WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT

FIFTH MEETING
Ottawa, 28-30 May, 1986 WCED/86/6

MEMORANDUM

TO: All Members of the World Commission on Environment and Development

FROM: Jim MacNeill, Secretary General

DATE: 12 May, 1986

RE: Report of the Advisory Panel on Energy and Sustainable Development

Enclosed is a copy of the final draft of the Report of the Advisory Panel on Energy and Sustainable Development, for your consideration and discussion in Ottawa.

The Chairman of the Advisory Panel, H.E. Enrique Iglesias, has accepted the Chairman's invitation to come to Ottawa, and personally present the report to you. He will also join in your discussion under agenda Item 6.1 (WCED/86/6/. As soon as feasible after the Ottawa Meeting, with your approval, I plan to have the report copy edited and published through commercial channels.

Action Required: For Discussion

ENERGY AND SUSTAINABLE DEVELOPMENT

Report to the

World Commission on Environment and Development

by its

Advisory Panel on Energy

Final Draft - May 12, 1986

WCED:0331j-0378j/JP

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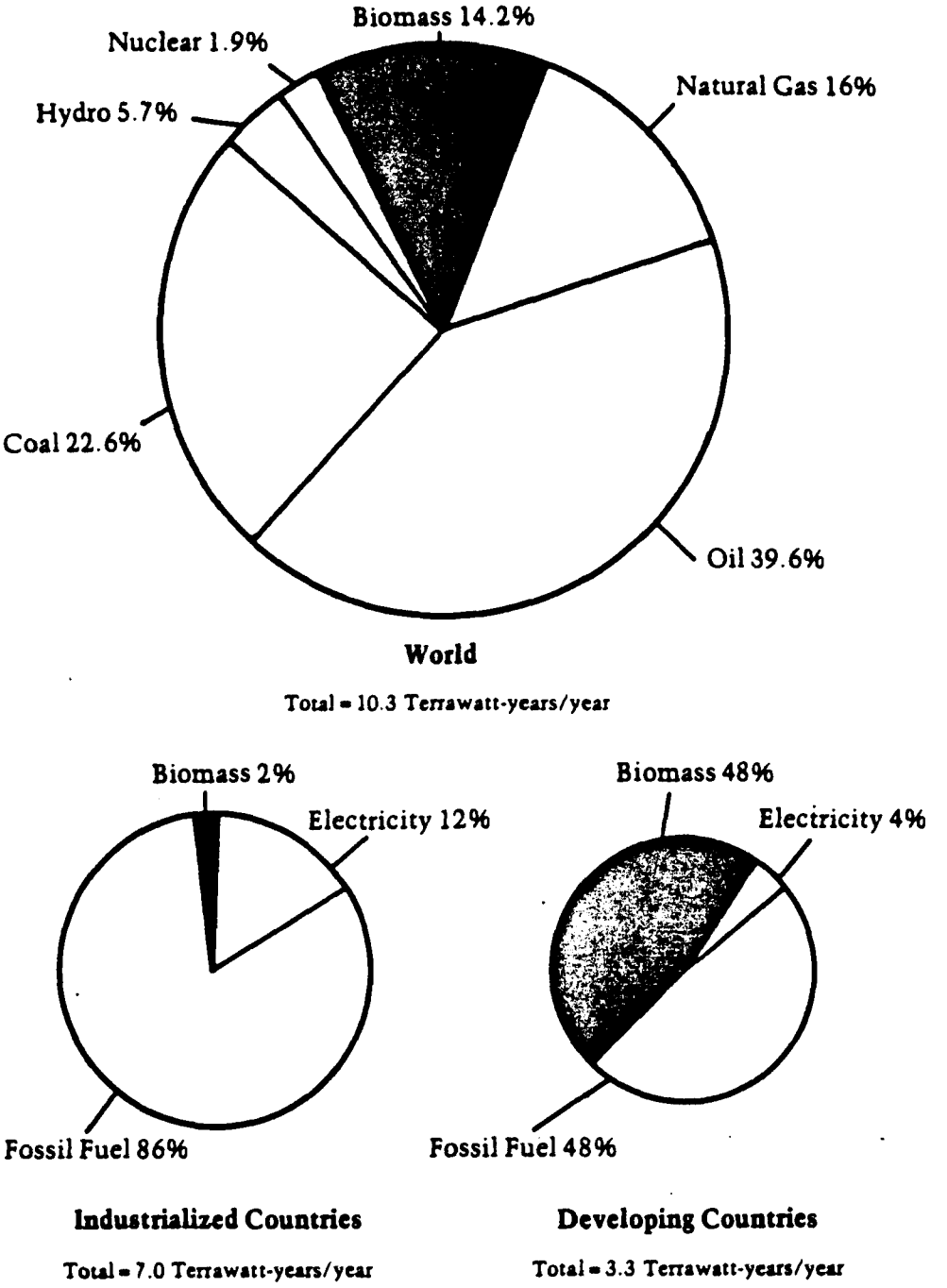
I. WORLD ENERGY PRICES, ENVIRONMENT AND DEVELOPMENT

1. When this Panel was established by the Commission in March 1985, world oil prices stood $28-$30 per barrel and economic development everywhere was being planned on the assumption of a steady increase in the price of energy. As the Panel completed its report in May 1986, world oil prices stood at around $10-12 per barrel; and old prophets were announcing a new era of cheap energy.

2. With the breakdown of effective stabilizers, oil prices have become impossible to predict. Looking to the next decade and the year 2000 and beyond, however, it seems clear that, in the face of increasing economic activity and of constantly rising demand, the supply of this non-renewable resource will emerge as the decisive factor in determining prices. It is imperative, therefore, that a period of cheap hydrocarbon energy should not be taken as a permanent phenomenon. Short term gains are always tempting to those in a position to grab them, whether producers or consumers. Such gains may temporarily set back, but they in no way alter the fundamental character of the transition under way to a broader mix of energy sources, with a steadily increasing proportion of renewables.

3. The world can stumble through this transition, from shock to shock, at a great cost to sustainable development, including the environmental bases of development. Or it can manage the transition, effecting more sustainable mixes of energy supply and patterns of energy consumption. This, however, will require a transformation in energy policies and institutions.



Source: Robert Williams, "Potential Roles for Bioenergy," presentation at the WRI/RBF symposium; Goldemberg, Johansson, Reddy, and Williams, "End-Use Oriented Global Energy Strategy."

Figure 1: GLOBAL DISTRIBUTION OF PRIMARY ENERGY USE, 1980
(Source: Miller - 1986)

4. An effective arrangement to stabilize wild fluctuations in the world oil price, at a reasonable level in real terms is essential to this transformation. In the absence of such an arrangement, oil prices are bound to fluctuate over a wide range. In 1979, the time was ripe to conclude such an arrangement but the opportunity was lost because of myopia among the exporting and confusion among the importing countries. In 1986 the time is ripe again, but there is a very real danger that the opportunity will again be lost, this time because of myopia among the importing and confusion among the exporting countries.

5. The economic, social and environmental costs of losing this opportunity are much clearer today than they were in 1979.

5.1 In the industrialized countries the griplock between energy and development was finally broken during the past decade. The incremental energy content of growth fell in many countries, in some from 1.2 to 0.5 units, resulting in substantial gains in overall economic efficiency and competitiveness and substantial reductions in the costs of environmental damage. The momentum that produced energy efficiency gains of up to 2 per cent a year is now threatened in transportation, industry, agriculture and other sectors and could quickly be lost.

5.2 Developments that made sense with oil at $25 per barrel, suddenly make no sense at all with oil at around $10 per barrel. Many producers, including new ventures in renewables and conservation, have been devastated, and massive investments in the

search for new oil, and in the development of renewable energy sources that will be needed through the transition, have been placed in temporary and perhaps terminal jeopardy.

5.3 Developments that need to be sustained through the year 2000 and beyond, and these include most major developments in transportation, agriculture, industry and other sectors, need to be based on a realistic view of the energy transition. Planning the future on the basis of cheap energy will redound with a vengeance against development and equity when prices rebound, as happened in the 1970s.

5.4 The material and commodity content of growth has also fallen during the past decade because of the development of substitutes. A temporary period of cheap oil will enhance the position of oil-based substitutes, in textiles and rubber for example, and further reinforce this process. In the future, therefore, growth in developing countries will not benefit to the same degree from growth in industrialized countries.

5.5 Failure to re-establish world oil prices, and hence consumer prices of energy at a level that sustains annual gains in energy efficiency and a steady shift to renewables will threaten many nations not only with reduced development potential, but also with reduced security. A period of unreasonably low prices will re-establish high energy supply and consumption patterns, with a higher dependence on fossil fuels. These patterns will reinforce the

processes of transboundary air pollution and environmental acidification now underway in Europe and North America and will hasten their spread to other regions in Asia, Africa, and Latin America. They will also accelerate the processes of climatic change now underway. The scientists concerned recently warned that within the next 40 - 60 years, climatic change could provoke not only a major shift in climatic zones but also sea level rises of 25 to 145 centimetres, thus adding a steady shift in the boundaries of coastal states to the agenda of international tensions.

6. Effective attempts to stabilize wild fluctuations in the world oil price will no doubt take some years to negotiate. In the meantime, nations may choose to allow consumer prices to fall to levels dictated by the market or they may deploy various measures to sustain prices at higher levels.

7. At the moment, it is the former course that is generally being pursued. With oil prices falling to around US$ 10 a barrel, raising the prospect of oil at pre-1973 prices in real terms, confident talk of the market soon finding its own "natural floor" has been silenced. Extreme price uncertainty is leading to unbridled market speculation in oil futures which is imposing severe economic and social hardship on the oil exporting nations. In the longer term, with unrestricted demand gradually overtaking supply, the stage will be set for yet another energy shock, and a repeat of the economic, social and environmental experience of the 1970's.

8. On the other hand, consumer nations and especially the major industrialized countries could take steps to sustain prices and capture in their budgets a major proportion of the gap created by the sudden collapse of world oil prices. This would provide a major source of revenue, enabling governments to reduce their heavy debt burden and return to sounder fiscal management. It would ensure that the momentum producing more sustainable patterns of energy consumption and supply is not lost and that annual gains in energy efficiency continue. It would reduce the rising cost of damage from urban air pollution and the acidification of the environment and it would buy the time needed to develop and apply strategies to reduce and/or adapt to climate change. Moreover, in thus aggregating a portion of the over $ 100 billion windfall flowing to their consumers, industrialized countries would be in a position to increase substantially their contributions to bilateral and multilateral agencies to support developing countries to establish the institutions and effect the policies and environmental regeneration needed to manage the energy transition.

9. This Panel recognizes, however, that generally action to impose higher consumer prices would be extremely difficult due to domestic political and international economic constraints. Perhaps the only genuine solution lies in the steadily growing realization that oil is such a crucial raw material in future strategies for environment and development that it is too important to be treated as just another commodity and left to the vagaries of a volatile world market. Instead, both producers and consumers should co-operate to develop policies to build some limited form of global convention for the more orderly production and marketing of oil.

II. THE STRATEGIC CHOICES

10. The energy supply and consumption patterns of the year 2000 and beyond are being determined today. The same is true, of course, of patterns of population growth, industrialization, urbanization, agriculture and transport. But energy patterns are unique. They can widen the opportunities for future economic and social development or they can constrain them, in some cases eliminating them altogether. They can provide the basis for a high and sustainable level of security and comfort; or they can destroy it, reinforcing insecurity, widespread poverty and human misery. At the limit, they can determine the capacity of this planet to sustain the life support systems on which all other development depends.

11. There is no doubt that certain energy patterns today threaten the sustainable development of the countries and regions in which they are dominant. This is clearly true of the fuelwood crisis: according to an FAO study [1/], in 1980, 1,300 million people lived in wood deficit areas (defined as areas where people can still satisfy minimum needs, but only through unsustainable overcutting), and over 110 million in acute scarcity areas (defined as areas where even through overcutting people cannot satisfy minimum needs). The same study projects that by the year 2000 about 3,000 million people may live in wood deficit and acute scarcity areas, leading to increasing deforestation, erosion, desertification and the diversion of plant and animal wastes from soil replenishment (See Table 1).

12. It is also true of acidification of the environment in Europe and North America, a phenomenon now spreading to parts of Asia, Africa and Latin America. The silent accumulation of acid has led to the widespread sterilization of lakes and, more recently, to soils. The later may be the principal cause of the accelerating death of Europe's forests, the front line in the security system of any community, nation or region. Without them, a nation's economy is naked, its soil exposed to rapid run off and erosion, its valleys to flooding and its valley homes and agriculture to destruction. In October 1985, Switzerland was reeling from a decision to evacuate 70 people from a mountain village, perched below a forest that had been killed by acid rain. In 1986, they may need to evacuate over 100,000 people. Here, tomorrow has become today.

Region	1980				2000	
	Acute scarcity		Deficit		Acute Scarcity or Deficit	
	Total Population	Rural Population	Total Population	Rural Population	Total Population	Rural Population
Africa	55	49	146	131	535	464
Near East and North Africa			104	69	268	158
Asia and Pacific	31	29	832	710	1,671	1,434
Latin America	26	18	201	143	512	342
Total	112	96	1,283	1,052	2,986	2,398

Note: a. Total population and rural population (total population less that of towns with more than 100,000 inhabitants) in zones whose fuelwood situation has been classified.
Source: Adapted from Food and Agriculture Organization, 1983, Reference 67.

Table 1: POPULATIONS EXPERIENCING A FUELWOOD DEFICIT 1980 and 2000 (in millions). (Source WRI-1986)

13. Certain patterns of energy consumption could undermine sustainable development on a global basis. Climate change has now emerged as a "serious and plausible" threat to the economic and social development of nations and could place intolerable burdens on worldwide political stability within the next 40 to 60 years.

14. Fortunately, however, there are choices open to most nations and to the international community that could reduce, if not prevent, the threats that certain types of energy patterns pose to sustainable development. Some of these choices hinge on policies to reduce the future demand for energy without reducing the potential for economic growth. Others hinge on policies to better manage the burning of fossil and other fuels, internalizing the enormous costs they now impose on their own community and on other nations and regions. Still others hinge on policies to induce a steady shift in the energy mix from non-renewable to renewable sources of energy. All require changes in existing policies and new and strengthened institutions at the national and international level.

A. A HIGH OR LOW ENERGY FUTURE

15. The major strategic choice before governments and the world community is illustrated in Figure 2, which includes some of the better known projections[2/] of energy use through the middle of the next century. It will be seen that by the year 2000 global energy consumption varies by a factor of five between the lowest and the highest projections, and by the year 2020 the spread between the projections is too large to portray on this figure.

