout life may become a main determinant of trends in energy consumption.

For developing countries the question must be asked whether the consumption pattern of the industrialized nations will be repeated. So far, the pattern of urbanization, motorization, and unbundling of families appears similar.

For all societies, transportation and communication have advanced in lockstep as complementary goods. Increases in communication increase demand for transport, and increases in transport increase demand for communication. If one wishes to travel less, a good strategy is to give up the telephone. There is no evidence yet that communication substitutes for travel.

Specific research questions include:

1. Where and how will we live? What will be the size and kind of homes and households?

2. Where and how will we work? Can the relationship between transportation and communication be changed?
3. Where and how will we play? Will leisure be energy-intensive or not?
4. What have been the most significant behavioral changes in recent decades that have been favorable for energy efficiency?
5. How can lifestyles and behavior be changed while respecting individual rights? What is the potential of education in this regard? How is it best to project notions of needs for lifestyle change so that acceptance may be encouraged?
6. Can market research and consumer psychology be employed more constructively from the perspective of global environment?
7. What are the implications for energy demand of a continuation of recent trends in lifestyle?
8. What are the implications for lifestyle of various goals for carbon emission reduction?

CONCLUSION

We have identified seven major barriers to reduction of carbon emissions: plural rationalities, consensus formation, time horizons, economic distortions, organizational design, technology diffusion, and lifestyles. In each area it is evident that proposals for action and change could be made now. At the same time, it is evident that much more remains to be learned about the barriers to action, and that contributions can come from anthropology, philosophy, sociology, political science, psychology, organizational behavior, market research, economics, history, statistics, demography, geography, and development studies, and from the integration of all these disciplines. The task of addressing the social and institutional barriers to carbon emissions will be with us for decades and perhaps centuries. It is necessary to deepen our partial views of the barriers, to study the actions to reduce them for efficiency, flexibility, fairness, affordability, administrative burden, and sustainability, and to try to come to collective views of how action should proceed.

What Is the Significance of the Linkage between Strategies to Reduce CO_2 Emissions and Other National and International Goals?

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INTRODUCTION

This report is a summary of the discussions in Group 4. The group's mandate was to examine the significance of the linkages between strategies to reduce CO_2 emissions and other national and international goals. Attention should be given to identifying research agendas and the need for further analysis.

The discussion within the group was structured around a preliminary set of issues. The following summary is based on a framework agreed upon after the discussions.

Discussions on wide-ranging topics can never be exhaustive. What follows is therefore a juxtaposition of the discussion and complementary statements.

BACKGROUND, GOALS, VALUES

(1-2 pages on IPCC conclusions, with the following highlights:

1. the need to stabilize GHG concentrations in the atmosphere;
2. differences in per capita emissions, between major countries and between first, second, and third worlds;
3. impacts and their regional distribution.)

(1/2 - 1 page on goals/values for global climate change policies, based on the following principles:

1. the world's population will increase to perhaps 10 B, with large-scale and possibly catastrophic consequences for natural ecosystems unless decisive actions are taken soon on both the national and international levels
2. the duty of man to preserve biological diversity

3. the duty to reduce socio-economic inequities between the rich and the poor.)

Climate change is a slow process in practical terms, with irreversible consequences. It raises fundamental ethical questions. Man has to think consciously about the extent to which he has the right to interfere with the connatural world (Meyer-Abich). The possibility of climate change illustrates the need for what could be called the ecological equivalent of the UN Declaration of Human Rights: every species has the right to exist and man does not have any natural or obvious right to interfere.

It was argued in the group, although not universally accepted, that man's perception of his role in nature is changing. An increased awareness of man's responsibilities can be found in certain countries. It is an important topic of research to better document shifts in values in contemporary societies.

basic question of
(1) equality of conditions
(2) moral/legal equality

Climate change also affects social issues and the inequities between the rich and the poor. Over the last century, industrialization has led to drastically reduced inequities. The modern democratic industrialized society is in most ways a more egalitarian society than its predecessor or contemporary less developed nations. At the same time, these reduced inequities have occurred at the expense of the environment and the living world.

Not so

That future development in already industrialized as well as industrializing and developing countries does not continue on the path of reducing inequities at the expense of nature is a value in its own right.

