THE INTERNATIONAL ENERGY SITUATION AND PROSPECTS OF ITS FURTHER DEVELOPMENT

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December 1981
PP-81-14

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PREFACE

IIASA's Energy Systems Program has performed an extensive analysis of the long-range global energy problem. In 1981 *Energy in a Finite World* (IIASA's Energy Systems Program 1981) was published--a report summarizing the major findings of an international team of experts working since 1972 under the leadership of Wolf Häfele. In the format of two scenarios--a High and a Low scenario--the factual basis for balancing demand and supply in a cooperative world was laid down.

How to use this body of knowledge and information in the real world context--competitive, full of conflicts, and highly discounting both in time and space--was a spontaneous question that came up in the intense dialogue between the Energy Systems Program and many audiences in science, industry and policy making.

This paper tries to capture and order some of the suggestions put forward in this dialogue, in order to apply a long-range and global perspective to short-term national decision making.

The paper was prepared in January 1981. The conclusions then put forward seem to be supported by the political events that have occurred since, both by those in Egypt and more generally and recently in the Middle East. Default of updating of this paper to actual publication is therefore intended.

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THE CHANGED INTERNATIONAL ENERGY SUPPLY SITUATION

The events of 1973 have prompted a drastic change in the world's oil markets--and more than that: it appears that the process that is called general economic and industrial development has in some fundamental respects entered a critical stage.

This was not obvious during the five years between 1973 and 1978, when what was going on was understood as being a disturbance in a major, though clearly separable, sector of the overall economy. The explication seemed appropriate, for oil was not scarce; there was a problem of oil price, but contrary to expectations the recycling of petrodollars worked out satisfactorily.

Since then there have been increasing signs for an impending break to arise in the practice of international division of labor and consequently in free trade and exchange. Generalizing from such signs, which are clear now in the international energy field, is not out of place: energy is a basic production factor and both directly and indirectly affects all human material dealings and therefore also general international trade.

The events that followed after 1978 were clearly different from the initial development after 1973. Those listed below are closely related to the international energy problem.

- In 1978, i.e., four years after the first oil crisis, Western industrialized countries for the first time clearly adjusted downward their estimates of medium- and long-term economic growth.

- During 1978 the imminent downfall of the government of the Shah of Iran became obvious, starting off severe political instability in the region of the Persian Gulf.

- As a consequence of the Iranian revolution, spot market oil prices doubled and the official OPEC price listing was raised to $30 per barrel of oil.

- The volume of Iranian oil exports predominantly going to Western countries was greatly reduced. But even the Eastern countries appeared to be directly affected by the export policy of the Gulf region, due to the indefinite postponement of the three-partite natural gas trade between Iran, the U.S.S.R., and Western Europe.

- Following the taking of hostages in the U.S. embassy in Teheran and the invasion in Afghanistan, governments ordered trade embargoes.

- Oil transport and delivery from production facilities in the area of Shat-el-Arab was crippled by the outbreak of war between Iraq and Iran.

- With the strain on Soviet potential for delivering oil to other CMEA members, supply deficiencies in the Eastern countries became apparent. For meeting their future oil deficits, the allies were referred to the world oil markets by the U.S.S.R. in the later half of 1980.

- At the time Saudi Arabia decided to make up for the gap in overall OPEC oil exports resulting from the Iran-Iraq war by stepping up its short-term oil production.

- The nuclear energy debate in Western industrialized countries gradually calmed down in the course of 1980; this was due to a marked slowdown in economic growth and a correspondingly lower demand for rapidly extending national electricity supply systems.

- In spite of the accident in the U.S. nuclear power plant Three Mile Island, Sweden, Switzerland, and the F.R.G. worked out political compromises permitting a limited buildup of nuclear supply capacities.

THE LONG-TERM GLOBAL ENERGY PERSPECTIVE

There is one aspect in particular in which scientific analysis may contribute to an assessment of the international energy supply situation, that is, by making transparent the technical opportunities of and the constraints for a solution to the global energy problem.

A comprehensive study attempting to approach the energy problem in this way has been undertaken and recently completed by the Energy Systems Program of the International Institute for Applied Systems Analysis (IIASA) at Laxenburg, Austria (1981). The study looks into what options basically exist for balancing energy supply and demand in major world regions over the period from 1980 to 2030. In doing so it accounts for different Eastern and Western viewpoints and attempts an adequate representation of the requirements peculiar to the developing countries.

