WORLD ENERGY DEMANDS AND THE MIDDLE EAST

Part I of Two Parts

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WORLD ENERGY DEMANDS AND THE MIDDLE EAST

1972 Annual Conference Record

Part I of Two Parts

First Session, Friday morning, September 29, 1972
Presiding: Parker T. Hart, President, The Middle East Institute

KEYNOTE ADDRESS

THE MIDDLE EAST AND WORLD ENERGY

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My task this morning is to introduce this conference to some of the unbelievably complex problems and issues up for discussion today and tomorrow. All I can really promise is to be brief. At the outset, I shall say a few words about world energy supply and demand -- drawing entirely on the work of others, the flood of studies now appearing under the auspices of a wide variety of sponsors. Later, I shall try to be more original and relate the conclusions of some of these to the Middle East. In passing I promise to inflict you with a few of my own prejudices on this tantalizing subject.

As to world energy supply and demand, and the so-called energy "crisis" predicted by many, I have only a few thoughts to offer.

First, if we assume conservative incremental growth rates in energy demand at four and a half per cent to five per cent yearly, world energy demands of all kinds should move upward from 50Q's (Q = 1 x 10^{12} KWH or a million million KWH) yearly today to 120Q's by 1985 and over 200Q's by 2000 A.D. Energy demand will more than double (maybe triple) by 1985, and certainly quadruple by the end of this century. After allowance for forecasting error -- endemic to energy demand projections -- steady upward movements in world energy demand seem inevitable. This is hardly an observation of great originality.

Second, nobody knows what end-use patterns for energy will emerge fifteen to thirty years from now. These will vary from nation to nation, continent to continent, high income to low income areas, and will largely reflect prevailing levels of technology and public policy in consuming areas. Today in the United States, for

example, industry takes just under one-third of all energy produced, electric utilities and transportation consume half (25% each), and residential users (14%) and commercial enterprises (5%) together take the remaining 20 per cent. In this field, forecasters are many and their accuracy infrequent.

Third, the sources of all this energy for the next thirty years are probably more predictable. Today, out of the 50Q's consumed, 90 per cent comes from fossil fuels -- oil, gas and coal -- and only ten per cent from other sources combined (hydro, nuclear, wood). By 1985 fossil fuels will almost certainly still provide three quarters of the world's energy and by 2000 A.D. about the same. Over these years, coal's relative role will have dropped somewhat (although tonnage will rise enormously), and nuclear energy will (hopefully) account for about 20 per cent of world energy needs by the end of the century. During the decade of the 1970s, the world will consume more oil than all the oil used by man since the dawn of history! The lesson here is simple and stark -- the world's energy will probably come mainly from fossil fuels for the next two generations.

Fourth, I shall address the questions of "are there enough fossil fuel sources available worldwide to sustain these enormous demand increases?" The answer to this question is an emphatic "yes"! A sensible consensus of forecasts on economically recoverable fossil fuels shows at least 35,000Q's potentially available (today's total world energy consumption is 50Q's), enough to last us several hundred years. Two-thirds of these reserves (24,000Q's) consist of coal and lignite and one-third (10,000Q's) are in oil, gas, oil shales and tar sands. The world's fossil fuel resources are still huge.

Fifth, the question then arises "why worry?" To this the answer is again simple. We should indeed worry, right now; and better yet, do something! Although fossil fuel sources are abundant, a number of problems -- some physical, others almost metaphysical -- inhibit their development and use. Among these are location (of big producers and consumers of energy, often with oceans between them), transport facilities (mainly pipelines, tankers and rail), transformation arrangements (such as refineries and electric power generators), finance for the huge investments required each year to make it all possible, feasible substitutes, pollution considerations, and above all cost -- from the raw materials for energy to the final charge to ultimate consumers of industrial fuels, household heating oil, electricity and gasoline. Despite the abundance of hydrocarbon fuels, supply dislocations and/or constraints on energy use or availability are distressingly possible, indeed probable. Illustrative of this, the US and Venezuela are "peaking-out" as oil producers, gas shortages in several areas already loom in the US, electric power generating capacity is falling well behind demand and domestic refining capacity for the US is already barely adequate. Hopefully I have made the case for worry.

Foremost among these difficulties is the fact that the world's big energy consumers (the US, Europe and Japan -- which together consume about 80% of the world's energy) each year grow more dependent on imported oil and gas, on the long sausage-link chain of (ever larger) jumbo tankers carrying the fuel, and on the economic arrangements negotiated between producing governments and international oil companies. Japan and Europe have long since become "hooked" on Middle Eastern (and North African) oil. The US will, unless miracles occur, be importing 15 million barrels of crude daily (half our oil consumption) by 1985, probably sooner. The "addict-pusher" relationship, unique in the world's economic history, is spreading. And the ramifications -- up for discussion here today and tomorrow -- offer both hope for the future and reasons for real fear (for all parties) if things go wrong.

I shall now turn to the second part of my remarks this morning. From here on I should like to discuss a few of the implications of the foregoing and attempt some admittedly subjective speculation.

First, it is clear to all that nuclear energy as a challenger to fossil fuels is maddeningly slow in arriving. Since 1945, for example, the US has acquired less than two plant years per year of nuclear power generating experience -- and less than one per cent of our energy comes from nuclear plants. At the moment we are spending about $1 billion yearly on non-fossil fuel energy experimentation -- much of it on the liquid metal fast breeder reactor. Although we have altered the 1901 Webster's Dictionary definition of uranium as a "worthless metal," we have made precious little progress in putting nuclear power to work in the American economy. The reasons are well known -- high cost (relative to fossil fuels), difficulties with the disposal of heat and radioactive waste and fears of radioactive exposure of nearby communities. If the breakthroughs do come, the world's energy problems could be solved for thousands of years. But I repeat, they are unbelievably slow in coming. And, I also remind you, these same breakthroughs have been "just around the corner" for a quarter of a century.

Second, we have made even less progress in developing "far out" substitutes for fossil fuels. I refer here to schemes for harnessing ocean temperature gradients (such as the Caribbean thermocline), magneto-hydrodynamics, fuel cell energy, solar energy and the other potentially rich sources of power. Research goes ahead, at snails' pace, and cost for these fossil fuel substitutes remains prohibitive.

Third, the most progress still seems to be occurring in the processing and utilization of fossil fuels -- extracting sulfur from fuel oil, drilling in ever deeper water for oil and gas, elimination of pollution by refineries, coal liquefaction and gasification, improved ocean transport technology for oil, cryogenic tankers for gas,

shale and tar sands development. Ironically, the big advances are still occurring in fuels which although still abundant, are indeed finite. And for many of these, cost is still prohibitive.

Fourth, the combination of soaring oil and gas demand, sharp upward shifts over the past two years in net per-barrel takes by Middle Eastern governments (Saudi Arabia gets about $1.50 per barrel today, Libya over $2.00 and Algeria well over $2.50) coupled with growing skill in negotiating by Middle Eastern governments has created a new and interesting situation. These nations not only control major portions of the free world's proven crude oil resources, but they also have at their disposal huge quantities of foreign monetary reserves. Libya's foreign exchange holdings now exceed $3 billion. Saudi Arabia's reserves will probably top $2 billion this year and five years hence could conceivably rise to $10 - $12 billion -- more than the reserves behind the US dollar, and more than the total shareholders' equity in any but the largest of America's biggest corporations. Receiving an estimated $15 billion yearly for their oil by 1980, Eastern Hemisphere oil producing nations are rapidly emerging as immensely significant forces in world trade and finance.

In the above connection, it is worth noting here that these massive Middle Eastern government (and privately held) funds are increasingly important to international liquidity and the big reserve currencies. Before 1968, about two-thirds of Middle Eastern reserve balances were in sterling and one-third in dollars. Now (of much larger totals) about three-fourths are in Eurodollars and dollars, and only one-fourth in sterling. Out of a total Eurodollar market of about $58 billion, as much as $10 billion could well be Middle Eastern owned. Today there is a net dollar inflow of about $2 billion yearly for the US from all this and sterling acquires at least $500 million. By 1980 total purchases of goods and services by Middle Eastern nations from the US, Europe and Japan could exceed $5 billion yearly and transfers of new funds to Western money markets might equal this figure. In contrast to today, the oil imports associated with all this could, in the opinion of many informed experts, create balance of payments deficits of $20 billion yearly for the US by the end of this decade. The numbers, and their implications, are staggering.

Fifth, and equally thought provoking, is the residual impact of the dramatic shifts now taking place in arrangements for producing, transporting and marketing Middle Eastern oil. The Tehran, Tripoli and Geneva negotiations of the past eighteen months have led to sharp upward revisions, not only of revenues to producing governments but also of energy costs to all concerned -- ultimately to all of us, you and me. The current OPEC participation negotiations will certainly have the same effect. Added to this, on the heels of the Tehran and Tripoli meetings, Iraq and Libya have undertaken partial nationalizations, as had Algeria earlier and more completely. Rare indeed today are those

intervals during which an "eyeball to eyeball" confrontation between producing governments and oil companies is not actually taking place or about to begin. Oil companies are really under the lash, and their historic role as middlemen between producers and consumers is being challenged lustily.

The above situation is accompanied by a quantum jump in the chances for supply interruption, oil price fluctuations, less predictable producer government incomes and other by-products of destruction of the twenty-five year old arrangements for providing Eastern Hemisphere oil to the world's big energy-short consumers. This could be calculated, the result of human error, or a combination of many potentially self-destructive elements inherent in the situation. Whatever the cause, energy crises of varying degree for the US could result.

On the theme of potential causes of energy crises, let us look first at producer governments. It is hard for me not to sympathize this morning with the individuals who shape oil policy in Middle Eastern nations. Looking back over the past quarter century they see, miraculously for them, cheap Middle Eastern (and North African) oil as the major cause for the slow advent of nuclear power in Europe, Japan and the US. They also, more soberly, see their huge oil deposits as finite and conceivably nearing exhaustion by the year 2000. Most feel that their oil, despite recent increases, is under-priced. Their mandate is to get the highest (stable) price for a wasting resource, yet they must offer terms sufficiently attractive to encourage exploration. They must also find ways to dispose of the ever-greater quantities of oil which the current "participation" negotiations will probably oblige them to dispose of somehow. Meanwhile, each year their development programs need more funds, and their arms expenditures rise -- as they match the ways of Western nations and the Soviet Union! So they must negotiate tax-paid costs per barrel which keep the ministers of development and finance and defense at home happy, and themselves in office. At the same time, they must convince their big customers that flat-out programs to develop alternative energy sources are unnecessary and that the international consumer stands willing to pay ever higher bills for his fossil fuel energy. This all adds up to a very tough job.

Even more difficult, Middle Eastern oil ministers feel that they must press oil companies for more per barrel without upsetting the delicate balance of market forces which (to their great benefit) has kept the price of crude oil remarkably free from wild fluctuation over the past two and a half decades. Wholesale nationalization of companies would, in the opinion of many experts (Arab, Iranian and Western) bring about just such fluctuations, and possibly sharp declines in net producer-government revenues per barrel. Moreover, huge tax-paid-cost-per-barrel-increases could conceivably face Western nations with no alternative but to go "flat out" in developing substitutes.

While the latter path would be costly indeed for industrial oil consuming nations, it could be disastrous for the big "one crop economy" oil exporters. And, ironically, they could find themselves -- after their oil postponed the advent of nuclear power worldwide for twenty years -- becoming the catalyst to force the pace of nuclear development in Europe, the US and Japan.

Still more difficult, moderate Arab oil ministers (and there are many, I remind you, despite the impression imparted by American newspapers) must placate public opinion at home on the matter of oil and the Arab-Israel problem. Several Arab leaders have called outright for the use of oil as a weapon against Israel. This in effect means denial of oil to the US -- Israel's main arms supplier and financial supporter. Militant Palestinian resistance groups echo this call repeatedly. To resist these appeals and still appear to be a patriotic Arab today is not easy -- particularly during an election year in the United States.

Let me now point to another element on the long list of forces which might help create an energy crisis for the United States. I refer to the genuflecting to the ethnic vote now being engaged in publicly by candidates in the forthcoming elections. (To their credit, many American Jewish organizations have in recent weeks deplored this practice.) It has become a well-known feature of American politics, both parties do it, and each vies for public acclaim as the supporter of Israel -- its existence, its economy and, if necessary, its geographic expansion. Many vote-gatherers link their appeal to ethnic voters with attacks on oil company profits and recommend elimination of tax allowances now permitted by law. Republican and Democratic congressmen by the dozen echo the same theme, frequently adding the pollution issue to their polemics. Rare indeed today is the US political figure who points to the coming domestic oil and gas shortage, suggests that an improvement in US-Arab relations might be constructive and assesses the role of oil companies in the equation in emotionless terms. Between now and November we shall be treated to a bizarre symphony on this theme by politicians of both parties.

Let me now turn to the international oil companies, which remain a major element in the situation. As noted earlier, their historic role is facing challenge. There is little doubt that today they are competitive (often viciously so, particularly in product markets), disagree among themselves on many matters and face immense difficulties. They operate, American academic folklore to the contrary, without the protective cushion of the fabled "cartel," and short-term surpluses (caused by weather and business conditions) are a persistent problem to most of them. To provide for oil's role alone in soaring world energy demand will require them somehow to find over $500 billion in new investment over the coming decade. Yet their modest yearly rates of return on investment (ranging from 8% to 12%) simply do not permit

them to generate such funds -- as the Chase Manhattan Bank has recently made vividly clear. Whether their managements are up to this task will be critical. To survive they must submit to flaying by vote-seekers in US elections, OPEC oil ministers, ecologists (both serious and hare-brained) and the squads of academics pontificating learnedly about multi-national enterprise on campuses across America. Whether one likes oil companies or not, there is at the moment no workable substitute for them in sight. The energy-hungry world, as well as the producing governments, both need them desperately. They perform a task which can hardly, at this juncture, be done by the US Interior Department, the Office of Emergency Preparedness, or even by Ford Foundation Energy Study staffs.

Let me now identify still another crucial element in the international energy drama. It is ourselves, all of us, you and I. A few examples: We all want to "live better electrically" (the motto of the New England Electric Co.) and daily bring into our homes new gadgets requiring more power generated, in all likelihood, from high sulfur oil or other polluting fuels. We resist heroically any attempts to raise energy costs to consumers although these are still at real levels lower than in 1940. We watch with clinical detachment while the Federal Power Commission maintains gas prices at levels which discourage exploration, encourage uneconomic consumption, make import arrangements difficult indeed to conclude and virtually guarantee a series of gas crises. Overnight our news media (and the deep-thinkers in Sproul Plaza and Harvard Square) develop passionate concern for the mating habits of Alaska caribou and campaign noisily against intrusion of Arctic pipelines into this essential activity. As our per capita electric consumption edges upward inexorably, we join conservationist groups and work ardently to block power production by nuclear plants. We continue our love affair with the 8 mile-per-gallon automobile, use it to move 130 lb. American women about (usually alone), add mileage-cutting anti-pollution devices yearly, and continue to fill our tanks with high-octane rather than no-lead gasoline. We overheat our houses and open windows to cool them -- one expert (Professor David Rose of M.I.T.) has estimated that Manhattan Island each day puts more heat into the atmosphere than the sun lavishes upon it! Each day we buy more items packaged in throw-away aluminum containers -- made from the most energy intensive metal of them all. We applaud our elected representatives as they deride oil producing countries in the Middle East as part of their vote gathering, and make moderation by these nations in energy matters more difficult. Vilifying oil companies by latter day Ida Tarbells remains a part of the noble American academic and political tradition. We too, all of us, play a self-destructive role in the energy drama.

In conclusion I should like to point to three more-or-less certain, and predictable, developments which will probably accompany the confusing elements I have just described.

The first of these safely predictable developments concerns energy costs. Most of us here today will agree with me, I feel certain, that substantial increases are inevitable, some would say desirable. The bargain rates for all kinds of energy -- coal, oil, gas -- which Americans have enjoyed for forty years cannot endure much longer. And the recent increases -- averaging about 30 per cent to consumers -- are only the beginning. Without these, and they must be paid for by you and me as ultimate users of energy -- new energy reserves won't be developed, pollution cannot be kept at tolerable levels, substitute energy sources won't evolve and some real crises could face us. Even with the increases, crises may come. These costs will in aggregate be staggering, far greater than the estimated $100 billion (8-10% of GNP) which we now pay for our energy.

Another safe prediction concerns consumer government organizations. Many of you here today are aware of the so-called "Zurich Club." This loose confederation (or better, "discussion group") of consuming-government energy planners and national oil company executives -- from Japan, Spain, Austria and Germany -- was recently formed for periodic review of problems besetting the big energy-importing countries. It is still a far cry from a "consuming government OPEC," but it could well signal entry of a countervailing power into the jousts heretofore reserved for producing governments, OPEC and oil companies. Under some circumstances it could be a real annoyance to the latter three. Under others, its role could be constructive and moderating. In the opinion of some observers it might, ironically enough, help preserve the profitable arrangements now enjoyed by its multitude of critics. It is safe to predict that the "Zurich Club" -- or its successor -- will be with us for a long time.

My third safe prediction concerns the coming popularity of "energy" as a field of thought, subject for enquiry and perhaps, a new academic discipline. Studies by the hundred are now underway, and these are only the beginning. Universities are tooling up everywhere to focus teaching and research on energy matters. A clanging, Omdurman-like charge of untethered academics, graduate students and Washington "operators" onto the field has begun. The Ford Foundation has made its usual large grant to find instantaneous solutions to unbelievably complex problems. Ph. D. dissertations by the thousand will result, in every conceivable discipline. A few examples: Psychology ("How to teach caribou to jump over a 48" pipe"). Linguistics ("Frequency of recurrence of the words Shell and B.P. in speeches by Harvard Square eco-freaks"); Political Science ("How to convince the world that neither Arab nor American politicians really mean it when they lavish invective on one another"); Sociology ("Can American society survive without electric tooth-brushes?"); Economics (here the possibilities for banality are too numerous to mention). Out of all this, probably initially in the "hard sciences," will come some good work. We must also look forward to an avalanche of drivel. Hot air pollution will be a major by-product of it all. I close by expressing the fervent hope that we hold ours to a minimum in these meetings.

Panel I

PRESSURES OF ENERGY DEMANDS ON RESOURCES

Presiding: Hollis M. Dole, Assistant Secretary, Mineral Resources,
U. S. Department of the Interior

Survey of World Energy Resources
M. King Hubbert, Research Geophysicist,
U. S. Geological Survey

Fossil Fuels
Robert E. King, Consultant

Alternative Sources of Energy
R. S. Carlsmith, Director of Energy Team,
Oak Ridge National Laboratory and Associate
Director ORNL-NSF Environmental Program

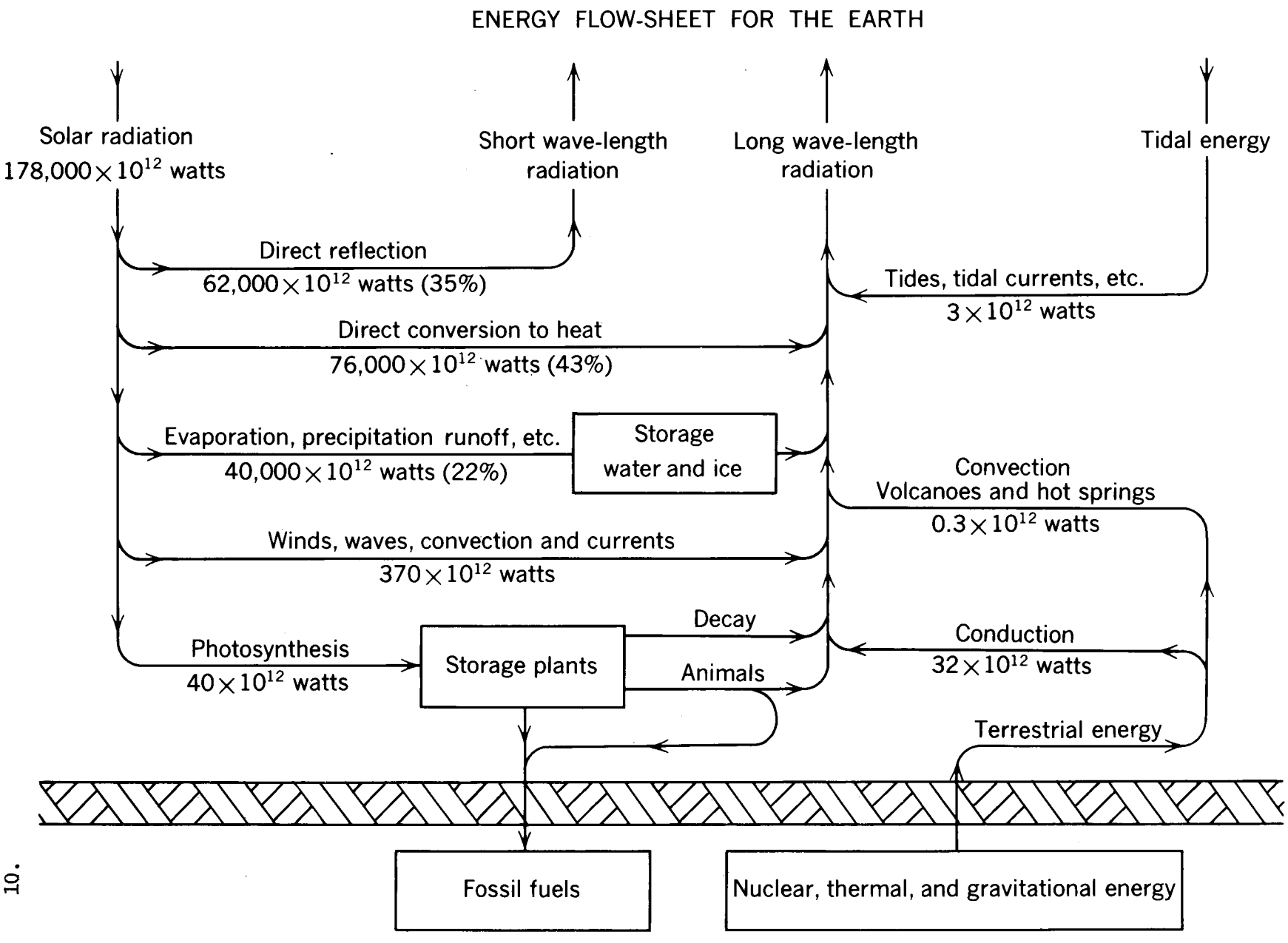

Figure 1.
World energy flowsheet (Hubbert, 1962, Fig. 1).

Plenary Panel I, Pressures of Energy Demands on Resources
Friday morning, September 29, 1972
Presiding: Hollis M. Dole, Assistant Secretary, Mineral Resources,
US Department of the Interior

SURVEY OF WORLD ENERGY RESOURCES

M. King Hubbert
Research Geophysicist, U. S. Geological Survey

By now it has become generally recognized that the world's present civilization differs fundamentally from all earlier civilizations in both the magnitude of its operations and the degree of its dependence upon energy and mineral resources -- particularly energy from the fossil fuels, and the industrial metals. Our program today is concerned with the energy component of this system. The significance of energy lies in the fact that it is involved in everything that occurs on the earth -- everything that moves. In fact, in the last analysis, about as succinct a statement as can be made about terrestrial events is the following: The earth's surface is composed of the 92 naturally occurring chemical elements, all but a minute radioactive fraction of which obey the laws of conservation and of nontransmutability of classical chemistry. Into and out of this system is a continuous flux of energy in consequence of which the material constituents undergo either continuous or intermittent circulation.

The principal energy inputs into this system (their magnitudes measured in thermal watts) are three (Fig. 1): (1) $178{,}000 \times 10^{12}$ thermal watts from the solar radiation intercepted by the earth's diametrical plane; (2) 32×10^{12} thermal watts conducted and convected to the earth's surface from inside the earth; and (3) 3×10^{12} thermal watts of tidal power from the combined kinetic and potential energy of the earth-moon-sun system. Of these inputs of thermal power, that from solar energy is overwhelmingly the largest, exceeding the sum of the other two by a factor of more than 5,000.

Of the solar input, about 30 per cent, the earth's albedo, is directly reflected and scattered into outer space, leaving the earth as short-wavelength radiation; about 47 per cent is directly absorbed and converted into heat; about 23 per cent is dissipated in circulating the atmosphere and the oceans, and in the evaporation,

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precipitation, and circulation of water in the hydrologic cycle. Finally, a minute fraction, about 40×10^{12} watts, is absorbed by the leaves of plants and is stored chemically by the process of photosynthesis, whereby the inorganic substances, water and carbon dioxide, are synthesized into organic carbohydrates.

Small though it is, this fraction is the energy source for the biological requirements of the earth's entire populations of plants and animals.

From radioactive dating of meteorites, the astronomical cataclysm that produced the solar system is estimated to have occurred about 4.5 billion years ago and microbial organisms have been found in rocks as old as 3.2 billion years. During the last 600 million years of geologic history, a minute fraction of the earth's organisms have been deposited in swamps and other oxygen-deficient environments under conditions of incomplete decay and eventually buried under great thicknesses of sedimentary muds and sands. By subsequent transformations, these have become the earth's present supply of fossil fuels: coal, oil and associated products.

About two million years ago, according to recent discoveries, the ancestors of modern man had begun to walk upright and to use primitive tools. From that time to the present, this species has distinguished itself by its inventiveness in the progressive control of an ever larger fraction of the available energy supply. First, by means of tools and weapons, the invention of clothing, the control of fire, the domestication of plants and animals and use of animal power, this control was principally ecological in character. Next followed the manipulation of the inorganic world including the smelting of metals and the primitive uses of the power of wind and water.

Such a state of development was sufficient for the requirements of all pre-modern civilizations. A higher level industrialized civilization did not become possible until a larger and more concentrated source of energy and power became available. This occurred when the huge supply of energy stored in the fossil fuels was first tapped by the mining of coal, which began as a continuous enterprise about nine centuries ago near Newcastle in northeast England. Exploitation of the second major fossil-fuel energy supply, petroleum, began in 1857 in Romania and two years later in the United States. The tapping of an even larger supply of stored energy, that of the atomic nucleus, was first achieved in a controlled manner in 1942, and by now the production of nuclear power from plants in the 1,000-megawatt range of capacity is in its early stages of development.

In addition to increased energy sources, energy utilization was markedly enhanced by two technological developments near the end

of the last century, the development of the internal combustion-engine utilizing petroleum products for mobile power, and the development of electrical means for the generation and distribution of power from large-scale central power plants. This also made possible for the first time the large-scale use of water power. This source of power derived from the contemporary flux of solar energy has been in use to some degree since Roman times but always in small units -- units rarely larger than a few hundred kilowatts. With electrical generation and distribution of hydropower, first accomplished at Niagara Falls about 1895, progressively larger hydropower stations have been installed with capacities up to several thousand megawatts.

ENERGY FROM FOSSIL FUELS

To the present, the principal sources of energy for industrial uses have been fossil fuels. Let us therefore review the basic facts concerning the exploitation and utilization of these fuels. This can best be done by means of a graphical presentation of the statistics of annual production.

World Production of Coal and Oil

Figure 2 shows the annual world production of coal and lignite from 1860 to 1970 and the approximate rate back to 1800, on an arithmetic scale. Figure 3 shows the same data on a semilogarithmic scale. The significance of the latter presentation is that straight-line segments of the growth curve indicate periods of steady exponential growth in the rate of production.

Annual statistics of coal production earlier than 1860 are difficult to assemble, but from intermittent earlier records it can be estimated that from the beginning of coal mining about the 12th century A.D. until 1800, the average growth rate of production must have been about two per cent per year with an average doubling period of about 35 years. During the eight centuries to 1860, it is estimated that cumulative production amounted to about 7×10^9 metric tons. By 1970, cumulative production reached 140×10^9 metric tons. Hence, the coal mined during the 110-year period from 1860 to 1970 was approximately 19 times that of the preceding eight centuries. The coal produced during the last 30-year period from 1940 to 1970 was approximately equal to that produced during all preceding history.

The rate of growth of coal production can be more clearly seen from the semilogarithmic plotting of Figure 3. The straight-line segment of the production curve from 1860 to World War I indicates

a steady exponential increase of the rate of production during this period at about 4.4 per cent per year with a doubling period of 16 years. Between the beginning of World War I and the end of World War II, the growth rate slowed down to about 0.75 per cent per year and a doubling period of 93 years. Finally, after World War II, a more rapid growth rate of 3.56 per cent per year and a doubling period of 19.8 years was resumed.

Figure 4 shows on a arithmetical scale the annual world crude-oil production from 1880 to 1970. Figure 5 shows the same data plotted semilogarithmically. After a slightly higher initial growth rate, world petroleum production from 1890 to 1970 has had a steady exponential increase at an average rate of 6.94 per cent and a doubling period of 10.0 years. Cumulative world production of crude oil to 1970 amounted to 233×10^9 barrels. Of this, the first half required the 103-year period from 1857 to 1960 to produce, the second half only the 10-year period from 1960 to 1970.

When coal is measured in metric tons and oil in US 42-gallon barrels, a direct comparison between coal and oil cannot be made. Such a comparison can be made, however, by means of the energy contents of the two fuels as determined by their respective heats of combustion. This is shown in Figure 6, where the energy produced per year is expressed in power units of 10^{12} thermal watts. From this it is seen that until after 1900 the energy contributed by crude oil was barely significant as compared with that by coal. By 1970, however, the energy from crude oil had increased to 56 per cent of that from coal and oil combined. Were natural gas and natural-gas liquids also to be included, the energy from petroleum fluids would represent about two-thirds of the total.

U.S. Production of Fossil Fuels

The corresponding growths of the production of coal, of crude oil, and of natural gas in the United States are shown graphically in Figures 7 to 12. From before 1860 to 1907, annual U.S. coal production increased at a steady exponential rate of 6.58 per cent per year with a doubling period of 10.5 years. After 1907, due largely to the increase in oil and natural-gas production, coal production has fluctuated about a rate of approximately 500×10^6 metric tons per year. After an initial higher rate, US crude-oil production increased steadily from 1870 to 1929 at about 8.27 per cent per year with a doubling period of 8.4 years. After 1929, the growth rate has steadily declined to a 1970 value of approximately zero. From 1905 to 1970, the US production of natural gas increased at an exponential rate of 6.6 per cent per year with a doubling period of 10.5 years.

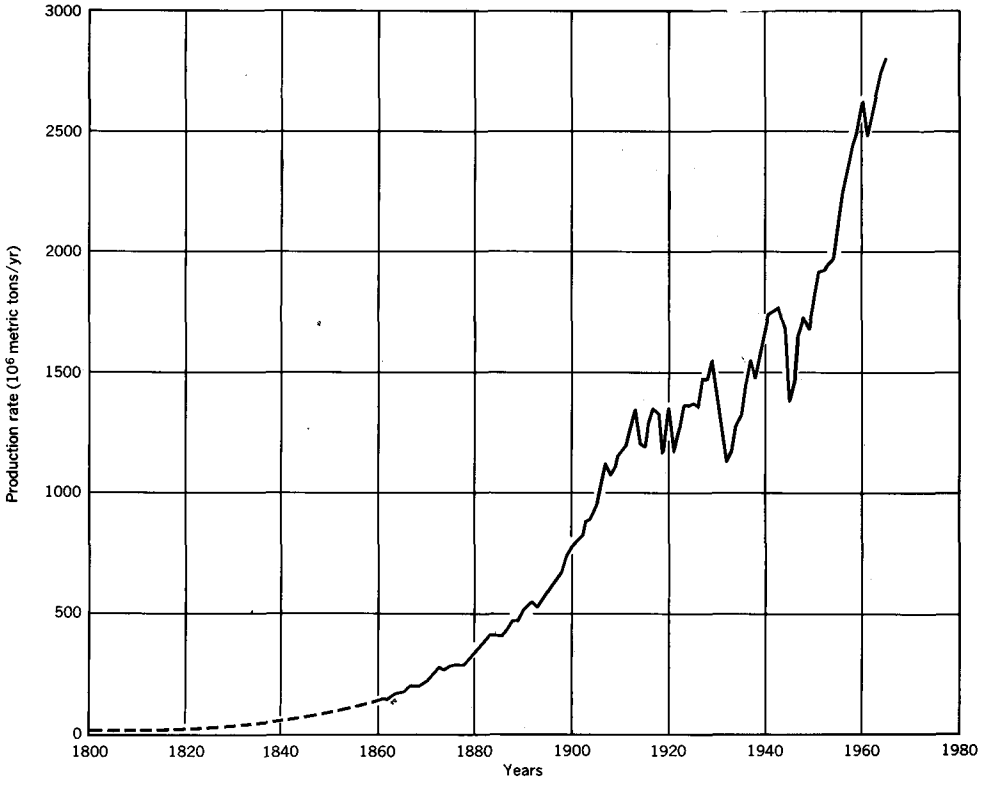


Figure 2.
World production of coal and lignite (Hubbert, 1969, Fig. 8.1).

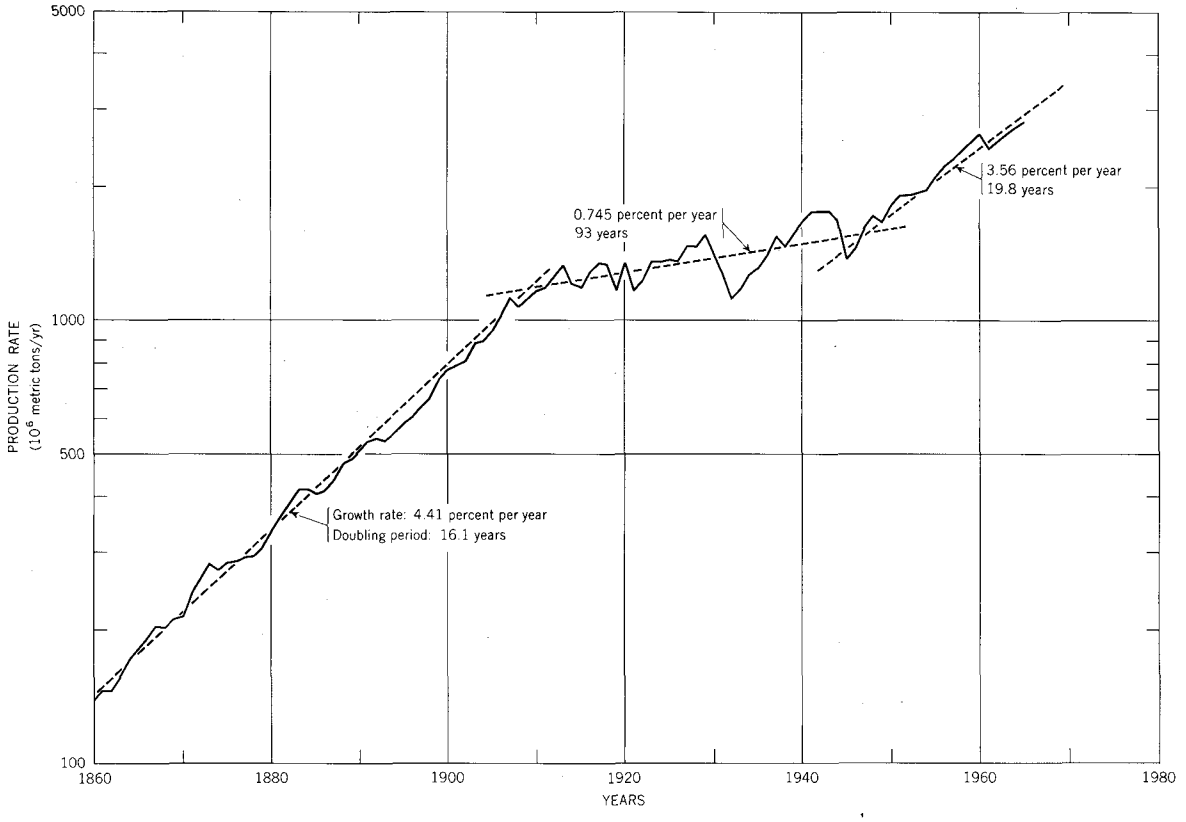


Figure 3.
World production of coal and lignite (semilogarithmic scale)
(Hubbert, 1971, Fig. 4).

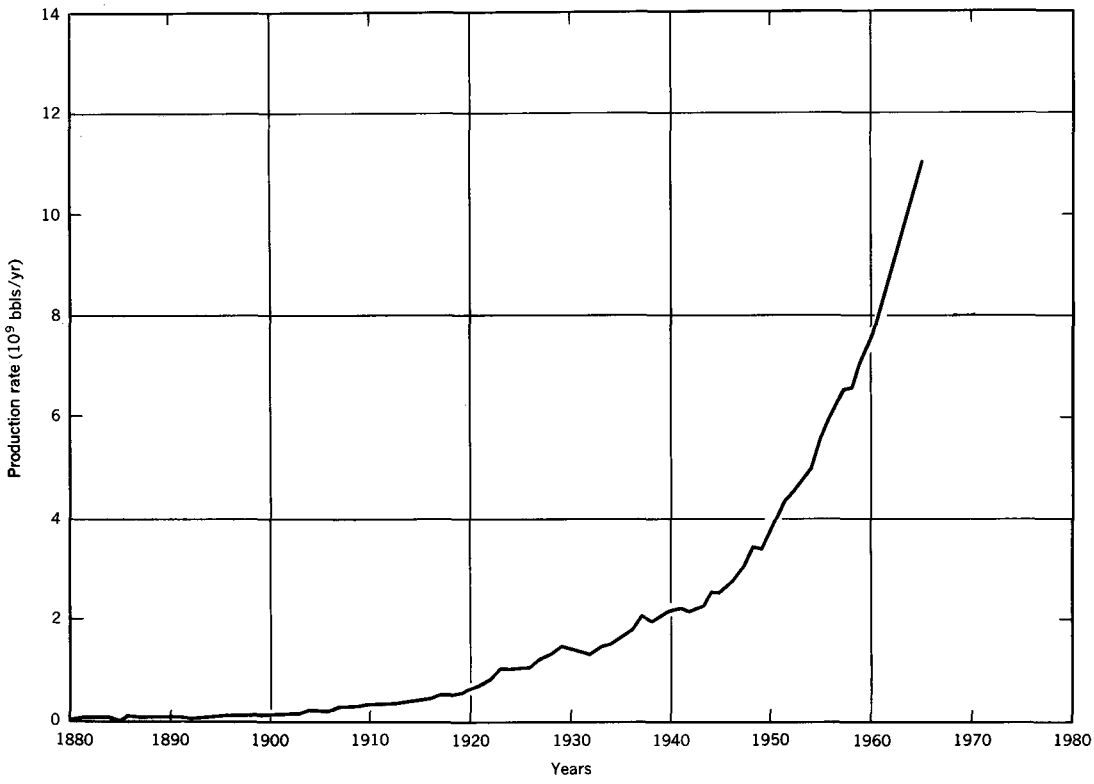


Figure 4.
World production of crude oil (Hubbert, 1969, Fig. 8.2).