The opportunity exists to avoid being trapped once more in resolving social inequities at the expense of nature. Climate change policies should not increase present or future inequities.

Note: studies of climate change concern not only the natural sciences, but the social sciences and the humanities to an equal extent. It is important that research is broadened into these fields as well. It is a question with implications both for the methodologies used in assessing climate change policies as well as science policy in general.

LINKAGES BETWEEN DIFFERENT POLICY AREAS AND CLIMATE CHANGE POLICIES

(1/2-1 page on the general principles of policy with respect to climate change: the precautionary principle, the need for adaptation and mitigation as well as prevention strategies, etc. Keyword: robust strategies!)

Actual climate change will have implications for many different policy areas, which are impossible to identify in advance. Robust policies, i.e., those reducing the risk of climate change as well as reducing the consequences of climate change, will in all likelihood also be linked to many different policy areas. The following list should not be seen as exhaustive.

1. Energy efficiency. It was generally agreed that increased energy efficiency is of major importance. It should be possible to stabilize the CO_2 emissions from industrialized countries by, say, the year 2000 through efficiency measures alone, and also to reach a goal of perhaps a 20 percent (or more) reduction compared to, say, the 1990 level. Some members of the group felt that it was also possible to reduce energy use much more in industrialized nations. Lovins' analyses were quoted as illustrations of the potential of energy efficiency to be tapped. It was also agreed that the most important research issue with respect to energy efficiency has to do with barriers to implementation. Clearly, policies to increase energy efficiency should be the linchpin of any robust strategy. The group did not discuss the pros and cons of different energy supply options.

2. Energy efficiency as an element of a robust strategy of climate change is linked to the issue of why energy intensity differs between nations with a very similar standard of living. Schipper pointed out that these differences relate to various policies as well as to socio-cultural-political differences between nations. Industrial energy use, for example, does not differ terribly much between, say, the US and Japan (the latter is more efficient, though), since international competition tends to homogenize plants and technologies. It is the sectors not exposed to international competition where the greatest differences can be seen: housing, transportation, commercial services, etc. Some countries have tax deductions for interest rates on single family housing. Some have tax deductions for transportation to and from work. Some have favorable conditions for so-called company cars. Such policies in general tend to stimulate area-intensive living and thus high transportation needs. Since the infrastructure is involved, a long timescale is needed for changing basic conditions. Such policy differences reflect important social realities. In some countries second homes are very important and lead to a considerable amount of traveling for leisure.

In addition, some countries subsidize energy or particular forms of energy. The FRG subsidizes (German) hard coal, as does Britain to some extent. India subsidizes rural electricity. The East European countries and the Soviet Union have subsidized energy in general. Such policies should be scrutinized and carefully assessed. One important question is the extent to which the subsidization of energy should be brought up by the various aid organizations (the World Bank, the IMF, etc.).

3. There are also important linkages between more specific environmental policies and a robust climate change policy. Several examples were mentioned in the group: the Los Angeles air quality management policy will have a reduced CO_2 emission rate as one of its consequences, it was said (HOW??). Policies to reduce VOCs from landfills in the US have been found to be very cost-effective measures to reduce the overall greenhouse effect.

A third example, repeatedly brought up, was the need for a policy or program to reduce the environmental burden in and from the central European coal belt. Coal mining and burning in the industrial complexes in southwestern Poland, southeastern Germany (the former GDR), and northwestern Czechoslovakia have had a catastrophic impact on the local environment (heavy metals in metals processing, carcinogens in coking) as well as on the regional environment (the Elbe, Oder/Neisse, and Vistula Rivers) and northern European acidification (SOx). Coming to grips with this issue will require a comprehensive industrial restructuring of the whole region, with important benefits for health, environment, and climate.

4. On a broader scale, a robust climate strategy can also be linked to issues of war and peace. Permanently reducing the risks of international conflict along the former Iron Curtain and along the east European/Soviet border should be facilitated by economic integration of a kind similar to that which occurred after World War II in western Europe and after 1980 in southern Europe. The successful democratization of this region should also be seen in the light of economic and social integration with the more advanced west European economies. The experiences from western Europe are that reduced environmental damage requires modern technology, rapid capital formation, and a high level of education. Only economic integration can also bring this about in, say, the Soviet Union. The rate at which CO_2 emissions are reduced east of the Elbe is probably directly proportional to the rate of economic integration. In this sense, insecurity and environmental degradation is linked between the first and the second world.