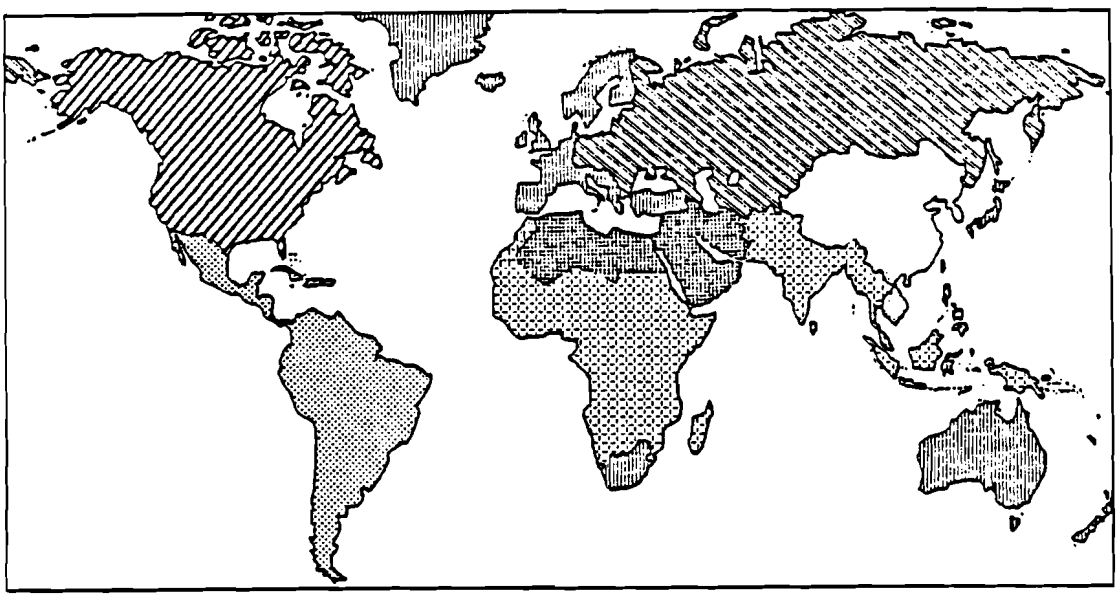
Interpretation of the study results is crucially dependent on the assumption that efficient use is being made of energy in a mostly cooperative world. The assumption translates into a cost-dependent, but unrestricted, access to all of the globe's energy resources. The only important exception to this rule is Mid-East and North African oil resources (located in one scenario region); on account of the situation in this area before 1978, availability of these resources was considered to be limited. By invoking basic assumptions of this kind it was possible to quantify the further development of the energy system with respect to the minimum technical and economic requirements and in accordance with a further development of the world's economy. These assumptions do not permit one to predict the development that is most probable to occur, however (Figure 1).

A main result of the study is the insight that fossil energy sources must and will continue to dominate the energy supply of the next 50 years. Other fossil energies that will be used increasingly, complementing the conventional reserves of oil and gas, are coal and less easily accessible and "dirtier" hydrocarbons as well as oil shales; tar sands; natural gas from deep-gas formations; and oil from polar and deep off-shore deposits. Before the year 2000 it will already be necessary to make this transition to fossil resources which can only at very high cost be exploited, transported, and processed to synthetic fuels. Because of the concentration of deposits of coal and unconventional oil and gas resources, this development is expected to influence considerably the environment, the labor situation, and the economic sectors concerned (Figure 2).

Meeting the demand for liquid hydrocarbons turns out to be a particularly pressing issue. Although the study assumes sizeable energy conservation measures in general and more rigid limitations on the use of liquid fuels in transportation and for chemical feedstocks, it nevertheless spells the need for building up a synfuel industry on a global scale during the next twenty years (Figure 3).

A similarly radical challenge is the assumed development of renewable energy sources, that is, of hydropower, biomass, and localized sources, such as solar energy for hot water and low temperature uses. However, in terms of the overall global energy balance the potential contributions from these sources are rather limited.

The last observation also applies to nuclear energy. In absolute numbers, nuclear energy provides an increasingly large amount. But its application is expected to be restricted to electricity supply, which in turn meets only 20% of the overall final energy demand. By using nuclear energy for electricity purposes, sufficient quantities of coal become available worldwide that could be used for the necessary buildup of a synfuel industry. Yet, in spite of this limited use of nuclear energy, it still appears necessary to introduce nuclear breeder reactors around the year 2000. This is due to the earth's constrained resources of natural uranium; the energy yield that can be obtained from them by employing present-day light water reactors only compares to the energy content of classical oil resources.