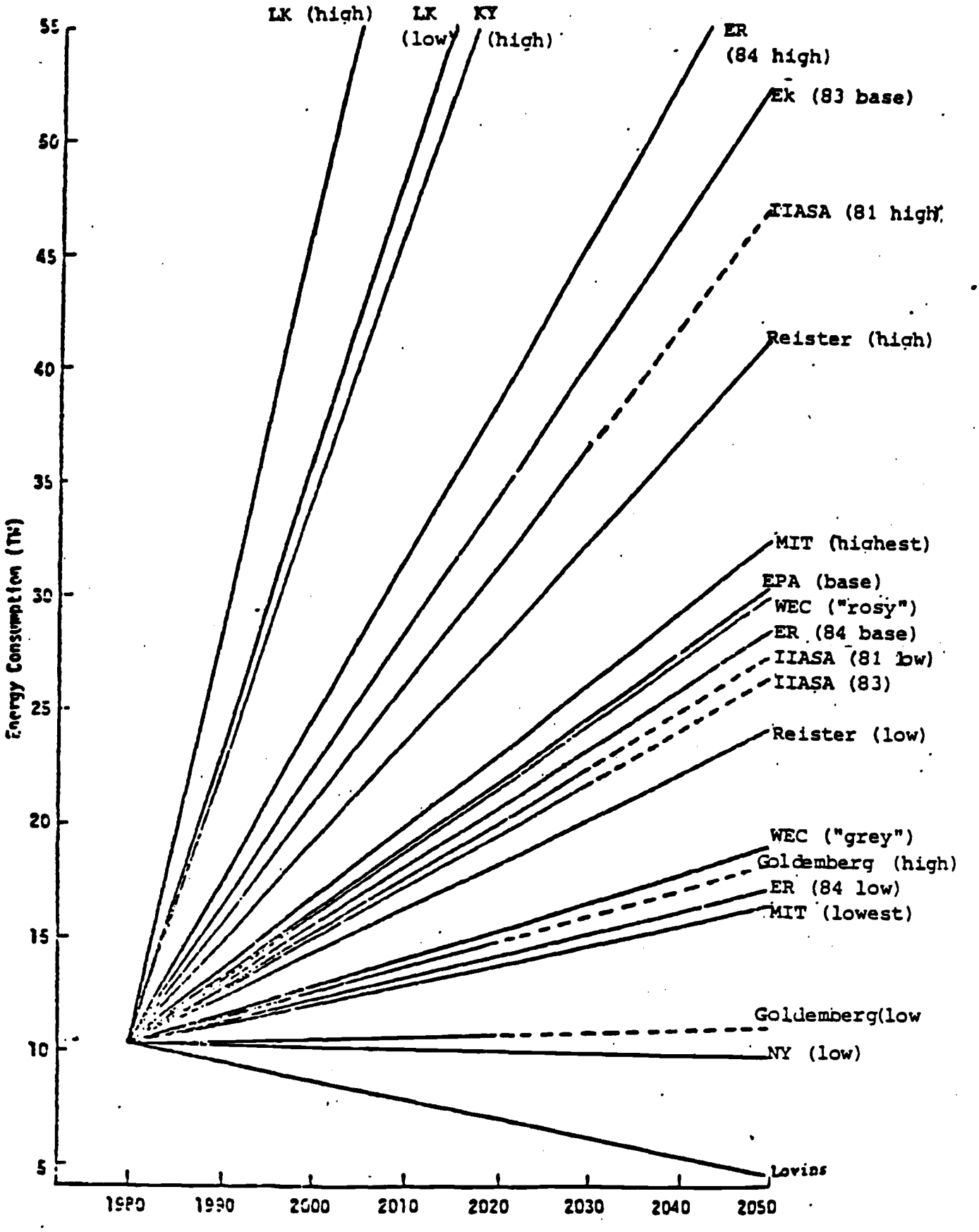


Figure 2: PROJECTIONS OF PRIMARY ENERGY CONSUMPTION
(Source: Keepin - 1985)

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16. In examining Figure 2, it is vital to understand that energy use projections are not in any sense predictions of the future. They are projections of possibilities, useful only to analyse what can happen under different assumptions concerning all the factors that together determine the growth or decline in, and the pattern of energy consumption. The differences in Figure 2, thus reflect not so much differences in methodology, as different assumptions which will influence energy patterns, especially gains in energy productivity.

17. Given the rich range of projections now available in various studies, the Panel has not attempted to add yet another of its own. Instead, and for the sole purpose of illustrating the energy, economic and environmental implications of a high and a low scenario, two of these projections have been employed, representing respectively a credible "upper bound" and "lower bound".(See Table 2 for some details of the two studies.)[3/]

18. The Panel's purpose in employing these projections, therefore, is not to evaluate and defend the absolute numbers involved. Rather it is to show that two radically different energy futures are possible reflecting different policies and institutions. The projections also provide parameters within which to discuss the consequences of two broad directions for development and for sustaining the environmental bases of development.

19. The high scenario is indicative of the direction in which energy consumption and supply patterns are heading if existing policies and institutions remain essentially unchanged. It is a trend scenario. It is included in a study published in 1981 by the

Table 2: SELECTED DATA IN THE "HIGH" AND "LOW" SCENARIOS

(Source: Adopted from Goldemberg - 1985a)

	Energy Use (TW)		GNP (T$)		% per annum	GNP/E		% per annum
	1980	2020	1980	2020		1980	2020	
LOW SCENARIO (Goldemberg et al)								
ICs	7.0	3.9	7.6	15.2[a]	1.7%	1.1	4.0	3.3%
DCs	3.3	7.3	2.0	20.0[b]	6.0%	0.6	2.7	2.7%
WORLD	10.3	11.2	10.0	33.0[c]	3.0%	1.0	2.9	3.0%
HIGH SCENARIO (IIASA)								
ICs	7.0	20.1						
DCs	3.3	15.1						
WORLD	10.3	35.2	10.0	23.0[d]	2.1%	1.0	0.67	-1.0%

Footnote:

GNP growth rates were calculated based on data from Goldemberg - 1985, that are compatible with:

a. GNP doubling
b. GNP 10 fold
c. GNP 3% per year
d. GNP 2.1% per year

International Institute for Applied Systems Analysis. It assumed world economic growth at average annual rate of 2.1 per cent.[4/] With no gains in energy efficiency, indeed with energy efficiency on a global basis falling at rate of 1.0 per cent per year, it projects a tripling of global energy consumption over 1980 levels by 2020.

20. The most recent examination of the technical feasibility of reaching a low energy future is that contained in a 1985 study by an international group of energy analysts.[5/] It is not strictly an energy projection, but rather a feasibility study or an existence proof, demonstrating what could be achieved if all future development incorporated the most energy-efficient technologies and processes now available and in use in the housing, industry, transportation and other sectors. Assuming this were possible, the study projects a 50 per cent drop in per capita energy consumption in industrialized and only a 30 per cent increase in developing countries.

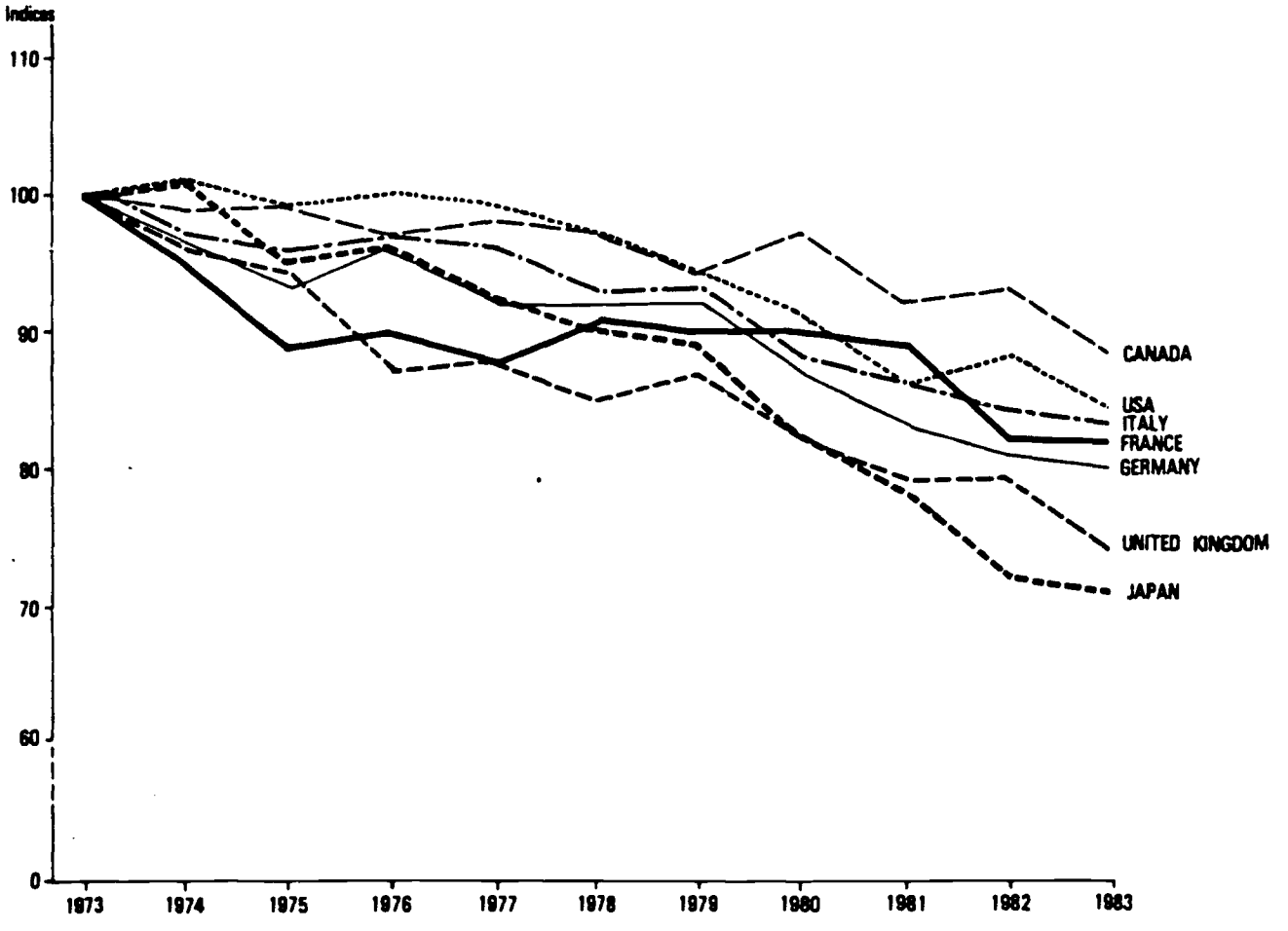
21. These and other assumptions produce a mere 10 per cent increase in global energy consumption by 2020, a striking figure recognizing that it is compatible with economic growth rates similar to those employed to project the high scenario. In fact, no GDP growth rate was explicitly assumed in the projection. However, according to the authors, it is consistent with an average annual growth rate of 1.7 per cent in the industrialized countries and up to 6 per cent in developing countries. It is also consistent with an average annual growth rate globally of up to about 3 per cent per year.

22. Taken together, these assumptions imply that average annual gains in energy efficiency of 3.3 per cent and 2.7 per cent can be reached and sustained in industrialized and developing countries respectively. While this may be technically feasible, it presumes very high rates of penetration of energy efficient technologies and processes. Without in any way diminishing the value of the study, the Panel feels that somewhat less optimistic assumptions would be more reasonable, given past performance and well known economic, social and institutional constraints. Figure 3 shows data about the past performance of the OECD region. On the average, they have achieved annual energy efficiency increases of 1.7% per annum between 1973 and 1983. For them to achieve rates as high as 3.3% would require the rate of penetration of new technology to increase substantially, an unlikely event when the world is facing a period of declining real prices for oil.

23. In the case of developing countries, a lower energy scenario requires not just a rise in the rate of penetration of new technologies, but also a reversal of current trends. According to a World Bank report[6/], in the '60s and the '70s the energy content of GNP in developing countries actually increased by well over 2% a year. A reduction of 2.7% in the future would constitute a departure of 4.7% from current trends.

24. In view of this, the Panel feels that it would be more reasonable to expect the energy future to unfold somewhere between these two projections. Nonetheless, given the interrelated economic, environment and development implications of the high and low energy scenarios, the nations of the world should aim for the

lowest possible energy future compatible with their economic and social priorities. This Panel recognizes, however, that while this may be the ultimate aim and the goal toward which to tend, if in respect of each decision the lowest is not possible than, reluctantly, a higher option would have to be accepted.



Note : Indices (base 100 in 1973) are calculated from values of ratio

$$\frac{\text{Total Primary Energy Requirements}}{\text{Gross Domestic Product}}$$

Source: OECD - 1985

Figure 3: TOTAL ENERGY REQUIRED PER UNIT OF GROSS DOMESTIC PRODUCT (Source: OECD - 1985)

25. In view of this, the Panel felt that if the low energy scenario could actually be achieved, it would have been sufficient to target future policies on increasing the energy content of development and controlling the emission of pollutants. But if, as seems likely, substantial increases in energy consumption will take place, then all countries, and particularly developing countries will have to explore urgently all avenues for increasing the supply of energy in environmentally benign ways, particularly from renewable sources.

a) Energy Supply Implications

26. The energy supply implications of the high scenario are simply staggering. By the year 2020, oil and natural gas would have to be produced at almost twice the 1980 rate, while coal production would need to increase by a factor of 1.8. This increase in fossil fuel use implies a capacity equivalent to bringing a new Alaska Pipeline (2 mboe/day) into production every one to two months! (It should be noted that even the 1980 level of oil consumption carried through to 2020 would require the discovery of 20 per cent more proven reserves than existed in 1985.[7/]) More than 6TW of nuclear capacity would also have to be installed by the year 2020, an increase of 3,000 per cent over 1983 levels! That would require commissioning approximately 150 large, 1GWe nuclear reactors per year.

27. Existing reserves would be able to cover the requirements for natural gas and coal, but it is questionable if the necessary infrastructure for mining, transporting and converting these fuels could be developed in this short period in all the countries concerned. In the case of coal, for example, about 90

per cent of all reserves are found in just three countries (USA, USSR and PRC), and these countries would have to essentially double their production. Furthermore, this coal would have to be transported to the other countries, requiring an enormous increase in rail, pipeline and terminal handling capacity.

28. In the case of the low scenario, the implications on energy supply are still considerable, but clearly much more manageable. Oil and coal would be used at rates approximately 20 per cent less than in 1980, and only nuclear, hydro and natural gas would increase above 1980 levels by factors of 2.4, 1.4 and 0.8 respectively. Since new additions to the supply of a particular energy source are proportionately much more expensive than existing sources, the potential gain by not having to open up new supplies could be very large indeed. The main implications of the low scenario, however, are on energy demand management.

b) Economic and Development Implications

29. The economic implications of the high scenario are also substantial. The investment requirements are so enormous that even the industrialized countries would find them difficult to support. In developing countries, the high level of investment required would siphon off capital required for other sectors, which would be starved. In fact, many now believe that these requirements would be a drag on development making it impossible to improve living standards in developing countries.