The third world is a more complex matter. A nonsustainable, environmentally degrading process could result in poverty and destitution on a scale that also could lead to threats of war and social unrest. Deforestation is an example that bears on both unsustainability and climate change.

Assuming that the same conclusion holds for the third world as for the first - namely, that security is coupled to social stability, democracy, and the well-being of the general population - the conclusion is that strategies to reduce security risks will require increased standards of living which in turn are likely to be more energy-intensive. Thus, in the third world, there could well be a negative link between security and environment: when the conditions for security improves, the risks for the environment increase. Clearly, this illustrates the need for development patterns that combine well-being and social stability with low CO_2 emissions.

5. This brings us to the general question of economic development, population growth and climate change. There are obvious linkages here.

(Perhaps a few lines about China, as the most obvious illustration about the relation between climate change, development, and population.)

First, however, a digression into the empirical state of development.
(1/2-1 page)

The third world is not a homogenous entity. Some countries, particularly in Southeast Asia, are rapidly developing and increasing their energy use. Other regions of the world appear almost stuck in hopelessness and disorder (Africa). For a possible climate change, the emerging energy supply systems in southern and Southeast Asia is probably critical.

The potential for energy efficiency should not be underestimated in the rapidly developing countries of Southeast Asia. Schipper gave an example of refrigerators in Indonesia, as an outcome of a World Bank study. The Bank had found that mobilizing the capital for the projected expansion of the electric utility industry was probably impossible; increased efficiency of electricity use was therefore necessary. In the end it was found that the Japanese appliance manufacturers did not supply the third world with the same high efficiency products as they did the home markets. Similar examples could be found in India, where the government turned down a World Bank offer of capital for a factory to supply more efficient fluorescent lightbulbs as an alternative to capital for more power plants.

There are important issues of both policy and research present here. In particular, the actual mechanics of technological transfer to third world countries and the role of trade and financing should be analyzed.

Population growth, economic development, and climate change have to be seen in the context of the global economic system. There is an intense debate over issues of development in general, and the relations between development and the world trade and credit system in particular. There were those in the group that felt that a fundamental transformation of the world trade and credit system was needed in order to influence decisively the relationships between trade, equity, and reduced risk for climate change.

INTERNATIONAL INSTITUTIONS, ORGANIZATIONS, AND REGIMES

(A few words on the relations between institutions, organizations, and regimes. The key word here is regime, with the underpinning organizations. Three aspects will be discussed: 1) existing organizations, 2) possible CO_2 reduction agreements, and 3) verification issues.)

The group discussed the role of the existing international organizations in a possible climate change regime. It was generally felt that the present organizations, such as the ECE, the OECD, the EC, and the IMF, the IBRD and UNEP, WMO and UNDP have the potential to adapt. Emphasis should be given to this, rather than to the need to invent entirely new organizations. (This paragraph will be expanded somewhat.)

As an example of the capacity to adapt, the ozone depletion fund (note: name!!) was mentioned. A couple of years ago one could have guessed that such a mechanism would be set up. Today it exists.

This is not to say that the present organizations do not have drawbacks. (Expand somewhat - IMF, UNDP, World Bank, etc. - in particular the latter.)

Other international actor should not be underestimated. We discussed above the role of the international appliance manufacturers in relation to the electricity demand in the third world. Clearly, they should give more concern to efficiency. And clearly, they should be more closely monitored. Other examples abound. (Expand somewhat!)

This is linked to the international trade regime and GATT. (The section below will be moved to here and expanded. This whole problem bears heavily on the debate during the 1970s of NIEO, and this might well surface again under a climate heading.)

At the same time, the role of the financing institutions should not be underestimated, as the role of the World Bank illustrates. Surveillance and transparency are needed.

Nongovernmental organizations, such as international environmental organizations, play an increasingly important role. They raise awareness, they are watchdogs, they alert their respective national member organizations to issues for which they should petition their respective governments for appropriate responses. They are particularly effective when it comes to organizations such as the World Bank, UNDP, and possibly also the IMF. Washington is an important scene for international environmental lobbying.