Region I	(NA) North America
Region II	(SU/EE) Soviet Union and Eastern Europe
Region III	(WE/JANZ) Western Europe, Japan, Australia, New Zealand, S. Africa, and Israel
Region IV	(LA) Latin America
Region V	(Af/SEA) Africa (except Northern Africa and S. Africa), South and Southeast Asia
Region VI	(ME/NAf) Middle East and Northern Africa
Region VII	(C/CPA) China and Centrally Planned Asian Economies

FIGURE 1. The Seven World Regions in IIASA's Energy Study (1981).

For estimation of the long-term development of energy demand and supply, the globe's more than 160 countries were grouped into world regions, their allocation depending on levels of economic development and fossil resource base. The study assumes free access to all energy resources (except for oil and gas resources in the Middle East and Northern Africa).

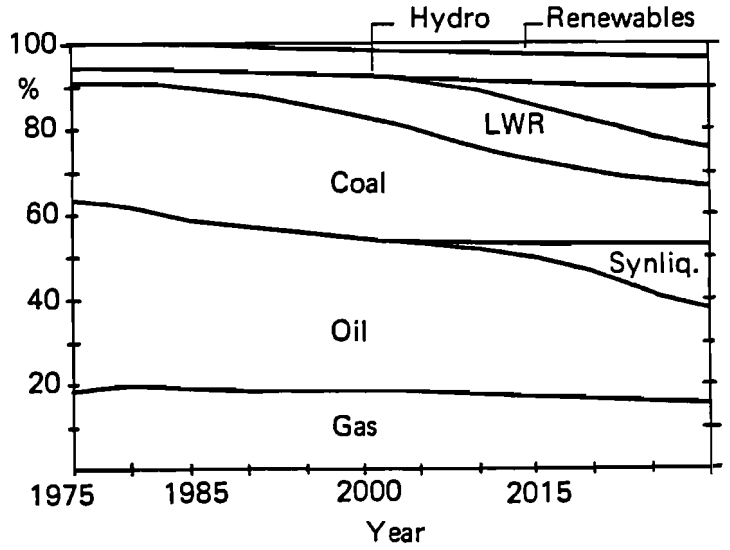


FIGURE 2. Primary Energy Shares in a Future Global Energy Balance (IIASA 1981).

Within a wide range of increasing per capita world energy demand, of only 25% up to almost twice the value, there are only minor shifts in the primary supply picture. The extended use of conventional energy sources in some regions, however, accelerates the need for change to more costly and controversial energy sources in other regions. The transition towards a world's energy supply that is based on nuclear and direct solar energy can be initiated but not completed in this 50 year period.