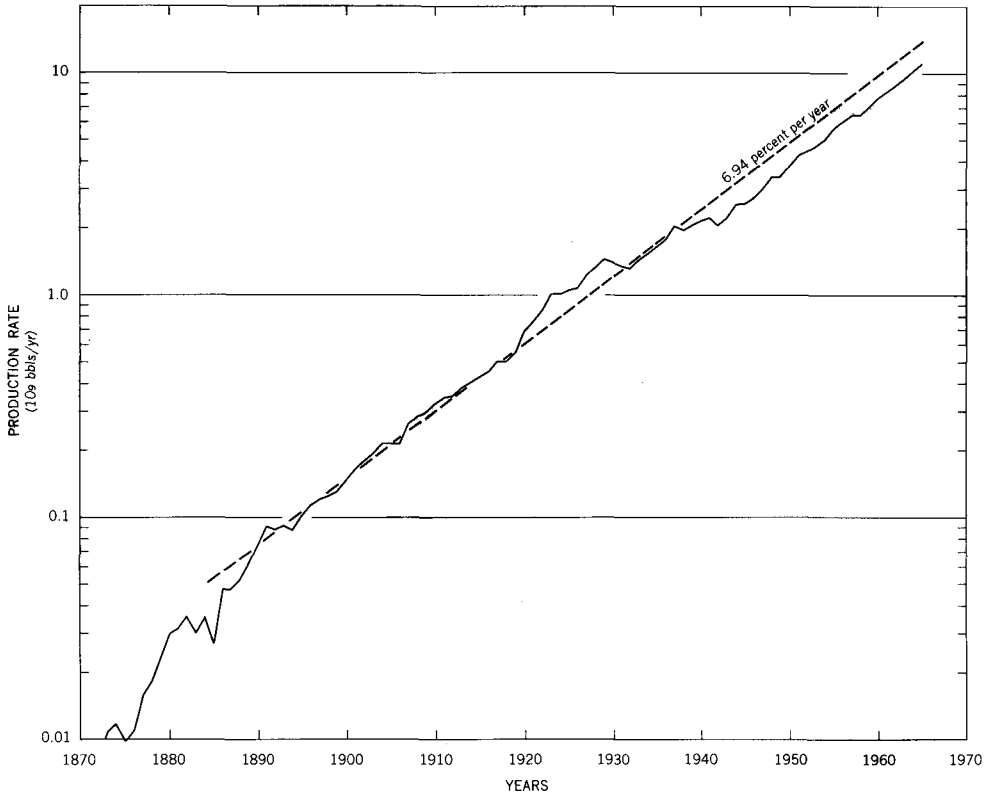
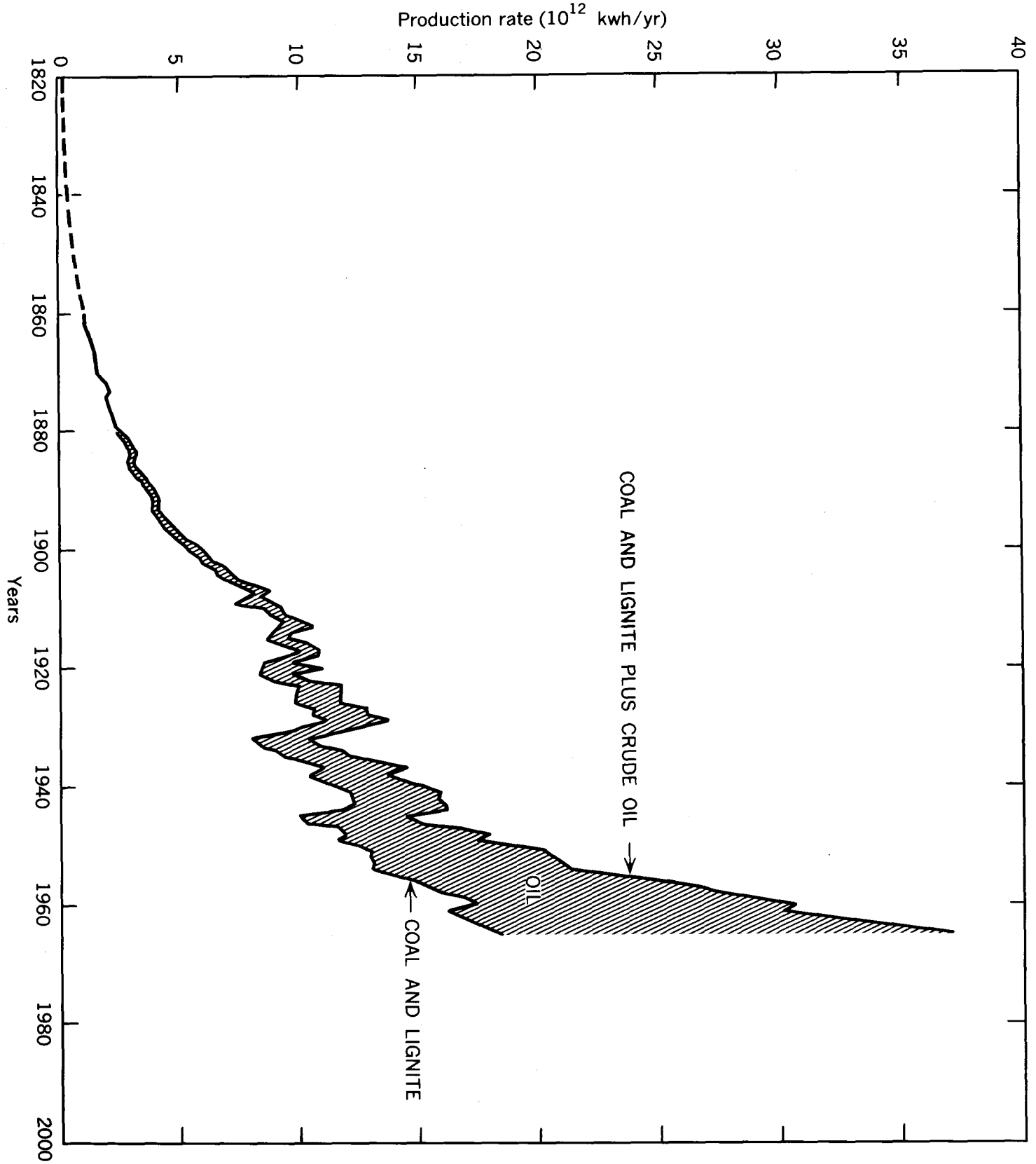


Figure 5.
World production of crude oil (semilogarithmic scale)
(Hubbert, 1971, Fig. 6).

Figure 6.
World production of thermal energy from coal and lignite plus crude oil (Hubbert, 1969, Fig. 8.3).



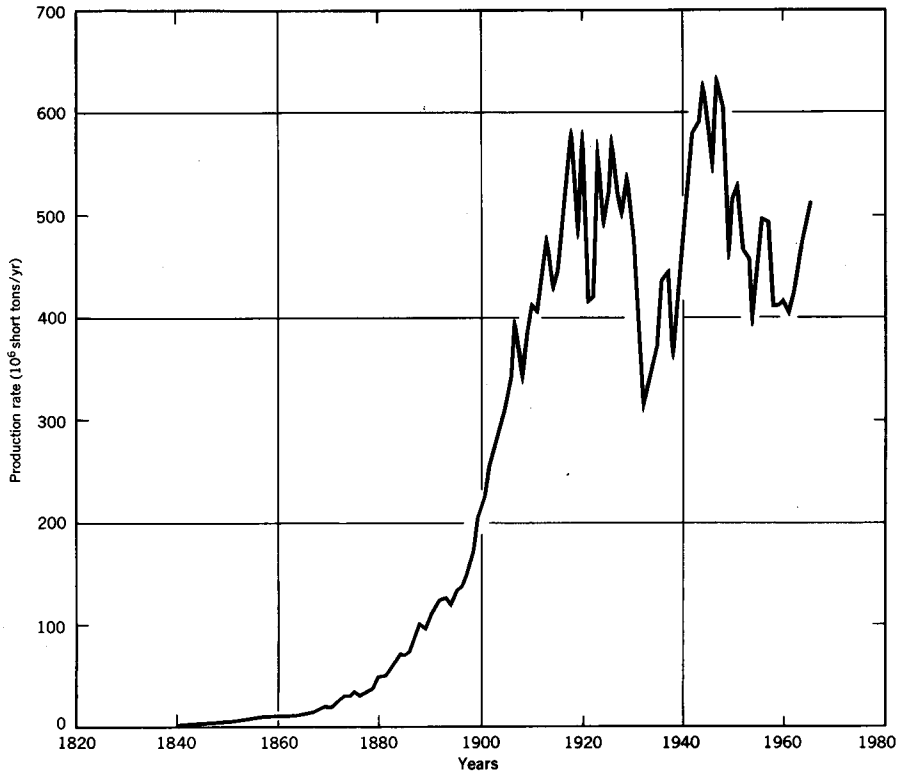


Figure 7.
U.S. production of coal (Hubbert, 1969, Fig. 8.4).

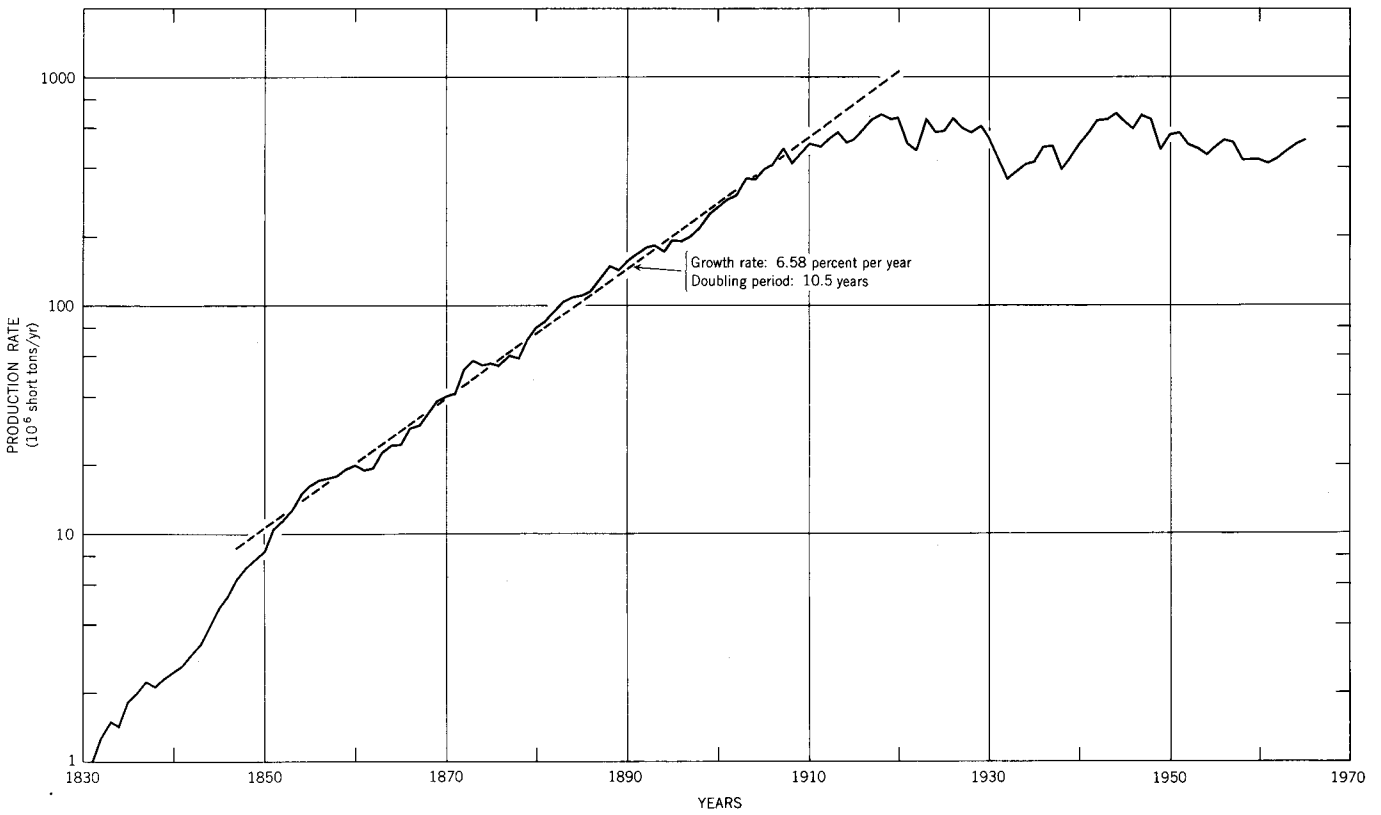


Figure 8.
U.S. production of coal (semilogarithmic scale).

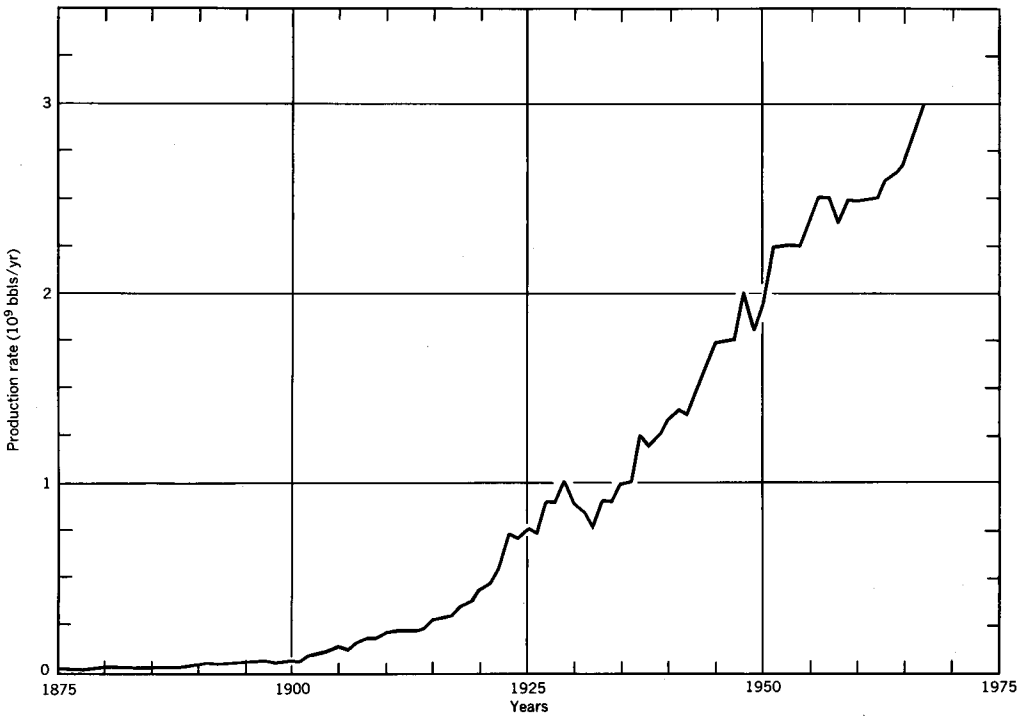


Figure 9.
U.S. production of crude oil, exclusive of Alaska
(Hubbert, 1969, Fig. 8.5).

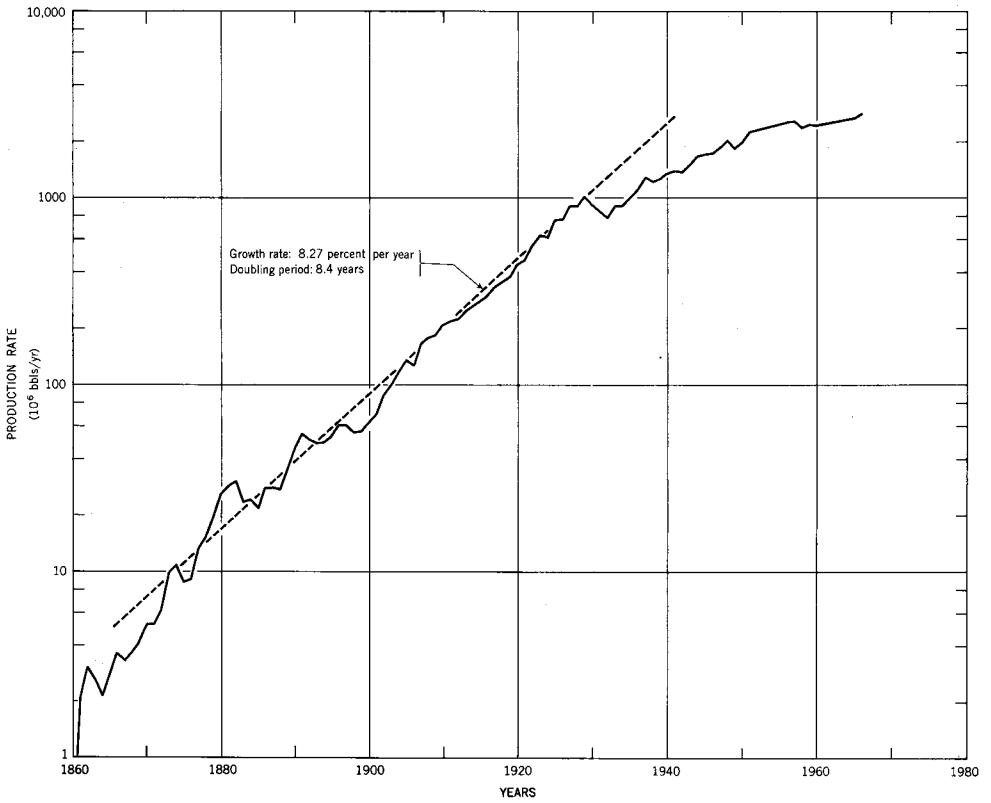


Figure 10.
U.S. production of crude oil, exclusive of Alaska
(semilogarithmic scale).

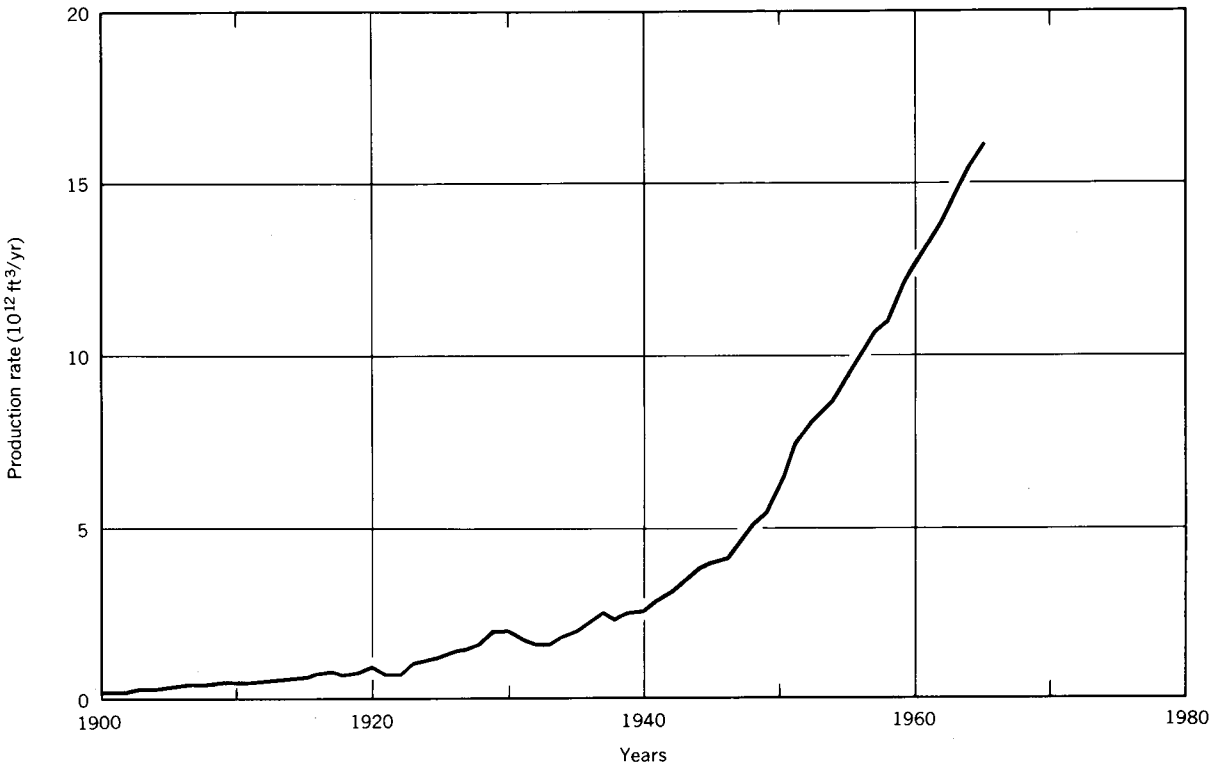


Figure 11.
U.S. net production of natural gas (Hubbert, 1969, Fig. 8.6).

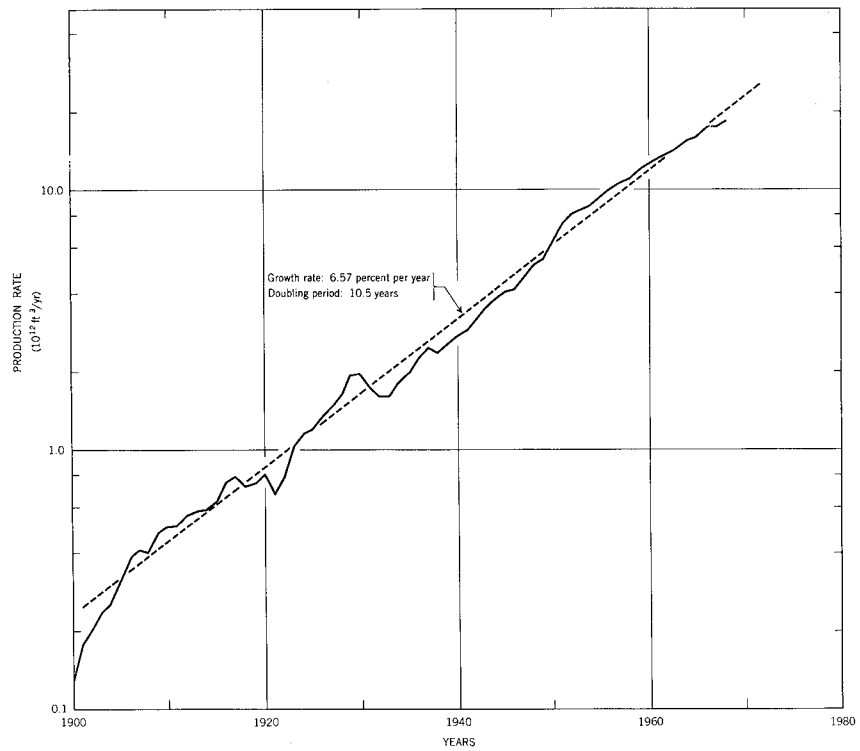


Figure 12.
U.S. net production of natural gas (semilogarithmic scale).

Finally, Figure 13 shows the annual production of energy in the United States from coal, oil, natural gas, and hydro- and nuclear power from 1850 to 1970. From 1850 to 1907, this increased at a steady growth rate of 6.9 per cent per year and doubled every 10.0 years. At about 1907, the growth rate dropped abruptly to an average value from 1907 to 1960 of about 1.77 per cent per year with a doubling period of 39 years. Since 1960, the growth rate has increased to about 4.25 per cent per year with the doubling period reduced to 16.3 years.

DEGREE OF ADVANCEMENT OF FOSSIL-FUEL EXPLOITATION

The foregoing are the basic historical facts pertaining to the exploitation of the fossil fuels in the world and in the United States. In the light of these facts we can hardly fail to wonder: How long can this continue? Several different approaches to this problem will now be considered.

Method of Donald Foster Hewett

In 1929, geologist Donald Foster Hewett delivered before the American Institute of Mining Engineers one of the more important papers ever written by a member of the United States Geological Survey, entitled "Cycles in Metal Production." In 1926, Hewett had made a trip to Europe, during which he visited 28 mining districts of which about half were then or had been in times past outstanding sources of several metals. Geographically, these districts ranged from England to Greece and from Spain to Poland. Regarding the purpose of this study, Hewett stated (p. 65):

> "I have come to believe that many of the problems that harass Europe lie in our path not far ahead. I have therefore hoped that a review of metal production in Europe in the light of its geologic, economic and political background may serve to clear our vision with regard to our own metal production."

In this paper, extensive graphs were presented of the production of separate metals from these various districts showing the rise, and in many cases the decline, in the production rates as the districts approached exhaustion of their ores. After having made this review, Hewett generalized his findings by observing that mining districts evolve during their history through successive stages analogous to those of infancy, adolescence, maturity and old age through which human beings individually progress. He sought criteria for judging how far along in such a sequence a given mining district or region

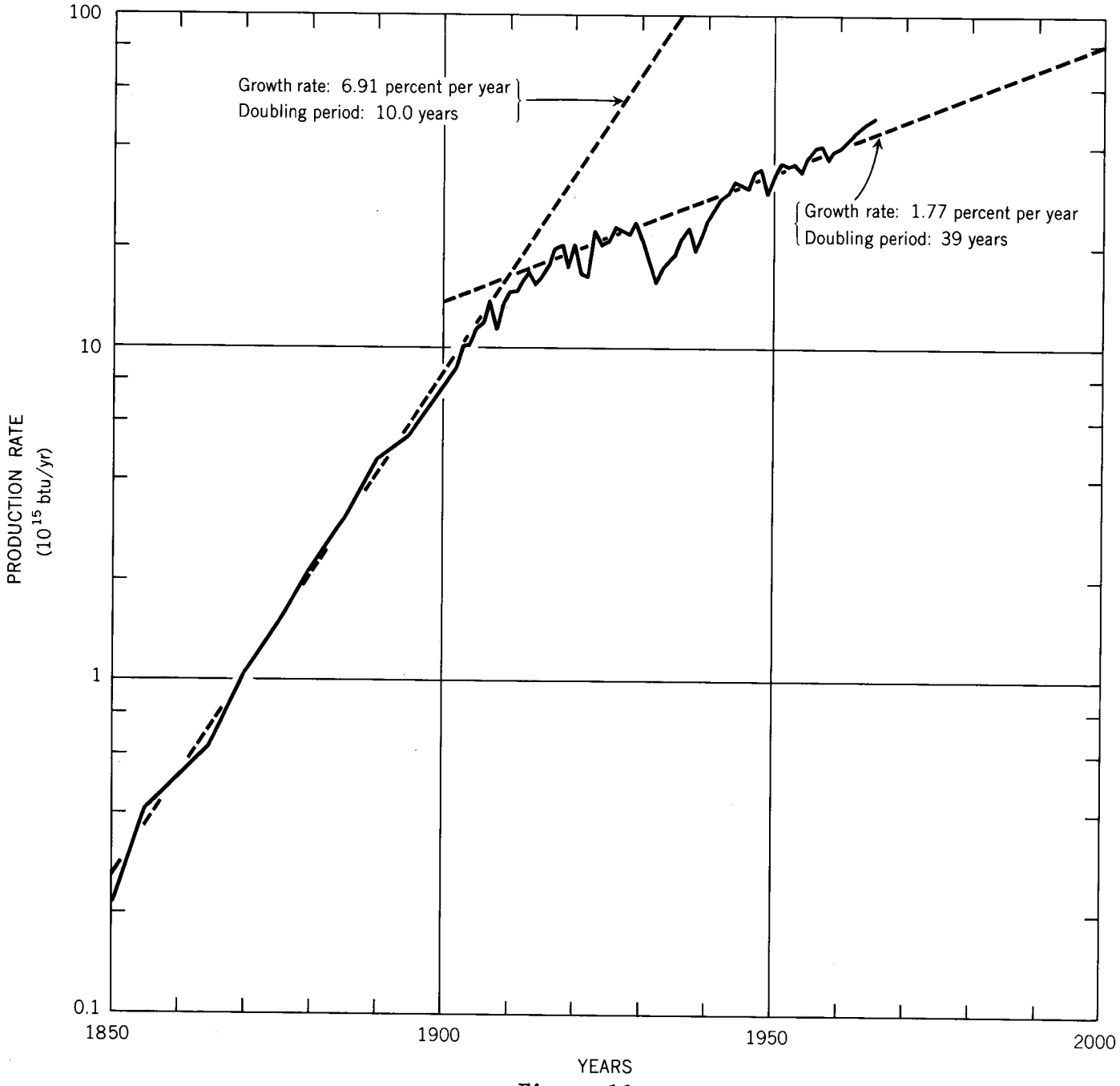


Figure 13.
U.S. production of thermal energy from coal, oil, natural gas, water power, and nuclear power (semilogarithmic scale).

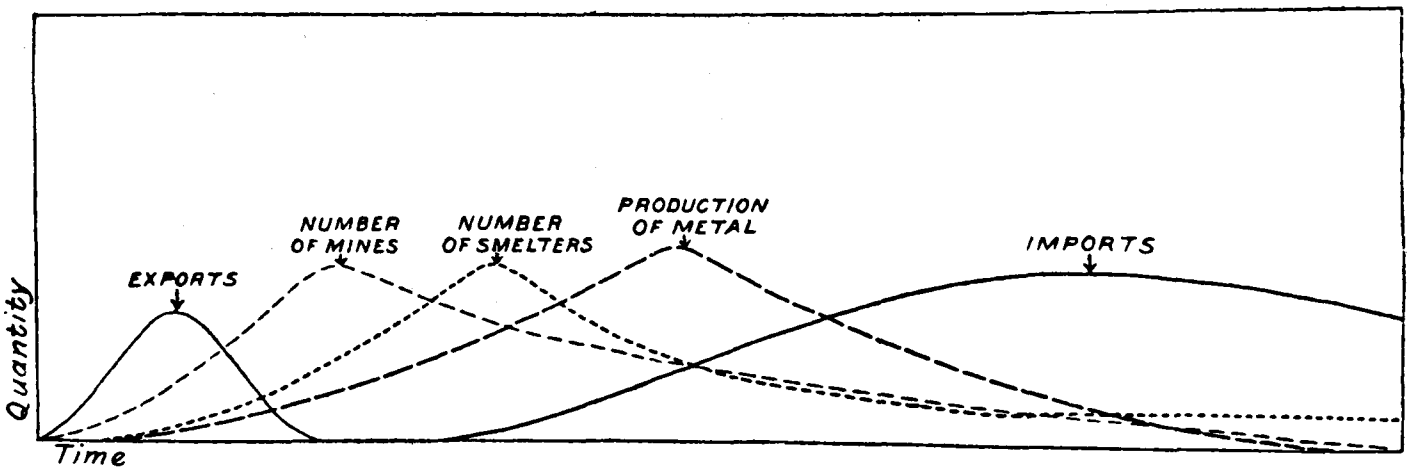


Figure 14.
Fig. 7 from D.F. Hewett's paper, "Cycles in metal production" (1929).

had progressed, and from his study he suggested the successive culminations shown in Figure 14 (Hewett's Fig. 7). These culminations were: (1) the quantity of exports of crude ore, (2) the number of mines in operation, (3) the number of smelters or refining units in operation, (4) the production of metal from domestic ore, and (5) the quantity of imports of crude ore.

Although not all of Hewett's crieteria are applicable to the production of the fossil fuels, especially when world production is considered, the fundamental principle is applicable, namely, that like the metals, the exploitation of the fossil fuels in any given area must begin at zero, undergo a period of more or less continuous increase, reach a culmination, and then decline, eventually to a zero rate of production. This principle is illustrated in Figure 15 in which the complete cycle of the production rate of any exhaustible resource is plotted arithmetically as a function of time. The shape of the curve is arbitrary within wide limits, but it still must have the foregoing general characteristics.

An important mathematical property of such a curve may be seen if we consider a vertical column of base Δt extending from the time axis to the curve itself. The altitude of this column will be the production rate

$$P = \Delta Q / \Delta t$$

at the given time, where ΔQ is the quantity produced in time Δt. The area of the column will accordingly be given by the product of its base by its altitude,

$$P \times \Delta t = (\Delta Q / \Delta t) = \Delta Q.$$

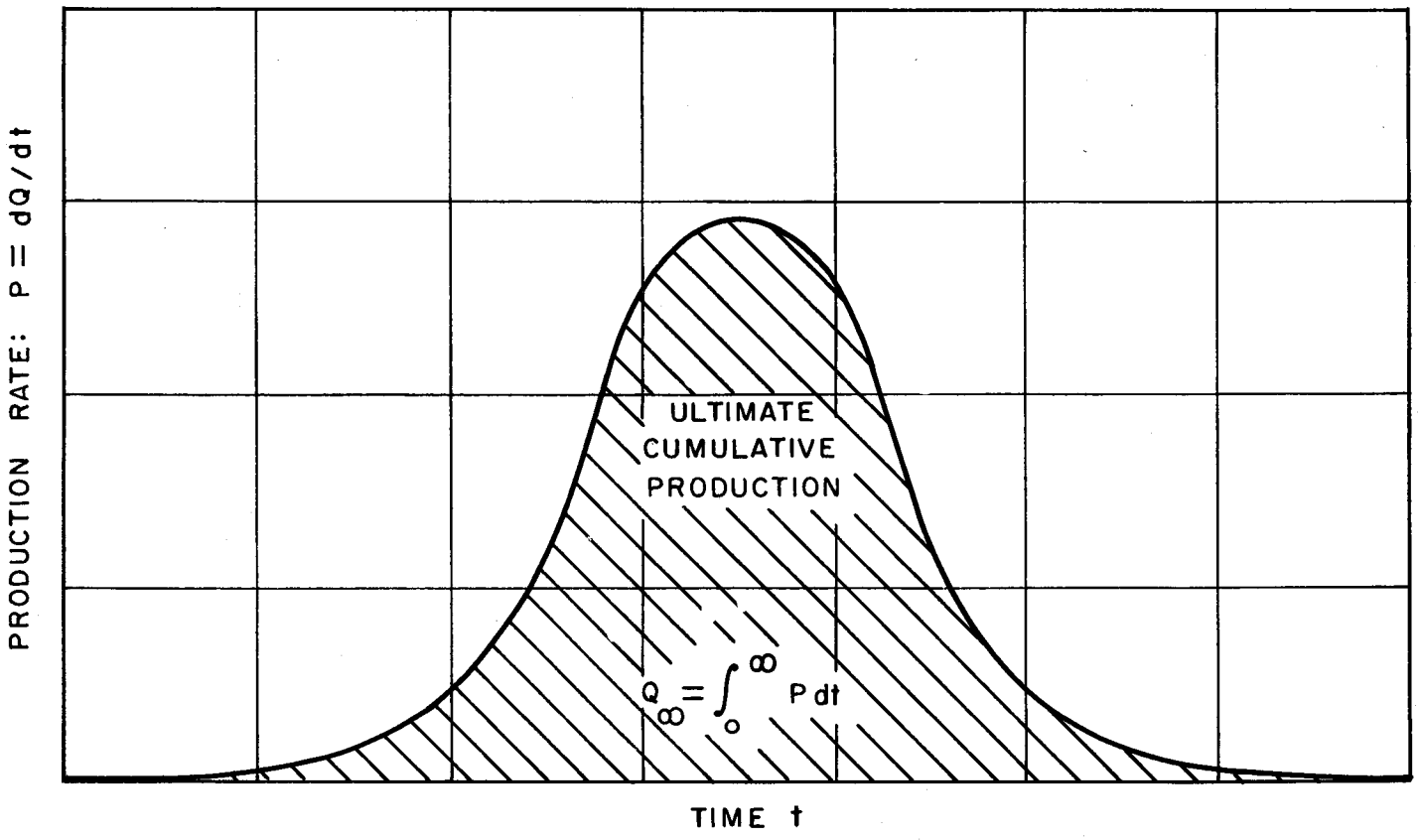


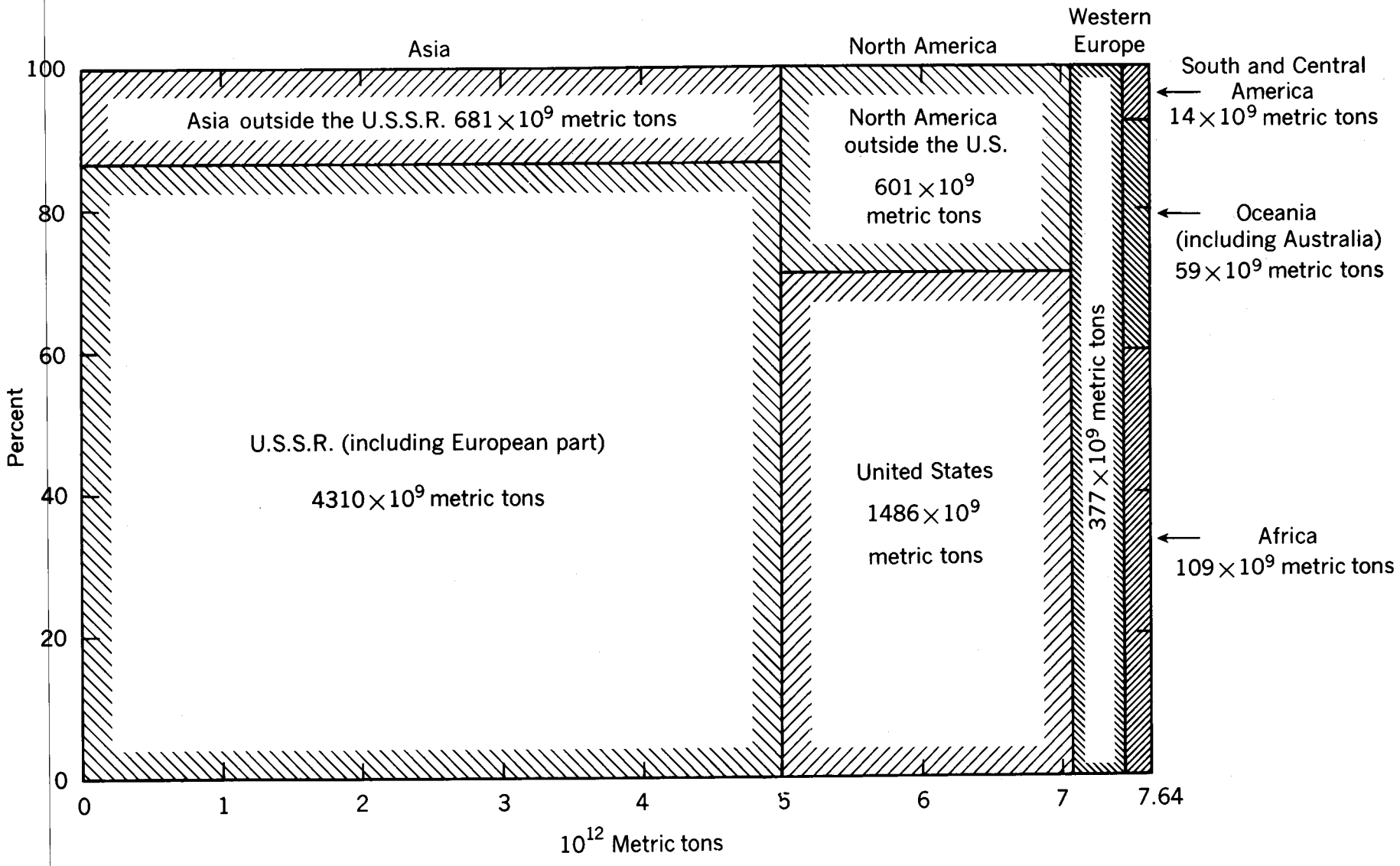
Figure 15.
Mathematical relations involved in the complete cycle of production of any exhaustible resource (Hubbert, 1956, Fig. 11).

Hence, the area of the column is a measure of the quantity produced during the time interval Δt, and the total area from the beginning of production up to any given time t will be a measure of the cumulative production up to that time. Clearly, as the time t increases without limit, the production rate will have gone through its complete cycle and returned to zero. The area under the curve after this has occurred will then represent the ultimate cumulative production, Q_∞. In view of this fact, if from geological or other data the producible magnitude of the resource initially present can be estimated, then any curve drawn to represent the complete cycle of production *must be consistent with that estimate*. No such curve can subtend an area greater than the estimated magnitude of the producible resource.

Utilization of this principle affords a powerful means of estimating the time scale for the complete production cycle of any exhaustible resource in any given region. As in the case of animals, where the time required for the complete life cycle of, say, a mouse is different from that of an elephant, so in the case of minerals,

Figure 16.

Averitt (1969) estimate of original world recoverable coal resources (Hubbert, 1969, Fig. 8.24).



the time required for the life cycle of petroleum may differ from that of coal. This principle also permits a reasonably accurate estimate of the most important date in the production cycle of any exhaustible resource, that of its culmination. This date is especially significant because it marks the dividing point in time between the initial period during which the production rate almost continuously increases and the subsequent period during which it almost continuously declines. It needs hardly be added that there is a significant difference between operating an industry whose output increases at a rate of five to ten per cent per year and one whose output declines at such a rate.

Complete Cycle of Coal Production

Because coal deposits occur in stratified seams which are continuous over extensive areas and often crop out on the earth's surface, reasonably good estimates of the coal deposits in various sedimentary basins can be made by surface geological mapping and a limited amount of drilling. A summary of the current estimates of the world's initial coal resources has been published by Paul Averitt (1969) of the U.S. Geological Survey. These estimates comprise the total amount of coal (including lignite) in beds 14 inches (35 cm) or more thick and at depths as great as 3,000 feet (900 meters), and in a few cases as great as 6,000 feet. Averitt's estimates as of January 1, 1967, for the initial producible coal, allowing 50 per cent loss in mining, are shown graphically in Figure 16 for the world's major geographical areas. As seen in this figure, the original recoverable world coal resources amounted to an estimated 7.64×10^{12} metric tons. Of this, 4.31×10^{12}, or 56 per cent, was in the USSR, and 1.49×10^{12}, or 19 per cent, in the United States. At the other extreme, the three continental areas, Africa, South and Central America, and Oceania together contained only 0.182×10^{12} metric tons, or 2.4 per cent of the world's total.

Figure 17 shows two separate graphs for the complete cycle of world coal production. One is based upon the Averitt estimate for the ultimate production of 7.6×10^{12} metric tons. These curves are also based upon the assumption that not more than three more doublings, or an eight-fold increase, will occur before the maximum rate of production is reached. The dashed curve extending to the top of the drawing indicates what the production rate would be were it to continue to increase at 3.56 per cent per year, the rate that has prevailed since World War II. For either of the complete-cycle curves, if we disregard the first and last ten-percentiles of the cumulative production, it is evident that the middle 80 per cent of Q_∞ will probably be consumed during the three-century period from about the year 2000 to 2300.

Figure 18 shows the complete cycle of U.S. coal production for the two values for Q_∞, 1486×10^9 and 740×10^9 metric tons.