A final form of concerted international action should be mentioned. Many cities of various sizes are trying to establish environmental programs. The case of the Danish/Schleswig-Holstein Brundtland cities were mentioned, and other examples as well. Informal networking of this kind is likely to play a larger part in the future, as telecommunications and travel possibilities increase. The example of Los Angeles in air quality management has led some larger cities to discuss joint procurement of environmentally sound vehicles.

The second element of a CO_2 reduction regime concerns goal formulation and agreeing to joint reductions or sharing reduction possibilities.

It was felt that it is important to study closely and develop different suggestions for, e.g., tradeable permits and international/regional CO_2 taxes. There are several reasons for this, the most important one being the uneasiness that many countries feel about across the board percent reductions. It is hardly reasonable to ask Portugal to meet the same percent reduction as the Federal Republic of Germany.

The EC is the only organization which has managed to negotiate an agreement over differentiated emission control measures (the large scale combustion plant directive).

Similar negotiations concerning climate change and CO_2 reduction will be necessary in the future. A system of tradeable emission permits might be a way forward. It could be introduced on the West European level - as a sort of carbon equivalent of CAP - and then gradually enlarged to include, e.g., eastern Europe (which would have emission rights to trade!).

The third related issue concerns goal setting and verification. Here it was felt that some countries, notably the FRG and Holland had come the furthest. Other countries had expressed themselves in more general terms. More precise agreements on the rules for verifications were seen as desirable. It was hardly felt to be a big problem, since the statistics of fossil fuel use are seen as relatively good and reliable. Transparency of emission data is important, however.

The US was generally seen as a problem, less committed as it is to reducing the risks of climate change. The group felt that it was necessary to engage the US in a constructive dialogue about goal setting and verification, even if it were not possible to agree on actual goals. It was suggested that a serious (?)exercise between the most concerned OECD nations would also bring the US into the discussion. The OECD could possibly be a forum for such meetings.

The possible linkage between an international CO_2 reduction regime to the international trade regime was discussed. It was pointed out that the Montreal Protocol on Ozone Depletion contained statements/agreement that were/was not regarded as conforming to the GATT rules. (It was also argued that the GATT secretariat had actually agreed to these formulations in the statement). This was not seen as any great problem concerning CFCs, since the reduction has taken place so rapidly anyways. But CO_2 could well be another matter.

Finally, timing was discussed and two competing views emerged. It was said that a tentative agreement could already have been reached in Geneva between the most interested and committed nations. It was also said that it was more important to get the first agreement right than signed quickly. The process was stressed: precedents from other international environmental agreements suggest that the process is more important in the end than the results of the initial meeting (LRTBAP, Rhine Commission, North Sea conferences, etc.).

On leadership and leading countries (to be expanded).

METHODOLOGIES

The group spent considerable time discussing methodologies for analyzing CO_2 reduction strategies and robust climate change policies.

First, it was strongly felt that attention should be given to both value conflicts and action conflicts. This was partially related to the classic discusion within C/B-analysis of options versus existence values.

It was also partially related to the fact that climate change is for all practical purposes irreversible, and most probably would lead to large-scale extinction of various species. It was strongly felt that C/B analysis can in no way be allowed to legitimize this.

Timescales were also felt to be serious problems. First, the exceptionally long time period involved - decades - make discounted values meaningless. Second, the uncertainty involved -

to the point of sheer ignorance - of the characteristics of, say, the agricultural sector in some fifty years' time implied exceptional problems of analysis.

C/B analysis was seen to be a possible tool for certain, more limited studies, but needed to be complemented with other methods. Experiences from risk analysis had shown that the most important differences between, say, different energy systems did not lend themselves to quantification. Comparing large-scale, long-term use of coal with a similar use of nuclear power would, for instance, require weighing the risks of nuclear accidents against the risks of climate change - hardly a simple numerical problem.