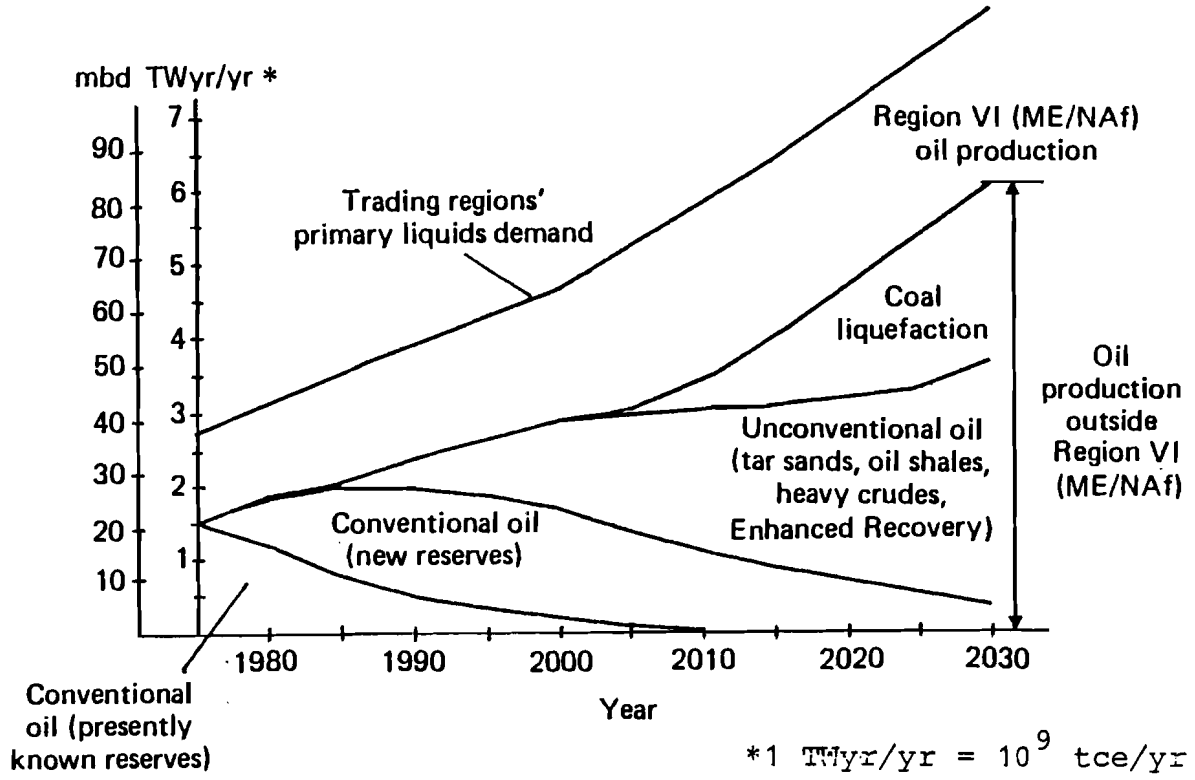


FIGURE 3. Global Oil Supply Excluding Centrally Planned Economies, IIASA High Scenario (IIASA 1981).

Although the use of liquid hydrocarbons is increasingly limited to feedstocks and transportation, the two IIASA scenarios (cf. Figure 4) require enormous exploitation efforts for unconventional oil. For comparison, the new oil fields assumed to be available in 1990 would have to provide the same amounts as are now being exported from Region VI. Ten years later, oil from tar sands and shales would have to increase at the same rate, and shortly after 2000 coal would have to be liquified at a world scale in order to meet the demand for liquid hydrocarbons. These considerations presuppose continuity of exports from the Mid-Eastern and Northern African oil countries.

In trying to understand the future of the world's energy system it does not help to take one's cue from what shares the various primary energies are capable or expected to contribute. Rather, the imbalance in the prospective development comes out clearly if one weighs the stupendous amount of investments that would be required for the provision of any type of energy and its economically efficient use against the modest improvement in material welfare that could be achieved in this way. It appears that both IIASA reference scenarios, fixing rates of economic growth in accordance with possible energy supply options, clearly undercut current aspirations. While the economic growth in the industrialized countries is assumed to continually recede at annual growth rates of one percent or less than one, the per capita income in the developing countries turns out to remain at generally the same distance from that in the developed nations (Figure 4).

THE CASE OF THE RESOURCE-POOR INDUSTRIALIZED COUNTRIES

Besides exploring the overall global energy problem, IIASA's investigations also shed light on the critical conditions of energy supply in Western European countries and in Japan which, for purposes of the study were considered one region. These OECD countries (excluding the U.S.A. and Canada) were found to be crucially dependent on energy imports still until the year 2030.

Stabilizing this region's oil imports at present levels does appear possible, but the price eventually to be paid for following the higher economic growth path (and not the lower reference scenario) is big imports of coal and natural gas. Given the global resource situation, these imports--in whatever technical form, as feedstocks or synthetic fuels--will have to come from North America or Siberia. (Note that Australian and South African energy resources are accounted for as domestic regional resources.) In either reference case, this group of OECD countries will be the only world region to compete with the group of resource-deficient developing countries for oil that is produced in the Middle East and in North Africa. According to the study, North America may in contrast become independent of Mid-East oil by 2000, owing to its large domestic fossil resource base. Other regions that may maintain their resource independence are the Eastern countries as well as China (Figure 5).

A separate and very detailed study has been undertaken by IIASA in cooperation with the Commission of the European Communities (1980), with the goal of looking into the medium- and long-term energy prospects of the EC countries. Here the unfavorable condition of the region comes out even more clearly. In order not to exceed an import ceiling of about 50% of the primary energy needs the EC will have to provide for reduced economic growth, very big energy conservation efforts, and the development of all domestic energy sources including nuclear energy, as well as the implementation of new conversion technologies for energy, transport, and utilization. Altogether five scenarios were elaborated to check out the interplay of different technological, economic, and consumption-oriented factors.

Region	Historical Growth Rate of Per Capita GDP (%/yr) 1950-1975	GDP Per Capita (dollars) 1975	Projected Growth Rate of Per Capita GDP (%/yr) High Scenario 1975-2000	High Scenario 2000-2030	Low Scenario 1975-2000	Low Scenario 2000-2030
I (NA)	1.9	7,046	2.9	1.8	1.7	0.7
II (SU/EE)	6.7	2,562	3.6	3.2	3.1	1.9
III (WE/JANZ)	4.0	4,259	3.0	1.8	1.7	0.9
IV (LA)	2.9	1,066	3.0	2.4	1.6	1.9
V (Af/SEA)	2.5	239	2.8	2.4	1.7	1.4
VI (ME/NAf)	5.7	1,429	3.8	2.8	2.4	1.2
VII (C/CPA)	5.1	352	2.8	2.4	1.6	1.4

NOTE: All growth rates are average annual growth rates (rounded) over the time period shown; actual projections have decreasing growth rates.