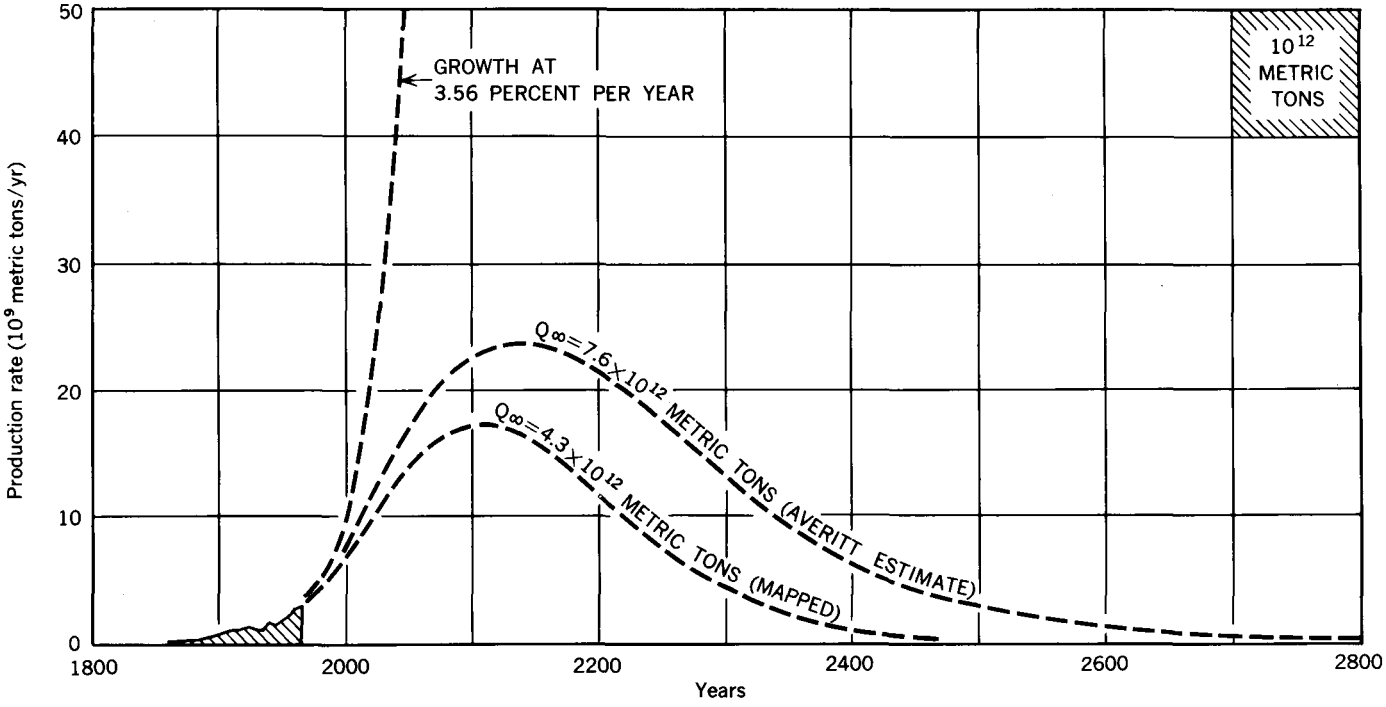


Figure 17.
Complete cycle of world coal production for two values of Q_∞ (Hubbert, 1969, Fig. 8.25).

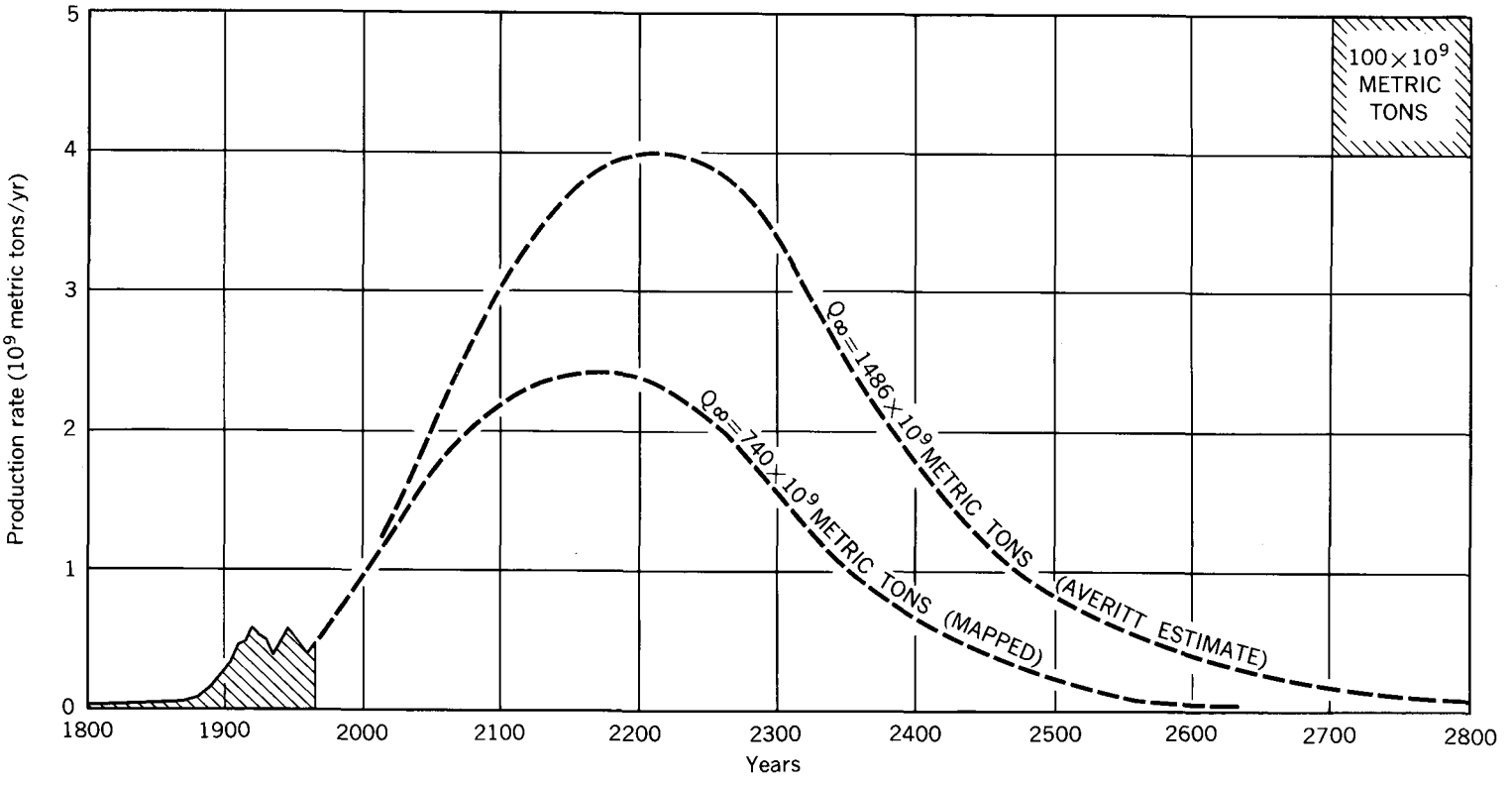


Figure 18.
Complete cycle of U.S. coal production for two values of Q_∞ (Hubbert, 1969, Fig. 8.26).

Here too the time required to consume the middle 80 per cent would be the three or four centuries following the year 2000.

A serious modification of the above coal-resource figures has been given by Averitt (cited in Theobald, Schweinfurth, and Duncan, 1972, P. 3-4 and Fig. 2). Here, Averitt, in February 1972, has given an estimate of the amount of remaining coal in the United States that is recoverable under present economic and technological conditions. This comprises coal in seams with a minimum thickness of 28 inches and a maximum depth of 1000 feet. The amount of coal in this category is estimated to be 390×10^9 short tons or 354×10^9 metric tons. Adding the 37×10^9 metric tons of coal already produced gives 391×10^9 metric tons of original coal in this category. This amounts to only 26 per cent of the 1486×10^9 metric tons assumed previously. Of this, 9.5 per cent has already been produced. If we apply the same ratio of 26 per cent to the previous world figure of 7.6×10^{12} metric tons, that is reduced to 2.0×10^{12} metric tons. Of this, 0.132×10^{12} metric tons, or 6.6 per cent has already been produced.

Revisions of Figures 17 and 18 incorporating these lower estimates of recoverable coal have not yet been made, but in each instance the curve for the reduced figure will encompass an area of only about one-quarter of that of the uppermost curve shown, and the probable time span for the middle 80 per cent of cumulative production will be cut approximately in half.

Estimates of Petroleum Resources

Because oil and gas occur in limited volumes of space underground in porous sedimentary rocks and at depths ranging from a few hundred feet to five or more miles, the estimation of the ultimate quantities of these fluids that will be obtained from any given area is much more difficult and hazardous than for coal. For the estimation of petroleum, essentially two methods are available: (1) estimation by geological analogy, and (2) estimation based upon cumulative information and evidence resulting from exploration and productive activities in the region of interest.

The method of estimating by geological analogy is essentially the following: A virgin undrilled territory, Area B, is found by surface reconnaissance and mapping to be geologically similar to Area A which is already productive of oil and gas. It is inferred, therefore, that Area B will eventually produce comparable quantities of oil and gas per unit of area or unit of volume of sediments to those of Area A.

Although this is practically the only method available initially for estimating the oil and gas potentials of an undrilled region, it is also intrinsically hazardous, with a very wide range of uncertainty. This is illustrated in Table 1 in which the estimates made in 1953 for the future oil discoveries on the continental shelf off the Texas and Louisiana coasts are compared with the result of subsequent drilling.

Table 1

Petroleum estimates by geological analogy:

Louisiana and Texas continental shelves

(crude oil, 10^9 bbls)

	U.S. Geological Survey estimates 1953	Cumulative discoveries to 1971
Lousiana	4	ca 5
Texas	9	Negligible

U.S. Geological Survey 1953 Potential Oil and Gas Reserves of the continental shelf off the coast of Louisiana, Texas and California: Statement prepared by the Fuels Branch, Geological Division USGS, at request of Committee on Interior and Insular Affairs, U.S. Senate, February 16, 1953.

In 1953, the U.S. Geological Survey, on the basis of geological analogy between the onshore and offshore areas of the Gulf Coast and the respective areas of the continental shelf bordering Texas and Louisiana, estimated future discoveries of nine billion barrels of oil on the Texas continental shelf and four billion on that of Louisiana. After approximately 20 years of petroleum exploration and drilling, discoveries of crude oil on the Louisiana continental shelf have amounted to approximately five billion barrels; those on the continental shelf off Texas have been negligible.

The second technique of petroleum estimation involves the use of various aspects of the Hewett criterion that the complete history of petroleum exploration and production in any

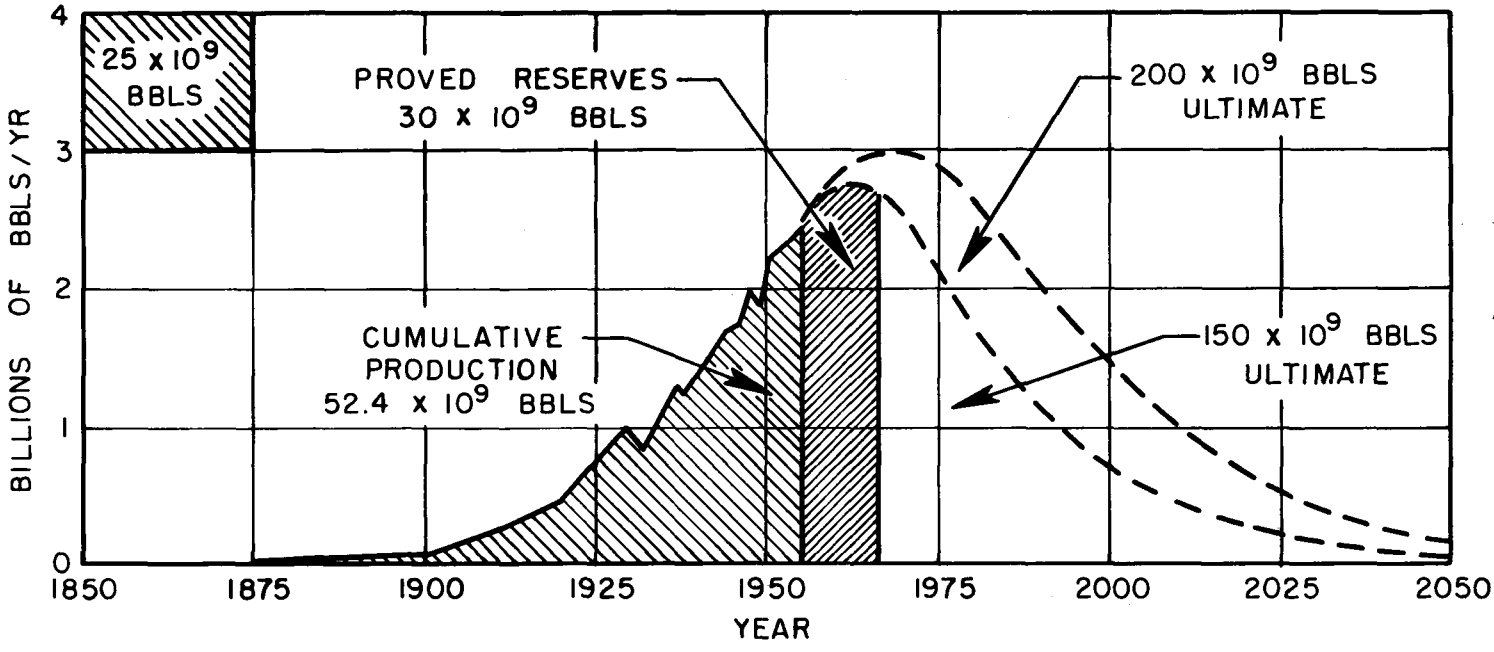


Figure 19.
1956 prediction of the date of peak in the rate of U.S. crude-oil production (Hubbert, 1956, Fig. 21).

given area must go through stages from infancy to maturity to old age. Maturity is plainly the stage of production culmination, and old age is that of an advanced state of discovery and production decline.

In March 1956, this technique was explicitly applied to crude-oil production in the United States by the present author (Hubbert, 1956) in an invited address, "Nuclear Energy and the Fossil Fuels," given before an audience of petroleum engineers at a meeting of the Southwest Section of the American Petroleum Institute at San Antonio, Texas. At that time, the petroleum industry in the United States had been in vigorous operation for 97 years, during which 52.4 billion barrels of crude oil had been produced. A review of published literature in conjunction with inquiries among experienced petroleum geologists and engineers indicated a consensus of opinion that the ultimate amount of crude to be produced from the conterminous 48 states and adjacent continental shelves would probably be within the range 150 billion to 200 billion barrels. Using these two limiting figures, the curve for the complete cycle of U.S. crude-oil production shown in Figure 19 (Hubbert, 1956, Fig. 21) was constructed. Those curves showed that if the ultimate cumulative production, Q_∞, should be as small as 150 x 10^9 bbls, the peak in the rate of production would probably occur about 1966 -- about 10 years hence. Should another 50 x 10^9 bbls be added, making Q_∞ = 200 x 10^9 bbls, the date of the peak of production would be postponed by only about five years. It was accordingly predicted on the basis of available information that the peak in U.S. crude-oil production would occur within 10-15 years after March 1956.

This prediction proved to be both surprising and disturbing to the U.S. petroleum industry. The only way it could be avoided, however, was to enlarge the area under the curve of the complete cycle of production by increasing the magnitude of Q_∞. As small increases of Q_∞ have only small effects in retarding the date of peak production, if this unpleasant conclusion were to be avoided, it would be necessary to increase Q_{oo} by large magnitudes. And this was what happened. Within the next five years, with insignificant amounts of new data, the published values for Q_{oo} were rapidly escalated to successively higher values -- 204, 250, 372, 400, and eventually 590 billion barrels.

In view of the fact that values for Q_{oo} used in Figure 19 were semisubjective judgments, no adequate rational basis existed for showing conclusively that a figure of 200×10^9 bbls was a much more reliable estimate than one twice that large. This led to the search for other criteria derivable from objective, publicly available data of the petroleum industry. The data satisfying this requirement were the statistics of annual production available since 1860, and the annual estimates of proved reserves of the Proved Reserves Committee of the American Petroleum Institute begun in 1937. From these data, cumulative production from 1860 could be computed, and also cumulative proved discoveries defined as the sum of cumulative production and proved reserves after 1937.

This type of analysis was used in the report, *Energy Resources*, (Hubbert, 1962) of the National Academy of Sciences Committee on Natural Resources, advisory to President John F. Kennedy. There is not time here to review this study in detail, but its principal results are shown in Figures 20 and 21 (Hubbert, 1962, Figs. 27 and 28), in which it was found that the rate of proved discoveries of crude oil had already passed its peak about 1957, proved reserves were estimated to be at their peak in 1962, and the peak in the rate of crude-oil production was predicted to occur at about the end of the 1960 decade. The ultimate amount of crude oil to be produced from the conterminous 48 states and adjacent continental shelves was estimated to be about 170 to 175 billion barrels.

The corresponding estimates for natural gas are shown in Figures 22 and 23 (Hubbert, 1962, Figs. 46 and 47). From these figures it will be seen that the rate of proved discoveries was estimated to

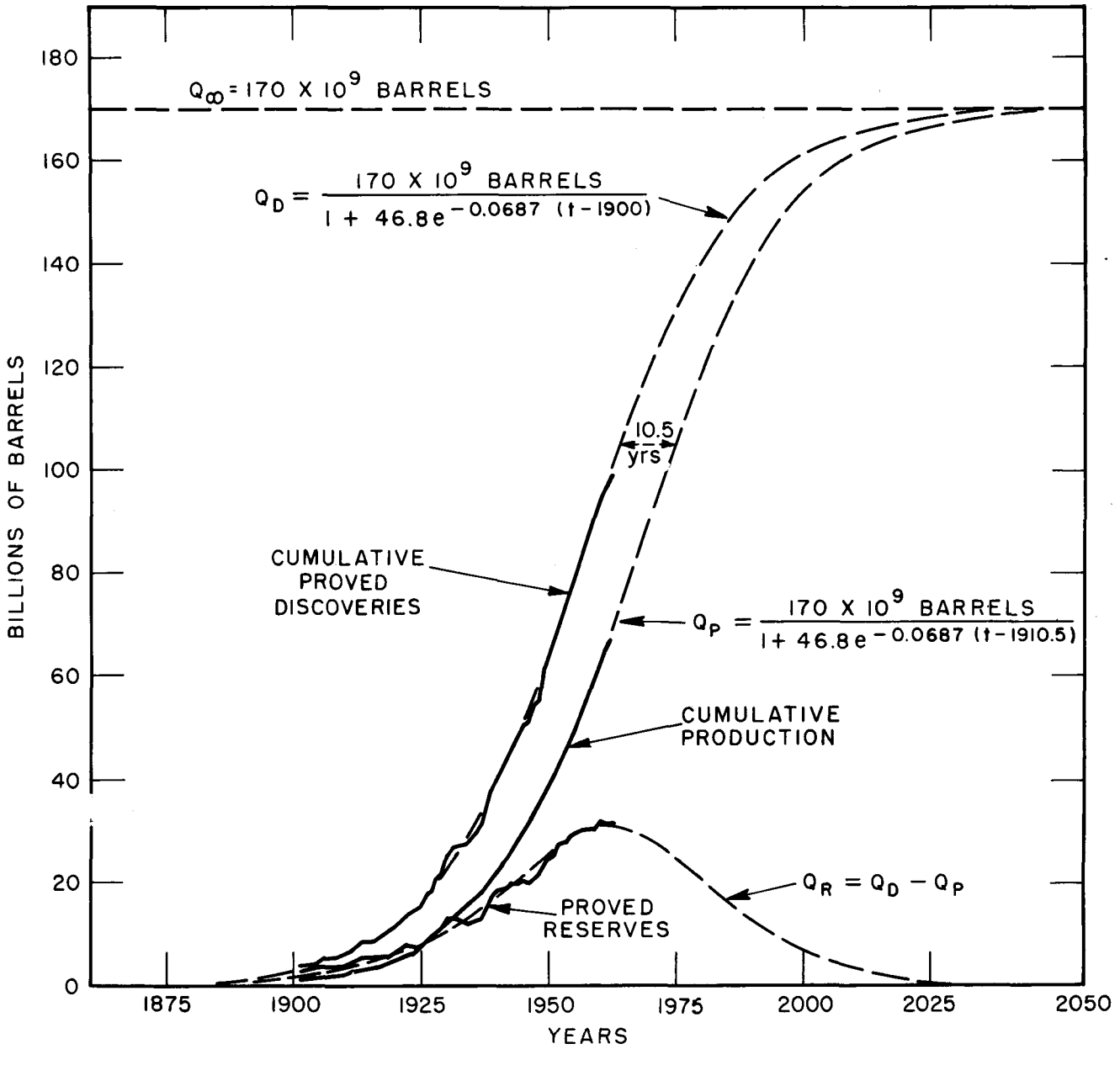


Figure 20.
Curves of cumulative proved discoveries, cumulative production, and proved reserves of U.S. crude oil as of 1962 (Hubbert, 1962, Fig. 27).

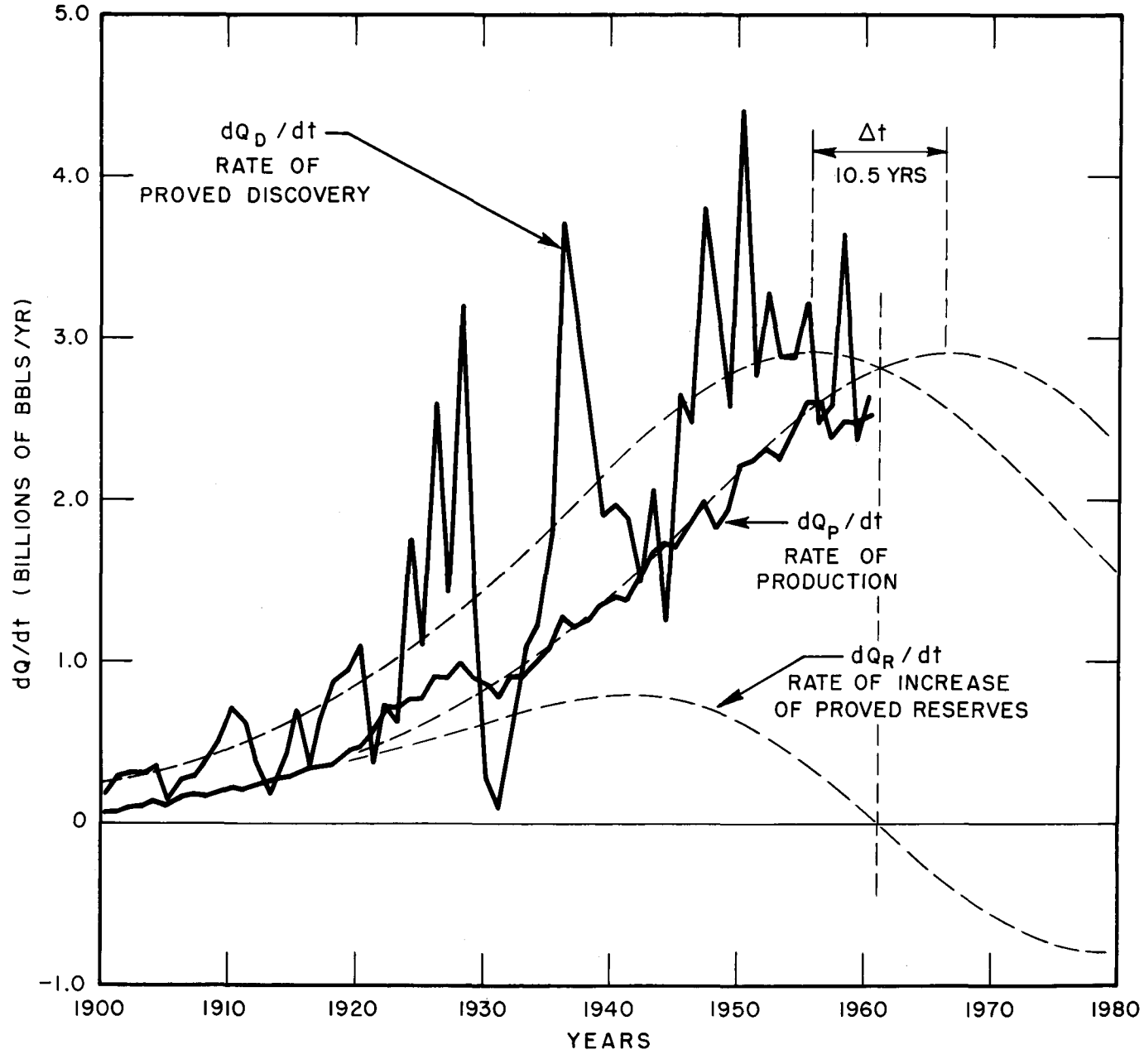


Figure 21.
Curves showing the rates of proved discovery and of production, and rate of increase of proved reserves of U.S. crude oil as of 1961.

Note prediction of peak of production rate near end of 1960 decade (Hubbert, 1962, Fig. 28).

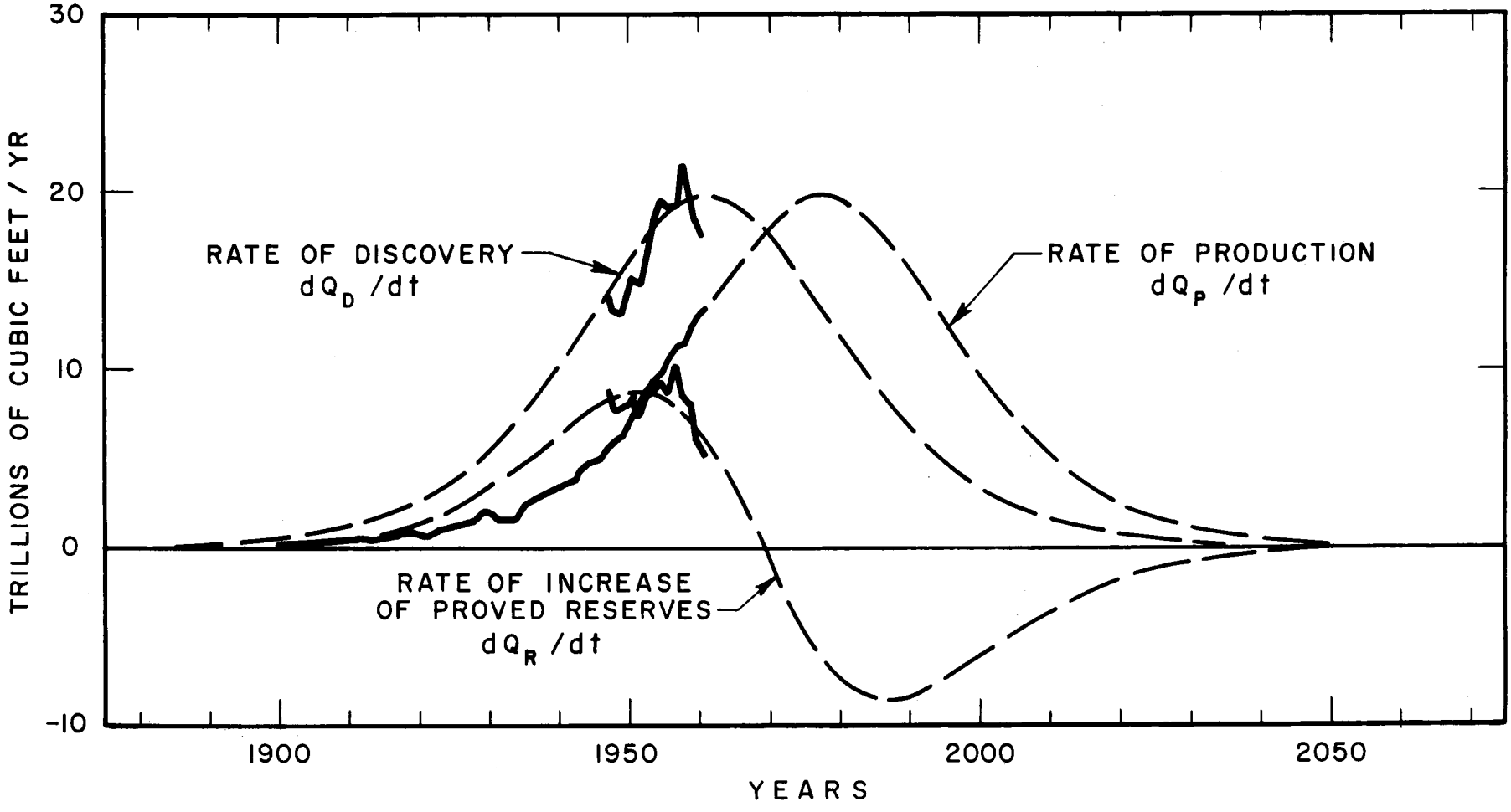


Figure 22.

1962 estimations of the dates of the peak of rate of proved discovery, rate of production, and of proved reserves of U.S. natural gas (Hubbert, 1962. Fig. 46).

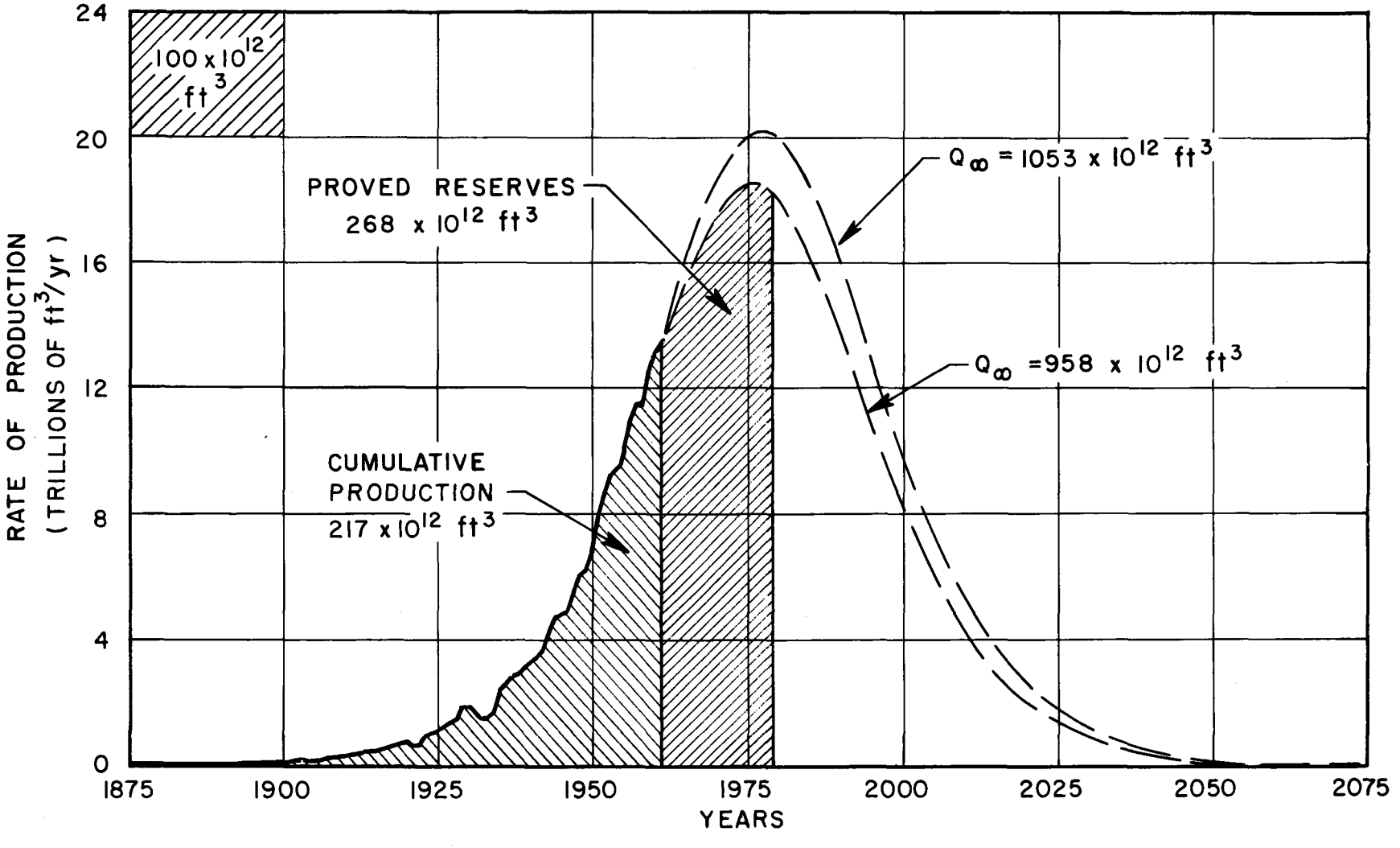


Figure 23.
1962 estimates of ultimate amount of natural gas to be produced in conterminous United States, and estimates of date of peak production rate (Hubbert, 1962, Fig. 47).

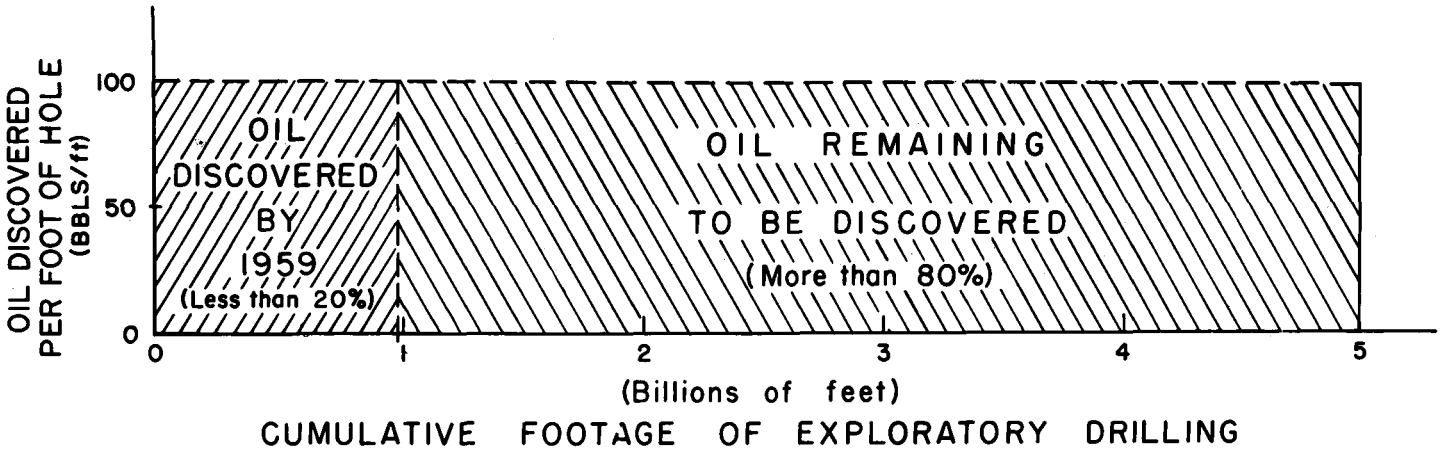


Figure 24.
Zapp (1962) hypothesis of oil discoveries per foot versus cumulative footage of exploratory drilling for conterminous United States and adjacent continental shelves (Hubbert, 1969, Fig. 8.18).

be at its peak at about 1961. Proved reserves of natural gas were estimated to reach their peak ($dQ_Y/dt = 0$) at about 1969, and the rate of production about 1977.

At the time the study was being made, the U.S. Geological Survey, in response to a Presidential directive of March 4, 1961, presented to the Academy Committee estimates of 590×10^9 bbls for crude oil and 2650 ft^3 for natural gas as its official estimates of the ultimate amounts of these fluids that would be produced from the conterminous 48 states and adjacent continental shelves.

T. A. Hendricks of the U.S. Geological Survey has stated that these estimates were intended to include Alaska and the neighboring areas, but in neither the original unpublished report in which these estimates were presented to the Academy Committee, nor in associated correspondence was this either states or implied.

These estimates were, by a wide margin, the highest that had ever been made up until that time. Moreover, had they been true, there would have been no grounds for the expectation of an oil or gas shortage in the United States much before the year 2000. These estimates were cited in the Academy Committee report, but because of their wide disparity with any available evidence from the petroleum industry, they were also rejected.

As only became clear sometime later, the basis for those large estimates was an hypothesis introduced by the late A. D. Zapp of the U.S. Geological Survey. This is illustrated in Figure 24 (Hubbert, 1969, Fig. 8.18). Zapp (1962) postulated that the exploration for petroleum in the United States would not be completed until exploratory wells with an average density of one well per each two square miles had been drilled either to the crystalline basement rock or to a depth of 20,000 ft in all the potential petroleum-bear-

ing sedimentary basins. Zapp estimated that to drill this pattern of wells in the petroliferous areas of the conterminous United States and adjacent continental shelves would require about 5×10^9 feet of exploratory drilling. He then estimated that as of 1959, only 0.98×10^9 feet of exploratory drilling had been done and concluded that at that time the United States was less than 20 per cent along in its ultimate petroleum exploration. He also stated that during recent decades there had been no decline in the oil found per foot of exploratory drilling, yet already more than 100×10^9 barrels of oil had been discovered in the United States. It was implied, but not expressly stated, that the ultimate amount of oil to be discovered would be more than 500×10^9 bbls.

This was confirmed in 1961 by the Zapp estimate for crude oil given to the Academy Committee. At that time, with cumulative drilling of 1.1×10^9 feet, Zapp estimated that 130×10^9 bbls of crude oil had already been discovered. This would be at an average rate of 118 bbls/ft. Then, at this same rate, the amount of oil to be discovered by 5×10^9 feet of exploratory drilling should be 590×10^9 bbls, which is the estimate given to the Academy Committee. This constitutes the "Zapp hypothesis." Not only is it the basis for Zapp's own estimates, but with only minor modifications it has been the principal basis for most of the higher estimates subsequently.

The most obvious test for the validity of this hypothesis is to apply it to past petroleum discoveries in the United States. Has the oil found per foot of exploratory drilling been nearly constant during the past? The answer to this is given in Figure 25 (Hubbert, 1967, Fig. 15) which shows the quantity of oil discovered and the average amount of oil found per foot for each 10^8 ft of exploratory drilling in the United States from 1860 to 1965. This shows an initial rate of 194 bbls/ft for the first unit from 1860 to 1920, a maximum rate of 276 bbls/ft for the third unit extending from 1929 to 1935 and including the discovery of the 5×10^9 bbl East Texas field, and then a precipitate decline to about 35 bbls/ft by 1965. This is approximately an exponential decline curve whose integration for unlimited future drilling gives an estimate of about 165×10^9 for Q_∞, the ultimate discoveries.

The superposition of the actual discoveries per foot shown in Figure 25 on the discoveries per foot according to the Zapp hypothesis from Figure 24 is shown in Figure 26 (Hubbert, 1969, Fig. 8.19). The blank area between the two curves represents the difference between the two estimates -- an apparent overestimate of about 425×10^9 bbls.

To recapitulate, in the Academy Committee report of 1962, the peak in US proved crude oil discoveries, excluding Alaska, was estimated to have occurred at about 1957, the peak in proved reserves at about 1962, and the peak in production was predicted for about 1968-1969. The peak in proved reserves did occur in 1962, and the peak in the rate of production occurred in 1970 (Fig. 27). Evidence that this is not likely to be exceeded is afforded by the fact that for the

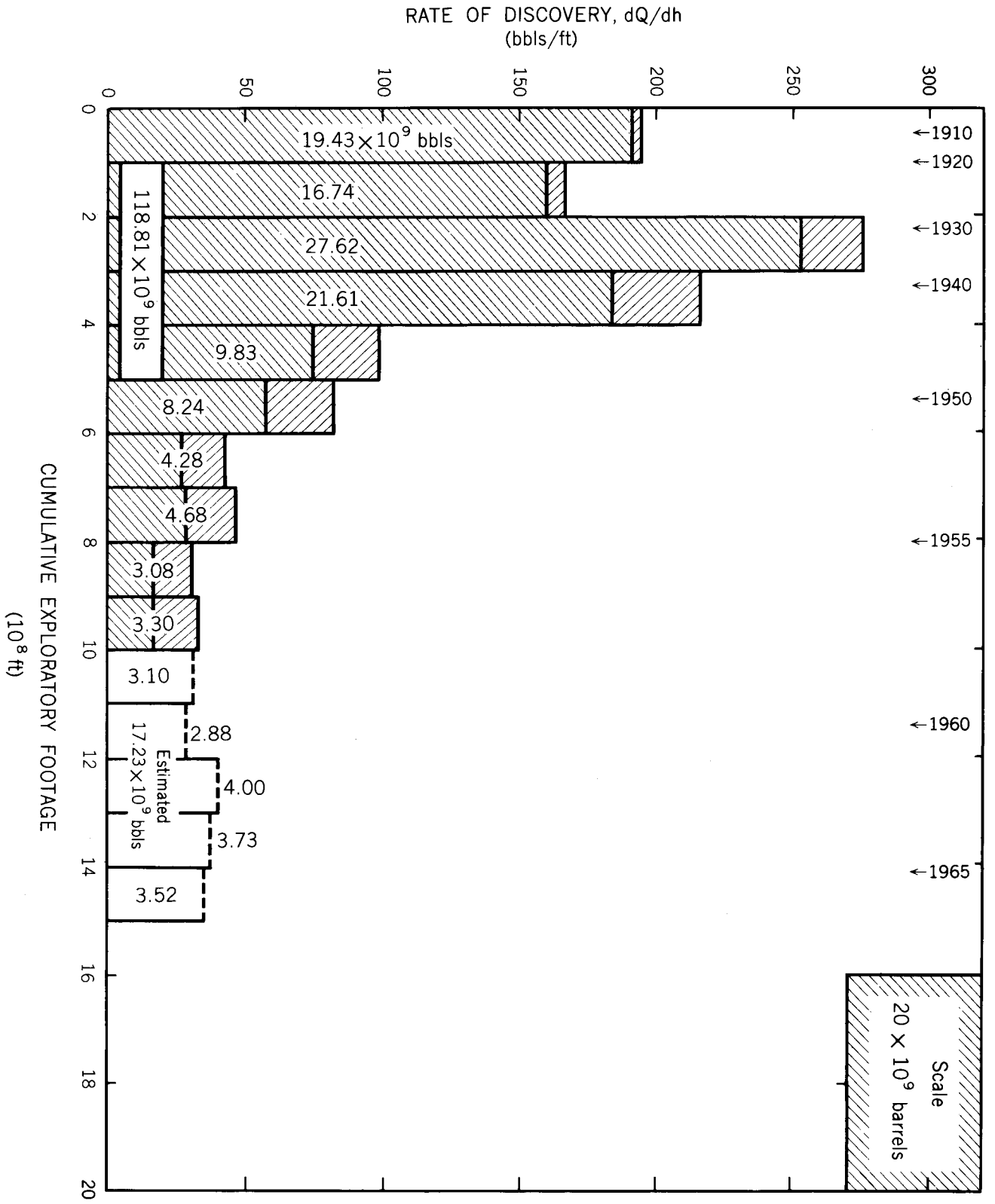


Figure 25.
Actual U.S. crude-oil discoveries per foot of exploratory drilling as a function of cumulative exploratory drilling from 1860 to 1965 (Hubbert, 1967, Fig. 15).