30. According to World Bank estimates, US$ 130 billion would have to be invested every year in energy projects in order to raise per capita levels of commercial energy consumption in developing countries from 0.54 to 0.78 kW between 1980-1995 (which is necessary to reach the high projection by 2020). Moreover, half of this, that is US$ 65 billion (compared to the US$ 3.5 billion currently being loaned in the energy sector) would be in foreign exchange, equivalent to about 4 per cent of aggregate GNP of these countries.[8/] This level of investment, involving such a huge charge on foreign exchange earnings would push most energy importing developing countries further into the already serious debt crisis.

31. The economic implications of the low scenario, on the other hand, could be beneficial. While achieving more or less the same level of economic growth as the high scenario, it does it with a much lower level of energy consumption. Not only are investment requirements and corresponding debt burdens lower, but also a greater reliance on renewable forms of energy would have a much higher employment impact, especially in rural areas. Lower levels of conventional energy production would also reduce the required investment to prevent or control that damage. Greater reliance on renewables, if properly managed, could lead to significant opportunities for environmental regeneration, providing an economic base for reforestation, wasteland reclamation and other measures.

32. Although it is not possible to quote a figure for the overall investment requirements of the low scenario, as it was done for the high scenario, it can be shown that under a wide range of circumstances, the extra capital

requirements for improved end-use technologies will be more than offset by capital savings for lowered energy needs.[9/] For example, in the case of Brazil, it has been shown that for a discounted, total investment of $4 billion in more efficient end-use technologies (e.g., more efficient refrigerators, lighting, motors, etc.) it would be feasible to defer construction of 21 GWe (gigawatts electric) of new electrical supply capacity, corresponding to a discounted capital savings for new supplies of $19 billion in the period 1986 to 2000.[10/]

33. Similarly, in the case of an advanced steel making process, such as the Swedish Elred and Plasmamelt processes, the overall investment requirements are in fact lower than for conventional ones, accompanied by savings of 50 per cent or more in energy consumption.[11/] Again, the difference saved could be invested in some other sector of the economy.

c) Environmental Implications

34. The high scenario with its heavy reliance on fossil fuels and its huge requirements for investment in other conventional sources of energy, carries equally staggering environmental implications.

35. In terms of fossil fuel use, for example, the high scenario would result in substantial increases in the consumption of coal, oil and natural gas. It is the increase in the first of these, coal, which is most worrysome, since the environmental and health impacts of coal are greater than those of oil. Overall, there would be a more than a doubling of the production of carbon dioxide, which would bring the world much closer

to possible major climatic changes. Increased fossil fuel combustion in power stations as well as in automobiles would also aggravate the acid rain problem in industrialized countries and developing countries alike.

36. In developing countries, the indirect environmental impacts of such a high energy use scenario could be disastrous. On the one hand, local energy supplies would have to be substantially increased. Carelessly installed energy development projects, such as the construction of large dams have greatly contributed to land degradation and consequent environmental impacts.

37. On the other hand, the high energy costs implied by such a high-energy future will require energy importing developing countries to step up commodity production for export (as opposed to production for local consumption) to be able to pay for the higher debts incurred. More land has to be devoted to non-food, export oriented agricultural production, which means either the opening up of more forests (i.e., deforestation) or/and the marginalization of even more subsistence farmers onto marginal, lower quality lands. In both cases, the environment suffers in the process. Deforested land is often misused, and results in eroded topsoils. Marginalized farmers are obliged to overuse the low quality soils, and the results are again the same. Soil erosion, silting up of reservoirs downstream, and eventually floods. In all cases, the impacts have tremendous developmental costs, which society as a whole has to pay for.

38. In the case of the "Low" scenario, there will remain a large number of evironmental impacts to be avoided or abated. There will, however, be no increases above the 1980 levels. In fact, although fossil fuel use remains essentially constant, there is a small drop in the rate of CO2 production due to changes in the fossil fuel mix (i.e., more natural gas and less coal and oil). This will slow down the rate of climatic change, giving more time for the world community to deal with the problem.

B. REDUCING FOSSIL FUELS

39. Although all energy systems have undesirable environmental impacts, high levels of fossil fuel consumption are a special concern, particularly in industrialized countries, and in the industrialized and urban regions of developing countries. They pose three interrelated threats to sustainable development: air pollution[12/], acidification of the environment[13/] and climatic change[14/]. Some industrialized countries may possess the economic and social resilience and institutional capacity needed to cope with these threats, but most developing countries do not. In developing countries the principal threat is the foreign exchange costs of the imported fuels (See Table 3), and of the pollution control equipment. Moreover, in many of them, the high energy scenario would impose even greater direct damage to their resource base, accelerating deforestation, erosion, siltation and flooding and reinforcing the fuelwood crises. We will come back to this after a brief look at the fossil fuel implications.

Country	1983	Country	1983
Central & S. America		**Africa**	
Argentina	9%	Algeria	2%
Brazil	56	Burkina Faso	50
Chile	24	Cameroon	4
Colombia	21	Egypt	12
Costa Rica	22	Ivory Coast	16
Dominican Republic	71	Madagascar	32
El Salvador	57	Morocco	57
Guatemala	68	Niger	17
Honduras	28	Senegal	58
Nicaragua	46	Sudan	57
Panama	82	Togo	18
Paraguay	1		
Peru	2	**Asia**	
Trinidad & Tobago	4	Bangladesh	20%
Uruguay	28	Hong Kong	7
Venezuela	1	Indonesia	20
		Korea, Rep. of	28
Europe		Malaysia	16
Greece	59%	Pakistan	49
Portugal	48	Philippines	44
Turkey	66	Singapore	40
Yugoslavia	33	Sri Lanka	40
		Thailand	39
		Middle East	
		Jordan	101%

Source: World Bank *World Development Report 1985.*

Table 3: ENERGY IMPORTS AS A PERCENTAGE OF MERCHANDISE EXPORTS IN DEVELOPING COUNTRIES
(Source: Miller - 1986)

a) Air Pollution

40. During the past three decades of rapid growth, urban air pollution has increased dramatically, more or less in pace with fossil fuel consumption for space heating (and cooling), automobile transport, industrial activities and power generation. Beginning in the late '60s, a growing awareness of the effects of polluted air on human health, property and the environment

created a demand for action. Some industrialized countries responded, enacting control measures of various kinds. Most imposed standards that resulted in the development of curative measures, including add-on technologies. Some imposed liability and required compensation for damage, especially damage to human health. While expensive, this react-and-cure approach led, in time, to reduced emissions of some of the principal pollutants and cleaner air over some cities. London, Tokyo, Montreal and New York are a few of the better known success stories. In time, it also induced innovation in the development of environmentally efficient technologies for household cooking and space heating, for industrial processes and for power generating.

41. Many industrialized countries, however, and virtually all developing countries failed to share in this experience. Instead, they witnessed a steady deterioration in the quality of their air with all its attendant effects. Air pollution has reached dramatic levels in most major Third World cities, far exceeding the worst cases of the '50s in western industrialized countries. Sao Paulo, Rio de Janeiro, Buenos Aires, Lagos, New Delhi, Bangkok and Seoul and many other cities feature in recent studies. Mexico City, already known as one of the worst air pollution cases in the world, suffered a 50 per cent increase in levels of contamination in 1979 alone.

42. The fossil fuel emissions of principal concern include sulphur dioxide, nitrogen oxide, carbon monoxide, various hydrocarbons, fly ash and suspended particulates. They attack human health, damaging body tissue and the nervous system, bringing increased

respiratory diseases and cancer, and causing higher morbidity and mortality in sensitive segments of the population. Transformed into acid, they burn and kill vegetation, corrode buildings and vehicles and eventually contribute to land and water pollution. Excepting a few western industrialized countries, studies of the social and economic costs that these effects impose on the economy of communities and nations are non-existent, or non-available. The few studies available, however, demonstrate that they are enormous, and in most of the world they are growing rapidly.

43. The sources of air pollution vary from city to city. So do the impacts, given each city's unique natural setting, altitude, climate and weather patterns. Factories, industrial plant and other fixed activities are a major source. The heavy oil burnt for household heating and thermal power generation is a leading cause of sulphur pollution. Trucks and automobiles contribute heavily to emissions of nitrogen oxide, carbon dioxide and hydro carbons. In many Third World cities, a thick film of smoke from burning raw coal, wood, charcoal and animal dung for cooking and heating provides a constant reminder of the toxic nature of the air being breathed.

44. Today, the fossil fuel sources of air pollution are largely controllable in both industrialized and developing countries. Most are preventable, and at a cost to the community and nation that is usually far less than the damage costs that will otherwise be incurred, not to mention the eventual costs of retrofitting vehicles, homes and industry, when the effects of air pollution exceed the limits of community tolerance.

45. Under the high energy scenario, however, both prevention and control would be extremely difficult and expensive. Indeed, given projected economic trends on the one hand, and the state of awareness, legislation and institutional capacity in most developing countries on the other, it is doubtful that they could keep up with future sources, let alone catch up with present sources and cure past damage. For similar reasons, this may well be beyond the capacity of many industrialized countries.

46. The most cost-effective means of prevention available, perhaps the only ones available to some industrialized and all developing countries given the high cost of pollute-and-cure processes, are those implicit in the low energy scenario. Moreover, these and other means would reinforce those needed to prevent and control another major fossil fuel threats to sustainable development: acidification of the environment.

b) Acidification of the Environment

47. The measures taken by industrialized countries in the '70s to control urban and industrial air pollution (high stacks, for example) very often simply transferred the problem elsewhere, to another media or, more seriously in the short run, to the hinterland in their own and other countries. This was manifest in a rapid rise in transboundary air pollution in Europe and North America and in widespread acidification of the environment. In consequence, as shown in Figure 5 the perception of air pollution has shifted from that of a local problem, involving one or more communities, to that of a regional problem involving entire continents.

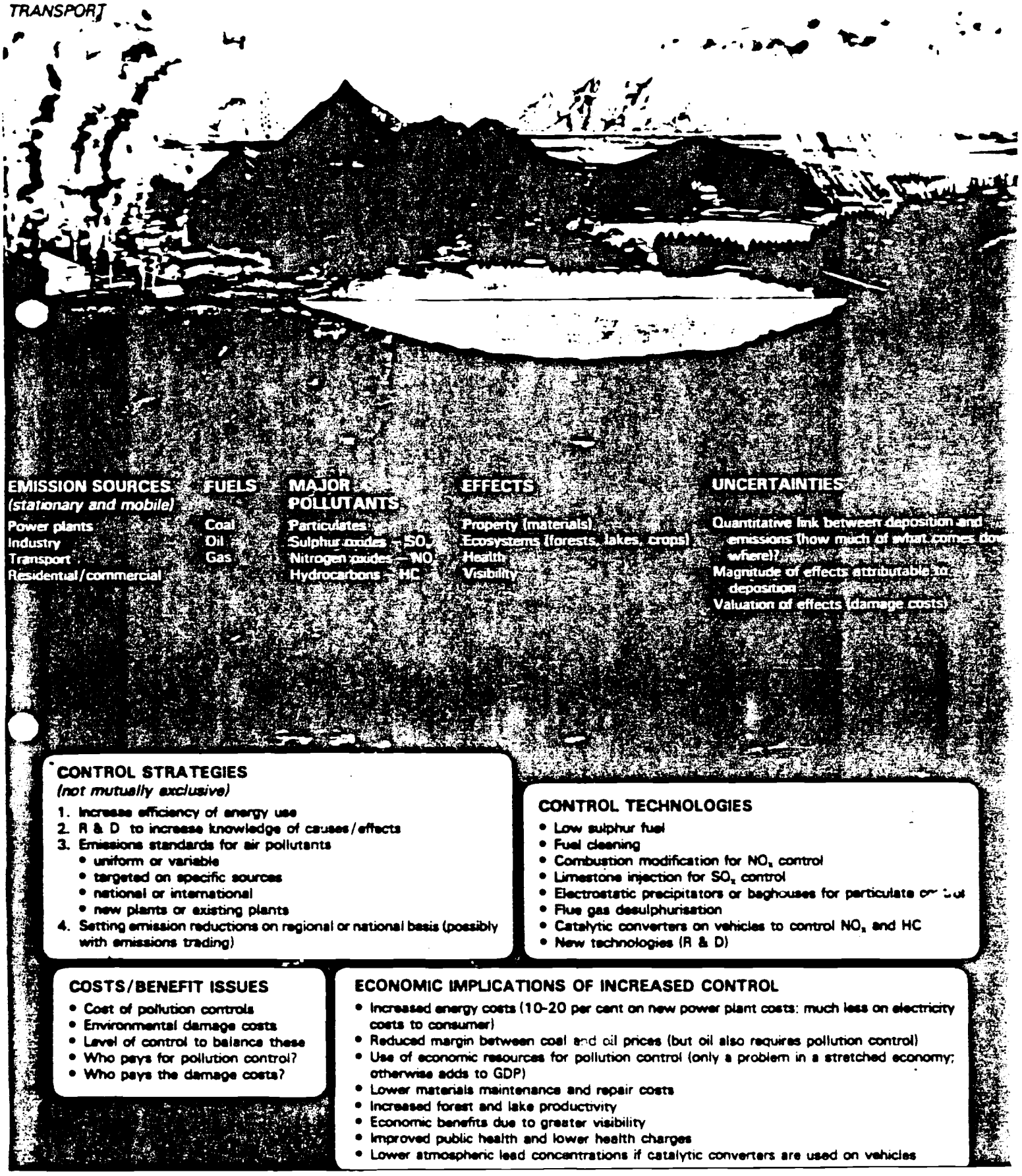


Figure 4: SCHEMATIC VIEW OF THE ACID RAIN PROBLEM

(OECD-1984)

WCED:0331j-0378j/JP

48. During long distance transport in the atmosphere, emissions of sulphur oxide, nitrogen oxide and volatile hydrocarbons are transformed into sulphuric and nitric acids, ammonia salts and ozone. They fall to the ground, sometime thousands miles from their point of emission, as dry particles or in rain, snow, frost, fog and dew.

49. Silently accumulating over the decades, the damage to the environment first became evident in Scandinavia in the '60s and has since mounted at an accelerating pace. Several thousand lakes in Europe and North America have registered a steady decrease in pH levels to the point where they no longer support fish life. The same acids attack stonework and corrode metal structures causing billions in damage annually. It enters drinking water supplies, liberates potentially toxic metals such as cadmium, lead, mercury, zinc, copper and aluminium, and poses risks to human health.