FIGURE 4. Growth of Per Capita GDP in the World Regions (IIASA 1981).

Optimism or pessimism characterizing the growth rate projections in the two IIASA scenarios can be assessed by comparing them to historical growth rates. The IIASA Low scenario, for example, does not anticipate a radical improvement in material welfare for the world's poor living in Regions V and VII by 2030; their share in the global population is expected to rise from 57% to 65%.

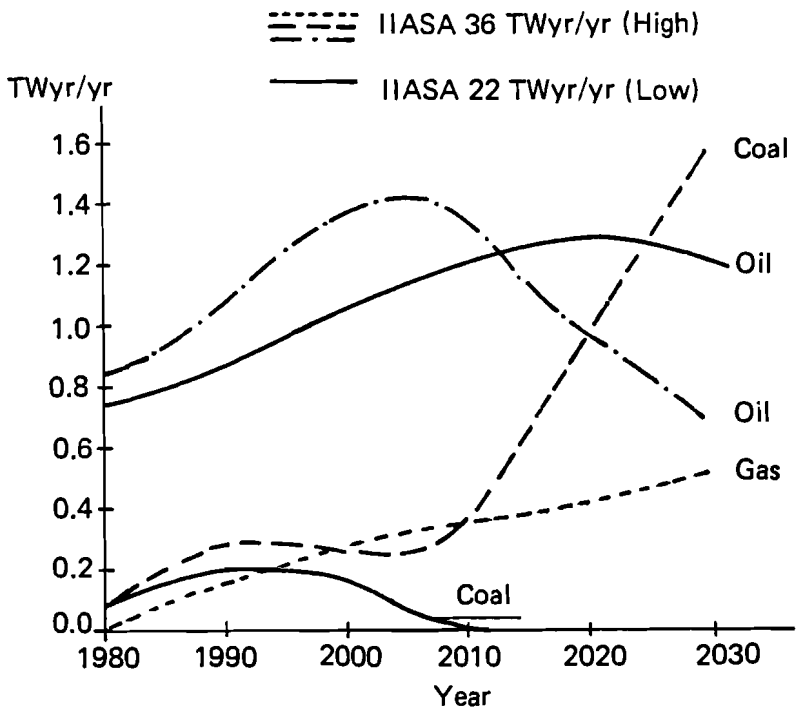


FIGURE 5. Energy Imports of Western Europe and Japan (IIASA 1981).

In spite of enhanced energy saving and oil substitution, Region III remains dependent on the Mid-East during the next 50 years in IIASA's Low scenario. In the High scenario, the oil imports are cut down after 2000 at the cost of an ever greater dependence on coal, coal-derived products, and natural gas. In order for enough oil to be available to Region III, U.S. oil imports are assumed to go down to zero by the year 2000 and centrally planned economies to be able to produce sufficient oil of their own.

As a result, the scenarios reveal how tightly and directly linked general economic growth, nuclear power buildup, and possible reductions in oil imports are for the EC region in the short and medium term. Only around and after the year 2000 will the EC energy system be flexible enough to loosen the ties of this direct interchange with the help of the alternative energy measures considered. One may suspect that a similarly detailed analysis of the energy situation in Japan would show that the problem of the latter is analoguous (Figures 6 and 7).