It was also felt that the analyses that would have to be done needed to include - regardless of the methodology employed - distributional aspects. This might be more (?)feasible if it were done on a regional basis. The IPCC is currently engaging in regional studies in twelve (eighteen?) places in order to learn about methods and processes. There are several reasons for this. One is that the IPCC impact studies so far are very rudimentary and should be seen as illustrations of what might happen rather than as (?definite) predictions. The need to develop better methods is obvious. Another reason is that the whole question of winners and losers is more easily analyzed on the well-defined regional level. Here it should be added that group members stressed that the conclusions from scientific research sometimes appear to depend on the place from which the research emanates; the Europeans have had trouble accepting US ozone depletion studies, the UK had trouble accepting Scandinavian acid rain studies, and third world countries not infrequently have problems accepting results about deforestation. There is therefore a strong educational value to having joint research. Brazil and India are among the few developing countries that have a strong enough research base of their own.

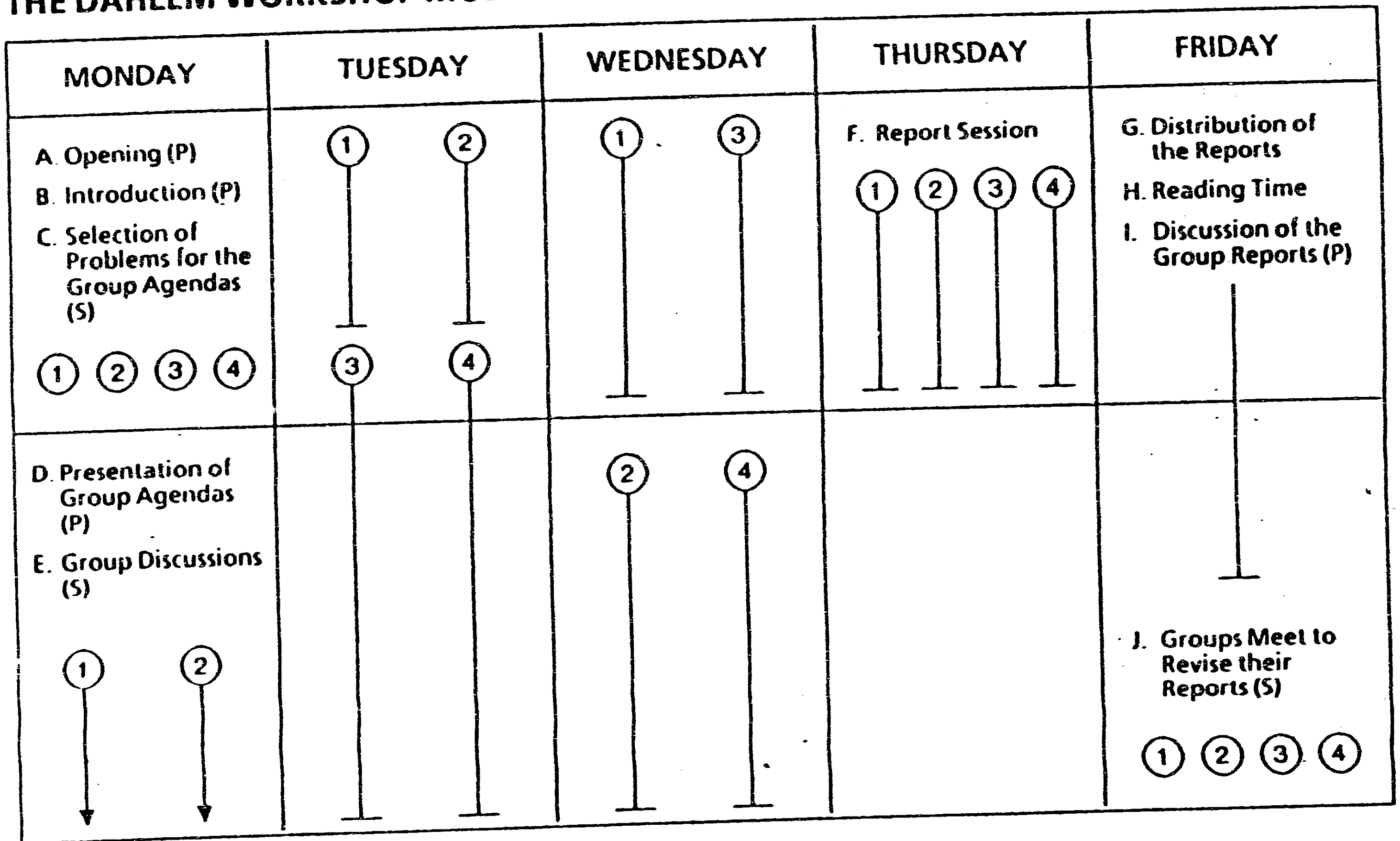
CONCLUDING NOTE: MORE SHOULD BE SAID ABOUT RESEARCH IDEAS!!