50. The evidence underlying the urgent need for action on the sources of acid rain is mounting with a rapidity that exceeds the capacity of scientists and governments to assess it.[15/] Up to now, the greatest damage has been reported over Eastern and Western Europe, which are currently receiving more than one gramme of sulphur on every square metre of ground each year. There was little evidence of tree damage in Europe in 1970. In 1982, the Federal Republic of Germany reported visible damage to 8 per cent of its trees; in 1983, this rose to to 34 per cent and to 50 per cent in 1985.[16/] Sweden reported light to moderate damage in 30 per cent of its forests; and reports from other countries also become extremely disquieting. So far an estimated 5-6 per cent of all European forest land is affected.

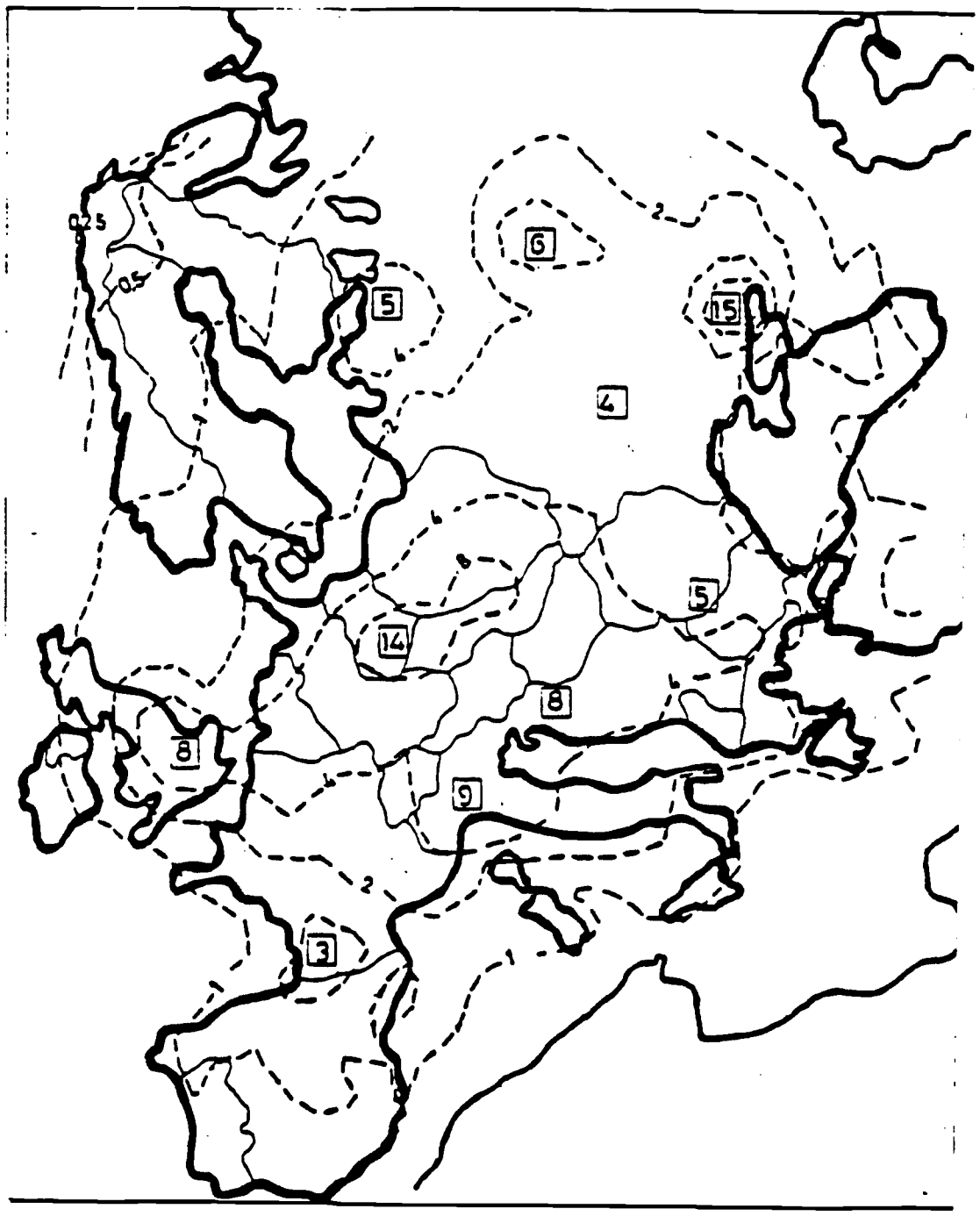


Figure 5: ACID DEPOSITION ON EUROPE (Isolines of Average Annual Total Deposition of Sulphur, expressed as grams of sulphur per square meter of ground per year, based on the period October 1978 - September 1982. Maxima are shown as boxed numbers. Source: adapted from EMEP/MSC-W Report 1/85)

WCED:0331j-0378j/JP

51. Have European soils reached a trip-over point? The evidence is not all in, but many reports consistently show soils in parts of Europe becoming acid throughout the tree rooting layers (c. 100cm deep). The acidity is frequently below pH 4.0 when aluminium comes into solution as a mobile element, toxic in very low concentrations to plant roots. Forest death could be caused by the co-action of acid soils containing mobile aluminium and by direct needle damage in conifers from the interaction of the pollutants mentioned above.

52. If this is true, we may be witnessing in Europe an immense, regional acid-base chemical titration with potentially disastrous results being signalled by widespread tree damage and death, in effect, a kind of "environmental litmus paper", indicating a change to irreversible acidification whose remedial costs are beyond economic reach. Comparatively speaking, forest death on a regional scale would be socially and economically trivial compared to such consequences as erosion, siltation, flooding of farmlands and towns and local climatic change.

53. The effects of air pollution, such as forest death, acidification of lakes and damage to structures is evident. The sources are multiple, including damage from ozone and suplhur dioxide, deposition of excess nitrogen-nitrate-ammonia, and the deposition of acids and heavy metals. No single pollutant control strategy is likely to be effective in dealing with forest decline - it will take nothing less than a total integrated mix of strategies and technologies, tailored for each region, to significantly improve air quality.

54. Evidence of acidification in the newly industrializing countries of Asia, Africa and Latin America is beginning to emerge. China, Korea and Japan seem particularly vulnerable, given industrialization trends in the former two, as do Venezuela, Colombia, Ecuador and Brazil. So little is known about the likely environmental loading of sulphur and nitrogen and about the acid neutralizing capacity of tropical lakes and forest soils that, at a minimum, a comprehensive programme of investigation should be formulated without delay.[17/]

55. Developing countries cannot afford to repeat the mistakes made in Europe and North America. In the US, it has been estimated that reducing sulphur dioxide emmissions by half from existing sources would cost US$ 3-4 billion a year, increasing electricity rates by 2-3 percent. If NOx were figured in, the costs might be as high as US$ 6 billion a year.[18/] Estimates of the annual costs of securing a reduction in sulphur emissions in EEC Europe of 55 to 65 per cent between 1980 and 2000 range from US$4.6 to $6.7 billion (1982) per year. Controls on stationary boilers to reduce nitrogen levels by only 10 per cent per year by 2000 range between US$ 0.1 and $0.4 billion (1982). While high in absolute terms, even in countries whose energy systems depend heavily on coal-based thermal power, these figures translate into a one time increase of about 6 per cent in the price of electrical power to the consumer.

56. Estimates of damage costs in Europe are less reliable and, given the trends noted above, necessarily very conservative. Nonetheless, studies place damage costs due to material and fish losses alone at US$ 3.0

billion a year; while damage to crops, forests and health are estimated to exceed US$ 10.0 billion per year. But again, the evidence is not yet in. Recent Japanese laboratory studies indicate that air pollution and acid rain can reduce some wheat and rice crop production, perhaps by as much as 30 per cent. Given population trends and the needs for future food security, these are costs that no developing country would wish to contemplate.

57. Yet, in pursuing the high energy "trend" scenario, developing countries will inevitably incur substantial acidification with its attendant damage costs and threats to their sustainable development. Industrialized countries must either continue to accept these costs or adopt expensive retrofit measures. The dilemma of deciding who should bear the cost of curative measures, and when and how, has divided the nations of North America and Europe and driven acid rain to the top of their agendas for regional action.

58. The strategies implicit in the low energy scenario offer the most cost-effective means of reducing future levels of acidification in industrializing and developing countries alike. And they would buy time for the nations of the world to assess and prepare for the implications of global climatic change.

c) Climatic Change

59. Upon combustion, fossil fuels also emit the gas carbon dioxide, which accumulates in the atmosphere. The pre-industrial concentration was 280 parts of carbon dioxide per million parts of air (by volume - ppmv). This concentration reached 340 ppmv in 1980 and is

expected to double (to 560 ppmv) between the middle and the end of the next century. How soon depends almost entirely on the energy paths followed in the meantime. In contrast to the emissions mentioned above, no technologies exist to control the emissions of carbon dioxide.

60. Other gases are also accumulating in the atmosphere, principally, chlorofluorocarbons (used as aerosol propellants in spray cans and in refrigerators as a coolant); methane (rising from wet, reducing soils, e.g. rice-paddies, or from the earth's surface, especially where oil or gas is exploited); nitrous oxide (derived from the breakdown of nitrogenous fertilizers); and ozone (generated by industry and internal combustion engines).

61. The question of climate warming caused by rising concentrations of these "greenhouse" gases in the atmosphere has been the object of intense assessment, nationally and internationally. The question is enormously complex given the interactive nature of the meteorological, oceanographic and ecological factors conditioning climate, ecosystem and sea level responses.

62. After reviewing the latest evidence in October 1985, however, scientists from 29 industrialized and developing countries concluded that climate change must be considered a "plausible and serious possibility".[19/] They estimated that the concentration of greenhouse gases in the atmosphere could lead to a rise in global mean temperatures in the first half of the next century "greater than any in man's history". A global warming of 1.5°C to 4.5°C at the equator (greater at higher latitudes) should be anticipated within the next 45 years.

63. Before the warming effect of the other trace gases was appreciated, it was thought that CO_2 alone would not generate such a rise until much later - the last half of the next century. The effect of the other trace gases, however, which are increasing rapidly, is to advance considerably the date of significant warming.

64. The great concern, of course, is that a global warming of 1.5 - 4.5^{o}C would lead the sea level to rise from 25 - 145 cm, caused mostly by thermal expansion of sea water. This would inundate low lying coastal cities and agricultural areas, and many countries could expect their economic, social and political structures to be severely hit.

65. As rising seas invade and shift the boundaries of coastal states and modify the levels of shared bays, estuaries and international waterways, local agony could translate swiftly into international crisis. This would be accentuated by the effects of changing climate on inland crops, forests and ecosystems. Although knowledge about these effects cannot be certain until they occur, experts believe that crop boundaries will move to higher latitudes, and will do so much quicker than forest boundaries because of the longevity of trees. The effects of warmer oceans or marine ecosystems on fisheries and food chains is also virtually unknown.

66. Melting of small glaciers would result in a further rise of 20^{+}cm over a century. It is now thought unlikely that a global temperature rise of 4.5^{o}C would eventually cause the Western Antarctic Ice sheet to collapse. But if so, this would add another 5 metres to ocean levels gradually, it is thought,

perhaps over several hundred years. However gradual, the reality based on by then past experience and the knowledge that, by then, system inertia may be irreversible, would increase the agony of coastal areas and sharpen sources of international dispute.

d) Some Policy Directions

67. Nobody knows how communities and nations will respond to these situations as they evolve. Governments, however, and the world community are in a position to anticipate them and to take certain measures to prevent them or reduce their impact or, in the case of climatic change, at least buy time to facilitate adaptation to the consequences.

68. We seem to be entering an era where sooner or later nations will have to formulate and agree upon long-term policies for all energy-related activities affecting sustainable development and influencing the radiation climate on earth. This will not happen soon, but given the complexities of international negotiations on such issues and the time lags involved it is urgent that the process start now.

69. What is needed for these energy-related issues, in fact, marked as they are by varying degrees of uncertainty, is a three-track strategy combining, on the first track, improved monitoring and assessment of the evolving phenomena; on the second, increased research to improve our knowledge about the sources and effects of the phenomena; and, on the third track, the development and implementation of new or modified clusters of economic, finance, trade and sectoral policies that would prevent or reduce avoidable and

destructive impacts of these phenomena on human health, resources and ecosystems, especially those involving a high risk of irreversibility and transgenerational transfers.

70. No single nation has the institutional, professional and resource capacity needed to undertake the research, monitoring and assessment that is now required. And no nation has the political reach to entertain the changes in the structure of policies that will be necessary. Increasingly sophisticated forms of international burden sharing to address these issues are required at both the regional and global levels. This should include an immediate start on an internationally-binding convention covering all energy-related environment and development questions.

71. While this proceeds, more immediate policy measures can and should be adopted. The most urgent, as mentioned earlier, is an effective arrangement to stabilize wild fluctuations in the world energy prices and hold them at levels that will maintain steady gains in energy efficiency and a shift in the energy mix towards more renewables. A wide range of specific measures are available to increase energy efficiency in housing, industry, transportation, agriculture and other sectors. Most are very cost-effective and the potential has scarcely been touched. Carbon dioxide output globally could be halved by energy efficiency measures over the next 50 years or so without any reduction of the tempo of GDP growth. And, as noted earlier, these measures would also serve to reduce other emissions and thus reduce acidification and air pollution. In addition, they would also improve balance of payments, reduce debt burdens and provide rich sources of revenues for countries to improve sound fiscal management.

72. Many other mutually reinforcing measures should also be entertained. Measures to deliberately switch the fossil fuel mix, for example. The current global energy mix (per cent) is oil 41; coal 24; gas 17; other 18. One TWyr of energy from gas or oil or coal liberates 0.43; 0.62; 0.75 gigatons of carbon respectively.

73. Apart from fuel cleaning and fuel switching, financial mechanisms should be established that build the external costs of different energy sources into their price. Strengthened economic incentives and disincentives favouring environmentally attractive energy investments are needed; as are emission limits, with licences to reflect them; and flexible trading in such licences; and improved regulatory measures.

74. Some measures would serve to control or reduce still other problems. Nitrogen oxides, for example, could be reduced by more careful nitrate fertilizer controls. This may also help to reduce the chronic problem of eutrophication and the growing problem of nitrates in drinking water, currently an important health hazard to small babies in many areas worldwide.

75. Gases other than carbon dioxide are thought to be responsible for about one third of present global warming and it is estimated that they will cause about half the problem around 2030. F11 plus F12 alone are thought to be responsible for 20 per cent of the present day temperature rise, and since they are produced by one large manufacturer worldwide, they might be an obvious starting point for management. A roughly four-fold increase in F11 and F12 is expected before 2050 at present rates of emission; this is

estimated to cause a reduction in the stratospheric ozone shield of 10-30 per cent, thus allowing greater ultraviolet radiation to reach the earth's surface.