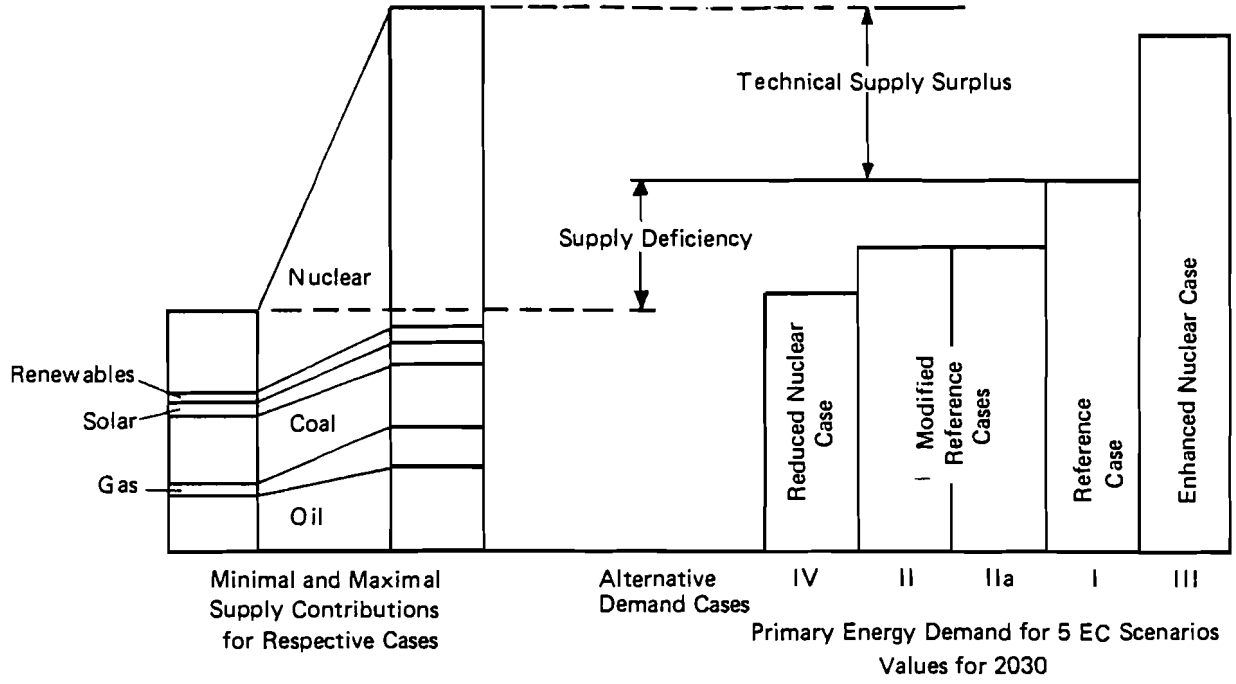
LIMITS AND UNCERTAINTIES OF THE GLOBAL AND REGIONAL LONG-TERM PERSPECTIVE

IIASA's energy study attempts to show what appears feasible under technical, environmental, and economic boundary conditions. The energy strategy quantifications--indicating the scope of using the various energy technologies as well as the levels of energy production and exchange--provide a yardstick against which one may gauge and compare developments in various parts of the world and their interactions. The initial assumption of the world's demand for energy being met under conditions of considerable international cooperation is the basis for this comparison. Assuming a certain measure of political rivalry, economic competition, and social friction to continue to persist in real-world affairs, this premise implies that the IIASA scenarios are the utmost of what can be considered politically feasible.

Given a definition of the upper boundary of the development conceived, it is possible to identify modifications thereof that cannot be downright excluded but generally suggest an aggrevation of the energy problem in parts of the global system.

For one thing, the actual development since 1975, the base year for the study calculations, does not match the assumption of a free, production cost-dependent access to the world's energy reserves. Countries other than the OPEC group have come to limit their oil and gas productions in view of national long-term needs. Norway and Mexico are examples. For another thing, it is a matter of doubt whether known fossil resources such as Canadian tar sands or U.S. oil shales for example are in fact going to be exploited effectively or whether and at what scale nuclear energy is going to be used, given the public's perception and the existing factual knowledge of the ecological and social impacts of these options. Still another discrepancy between the scenario and real-world situations is the fact that almost all primary energy producers have followed adjusting their commodity prices upward just as OPEC did after 1973.

Thus oil still functions as the reference energy source in energy supply. Needless to say, it is very hard upon nations to try to accommodate under such circumstances the effects such oil price increases have on their foreign trade balance, by shifting imports to other fossil energy forms such as gas or coal; this dilemma by definition does not arise in the IIASA scenarios (Figure 8).



FIURE 6. Five Long-Term Energy Scenarios for the EC (Commission 1980).

Five scenarios were developed to describe possible combinations of desirable economic growth, technical energy conservation, and supply options. As a result, nuclear energy and oil appear to be the supply options most strongly affected by economic growth and technological progress.