One important region to study is the central European coal belt - the coal mining area in southwestern Poland, southeastern Germany (the former GDR), and northwestern Czechoslovakia.

APPENDIX B

DAHLEM RESEARCH CONFERENCE FORMAT

THE DAHLEM WORKSHOP MODEL



Key: (P) = Plenary Session;
(S) = Simultaneous Sessions;
○ = one discussion group

Explanation of the Dahlem Workshop Model

A. Opening
Background information is given about Dahlem Konferenzen and the Dahlem Workshop Model.

B. Introduction
The goal and the scientific aspects of the workshop are explained.

C. Selection of Problems for the Group Agenda
Each participant is requested to define priority problems of his choice to be discussed within the framework of the workshop goal and his discussion group topic. Each group discusses these suggestions and compiles an agenda of these problems for their discussions.

D. Presentation of the Group Agenda
The agenda for each group is presented by the moderator. A plenary discussion follows to finalize these agendas.

E. Group Discussions
Two groups start their discussions simultaneously. Participants not assigned to either of these two groups attend discussions on topics of their choice.
The groups then change roles as indicated on the chart.

F. Report Session
The rapporteurs discuss the contents of their reports with their group members and write their reports, which are then typed and duplicated.

G. Distribution of Group Reports
The four group reports are distributed to all participants.

H. Reading Time
Participants read these group reports and formulate written questions/comments.

I. Discussion of Group Reports
Each rapporteur summarizes the highlights, controversies and open problems of his group. A plenary discussion follows.

J. Groups Meet to Revise their Reports
The groups meet to decide which of the comments and issues raised during the plenary discussion should be included in the final report.

APPENDIX C

LIST OF PAPERS PREPARED

Dahlem Workshop on
LIMITING THE GREENHOUSE EFFECT: OPTIONS FOR CONTROLLING ATMOSPHERIC CO_2 ACCUMULATION

Table of Contents (November 12, 1990) **Paper No.:**

Table of Contents (cont.) **Paper No.:**

APPENDIX D

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The role of energy efficiency in reducing greenhouse gas emissions; the development and assessment of energy/CO_2 scenarios

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Risk communication; role of national energy strategies in the problems of climate change, ozone depletion, acid rain. Analysis of investments by electric utilities and problems of implementation.

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Energy and environment: assessment studies of technological and strategic options for limiting the greenhouse effect

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Renewable energies, hydrogen technologies and systems development, energy efficiency

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Technology responses to global climate change: energy conservation; strategic technology planning methods

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Future world and the USSR energy development with minimum greenhouse gases emissions

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Rational energy use: technical, economic and policy aspects. social costs of energy use; technology assessment

---

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Efficient end-use of energy, especially electricity (technology, implementation methods, policy, climatic implications)

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The economics of emissions abatement

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Energy systems analysis, technology assessment

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Energy use and Global Climate Change in African LDCs.

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Global climate change: development of climate models to test the efficiency of different measures to reduce the additional greenhouse warming due to CO_2, CFCs, CH_4, and N_2O emissions.

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Long-term projection of energy demand in Korea

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Policy, energy, and human systems analysis for global environmental change

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Rational energy use; external costs of energy systems; long term projections of energy demand

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Alternative futures. Conflict Resolution. Political discourse.

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Sustainable development and the environment - "Our Common Future" ~~report by WCED~~
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Impacts of global climate change; relationship between climate change and international security; water resources

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Thermal hydraulics in nuclear power plants safety analysis

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Philosophy of nature: energy systems; implications of climate change

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Energy research

APPENDIX E

ITINERARY

12/07–12/08/90	Travel from Oak Ridge, Tennessee to Berlin, Germany
12/09–12/14/90	Participate in Dahlem Conference on Climate Change
12/14/90	Travel from Berlin, Germany to Oak Ridge, Tennessee

END

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