76. Nuclear energy could also have an important role to play in attacking all fossil-fuel related issues. The conditions under which its development can be maximized are discussed below. They need to be established and implemented through a new and binding international agreement.

77. Much of the uncertainty concerning the future global energy path could be cleared away if negotiated agreements could set "ceiling" levels for the quantities of the principal transboundary air pollutants, including carbon dioxide and work backward to map out exactly what energy strategies would be needed in future to peg them below these ceilings. The available range of strategies can provide ample room for national priorities and for the energy supply conditions that are unique to each nation, but a lot of policy development work is needed to obtain them. This should proceed hand in hand with accelerated research to reduce remaining scientific uncertainties.

78. What is needed urgently is a concerted act of political will. The uncertainty about where we shall finally end up globally says more about policy irresolution at the political level than any shortcoming in the science of these issues.

C. INCREASING RENEWABLE ENERGY

a) The Potential for Renewables

79. Renewable energy sources provide more than 20 per cent of the energy consumed worldwide, of which 14 per cent is comprised of biomass and 6 per cent of hydro. Worldwide, reliance on these sources has been growing by more than 10 per cent a year since the late '70s, mainly because of a surge in hydro power and wood fuels.

80. Although wood ranks only fourth in the world's energy budget after coal, oil and natural gas, about half the world's population relies on it, mainly for cooking, and its use has been expanding at 2 per cent annually. Wood fuels are the most important energy source for over 2 billion people in developing countries, where 30 - 98 per cent of all energy consumed comes from biomass. Although they are in adequate supply in many countries, 1,300 million people live in areas that can satisfy minimum needs only through unsustainable overcutting; and over 110 million people live in areas where even with such overcutting minimum needs cannot be satisfied. By the turn of the century, unless counter measures are taken now, 3 billion people will suffer from a severe or absolute scarcity of fuelwood.

81. Where fuelwood is scarce people turn to agricultural and animal wastes for fuel. The energy potential of such wastes is very high indeed, especially when used in modern conversion devices, such as gasifiers. However, in most rural societies, much of these wastes have "other" uses, and their diversion for energy purposes may result in problems, such as in particular the diversion of nutrients from agricultural lands

(See Figure 7 below). Policies for enhanced use of biomass wastes, therefore, should be based on careful local studies.

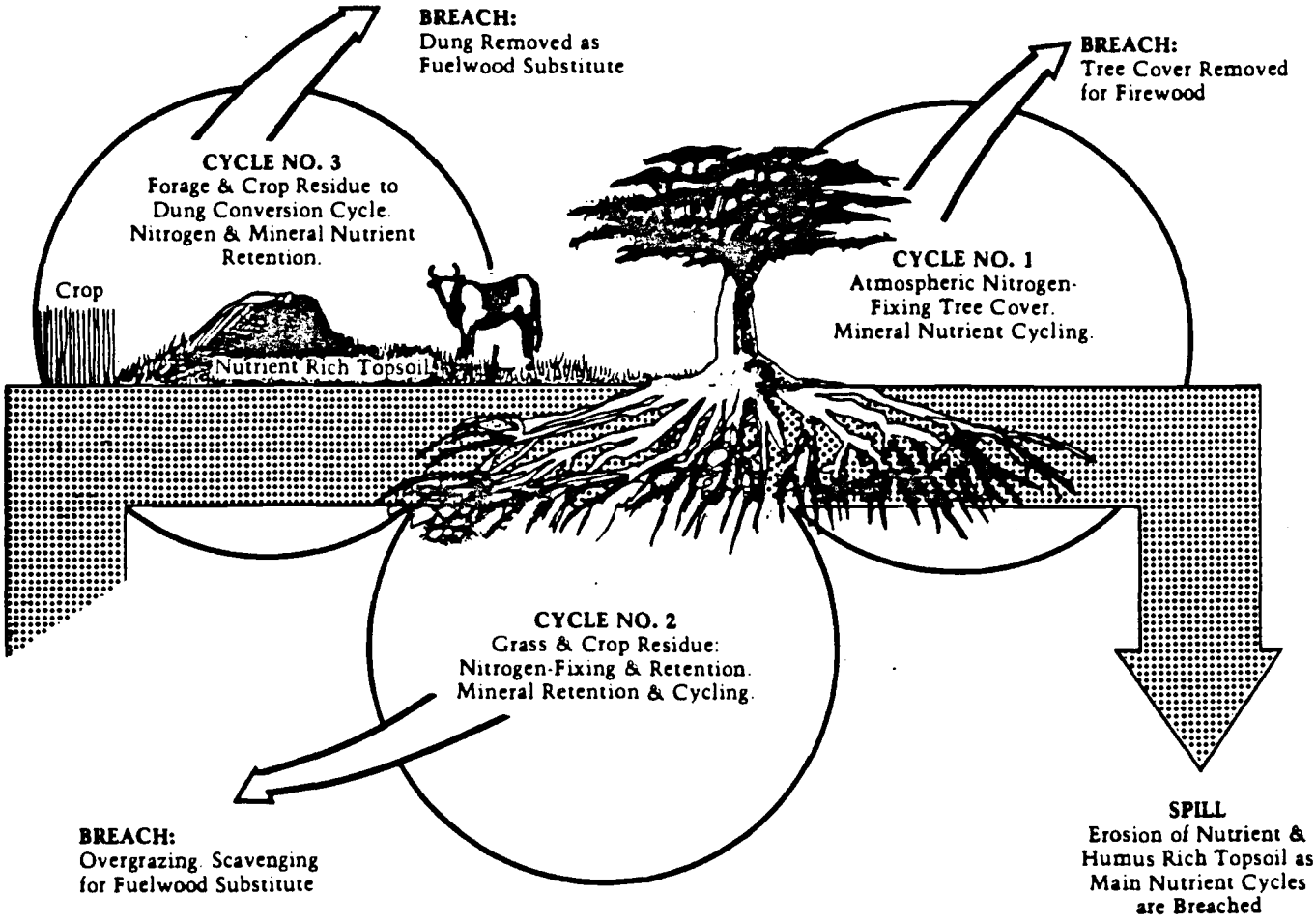


Figure 7: PATTERN OF DETERIORATION IN ETHIOPIAN AGROECOSYSTEMS (Source: Miller - 1986)

82. In contrast, there is a vast unrealized potential for fuelwood use in northern countries. In fact, it is becoming a popular fuel for domestic and industrial heating in Canada, USA and the Scandinavian countries.

83. Hydropower, second to wood among the renewables, has been expanding at nearly 3 per cent annually. Although hundreds of thousands of megawatts of hydro power have been harnessed throughout the world, the remaining potential is huge, especially in the Third World.

84. Solar energy is currently of small importance globally, but it is beginning to assume an important place in the energy consumption patterns of some countries. In many parts of Australia and Greece, for example, solar water and household heating is widespread. Prior to the recent price shock, Israel expected that 60 per cent of its water would be heated by solar energy by 1990. A number of East European and developing countries have active solar energy programmes and the United States and Japan support solar sales of several hundred million dollars a year. With constantly improving solar thermal and solar electric technologies, it is likely that their contribution will substantially increase.

85. The Brazilian alcohol programme in 1984 produced about 10 billion liters of ethanol from sugar cane and replaced about 60% of the gasoline that would have been required in the absence of the programme.[20/] The cost has been estimated at US$ 50-60 per barrel of gasoline replaced. When subsidies are removed, and a true exchange rate is used, this is competitive at 1981 oil prices.

86. Although with the present oil glut the programme has become temporarily uneconomic, the programme provides additional benefits of rural development, employment generation, increased self-reliance, and reduced vulnerability to future crises in the world oil markets.

87. The Brazilian ethanol programme is particularly efficient at generating jobs - requiring and investment of $6,000 - $28,000 per job, which compares with an average of $42,000 for the brazilian industry sector, and $200,000 for the oil-refining, petrochemical complex at Camarcari.[21/]

88. An other promising option is the production of methanol from wood. Like ethanol, methanol has many advantages over gasoline. It produces a clean exhaust gas consisting of carbon dioxide and and steam. However, some health aspects of using alcohol fuels need careful monitoring. For developing countries, methanol from wood is a viable option only if it is linked to large scale forestry programmes. An added bonus of such programmes is that it is possible to obtain charcoal as a byproduct, a nearly smokeless fuel, able to satisfy a number of end-uses in developing countries, including cooking and artisanal requirements.

89. The use of geo-thermal energy has been increasing rapidly, more than 15 per cent per year, in both industrialized and developing countries. Exploration is expected to uncover a world geo-thermal capacity exceeding 10 gigawatts by 1990 and the engineering and other experience gained during the past decades could provide the basis for a major expansion in geo-thermal rich countries.

90. It is difficult to assess the full potential for sustainable development of renewable energies either globally or on a regional or national basis: one estimate placed the long-term maximum potential globally at 10 TW (See Table 4), a value equal to the 1980 level of energy consumption worldwide.[22/]

Source	*1980*	*2000*	*Long-term potential*
		(exajoules)	
Solar energy: passive design	<0.1	3.5–7	20–30
Solar energy: residential collectors	<0.1	1.7	5–8
Solar energy: industrial collectors	<0.1	2.9	10–20
Solar energy: solar ponds	<0.1	2–4	10–30+
Wood	35	48	100+
Crop residues	6.5	7	—
Animal dung	2	2	—
Biogas: small digesters	0.1	2–3	4–8
Biogas: feedlots	<0.1	0.2	5+
Urban sewage and solid waste	0.3	1.5	15+
Methanol from wood	<0.1	1.5–3.0	20–30+
Energy crops	0.1	0.6–1.5	15–20+
Hydropower,	19.2	38–48	90+
Wind power	<0.1	1–2	10+
Solar photovoltaics	<0.1	0.1–0.4	20+
Geothermal energy	0.3	1–3	10–20+
Total	63.5	113–135	334–406+

+ indicates that technical advances could allow the long-term potential to be much higher; similarly, a range is given where technical uncertainties make a single estimate impossible.

< means less than.

Source: Worldwatch Institute

Table 4: WORLD USE OF RENEWABLE ENERGY, 1980, 2000 AND POTENTIAL (Source: Deudney & Flavin - 1983)

91. The remaining potential is clearly very large, however, and could expand significantly with new technologies. While the extent and rate at which renewables are developed will depend on technology, it will depend even more in the short run on policies that attack certain economic, environmental and institutional constraints.

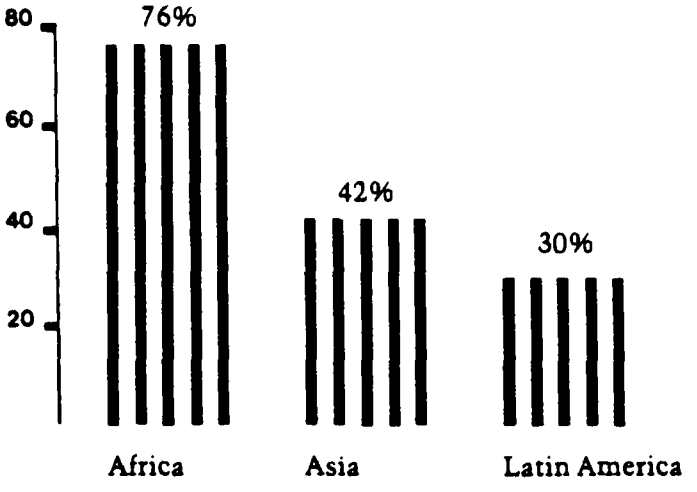
b) The Fuelwood Crisis

92. This is especially true for those developing countries with a vast number of poor, rural and urban household, whose livelihoods and well-being depend on access to local supplies of traditional fuels like fuelwood, cow dung and crop residues. At the same time unprecedented pressures are being placed on the same biomass base from the agricultural and urban-industrial sectors.[23/] Forests are being cleared at a rapid rate to open up new agricultural land and much of this is induced by the need to produce more goods for export (tea. coffee, meat, etc.) to pay debts incurred to import or develop new sources of energy.

93. Some forest loss is inevitable, of course, to make way for human settlements, agriculture and industry. The continued rapid loss of forest cover, however, will be ecologically, environmentally and consequently economically disastrous for the regions concerned. Many of society's most important values are locked up in forests and disappear with them. But apart from that deforestation causes soil degradation and erosion, siltation of reservoirs, reduced electricity production, flooding and loss in agricultural yields.[24/]

94. When fuelwood is no longer available in an area rural people turn to burning biomass wastes, such as cow dung, rice husks and cotton stalks. In some cases these practices do no harm, since a true waste product is incinerated (e.g., cotton stalks). In other cases, however, much needed organic nutrients are diverted from the soil (e.g., animal manure, some wet biomass, etc.). Since developing countries are already using a

great deal of renewables, mostly in the form of woody biomass (See Figure 8), agricultural and animal wastes, the concern is not necessarily to introduce new systems, but in the first place to modernize and make more efficient the existing systems, as is assumed in the low projection.



Source: J. Dunkerley and W. Ramsey, *Analysis of Energy Prospects and Problems of Developing Countries*, Washington, D.C. Resources for the Future, 1983.

Figure 8: PERCENTAGE OF TOTAL ENERGY SUPPLIED BY FUELWOOD, 1980 (Source: Miller - 1986)

95. One fact, however, seems certain. While we cannot go on using fuelwood and other biomass sources the way we do today, no significant substitution seems possible in the near and even medium term future. Given this immediate, and basic need for domestic fuel, and the low level of substitution possibilities, it seems, at least in the short term, that the only way out of this problem is to treat fuelwood like food, and grow it as a subsistence crop.

96. The scarcity of fuelwood, however, represents more than just a lack of an energy source. Trees in rural communities are an important source of livelihood for people, in addition to being sources of fuelwood. In particular, trees supply fruits, fodder, fertilizer, medicines, poles for construction, shade and raw materials for a host of artisanal activities.

97. Wood as a renewable energy source is usually thought of in the context of the traditional sector. This, however, is far from the truth. Wood is an important feedstock for advanced energy conversion processes in both developing and in industrialized countries, including for the production of electricity and potentially for other fuels, such as combustible gases and liquids.

98. Given present trends, in the next few decades the woodfuel crisis will undoubtedly worsen and the theoretically renewable supply of trees will increasingly become non-renewable. Population will grow substantially, and even if per capita consumption remains steady, total woodfuel demand will grow. Proportionately more of this population increase will take place in urban conglomerations, where generally charcoal use is higher. Overall, given the inefficient charcoal kilns now widely used, to deliver the same energy at the point of end-use charcoal requires twice as many trees as straight fuelwood. Consequently per capita wood requirements will grow. Finally, urban and industrial demand for wood based fuels will also grow in the future because of the high price of alternatives, either in the form of traditional fuelwood and charcoal, or as feedstocks for more advanced biomass conversion systems.