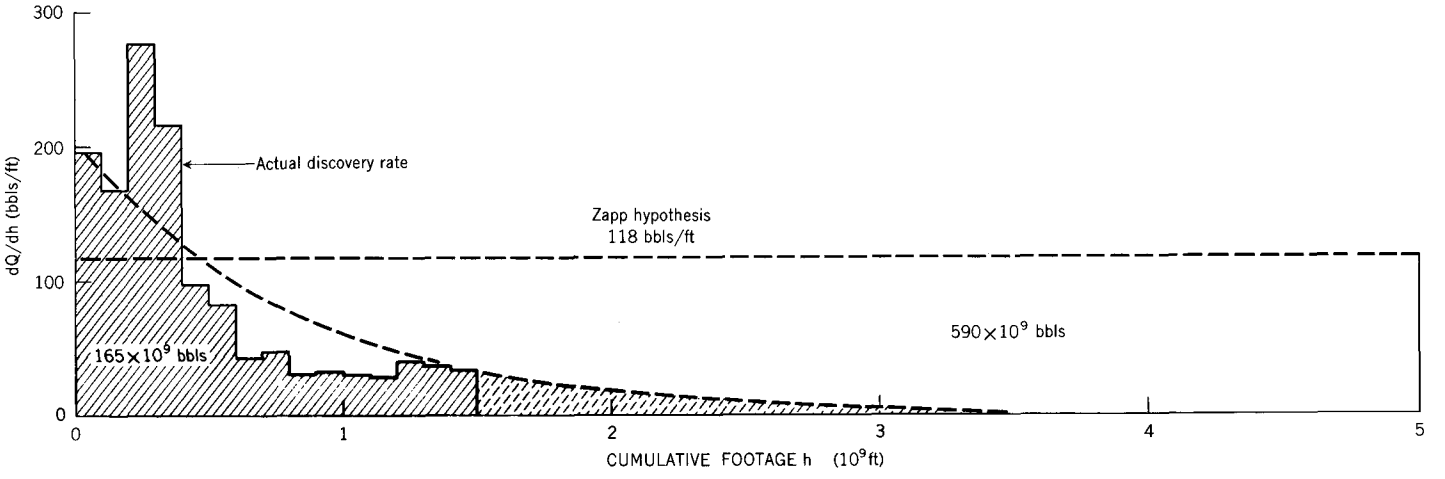


Figure 26.
Comparison of U.S. crude-oil discoveries according to Zapp hypothesis with actual discoveries. The blank area between the two curves represents an overestimate of about 425 billion barrels (Hubbert, 1969, Fig. 8.19).

six months since March 1972, the production rates of both Texas and Louisiana, which together account for 60 per cent of the total US crude-oil production, have been at approximately full capacity, and declining.

As for natural gas, the Academy report estimated that the peak in proved reserves would occur at about 1969 and the peak in the rate of production about 1977. As of September 1972, the peak of proved reserves for the conterminous 48 states occurred in 1967, two years ahead of the predicted date, and it now appears that the peak in the rate of natural-gas production will occur about 1974-1975, two to three years earlier than predicted. In the 1969 Academy report, the ultimate production of natural gas was estimated to be about 1000×10^{12} ft^3. Present estimates by two different methods give a low figure of 1000×10^{12} and a high figure of 1080×10^{12}, or a mean of 1040×10^{12} ft^3.

Because of its early stage of development, the petroleum potential of Alaska must be based principally upon geological analogy with other areas. The recent Prudhoe Bay discovery of a 10-billion barrel field -- the largest in the United States -- has been a source of excitement for an oil-hungry US petroleum industry, but it still represents less than a three-year supply for the United States. From present information, a figure of 30×10^9 bbls is about as large an estimate as can be justified for the ultimate crude-oil production from the land area of Alaska, although a figure greater than this is an admitted possibility. Adding this to a present figure of about 170×10^9 bbls for the conterminous 48 states gives 200×10^9 bbls as the approximate amount of crude oil ultimately to be produced in the whole United States.

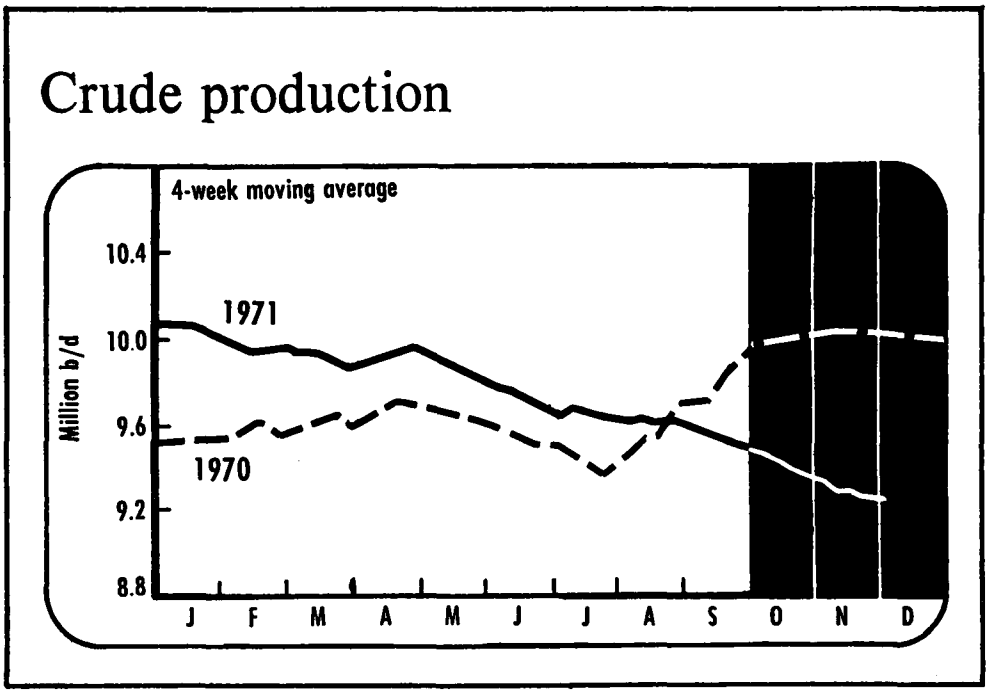


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Figure 27.

World Crude-Oil Production

In the present brief review, only a summary statement can be made for the petroleum resources of the world as a whole. Recent estimates by various major oil companies and petroleum geologists have been summarized by H.R. Warman (Warman, 1971) of the British Petroleum Company. In this review, Warman gave 226 x 10^9 bbls as the cumulative world crude-oil production and 527 x 10^9 bbls for the proved reserves at the end of 1969. This totals 753 x 10^9 bbls as the world's proved cumulative discoveries. For the ultimate recoverable crude oil, Warman cited the following estimates published during the period 1967-1970:

Year	Author	Quantity (10^9 bbls)
1967	Ryman (Esso)	2090
1968	Hendricks (USGS)	2480
1968	Shell	1800
1969	Hubbert (NAS-NRC)	1350-2100
1969	Weeks	2200
1970	Moody (Mobil)	1800

Then, to this, Warman added his own estimate of 1200-2000 x 10^9 bbls. A recent unpublished estimate by the research staff of another oil company is in the mid-range of 1900-2000 x 10^9 bbls.

From these estimates, there appears to be a convergence toward an estimate of 2000 x 10^9 bbls, or slightly less. The implication of such a figure to the complete cycle of world crude-oil production is shown in Figure 28 (Hubbert, 1969, Fig. 8.23), using two limiting values of 1350 x 10^9 and 2100 x 10^9 bbls. For the higher figure, the world will reach the peak in its rate of crude-oil production at about the year 2000; for the lower figure, this date would be about 1990.

Another significant figure for both the US and the world crude-oil production is the length of time required to produce the middle 80 per cent of the ultimate production. In each case, the time is about 65 years, or less than a human lifetime. For the United States, this subtends the period from about 1937 to 2003; for the world, from about 1967 to 2032.

Another category of petroleum liquids is that of natural-gas liquids which are produced of a byproduct of natural gas. In the United States (excluding Alaska), the ultimate amount of natural-gas liquids, based on an ultimate amount of crude oil of 170 x 10^9 bbls, and 1040 x 10^{12}ft of natural gas, amounts to about 36 x 10^9 bbls. Corresponding world figures, based on an estimate of 2000 x 10^9 bbls for crude oil, would be about 400 x 10^9 bbls for natural-gas liquids, and 12,000 ft^3 for natural gas.

Other Fossil Fuels

In addition to coal, petroleum liquids, and natural gas, the principal other classes of fossil fuels are the so-called tar, or heavy-oil sands, and oil shales. The best known and probably the largest deposits of heavy-oil sands are in the Athabasca Sandstone and two smaller deposits in northern Alberta containing an estimated 300 x 10^9 bbls of potentially producible oil. One large-scale mining and extracting operation was begun in 1966 by a group of oil companies, and others doubtless will follow as the need for this oil develops.

Unlike tar sands whose fuel content is a heavy, viscous crude oil, oil shales contain hydrocarbons in a solid form known as kerogen, which distills off as a vapor upon heating and condenses to a liquid upon cooling. The extractible oil content of oil shales ranges from as high as 100 US gallons per short ton for the richest grades to near zero as the grades diminish. When all grades are considered, the aggregate oil content of the known oil shales is very large. However, in practice, only the shales having an oil content of about 25 gallons or more per ton and occurring in beds 10 feet or more thick, are considered to be economical sources at present.

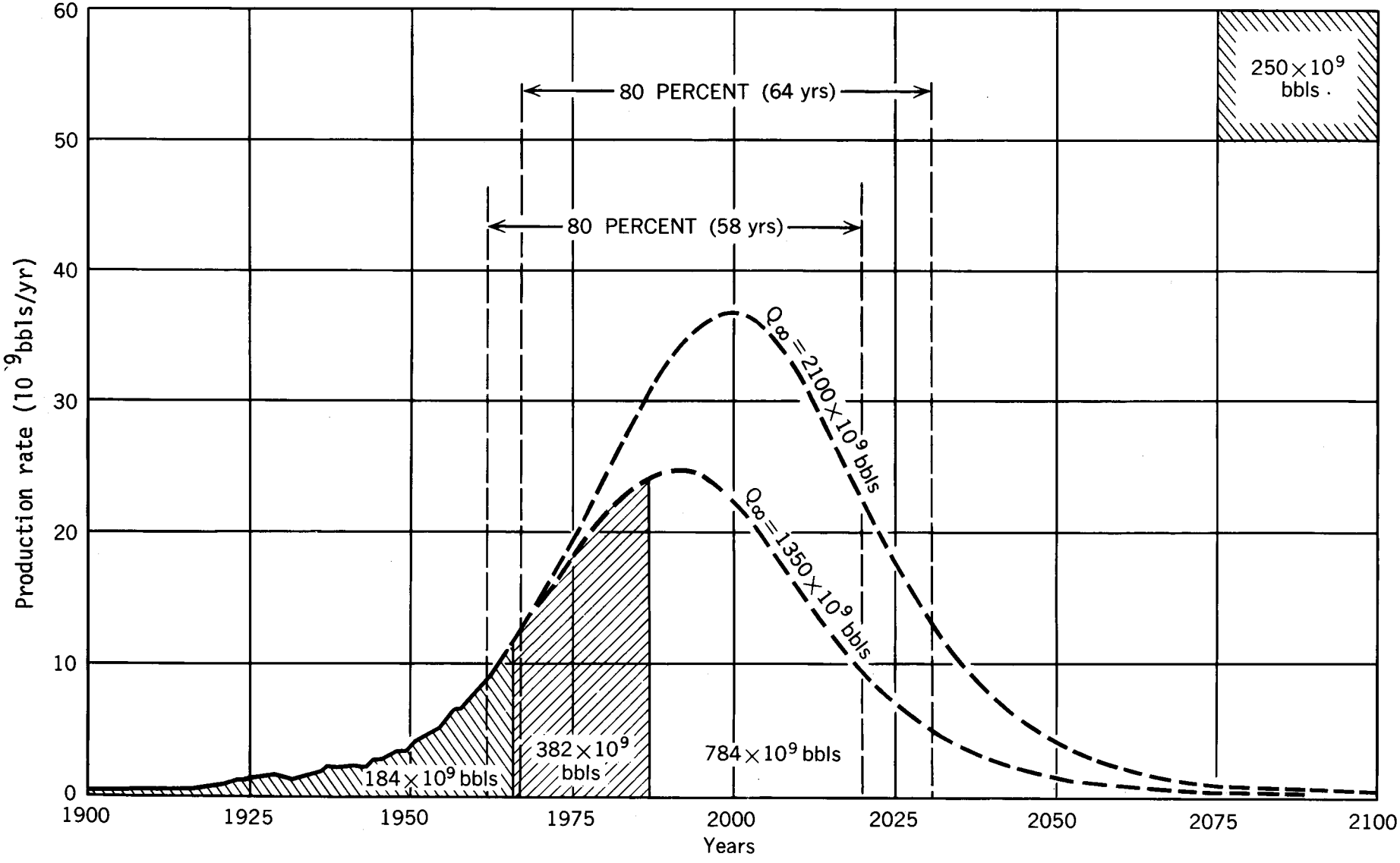

Figure 28.

Complete cycle of world crude-oil production for two values of Q_{∞} (Hubbert, 1969, Fig. 8.23).

According to a world inventory of known oil shales by Duncan and Swanson (1965) the largest known deposits are those of the Green River Formation in Wyoming, Colorado, and Utah. From these shales in the grade range from 10 to 65 gallons per ton, these authors estimate that only 80 x 10^9 bbls are recoverable under 1965 economic conditions. Their corresponding figure for oil shales outside the United States is 110 x 10^9 bbls.

The absolute magnitudes of the world's original supply of fossil fuels recoverable under present technological and economic conditions, and their respective energy contents in terms of their heats of combustion are given in Table 2.

Table 2.

Approximate magnitudes and energy contents of world's original supply of fossil fuels recoverable under present conditions.

Fuel	Quantity	Energy content		Per cent
		10^{21} thermal joules	10^{15} thermal kwh	
Coal and lignite	2.35 x 10^{12} metric tons	53.2	14.80	63.78
Petroleum liquids	2400 x 10^9 bbls	14.2	3.95	17.03
Natural gas	12,000 x 10^{12} ft^3	13.1	3.64	15.71
Tar-sand oil	300 x 10^9 bbls	1.8	0.50	2.16
Shale oil	190 x 10^9 bbls	1.1	0.31	1.32
Totals		83.4	23.20	100.00

The total initial energy represented by all of these fuels amounted to about 83 x 10^{21} thermal joules or to 23 x 10^{15} thermal kilowatt-hours. Of this, 64 per cent was represented by coal and lignite, 17 and 16 per cent, respectively, by petroleum liquids and natural gas, and three

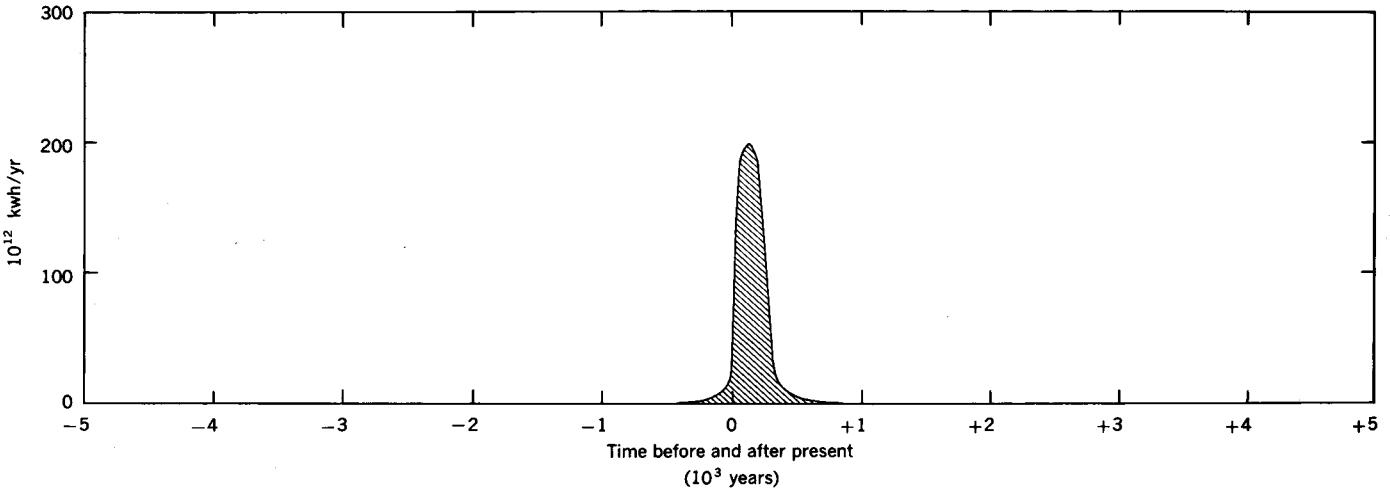

Figure 29.
Epoch of fossil-fuel exploitation in perspective of human history from 5000 years in the past to 5000 years in the future (modified from Hubbert, 1962, Fig. 54).

per cent by tar-sand and shale oil combined. Although the total amount of coal and lignite in beds of 14 or more inches thick and occurring at depths less than 3,000 feet, as estimated by Averitt, are very much larger in terms of energy content than the initial quantities of oil and gas, the coal practically recoverable under present conditions is only about twice the magnitude of the initial quantities of gas and oil in terms of energy content. Therefore, at comparable rates of production, the time required for the complete cycle of coal production will not be greatly longer than that for petroleum -- the order of a century or two for the exhaustion of the middle 80 per cent of the ultimate cumulative production.

To appreciate the brevity of this period in terms of the longer span of human history, the historical epoch of the exploitation of the fossil fuels is shown graphically in Figure 29, plotted on a time scale extending from 5000 years in the past to 5000 years in the future -- a period well within the prospective span of human history. On such a time scale, it is seen that the epoch of the fossil fuels can be only a transitory or ephemeral event -- an event, nonetheless, which has exercised the most drastic influence experienced by the human species during its entire biological history.

OTHER SOURCES OF INDUSTRIAL ENERGY

The remaining sources of energy suitable for large-scale industrial uses are principally the following:

1. Direct use of solar radiation.
2. Indirect uses of solar radiation.
   a. Water power.
   b. Wind power.
   c. Photosynthesis.
   d. Thermal energy of ocean water at different temperatures.
3. Geothermal power.
4. Tidal power.
5. Nuclear power.
   a. Fission.
   b. Fusion.

Under the present limitations of space and time, these can only be discussed summarily.

Solar power. -- By a large margin the largest flux or energy occurring on the earth is that from solar radiation. As shown in Figure 1, the thermal power of the solar radiation intercepted by the earth amounts to about $178{,}000 \times 10^{12}$ thermal watts, or, according to more recent measurements of the solar constant, about $173{,}000 \times 10^{12}$ thermal watts. This is roughly 5,000 times all other steady fluxes of energy combined. It also has the expectation of continuing at about the same rate for geological periods of time into the future.

The largest concentrations of solar radiation reaching the earth's surface occur in desert areas within about 35 degrees of latitude north and south of the equator. Within this belt are southern Arizona and neighboring areas in the southwestern part of the United States, northern Mexico, the Atacama Desert in Chile, and a belt across northern Africa, the Arabian Peninsula, and Iran. In southern Arizona, the thermal power density of the solar radiation incident upon the earth's surface ranges from about 300 to 650 calories per square centimeter per day, from winter to summer. The winter minimum of 300 calories per square centimeter per day, when averaged over 24 hours represents a mean power density of 145 watts per square meter. If ten per cent of this could be converted into electrical power by photovoltaic cells or other means, the electrical power obtainable from one square kilometer of collection area would be 14.5 megawatts. Then, for an electrical power plant of 1,000 megawatts capacity, the collection area required would be about 70 square kilometers, or a square area about 8.4 kilometers, or five miles, to the side. At

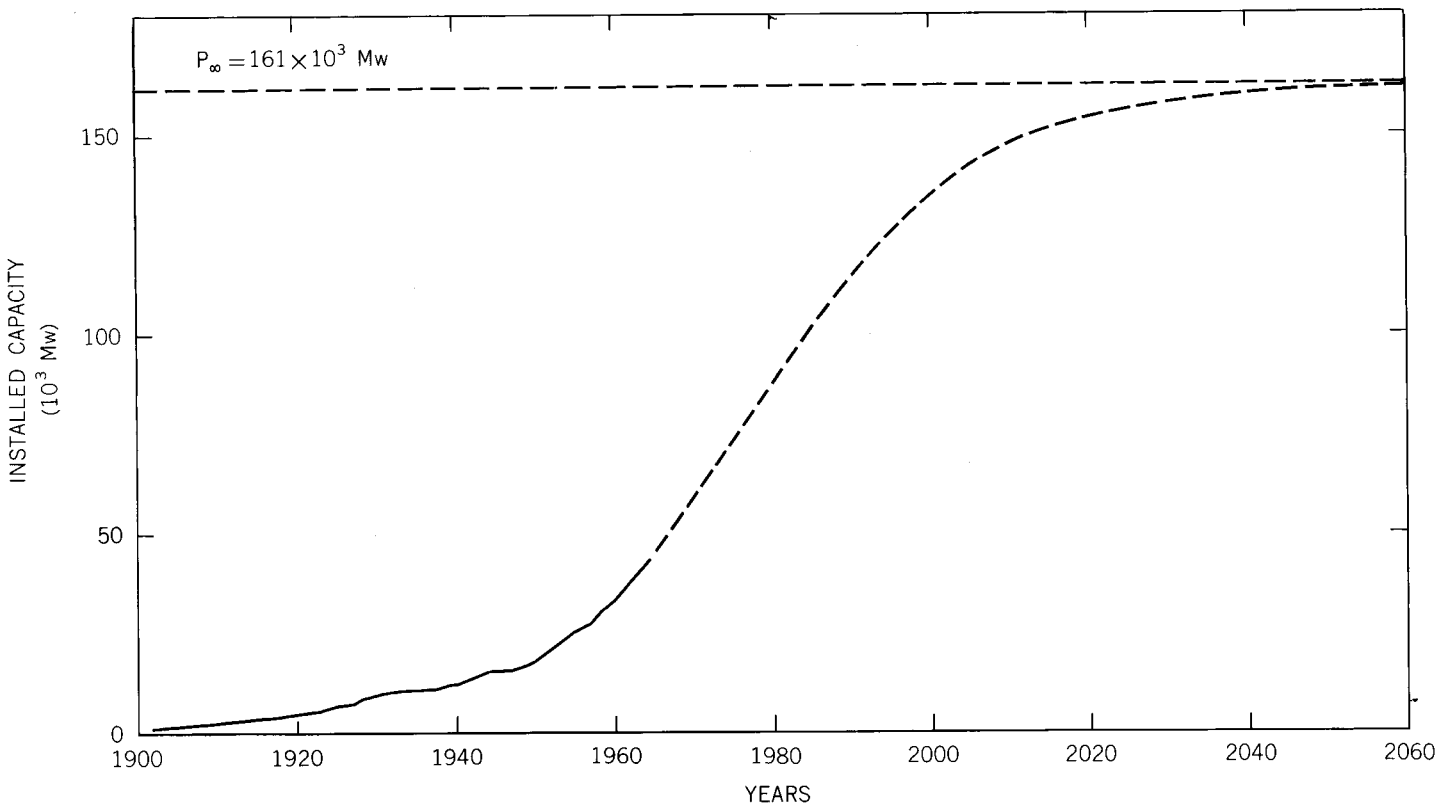

Figure 30.
Installed and potential hydroelectric-power capacity of the United States (Hubbert, 1969, Fig. 8.28).

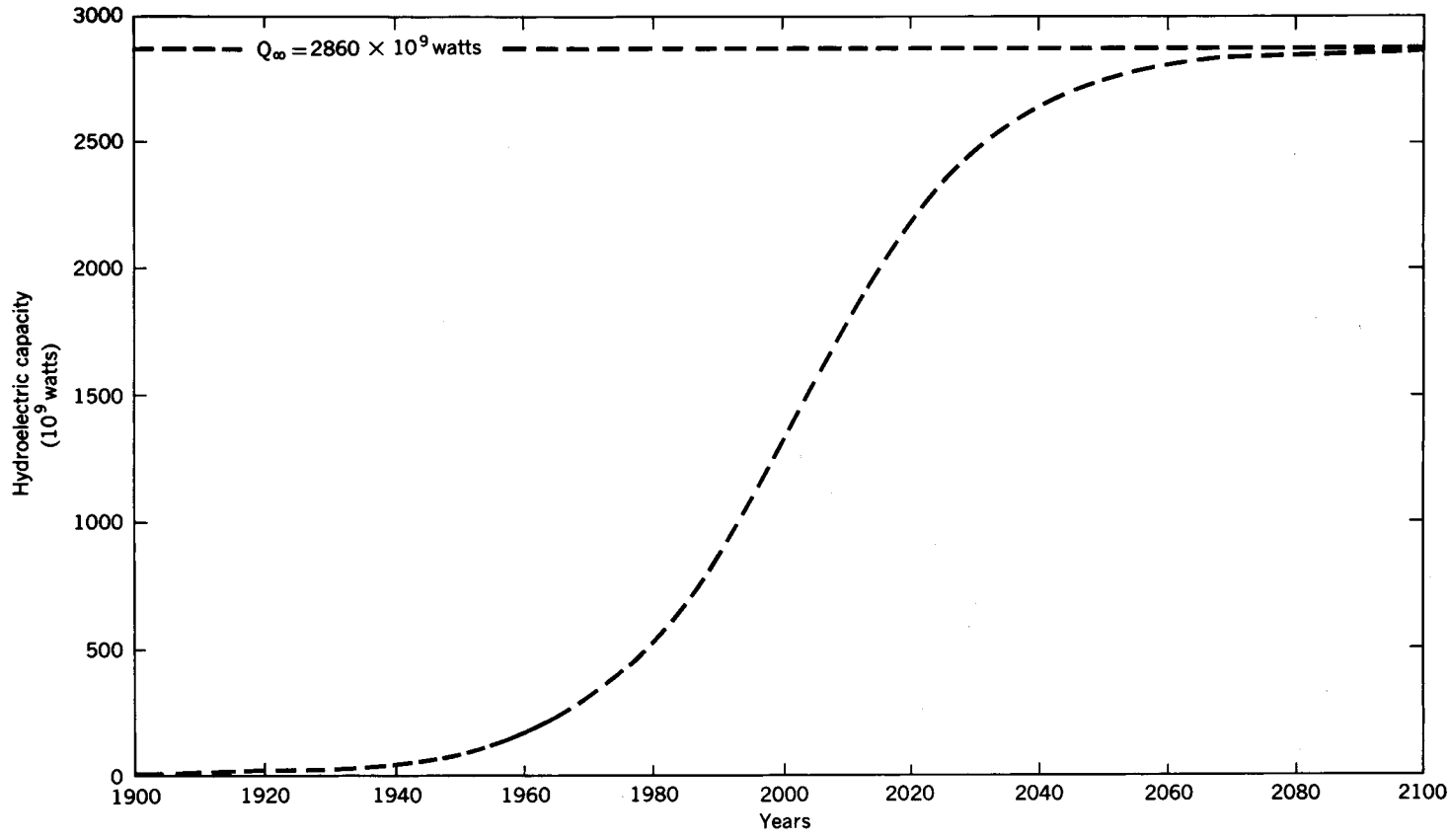

Figure 31.
Installed and Potential world hydro-electric-power capacity.

such an efficiency of conversion, the collection area required to generate 350,000 megawatts of electrical power -- the approximate electric-power capacity of the United States at present -- would be roughly 25,000 square kilometers or 9,000 square miles. This is somewhat less than ten per cent of the area of Arizona.

Such a calculation indicates that large-scale generation of electric power from direct solar radiation is not to be ruled out on grounds of technical infeasibility. It is also gratifying that a great deal of interest on the part of technically competent groups in universities and research institutions has arisen during the last five years over the possibility of developing large-scale solar power.

Hydroelectric power. -- Although there has been continuous use of water power since Roman times, large units were not possible until a means was developed for the generation and transmission of power electrically. The first large hydroelectric power installation was that made at Niagara Falls in 1895. There, ten 5,000-horsepower turbines were installed for the generation of alternating-current power which was transmitted a distance of 26 miles to the city of Buffalo. The subsequent growth of hydroelectric power in the United States is shown in Figure 30 and that for the world in Figure 31.

In the United States by 1970, the installed hydroelectric power capacity amounted to 53,000 megawatts, which is 32 per cent of the ultimate potential capacity of 161,000 Mw as estimated by the Federal Power Commission. The world installation (Fig. 31) by 1967 amounted to 243,000 Mw which is 8.5 per cent of the world's estimated potential hydroelectric power of 2,860,000 Mw. Most of this developed capacity is in the highly industrialized areas of North America, Western Europe and the Far East, especially Japan.

The areas with the largest potential water-power capacities are the industrially underdeveloped regions of Africa, South America, and Southeast Asia whose combined capacities represent 63 per cent of the world total.

The total world potential water power of approximately 3×10^{12} watts, if fully developed, would be of about the same magnitude as the world's present rate of utilization of industrial power. It may also appear that this would be an inexhaustible source of power, or at least one with a time span comparable to that required to remove mountains by stream erosion. This may not be true, however. Most water-power developments require the creation of reservoirs by the damming of streams. The time required to fill these reservoirs with sediments is only two or three centuries. Hence, unless a technical solution of this problem can be found, water power may actually be comparatively short lived.

Tidal and Geothermal Power

Only brief mention can be made ot tidal and geothermal power.

Tidal Power. -- Tidal power is essentially hydroelectric power obtainable by damming the entrance to a bay or estuary in a region of tides with large amplitudes, and driving turbines as the tidal basin fills and empties. An inventory of the world's most favorable tidal-power sites gives an estimate of a total potential power capacity of about 63,000 Mw, which is about two per cent of the world's potential water-power-capacity. At present, one or more small pilot tidal power plants of a few megawatts capacity have been built, but the only full-scale tidal plant so far built is that on the Rance estuary on the English Channel coast of France. This plant began operation in 1966 with an initial capacity of 240 Mw and a planned enlargement to 320 Mw.

One of the world's most favorable tidal-power localities is the Bay of Fundy region of northeastern United States and southeastern Canada. This has the world's maximum tides with amplitudes up to 15 meters, and a combined power capacity of nine sites of about 29,000 Mw. Extensive plans have been made by both the United States and Canada for the utilization of this power, but as yet no installations have been made.

Geothermal Power. -- Geothermal power is obtained by means of heat engines which extract thermal energy from heated water within a depth ranging from a few hundred meters to a few kilometers beneath the earth's surface. This is most practical where water has been heated to high temperatures at shallow depths by hot igneous or volcanic rocks that have risen to near the earth's surface. Steam can be used to drive steam turbines. At present, the major geothermal power installations are in two localities in Italy with a total capacity of about 400 Mw, the geysers in California with a planned capacity by 1973 of 400 Mw, and at Wairakei in New Zealand with a capacity of 160 Mw. The total world installed geothermal power capacity at present is approximately 1,500 Mw.

What the ultimate capacity may be can be estimated at present to perhaps only an order of magnitude. Recently, a number of geothermal-power enthusiasts (many with personal financial interests in the outcome) have made very large estimates for power from this source. However, until better information becomes available, an estimation within the range of 60,000 to 600,000 Mw, or between two and 20 per cent of potential water power, is about all that can be justified. Also, as geothermal-power production involves "mining" quantities of stored thermal energy, it is likely that most large installations will also be comparatively short-lived -- perhaps a century or so.

NUCLEAR POWER

A last major source of industrial power is that of atomic nuclei. Power may be obtained by two contrasting types of nuclear reactions: (1) the fissioning of heavy atomic isotopes, initially uranium-235, and (2) the fusing the isotopes of hydrogen into heavier helium. In the fission process, two stages are possible. The first consists of power reactors which are dependent almost solely upon the rare isotope, uranium-235, which represents only 0.7 per cent of natural uranium. The second process is that of breeding, whereby either the common isotope of uranium , uranium-238, or alternatively, thorium, is placed in a reactor initially fueled by uranium-235. In response to neutron bombardment, uranium-238 is converted into plutonium-239, or thorium-232 into uranium-233, both of which are fissionable. Hence, by means of a breeder reactor, in principle, all natural uranium or thorium can be converted into fissionable reactor fuel.

Uranium-235 is sufficiently scarce that without the breeder reactor the time span of large-scale nuclear power production would probably be less than a century. With complete breeding, however, it becomes possible not only to consume all natural uranium, or thorium, but to utilize low-grade sources as well.

The energy released by fissioning of a gram of either uranium-235, or plutonium-239, or uranium-233, amounts to 8.2×10^{10} joules of heat. This is approximately equivalent to the heat of combustion of 2.7 metric tons of bituminous coal or 13.4 barrels of crude oil. For the energy obtainable from a source of low-grade uranium, consider the Chattanooga Shale which crops out along the western edge of the Appalachian Mountains in eastern Tennessee and underlies at minable depths most of several Midwestern states. This shale has a uranium-rich layer about 16 feet or five meters thick with a uranium content of 60 grams per metric ton, or 150 grams per cubic meter. This is equivalent to 750 grams per square meter of land area. Assuming only 50 per cent extraction, this would be equivalent in terms of energy content to about 1,000 metric tons of bituminous coal or to 5,000 barrels of crude oil per square meter of land area, or to one billion metric tons of coal or five billion barrels of oil per square kilometer. In this region, an area of only 1,600 km^2 would be required for the energy obtainable from the uranium in the Chattanooga Shale to equal that of all the fossil fuels in the United States. Such an area would be equivalent to that of a square 40 km, or 25 miles, to the side, which would represent less than two per cent of the area of Tennessee.

Fusion. -- The fusion of hydrogen into helium is known to be the source of the enormous amount of energy radiating from the sun. Fusion has also been achieved by man in an uncontrolled or explosive manner in the thermonuclear or hydrogen bomb. As yet, despite intensive efforts in several different countries, controlled fusion has not been achieved. Researchers, however, are hopeful that it may be within the next few decades.

Should fusion be achieved, eventually the principal raw material will probably be the heavy isotope of hydrogen, deuterium. This occurs in a sea water at an abundance of one deuterium atom to each 6,700 atoms of hydrogen. The deuterium-deuterium, or D-D, reaction involves several stages, the net result of which is:

$$5\ {}_{1}^{2}D \rightarrow {}_{2}^{4}He + {}_{2}^{3}He + H + 2n + 24.8\ Mev;$$

or, in other words, 5 atoms of deuterium upon fusion produce one atom of helium-4, one atom of helium-3, one atom of hydrogen and two neutrons, and in addition release 24.8 million electron volts, or 39.8×10^{-13} joules.

It can be computed that one liter of water (10^{-3} m^3) contains 1.0×10^{22} deuterium atoms, which upon fusion would release 7.95×10^{9} joules of thermal energy. This is equivalent to the heat of combustion of 0.26 metric tons of coal or to 1.30 barrels of crude oil. Then, as one km^3 of sea water is equivalent to 10^{12} liters, the heat released by the fusion of the deuterium contained in one km^3 of sea water would be equivalent to that of the combustion of 1300 billion barrels of oil or 260 billion tons of coal. The deuterium in 33 km^3 of sea water would be equivalent to that of the world's initial supply of fossil fuels.

ECOLOGICAL ASPECTS OF EXPONENTIAL GROWTH

From the foregoing review, what stands out most clearly is that our present industrialized civilization has arisen principally during the last two centuries. It has been accomplished by the exponential growth of most of its major components at rates commonly in the range of four to eight per cent per year with periods of doubling from eight to 16 years. The question now arises: What are the limits to such growth, and what does this imply concerning our future?

What we are dealing with, essentially, are the principles of ecology. It has long been known by ecologists that the population of any biologic species, if given a favorable environment, will increase exponentially with time; that is, that the population will double repeatedly at roughly equal intervals of time. From our previous observations, we have seen that this is also true of industrial components. For example (Fig. 32), the world electric-power capacity is now growing at eight per cent per year and doubling every 8.7 years. The world automobile population, and the miles flown per year by the world's civil aviation scheduled flights are each doubling every ten years. Also, the human population is now doubling in 35 years (Fig. 33).

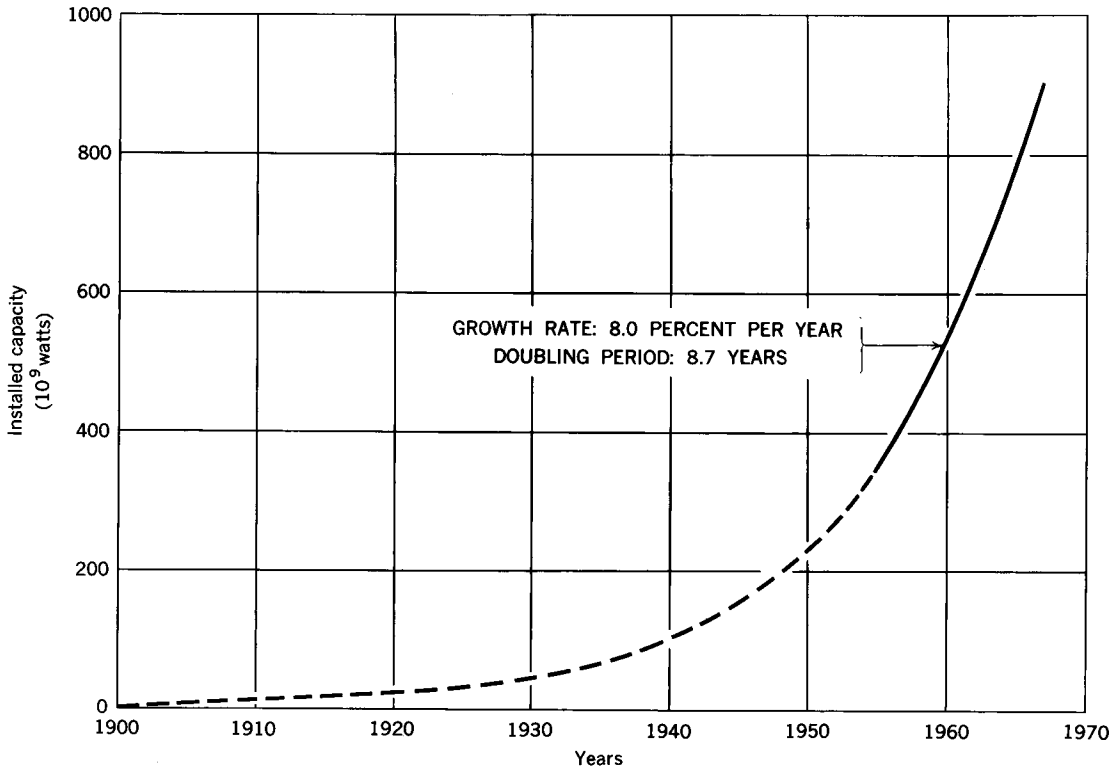

Figure 32.
World electric-generating capacity as an example of exponential growth (Hubbert, 1971, Fig. 2).