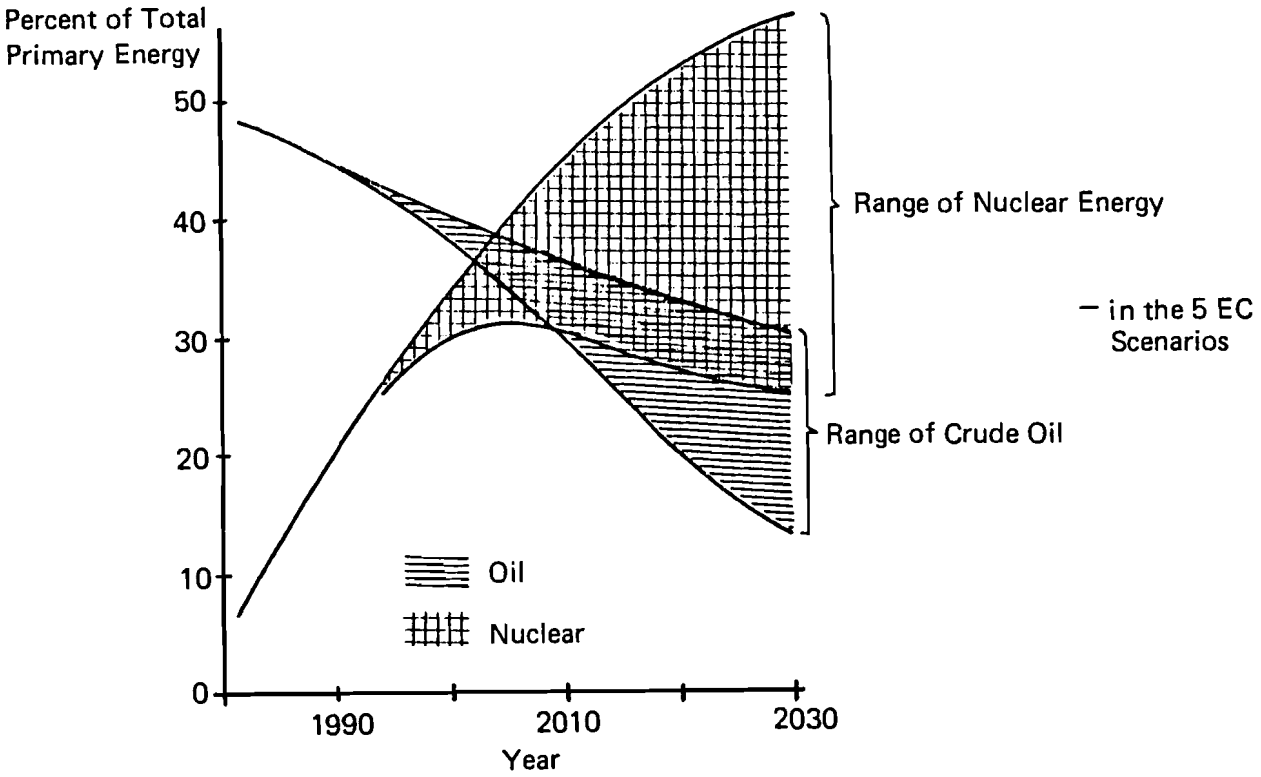


FIGURE 7. Comparison of the Role of Nuclear Energy and Crude Oil in the Five EC Scenarios (Commission 1980).

In the short and medium term, the EC scenarios indicate the tight coupling between oil dependence and nuclear programs. Only after almost 20 years can other energy sources, and in the first place coal, help decouple the triad of economic growth, oil, and nuclear energy. It is highly unlikely that the projected nuclear capacities will materialize in the 1980s and 1990s. The actual economic development since 1975, the calculation base year, leads one to conclude that the inherent economic potential may not be used fully either.