99. The challenge ahead of developing countries is tremendous: to stabilize, and increase sustainable wood production to satisfy all legitimate demands in all sectors, at a time when unprecedented, and increasing pressures are exerted on these same resources from agriculture and industry.

100. Often the picture is further complicated by complex socio-political factors. In many areas, in spite of a relative abundance of trees the availability of woodfuels is very low. One finds that the reasons tend to include problems like access to and ownership of trees, or the role of women in society.[25/]

c) Toward a Renewable Energy Economy

101. The policies required for a steady transition to a broader and more sustainable mix of energy sources are beginning to emerge. Those associated with the high scenario, however, with their emphasis on fossil fuels and other conventional sources would have a negative effect on this essential process. National and international institutions would remain attached to supply-side planning and the promotion of conventional fuels. The limited budgets available for energy research and development would continue to focus almost entirely on improving conventional sources.

102. In contrast, the policies implicit in the low scenario could favour the promotion of renewables. The low scenario, for example, requires decentralized energy systems, able to satisfy a wide range of end-uses, employing the most economically available sources. Very often, this will be various forms of energy saving measures: insulation for space heating and cooling;

fuel-saving vehicles; energy efficient production machinery or processes; co-generation; etc. Or, it could be various forms of locally available renewables: active or passive solar; biomass; etc.

103. With the exception of large-scale hydro, most renewable energy sources are compatible with the less intensive, decentralized systems that now exist in most developing countries and that will emerge in other parts of the world. In fact, most renewables are characterized not only by decentralization, but also by diversity. Unlike non-renewables, this enables each country to tailor its energy economy to its indigenous resources. Although, every country possesses some sun, wind and biomass, some are better endowed with certain renewables than with others. Some may wish to rely on one locally abundant form of renewable energy; hydro power, for example. Others may be able to develop highly diversified renewable energy economies. Biomass gasifiers, biogas plants, small hydro installations, and most solar and wind systems work well in small to medium scale and are often the best match for family and village or community use, especially in developing countries. Some large countries or regions, Brazil, India, North America may be wise to develop the entire panoply of renewable sources: from energy crops, including alcohol and wood fuel plantations through to wind, solar and photovoltaics.

104. As they evolve, renewable energy economies will also reinforce the self-reliance goals of most developing countries. Certain renewable energy systems could either displace imported fuels, or satisfy new demands without the need to import additional energy. This is particularly true of hydro-electric plants, biomass gasifiers, biogas plants, ethanol distilleries, various solar electric and solar heat systems.

105. For developing countries, reliance on locally available energy sources should improve balance of payments and reduce debt loads. The outlays of foreign exchange are negligible, particularly if conversion hardware is locally manufactured. In addition, many renewable sources are virtually inflation-proof. Once the initial investment is made, the cost of running hydro and solar is tied to maintenance.

d) Some Policy Directions

106. A number of policy measures are critical to speed the transition to renewables, policies that reinforce the low energy scenario and vice versa.

107. The economic, social and environmental consequences of renewables require serious evaluation and comparison with non-renewables. Sustainability is the limiting factor with some renewables. Using them above sustainable limits will render them non-renewable, and consequently unsustainable. It is very important that these limits be continuously assessed and monitored in every country. Countries should undertake a full assessment of their potential for renewable energy, and the economic, social and environmental consequences of steady shift to renewables.

108. The influence of unreasonably low fossil fuel prices has already been noted. The high level of hidden subsidies for conventional fuels built into the legislation and energy programmes of most countries also distort choices against renewables. These subsidies are legion, including not only research and development, but also depletion allowances, tax write-offs and direct support of consumer prices. Countries should undertake a full examination of all subsidies and other forms of support to various sources of energy and publish the results.

109. Beyond that, given the advantages of a renewable energy economy to their development, countries should also reorient certain fiscal and tax policies that now penalize renewables. At a minimum, they should be neutralized and in some cases they should be recast to give individuals, entrepreneurs, private companies and parastatals the promise of a gain sufficient to induce them to invest in new energy technologies that improve both economic efficiency and the environment. Developing countries should consider the establishment of small venture capital funds at national, regional or global level to finance renewable energy projects. International development assistance agencies and financial institutions should assist in this.

110. Both industrialized and developing countries should critically evaluate the feasibility of shifting the basis of thermal power generation from the combustion of fossil fuels to gasification. Where available, biomass fuels should be included in the assessment. Following comprehensive economic analyses, wherever feasible, countries should step up the pace of shift from coal and oil to gas and renewable energy sources, such as solar thermal, solar photovoltaic, biomass, and eventually subject to the resolution of the waste disposal, safety and non-proliferation issues, to nuclear power. In particular, the transport fuel base should be shifted from gasoline and diesel to alcohol fuels where a full socio-economic comparative analysis shows this to be worthwile under local market conditions.

111. Progress in renewable energy technologies depends on a much greater level of research and development. The current effort has registered some success, but in most

countries it is dwarfed by the effort put into fossil fuels and nuclear. In addition to increasing the level of direct support, all countries should offer high tax write-offs to corporations that undertake research into new energy technologies and high investment write-offs for tax purposes for investment in energy-saving or new energy technologies.

112. The shift to a renewable energy economy in developing countries must include strategies for the stabilization and increase of sustainable wood production to satisfy growing demand, both in the traditional and in the modern sectors. This has to be carried out in environmentally favourable ways, which enhance and not reduce the countries' agricultural priorities.

113. In particular, existing trees and forests will have to be managed in environmentally and economically sustainable ways. Additional trees and forests should be planted in different ways; agroforestry programmes, large- or small-scale dedicated energy plantations, village- and community-scale woodlots or as conventional forests. The aim should be to make tree growing financially viable. Where possible, wood conversion processes should be made more efficient, particularly in charcoal making.

114. In the subsistence sectors, the need is to make available food and fuelwood together, locally where the demand is and not in distant countries and forests respectively. The definition of what is local is site-specific, but presumably extends to that boundary, within which distribution is still feasible.

115. Particular attention should be paid to enhancing fuelwood supplies for subsistence farmers (where most fuelwood is still collected as a "free" good). Extension work, appropriate agricultural and agro-forestry programmes, mostly organized by local communities and NGOs and in particular the role of women must be strengthened and supported.

116. In examining their current structure of energy subsidies, the governments concerned should therefore pay special attention to the fuelwood crisis. Those fiscal, tax and other policies that induce practices adding to pressures on fuelwood should be reversed and special programmes of incentives to farmers to augment fuelwood resources should be introduced. This could include annual loans to farmers based on the number of surviving trees every year, till the initial crop is harvested, recovering these loans from the sale of the crop.

117. Institutional barriers to renewables are formidable in many countries. Electrical utilities, for example, often have enjoyed a complete monopoly not only in power distribution (which is normally justifiable) but also in power generation. In some countries, a relaxation of these powers, requiring utilities to buy power generated by industry, small systems and individuals at avoided costs, has created many opportunities for the development of renewables. Beyond that, requiring utilities to adopt an end-use approach in planning, financing, developing and marketing energy can open the door to a wide range of energy saving measures as well as renewables. All countries should consider this urgently and international development agencies should support it.

118. More efficient woodstove programmes do help in saving wood, but their main benefits will be cleaner and healthier kitchens and more available time for the women to do other activities than searching for fuel. More efficient stoves, and other wood saving technologies like aluminium pots and pressure cookers make sense in areas where wood is purchased, and saved wood translates into saved money. In rural areas, changing cooking habits is more difficult, and not strictly necessary from an energy point of view. General improvements in the standard of living due to increased agricultural or small-scale industrial production, etc., generally result in people opting for more efficient cooking and other energy conversion appliances anyway. Clearly, countries should adopt all possible methods to increase the efficiency of use of renewables in the home. Where efficient distribution can be assured, developing countries should take up phased time-bound programmes designed to gasify biomass used as a cooking fuel. Developing countries should also exploit crop residues as an important source of biomass and use them scientifically to yield cooking fuels.

D. MAKING NUCLEAR ENERGY ACCEPTABLE

119. Nuclear energy is one of the most important potential sources for centralized production of electricity for the future.[26/] It is part of the quest for clean power in the post fossil fuel world, primarily of interest in the industrialized countries, though some of the newly industrialized countries which are not well endowed with other resources also have ambitious programmes. Both the "High" and the "Low" projections assume a certain growth of nuclear power. In the former the projected installed capacity by 2020 would be 8.1 TW, compared to 0.2 TW in 1980, while in the latter 0.8TW.

120. Nuclear energy, however, is facing a number of serious problems. The resolution of the problems of radioactive waste disposal, including the decommissioning of nuclear reactors, and the public perception of the nuclear fuel cycle are the most important, although other critical issues exist, such as safety questions, trade in nuclear technology, the appearance of new types of reactors and the proliferation of nuclear weapons.

121. The Chernobyl accident strengthens the view of this Panel that no nation can make decisions on energy matters on its own. Just as much the fossil fuel emmission from a plant may cause harm in a neighbouring or even distant country, or the damming of a river may have implications in a neighbouring country, nucear safety issues also have regional and even global implications. A sovereign nation may decide that lower safety levels can be tolerated in a nuclear reactor, but in case of an accident the released radioactive fallout does not respect national boundaries. Nuclear safety is a regional, often global concern, and consequently should be the subject of internationally binding agreements and conventions supervised by the IAEA and other international bodies.

122. Such an agreement should provide that, in the case of an accident, neighbouring countries would be notified immediately and automatically. Detailed information about the nature of the accident should follow quickly concerning not only the releases of radioactive materials, but also any other information necessary to enable neighbouring countries to take appropriate preventive action.

123. In most countries nuclear power agencies have lost the confidence of the public. There seems to be a mixture of various strategies which would have to be followed for a long time to regain this confidence.[27/] These strategies will have to include a demonstrated record of safe operation of the nuclear fuel cycle, new reactor types which are inherently safe rather than inherently unsafe, much more transparency in all sectors of the nuclear fuel cycle, and resolution of outstanding questions of decommissioning of nuclear reactors and radioactive waste management, including sites for the permanent disposal of high-level radioactive wastes. The clear separation of civilian and military nuclear activities in all countries is also a necessary condition for making nuclear power acceptable.

124. The resolution of the problem of disposal of radioactive wastes will not be easy, partly due to the extreme complexity of any of the proposed or potential disposal methods, but mostly due to the fact that "absolute" proof of safe disposal is impossible; only time will tell if the disposal configuration chosen today will function as designed. This time can be as long as up to a million years. It must also be kept in mind that while very little data is available from industrialized countries, who are members of the nuclear club, on the sources of radioactive waste, a large proportion of those wastes come from the processing of nuclear fuels used for non-pacific uses, i.e., in the production of nuclear weapons.

125. Some countries have introduced legislation tying any further growth of nuclear energy and export/import of nuclear reactor technology to a satisfactory solution

of the problem of disposal of radioactive wastes. This has intensified the search for environmentally acceptable forms of management of these wastes, and has brought some nations closer to solutions for their final disposal. We welcome this, and urge that all nuclear countries introduce similar, and increasingly strict legislation.

126. Consequently, the technology of disposing of even the long-lived, high-level wastes in environmentally acceptable ways has now reached the stage of technical feasibility, and a number of nations are well underway in the implementation of waste disposal programmes.[28/]

127. The extremely long time horizons create particularly difficult problems. The question arises, whether this generation has the right to bury wastes in geological formations, which may harm future generations, however small that probability may be. In fact, geological disposal of long-lived radioactive wastes is an attempt to bypass the polluter pays principle, by transferring some of the potential costs and radiation harm of the back-end of the nuclear fuel cycle to generations not yet born. This is more than a theoretical question, since at least in principle, it is possible to transmute the long-lived nuclides to ones with much shorter half lives - although at higher cost.[29/]

128. We propose that all governments establish a goal of working toward "closing" energy cycles. The aim would be to extend the polluter pays principle into the time dimension. The ideal of achieving clean-up at exactly the same time as energy production will in most cases be impossible, but efforts should be made to reduce the time delay as much as practically possible, preferably

within the same generation. In particular, we recommend that the "transmutation option" for the elimination of long-lived radioactive wastes be further studied and developed to reach the stage of technical feasibility in order to allow full cost/benefit comparison with the "geological disposal option" presently practiced.

129. The disposal of radioactive wastes is one area which lends itself well to international cooperation. Small nations do not possess all the scientific, technical capability to carry out the necessary research and development work. Some nations have superior/inferior geologies for the disposal of radioactive wastes. Consequently, the scope for international co-operation on the development of waste disposal methods, and where possible on international/regional repositories is great.

130. In this context, there is urgent need for the creation of an international review group, consisting of top-level experts, independent of their governments to generate guidelines and evaluate national proposals for the disposal of radioactive wastes - a role similar to that of the International Commission for Radiation Protection (ICRP) in the area of radiation dose and protection.

131. Recently, some industrialized, nuclear countries (e.g., FRG, Switzerland, etc.) have shown interest in making agreements with developing countries (e.g., PRC, Sudan, Ethiopia, etc.), whereby the latter would take the nuclear wastes of the former for a fee. Although as of date of writing no such agreements have yet been signed, the possibility is very dangerous indeed. This

Panel considers this irresponsible, even when the recipient country has agreed to do so. Such a practice would be yet another attempt to bypass the polluter pays principle by shifting some of the potential costs and radiation harm of the back-end of the nuclear fuel cycle to a different geographical location than where the beneficiaries are located. Radioactive wastes should be disposed on the territory of the country enjoying the benefits of nuclear power. On the rare occasion, when this is not possible for geological or other reasons[30/] disposal in an other country should be subject to strict international safeguards, supervised by the IAEA and the independent review group proposed above.

132. It is likely that in the future a number of new countries will join the international nuclear reactor buyers. One important area where action will be required is an international agreement on suppliers and receivers concerning the transfer of nuclear technology. The agreement would have to cover assurances for the disposal of all the resulting radioactive wastes, safety standards, and licensing procedures.

133. The nuclear reactor industry is going through a tremendous change in this decade. A host of entirely new types of reactors, including relatively small ones (10 - 300 MW) are now under development, many of which are designed for potential markets in developing countries.[31/] Some industries are planning 100% package deals, where the reactor could be assembled at the factory location, and then shipped to location on rail or on barges, where it would simply be hooked onto a national grid.

134. The problems as well as potentials of these developments are tremendous. On the one hand, standardized construction will enable manufacturers to ensure higher safety. On the other hand, problems such as technological dependence, as well as the need for highly skilled operators will have to be addressed by the receiver countries.

E. INCREASING ENERGY EFFICIENCY

135. Energy efficiency should be the cutting edge of national energy policies and sustainable development; and measures to achieve it deserve the highest priority on national agendas. Although impressive gains in energy efficiency have been made since the first oil shock, as seen in Figure 3, the results have been uneven. Some countries have made great progress, others have gone backwards. The latter's potential is not limited to the achievement of the former; in both cases, the opportunities for future gains are enormous. But both will require deliberate policies.