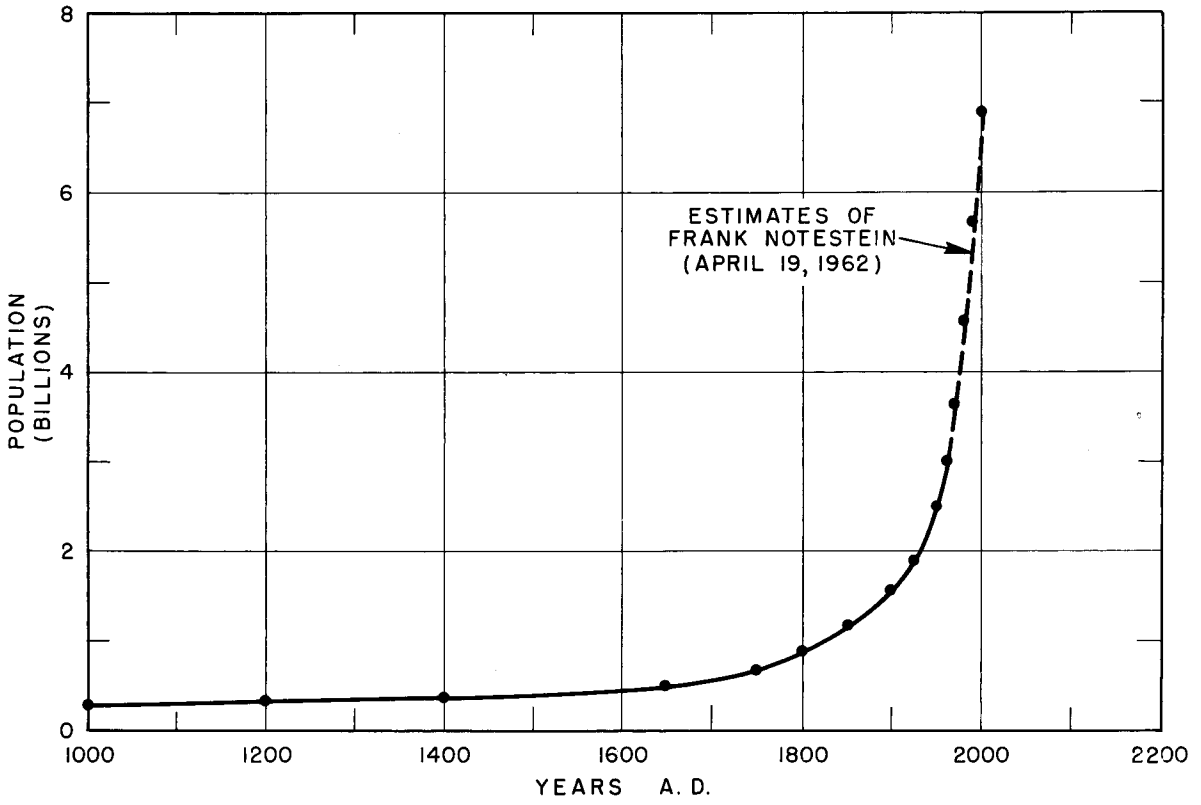

Figure 33.
Growth of human population since the year 1000 A.D. as an example of an ecological disturbance (Hubbert, 1962, Fig. 2).

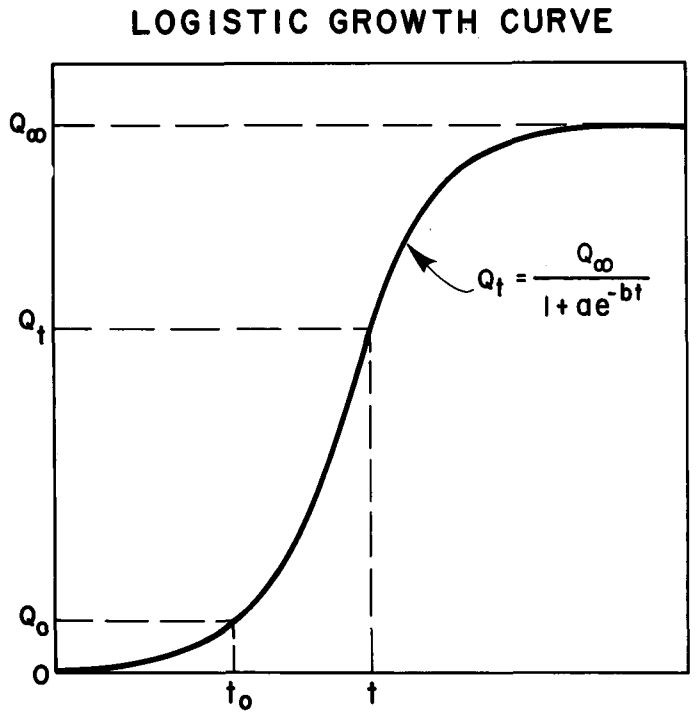

Figure 34.
The logistic growth curve showing both the initial exponential phase and the final slowing down during a cycle of growth.

The second part of this ecological principle is that such exponential growth of any biologic population can only be maintained for a limited number of doublings before retarding influences set in. In the biological case, these may be represented by restriction of food supply, by crowding, or by environmental pollution. The complete biologic growth curve is represented by the logistic curve of Figure 34.

That there must be limits to growth can easily be seen by the most elementary arithmetical analysis. Consider the familiar checkerboard problem of placing one grain of wheat on the first square, two on the second, four on the third, and doubling the number for each successive square. The number of grains on the nth square will be 2^{n-1}, and on the last or 64th square, 2^{63}. The sum of the grains on the entire board will be twice this amount less one grain, or $2^{64}-1$. When translated into volume of wheat, it turns out that the quantity of wheat required for the last square would equal approximately 1,000 times the present world annual wheat crop, and the requirement for the whole board would be twice this amount.

If, instead of wheat grains, one average-sized American automobile could be doubled 64 times, and the resulting cars were stacked evenly over all the land areas of the earth, they would form a layer 2,000 kilometers, or 1,200 miles deep.

From such simple examples, it follows unequivocally that exponential growth, either biological or industrially, can be only a temporary phenomenon because the earth itself cannot tolerate more than a few tens of doublings of any biological or industrial component. Furthermore, most of these possible doublings have occurred already.

After the cessation of exponential growth, any individual component has only three possible futures: (1) It may, as in the case of water power, level off and stabilize at a maximum; (2) it may overshoot and after passing a maximum, decline and stabilize at some intermediate level capable of being sustained; or (3) it may decline to zero and become extinct.

Applied to human society, these three possibilities are illustrated graphically in Figure 35. What stands out most clearly is that our present phase of exponential growth based upon man's ability to control ever larger quantities of energy can only be a temporary period of about three centuries duration in the totality of human history. It represents but a brief transitional epoch between two very much longer periods, each characterized by rates of change so slow as to be regarded essentially as a period of non-growth. Although the forthcoming period poses no insuperable physical or biological difficulties, it can hardly fail to force a major revision in those aspects of our current culture whose tenets are dependent upon the assumption that the growth rates which have characterized this temporary period can somehow be sustained indefinitely.

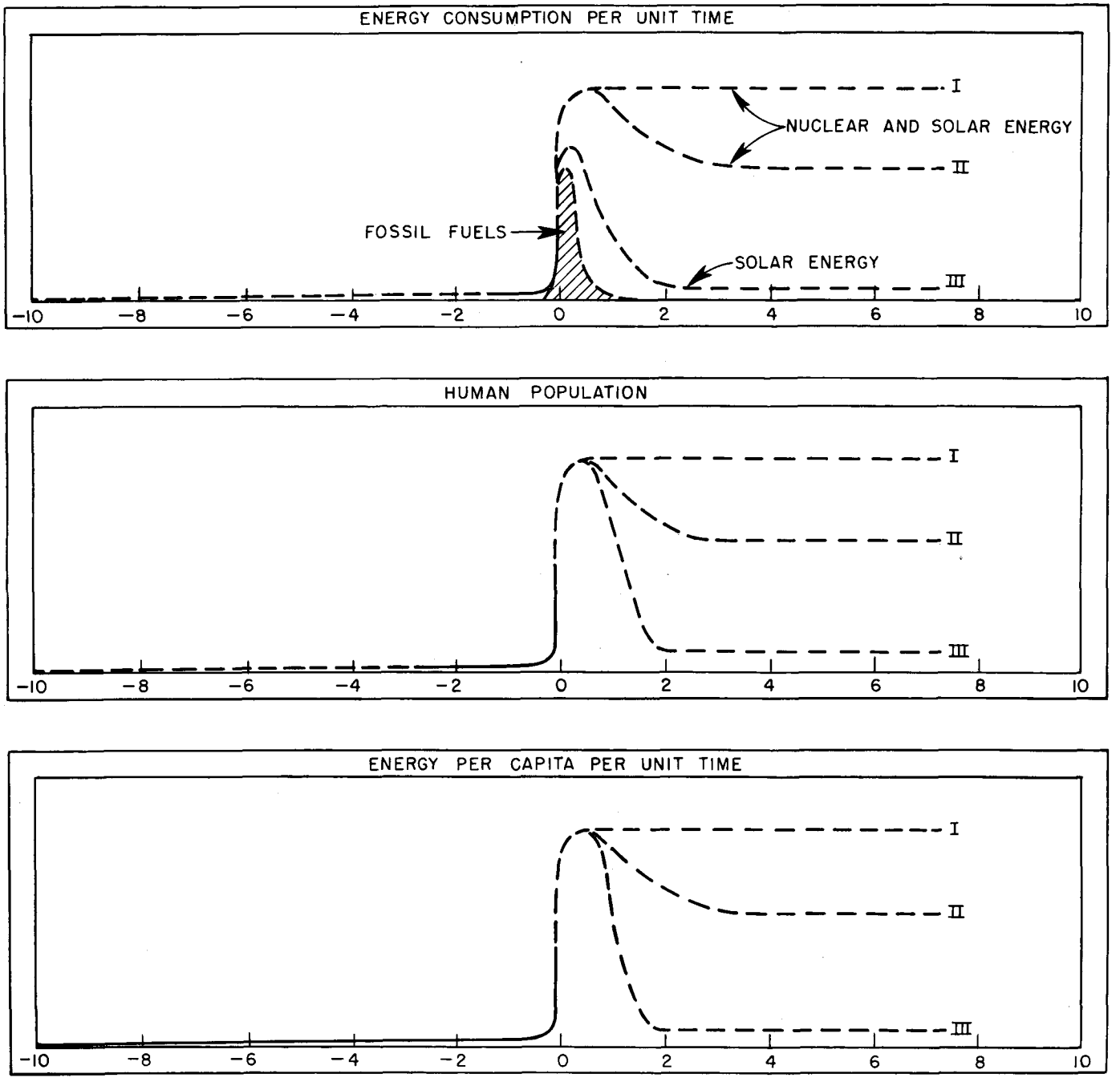

Figure 35.

Epoch of current industrial growth in the context of a longer span of human history (Hubbert, 1962, Fig. 61).

REFERENCES CITED

Averitt, Paul, 1969, Coal resources of the United States, January 1, 1967: U.S. Geological Survey Bulletin 1275, 116 p.

Duncan, D. C., and Swanson, V. E., 1965, Organic-rich shale of the United States and world land areas: U.S. Geological Survey Circular 523, 30 p.

Hewett, D. F., 1929, Cycles in metal production: Am. Inst. Min. Met. Eng. Tech. Pub. 183, 31 p.; Trans. 1929, p. 65-93; discussion p. 93-98.

Hubbert, M. King, 1956, Nuclear energy and the fossil fuels: American Petroleum Institute, Drilling and Production Practice (1956), p. 7-25.

_____, 1962, Energy resources: National Academy of Sciences - National Research Council, Publication 1000-D, 141 p.

_____, 1967, Degree of advancement of petroleum exploration in United States: American Association of Petroleum Geologists Bulletin, v. 51, p. 2207-2227.

_____, 1969, Energy resources, *in* Resources and man, a study and recommendations by the Committee on Resources and Man of the Division of Earth Sciences, National Academy of Science - National Research Council: San Francisco, W. H. Freeman, p. 157-242.

_____, 1971, Energy resources for power production, *in* Environmental aspects of nuclear power stations: Vienna, International Atomic Energy Agency, p. 13-43.

Theobald, P. K., Schweinfurth, S. P., and Duncan, D. C., 1972, Energy resources of the United States: U.S. Geological Survey Circular 650, 27 p.

Warman, H. R., 1971, Future problems in petroleum exploration: Petroleum Review, v. 25, no. 291, p. 96-101.

Zapp, A. D., 1962, Future petroleum producing capacity of the United States: U.S. Geological Survey Bulletin 1142-H, 36 p.

Plenary Panel I, Pressures of Energy Demands on Resources
Friday morning, September 29, 1972
Presiding: Hollis M. Dole, Assistant Secretary, Mineral Resources,
US Department of the Interior

FOSSIL FUELS

Robert E. King
Consultant

Oil and natural gas provide about 60 per cent of the energy for the world, and 77 per cent for the United States. Consumption is increasing annually, commensurate with increase in the gross national product. Present consumption worldwide is nearly 50 million barrels of oil per day and 125 billion cubic feet of gas, equivalent to about 17.4 million bbl of oil. By 1980, estimated demand for oil alone will be 92 million b/d.

The US is still the world's largest oil producing nation, though in 1972 imports into this country have increased to nearly 4,500,000 b/d, and domestic production has started to decline. At the beginning of 1972 market demand proration was still in effect in many states of the US. Since then controls have been removed state by state, except where required for purposes of conservation. Domestic supplies of natural gas are barely sufficient to meet present demand, and inadequate for a normal rate of increase. Consumption in Japan, the world's third largest energy consuming nation, is more than 4,900,000 bbl of oil daily and Japan is importing liquefied natural gas from Alaska. How can the present rate of worldwide oil production be sustained, let alone take care of growth in demand of the next decades?

The main factor in the supply of large volumes of oil is the existence of oil fields with giant size reserves capable of sustaining a high rate of production. Capital and operating costs per unit of production are lower from giant fields than from smaller fields. Economies of large scale operations enable utilization of resources half way around the world from consuming countries, and can overcome severe climatic and logistical problems.

In the US it is customary to refer to oil fields with recoverable reserves of 100 million bbl and more as "major" fields. Usage varies, but oil fields with reserves of more than 500 million bbl are commonly called "giant" fields. When we reflect that an

oil field with reserves of 100 million bbl can only furnish, during its entire life of 25 to 40 years, enough oil to supply the world for two days or the US for a week, we have a conception of the rate at which we are depleting irreplaceable reserves. Major fields with reserves on the order of 100 million bbl are important to the economies of consuming nations, and the fields with reserves of five million to 50 million bbl can be profitably operated and locally important. However, world trade in oil is dominated by the output of giant fields or by that of producing areas with clusters of fields with reserves in the 100 to 500 million bbl range.

Fewer than five per cent of the world's oil fields are giants, but they account for 85 per cent of its oil production. In North America a greater contribution to production and reserves is made by the multitude of medium and small sized fields than in the rest of the world, and the percentage of contribution of the giants is less, but still striking. In 1968 there were 45 giant fields in North America out of a total of 26,250 fields, and they held 35 per cent of the continent's originally recoverable oil. This figure does not include reserves of the Prudhoe Bay field, which would increase the total giant field percentage. In 1966, fields in the US with reserves of more than 100 million bbl produced 58 per cent of the country's oil.

Clearly the huge demands for oil of the coming years will have to be met chiefly by giant fields. All of you are cognizant that the countries bordering the Persian Gulf have the world's most extraordinary concentration of giant and supergiant oil fields, a total of at least 50. Libya and Algeria also have a dozen or so giants. In 1972, 16.7 million bbl of oil per day is being exported from the Persian Gulf region, and this is the chief source of supply to Western Europe and Japan. In addition three million bbl a day are exported from North Africa to Europe. With US production steady and headed for a gradual decline until Prudhoe Bay finally comes on production, imports into this country are expected to increase to about 15 million b/d by 1985, more than three times the present level of imports, and it is expected that much of the increase will have to come from the Middle East.

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We will make a rapid survey of the rest of the world to see what other regions have proved or probable concentrations of giant fields that could offer an alternative or additional source of supply to the Middle East during the next 15 to 20 years.

The greatest number of giant oil fields outside the Middle East, and the highest potential for future discoveries, is in the Soviet Union. Most Russian oil production until World War

II was from a group of giant fields near Baku on the west side of the Caspian Sea. During the late 1930s new fields were found in the large sedimentary basin between the Volga River and the Ural Mountains. After World War II exploration and development in this region were accelerated, and the Volga-Ural region became the leading oil producing region of the USSR. One of the major contributors to this growth was the Romashkino field, found in 1948, with reserves of more than 14 billion bbl of oil. Production in the Volga-Ural region has now begun to decline, despite water flooding and gas injection into most of the producing reservoirs.

In the 1950s exploration began in the West Siberian basin, three times the size of Texas. The first major oil discovery was made in this basin in 1961, along the mid-course of the Ob River, in Tyumen Province. This was followed by a succession of more than 100 large to giant oil and gas discoveries, including Samotlor, a 15 billion bbl oil field, which was found and delineated in 1966 to 1968. One or more other fields, when further developed, may prove to have reserves of comparable size.

Operating conditions in the West Siberian basin are very severe, in swampland in the midst of the taiga or larch forest. Only ten per cent of the basin has been carefully explored -- the part near the major water courses. New discoveries in 1971 and 1972 have proved that oil production will be found far beyond the present productive portion of the basin.

A 48" pipeline loop, completed in 1972, links the West Siberian oil fields to Omsk and the Volga region on the west and to Irkutsk on the east, and production has reached 1,500,000 b/d, 450,000 b/d from Samotlor alone.

Elsewhere in the Soviet Union, two giant oil fields with reserves of 1.1 to 3.6 billion bbl were found in 1961 on the Mangyshlak Peninsula east of the Caspian Sea in Kazahkstan. The oil is very waxy, and the pipeline built to Kuybyshev required special facilities for handling. Production is expected to reach 500,000 b/d by 1975. There is a high potential for further giant fields under the Caspian Sea west of Mangyshlak, and exploratory drilling is to start this year. There is also a very high potential for giant fields on a trend across the southern Caspian Sea between Baku and the Cheleken Peninsula of western Turkmenistan. Several large fields are already producing near the coasts of the Caspian on this trend, and many more probably remain to be found.

Consumption of oil in the USSR will grow rapidly in the next 20 years, and there will be local tight supply of petroleum products during the next several years as pipelines are being built and refineries expanded. Production from the Volga-Ural basin and the Baku area will decline, but new supplies from the West Siberian basin and the Caspian Sea will make up the deficit. Present oil

reserves in the West Siberian basin should meet Russian requirements for years to come. Probable reserves yet to be discovered should provide a considerable surplus for export by 1980.

Japanese companies are negotiating with Russian authorities for the supply of pipe and related equipment for a large diameter pipeline from western Siberia to Nakhotka on the Pacific. Gulf Oil Corporation is reported to have offered technical assistance. The low sulfur content of western Siberian crude oils is a big plus for the Japanese market. Besides supplying the burgeoning requirements of Japan, there is likely to be a surplus of crude to export to the west coast of the US. On the other hand, it seems unlikely that much West Siberian oil will be available to export westward from Russia to the US because the crude piped west will primarily supply European needs, including the requirements of European Russia.

We will now consider another region with giant oil fields and the potential for many more. This is the central and northern North Sea. Exploration there began in 1962 and between 1965 and 1970 large gas fields were found off the English coast. As exploration moved north, important oil discoveries were made in 1969, and new oil fields are continuing to be found.

The first giant oil field discovered was Ekofisk, east of Scotland on the Norwegian side of the median line of the North Sea. Five nearby, possibly somewhat smaller fields have been found near Ekofisk, and total reserves of the six fields may be more than two billion bbl, though unique characteristics of the oil reservoir make it difficult to estimate the recoverable reserve. The largest reported reserve of any oil field in the North Sea is in the Forties field, east of Aberdeen, Scotland, which has reserves of about two billion bbl. The greatest exploratory activity in 1972 is in the northern North Sea between the Shetland Islands and Bergen, Norway. The newly found Brent and Cormorant fields, just above 61°N latitude, have reserves of at least one billion bbl each, but it is suspected they may be much greater. Half a dozen smaller oil fields have been found in the central and northern North Sea. With further drilling some of these fields may develop to giant size, but at any rate, as pipelines are built from the giant fields to onshore terminals the smaller fields can be tied into the system and make a significant contribution to total North Sea oil production.

Presently discovered reserves in the UK North Sea area should sustain a rate of production of one million bbl of oil per day by the late 1970s, when the fields are on full production. This will be 40 per cent of the UK consumption at that time. Total oil reserves found to date in the North Sea are probably about 12 billion bbl, capable of sustaining a production of three million b/d. Some of the largest and most promising structural prospects of the northern North Sea are only now being drilled for the first time, and most of the Norwegian area has not yet been licensed, though much of the untested area is known to contain favorable structures.

It is reasonable to assume that by 1977 recoverable reserves of 30 billion bbl will have been found, and that these can sustain a production rate of six million bbl of oil per day by the late 1980s, which would be sufficient for the requirements of the UK and Norway.

There are formidable technological problems in putting these fields on production. The Brent field is in water 475 ft. deep, winds reach a velocity of 100 miles per hour, and waves are as high as 95 ft. Problems of field development, and high capital investment, will particularly affect future discoveries which may be confidently expected in the Norwegian Trench, east of all exploratory activity to date, in water depths of more than 600 ft.

The lead time from discovery to large scale production in the northern North Sea fields is five years. Development of the Forties field will cost $750 million, and of Brent and Cormorant possibly $1.25 billion each. The first oil deliveries from Forties are expected to be in 1974, with production at a rate of 250,000 b/d by 1975. It is hoped that Brent can be put on production at a rate of 300,000 b/d in early 1976. Only the high production rate from prolific fields can offset the high capital costs, and make such production economic. Despite the large size of the North sea fields, production from them will probably replace only about 15 per cent of oil imports into all of Western Europe in the 1980s.

Since the end of the Biafran uprising in early 1970 there has been a great increase in production from Nigeria, and a series of large and even giant oil discoveries, chiefly offshore, has been made in Nigeria, Gabon, Congo, Zaire and Cabinda. Current production from equatorial West Africa is more than two million b/d. The potential for new discoveries is great, and the oil is low in sulfur. Favorable geological conditions extend to depths as great as 8,000 ft. offshore, and major companies have acquired licenses extending out to the floor of the deep sea, though the continental shelf and slope are quite narrow off some of the more promising basins. After further technological advances, deep water fields off West Africa will probably start commercial production by the 1980s, and total production from them may reach a rate of several million b/d.

The Prudhoe Bay field, with reserves of more than 10 billion bbl, has the potential of supplying the needs of the Pacific states of the US with a large share of their requirements, and it is hoped that production can start in 1976, in volumes rising eventually to two million b/d. The ultimate reserves of this field may prove to be larger than present estimates, which are probably conservative, and many additional fields are likely to be discovered on the North Slope, probably smaller than Prudhoe Bay.

The Canadian Arctic, primarily the Mackenzie Delta and Arctic islands in the far north, are being very actively explored,

but so far indications are that the reserves to be found are primarily of natural gas.

Turning to South America, in Venezuela the potential of the Gulf of Venezuela and Tablazo Bay, north of the prolific Maracaibo basin, may be very great. On the other hand, southern Lake Maracaibo was regarded as having equal promise until an active drilling program was recently carried out, with very disappointing results.

Large reserves have been found in recent years along the eastern side of the Andes in southern Colombia, Ecuador, and northern Peru. In southern Colombia and Ecuador giant fields have been discovered, and two pipelines have been built across the high Andes to Pacific ports. New fields have also been found in northeastern Peru. The possibilities for further expansion of production are great; however, the first field found in this province, Orito in southwestern Colombia, has shown a sharp decline in production since it was connected to the pipeline. It is hoped that the Ecuadorian fields alone will produce up to 250,000 b/d. The Colombian and Ecuadorian crude will probably have a significant impact on world supply patterns.

Indonesia is now producing nearly 1,200,000 bbl of oil daily, 75 per cent of it from a cluster of large to giant fields onshore in central Sumatra. Since 1968 there has been intensive exploration offshore in all parts of Indonesia, with considerable success in two areas - the Makassar Strait off east Borneo or Kalimantan, and the southwestern Java Sea north and west of Djakarta. Results to date indicate that favorable conditions for large fields are localized and do not embrace the entire large offshore area of Indonesia, and they also suggest that in the favorable offshore areas the fields are most likely to range from 75 to 485 million bbl in reserves, and are not in the giant class. These fields will provide an important auxiliary source of crude, chiefly to Japan, but they are unlikely to exceed the onshore central Sumatra fields in productivity. Indonesian production may peak at about two million b/d in the late 1970s. Important oil fields off Sarawak and Brunei now produce 220,000 b/d, and will continue to augment the Southeast Asian supply, probably reaching a rate of 500,000 b/d after recent discoveries go on full production.

Australia, long without indigenous oil, is now producing 350,000 b/d, 50 per cent of the nation's needs, mostly from offshore fields and from a coastal island. The northwestern continental shelf of Australia has a high hydrocarbon potential, though this may be chiefly for gas rather than oil. Discoveries of the rest of this decade may make Australia self-sufficient in oil, but are unlikely to provide a surplus for export.

What of the potential for increasing reserves and production in the low 48 states of the US? The National Petroleum Council sponsored a frequently cited study of US petroleum potential, which

estimated probable, potential and speculative reserves of 141 billion bbl at the present 30 per cent average rate of recovery. I feel that this estimate is much too optimistic. The oil may exist in the ground, but a great deal of it is in small reservoirs, at depths of more than 10,000 ft. which will be difficult to find and excessively costly to produce. On the other hand, there are giant fields offshore of southern California awaiting development whenever economic necessity prevails over environmental concern.

On land major oil fields continue to be found, despite frequent assertions to the contrary. Major field discoveries are not identified until the fields are nearly fully developed, and they do not appear in the annual API reserve estimates in the year of discovery, but in later years as revisions and extensions. The most notable discoveries of recent years are the series of deep fields along the Florida-Alabama line, and the Bluebell-Altamont field of northeastern Utah. Major stratigraphic trap discoveries have been made at depths of around 11,000 ft. in southern Oklahoma and southern Arkansas. In part the new discoveries are attributable to the great improvement in the technology of seismic exploration in recent years, which results in finding prospects for oil that could not have been located in earlier years.

Despite the discovery rate in the lower 48 states in recent years, the quantity of new oil found is sufficient only to arrest the decline in domestic production which has already set in, and I do not believe the assertion sometimes made that the rate of discovery of new reserves can be increased to relieve us from an accelerated rate of imports.

The possibility of large oil discoveries on the continental shelf off the Middle Atlantic states and New England has been widely publicized recently but I am skeptical of the oil prospects of this offshore region. I do not have access to the detailed seismic data obtained by many companies on the eastern shelf in recent years, but it appears that large structural traps are rare, and that the greatest hope is for important stratigraphic traps. Stratigraphic traps are elusive targets for drilling despite the technological advances in geophysical exploration. In Canadian Atlantic waters from Georges Bank northeast to the Grand Banks and Flemish Cap there are numerous large structures, and drilling to date has proved oil and gas reserves, though there is some doubt about the present economic feasibility of putting them on production. The favorable structural characteristics of the Canadian offshore area do not appear to extend southwest into US waters.

Perhaps the area of greatest potential off the coast of the US is the continental slope of the northern Gulf of Mexico. There, numerous huge structures underlain by salt occur in water depths of 300 to 3,000 ft. Some shallow holes have been drilled

in the region for geological information, but the oil and gas potential are unknown and sovereignty over the deep water area is still undetermined. This zone may well have a large number of undiscovered giant fields, though it is possible that the relationship in geologic time between oil generation and structural growth was not favorable for trapping large volumes of hydrocarbons.

An important factor to consider in increasing oil reserves, particularly in the US, is improvement in the recovery factor of oil in place. The US average of recovery from oil reservoirs has been 30 per cent, though it approaches 50 per cent in some regions with generally high reservoir permeability such as the Gulf Coast. At present the industry has gone about as far as it can in secondary recovery practices, chiefly water flooding and gas injection. If ultimate US oil recovery from presently known reservoirs can be increased 10 per cent through tertiary recovery processes, the known producible reserves of the country would be increased by some 40 billion bbl. Whether this is a good possibility is unknown. Company research laboratories are actively seeking means to improve the recovery of oil in place, but few data are available on progress. Recently a tertiary recovery project, injection of CO_2 gas, has been initiated in the large Kelly-Snyder field of west Texas, and this may have considerable promise, but it is dependent on the availability of large volumes of CO_2 gas.

Further exploration of the world's continental shelves and slopes down to 2,000 ft. or more of water depth may be very rewarding during the next two decades. Many promising areas have severe physical problems that will impede operations and make them very costly. Regions with severe problems include the Beaufort Sea off northwestern North America, the straits among the Canadian Arctic islands, Baffin Bay, Davis Strait, the Gulf of Alaska, and the Barents Sea. Somewhat less severe conditions prevail off the west coast of Norway north of 62° N lat., the shelves off Patagonia and the Falkland Islands, and south, west, and east of New Zealand. Conditions off West Africa and East Asia offer fewer problems. Any or all of these offshore areas may hold large oil and gas reserves, with giant sized fields capable of sustaining high volumes of production. Because of the technological problems and the high investment required, the deep offshore areas will hardly have been thoroughly explored before the year 2,000, and they may be major sources of world supply well into the 21st century.

We may now draw some conclusions from the rapid review of potential major sources of supply for the future from other regions than the Persian Gulf nations and North Africa. Western Siberian fields may supply much of the oil needs of Japan and some of the requirements of the US, starting in 1980. North Sea oil may supply 15 per cent of the needs of northwest Europe by 1980, and by 1985 increasing volumes of West African crude may be available for Western Europe and the eastern US. New oil fields coming on

production in northwestern South America, Indonesia, North Borneo and Australia will be locally important but will not have a major effect on world trade patterns. Beyond 1980 and continuing into the next century, oil from polar continental shelves and from continental slopes below 600 ft. of water will supply important amounts of oil. In spite of the large new supply sources, they are still inadequate to replace the large volumes of oil now supplied from the Persian Gulf region and North Africa. Under normal conditions these are expected to provide some 40 million b/d by 1980. The US will become increasingly dependent on high cost imports unless a new and unexplored offshore region yields immense reserves - and I think the continental slope of the northern Gulf of Mexico is a possibility for this.

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We now turn to future sources of natural gas. In the preceding roundup of future oil supplies, many of the regions with high gas potential have already been mentioned. However compatible natural gas is with oil, there are some important differences in its distribution. In most oil producing regions gas is recovered as a by-product of oil production, and dry gas reservoirs are present in the same depth range as the principal oil production. In deep basins, however, oil phases out at depths below 15,000 ft., and below 20,000 ft. oil is rarely found. As reservoir porosity decreases downward, the ability to store oil decreases. On the other hand, the reserves of gas in some of these reservoirs is very great because the amount of gas compressed in small pore spaces becomes greater with the increase of pressure. This accounts for the high volume gas production of certain ultra-deep fields of western Oklahoma and Texas. The dominance of gas with depth makes it unlikely that ultra-deep drilling will increase US oil reserves, but the opposite is true of gas. Some large sedimentary basins have immense gas reserves but no commercial oil, probably because the organic source material for gas may be humic and lignitic, whereas protinaceous organic matter is required as a source for oil.

The greatest gas reserves in the world lie in the northern part of the West Siberian basin, near the arctic Circle. The fields are productive from reservoirs of a younger geological age than the large oil fields farther south in the same basin. No significant amount of oil has been found in the northern gas province of western Siberia. Among the gas fields is Urengoi, the world's largest, with a reserve of 100 trillion cubic feet (Tcf), equivalent thermally to about 15 billion bbl of oil. Only limited production of gas is being taken from these fields, and Urengoi will not be tied to a pipeline for several years, because other immense gas fields of the Soviet Union, presenting fewer physical problems of transportation, are being utilized first. Among these are giant fields of Uzbekistan and Turkmenistan, located in vast sedimentary basins prolific in gas but

so far without oil. The Gasli field, with reserves of 17 Tcf, has been on production since 1963, and the even larger Shekhitli field, with reserves of more than 30 trillion, is being tied to the trunk pipeline system. Another huge gas field, Orenburg, in the southern Urals, is preparing to go on production. In eastern Siberia the Vilyuy basin near Yakutsk has a group of giant gas fields with total reserves of 28 Tcf.

The large gas reserves of European Russia and Middle Asia will be able to take care of most indigenous gas requirements of the Soviet Union for years to come, leaving a large surplus for export from northwestern and eastern Siberia. Gas is already being exported from the Soviet Union to Austria, and agreements have been signed for extension of pipelines to southern Germany, Italy, and even France. Some northwest Siberian gas probably will enter this system, but the greater part will be available for export as LNG. Discussions are already being held with Soviet authorities by both US government officials and representatives of major transmission companies for constructing pipelines, compressor plants, and ships for export of northwestern Siberian and Yakutsk region liquefied gas to the US. These costly and complex projects will not be completed before the 1980s.

The Groningen field of the northwest Netherlands, with a gas reserve of 65 Tcf, is on nearly full scale production and is supplying markets in Benelux, France, and Germany. The reserves are fully committed to existing contracts. A large share of British energy now comes from the southern North Sea, and an additional gas field in that region will start production soon. Britain can consume a great deal more gas than is now available. The northern North Sea is a potential source of future supply. The Forties oil field has a gas reserve of about 20 Tcf and the Frigg gas field, east of the Shetland Islands in Norwegian waters, has a reserve of 10-12 Tcf. More such fields will be found but the problem of getting this gas to markets is formidable, because the fields are in deep and stormy waters in the middle of the sea. Frigg and other fields may be linked by pipeline to a liquefaction plant in the Shetland Islands, though if sufficient reserves are found a pipeline to Scotland may be economically feasible. Possible major future supplies to Britain may come from the continental shelf northwest of the Shetlands, and from the Celtic Sea in the southwest.

The Canadian Arctic Islands and the Mackenzie River delta have been proved to have large gas reserves. Drilling now in progress will determine whether they are sufficient to justify construction of pipelines to the US. American gas transmission companies are investing millions to finance this effort, in order to have a call on the gas discovered. Before 1980 the projected natural gas pipeline from the Prudhoe Bay field, with gas reserves of 26 Tcf, will undoubtedly be built, through the Mackenzie valley to the north central US, and it will tie the Mackenzie delta fields into this system.

The wildcats drilled on the continental shelf off the Maritime Provinces of eastern Canada have evidently proved substantial gas reserves, and these will probably supply markets on part of the eastern seaboard.

Future increases in reserves of gas in the US may be anticipated in the Gulf of Mexico, in the Appalachian region, and perhaps on the eastern continental shelf, but they are unlikely to have a substantial effect on the rapid decline of domestic reserves. US production in 1971 was 62.4 billion cubic feet per day (cfd), and it is expected to peak at 65 billion cfd by 1975 and then decline to about 56 billion in 1980, when demand is expected to be 80.6 billion ft. The deficit between supply and demand of 24.6 billion cfd will have to be met by imports from Arctic Canada and of liquefied natural gas. During the same period Japan, with negligible indigenous gas production at present, is expected to have a demand of 27 billion cfd by 1980, and all of this must be imported.

LNG projects are presently in operation in Algeria and they are being developed in Brunei and Sarawak, Iran, and offshore of eastern Trinidad. Plans are being considered for projects in Nigeria, the northwest shelf of Australia, central Australia, and offshore Ecuador. Present plans for large scale importation of LNG indicate that imports may reach a large volume in 1976 and will increase as supplies become available from diverse sources. The severe technological problems of obtaining LNG from remote Arctic and sub-Arctic areas in Siberia suggests that LNG from these fields will not be available in quantity until 1980. Until 1972 many analysts of petroleum industry trends have assumed that LNG will be a relatively unimportant supplement to US domestic supplies because of the high capital cost of developing LNG projects and the high cost to the consumer required to meet these costs. It is now forecast that by 1980 at least 200 methane tankers will be carrying about 40 billion cfd to the US, Japan, and Western Europe. By the end of the century a large percentage of US natural gas will be imported, and the price will be on the order of $1.00-$1.50 per MCF delivered at major consuming centers, based on present value of the dollar.

An alternate source of high priced gas is gas manufactured from imported naphtha or from coal. Projects are now underway for manufacture of synthetic gas; however, there is competition for naphtha from petrochemical companies, and an adequate supply of raw material for the plants can be assured only from coal gasification.

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There is a reserve of 700 billion bbl of asphaltic oil in place in the Athabaska tar sands of Alberta, and an additional large amount in other tar sand deposits of Alberta, Madagascar, eastern Venezuela, and elsewhere in the world. The first large scale production of oil from tar sands began in Alberta in 1968. The operator was beset with technological problems, chiefly related to removal of the large amount of overburden, and so far there has been

a deficit of millions of dollars on the operation. It is expected, however, that a profit may be shown in 1972 or 1973. Other operators are seeking approval for tar sand projects in Alberta, and it is probable that within a few years large scale oil production from this area will be commercially viable, though the stripping of great volumes of overburden and restoration of the landscape will continue to be a problem. I will not attempt to forecast when oil from tar sands will have an important impact on total supply, though it will certainly not be until the next century.

The forecast for oil shale is similar. Production of oil from shale has been carried on commercially in Estonia for a long time, but it is still in the planning stage for the world's greatest oil shale reserve, in northwestern Colorado and northeastern Utah. Oil cannot yet be produced from shale at a price competitive with liquid oil. A severe problem for oil shale production is the disposal of vast tonnages of residual shale as well as overburden, and the need for large quantities of water for processing the shale in this semi-arid region in the upper basin of the Colorado River, where water is at a premium for local agriculture and for downstream uses in California and northwestern Mexico.

I am not prepared to say much about coal, which can be discussed better by others. There are immense coal resources in the world, some of them little developed to date because, until recent years, they were far from main consuming centers. Now, with shovels capable of stripping vast tonnages, and with large marine bulk carriers and coal slurry pipelines, some of these more distant sources of supply are becoming an important factor in commerce. Examples of areas with large reserves are the Dakotas, Montana, Alberta, the San Juan basin, southeastern British Columbia, Queensland and South Africa. On the other hand, coal reserves in some of the older areas such as Britain and Western Europe are being mined commercially only because of government subsidies of one kind or another. As oil and gas supplies decrease in the 21st century, coal will undoubtedly replace much of the energy deficit. However, a price will have to be paid, because strip mining despoils the environment and underground mining creates problems of safety as well as to the environment. Moreover, combustion of most coal creates air pollution, and means must be found to clean up stack emissions better than we are doing now.

* * *

In conclusion, if the major industrial nations, except the Soviet Union, are deprived of a significant part of oil production now coming from the Persian Gulf countries and North Africa, there will be a severe shortage, only partly alleviated by major new supplies from the North Sea, the North Slope of Alaska, and the Soviet Union. Beyond 1980 new reserves developed on the outer continental shelves and continental slopes may supply much of the world's needs toward the end of the century. Increasing amounts of gas will be available through world trade in LNG, but at a high price

to the consumer. Potential sources of synthetic oil and gas from coal, tar sands, and oil shale are plentiful, but their large scale production will require extremely high investment, and will result in greater environmental damage than production of oil and gas from wells.

Plenary Panel I, Pressures of Energy Demands on Resources
Friday morning, September 29, 1972
Presiding: Hollis M. Dole, Assistant Secretary, Mineral Resources,
US Department of the Interior

ALTERNATIVE SOURCES OF ENERGY

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By "alternative sources" we mean alternatives to gas and oil which now supply 78 per cent of the energy used in the United States and 61 per cent for the entire world. In the United States we are particularly concerned with alternatives for transportation which is 95 per cent dependent on petroleum fuels.

Some of the more important alternatives that have been proposed are gas and oil from coal, oil from tar sands and from oil shale, nuclear fission, nuclear fusion, solar energy and geothermal energy. None of these sources is currently utilized on a large scale. Several of them will certainly become important in the future as they pass through the successive stages of technological development, large demonstration plants, and construction of full-scale commercial facilities. The main uncertainties lie in the time-scale required for development and construction work. Will these steps occur in time to afford a smooth transition from current energy sources, or will we be subjected to recurrent crises of shortages and rationing? A related set of questions has to do with economics. Will the costs for the new energy sources permit continued growth in consumption? A third set of questions, which may turn out to be of overriding importance in the long run, is whether satisfactory solutions can be found to the environmental impacts from the various energy sources.

I will start by considering coal as a source for new fuels. Over half the coal used in the US provides fuel for steam-electric plants. The remainder is burned in a variety of uses, essentially all without chemical pre-treatment. The disadvantages of using coal in this way are the severe contributions to air pollution (particulates, sulfur oxides and others) and the inconvenience of handling a solid fuel in many applications. The basic chemistry for converting coal into clean gaseous or liquid fuels has been known for many years.

However, the development of practical, large-scale processes has proceeded slowly. The need has not seemed urgent enough to attract a vigorous industrial development effort, and until recently these programs have not had a high priority for the government. The greatest current emphasis is being given to producing high-Btu pipeline quality gas from coal. There are at least four separate processes for doing this. These processes have reached the pilot plant stage or are close to that point. Preliminary economic projections indicate that any of these processes might eventually produce pipeline quality gas at prices in the range of 50 to 70 cents per million Btu. Initial production costs are likely to be considerably higher. These estimates seem high in comparison with current US natural gas prices of about 30 cents per million Btu at the wellhead. Nevertheless, with increasing shortages of natural gas in the next decade, the important question may be how fast full-scale coal gasification processes can be built and brought into operation.

Increased emphasis has also been given recently to processes which produce low-Btu gas from coal. The low-Btu gas would have to be used at the point of production since the cost of transporting it by pipeline would be excessive. Such processes give an opportunity for making electricity from coal and at the same time avoiding the serious air pollution problems that surround existing coal-burning plants. The Lurgi process, developed in Germany, is commercially available and may already be competitive with the available alternatives in some parts of the United States. More advanced processes which are under development promise to give lower prices eventually.

A number of processes are also under development which would produce synthetic crude oil from coal. Again, the basic chemistry and scientific feasibility of the processes are well established but economic feasibility is yet to be demonstrated. Pilot plants have been built for the Consol process (by Consolidation Coal Co.) and the COED process (by FMC Corp.). Several other processes have gone through extensive bench-scale development. Experience to date does not seem sufficient to give a basis for reliable cost estimates. Nevertheless, it is to be expected that development work will be intensified during the next few years under the pressure of increasing oil prices and demands.

All of the processes for converting coal into liquid or gaseous fuels imply greatly increased coal mining activity in the United States. Thus the development of these processes will bring into sharper focus the unresolved issue of environmental impacts from the mining. These questions will be particularly acute in the Rocky Mountain states with their large coal reserves accessible to surface mining.