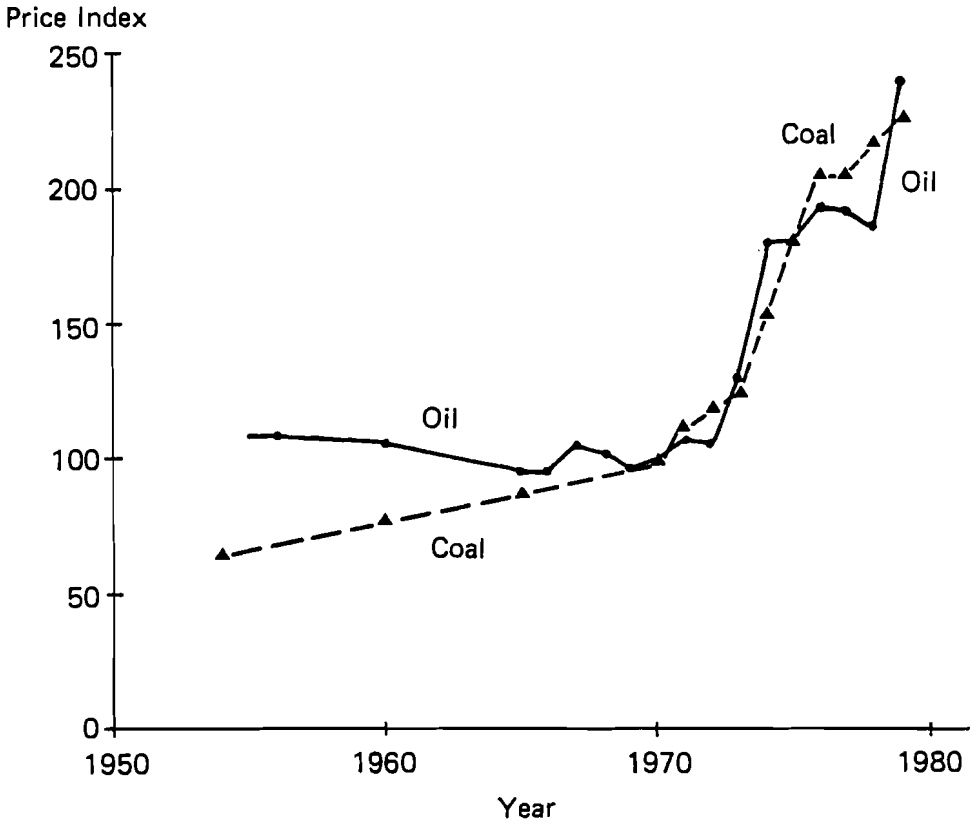


FIGURE 8. Development of Energy Prices for Industrial Large Consumers in the F.R.G. (Doblin 1981)

A long-term comparison of energy prices to be paid by the consumer shows that prices of oil and oil products have a reference function. In the F.R.G. as well as in other European countries and in the U.S.A., the prices of potential oil substitutes, apart from some exceptions, have closely followed the price trend set by OPEC countries.

A fundamental uncertainty about energy futures of Western Europe and Japan is due to substantial differences in the energy setting of those countries as compared to North America, Eastern countries, and the Middle East. Relative small fluctuations in the balancing of energy supply and demand in North America and the Eastern countries are bound to generate improportionately greater demands for OPEC oil. This follows from the distribution of energy consumption among the various regions buying energy on the international market. The resource-poor industrialized countries are extremely sensitive to such fluctuations since they would be forced to make up for their oil supply deficiencies by importing more of other fossil resources such as coal, unconventional hydrocarbons, and natural gas from North America and the Eastern countries. As regards any further reductions in the availability of oil from the Persian Gulf region, Western Europe and Japan would be just as susceptible to them.

This predicament essentially suggests that Western Europe and Japan should undertake to reinforce development of their own energy sources, complementing supplies by energy imports that in a case of classical resource scarcity are not automatically in overwhelming demand by the other industrialized regions. Here uranium and low-quality coals come to one's mind; but using them would presuppose independent technological programs that to some extent differ from the R&D programs for resource exploitation in the U.S.A. and Canada, and the Eastern countries.

This logic implies a duplication of efforts in international energy technology development that has purposely been excluded from the IIASA scenarios. While this diversification could in principle alleviate the supply risks for Europe and Japan, it would in the final analysis affect the global system in a similar way as if individual nations were trying to save their resources for the generations to come.

Realization of the strategies quantified in the IIASA scenarios postulates immense efforts and investments worldwide. It is not possible to state at this point to what extent this will encourage national or local efforts to search for solutions to the energy problem. If the actual trend were similar to what present circumstances seem to suggest, the problems that countries with a limited classical resource base will encounter would be even more severe than the prospective regional capital requirements quantified in the IIASA scenarios for the purpose of orientation. This reasoning applies directly to the countries of Western Europe and Japan. Practically the only resort left to them would be to accelerate the implementation of energy strategies mentioned in the previous section, which is to exploit and utilize all energy supply alternatives such as nuclear energy, unconventional fossil fuels, and renewables, and introduce much tighter energy conservation measures. There seems to be no room for them to choose from holding back on one or the other measure.

Besides, the economic difficulties arising from the energy problem may tend to set back efforts at speeding up the implementation of such programs. Chances are tough, for the costs

that arise would have to be borne at a time when the countries' balance of payments is charged with rocketing import bills and their stand against international competition is weakened by higher factor costs.

CONCLUSIONS

It is not possible to predict what new events will add to that list of political events summed up in the first section; and as a consequence one cannot assess the feedbacks they would have on the international energy supply system. Whatever they are going to be like, the national energy programs that are being initiated and implemented in the various countries will have to prepare for such feedbacks effectively. Inadequate preparations for the future--bona fide designed to buffer impacts of adverse political events on the international energy situation--might trigger such events or even their roots.

Factually speaking, national energy programs in their entirety seem to constitute a more reliable indicator of how the international energy situation will develop in the decades ahead than a crystal ball that should serve to predict how the list of political events that have accompanied "the energy problem" will be extended. But no attempt has yet been made to put together and look into the actual adjustments of the national energy programs to the development since 1973 in such a truly comprehensive fashion. Such a survey is missing. Even if it existed it should and could only be interpreted within a long-range and global perspective. This is the real development problem coming up for developed and developing, resource-rich and resource-poor nations alike.

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