136. The cost effectiveness of efficiency as the most environmentally benign source of energy is well established. There are many cases where the energy consumption per unit of output of "best practice" technologies is a half or less than that of typically available equipment. This is true of lighting, refrigeration and space cooling, which are growing rapidly in most developing countries and putting severe pressures on electricity supply systems. It is true of cooking fires and cooking equipment, with all their impacts on tree cover, the recycling of crop and animal residues now burnt for fuel, and soil erosion. It is true of cultivation and irrigation systems, of the

automobile, and many industrial processes and equipment. In many cases, the time required to pay back the additional investment in energy savings is often less than two years and frequently is measured in months or weeks.

137. These claims are often rejected by developing countries, and the poor generally, as concerns only of the extravagant and well-to-do. Nothing could more grievously misrepresent the truth. It is the poorest who are most often condemned to use energy - and other resources - least efficiently and productively; and who can least afford to do so.

138. The woman who cooks in an earthen pot over an open fire uses perhaps eight times more fuel than her affluent neighbour with a gas stove and aluminium pans. The poor who light their homes with a wick dipped in a jar of kerosene get one hundredth of the illumination of a 100-watt electric bulb and use just as much energy to do so. The cement factory, automobile or idling irrigation pump in a poor country is no different from its equivalent in the rich world. In both cases there is roughly the same scope for reducing the energy consumption (or peak power demand) of these devices without any loss of output or welfare. But in a poor country the benefits thus gained will mean much more.

139. This, however, is the tragic paradox of poverty. It is not energy, but rather poverty which is the limiting factor for the poor. They are forced to live on a meager current account, and thus use inefficient equipment, because they have no savings for investment capital to purchase energy efficient devices. Consequently they end up paying many times over for a unit of delivered services.

140. While there are countless examples of successful energy efficiency programmes in industrialized countries, these programmes face a large number of barriers in developing countries. In all countries, ignorance tends to be the most important constraint. Many consumers, including large industries, do not know how they use energy, what it costs them, how costs can be reduced, or how to set about reducing them. Information campaigns in the media, technical press, schools, etc.; demonstrations of successful practices and technologies; free energy audits; energy "labelling" of appliances; training in energy-saving techniques; and other techniques have been used successfully to increase awareness and they need to be extended.

141. Indifference is equally widespread. Apart from transportation and the most energy-intensive industries, energy typically accounts for only 3-5 per cent of total costs of an enterprise. The figure is much the same for middle to high income families in industrialized countries. It represents only 1-3 per cent of the family budgets in the warmer developing countries where there is little need for space heating. Where budgets are tight, therefore, investments in energy savings may be postponed regardless of the potential pay-off.

142. This tendency is reinforced by energy pricing policies, which may reflect subsidies and almost never reflect the real costs of producing or importing the energy, including the external health, property and environmental damage costs. Countries should evaluate the overall cost to government and society of different energy options, both renewable and non-renewable, with

all hidden and overt subsidies included. Economic pricing of energy - perhaps with safeguards for the poor - needs to be extended in all countries.

143. Developing countries face particular constraints in this area. They are generally in the throes of foreign exchange conditions which make it difficult to purchase efficient, but costly energy conversion devices. Often such technologies are new, not yet fully tested, and poor developing countries cannot take the risks of experimenting, and possibly failing with such technologies. Finally, many measures for energy savings tend to be the "fine tuning" of already functioning systems. These do not appear as attractive as new, large scale energy supply projects to aid agencies or to local government officials.

144. There are more subtle but no less important price and cost distortions. The economic benefits of improved energy efficiency, for example, may be captured by parties other than the industry or consumer who has to bear the investment costs. Energy efficiency measures which reduce peak electricity demand and thus postpone the need for investment in additional capacity are a case in point. Frequently, the ratio of the cost of avoided supply to the cost of the efficiency measure is two or three to one. In these and similar cases, there are strong arguments for systems to enable those who invest in energy efficiency measures to capture more of the financial rewards.

145. Many energy efficiency measures cost nothing to implement. Where investments are needed, they are frequently the main barrier to action, even when pay-back times are short. These barriers are often

absolute for the poor consumer or for small informal sector entrepreneurs. In these latter cases, subsidies will be necessary. Where investment costs are not insurmountable, there are many mechanisms for reducing or spreading the initial investment hurdle which can be adopted by the public or private sector, ranging from subsidies, tax credits and loans to "invisible" measures such as payment through the (reduced) energy bills.

146. Mandatory efficiency standards for equipment and appliances have four great advantages over strictly market measures. They can be relied upon to produce predictable energy savings, thus greatly assisting energy supply planning which must often be based on expected demand some 10 - 15 years ahead. They overcome the reluctance of manufacturers to take a gamble on producing more energy efficient technologies for uncertain consumer markets. They can induce both the spread of existing and the innovation of new technologies, processes and products as automobiles, chemicals, steel and other industries demonstrate. They can induce and push research and development efforts towards socially desirable goals.

147. The imposition of minimum energy consumption standards on the manufacture, import or sale of equipment is one of the most powerful and effective tools in promoting energy efficiency. Where the equipment concerned is traded internationally, these may require international action. Countries, and where appropriate, regional organizations, should introduce and or extend increasingly strict minimum efficiency standards for equipment and mandatory labelling of appliances.

a) Transport

148. Transport has a particularly important place in national energy and development planning. It is a major consumer of oil, accounting for 50 - 60 per cent of total petroleum use in the majority of developed and developing countries. It is a major source of local air pollution and regional acidification of the environment.

149. Looking to the year 2000 and beyond, vehicle markets will grow much more rapidly in developing countries, adding greatly to potential air pollution in cities where international norms are already exceeded. Indeed, unless strong action is taken, air pollution could become a major factor limiting industrial development in many Third World cities. In this context, fuel economy emerges as the most cost-effective means both to prevent further growth in air pollution from vehicle transport and to preserve a region's capacity for sustainable development.

150. In the western industrialized countries, energy use in transport grew quite slowly after 1973 and it began to decline in the late 1970's. Higher fuel prices and strong competitive forces, leading to large and rapid increases in the energy efficiency of the air traffic and automobile fleets, were mainly responsible for this turn-around. Progress was uneven, however, and the difference between the most and least efficient automobile fleets is wide. The Japanese automobile industry led the way and its fleet is the most efficient obtaining an average of 8 liters per 100 kilometers. The North American industry brought up the rear averaging a little below 16 liters per 100 kilometers.

151. With higher prices, fuel economy becomes a high-visibility issue for consumers as well as governments. It can continue to be a driving force behind technical innovations directed at dealing with a changing operating environment and gaining competitive advantage in the market place. In the absence of higher prices, however, mandatory standards providing for steady increase in fuel economy may be necessary. Either way, the potential for substantial future gains in fuel economy is enormous; improved body design, material substitutions, and engines and power trains are some of the technical paths now being pursued. If the momentum can be maintained, the current average fuel consumption of approximately 10 liters per 100 kilometers in the fleet of vehicles in use in developed countries could be cut in half by the turn of the century.[32/]

152. A key issue is how developing countries can secure similar improvements in the fuel economy of their fleets. Those countries that import their fleet, could mandate standards for new vehicles. In those countries where vehicles are assembled under licence with industrialized country manufacturers, however, the situation is different. The designs are frequently old fashioned and predate energy efficiency improvements. These countries should give priority to the reforms of licensing and import agreements under which they will have access to the best available fuel efficient designs and production processes.

153. The issue goes deeper, however. Transport is the one sector of demand where there are at present few substitutes for oil. While the scope for increases in energy efficiency in road haulage are immense, and will

lead to very significant savings in energy, fleet life in developing countries is nearly twice that in industrialized countries. Thus the rate of improvement in energy efficiency will be much slower, and will almost certainly fall behind the rate of growth in total transport demand, at least if historical trends in the latter are any indication of what will happen in the future. Thus, even under the most optimistic assumptions, developing countries could face a significant rise in the total demand for transport fuels over the next three to four decades.

154. In view of this, certain developing countries should explore the potential in non-oil based transport fuels. Some actually have: Brazil being the outstanding example. The obvious candidates are alcohol-based fuels, ethanol which is already in use in many developing countries and methanol which has so far been used mainly in racing cars because of its very superior flame speed. Both ethanol and methanol can be obtained from biomass, and the latter may also be obtained from coal and natural gas. In fact, in principle, their combustion yields only steam and carbon dioxide. But some recent research and experience indicates the possibility of other health hazards. As a result, there is an urgent need to monitor them closely, and to conduct research on their elimination similar to what has been done over a long period for hydrocarbon fuels.

155. The encouragement of more energy efficient modes of transport is another option. In developing countries - and historically in the industrialized countries - the trend has been the other way. In particular, rail has given way to road and the bus to private vehicles. But

reversing this trend is not easy, since the least efficient transport modes are the most convenient and flexible. And the provision of quality services that attract customers - in particular, more frequent and less crowded buses or trains - inevitably reduces overall fleet energy efficiency.

156. Changes of this kind are easiest if they are built-in to development strategies. If city growth is centred on multiple cores, or on new towns within an expanding metropolitan region, efficient and rapid mass transit systems can be used to link the centres in which most travel can be non-mechanized. Such major shifts in development patterns can often be achieved by simple legislative measures such as zoning and floor space regulations.

b) Industry

157. Industry is also a major source of energy demand accounting for 40 - 60 per cent of all energy consumed in industrialized countries and 10 - 40 per cent in developing countries. Like transport, it is a major source of pollution, especially in those countries that have not enjoyed strong environmental programmes over the past two decades.

158. Most trends point to a very rapid growth of industry through the turn of the century, but the form and pattern could be markedly different between industrialized and developing countries. Industry in the former has been undergoing a massive restructuring marked by a shift toward higher technologies, a substitution of synthetics for primary inputs, and a growing dematerialization of the economy.

159. At the same time, there has been significant improvement in the energy efficiency of production equipment, processes and products. The innovation behind these improvements has been driven, in part, by higher energy prices. As a result, every industry sector is now marked by plants that are comparatively energy efficient and, hence environmentally efficient and economically competitive. This is true of those sectors most frequently associated with newly industrializing countries, like iron and steel, non-ferrous metals, bulk chemicals, pulp and paper and food processing. These technologies should spread to older plants as capital is replaced.

160. During this period, there has also been significant shift of industrial capacity in the basic and traditional sectors of developing countries in industries that tend to be more energy intensive and polluting. Moreover, developing countries have tended to attract older technologies and processes which are comparatively inefficient and internationally non-competitive. While such technologies may be foisted on unsuspecting or unaware governments in some developing countries, it must be admitted that some developing countries actively seek to buy old plants as a part of their industrial strategy. If these trends continue, developing countries could end up with industrial sectors that are not only economically uncompetitive but also highly polluting, imposing heavy health, property and environmental damage costs on their cities and economies.

161. In this context, energy efficiency again emerges as the most cost-effective means both to prevent further growth in such damage costs and to promote a competitive and sustainable industrial sector.

162. The key issue, again, is how can developing countries ensure that future industrialization reflects the most advanced and resource efficient technologies available in each of the sectors concerned. Several measures seem within reach. Those countries that permit nationals or parastatals to import plants on a turn-key or other basis, or that permit multinationals to establish plants on their territories, should ensure that all permits, licences and contracts provide for the best available energy and environmentally efficient technologies and processes. Moreover, such contracts should require registration of complete plans for the safe management and disposition of all emissions inside and outside the plants, and of all wastes. Development assistance, export credit and other international financing agencies involved should ensure that both are included in the financial plans of the industry.

163. Developing countries often need to decide on comparative advantage of domestic production of industrial components. In these cases, the most energy intensive and polluting component might be imported, leaving the other to be made domestically, thus achieving a far lower overall energy intensity for the final product. Energy saving of as much as 20 - 30 per cent could be achieved by such skilful forms of industrial development.

164. The proper maintenance of industrial plant, especially older equipment, can also save much "down-time" and can pay real dividends in terms of energy saving. Industry-oriented energy conservation programmes, managed perhaps by an "energy service utility" with incentives to help existing industries to identify cost-effective opportunities for saving energy, could

reduce energy demands by a further one third. Saving of this order cannot only improve the competitiveness of a nation's industrial sector, but also improve its balance of payments, reduce its debt requirements and increase the capacity of the environment in Third World cities to accept more development.

165. Where the latest industrial designs are transferred to developing countries, either through retro-fitted process improvements or through embodiment in new plant designs, the improvement in energy efficiency can be truly dramatic. This improvement is vitiated only by the much longer life of plant and equipment in developing countries. This longer life stems only partly from the scarcity of capital and foreign exchange. An equally important reason is the existence of protected home markets and monopolistic structure of production which make such improvement unnecessary for raising or retaining high levels of profits. This means that even a modest package of fiscal and monetary incentives can significantly accelerate the pace of technological renewal, even within the given capital constraints.

c) <u>Agriculture</u>

166. Globally, agriculture is only a modest energy consumer, accounting for about 3.5 per cent of commercial energy use in the industrialized countries and 4.5 per cent in developing countries as a whole. A strategy to double food production in the Third World through massive increases in fertilizers, irrigation and mechanization would add only 140 million tons of oil equivalent to their agricultural energy use. This is only some 5 per cent of present world energy consumption and almost certainly a small fraction of the energy that could be saved in other economic sectors in the developing world through appropriate energy efficiency measures.

167. Agriculture is usually the least energy-intensive sector in national economies and the one with the highest economic and social return for each extra unit of energy input. The western industrialized countries have established clearly that the "high food - high energy" linkage can be broken. While energy use has grown, energy efficiency has grown even faster permitting a significant rise in productivity.

168. Much of the increase has taken the form of chemical fertilizers and pesticides. Failure to manage them properly, however, is now threatening the sustainability of agriculture in many areas. Increased pest resistance, loss of soil fertility, eutrophication of lakes, contamination of streams and nitrate pollution of water supplies are some of the effects undermining the potential for future gains in production at the rates enjoyed in the past. Measures for more effective management are dealt with in another report to the Commission.

169. Agriculture in developing countries, on the other hand, suffers from low levels of energy use and productivity and the potential for increasing both is enormous. It is hard to find examples where increasing levels of energy use does not bring more than proportional increases in yield, income and profits.

170. Fertilizers are perhaps the most significant case in point. Increasing yields through higher applications of appropriate nutrients is perhaps the most important means available to developing countries to secure the annual gains in food production needed for their growing populations. In this regard, locally available sources of organic fertilizer can be more fully

exploited. Some 10-15 million tons of nitrogen and 5 million tons each of potassium and potash could be had in the Third World if only half the available human and animal manure were used. A comprehensive composting or biogas programme in the Third World could provide an estimated 50 - 100 million new jobs and in the latter case produce high-grade energy for cooking, lighting and irrigation pumping.