We should also include under the heading of "new energy sources" the development of tar sands and oil shale. Here the principal questions are those of finding economical and environmentally acceptable methods of mining and disposal of the waste material. Recovery from tar sands has recently become commercial in western Canada. The potential energy resource from these sources (particularly from oil shale) is so large that they will clearly be utilized at some point in time. However, the amount of waste material that would be produced by conventional mining methods is also very large, and restoration of the land disturbed by mining will be a formidable problem. It may be that use of these sources will depend on the further development of *in situ* recovery processes on which considerable work has already been done by the US Bureau of Mines.

The energy sources I have discussed thus far are all various forms of fossil fuels. As such they could potentially be used either for generation of electricity or for combustion at the point of final use. The remainder of the new energy sources are non-fossil and, except for solar energy, are primarily applicable to production of electricity. Their usefulness is thus limited to applications where electricity is a reasonable substitute for current energy sources. In the US electricity makes up only eight per cent of total energy consumption at the point of final use. For many applications electricity can, and gradually is being substituted for other forms. However, in the transportation sector, which uses 24 per cent of total energy, there is almost no use of electricity, and very little prospect of near-term substitution of electricity (within the next 15 years). In the more distant future it is possible that electrically driven vehicles will be important. It has also been suggested that both surface and air transportation may eventually depend on synthetic chemical fuels such as hydrogen or methanol which can be manufactured by means of electric energy.

The first of the non-fossil energy sources is nuclear fission. Reactors which utilize the fissioning of uranium have been under intensive development in the US and several other industrialized nations since the early 1950s. US government expenditures are currently around $200 million per year, far exceeding the amounts being spent on any other energy research and development program. The construction of full-scale first-generation reactors started in 1965 and since that time over 50 per cent of new generating plants to be undertaken have been of the nuclear variety. In spite of this very large commitment of money and resources, the contribution of nuclear energy is not yet significant: in 1970 it accounted for only one per cent of US electrical energy. By 1990, 40 years after the start of intensive development, nuclear energy may provide one-half of the US electrical capacity, illustrating clearly the very long time-span required to introduce an important new energy technology.

The first-generation, water-cooled nuclear reactors make use of less than one per cent of the energy potential of uranium. Nearly all of the current development work is going into perfecting sodium-cooled second-generation reactors called breeders. The main advantage of the breeders will be that they can exploit over 50 per cent of the fission energy potential of the uranium, thus extending the lifetime of known uranium reserves from a few decades to thousands of years. Construction of the first breeder demonstration plant in the US will start next year. Full-scale commercial breeders will probably make their appearance in the late 1980s.

There do not appear to be any fundamental scientific questions regarding the feasibility of breeders. However, questions have been raised regarding the urgency of development and the relative priority assigned to research and development work on this program compared to other energy sources. There have also been challenges to the construction of both types of nuclear reactors on environmental grounds. Such objections are chiefly concerned with the possibility of the accidental release of radioactivity, either from a malfunction of the reactor itself or from the spent fuel after it has been removed from the reactor for ultimate waste storage. The probability of serious radioactivity incidents occurring is extremely low but can never be reduced to zero in a theoretical sense. As a result, there is a question of public acceptance of nuclear reactors which is not yet entirely settled.

Looking farther into the future we can see the possible utilization of nuclear fusion as an energy source. If a practical embodiment of this process can be found, it would make use of lithium and heavy hydrogen as the basic fuels and would provide an almost inexhaustible source of energy. However, even scientific feasibility of developing fusion reactors is not yet demonstrated.

Fusion would also have relatively mild environmental impacts. An operating system would emit hardly any pollutants, except waste heat, to the surrounding biosphere. The potential for accidents should be extremely low. The leakage of tritium would have to be avoided, and some radioactive materials associated with activation of the structure would have to be disposed of, but these problems would be several orders of magnitude smaller than with fission reactors.

Nevertheless, fusion must be classified in the speculative category until a device is built which is capable of achieving net power production. The conditions for such a scientific breakthrough are known theoretically to involve a combination of high temperature, high fuel density, and long containment time. Intensive research through two decades has resulted in continually closer approach to the necessary conditions. At present, the United States is spending

about $60 million per year in this area, and could reach the point of demonstrating scientific feasibility by about 1980. Beyond that point, continued development would require much larger expenditures of money to translate the concept into engineering practicality. By comparison with the development schedule for fission power, it can be estimated that the first commercial fusion devices are not likely to appear before the year 2000, and that we will be some years into the next century before this energy source becomes an important energy producer.

There is increasing interest during the last few years in the sun as a source of energy, although only a few million dollars per year is being spent for development work. The attractiveness of solar energy comes from the fact that this source is abundant, inexhaustible and available everywhere. The main drawback is that the energy from the sun is dilute. As a result one needs large collection areas covered with expensive equipment to trap the energy. A further drawback is that the diurnal, seasonal and geographical variations in solar intensity impose requirements for large amounts of energy storage in most applications. It takes extreme ingenuity to devise methods for accomplishing all of this without incurring excessive capital costs. Thus far practical applications have been limited to a few small-scale household applications. In the future, solar energy might become a major worldwide energy source. This could come about as a result of rising fuel costs and environmental protection costs for the alternative sources. It could also come about through innovative developments in some of the work that is now being started in solar energy. Some of the concepts which are potentially attractive are direct conversion of solar energy to electricity, thermal conversion to electricity, and the use of biological processes to convert sunlight into hydrogen or methane.

Geothermal energy has been used for many years to produce electricity in places where steam or hot water are found near the surface. However, there are relatively few locations where such conditions prevail. Recent increased interest in geothermal energy derives from suggestions that energy be obtained from hot rock which underlies much of the earth's surface at depths of a few miles. It remains to be seen whether drilling and heat removal processes can be developed to make practical use of this energy source. If so, the geothermal resource is large enough to supply a substantial portion of the world energy demands.

As a final possible energy source I would like to mention the possibilities for using the solid waste generated by cities and by agricultural activities. These materials can be burned to produce heat or processed to give methane. The potential energy recovery is significant, and a waste disposal problem might be alleviated at the

same time. Here, the economics and feasibility are not so much dependent on the development of new technologies as on the development of institutional arrangements which could cope simultaneously with energy production, secondary materials recovery, and large-scale waste disposal in an environmentally acceptable manner.

I will not discuss other alternatives such as energy from wind, tides, ocean currents or thermal gradients. Although a number of interesting proposals have been advanced to make use of these sources, none of them now appear sufficiently attractive to warrant extensive development work. Additional use of hydro-electric resources will be important only for some of the developing nations.

It would be inappropriate for me to close this discussion of new energy sources without mentioning energy demand. The reason we are so concerned with the development of all of these energy technologies is that we anticipate continued growth in demand. US energy demand has been growing at about three and one-half per cent per year; the electrical energy portion has been growing at seven per cent per year. Most planning is done on the very questionable assumption that such growth rates will inevitably continue. Thus only about one per cent as much research and development work is done on energy demand questions as is devoted to supply problems. Nevertheless, the small amount of research that has been done on energy demand has indicated a large potential for more efficient energy use as one step toward averting supply shortages. For example, in passenger transport, airplanes use eight times as much energy per passenger mile as do buses. In freight transport airplanes use 50 times as much energy as railroads. These statistics suggest the need for a reexamination of policies affecting the economics of transportation.

Other sectors of energy use also display great opportunities for increases in the efficiency with which energy is used. We see examples ranging from the design of home appliances and the design of systems to use waste heat from power plants to the technology for mining coal. A considerable pressure toward energy conservation will be evident in the next few years through rising prices and the resulting market adjustments. It may also be time for a thorough-going reexamination of present government policies of promoting increased energy use through subsidies and taxation. None of these changes is likely to solve our energy problems by itself, but together they may go a long way towards keeping energy supply and demand in balance. The nature of this balance will have political and economic implications for the Middle East which should not be overlooked at this Conference.

Afternoon Session, Friday, September 29, 1972
Presiding: Peter F. Krogh, Dean, School of Foreign Service,
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EVOLVING RELATIONSHIPS AMONG THE OIL COMPANIES, THE OIL PRODUCING GOVERNMENTS AND THE MAJOR CONSUMERS: CONFRONTATION OR COOPERATION?

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Ex post facto criticism is appealing. It boosts the ego of the critic whose hindsight is clear and uncluttered. It enables him to demonstrate, to himself at least, that calamaties could have been avoided or injustices corrected if only he had been in charge. This can be a pleasant exercise. Most of us know exactly how we would have avoided the first World War if only we had been sitting in the chancelleries of Europe at the time. This type of criticism can also be ungracious. We have heard recently that President Lincoln has been overrated because he did not advocate the social mingling of races at the same time he freed the slaves. Such criticism can be of value if it guides us to the avoidance of future error but it is usually stale and flat; it is rarely meant by the critic to be constructive and never is it construed as such by those being criticized.

Today the international oil industry is facing widespread attacks and even condemnation in this country, in other consuming countries, and in the producing countries. There may be some in the industry itself who claim never to have made error or misjudgment but I have never met such a paragon. There are some, however, who, at any given time, have maintained that the status quo was perfect and must not be changed. I have met a few of these. But the majority of the industry executives recognize that change is inevitable and they are prepared to adjust to it.

The critics of the industry run a wide gamut from those who say that it is slow to recognize changing times, to those who ascribe only evil to its actions and to its motives. I have just returned from a short tour of Latin America; in one country there

were posters and signs on walls accusing the oil industry of sucking dry the blood of the country and calling for the immediate nationalization without compensation of all of its assets. This was in a country where the oil industry had invested hundreds of millions of dollars and only a few days earlier finally had begun production. Not much blood had been sucked. And such posters, if they are ever suspected of reflecting the views of the government, can hardly be a recommended method of encouraging new investments.

Critics of the industry in the Middle East frequently base their judgment on its actions in the inter-war period or even in the early days of this century. The sums paid by the companies in fees and royalties at that time were indeed small and the profits of the industry sometimes were large. But the industry was new; the risks were great and to judge any action taken then by today's standards, to complain that the industry did not, fifty years ago, split profits equally or offer producing governments a share in the producing end of the industry, demands retrospectively a change of thinking which did not and could not have existed. These critics ask for a collective responsibility of the industry at a time when the industry itself was divided by fierce competition. Had one company in one country voluntarily offered in 1930 what the producing countries have achieved today it would have been immediately wiped out by competition which could have won much more advantageous terms in other countries. We must remember that cooperation among the producing lands was scarcely a concept forty years ago. Even OPEC's first few years were hard; it was only with the signs of an impending world wide oil shortage that OPEC's influence began to be significant and only then that prospects of collective action by the producers become realistic.

I imagine I would bring smiles to all faces -- some indulgent and some cynical -- if I were to attempt a longer defense here of the industry's past actions. An apologia for the traditional system of concessions might seem to put me into the ranks of the demented. Yet given the world as it existed forty or sixty years ago I doubt if there could have been another system which would have worked as well. Even given perfect retrospection, it appears to have been efficient in finding and producing oil, providing the world with cheap, abundant energy, and giving the producing nations large and in many cases enormous and growing sources of funds. This in itself should be viewed as an excellent accomplishment. Nonetheless, there is criticism of past actions; the consumers complain that the prices they paid for oil were not low enough, and the producer governments that the payments made to them should have been even higher. On balance I would say, both consumers and producer governments profited.

Future historians and philosophers may look at the actions of the industry from quite a different direction. They very likely

will look at the squandering of resources of this generation and be appalled at its consequences to the planet and the lack of permanent benefit it has brought to many consumers and to producers. Senor Perez Alfonso of Venezuela, whom I consider a great and good man, has for years urged his country to cut back oil production and, more important, to reduce oil revenue. This income is not being used wisely, is his thesis; it has weakened the moral fiber of the people; it has destroyed the local artisan. The oil should be kept in the ground; the national income should be reduced, for this is the only way the government and the people can be forced into the discipline and self-abnegation which are necessary to purge the body politic and regenerate the soul of the people.

Kuwait and Libya have actually reduced production. Conservation was one of the reasons for doing this, but the views of Senior Perez Alfonso must also have been taken into account there.

Theoretical economists play with their models and they look with scorn on the views of Perez Alfonso and the actions of Kuwait and Libya. They speak of "discounted cash flow"; of "present value of oil produced in 1990" and they find no sense whatsoever in voluntary relinquishment of present income. What they fail to see is the main point of the Kuwaiti action and the Perez Alfonso thesis. If money is spent in non-productive ways, what value to the country is there in increasing oil production or even in maintaining it? Would it not be better to keep the oil in the ground and let it be used by future generations? Furthermore, they believe the price of oil can be expected to rise, at least in the next decade or two; and substantially higher income per barrel would be won in 1980 than in 1972.

This is a pessimistic view, but in some cases it is a realistic one and it should not be ridiculed; neither should attempts be made to persuade the producers that their views are misguided or wrong, at least under present circumstances. The only convincing argument is to change the circumstances.

Few governments have the courage or honesty to admit that they cannot use their income wisely and therefore hope that a successor regime will have greater capacity and greater integrity. The <u>beau ideal</u> of Perez Alfonso is perhaps realized in Kuwait but even there I suspect that the hope of higher prices for future production played at least as important a role in the decision to cut back production as did the effort at self discipline and the desire to secure the well being of future generations.

The theoretical economist is theoretically on sound ground and there is no reason why the practice could not be adjusted to meet the theory. If oil income is invested wisely at home or abroad, the

benefits to the oil producing countries could be greater than any hoped for increases in cumulative future income; this generation as well as the next could be elevated.

It will be a matter of considerable importance to the consumer to demonstrate to the producer governments that they can invest their income wisely; that investments at home will raise the living standards of their people and that investments abroad will earn at least as much as oil prices will rise. To say that Arab governments will have huge capital surpluses is, of course, quite correct; but the Arab world as a whole will not be capital rich in the immediate future. If Arab nationalism, or indeed the expression "Arab world" means more than just an anti-Israel policy, then the oil producers will have to consider the possibility of increased investments in the oil-poor Arab countries. Another consideration is the possibility, which every oil producer must face, that new forms of energy, new hydrocarbon discoveries or new methods of discovery will mean that oil production voluntarily foregone now will never be made up. I don't mean to imply that this is a certainty; it is not a forecast of even a probability; but it is possible.

OPEC was founded a little over a decade ago amid general skepticism as to its chances of success. There are still those who consider it a monstrosity which cannot endure much longer. This skepticism seemed justified at first -- at least partially. OPEC for ten years was not able to achieve its primary objective of raising tax reference prices back to pre-1960 levels. Venezuela was the prime mover in OPEC, its inspiration and its innovator. Venezuela saw quite clearly that prices could not be raised as long as there was an oil surplus in the world and Venezuela proposed international pro-rationing -- deliberate cutbacks of production. The Venezuelan analysis was of course correct but its execution proved impossible. No country was willing to cut back production, at least not in accordance with a formula acceptable to the rest of the OPEC membership.

The situation changed in 1967 with the closing of the Suez Canal. Tankers were in short supply and the Mediterranean oil became of unique importance to the world, in that it could not be made up elsewhere if lost. Libya realized this and it imposed production limitations and then negotiated higher prices. "Negotiate" is not the right word. Price increases were won there and in the states of the Persian Gulf in 1970 and 1971. Coincidentally with these price increases, all oil producing countries except Saudi Arabia, and perhaps Iraq, were able to see that their production would reach maximum levels in a short time, probably within this decade, and then would start to decline. All producer governments became simultaneously much more interested in increased payments per barrel than in increasing volumes of production.

Producer restrictions or conservation measures, such as those taken by Libya or Kuwait, could scarcely be considered hostile acts even if the result is higher prices. The suggestion has been made that the oil producers are under obligation to continue production expansion and to keep prices low. The arrogance of such an attitude smacks more of the last century than of this one, and I hope it isn't seriously taken by the producers as in any way characteristic of the major consuming nations. I have heard no one suggest that the automobile manufacturers of Detroit or Turin are under any obligation to sell their products at constant or declining prices.

The recurrent prediction of OPEC's collapse ignores several crucial factors; the first is that not all OPEC countries need or even want additional income; the second is that not all, indeed very few of the producers, would be willing to try to increase sales by cutting prices; and third, there is no present alternative to oil. To compare OPEC with any coffee producers' association is laughable and to say that OPEC cannot last because no producer's cartel has ever lasted, ignores current realities.

The United States is now the world's largest importer of oil and the situation shows every sign of getting worse. In 1970 we imported 3.2 million barrels per day of oil; in 1971 3.7; this year imports rose to 4.6 million barrels per day and next year the estimates are nearly 6.0 million barrels a day. Ten years ago our shut-in capacity exceeded our imports; today we have almost no spare capacity.

The imported oil will cost us, in payments to producer governments, around $2.5 billion in 1973, based on published tax and royalty figures. There will be additional costs in shipping, foreign refining, non- remittance of profits of the oil industry which could raise this something close to $5 billion. Some of this will be returned in increased trade, particularly for oil imported from Venezuela and Canada, but we find that the marginal dollar of income in the Eastern Hemisphere is spent in the Eastern Hemisphere -- not in the United States -- and increased imports from the Eastern Hemisphere are drains on our balance of payments with almost no off-setting trade advantages. Secretary of Commerce Peterson has just announced that our balance of trade this year will be worse than last year's $2 billion deficit; in the second quarter of this year the annual rate was over $7 billion. Revaluation of currencies may help our exports and we hope it will help reduce our imports, but it has had no discernible inhibiting effect on our oil imports. The rate of growth in oil imports is increasing and, with currency adjustments, the amount paid per parrel has also gone up. With the further price increases we expect and with prospective imports of 12 million barrels per day in 1980, the net cost to the

US could be over $10 billion a year, taking into account company remittances and the most optimistic figures on increased US exports connected with this trade.

I should point out here that the import figure of 12 million barrels a day in 1980 was considered totally unrealistic when we first started using it two years ago. Now, in view of peaking out of domestic production in the United States, the difficulties in drilling in the Continental Shelf, delays in the Alaskan pipeline and, most important, the natural gas shortages, these import figures could prove to be conservative. Imports in 1973, as I pointed out, will be over a million barrels a day higher than in 1972 and if this growth rate continues, imports in 1980 could be closer to 15 million barrels a day. I hope not; in fact I hope very strongly that my own country will take vigorous action to reverse these trends. I have outlined frequently on other platforms the measures that might be considered to protect ourselves. Some will be expensive and many will be unpopular but they are credible and they must be taken. I have frequently expressed my absolute conviction that we will indeed move soon in this direction.

These are, of course, largely domestic measures but they have an intimate connection with the subject at hand. That is the consumer-producer-company relationship. It has been suggested at various times that it is somehow unnatural and even immoral that the Mid-East countries should sell their oil at prices 10 and even 20 times cost of production; and "natural forces" -- whatever they are -- will inevitably bring prices down. It has never been suggested that this formula should apply to US domestic oil. The cost of this production after all varies considerably. Some of the most productive fields in Texas and Louisiana have a cost of production only slightly more than that of the Middle East; cost of production in stripper-wells runs to $3 a barrel or higher. Does anyone think that there should be or could be a multiple price system for oil in the United States based exclusively on cost of production? In time of supply constraint or physical limitations on supplies, the same principle must apply; the cost of the marginal barrel will tend to set world prices. Ultimately, if not already, it will be the cost of alternative fuels which will set oil prices -- not the cost of production of the cheapest oil.

We entered a new era in energy supplies in 1967. Era is too grand a word; this period of sellers' ascendancy and buyers' extreme vulnerability will be brief, probably will not last longer than twenty or twenty-five years; and it may be considerably shortened. How long it is, and what its consequences will be for producers and consumers will depend largely on how the new relationships of the producers and the consumers develop.

The strength of the producing governments now is undeniable. I have described this in various testimony in the House and Senate, and in dozens of forums in the United States and I have not concealed my motives for doing so; I have been trying to prod the United States to action; to help create an atmosphere in which these actions will be acceptable. The trend in imports is disturbing and should be reversed. I am certainly not going to change my tone here and emphasize the strengths of the consumers or the weaknesses of the producers. I do want to point out as I have elsewhere that the situation is temporary; it will be survived, one way or the other, and the energy picture in the next century will be very different from that of today.

Threats to use oil as a political weapon made by the government of Libya and others are of considerable assistance in getting popular acceptance of the proposed belt-tightening; of measures to conserve energy and to develop domestic reserves and new energy forms. Although these threats are directed largely at the United States, the United Kingdom and West Germany -- indeed all consumer nations -- cannot help but note them and all cannot fail to ask if they could not be subject to such threats sometime in the future over issues not presently clear or even known.

Any threats to cut off oil supplies are, of course, disconcerting and must be taken seriously. If a consumer's normal supply is disrupted for political reasons and if there is not an adequate supply of alternative oil, the consequences could be most grave. No country engaging in normal commercial relations with another in a product as important as oil could look with equanimity on its supplies being blocked and no one should think that any consumer could accept such action without looking at measures, no matter how drastic, to protect itself.

The consumers are, of course, not totally without power, or rather I should say they would not be without power if they were united. The OECD (The Organization for Economic Cooperation and Development) contains all of the major consumer-importers of oil and it conceivably could evolve into an action body -- but it would be difficult. The Under Secretary of State, Mr. John Irwin, last spring raised with the European Economic Community the possibility of increased cooperation with them on energy matters. The subject has also been informally discussed with the Japanese and others and the advantages if not the mechanism of such cooperative effort are well understood; the disadvantages of isolated, individual efforts in the energy field are even clearer. We all need new sources of energy already; this will become much more evident in the next few years, even assuming total tranquility in OPEC and unrestrained production in all OPEC countries up to the physical capacity level.

And we would need to look for new energy sources even if oil prices were declining as some have predicted. If we do not -- if we merely sit back and use up the oil -- I suspect future observers will ask why we did not see the parallel with gas supplies in the United States. Gas prices have been kept down by government regulations; consumption has increased rapidly and at this moment the supply curb is crashing into the demand curb; domestic production is declining and the demand for gas cannot be met. We now look to imports of liquefied natural gas at prices much higher than the domestic prices, sometimes six or even ten times as high as wellhead prices. Or we look to imported oil to make up the energy deficit. Should we face an actual shortage of oil in the next decade -- caused either by physical or political factors -- there will be no cheap available alternative. Unless new sources of energy are developed very quickly, there will be no alternative at any price.

We as consumers should recognize that the oil "era" has entered a new phase; prices are going up and supplies are limited; this is not a pleasant prospect. It would be far nicer to say that OPEC will collapse, that prices will decline and that supplies will be unlimited forever after. This would be a dangerous path to follow. If I might take a few references out of context, we have been taught to "consider the lilies how they grow; they toil not; they spin not; yet verily I say unto you that Solomon in all of his glory was not arrayed as one of these." This advice, I believe, is less applicable to our immediate energy problem than is the parable of the timid servant who, when given a talent, buried it rather than putting it to work and was then cast himself into hell; or perhaps even more apt is the one of the foolish virgins who did not secure for themselves adequate supplies of oil to see them through the night. To switch my sources: listen if you must to the siren song of cheap available energy in unlimited quantities, but make sure you are firmly bound to the mast and make sure that those who control the direction of the ship have their eyes firmly on their goal and their ears stuffed tightly shut.

If consumers band together to search for new energy forms or to ration available energy in periods of shortages, this should cause no surprise or offense. If consumers encourage companies to resist further price increases, this should also cause no surprise. Many consumers already believe that the companies have not been adequately vigorous in resisting producer demands, as they could and usually did pass on the increased costs to the consumers. The producer governments have banded together in a well functioning organization. Their immediate adversaries are only the companies -- an unequal contest. Some consumers, at least the major ones, have accepted, with reasonable equanimity, the price increases forced on

the companies in the last two years. The poor ones, India and the Phillipines to mention only two, have been hard pressed even to accept last year's increases. How they will pay for future increases is not clear. It is certain, however, that they will be hurt badly.

The consumers must take action to secure adequate supplies of energy for themselves not only for the next decade but for the next century. This will have little to do, in the long run, with threats to cut off oil supplies but will be based on the clear, indisputable fact that oil supplies are finite and not replenishable; that low-cost energy from hydrocarbons will sometime no longer be available; that new sources of hydrocarbons from coal and shale will be at higher costs and that new sources of energy -- from the sun, geothermal traps, tides and the atom -- must be found and developed very soon. This action must be taken by the consumers as it is of vital importance to them. Whether it is done in a deliberate, coordinated fashion, as is desirable, or piece-meal and erratically as now seems to be the case, or frantically when shortages actually appear, is a crucial decision now before the consumers. It is the interim period, i.e. until 1985, the period of oil predominance and before the advent of new sources of energy, that most concerns us as consumers. This period should also be one of great concern to the producers, for what happens during this time will importantly determine their position in the post-oil world.

The role of the companies during this period will also be of considerable concern to us. One factor of obvious interest of the United States is the contribution these companies make to our balance of payments. An equally important interest to all consumers, including the United States, and I would hope also to the producers, is the companies' ability to find, develop, transport, refine and market oil. National companies of the producers or the consumers have as yet not been able to replace the international private companies, at least not in any satisfactory manner. This may not always be true. But it promises to be valid for sometime to come. The move in OPEC toward participation is disquieting, largely because the role of the companies in the new relationship is still unclear to us.

At the beginning of this talk I referred to the end of the traditional concessions system. I would like to go back here and say in its defense that not only did it function well, but, with modifications, it would probably have been the best system for the immediate future. It could best benefit both consumers and producers with adequate supplies of reasonably priced energy. It might even be the best system for the long run as the companies themselves are not anxious to deplete reserves but to develop them to the maximum extent; and when present recovery measures are no longer sufficient, they

exclusively to non-oil related matters in the country. If this were the case, there would be small incentive for the companies to increase production. This eventuality may be a straw man of no substance whatsoever, but I would like to see it knocked down before we go much further. If the arrangements do protect oil company interests, as we hope they will, and if the companies have access to adequate supplies of oil, and if the terms are reasonable, the new relationship could be satisfactory. The important factor, however, would be the stability of the new agreements. And it is here where there is an important difference in view between the companies and the consumers on one hand and the producers on the other. The companies and consumers assume that a contract is a contract and should be honored by both sides. That this is a basic part of both Islamic and Western jurisprudence also seems clear. The OPEC doctrine that changing circumstances allow agreements to be altered unilaterally is not conducive to stability. No one, or at least very few, even in the companies, still maintain that concessions signed a generation ago must last unchanged for a hundred years. The companies in the past have negotiated significant changes in their concessions with the host governments. With new agreements now to be reached which will alter not only the details but the character of the contracts, the need for stability is greatly increased. If new arrangements are devised which seem satisfactory today, and I am reasonably sure they will be, what assurances do the companies or the consumers have that these will not be changed tomorrow? Circumstances change daily. This uncertainty will surely help the consumers decide to accelerate their search for new energy sources.

For OPEC to say today that an agreement is firm is quite necessarily viewed in the OPEC context; that is, the agreement will be firm until circumstances change and may be changed thereafter. I hope that it will be possible to devise agreements which will last, and I am pleased with the recent statements made by Shaykh Zaki Yamani of Saudi Arabia on the stability of the new arrangements. We hope that other OPEC governments will make public statements in the same vein. There is no point in trying to deny or to cover up the fact that confidence of the consumers has been shaken, that full restoration of this confidence will be difficult and will not be complete before we have experienced several years of the new stability.

Various consuming countries are looking at new relationships with the producer governments. Some national oil companies have already reached agreements with some OPEC governments but they have not been more productive or stable than those concluded by oil companies and they have been considerably less successful in finding and developing new sources of oil. Some consumer governments seem to be looking at more comprehensive government arrangements and these

will turn to secondary and tertiary recovery measures to get additional oil. I think this thesis could be developed further and in considerably more depth and I am sure that some of the companies have already done so. But we should not spend too much time on it. As valid as it may be theoretically, it is irrelevant if the producing governments do not believe it; and they do not. They believe they must gain experience in running the industry in their own countries and this is not a frivolous goal. They also believe that the companies are more interested in their own well-being and in supplying their customers with oil than they are in looking for additional reserves in any one country. The producer governments may be excused if they have some concern on this point as it is of far more importance to them than it is to the international companies what happens within their own borders. In any case, the new patterns are already emerging and we will have to live with a new company-government relationship which will accord with the will of the countries and which meets basic nationalist aspirations.

The new arrangements will also have to meet some of the desiderata of the consumers on price and stability of supply; and the companies should be allowed by both the producers and consumers to make a fair return on their investments. The companies are not mere middle men who cream off vast sums of profits and perform no service -- in spite of the frequency of this accusation in many consuming as well as producing countries. This is a dubious assertion and I strongly suspect that if the companies were suddenly removed from the international scene that the producers would get less money per barrel or the consumers would pay more; and quite possibly both could happen. The companies perform a service and they must get some remuneration. At present, from wellhead to gasoline pump, their profits are hardly excessive. We can look at the companies' own financial statements; we look at their volume of sales and the size of their investments and the attractiveness of investing in international oil vanishes. The heartiest critics of the oil industry in the United States speak of their unconscionable profits but we see no rush by these critics to invest in this lucrative field.

The current OPEC demands for participation seem to meet the current aspirations of the producing governments. The companies have accepted the principle of participation, at least up to 20 per cent. The demand for 51 per cent is, of course, more difficult. How "51 per cent" is interpreted will be of crucial importance. Will joint company decisions in the future be based on a simple majority vote? In this case the company could decide that all its profits would go to the government; or could decide to devote its profits

perhaps could be fruitful, although if the consumer goes into negotiations solely with the goal of driving prices lower and the producer with the goal of getting more money per barrel, it is difficult to see their common ground.

The key to the new relationships, I believe, lies primarily in the capital requirements of the industry in the next decade. The oil industry in the past has generated its own capital out of its own operations. It can do so no longer. Profits are restricted and even if they were allowed to return to the levels of 15 years ago they would be insufficient to meet the enormous capital needs for the next 10 or 15 years. A major US bank has estimated the capital requirements of the industry at $500 billion in the decade ahead. Where can this come from? The companies will, of course, supply a good deal; and they will be able to borrow more. But can this be sufficient? I think it is clear that it cannot be and the industry will have to find new sources of capital. There aren't many; in fact, there seem to be only two: the major consuming countries, notably Japan, Germany, and Italy, and the oil producing companies themselves, most notably Saudi Arabia. This may be distasteful to some in the industry. It shouldn't be; there are few alternatives. The Iranian National Oil Company is already in North Sea exploration. The Kuwaiti National Oil Company could do the same or it could build refineries in Europe. The Saudi National Oil Company could emulate British Petroleum and enter the United States market if it wished. The Germans could buy into the Abu Dhabi Petroleum Company as they had planned. The consummation of this deal was arrested by the OPEC demands for participation, but once this issue is settled, there is no reason why it could not be reopened, or why similar arrangements could not be discussed. Participation downstream is not going to be achieved in the same manner as participation in production. It should not be scorned by the industry; and I don't believe it will be. Some companies may not be able to adjust to the new circumstances but those who show the imagination to take advantage of the new situation will surely be those which will prosper.

The producing nations will need to invest their enormous incomes. Their own countries will get first priority but there are limits to the amount of capital that can be absorbed in the time available and they will probably find to their interest to invest at least some of their surpluses in the oil industry outside their borders. The Shah has been quoted as saying that the National Iranian Oil Company will soon be the largest oil company in the world. This should not be taken as hyperbole but as a statement of intent. The Iranian National Oil Company and the Saudi Oil Company will soon have huge amounts of petroleum available. If they wish

to expand into transport, refining and marketing overseas, let us rejoice at the broadened base of the industry, not be frightened of the new competition. There is no reason why the Saudi or the Iranian oil company should not participate with American oil companies in building in the United States or elsewhere the new refineries we will need; there is no reason why they should not invest in the coal mines which will produce important sources of energy for us long after our oil is exhausted. There is no reason why they shouldn't invest in nuclear reactors here. For that matter, there is nothing inhibiting investment in non-energy related fields. We would welcome such investment as an off-set to the payments for imported oil. I think the world should also welcome it as an important contribution to the construction of the new interdependency.

We have talked a long time about the interdependence of oil producers and oil consumers; the argument is used in this country by those who want to open the doors to unlimited imports and who say that the producers would "never" dare to cutoff deliveries to us or to any one else. It is the "they can't drink the oil" or the "they need us more than we need them" school. I am talking about a much more positive form of interdependency than this.

We are facing a dramatically changing situation in the world oil scene. How the play ends will be largely the choice of the producer governments. They can create an atmosphere of dissent and distrust amid a rain of threats; they can bury their funds in the ground or in the floating currency markets of Europe. The inevitable result of this would be that the consumers would do everything they could to end their dependence on oil as soon as possible. Or the producers can create an atmosphere of trust; they can invest in the consuming countries and help off set the consumer's balance of payments problems. They will have to modify or at least stabilize their doctrine of "changing circumstances."

The consuming governments on their side will have to be forthcoming and cooperative in the matters of investment within their own borders. This will be easier. Most of the important importers, including especially the United States, already have liberal policies on foreign investments and the advantages of creating true interdependence are much more clear and much more immediate for the consumers than they are for the producers, at least in this short interim period. But in an historical time frame, 20 years is but a moment. The investments and particularly the relationships that are developed by the producing states during this period of oil's primacy will set their prosperity for succeeding generations.

There is reason for optimism. The United States is going to move to solve its own energy problems; our allies are greatly concerned and the advantages of satisfactory arrangements between producers and consumers and companies are obvious, especially when set against the disadvantages and the dangers of a confrontation in an atmosphere of threats and counter threats and boasts of power and strength on all sides. We must assume reason will prevail and that in these new relationships there be no losers; there be no one humiliated or forced into a position against his will. There can be a situation in which there will only be winners. And this is possible in diplomacy if not physics.

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Q. I just wanted to ask a point of information. I missed a point which was very important. You mentioned that you expected that the United States would take vigorous action to reverse the trend. I wonder if your conclusion from that was that by 1980 we would be importing considerably less than this horrendous figure.

A. Exactly. But as the figure we are talking about 12 to 15 million barrels a day assumes only one action and that is that the Alaska pipeline is finished. If that's not finished it's going to be even worse. Now I'm talking about actions beyond that -- that of drilling on the continental shelf, opening up navy petroleum reserves, stimulation of gas supplies and measures to conserve or to reduce consumption.

Q. What about a joint energy policy with Canada?

A. Those negotiating with the Canadians -- perhaps negotiating is not the right word -- we've been talking with the Canadians for the last four years on this and, every year if you talk to me, I say I'm very optimistic, we are going to conclude the agreement before the end of this year. No, I really think this year we'll have an agreement with Canada quite soon.

Q. Will that improve the availability .....

A. Not much. In fact very little, alas. But if Canada only has about two hundred thousand barrels a day right now to supply us, the reserves in the Canadian prairie provinces are not great. We would hope that by allowing Canada free entry into our market that there be stimulation of exploration in the Canadian Arctic and that this then in the future would supply us with more oil. But this is a hope -- this is an action we should take but it's not going to solve the problem by itself. It's one of the things that should be done.

Q. You were talking about the whole question of an integrated policy, rather than just a ragtag approach to it, but I wonder if beyond the whole question of just energy policy itself -- as important as it is to bring this together -- whether anyone is doing something to integrate many other factors in terms of power, population impact and relating this to population growth or if the stabilization of population and in terms of power, consumer approaches and work with trade associations and other people who are always stimulating greater activity.

A. Particularly in the United States, yes, this is part of the program that we have to have, that is, we have to take measures to reduce the rate of growth and consumption. I'm not talking about reducing consumption. I don't think that's realistic in this time frame. Perhaps someday we're going to have to talk about that too. But the growth doesn't have to take us up to 24 or 27 million barrels a day in 1980. If we got the same mileage on our cars today that the Europeans get on theirs we could save in 1980 around 3 million barrels a day of gasoline or petroleum. An article in the Wall Street Journal yesterday on light said that we, all of our homes and offices and factories are over-lighted. Cut that back and you can save a very substantial amount of energy, they maintain. Well, as we were told this morning that's not true. You can save very little there. There are things that can be done. The question of aluminum manufacturing in the United States should be considered very carefully. Should we be using energy to manufacture aluminum when we can transport this same energy now, quite cheaply, to population centers? In other words, shouldn't we be importing aluminum rather than energy. Shouldn't aluminum be manufactured in the areas such as the Persian Gulf where energy is cheap. We do have a plant now in Bahrain and we have discussed plans in Saudi Arabia, I believe. But this is not something to be done immediately, the plants exist in the developed countries and they are going to continue producing. But perhaps future aluminum demands should be met there. We have to look at our use of aluminum because aluminum is really concentrated energy. Oregon has passed a law forbidding the use of the flip-top aluminum can; an aluminum can requires about ten times as much energy to make as the tin can does. They have also put a tax of five cents on non-returnable bottles and cans. This is an action that has, incidentally, been sustained in the court and could be considered nationally. They took the action in Oregon strictly for ecological reasons but the benefits in savings in energy are substantial. There are lots of things that we can do, but I'm not going to get into the question of population control.

Q. We had some discussion earlier this afternoon from Dr. Stauffer about various hypothetical political risks to oil supplies from the Middle East and, as I recall it, he named them as follows: First, a new outbreak of the Arab-Israeli conflict; second, some local

political conflict in the Persian Gulf and, thirdly, any political temporary boycott by decisions of the governments. In view of your sober appreciation of the power of the producer countries under OPEC, I wonder whether you would give your own ranking of some of these risks.

A. The three things Tom listed are of course extremely important.

As to his point one, I'm not sure where I would put that in this category. It's a very important consideration; it could happen. In '67, at the time of the boycott of the United States, the United Kingdom and West Germany, our imports from eastern hemisphere were very small and it was quite easy to make this out by shifting tankers around and increasing production in the United States and other measures. If we do import nine million barrels a day from the eastern hemisphere, it's not going to be able to switch tankers around easily. We've enumerated the threats that have been made since the beginning of this year -- there have been some fifteen that have been made by responsible Arab officials at one time or another. As I said, the notable exception and sobering statement was made by His Majesty the King of Saudi Arabia. If we get to the position where we cannot make up this oil when we're importing, say, nine million barrels a day from countries that do make the threats, there's not going to be that much spare capacity in all the rest of the world combined. And if the threats are made we have to consider them credible. The oil could be cut off. Maybe it wouldn't be. Maybe this should be a low priority, but it's something that we have to consider, exactly as we have to consider the dangers of the destruction of the properties in the event of an Arab-Israeli war. This is why I said several times in the course of this talk that the United States as a great power has to be essentially self-sufficient in energy. There's no doubt that the Soviet Union is going to remain a net exporter of energy at least for the next decade. And China is in balance. China takes care of its own needs; they are as of now fairly small. As a great power, we can import some and we will import some. I certainly don't mean to suggest that I'm talking about complete self-sufficiency. This is absurd. We could raise all of the coffee that we need in greenhouses in Maine and we can supply all of our needs in energy. But the cost will be very, very considerable. What I'm talking about is reducing this figure of 12 or 15 million barrels a day imported to something much more tolerable. Even if there weren't the security problem, there would be the balance of payments problem. Can we afford an additional 10 billion dollar a year drain on balance of payments in 1980? This is why I'm talking about off-setting investments in the United States. If the OPEC countries, notably Saudi Arabia again, wish to invest in the United States -- if they put a lot of their money into the United States -- then this balance of payment problem becomes much less severe.

Q. You said the United States Government is going to do something soon to deal with the problem and you hinted at the possibility

of rationing or limiting use. Are there any other things that are being considered that you could elaborate on at this point?

A. No, I did enumerate possibilities. I mentioned the Continental Shelf, the navy petroleum reserve, Alaska, Gulf of Alaska, North Slope Alaska, agreements with Canada and possibly with Venezuela.

Q. I'm interested in your reference to so-called downstream participation and possible forms of investment by producing states in this country. Are you envisioning investment generally, or do you have in mind the possibility of specific investment in refining or the marketing sector. If you choose the latter, I wonder how you would respond to a producing state arguing that a relatively low rate of return has traditionally been earned in this sector.

A. That's an extremely good point. But I thought that I had answered it in the talk, but I obviously didn't make it clear. The oil companies or the national oil companies are going to have access to a large amount of oil in the future. They can take this oil and they can give it back to the companies if they want -- provisions presumably will be made for that. And this then would be, as some people have accused, just a device to raise taxes. They can take the oil in the form of a scrap of paper and then pass it right back to the companies, and they cream off their two or five or ten cents a barrel for the oil. I'm sure Shaykh Zaki Yamani will talk about this tomorrow, but I'm sure that no country in OPEC is really considering that. They look at the oil industry in their boundaries as their life blood -- they want to have something to do, some say in the running of it. Some countries are moving toward nationalization; Algeria already has. Libya has nationalized British Petroleum and Iraq has nationalized the Iraq Petroleum Company, or at least the Kirkuk branch. The other countries in OPEC -- and they've said this publicly -- are looking at participation as an alternative to nationalization but they have to have the say in the operation of the industry. They're going to have access to oil and they are going to want to put this downstream. This is what they can do with it: they can build refineries, they can buy refineries, they can build marketing outlets or they can buy existing marketing outlets but they're going to want in and I think anybody who doesn't recognize this just hasn't been looking at the world oil thing. They're going to want to have some say -- in fact a controlling say -- in a good deal of the operation all the way from the well right down to the pump. And that they're going to get. I did say, however, that there's no reason why the investment should be limited to downstream operations. It could be in anything. It could be in other energy fields or it could be in non-energy related fields. You're quite right, of course, that the downstream operations are not profitable and if they were looking strictly at profit -- what I said in the course of the talk was - why change the existing system? If they are interested only in profits, they get more money by just continuing the

existing concessions and raising the taxes or raising the tax reference prices. But they don't look at it that way.

Q. You mentioned that.....Arab countries that conserve, do so because they are not using their money wisely and they're not investing it in other Arab countries. I wonder if you realize the Arab Fund for Economic Development, the Kuwait Fund, Abu Dhabi Fund...I see no serious attempt by your government to do something about the oil problem or the balance of payments problem. Do you think sometime after November there will be a serious policy?

A. On point one. Yes, of course I'm familiar with the development funds, particularly the Kuwaiti one. It's good and I suggested that it might even be expanded. But what I said was that Kuwait took the action to limit production because it couldn't use the money adequately. That is, if Kuwait were really convinced that it could invest the money from its oil now and get a greater return from that money than it would get by leaving the oil in the ground, then presumably it would do so. But it decided that it can't do that. Kuwait is not spending all of its money in Kuwait. It's not investing all of its surplus in the other Arab countries. It's accumulating surpluses, or was.

Q. For a long time the Kuwaiti Government has asked the oil companies to invest some of their profits in Kuwait. You did not mention this. But you wanted the Kuwaiti Government and the Arab producing countries to invest in the United States. I think this is a tremendous value judgment.

A. Well, I said it would be fine if the oil producing countries invest in the United States. There's been some suggestion that we would oppose that. I'm trying to lay that to rest. We will not oppose it. On the contrary, we will welcome it. The oil companies don't have all that additional capital to invest in Kuwait. They don't have that additional capital to invest anyplace. They are having to borrow capital and, as I said, they're going to have to go on the equity market. The oil producing countries and the oil consuming countries are going to have to supply this money. To say that the oil companies have vast amounts of surplus capital that they should be investing in fertilizer plants or in other things is perhaps a bit out of date. I just don't think that they have this surplus capital today.

Q. I wonder if you would expand on the relationship between what the ecological research people and what you are doing about increasing energy resources.

A. Yes, I have a varying relationship with the ecologists. When I talk about cutting back on consumption, about abandoning the

throw-away cans, putting a high tax on disposable bottles, they think it's just great. When I talk about drilling in the Gulf of Alaska or off the east coast of the United States, they think it's less great. The problem is complex, it's enormous and it's going to have to be faced on many fronts. I think that the ecologists are wise. I consider myself an ecologist -- I consider that I have as much regard for nature as any American. I also think that we have a need for energy and that we're going to have to increase the supply. Some of the decisions that have been made in the name of clean air and clean water have not been all that intelligent from the point of view of energy. That is the decision to remove lead from gasoline. Quite admirable in itself, because everybody knows that lead is poison and that's of course why the decision was made. Lead sounds bad but you remove the lead and your consumption of gasoline is going to go up very, very markedly. Not only is the consumption going up, but you're going to put more unburned hydro-carbons in the air and this is a trade-off -- lead or unburned hydro-carbons in the air. Well, the decision has already been taken. Remove lead from the gasoline -- it wasn't perhaps that good a decision. Some of these decisions perhaps haven't been thought out as well as they could have been. And many of the actions that we are going to take to clean up the air and water are going to require more energy. In fact, all of them will to some degree.

Q. Wouldn't it be a lot cheaper to have good relations with the Arabs than to go to all these elaborate methods to increase energy supply in the United States? Why do I say cheaper? First, the consumer will not pay $5 billion or more a year for domestic sources. Second, because of ecology, the degrading of the environment must be added to the costs. Third to overcome the theoretical risks mentioned this morning requires money. Point four -- the balance of payments is serious in the short run, but in the long run, according to studies that have been made by the Interior Department, 46 cents of each dollar spent on Middle East oil will come back to the United States.

A. A very good point. Of course it's extremely important that we and all the major consumers have good relations with the Arabs. We should do whatever we can to improve them. But that's not the whole picture. That is, the Arabs don't have an infinite supply of oil and I think I said several times in the talk that actions are going to have to be taken regardless of the threats. Oil is finite, it is going to run out sometime, and even Saudi Arabia doesn't have inexhaustible supplies. It's going to run out in the foreseeable future and therefore we should be moving right now on these other energy sources. Now I'm not sure what points two and three were but point four was the balance of payments. And I think your figures on the balance of payments returns are wrong. I did refer to the

increased trade, but I said that the increased trade comes largely from Canada and Venezuela. If we import a barrel from Canada or Venezuela, that is returned largely to the United States. But the marginal dollar in the Persian Gulf goes to Japan, Germany, England and only marginally to the United States.

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Presiding: Parker T. Hart, President, The Middle East Institute

PROSPECTS FOR COOPERATION BETWEEN OIL PRODUCERS, MARKETERS AND CONSUMERS: THE ISSUE OF PARTICIPATION AND AFTER

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There are these days ever-increasing worries about the not too distant future when the world is expected to face an energy shortage. Such a shortage would not only harm the world's economic progress, but would probably have adverse effects on all aspects of its civilization as well.

Oil is the chief source of energy today, and so long as there are sufficient reserves of it to keep it flowing, it will continue to be so. However, the rate of increase in world consumption of oil exceeds the rate at which new fields are being discovered. This calls for doubling all efforts in exploration and drilling. Atomic energy provides no comfort, for its part in environmental pollution places serious limitations upon it. Furthermore, the uses to which it can be put are also limited and it cannot therefore be considered a real substitute for oil.

Whenever the energy shortage is the subject of discussion, the Kingdom of Saudi Arabia, as the owner of the largest proved oil reserves in the whole world and of vast unexploited areas where the geological and geophysical tests indicate the presence of huge amounts of oil, emerges as an important factor. It would be no exaggeration to say that Saudi Arabia alone has in its lands as much oil as all the Gulf States, including Iran, Kuwait, and Iraq, put together. It is therefore abundantly clear that the United States of America has a real interest in building as from now an economic bridge linking it with Saudi Arabia. This bridge would become bigger and stronger with time and would aid the United States in meeting the expected energy shortage and perhaps even in solving the balance of payments problem that would be caused by it.

As is well known, there are two new factors that will undoubtedly have an important bearing upon strategy and positions of strength in the oil industry. I have already mentioned the first factor, which is the expected excess of demand over supply. The second factor is the implementation of the principle of participation, agreement on which has now become a highly probable matter.

Before entering into the details of the subject, allow me to recall certain facts about the oil industry. The parties to the oil industry are three in number: the producers, the consumers, and the producing oil companies. Prior to the sixties, the producers were in a weakened position. The major oil companies, on the other hand, had unrestricted freedom of action, and heedless of the interests of the producing countries, they resorted to depressing the prices of oil. They were perhaps pushed into taking this action by pressure from the consumers and also by economic and competitive considerations. But the unjust effects of their action on the revenues of the producing countries were felt and this led the producers to get together and form an organization for the purpose of protecting their interests. That is how OPEC came into being.

The oil companies chose to ignore the new Organization and for over a decade, rejected a basic demand by the producing countries; that is, a few cents increase in posted prices. Posted prices remained at the same level while the prices of commodities imported by the producers went up steadily. This meant, in effect, a reduction in the producers' revenues. When the economic situation began to change, OPEC reacted to the companies' conduct. The Tehran and Tripoli Agreements brought about increases in posted prices to much higher levels than those originally contemplated by the producing countries.

However, a fair price for their oil was not the sole demand by the producing countries. The producers had been made to feel that they were foreign to their own natural resources, with neither control over them nor say in how they were utilized.

When the principle calling for the control of natural resources by the people who own them became firmly established and received world-wide acceptance, and when the winds of nationalization appeared in the horizon, Saudi Arabia started to seek a solution that would be an alternative to nationalization -- a solution that would preserve stability in the oil industry and maintain its increasing prosperity. In this we were motivated by our natural dislike for the principle of nationalization which goes against our economic system, and by fear of the disastrous effects it would have on the oil industry's development. Such adverse effects would damage our interests as well as those of the major oil companies and the consumers. The only alternative to nationalization, therefore, was the principle of participation.

We started discussing participation with Aramco in 1963, and in 1965 we had further discussions. At those early stages the bases of participation entailed far less than what we are demanding today. Our call to participation gained momentum in 1967 and we made it an official demand in 1968. Later it was officially adopted by OPEC despite the fact that some of that Organization's member countries believe in nationalization as the only route to their right to control their own natural resources.

We are now in the final stage of our negotiations, which we hope will result in a just and equitable agreement. This agreement may cost more and have stricter conditions than what we were asking for in 1963 and 1968, but it will provide real coordination and harmony between the interests of the three parties concerned. These are benefits that would no longer be attainable if we were to wait further and allow the raging storm of nationalization to strike our land. The harmony of interests would be undone and many other evils would befall everyone concerned. Needless to say, we can avoid all these evil effects by the correct implementation of participation.

What do I mean by the correct implementation of participation? It is not that the producing States should simply own 51 per cent of the capital of the companies operating on their lands. That, in my opinion, would not differ very much from partial nationalization and would not lead to the desired stability in the oil industry. What I mean is that the national oil companies in the producing countries should enter the marketing stages and invest their surplus revenues in marketing their participation shares of the oil. Such investment would definitely lead to important benefits for the consumers. The consumers must not ignore these potential benefits and must, in fact, encourage us to achieve them.

Before elaborating on the benefits to be attained by the proper implementation of participation, I would like to point out the existence of a strong trend within OPEC. The majority of the member countries are being persuaded to adopt a program to limit production. The Production Program is a relatively old idea which came near to being blessed by an OPEC resolution as far back as 1964. It was Saudi Arabia that used its right of veto to defeat the resolution and has since consistently opposed it for economic and other reasons.

And now, with the rise in oil prices and the great increase in the producing countries' revenues, we are about to enter an era where we shall be unable to spend our surplus incomes inside our own countries. This will lead us to reconsider the value of keeping our revenues in the banks and realizing interest on them, as compared with the appreciation in the value of our crude oil if it were to be

left in the ground. We should find that leaving our crude in the ground is by far more profitable than depositing our money in the banks, particularly if we take into account the periodic devaluation of many of the currencies. This reassessment would lead us to adopt a production program that insures that we get revenues which are adequate for our real needs. Such a program, however, would harm the interests of the consumers and of the oil companies. It would also aggravate the energy shortage problem and force prices to very high levels.

On the other hand, the correct application of the principle of participation would allow our national oil companies to invest surplus revenues in marketing our share of the oil thereby providing for the absorption of the surplus. This would be the first salutary effect of participation as advocated by Saudi Arabia. The second benefit would be the gains to be made by the consumers as a result of the new investments in their markets. These investments by the producers would enhance real stability and create a strong economic link between producers and consumers. The balance of payments situation in the consumer countries, which is affected by the import of energy supplies, would improve. At the same time, our national oil companies would become a connecting factor between producers and consumers and play exactly the same role played at present by the international oil companies.

It is our belief that the existing oil concessions cannot continue in their present form. The parties concerned must accept a change in the situation. They must accept one of the two alternatives -- participation or nationalization.

In the case of nationalization, or conditions of instability and uncertainty, the oil companies would find it difficult to justify significant investments in further exploration and drilling operations. Yet these additional operations are of vital importance and all efforts must be united to maintain them. Here the third benefit to be derived from participation becomes visible. With participation, a healthy and congenial atmosphere that welcomes investment would be created and, when the time comes, the producing countries themselves would bear 51 per cent of the drilling and development costs.

In view of the limited time available to me, and in order that I may have sufficient time for answering your questions which I consider to be the most important part of my topic today, I shall not go into further details about the benefits of participation. It suffices me to say that participation would bring about important changes in the oil industry, strengthening the existing structure and protecting it. The three traditional parties to the oil industry would remain as they are and be joined by our national oil companies as a

fourth element which cooperates with the consumers and the oil companies and draws their points of view and that of the producing countries closer to each other.

We are now faced with two problems of unequal importance. The less important problem is that of determining the new oil prices in 1975. The other and far more serious problem is that of the expected shortage of energy supplies in the eighties. Our national oil companies will not be in a position to play a leading role in 1975, for they will still be in the preliminary phases of their development on the international stage. They will, however, be much more effective in the succeeding rounds and will help in resolving differences and bringing views closer to each other.

To return to the price issue in 1975 and after, there is no doubt that it will constitute a problem in the future. It is a fact that the trend of oil prices is going upwards and there is no way of changing it. However, the OPEC countries must make only reasonable demands based on justice. The consumer countries on the other hand must accept an equitable increase in prices and absorb the whole of such increase, so as to leave the oil companies enough profits to enable them to continue their exploration activities and development of producing fields. I cannot visualize the oil industry developing and coping with the energy shortage problem without the support of the major industrial countries. And, after all, the very economies of these industrialized countries depend on oil, for which modern science has so far failed to produce a real substitute. I only hope that the desire for lower price oil today will not aggravate the expected problem of energy shortage in the future. Allowing for oil prices to rise in a reasonable manner will encourage further exploration for oil. It will also permit the development of new sources of energy which are at present considered too costly and not feasible economically.

When the age of scarce energy dawns, our national oil companies will play an important role in the consumer countries in which they invest. They will have to feed the refineries they own, wholly or in part, with their own crudes. This would go a long way toward alleviating the energy shortage in those countries, which even today are seeking to establish economic and financial relationships with our national oil companies.

Finally, I have this to say. In the light of the facts I have just mentioned, we in the Kingdom of Saudi Arabia extend our hand to the Government of the United States of America and call for a commercial oil agreement between the two countries which would give Saudi Arabian oil a special place in this country. The Agreement should exempt our oil from restrictions and duties and encourage the increasing investment of Saudi capital in marketing the oil. This would practically guarantee its continuous flow to these markets.

In the last resort, there will never be a substitute for Saudi Arabia in the field of oil, as indeed there will never be anything to parallel its friendly policies towards this country.

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Q. It has been suggested that the nationalization of IPC by Iraq has made it possible for you and the oil companies to expedite the negotiations. My question has two parts, one, is this correct? Two, in the case that an agreement is finally concluded between the producing countries and the oil companies, will this in turn expedite the settlement of the problem between IPC and Iraq?

A. Well, I agree with you that the nationalization of IPC was a shock to the oil companies. Some of them were not aware of the facts of life, and now realize that they have to face either nationalization or participation. And this is why, in my opinion, they are moving closer to our side. The second part of your question is whether our agreement on participation will make it easier for both Iraq and IPC to settle their problems. My answer is yes. I think this will be the case. One of the most important issues they have is the compensation and, probably, when we agree on something this also could be implemented in Iraq. We all know that Iraq is involved as well in the participation negotiation for the other fields down in the south and the Mosul field.

Q. Sir, in your concluding remarks you made a very important statement calling for an agreement with the United States almost without restrictions. Last night we heard Mr. Akins declare that the United States, with certain exceptions, could not afford to be dependent indefinitely on imported crude, and he called very strongly -- most of us here thought -- for the development of a national energy policy which would increase American self-sufficiency. Am I right or wrong in supposing there is a certain dichotomy between these two views?

A. I never suggested that the United States of America will consume at least 70 per cent from our crude. We have to contribute a great deal to the consumption in this country and this is enough to ensure a better solution for your problem one day in the future. I think if we come and invest huge capital in this country this is an enough guarantee for this country that we cannot forget that huge capital invested here, and we will continue to feed our refineries with our crude.

Q. Minister Yamani, you mentioned that initially -- towards 1975 -- as the national oil companies begin to undertake their new responsibilities resulting from these participation talks and the agreements which would be made, they will have an increasingly stronger role to play in terms of the downstream end of the business, and that when the age of scarcity comes as you pointed out -- I suppose you meant somewhere between 1980 and 1985 -- the national oil companies will be running a road through to their own refineries in consumer countries. If that is a correct understanding of what you were stating, what role do you see for the integrated international oil companies in the United States and in Europe? Can you talk about what's going to happen, in your opinion, compared to responsibilities, both activities of national oil companies and the OPEC countries, and at the same time what's going to be happening, in your opinion, to the large integrated international oil companies?

A. I cannot suggest that our national oil companies could be in any way a substitute for the international oil companies. I think the presence and the role of the international oil companies have to continue. We do need it in our country for their know-how and expertise, and you do need it in your countries as consumers for the amount of crude they produce and for their role as a buffer element. Now, when I said that our national oil companies will come to the stage as a fourth element, I was hoping that they will join forces with the international oil companies and with the consumers -- not as a substitute of the international oil companies.

Q. How do you see them, if I may ask you, joining with both the consumer governments is what I suppose you are implying, and with the international oil companies also. I don't understand the balance that I think you're implying.

A. Well, really, I'm still in the dark. I don't know what will happen after the implementation of participation. If the oil companies behave the same way they did in the past, be shy and near-sighted, I would say that we'll do business directly with the consumer. But I think they have learned their lesson and they will come to us and do business with us. In this case if the major, or the real volume of business, is done with the international oil companies, then we have a different case and the national oil companies will be an assistant -- an assistant to the international oil companies. But, if we do business with the consumers, and some of them have already approached us, for this, I think there will be very severe competition between them -- the international and the national oil companies.

Q. Mr. Minister, do you intend to elaborate on this suggestion on the increase of participation in marketing? Does this mean tankers, refineries, new installations in the Gulf area, or does

that also include the proposal made by Mr. Akins yesterday that some of the surplus capital might be invested in oil facilities in the United States or Western Europe, possibly even in other industrial non-energy installations in the United States?

A. No, it does not include what he said. That is exactly what he said. I think we are interested in going to the downstream operation investing in refineries and probably up to the pump stations. Of course, tankers will be one of the items on the agenda. However, I disagree with Mr. Akins on the possibility of investment in areas other than the oil industry and the downstream operation. I don't think we will do this.

Q. You mentioned something, Your Excellency, about the possibility of OPEC adopting an international program and Saudi Arabia has changed its attitude toward it. Could you say something more about it, or is OPEC going to adopt an international program?

A. My friend, you misunderstood me. I didn't say that Saudi Arabia changed its position with this. We still have the same previous one, as you know. And, unless we are kept away from the downstream operation, I said, in this case, we will start comparing the interest rate we receive from the surplus revenue we invest in the banks and bonds, and the appreciation in the value of a barrel of crude oil in the ground. And we will find out that the appreciation rate is much higher than the interest rate, and therefore this will force us to come to your idea of a production program. Otherwise we don't.

Q. You said in your remarks if I understood you correctly that participation in terms of 51 per cent would be just a disguised form of nationalization. Now, in addition to the downstream operations, participation that you have mentioned, are you thinking of some figure less than 51 per cent that could be part of that participation program?

A. No, sir, not at all. We think it's either 51 per cent or no participation. And the one per cent has a psychological significance. And this is what makes participation a substitute for nationalization.

Q. Mr. Minister, in this country I have often read about the concern of oil companies on the subject of the sanctity of contracts, a fear apparently which they have. Assuming that the agreement is reached on 51 per cent in the coming negotiations and the negotiations that are in progress, would you feel that the contracts being considered would have to be renegotiated in the near future?

A. I want to answer your question at length. First of all, it's very clear that we honor our contracts in Saudi Arabia and we are proud of this. Number two, the principle of the changes of circumstances is

a very well-known legal principle. Unfortunately sometimes, some of our friends don't distinguish between the changes of circumstances and the changes of mind. Now, when we talk about the changes of circumstances we talk about a well-established legal principle both in Islamic law, in the common law and in the civil law, the French system or the Roman system. And I think this is enough now for you to answer the first part of the question. Now, with regard to the agreement on participation, the reason why we spent such a very long time in negotiation is that we want an everlasting agreement which will end by the end of the concession agreement itself. This, of course, made it necessary for both of us to have some flexibility during the period of this agreement to change within the framework of the agreement without any necessity for further negotiation. So the agreement we are going to sign, I hope, will be an everlasting agreement until the expiration date of the concession agreement, with some flexibility in between.

Q. How near to signing an agreement are you?

A. Well, some times you are very near a target and you don't reach it. We are near the target. I hope that we can reach it.

Q. Minister Yamani, as I understand it there are three main issues in the discussions: (1) the compensation question, (2) the disposable crude and (3) the timetable for going from the initial 20 per cent to the ultimate 51 per cent. And, from your remarks in London last week, I understand that the disposition question either has been settled or is very close to settlement and that the compensation question also is close to settlement. The one remaining issue is the timetable. Could you elaborate on possibly how the disposition question was settled and what the remaining points of disagreement are on the other two issues?

A. I was asked almost the same question in London and I said that I didn't have a chance to report to my principals, and was therefore not in a position to report to the audience in London at that time. Until now I haven't had a chance to report to my principals on whose behalf I am negotiating. But I can say that the disposal of crude arrangement is about to be finalized. The other issues are under discussion. We will resume our negotiations sometime tomorrow and I hope we move faster.

Q. Your Excellency, I should like to ask you a question concerning flows of oil from Saudi Arabia. As you mentioned you would like to get a special relationship with the United States and as we see it, the United States could import every year an additional one million barrels a day according to reported sources. Now at the same time we were looking at producing capacity abroad. I get the impression that outside Saudi Arabia there are not enough increments coming along to

satisfy Western Europe and Japan and other countries in the Eastern hemisphere, so it seems to me there might be a possibility within a decade where your relationship with the United States might be harmful to other countries in the sense that they cannot get their incremental supplies.

A. Sir, we are now very attractive. And I don't know whether you are concerned with the United States only or you are also concerned with Western Europe, and I think it's all right if you are concerned with Europe. If the United States established this sort of relationship with Saudi Arabia this means that they will take some of our crude from you. It is a true fact. And this will be a harmful thing to Europe. But that's fair competition. Anyone who wants us, we are ready. And we do like to do business with this country -- we have very serious mutual interest with this country and we want to strengthen our ties. I want to say that right now we produce more than six million barrels a day, much more. And by 1980 we'll produce something around 20 million barrels a day.

Q. Minister Yamani, historically the downstream operation has negligible or in some cases non-existent profits. Why is the government of the Kingdom of Saudi Arabia interested in investing surplus funds in business that may bring in a return of less than the interest of money in the bank?

A. Well, I hope you aren't asking me to reveal some of the agreements we have made with the oil companies on the disposal of crude. But I want to tell you that it will be more profitable for our national oil companies to take that part of the crude from the oil companies and market it through their downstream operations than to leave it in the hands of the oil companies.

Q. Can you tell us whether or not the oil companies have at this point agreed to 51 per cent participation by Saudi Arabia by 1980 or some other date?

A. I think it's unfair to talk on behalf of the oil companies at this stage. But you can ask them, and I think there is no problem as far as we are concerned.

Q. In case you're going to invest your surplus earnings in consuming countries, how <u>do</u> you do this? Is this direct investment or through oil companies? Or how do you think of it?

A. I said that we have national oil companies who will own the 51 per cent of our share. And these national oil companies are separate commercial, legal entities which will go to the downstream, go in joint ventures with the consumers or other oil companies or alone, and build refineries and have an equity capital in the downstream. This might answer your question, I hope.

Q. I just want to say a lot of crystal balling has been going on in various circles in this country concerning the future of OPEC on the one hand, versus the future of the individual OPEC countries on the other, with respect to the policies of each. In your offer today for the United States to enter into a separate agreement with Saudi Arabia with respect to future supplies of oil, I noted a direction -- which is not necessarily -- and OPEC does all the negotiations by direction, I see the possibility of OPEC going one way and its members going another. I have no personal point of view on what way this is all going to end up -- there is an awful lot of speculation going on -- but would you comment on the significance of the offer you made and the relationship to that offer to the future nature of OPEC as a whole?

A. Sir, OPEC is not a commercial entity and therefore we never thought of OPEC anytime in the past or will never think of it in the future as an instrument to negotiate for commercial transactions. What I'm proposing today is a commercial agreement between an oil producing country and an oil consuming country. OPEC is a bargaining power and we will never, in the future, neither at present, go out of OPEC line. We will continue to support OPEC and we will continue inside OPEC. No individual member country in OPEC can afford doing otherwise, even Saudi Arabia with the very large reserves we have.

WORLD ENERGY DEMANDS AND THE MIDDLE EAST

Part II of Two Parts

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Part II of Two Parts

Panel II, Friday afternoon, September 29, 1972

Panelists: John D. Emerson, Energy Economist, Energy Economics Division, The Chase Manhattan Bank
Ragaei El Mallakh, Professor of Economics, University of Colorado
Thomas R. Stauffer, Research Associate, Center for Middle Eastern Studies, Harvard University

POLITICS OF OIL DEMAND AND SUPPLY

When analyzing the politics of oil demand and supply, the three factors of location, production and consumption are the most important to be considered. In order to better understand the intricacies of the relationships among these three factors and of the bargaining process that has evolved between producers and consumers, some examination of the present world energy situation is in order.

To begin with, it is important to note that fossil fuels are located randomly according to geological laws, with no regard for politics or economies -- an accident of nature, so to speak. The need and demand for fossil fuels to furnish energy and raw materials is a relatively new phenomenon. Only with the development of the modern industrial state have fossil fuels been used intensively to convert energy for purposes of work rather than for purposes of heat. Needless to say, the transition from an agricultural to an industrial economy, with its increase in work productivity per man hour, has occurred and undoubtedly will continue to occur at different rates in various parts of the world. In the non-communist countries one distinguishing factor between developed and developing economies is their per capita use of energy. At the present time, the developed nations require ten times as much energy as the developing countries.

Until as recently as 1965 world energy needs were fulfilled by abundant supplies of coal. For some time now, the demand for oil has exceeded the demand for coal, and in some areas oil has been displaced by natural gas as an energy resource. Viewed from the consumer's perspective, cost is the most important factor influencing the choice and rate of use of certain fuels. As the desire for a higher standard of living grows among the ever-increasing world population, the demand for fuels in one form or another will increase proportionately. However, should energy demands remain static, the level of energy production would probably decrease, resulting in a decline in the standard of living. This decrease in energy would not occur by conscious choice, of course, but rather would occur if

energy resources, regardless of price, proved to be insufficient. In terms of world economic stability, such an occurrence would be very undesirable.

At present rates of growth, potential worldwide energy demands will double between 1970 and 1985. In terms of petroleum, for example, North American consumption will increase from 36 million barrels in 1970 to 70 million barrels in 1985. During the same period, Europe's usage will increase from 22 million barrels in 1970 to 44 million, and fuel needs in the Far East will jump from 10 to 26 million barrels.

Given the indication that energy production in the developed countries will increase by only six per cent during this fifteen year period, the question may well be asked: How can the expected demand for increased petroleum production be satisfied? The answer to this question, in brief, will depend far more on the actions of governments than on the laws of economy. At the present time few alternatives exist to meet the growing demands for energy among the developed countries. Among them is nuclear energy inasmuch as the developed countries currently possess about one-fourth the world's supply of materials necessary for its production. Among countries lacking in these materials, an increasing resort to fossil fuel production will be necessary. Even in those countries which possess nuclear energy materials, however, their governments may be deterred or prevented from developing the resource for environmental reasons. Likewise, concern for the environment in some countries has resulted in a decreasing use of coal. Despite this ecological preference in those areas where oil and gas may become prohibitively expensive a return to coal as an energy resource can be expected. Moreover, among countries that can afford to do so, coal may be converted to a gaseous or liquid form considered less harmful to the environment. This process, while not expected to have a significant impact during the period 1970-1985, may well be adopted as a standard procedure.

Natural gas -- the least pollutant of present energy resources -- is the choice of many North American consumers, where there is presently large scale use of this fuel. However, it is expensive to transport natural gas to areas located great distances away from the supply. During 1970 to 1985, the use of natural gas will increase to a greater extent outside the United States where demand has already exhausted available supplies. In particular, the reliance upon natural gas by European countries will increase because of large and readily accessible supplies in the North Sea region. However, because of the desirability of this form of energy, even though the price of both pipeline and liquified natural gas will become quite high, there will be a market for whatever supplies are available.

All things considered, despite the influence of supply and demand for coals, natural gas, nuclear and solar power, the oil industry is still the balance wheel of world energy supplies, and production and investment in that industry will continue to be influenced by political decisions.

By 1985, oil demands will double in both North America and Europe. In North America, demands on imported oil will increase, while European demand for imported oil should decrease during the next fifteen years. For both areas, however, the Middle East will be the most important source of oil imports assuming necessary quantities are available. However, oil production in the area cannot significantly increase unless new reserves are located. Presently, the production of Middle East resources known to have existed in 1970 is expected to peak in 1975, and if demand continues at the current rate, an additional 500 billion barrels of oil reserves will have to be discovered. Such vast quantities of oil will be discovered primarily through a combination of opportunity and incentive. For example, the cost of leasing land for exploratory purposes must be made sufficiently attractive to encourage investors. In countries where the production of oil or gas is becoming too expensive, sand and tar shales may prove to be feasible alternatives, provided that governments are able to offer incentives for the development of these additional sources of energy. Nonetheless, even if large reserves of fuel are located, energy costs can be expected to increase by different amounts in different areas. The costs of capital, labor and government fees, all of which are rising, will continue to exert influence on the overall cost of energy production.

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In the context of the Middle East, considerations of energy demand and supply should be focused in terms of the interests and policies of the producing states, i.e. the sources of supply. To date, much attention has been devoted to questions of energy demand. The lack of attention given the producing countries has resulted both in a lack of information and in the formation of mistaken ideas among consumers of Middle Eastern oil. In particular, there has been a tendency to make little if any distinction among the behaviors of various Middle Eastern producing countries and to regard all Middle Eastern sources of supply, especially those in Arab countries, as insecure. It should be pointed out to those who have such attitudes, especially those in the United States and Western Europe, that the issue of nationalization arose first in Venezuela long before it surfaced in any Middle Eastern context, and also that there are other important areas of world oil production, e.g. Nigeria, where petroleum resources could hardly be considered secure. Conversely, a consideration of the facts will indicate that there is no basis for

the notion that Middle Eastern/Arab producers are inherently unstable vis-a-vis questions affecting the flow of oil and that the fears of nationalization and the related image of incomprehension of budgetary responsibilities on the part of the producing country governments are unfounded.

What can be said about Middle Eastern producing countries is that there has been a general lack of long range planning for goals to be achieved from their exhausible assets, namely oil. It is true that the ad hoc reactions of producers in the area to various situations have fostered an atmosphere of uncertainty among those dependent on the supply of Middle Eastern oil. On the other hand, it is also true that were the area's producing countries to devise long range economic plans for certain eventualities affecting the future of their petroleum assets, this too would strike fear in the hearts of foreign consumers of their oil. The question arises then: How can the politics of the producing states be formulated in order to best obtain the optimum rate for their exhaustible resources and at the same time to best regulate their balance of payments and imports so as to accumulate the revenues necessary for financing development? Thus far, the policies of the producing countries have varied according to the amount of their reserves, the absorptive capacity of their economies, their regional ties and existing internal investment opportunities. All indications are that the future concerns of the producing states will become increasingly multi-faceted and will generally be concentrated on the three issues of nationalization, conservation and participation.

As noted above, nationalization is not the norm among Middle Eastern oil countries but the exception. In the last three years, only seven per cent of Middle East production has been nationalized. This includes the nationalization of British Petroleum in Libya and Iraq Petroleum Company in Iraq, two cases in which obvious political motives were involved. Most Middle Eastern producing countries, however, have been realistic regarding policies towards nationalization and realize all too well the problems attendant to assuming the operation of the petroleum industry by themselves, especially in the areas of marketing and transportation. It should nonetheless be mentioned that the emergence of the USSR as a petroleum marketing country, whose oil imports have been increasing steadily since 1971, presents an alternative market for interested Middle Eastern oil producers. The present political relationship between the Soviet Union and certain Middle Eastern oil producing states makes this economic alternative a realistic one.

More important to the Middle East oil producing states than the issue of nationalization is that of conservation. The selective practice of prorationing governed by political and economic

considerations, seems to be the more likely course of action rather than outright cutting back on production. However, those producing countries possessing vast reserves such as Saudi Arabia, Iran and Abu Dhabi are less pressured by conservation policies. Nonetheless, all Middle Eastern producing countries are becoming increasingly aware of a growing emphasis on conservation needs. This awareness could eventually lead to "mothballing" the Middle Eastern petroleum capacity, thereby forcing alternative exploration sites such as those in the North Sea. Presently, opinion amongst the Middle Eastern oil producing countries regarding such a conservation tactic is divided.

Regarding the issue of participation of oil producing countries in the capital of the international oil companies, present fears of unilateral action are excessive and unjustified. The agreements reached in Teheran and in Geneva can be expected to guide participation until 1976. However, realistically speaking, it cannot be denied that the mutuality of economic interests between the oil producing states and the oil companies can be overriden by political considerations, and that more specialized means of applying pressure to achieve their political goals may be necessary for the producing nations of the Middle East.

In view of the foregoing, it is appropriate to ask: What are the implications for US policy regarding the politics of oil demand and supply? More specifically, does a US policy concerning oil demand and supply exist? The answer to the second question would seem to be that the US does not at the present time have an identifiable policy for dealing with the problems of oil. By the same token, however, it would seem that there does not exist any real energy crisis regarding the supply of Middle Eastern oil to the United States. The so-called crisis is in many ways an artificial one which has been manufactured by leaders or aspiring leaders of the Middle Eastern producing countries in whose territories are located the largest readily accessible sources of energy. Rather this "pseudo-crisis" of supply has been created by the hobbling of US domestic supplies through certain government policy actions. The real problem thus would seem to be the difficulties which confront importers of Middle Eastern oil. For the US, the importation of Middle Eastern oil is unfortunately bound up with this country's close involvement in the complexities of the Arab-Israeli conflict. Likewise, any decision, whether motivated by politics or economics, not to rely on the Middle East as the major source of oil imports will pose a problem of higher costs of domestic production.

The options that would appear to exist for a lessening dependence on oil imports by the US are (1) to develop a natural resource base adequate to meet its needs and (2) to deal with the presently conflicting goals regarding when, how and where to produce

these resources. However, at present there are no national priorities for energy needs and there seems to be no way to rationalize national objectives with existing demands. Despite the fact that future importation of foreign oil would appear to be less expensive than the future development of existing domestic resources, it is possible the US could develop that capacity at comparable prices. For example, recent studies have indicated that when various factors are taken into consideration, e.g. storage and security costs, foreign oil could be as much as 30¢ per barrel more expensive than domestic oil. It can therefore be said that while oil import restrictions originated almost incidentally, they can be regarded as important to the formation of a rational US policy of energy production in order to satisfy domestic demand. The absence of an identifiable US policy concerning oil notwithstanding, certain questions are susceptible of rational analysis in terms of US interests.

First, what is the institutional environment affecting the domestic supply of oil? In answer to this question it appears that this environment is currently a rather dismal one in which no specific steps have been taken to foster the development of domestic energy resources. For example, although there is an abundance of coal in the US, no funds have been allocated for additional production or for solving the problems involved in that production, e.g. strip mining, the disposal of tailings and the control of the pollutant sulfur content of coal. Nonetheless, coal remains the cheapest and most readily available source of energy in the US. The US oil potential is less than that of coal and the development of this energy source is hampered by various considerations. For example, production of the huge reserves which exist in Alaska are now beset by the heated controversy of ecology versus energy demands. Another debate continues to surround the validity of oil depletion allowances. Regardless of one's point of view, without the tax structure now operating in the US at least one-half of the oil would probably not have been produced.

Second, what are the factors affecting the production of natural gas? The price of domestic natural gas was fixed at a very low rate. Despite spiraling demand and consumption, there has been no corresponding assistance for investors to locate additional supplies. This has resulted in the rise in prices and the depletion of readily accessible supplies. Attention has therefore been focused on the possibilities of importing liquified gas, though at much greater costs, and on the production of synthetic gas.

Third, can an adequate domestic fuel supply be developed at costs comparable to the costs of imported fuels? In calculating the cost of future domestic production, the additional expenses of environmental protections must be considered. Likewise, the projected costs

of imported oil must in the future include the expense of necessary security provisions to protect the flow of oil. There appear to be extra or "hidden" costs involved in a reliance on either domestic or imported oil. At the present time, however, given the growing current demand, only imported oil will be able to fill future demands for energy in the United States. The domestic energy production structure will become inadequate.

This being the case, one final question must be considered: What are the security problems which accompany a dependency on imported oil as a primary energy resource? The likelihood of Middle East political boycotts of oil does not seem to be a very large threat at the present time, although Libya will continue to be a question mark in that respect. On the other hand, the physical destruction of facilities which would halt the production of oil would seem to be a more realistic threat, particularly in light of the possibilities of civil war in Venezuela, conflict within the states of the Persian Gulf and/or further hostilities between Israel and her Arab neighbors. Continued Israeli aggression towards certain Arab countries, moreover, would certainly seem to jeopardize the supply of Middle East oil to the east coast of the United States.

Is there anything the US can do to guarantee the security of its oil imports? In terms of Venezuelan imports, there would not seem to be much of a practical nature that the US could do in the event of a civil disorder in that country. On the other hand, is it possible for the US to effectively influence the actions of its Israeli protégés so as to diminish the risk to its petroleum imports from the Middle East? In view of the insecurity of the US oil imports from that area, the expense of continued closure of the Suez Canal and resulting storage costs to European consumers, it would seem that tensions in the Middle East have brought to the forefront vital choices regarding energy supplies not dealt with heretofore in this country.

In sum, it can be said that the growing concern for the conservation of energy resources and pressures for greater participation in the international oil companies will be the greatest influences on the politics of the oil producing states for some time to come. Likewise, one of the most important influences on the determination of oil importing policies will be which of several alternative sources of energy will be used to satisfy growing domestic demands in light of the issues of environmental preservation and current threats to the security of energy imports.

Rapporteur: *Nan Burroughs Anthony*

Friday evening, September 29, 1972
Toastmaster: Francis O. Wilcox, Dean, School of Advanced International Studies, The Johns Hopkins University

BANQUET ADDRESS

Christian A. Herter, Jr.
Special Assistant to the Secretary and
Director of the Office of Environmental Affairs,
U. S. Department of State

Dean Wilcox, I can't thank you enough for that very informal introduction in which you managed to get in almost everything about me, including a good many things I'd never heard of myself. Ambassador and Mrs. Hart, distinguished head-table guests, and members and guests of the Middle East Institute, I'm delighted to be here as at one point I had the opportunity of being more closely associated with the Middle East Institute. Last evening I was at a large banquet in New York and one of the speakers placed a glass of wine right on the stand -- a podium like this -- and started to deliver a speech. There were about a thousand people there and I think everyone was somewhat aghast by this gesture until the speaker said, "My address tonight is in the form of a toast and that's why I have the glass of wine here." I'm making no complaints at all, but I would like to start off even with a glass of water to toast the Middle East Institute. One of the things I regret, needless to say, is that I have not had a chance to be here during the day. I realize that you have had a number of very distinguished speakers, a very interesting day in which no doubt you've covered all the problems involving the Middle East, the energy problem, the energy crisis, the enormously complex problems of oil and gas and their future in relation to the rest of the world. I'm sorry I wasn't here because I'd have liked very much to have been part of that conversation.

I notice on the program that little was billed in the way of discussion of the environment but then I've been told that several people have managed to speak on this subject too and it may well be that much of what I'm going to say tonight has already been said to you but I hope not entirely so. In any case I feel that basically if one is talking energy, whether it's from the Middle East or elsewhere, and no matter what form the energy may be in, or the energy system that produces it, the environmental impact of the effort to

produce energy, particularly at the scale that we foresee and that you've discussed, is an impact that is a very real one. It's just not something that people feel strongly about emotionally, a sort of blemish on the motherhood of nature; it is now becoming something of very deep and real concern in terms of dollars and cents. Environmental considerations may not be the decisive factor in the decisions that have to be made in the areas which you were discussing this morning, but they are certainly a key factor.

I'd like, in the brief time I'm going to talk with you, to emphasize really two themes. The first is what you might call the growing awareness -- very obvious to us Americans primarily -- the growing awareness in the world of the environmental problem; and the second, the need for, in my judgment, both an increased awareness and an increased education as to what the very tough choices, options and trade-offs are going to be in the next decade, and which will fundamentally be resolved as a matter of public policy, political decision and to a large extent by the understanding and the decisions of the public as a whole.

The decisions on the trade-offs and the choices are not ones that are made by government in a vacuum. And they very much depend on the degree to which people understand what they are. I will mention some of them somewhat later in my remarks. But let me start with the question of awareness.

As I say, for us in the United States, the problem of environment, in a really intense sense, has not been with us terribly long -- in public consciousness perhaps five years or so -- but for most of the world it has meant very little. At least until the Stockholm Conference, I think this was true. I was very much involved as were many other people in the preparations for the Stockholm Conference on the Human Environment which took place this last June. The whole world got together, or virtually the whole world, this summer in Stockholm to try to deal for the first time with environment as a global problem. The preparations for this conference had been going on intensively for a little over two years; a twenty-seven nation preparatory group representing all the major geographic areas of the world had met four times; countries that were to participate and did participate were asked to write a national report. In this national report they were asked to describe what their environmental problems were -- what mechanisms, what machinery, what legal institutions they had for dealing with these problems and what they felt about international problems as they might have an impact on their own thinking and on their own policy.