171. Selective mechanization with small machines and improved use of animal draft power are also important energy interventions to break labour bottlenecks, significantly improving productivity and, in many cases, allowing double or even triple cropping. Access to more conventional sources of power would also pay high dividends in increased productivity. Farmers, for example, require energy to pump water for irrigation and other uses, or diesel for tractors, and they require it at precise times of the year. If they do not get it because of priorities elsewhere, yields suffer or crops may fail entirely.

172. The main constraints to increasing energy for agriculture in developing countries can be traced to unbalanced and inequitable development policies. Although there are vast differences in the political and economic power of rural societies to command energy resources, and genuine problems of resource distribution in rural areas, a balanced development strategy could achieve much in minimizing these problems.

III. INSTITUTIONAL REQUIREMENTS OF THE TRANSITION

173. Attention has been drawn at the beginning of this Report to the ways in which the oil price rises of 1973-74 and 1979 actively stimulated a movement away from oil into other energy forms and towards a concern with energy saving and efficient usage practices. Many countries began to review their national energy polices and there was great interest in coal, nuclear, natural gas and renewable forms of energy. In the early 1980s, after the initial economic upheavals had settled down, many began to see the steady transition from oil into other energy forms as a healthy sign in a world that formerly had been too heavily dependent on oil products. At about that time, predictions and forecasts about the future of oil abounded, most of them expressing pessimism about future prices. Those few analysts who prophesied drastic falls in oil prices as producers competed for a share in a shrinking world market were quickly dismissed. Nowadays, with prices dropping almost as dramatically as they originally rose and in real terms, once more approaching the 1973 prices, most serious analysts have a much healthier respect for uncertainty and many feel that the journey to any energy future involving oil may well mean a very bumpy ride for consumers and producers alike, unless radical action is taken now.

174. In spite of this, at the moment, energy seems to have slipped off the global agenda and many are asking whether worldwide preoccupations with conservation, renewables and coal are really necessary nowadays in a world of oil-glut.

175. And yet, for reasons connected with more stable and sustainable pricing policies and production arrangements, and for longer term oil availability, the transition must somehow be encouraged to go on. Already, many countries are learning that rapidly falling oil prices can be economically very dangerous. The ground lost towards transition must somehow be regained and more orderly oil pricing and disciplined production somehow restored. Increasing diversity in fuel use must be revived. This is in everybody's interest. But in the current climate, it is becoming ever clearer that at present, the world lacks the economic and financial structures, as well as the institutional arrangements and, above all, the mental attitudes to do so decisively.

176. After the price debacles of the last decade or so, many analysts would argue that oil is too important in the global economy to be treated as a mere commodity, competitively traded on volatile world markets. Instead, both producer and consumer countries should develop policies designed to build some form of limited but appropriately effective convention for the more orderly production and marketing of oil to the year 2000 and beyond.

A. NATIONAL ENERGY AGENCIES

177. An important aspect of the transition is the use of alternative energy sources in ways which are environmentally benign and developmentally sustainable but also cost-effective. Despite the immense amount of recent work done on the health/environment risks attached to various energy sources, very little attention has been paid to the true total costs to

society of fuel production, and transport, energy liberation and satisfactory management of the solid, liquid and gaseous waste products. In short, we still lack genuinely comprehensive systems analyses of complete energy cycle costings with the result that integral components of the energy production process, usually waste management, are not folded into the pricing of the resultant energy.

178. This produces serious price distortions between energy sources. Thus coal, or electricity from coal, without waste management costs included, are bound to appear less expensive than the gas option which is hence dearer, but cleaner in health/environment terms.

179. Another important feature is that energy sources vary widely, from wood fuels, crop-wastes, animal dung, through fossil fuels (gas, coal, oil) to electricity produced by hydraulic, nuclear, thermal or solar power. In many countries, responsibility for each of these is placed in separate utilities with little or no contact between them. And when, as has happened recently in many countries, a Ministry of Energy is formed, there are still serious and apparently insoluble demarcation disputes about such issues as whether fuel wood and crop-wastes should be handled by Energy, or should be lodged with Agriculture, Forestry or the Environment. It is also quite often unclear as to who has the responsibility for managing the environmental impacts of energy production, which through lack of action usually results in reinforcing the pricing distortions referred to above.

180. Again, the young Ministry of Energy often has an inadequate budget and may lack the power to devote funds to timely energy projects or to determine energy taxes, subsidies, extended credit facilities and pricing policies or other instruments of financial management control over the energy mix. Usually, the Ministry is so stretched professionally with day to day management imperatives that it also lacks the time to develop a comprehensive energy plan for the country, which is an essential starting point for the implementation of all the recommendations in this report. Furthermore, it is unable to develop the marketing of energy services as opposed to fuels in various sectors of the energy economy. Nor is it usually able to promote energy saving by fostering such important conservation procedures as energy audits, energy intensity analyses or thermal insulation of buildings.

181. All these shortcomings are so serious in terms of prudent energy management that governments should give the highest priority to establishing a top-level agency to plan and manage energy supply and demand of all types of energy in all sectors of the national energy economy.

182. **RECOMMENDATION:**

We recommend that each nation designate a lead agency or authority with a broad mandate for the development of energy policy and its co-ordination, covering <u>all</u> energy sources and uses, and with clear responsibility to assess and to take into account the effects of energy strategies on economic growth and on sustaining the environmental basis of that growth. All single fuel agencies, including nuclear, should be subordinate to its advice.

182.1 Moreover, this lead agency should also be required to effect meaningful co-ordination with finance, economic development, environment, transport, agriculture, and other relevant ministries, and vice versa.

182.2 To be effective, the agency must have access to some level of fiscal authority and become a primary source of advice on energy consumption taxes, subsidies, credit and other financial instruments used to influence energy development in favour of sustainable supply and consumption patterns

182.3 This agency should have a special mandate to remove institutional barriers to the transformation of electrical supply and distribution utilities into "energy service" utilities, responsible for purchasing supplies from all sources, including renewables, at remunerative prices; and for marketing these supplies, tailored to specific end-uses in households, industry, agriculture, and other sectors.

182.4 In developing countries, it is essential that these agencies develop realistic national energy plans, and that any proposals or demand for foreign aid for energy development be made in its context.

B. REGIONAL ENERGY COMMISSIONS

183. Air, river or marine pollution from waste products following energy production may cross national boundaries and cause problems for adjacent states of a world region, leading to damage and political embarrassment. The acid rain problem is a well known example of this, as are certain effluent accidents from nuclear installations. Another such issue is the regional identification or sites for the disposal of nuclear waste. They usually require collaboration by adjacent states for their solution which may involve mutually agreed or harmonized abatement and emission control codes of practice and standards.

184. Where many states are involved, detailed policy optimization practices based on overall least-cost solutions need to be worked out. Additional, surveillance, monitoring and early warning practices developed by member states of the region could be made conformable and inter-comparable so that regional exchange of comparable data can be used to strengthen the power of the regional management process.

185. On the more positive side, individual states with similar energy management problems may develop specialized technical skills for energy planning, hardware production or other expertise which they could more easily share if regional energy information exchange networks were developed. The activities of the SADCC Regional Energy Centre in Luanda is a good example of a step in this direction.

186. In fact, the advantages of Regional Energy Commissions are so numerous that a series of such commission should be developed globally to carry out the above activities and similar collaborative functions.

187. **RECOMMENDATION:**

We recommend that states sharing common borders or similar socio-economic and bio-climatic conditions strengthen existing and/or establish new regional organizations with broad mandates for regional co-operation and joint action to deal with interrelated economic, energy, environment and development problems and to manage the energy transition in a co-ordinated and cost-effective way. These agencies would provide a much needed capability to identify and seize opportunities for regional co-operation in financing, developing and exploiting new technologies for energy supply, energy saving and for environmental regeneration. They would also enable nations to develop regionally comparable economic and environmental statistics; baseline quantity and quality surveys of shared resources and an early warning capability to reduce and/or prevent an increasing range of environment and development hazards.

C. GLOBAL ENERGY ENVIRONMENT COMMISSION

188. Most energy-related problems, like the energy policies which induce them, reach across national boundaries, becoming regional and some even global problems. Consequently, some form of international action is require for their resolution. Moreover, it is often more efficient for a number of countries with similar geographical, economic and other characteristics to join forces and tackle regional problems in a regional forum.

189. International action, however, cannot be and is not a substitute for national action. In general, effective international action should be based on similar and parallel action at the national level.

190. It is abundantly clear from the discussion above, that no solution to these problems will be possible unless developing countries have access to assured finance from international sources. Now that the World Bank is folding up its energy accounting activities for developing countries, the idea of a "World Bank Energy Affiliate", or some similar organisation, with specific concerns for developing countries is more relevant than ever. Such a bank should increase overall energy related lending over present levels, with particular emphasis for projects involving energy efficiency measures.

191. The line of argument developed in the previous sections could be extended to problems that represent generally global externalities, such as the carbon dioxide and climate-warming issues or the release of radioactive gases to the atmosphere. These and similar global problems should form the basis for the creation of a Global Energy-Environment Commission whose task should be the development of internationally agreed abatement and/or adaptation strategies of the problem as it develops in tandem with policy development. The work of such a Global Commission would be greatly facilitated by liaison with the Regional Energy Commissions mentioned above.

192. RECOMMENDATION:

At the global level too, we recommend that existing institutional capacity be strengthened significantly in order to enable national to deal effectively with a growing range of energy-based environment and development problems that transcend regional boundaries. These include: climatic change; the acidification of the environment; air pollution,; marine and coastal water pollution; and the problems posed by heavy metals; fuelwood; deforestation and so on. We also recommend a three-track approach to these issues:

192.1 The first involves an acceleration of monitoring and assessment to improve our knowledge base, strengthen our capacity for anticipation, prevention and adaptation and reduce the level of uncertainty. To this end, existing arrangements for co-ordinated monitoring, assessment and research in the UN system need to be streamlined and broadened to include other sectors (e.g. agriculture, transportation, urban development) and other regions and countries likely to be severely hit by acidification of by shifts in climate, rising sea levels, or other phenomena.

192.2 The second involves policies to induce a several-fold research on energy and related strategies for the transition, including more effective instruments to influence energy demand and barriers to their implementation, more energy-efficient means of hating, transportation and industrial development,

efficiency standard for vehicles, equipment and appliances in international trade, alternative sources of energy, the economic costs of health, property and environmental effects of alternative sources of energy, the geo-political implications of energy-induced climate change, etc.

192.3 The third involves an immediate start on negotiations for an international convention on critical environment and development problems related to energy, including those mentioned above. To this end, the Secretary General of the United Nations should convene a special conference not later than 1989, and charge it with drafting such a convention, potentially as embracing and binding as that of the Law of the Sea.

IV. ANNEXES

A. MEMBERS OF THE ADVISORY PANEL

Chairman: 1. Mr. Enrique IGLESIAS (Uruguay)
Minister for Foreign Affairs

Members: 2. Mr. GU Jian(China)
Chief Engineer, Wuhan Energy Research Institute

3. Mr. Abdlatif Y. AL-HAMAD(Kuwait)
Director General, Chairman of the Board of Directors
Arab Fund for Economic and Social Development

4. Mr. Toyoaki IKUTA(Japan)
President, Energy Economics Institute, Tokyo

5. Mr. Prem Shankar JHA(India)
Senior Assistant Editor, The Times of India

6. Mr. Al Noor KASSUM(Tanzania)
Minister for Water, Energy, and Minerals

7. Mr. Ulf LANTZKE(FRG)*
Former Director General
International Energy Agency, Paris

8. Mrs. Wangari MAATHAI(Kenya)
Chairman: National Council of Women, Green Belt Movement

9. Mr. Francisco PARRA(Venezuela)
Formerly Secretary General of OPEC

10. Mr. David J. ROSE(USA)*
Professor
Massachusetts Institute of Technology

11. Mr. Carl THAM(Sweden)
Director General, Swedish International Development Authority

12. Mr. György VAJDA(Hungary)
Director, Electrical Power Research Institute; Member, Hungarian Academy of Sciences

13. Mr. Miguel WIONCZEK (Mexico)
Director, Programme on Energy & Development

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* Died during the period of the Panel's activities.

Special Adviser:

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Secretariat:

Kazu Kato, Programme Director
Janos Pasztor, Senior Programme Officer
Guadalupe Quesada, Secretary

B. NOTES AND REFERENCES

1/ FAO-1981

2/ Keepin - 1985

3/ For a more detailed discussion see Keepin - 1985 and Keepin 1984

4/ IIASA - 1981

5/ The group consisted of Jose Goldemberg of Brazil, Thomas B. Johansson of Sweden, Amulya K.N. Reddy of India , and Robert H. Williams of the USA. The initial findings of the group have been published in Goldemberg et al, - 1985a

6/ World Bank - 1985

7/ World Bank - 1983

8/ World Bank - 1983

9/ Goldemberg - 1985b

10/ The study was made by H. Geller of the Companhia Energetica de Sao Paulo, Brazil. Quoted by Goldemberg - 1985b

11/ Goldemberg - 1985b

12/ For more detailed discussion see the background papers Lohani - 1985, Weidner - 1985, Hashimoto - 1985, and CETESB - 1985

13/ For more detailed discussion see the background papers Torrens - 1985, Zhao - 1985, Rhode - 1985 and Goodman - 1985

14/ For more detailed discussion see the conference report Villach - 1985, and the conributions to various public hearings of the WCED, such as Mintzer - 1985 and Hare - 1986

15/ For a detailed discussion of the state of acidification in various European countries see WRI - 1986

16/ WRI - 1986

17/ Rodhe - 1985

18/ Quoted from page 224 of WRI- 1986

19/ Villach - 1985

20/ Goldemberg - 1985b

21/ Goldemberg - 1985b

22/ Deudney & Flavin - 1983

23/ There exists a large amount of literature on this. See for example: Chidumayo-1985, Ambio-1985, Beijer - 1985-86.

24/ See for example, Bandyopadhyay - 1986

25/ See for example Fernandes & Kulkarni - 1983, Chidumayo - 1985, Bradley - 1985.

26/ For a discussion of the potentials of nuclear energy see: IAEA - 1985

27/ For a more detailed discussion of this issue see KASPERSON - 1986.

28/ Parker, et al. - 1984, and IAEA - 1983, etc.

29/ Castaing - 1983

30/ For example, a number of nuclear reactor supplier countries also supply the nuclear fuel, which after use is returned to the supplier country for recycling or direct disposal. This is for example the case for nuclear reactors and fuel supplied to the CMEA countries by the USSR.

31/ For a more detailed analysis see Egan - 1986.

32/ MIT - 1984

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