Well, the interesting thing is that eighty-five countries responded. These reports are all on file and they're all available

and I would make a guess that of these eighty-five countries, sixty of the eighty-five had never heard the word "environment" before they were asked to prepare a national report. They simply were not only unfamiliar with what we would call problems of pollution alone, but with the broader problems of the environment such as urbanization and management of natural resources. Now this may seem strange but I I would point out that under our domestic legislation today we have what is known as a National Environmental Protection Act -- NEPA, as it is called for short, in which it is required by law that all federal agencies file a statement as to the environmental impact, if substantial, of any project that they undertake. This requires a full description of what the impact may be and what the alternatives to the particular project may be. This impact statement then becomes a matter of public knowledge, and the public can comment on it. The courts have upheld this required procedure, and in the Calvert Cliffs case, for example, construction of an atomic energy plant was held up for failure to file an environmental impact statement. I think there is a sophisticated analogy to the preparation for the Stockholm Conference in that several agencies in the United States Government had never before considered, or been forced to consider, the impact of what they were doing. For example, the Corps of Engineers. They've got some very good environmental people now but they obviously had never previously considered the environmental impact of their projects and they are the first to admit it. In the same way most of the 114 countries at Stockholm, in preparing their national reports, had never previously come to grips with their own environmental problems.

In sum, awareness in most countries is just arriving. Many developed countries now have it, but the developing countries are still pretty skeptical.

Now I don't want to say that the only thing Stockholm did was to create awareness. Actually it was a very successful conference and a great many specific results were achieved. One hundred and nine proposals for international or global action were agreed to, dealing in part with some specific immediate problems such as ocean dumping, endangered species, and the introduction of chemical compounds and toxic minerals into the environment. In addition, we authorized the establishment of what is called "earth watch," the necessary monitoring, research, and information referral systems so that man can begin to know what is happening to the global environment. There is little hard knowledge at the present time. You yourselves have heard the scientific arguments concerning the effect carbon dioxide may have on the atmosphere by the year 2000. Some claim a hothouse effect; the earth will get warmer, the icebergs will melt. Others say particulate matter, also generated by man's activities, will prevent the sun's rays from coming through and the earth will be cooler. The fact is that nobody knows for certain. We have no base lines from which to take measurements on an international or global basis.

Well Stockholm has moved all this forward, and we are in the process, I think, of moving rather rapidly to setting up these systems to assess the situation. Interestingly enough we also got agreement on institutional arrangements to carry these proposals out, which have to be approved by the UN General Assembly this fall, and, after considerable blood, sweat and tears, we agreed on a set of broad principles governing environmental conduct, called the Declaration.

And the whole problem of environment and development, not totally disassociated from the subject which you have been discussing today, was debated at great length. As you would suppose, many countries in this world are not nearly as keen about environment as the industrialized countries are. In fact, they consider it rather a diversion from their main task, that of economic development. Curiously enough, Stockholm was able, I think, to bring a little better understanding of why there is a direct association between environment and development and it was the Japanese who did more to bring about this understanding than anyone else. The Japanese got up and frankly bared their chests; in essence, they said "Look at what we've done since World War II. We've created an enormous economic complex without adequate planning and we're in a total mess as a result. We just simply want to tell you that these are the problems we have found, this is the mess we're in, and if there's one piece of advice we can give you, don't do it yourselves." Curiously enough, this made a tremendous impact and gradually it became apparent that perhaps environment wasn't the antithesis of development, that intelligent environmental management was something that could in fact enhance development. Well, as far as Stockholm is concerned, we're moving ahead and we hope by the first of the year to begin the process of actually carrying through and implementing the proposals that were agreed to. There are going to be some problems this fall, as none of the Soviet bloc were at the meeting because of no East German participation. This created some political difficulties, but nobody really seemed to care.

One of the recommendations of Stockholm is on the subject of energy, and is quite short. It sounds like recommendations we've heard many times before:

> "It is recommended that the Secretary General take steps to ensure that a comprehensive study be promptly undertaken with the aim of submitting a first report at the latest in 1975 on available energy sources, new technology, consumption trends, in order to assist in providing a basis for the most effective development of the world's energy resources with due regard to the environmental effects of energy production and use.

> Such a study to be carried out in collaboration with the appropriate international bodies, such as the International Agency on Atomic Energy (IAEA) and the OECD, the Organization for Economic Cooperation and Development."

And I would guess that this is a fair summary of what you've been focussing on today.

Maurice Strong, who ran the Conference on behalf of the UN, and who did the most extraordinary job of putting this whole effort together, is very anxious that the United States take on this particular energy study and be sort of the guiding force behind it.

Let me just point out a recent and encouraging development. Three years ago, the Russians stoutly denied that it was possible for a socialist state to have environmental problems. "No, we have no problems of this kind; it's only in capitalist societies that environmental problems exist." Well, I've just come back from a week in Russia where the United States and the Russians signed a bilateral agreement on environmental protection. One of the most far-reaching bilaterals in this area that has ever been signed. It was done in three days without serious problems, and so we now have joint projects, exchange of visits, exchange of scientists scheduled from November on in eleven different areas -- thirty projects involving exchange of scientists on the ground between the Russians and ourselves. This is something that has never happened. These are all in very specific areas. Their first visit is to St. Louis on air pollution modeling; we go to Leningrad. Other urban environment visits are scheduled between Atlanta and Leningrad and Kiev and San Francisco. Air pollution, marine and inland water pollution, pollution related to agricultural production, conservation and earthquake protection. Both sides will designate new communities in each country as a means of examining the environmental, physical, social, economic and other factors considered in the design and development of satellite and free standing new communities. Among those communities to be designated are Columbia, Maryland and Reston, Virginia in the United States, and Togliatti and Akademgorodok in the Soviet Union. This is, I think, an extraordinary change, an extraordinary development in the case of a country which denied the existence of pollution three years ago. Simply an example of increasing awareness.

Where has all this increased awareness that I've been discussing led to? In international terms, I suppose one can honestly say, a growing determination to deal with global problems, to find out what is happening, to improve understanding and expertise, particularly

in the developing countries. As an example, I'm leaving for London the end of the month for an ocean dumping conference, hopefully to produce an international convention on limiting the dumping of certain toxic pollutants in the ocean from land-based sources. [The Convention was in fact agreed to by ninety-one countries on October 31st.]

What has this awareness produced domestically? Well, I don't think I need to go through a recitation of what has happened in this country in the way of laws, standards, regulations, and court decisions. Our system may not by any means be perfect but by-and-large we're pretty tough in this country and we do have regulations, we do have standards, we do have enforcement agencies and for the first time the problem of keeping the environment in some sort of decent shape has become a matter of national policy. Thus, in considering the whole energy problem for this country and for the world over the next twenty years, as you are now doing, the environment has to be a factor of significant concern. It is here with us; it is not something that one just simply talks about. In very specific, realistic terms, it means money, a new factor to add to the price of energy that will be used. The environmental concern is a real constraint on simply operating as we used to.

My second point, which I will speak to briefly. And that is the need for a greater public education, understanding in the years ahead of the options and the trade-offs as between what you might call growth on the one hand and environmental deterioration on the other. The choices will not be made by government alone but by the force of public opinion. For example, what are the real options available to Con Edison in New York with respect to building a power plant, whether it's atomic or fossil fuel? The environmentalists want no plant, yet people will not tolerate black-outs. What price are they willing to pay for energy, either in terms of money or environmental degradation? As another example, I understand that at this point it's impossible to build a refinery along the east coast of the United States. Personally I'm delighted, but I'm not sure it makes any sense. In a number of areas that are very important to us, most people are not fully aware of what the options are; and of what are the arguments for one option versus the other. Do we, for example, wish to go ahead and impose the cost of pollution abatement on industry, raise the cost of doing business and manufacturing -- if this is to our considerable disadvantage in international trade and may cost jobs at home? If someone were asked, "do you want jobs or pollution?" I don't think anyone would doubt what the political answer would be. However, if they put the question, "Can you live with slightly fewer electrical appliances, less use of air conditioning if it means cleaner air and a much better environment?" Then it is a much more difficult question to answer. I think you would find a lot of people who would say "Yes, under those circumstances, we would accept it." The point

I am making is that these are very difficult choices, and will become more so in the years ahead, and I doubt that the options have been fully discussed and fully put forward to the American public. To do so in such a way that people can make an intelligent choice is a major challenge for our leadership. Thank you.

Panel I, Saturday morning, September 30, 1972

Presiding: Vincent M. Brown, Executive Director, National Petroleum Council
Panelists: Abbas Alnasrawi, Associate Professor of Economics, University of Vermont
David B. Ottaway, The Washington Post
Lee F. Dinsmore, U.S. Foreign Service (Ret.)

THE ECONOMIC AND POLITICAL IMPACT OF OIL UPON THE MIDDLE EAST AND NORTH AFRICA

In studying the economic and political impact of oil upon the Middle East and North Africa, it is important to keep in mind that the countries of these two areas vary from one another considerably in terms of their political and economic institutions; their size; the structure of their economies; the level of their development; their dependence on oil; and the manner in which their institutions respond to challenges presented by an ever-changing international oil industry. At the same time, it is equally important to note that these countries share in common a number of similar characteristics, such as economic underdevelopment; the fact that their oil resources have been developed primarily by foreign capital and technology through concessions; the fact that oil exports provide the main, and in some cases the only, source of their foreign exchange earnings; and a widespread awareness that their oil resources represent wasting assets, a realization that has prompted an increasing number of these countries to channel their oil revenues into various development programs with a view to encouraging more lasting economic growth and diversification. Because of both their differences and their similarities, as well as the relatively long history of petroleum development in the area, a study of the impact of oil in selected Middle Eastern countries should shed light on a number of issues confronting the area as a whole. Three countries or areas -- Iraq, Algeria-Libya, and the Arab principalities of the Lower Persian Gulf and the Sultanate of Oman -- will be singled out for purposes of analysis.

* * *

Of the three, Iraq has experienced the longest period of petroleum development and probably also the greatest amount of political and socio-economic change. As background to understanding current position of the Iraqi petroleum industry and the continuing impact of the oil sector on that country's economy and politics, it is helpful to recall that prior to 1961, the exploitation of Iraq's petroleum resources was regulated by concessions granted to the Iraq Petroleum Group of Companies (IPC). These companies were owned by

five of the major international oil companies -- British Petroleum, Shell, Compagnies Francaises de Pétrolières, ESSO and Mobil. By the terms of its concessionary agreements with these companies, the rôle of the Iraqi government was confined mainly to that of a recipient -- first, of royalties per unit of output and, secondly, of a certain percentage of the industry's profits. Although Iraq realized at an early stage the importance of oil revenues for purposes of capital formation, it was not until the early 1950s that oil revenues began to play an important rôle in the country's economic development.

In 1952 the government negotiated an agreement with the companies in which the principle of profit-sharing was introduced for the first time, together with a commitment on the part of the companies to increase substantially the volume of petroleum output in Iraq. As a result of this agreement, output increased from 140,000 barrels per day in 1950 to 1.7 million barrels per day in 1971, with oil revenues increasing from Iraqi Dinars (ID) 6.7 million to ID 350 million during the same period. The share of the oil sector in the Iraqi national income, according to available data, increased from 21 per cent in 1953 to 29 per cent in 1963 and then declined to 20 per cent in 1970. In the same period, the share of oil exports to total exports increased from 56 per cent to 94 per cent.

The impact of the rise in oil revenue on the Iraqi economy can best be seen through an analysis of its rôle in the country's various attempts to promote development from 1950 until the present day. Prior to the Republican Revolution of 1958, the principal development-oriented institution established by the Iraqi government, under the monarchy, was the Development Board to which 70 per cent of the country's oil revenues were allocated. The Board, which was entrusted with the task of developing the country's resources and raising the standard of living, created four development programs. As the details of the various plans and their results have been treated elsewhere, it is important here only to note that the Board failed to meet its development goals primarily because it was unable to use effectively the financial resources at its disposal. A few statistics will illustrate the point. For example, although total planned expenditure for the four development programs through March 1958 -- three months before the Revolution -- amounted to ID 320 million, only ID 183 million was actually spent, indicating an implementation rate of only 57 per cent. By economic sectors, the rate of implementation was 37 per cent for industry, 52 per cent for transportation and communication, 52 per cent for agriculture and 63 per cent for building and housing. On a yearly basis, the average expenditure was ID 26 million, or little more than 9.6 per cent of the national income.

Certain generalizations can be made about the guiding principles of Iraq's development policies during the pre-revolutionary period. These include the following:

(1) the clear indication that the government intended that the free enterprise economy prevailing prior to the creation of the Development Board be preserved;

(2) the government intention for the new development policy would leave the basic patterns of income and wealth distribution, as well as the relationships between major social classes and political groups, unchanged;

(3) the indication that the private sector was to remain outside the development program; and

(4) the indication that the focus of investment policy be upon building up the country's infrastructure through improved means of flood control and irrigation and by facilitating the construction of roads, bridges and harbors rather than strengthening the commodity producing sectors, such as agriculture and industry.

The approach to development after the deposition of the monarchy differed markedly. During the first five years following the Revolution (1958-1963), two development plans, both of which relied heavily upon oil revenues, were devised. The first plan was provisional in nature and was superseded by a five-year Detailed Economic Plan (DEP) in December 1961. Under the DEP a total of ID 556 million was allocated for investment. The industrial sector received the largest portion of this allocation (30 per cent) by building and housing (25 per cent), transportation and communications (24 per cent) and agriculture (20 per cent). More than half the total investment (56 per cent) was to be financed from oil revenues, with the balance being raised through foreign and domestic loans. The heavy emphasis on the industrial sector in the DEP relative to other sectors of the economy, an emphasis which stood out in previous development programs, was attributed to several factors.

First,in the pre-1958 programs the industrial sector had received a relatively low priority rating. Throughout its existence the Development Board had invested only ID 19 million, or 10 per cent, of its total funds in industries, and of that portion most went for the building of power stations. Secondly, the economic philosophy of the republican regime clearly favored industrialization. The new leadership held that industrialization was the only way for Iraq to bring to an end her state of economic dependence on foreign interests.

The Iraqi argument in favor of industrialization is worth mentioning, for it is a position that has been widely endorsed as

well as articulated with increasing frequency by other countries in the area. As the Iraqi government viewed this situation, the country's oil, its main source of wealth, was being regulated by a small group of foreign firms whose ultimate interest was the maximization of their profits. The new leaders also pointed out that, prior to 1958, the revenues from oil, because of the economic policies of the monarchy, were spent mainly on foreign imports. This resulted in the recycling of Iraq's wealth back into the economies of the countries of the oil companies, rather than retaining it in Iraq. To weaken this relationship and to achieve a greater measure of economic independence, a consensus existed among the new leaders that industrialization in Iraq had to begin, whatever the cost. Only such a policy, it was believed, would ultimately raise the level of individual incomes, which, together with agrarian reform, would help to reduce inequalities and promote social justice.

There were two other reasons for the emphasis on industrialization in the country's approach to economic development. One was the belief that, given the same amount of investment, returns from industry tend to be generally higher than the returns from investments in other sectors, mainly because the capital output ratio in industry tends to be lower. The other reason was to avoid over-reliance upon foreign sources for developmental assistance. In this regard, the DEP had included industrial projects financed by loans from the Soviet Union and Czechoslovakia.

In viewing the record of development under the first Five Year Plan following the Revolution, it is of interest to note that the overall rate of implementation was actually lower than it had been under the monarchy, i.e. 47 per cent as compared to 57 per cent during the earlier period. On the other hand, actual spending in absolute terms and as a proportion of Iraqi national income, was substantially higher. For example, the amount actually spent was ID 47 million per annum, or 12.8 per cent of the national income, as compared with only ID 26 million, or 9.6 per cent of the national income, for the earlier period. As in the plans formulated under the monarchy, however, the rate of implementation again varied according to sectors, as evidenced by a rate of 46 per cent in agriculture, 31 per cent in industry, 55 per cent in building and housing and 31 per cent in transportation and communication.

Following the overthrow of the Qasim regime in 1963, the DEP was suspended and replaced by two annual investment programs for 1963 and 1964, during which time a new Five Year Economic Plan (1965-1969) was formulated. The economic objectives of the new Plan were to raise the level of the national income at a rate of eight per cent per annum, to effect a change in the economic structure by developing the commodity sector, and to change the pattern of income

distribution. Although this was the first Iraqi Plan to be completed, the rate of implementation for projects formulated and approved was still no higher than the rates experienced during any of the earlier periods. For example, the rate for all sectors, taken as a whole, was 55 per cent, with individual sectoral rates of 32 per cent for agriculture, 53 per cent for industry, 60 per cent for transportation and communication and 53 per cent for building and housing. Actual spending was ID 60 million per year, or 10.5 per cent of the national income, a percentage that was actually lower than that for the 1958-63 period.

The current Iraqi Five Year Plan, also heavily dependent upon petroleum revenues, began in 1970. In comparison with its predecessors, this Plan seems to have attained a higher level of sophistication in terms of the utilization of more scientific planning and statistical techniques. The Plan also recognizes that agriculture was neglected in previous plans -- in spite of the fact that it continues to provide income for some 60 per cent of the Iraqi population -- and, accordingly, it has assigned top priority to developing the agricultural sectors of the country's economy. The Plan, in addition, is more realistic than any of the previous plans in terms of its total allocation and the rate of economic growth envisioned. For example, the target rate of income growth is projected at seven per cent annually, as compared to eight per cent in the two previous plans. At the same time, total investment is planned at an annual rate of ID 98 million, a level substantially lower than the rate of ID 113 and ID 112 million for the DEP during 1961-63 and the 1965-1969 Five Year Plans, respectively.

From the foregoing it can be seen that regardless of the economic and political orientation of the regime in Baghdad, successive development organizations in Iraq have consistently failed to attain their investment goals. By 1970 the end result was that the overall objectives of development policies articulated earlier -- economic diversification, the lessening of dependence on the oil sector and a high rate of economic growth -- had become as elusive as they were twenty years ago when development programs were first begun.

How can one explain this failure? The answer to this question, in brief, lies in a combination of factors. These include administrative inefficiency, over-ambitious planning and, above all, political instability, which weakened decision making and led to frequent changes and disruptions in the development programs. The conclusion that development policy failed to attain its stated objectives indicates that the oil sector had failed to act as a promoter or catalyst of economic transformation in its rôle as a source of revenue and the accumulation of foreign exchange. In retrospect,

the oil sector probably could have played a more important rôle in the process of economic transformation had it been an integral part of the Iraqi economy. It is revealing, for example, that apart from providing employment for a relatively small fraction of the Iraqi labor force, the pattern of development in the oil sector was somewhat removed from that of the rest of the economy. In short, the oil sector failed to serve as a strategic sector around which a number of other industries and economic activities could have evolved. On the other hand, such a pivotal rôle for the oil sector in Iraq was impossible so long as the concessionary system was the predominant mode of petroleum exploitation and so long as the concession covered the entire country. In this regard it is important to recall that, under the concessionary regime, all decisions concerning development of the oil industry were taken with the overriding objective of maximizing profit. This is not to say that the development of the oil sector in Iraq ought to have followed a different course, bur rather that a different course was not possible under the circumstances. What happened in Iraq as a result of these circumstances has the potential to occur elsewhere. Indeed, whenever the guiding principle of oil company policy is profit maximization (regardless of whether or not this coincides with the national policy goals of the oil producing country) conflicts are bound to arise as they did in Iraq in which case the conflicts that erupted between the companies and Iraqi policy makers ultimately led to the nationalization, which took place this year, of IPC.

Why did Iraq nationalize IPC? The background to this event is exceedingly complicated but in point of time it goes back to the 1952 Agreement, noted above between the government and the oil companies. As soon as that agreement went into effect, the Iraqi government raised a number of questions relative to cost calculations, prices, relinquishment,discounts, royalty expensing and a host of other issues, many if not all of which remain among the principal items in dispute between governments and oil companies today in other oil-producing countries in the area. Some of these issues were settled before the July 1958 Revolution, but others remained to become the subject of prolonged negotiations during the Qasim regime. These negotiations failed, however, and in their place the government passed the celebrated Law No. 80 (1961) which restricted company operations to those fields producing at the time -- less than one-half of one per cent of the concession area. This legislation was a landmark in the history of government-company relationships, not only in Iraq but in other oil-producing countries as well. Among its many far-reaching results was the creation in Iraq for the first time of a national oil company -- the Iraq National Oil Company (INOC) -- which was subsequently charged with developing the country's oil resources. This task proved to be difficult at first, but INOC has finally succeeded in producing and exporting oil. Experts disagree

as to the fiscal wisdom of direct exploitation by a national company, but in the Iraqi case, as in other Middle Eastern and North African countries, where similar national companies have been established, decisions of this nature are not predicated on purely fiscal terms. Rather they are taken on the basis of long term national interests as these are conceived by a country's leadership at a given point in time. Other observers point out, however, that had the government in the Iraqi case been able to reach an agreement with the companies, either first in 1961 or later in 1965 when extensive government-company negotiations were conducted, oil output and revenues would most certainly have increased considerably. On the other hand, it is probably equally true that had this been the case the same pattern of economic relationships between the government and the companies would have been maintained, and this was a pattern which Republican Iraq was clearly determined to change.

Although the past decade witnessed a solution to some of the more outstanding problems between the Iraqi government and the foreign oil companies, other problems remained unresolved. These problems included the issue of accumulated royalties, the level of output and the settlement of the consequences of Law No. 80. It should be emphasized that since the rejection of a 1965 draft agreement between the two parties, Law No. 80 became non-negotiable from the government's standpoint, while the companies insisted on maintaining the position that a resolution of all the problems outstanding between them and the government was contingent upon settling the consequences of this Act. With both parties locked into their positions, the stage was thus set for the inevitable confrontation which culminated in the nationalization of IPC last June.

The developments which preceded the nationalization of IPC illustrate the danger in which other governments in the Middle East and North Africa might find themselves and their development programs should they become dependent on a single source of revenue, the size and complexity of which is beyond their control. In the case of Iraq, this fact was painfully driven home when exports from IPC fields were drastically reduced in the early part of 1972, leading to a reduction in annual oil revenue of almost one-third. The position taken by Iraq both then and subsequently was widely supported by other oil-producing countries: no government could or should accept such a sudden and drastic reduction in its revenue. Moreover, in this instance the reduction was of such magnitude that it forced the government to embark upon an austerity program and to suspend implementation of the 1970-74 Five Year Plan for the current fiscal year. However, for its part, the company had argued that due to a decline in tanker rates, the oil from Iraq's Kirkuk fields had become more expensive to export relative to Gulf oil; hence the drastic cut in oil output and exports. In reply, the government maintained that

the changes in freight rates had nothing to do with the cut in output -- from a rate of 1.2 million barrels a day in February 1972 to 694 thousand barrels a day, or a reduction of some 44 per cent, in April 1972. It maintained that while freight rates did indeed decline between January 1971 and February 1972, the rate of production for the same period averaged some 1.1 million barrels per day. From this perspective, the drastic cut which took place after February 1972 appeared to have reflected instead a high level managerial policy by IPC aimed at punishing the Iraqi government for its independent oil policies and for its refusal to circumvent the effects of Law No. 80 during government-company negotiations held during January 1972.

The act of nationalization in Iraq, apart from the immediate causes which led to the event, should be viewed not merely as the almost inevitable result of a series of disputes between a particular government and a certain business firm. Rather the Iraqi case should be viewed in the context of a much broader movement taking place among Third World countries to gain an increasing measure of control over what they recognize to be the most important sectors of their economies. Seen from this perspective, for Iraq, no less than for most other oil producing states, control over the country's oil sector represents another and indeed perhaps one of the most important manifestations of their political and economic independence.

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In the North African context, Algeria, in many ways like Iraq, provides a different but no less interesting case study of the extent to which a country's oil industry can have an impact on its domestic and foreign policies. As background to the situation in Algeria, it is important to recall that less than ten years ago the Algerian government viewed the US, and much of the Western world in general, as an imperialist power which constituted a major threat to its security. Yet today it is to be seen entering into an increasingly intricate network of economic relationships with the US, particularly in the field of petroleum, the terms of which stand to provide the Algerian economy with some $20-25 billion dollars over the next twenty-five years. Thus the Algerian oil industry appears to be headed for an extraordinary period of expansion in the years to come. While it is too early to predict the ultimate outcome of these developments, it is nonetheless possible to take stock of the effect that the petroleum industry has already had on the country's development in terms of its politics and economy. The Algerian case may well have implications for the future course of development in other states, in particular in nearby Libya, the other major North African producing country.

At the present time the Algerian government does not earn sufficient revenue from its petroleum and gas resources to meet its needs, either in terms of its administrative costs or capital requirements for the country's developmental programs. Oil and natural gas in Algeria currently account for some $1.5 billion dollars annually in foreign exchange earnings. Of this sum, the government receives a sizeable portion but at the present time only enough to cover about two-thirds of the country's development budget for 1972.

Nonetheless it is clear that oil is of great importance to development in Algeria. At the center of the country's economy, for example, is SONATRECH, presently the tenth largest oil company in the world. In 1972 SONATRECH is expected to earn gross revenues of about $1.5 billion. The government is counting heavily on SONATRECH to provide the necessary financial means to help it carry out the country's development programs for some time to come. At the same time, the government is not relying upon the petroleum industry alone but has launched programs to set up a number of other industries. In short, Algeria is feeling the development pinch due to an extremely ambitious economic development program which aims to push the country to the "takeoff" point -- described as the level of development currently obtained by Rumania -- by the end of the decade.

The impact of oil on Algeria's options for rapid industrial development has thus been considerable. The substance of this impact has been manifested in several important developments. First, great emphasis has had to be placed on the formation of a technocratic and bureaucratic class capable of running a state socialist system. The rapid development of this class is one of the most striking features of contemporary Algerian society, all the more so in view of the fact that the sons of the Algerian bourgeoisie are re-emerging as an important segment of this class. Secondly, as a result, a shift in political power away from the army and toward this class has been evident for quite some time. Indeed, no important decisions nowadays are made without the approval of both the cabinet, comprised of civil servants, and the military-dominated Revolutionary Command Council (RCC), whose power has been declining, despite the fact that the corps group of its members who has remained loyal to President Boumedienne are still very much in control of the country. Thirdly, the emergence of this class has had in general a deradicalizing effect on Algerian politics and a stabilizing effect on the country's domestic politics in particular. Together with the army it has come to form the social base of the Boumedienne regime. Its support, moreover, has allowed Boumedienne to rule for seven years without significant national political institutions or a constitution and has given him time to develop slowly, from the bottom up, a new

political system. Finally, the emergence of this class has also made it possible for the government to check the controversial system of self-management ("autogestion") in the industrial sector. In this regard it is significant that the demise of this system has been accompanied by a parallel decline in the importance of radical leftist groups, such as former Ben Bellists, the labor unions and student unions. In sum, the preponderance of social and political power in Algeria now lies with this new class. Thus far there has been very little pressure from this class on Boumedienne to develop new national political institutions. This has led some observers to suggest that the technocrats may view the lack of such institutions as suiting their purpose and enhancing their power. On the other hand, there seems to be little doubt that this class has allowed Boumedienne to legitimize his regime mainly through the weight and example of economic success.

In the realm of foreign policy, the impact of petroleum has been equally profound. The rise to power of the technocratic class as a result of the country's commitment to rapid industrialization, together with other considerations, has been responsible in part for the growing "pragmatism" of Algerian foreign policy. In this regard it is important to note three major shifts in the country's foreign policy since the achievement of national independence from France in 1962. First, the fall of President Ahmad Ben Bella in 1965 marked a definite turn inward and away from an activist foreign policy. Second, the 1967 Six Day War, after which American interests were nationalized and gas exports to Great Britain were interrupted, a great debate ensued within the government over the political and economic costs of the country's involvement in the Arab-Israeli conflict, and a government crisis as a result of this debate was only narrowly averted. Third, when the government decreed the seizure and nationalization of French oil companies in February 1971, this meant the end of the traditional concession system in Algeria.

Out of these developments, the growing trend towards greater pragmatism in Algeria's foreign policy seems to stem from several factors. The first of these came on the heels of its economic nationalist revolustion against France. As the country came closer during the late 1960s to completing its revolution against France, the more "pragmatic" its government could afford to become. (Actually, it was not only against France that Algeria sought to turn the tables and establish a new relationship, but against all Western oil and gas companies.) Secondly, the need for markets and partners beyond France for its oil and gas brought home the need for a more realistic foreign policy. Thirdly, there was a pressing need to negotiate capital loans abroad; this requirement, in turn, created a parallel need to appear internationally as a dependable

partner, a need that became especially urgent during the negotiations in recent years between the government and the American El Paso Gas Company. Finally, there was the influence of the technocratic-bureaucratic class whose interests were deemed to lie with an expanding Algerian economy and the success of the country's industrialization program and not with foreign adventures or any greater regional and intentional involvements than were absolutely necessary.

If commitment to rapid industrialization, the formation of a new technocratic and bureaucratic class, and the deradicalization of domestic and foreign policy are among the effects of petroleum on the politics and national economy of Algeria, to what extent does it provide an example for, or any clues to, the likely impact of petroleum on developments in Libya? In order to attempt an answer to this question, it is important to keep in mind that very different social and economic forces are at work in the two countries, not to mention different types of leadership.

Thus far, Libya seems to be developing a hybrid politico-economic system, with its political institutions patterned after those in Egypt and its oil policies from Algeria. Any predications that Libya will in time become more "pragmatic" in its foreign policy in the manner and style of Algeria, however, would be extremely hazardous. In fact, for the following reasons, the end results of Libya's socialist and nationalist revolution may be quite different from what has happened in Algeria. To begin with, the potential of Libya's oil and gas economy staggers the imagination. In a country of barely two million people, <u>per capita</u> income has increased six-fold [or 600 per cent] since 1962 -- from $280 to $1,950. During the same period there has been an equally phenomenal 19-fold increase in the country's gross national product. In short, oil dominates the Libyan economy. The government receives well over 90 per cent of its revenues from oil and gas, whereas in Algeria the government at present receives only around 40 per cent. A development of related importance is the fact that non-petroleum exports in Libya had declined from 100 per cent in 1961 to less than one per cent in 1971. With oil revenues in 1971 averaging around $2.4 billion, the country's foreign exchange holdings had amounted to some $3.06 billion.

Despite the fact that the economic impact of petroleum in Libya has thus far been far more extensive than in Algeria, Libya nonetheless seems to be following the Algerian path in terms of its oil policy. The outlines of this policy have been manifested in a number of key events since the Qadhdhafi regime came to power. One of the first of these developments involved the reorganization in March 1970 of the Libyan National Oil Company, an institution

begun in 1968 under the monarchy. Shortly afterwards, in July 1970, the government nationalized the Libyan marketing facilities of three Western petroleum companies -- ESSO, Shell and ENI. Simultaneously, the government began to press petroleum companies operating in Libya to push ahead with the policy of Libyanizing their personnel. The next major event occurred in December 1971 when the government nationalized the interests of the British Petroleum Company in the Sarir oil field. (Even earlier the government had been running a small field previously conceded to the Phillips Petroleum Company that was producing some 4,000 barrels per day.)

Throughout the course of these events Libya has continued to push ahead in its effort to establish joint companies, in much the same manner as Algeria did, with the government possessing a 51 per cent interest in any such companies formed. Thus far Libya has pursued the 51 per cent principle chiefly with ENI in the course of setting up a joint ENI-Libyan drilling company and in negotiations over ENI's oil field rights. In April 1972, the government reached agreement with ENI on the principle of an increased share, starting at 25 per cent and rising to 50 or 51 per cent as production increased; recent reports, however, indicate that Libya did not obtain the 51 per cent interest she had sought. For its part in the arrangement, ENI received a contract to set up a training center for oil technicians and administrative personnel at Tobruk Higher Oil Institute and another contract to build a refinery at Zavia with an initial production capacity of 60,000 barrels per day. In other developments, the Libyan National Oil Company (LINOCO) has begun taking over refinery and chemical plants that Western companies were to have built (Continental Oil Company's ammonia plant project at Benghazi has been moved to Marsa al-Burayqah, near ESSO's Brega Plant). On the basis of these developments, all indications are that Libya will persist in the gradual takeover of the oil and gas industry, seeking new forms of partnership with foreign companies and almost certainly demanding a majority interest. The timetable may have slowed in the aftermath of the nationalizaiton of BP when some difficulties were encountered, but the overall goal remains the same.

At this point in the development of the Libyan petroleum industry, it is appropriate to ask: Are the moderating influences at work in Algeria present in Libya? The answer, in almost every instance, is no, not yet. The reasons are as follows. First, Libya has only just begun its economic revolution in the oil and gas sectors. Secondly, it is having some difficulty at the present time in placing its higher priced oil on to markets -- Libyan oil is not now competitive with Gulf oil. But a major problem of potentially even greater importance is Libya's self-imposed reductions in production. At the present time production is still declining from its 1970 peak of 3.3 million barrels a day, and for the first seven months of 1972 it

was running at 2.26 million barrels per day -- some 22 per cent down from the 1971 level of production. On the other hand, Libya has been able to find new markets in Eastern Europe. Moreover, buyers of what was formerly BP's share of oil from the Sarir field -- about 5.5 million tons -- have been found in the Soviet Union, Bulgaria, Yugoslavia and Rumania. A third reason is the fact that Libya has no pressing need for outside capital. The Three-Year Plan launched in the spring of this year, though large -- $3.2 billion -- is much smaller than the one in Algeria and the priorities are different. For example, $1.02 billion of the plan is to be allocated for land reclamation schemes, with only $241 million going for oil industry investment. Yet with $3 billion still on deposit in banks Libya is intending to build many of the same types of "industrializing industries" as Algeria has underway, such as petrochemical plants. Finally, the technocratic-bureaucratic class in Libya, by contrast to Algeria, is still very small. Most of this class is presently comprised of Egyptians, whose numbers have been estimated at between 70,000 and 100,000 and who serve in some of the highest positions in the administrative structure. On the other hand, there are indications, at least as seen in some quarters, that the simultaneous emergence of Abd al-Salam Jalud as Prime Minister and of a civilian cabinet of technocrats in the summer of 1972 may be a first step in the direction of greater moderation and more influence for civilians. This development is still too recent, however, and its implications for the future orientation of the economy and politics of Libya remain to be seen.

The key difference between Algeria and Libya remains the ratio of their respective capital supplies to their capital needs for development. In this sense, Libya is capital rich and Algeria, relatively speaking, is capital poor. The other major difference between the two is in their present levels of social development, with Algeria having a comparative advantage over Libya in this area at the present time. It may turn out that once locked into partnership with foreign companies, Libya may become slightly more moderate in its domestic and foreign policies, but this does not appear to be in the offing at anytime in the foreseeable future.

* * *

In the Lower Persian Gulf and Arabian Peninsula area, the political and economic impact of oil has had, in some instances, quite different effects than those experienced thus far in Iraq, Algeria and Libya, although there are similarities, especially in the case of Libya. One major result of oil income in the Gulf, for example, has been to introduce many of the Arabs of the area for the first time to other Arabs. Before oil income began to accrue these principalities, situated on the periphery of the Arab world, were

relatively unknown not only to the world at large but even to their neighbors. With the exception of Oman, most of these states had never figured very highly in Arab world considerations. Yet almost overnight they seem to have become the objects of widespread attention.

In most corners of the world the effect of sudden solicitous interest on a people whose previous existence was relatively unnoticed is almost certain to be profound. What has been the result in the case of the Lower Gulf principalities? The answer, in brief, is that oil income has had an impact across the entire spectrum of political and socio-economic life for the majority of the population. Within the time span of a few short years these people have had to adjust to the fact that they and their lands are of considerable importance economically and politically in both regional and international affairs.

As a result of oil revenues that have accrued to four of the shaykhdoms in the area -- Bahrayn, Qatar, Abu Dhabi and Dubayy -- the area now has sufficient funds to enhance its development. In the case of the Sultanate of Oman, however, outside help will continue to be required as long as the Sultanate is engaged militarily in its now seven-year-old war with rebels in Dhufar, its southern province. Nonetheless, Oman is on balance fortunate in that its neighbors are able to supply it with substantial economic assistance for the foreseeable future. Of related importance is the fact that in addition to the availability of funds, the leaders of the area are eager to use financial resources for economic and social development purposes. On the other hand, these states are confronted with a problem that, for the most part, is absent from Iraq and Algeria, although it exists in the case of Libya, namely that actual project planning and the commitment of funds for specific development programs will continue to depend on whether the necessary manpower will be available.

In confronting the multi-faceted tasks of development, the Gulf Arabs nonetheless possess an important cultural characteristic that predisposes them favorably toward the modernization of their societies. In this regard, it is important to recognize that the majority of the people of the Gulf live along the coasts. Historically, this has facilitated their acquaintance with and tolerance of peoples from different cultures than their own; many Gulf Arabs, for example, are at ease in one or more languages other than their native Arabic. These characteristics tend to set them apart from their Saudi neighbors, whose roots are in the land-bound Najdi deserts and highlands that have tended to instill conservatism in their inhabitants. This rather cosmopolitan trait of Arabs in the Gulf suggests also that they may to some degree be more open and perhaps vulnerable to

outside influences than their Saudi counterparts. Indeed, in view of the emerging political and social awareness in the area this seems to be the case. Under the impact of the petroleum industry, rapid cultural change has been particularly notable in the major population centers, and at the present time it can be described as occurring at a rate of change almost as fast as that occurring in the economic realm. In most of the shaykhdoms, however, neither economic progress nor social evolution can be balanced by planners since the differences between the population of the hinterland and the settled areas along the coast continue to be great. Next door to affluent shaykhdoms, and even at various places inside these shaykhdoms, tribesmen living in mountains and fishing villages continue to dwell in relatively primitive conditions, many of them living in wretched squalor. Fortunately in the case of Omán, the population is not very large. The present availability of funds in that country for the first time on a fairly large scale should begin to make more manageable the task of integrating the Omani people into the more developed sectors of their society and the parallel problem of providing them with educational, agricultural and health services.

One of the greatest sources of potential danger to these regimes is probably internal security. While there has already been the case of an abortive coup attempt in Sharjah, local security forces showed a surprising degree of solidarity and skill in preventing the success of that attempt. In addition to Sharjah, there are other shaykhdoms with ambitious individuals who envy those presently in power and who could be a source of attempts to overthrow the present traditionally-oriented leaders. Should a coup attempt arising from within the traditional tribal sources of political disruption succeed, it would not likely pose the prospect of radical change. If past coups in the area are any guide, the successful tribal coupmaker is more likely than not to continue the broad outlines of policy set down by his predecessor. Nonetheless, there may be other types of potential challengers to shaykhly rule with more pronounced ideological views who may focus attention on these shaykhdoms. Because the Lower Gulf states still depend on Arab teachers, technicians and advisors from the outside, some observers view these expatriate Arabs as a source of potential danger in that some of them are believed to espouse revolutionary ideologies. On balance, however, the number of expatriate Arabs or individuals of other nationalities committed to subversive activities in the area is believed to be exceedingly few.

In the long run a more likely source of tension may well prove to be the inevitable cultural lag that is likely to set in as the inhabitants of the area continue to adjust to their new and different rôles, now that Britain has abrogated its former treaties of protection for these states. Among the population at large there may

well develop a generation gap between the youthful elements and their more conservatively-oriented elders, with the former expressing signs of dissatisfaction with the thought of continuing to live with the traditional means by which leadership in these states has customarily been exercised. Thus far, however, all indications are that the growth of political awareness has not yet become a matter of great concern to the rulers presently in power.

The situation in neighboring Oman must be regarded as critical to the future prospects of development in the Arab shaykhdoms. Being larger in area and population, less easily controlled by security forces and lagging behind its neighbors in terms of economic development, the Omanis may be more prone than the Arabs of the shaykdoms to vent their impatience with the Omani government's policies for promoting economic improvement. More than any of of the Lower Gulf shaykhdoms, the Sultanate government, in short, is "under the gun" in the face of tremendous challenges to its capacity to begin to provide tangible political and socio-economic change. As much as any country in the area, if not more so, the Omani government is presently in need of considerable financial aid in its efforts to make up for the generation of neglect and waste presided over by the former Sultan, Sa'id bin Taymur, who was overthrown by forces supporting his son, the present ruler, in 1970. Thus far, however, the United Arab Amirates and Saudi Arabia have both realized that it is in their interest to devote a portion of their oil revenues to assist Oman in this undertaking.

The extent to which the two most powerful oil-producing states in the area -- Saudi Arabia and Iran -- can wield influence in the shaykhdoms and in Oman is as difficult to predict as the answer to the question of how they will go about it. At the present time, however, it is clear that Saudi Arabia has far more at stake in the continued existence of Gulf states favorably disposed toward it than does Iran, despite the fact that the Iranians tend to voice their concerns publicly to a greater extent than the Saudis. Iran, for its part, has made very clear its interest in establishing influential relations with the Arab shaykhdoms, both the oil "haves" as well as the "have nots." The Shah's strong position on the issue of the Tunbs and Abu Musa Islands -- claimed simultaneously by Sharjah and Ra's al-Khaymah -- demonstrated Iranian determination. In some instances, on the other hand, Iran has constructed and staffed medical facilities, has assiduously cultivated contacts by inviting Gulf Arab personalities to Iran and has sent prestigious delegations of its own to visit the area. In sum, Iran, more than any other state in the immediate area, works at its relationship with the Gulf Arab states.

By contrast, Saudi Arabia, although in a more natural position to have an influential presence in the Gulf-Oman area,

is hampered by the cautious reserve and formal restraint of its foreign relations, and this has tended to limit its rôle. More specifically, the boundary dispute between Saudi Arabia and Abu Dhabi is still undetermined. This dispute lies at the back of Abu Dhabi's distrust of Saudi Arabia and the Saudis' stiff attitude toward Abu Dhabi and its leading rôle in the Union of Arab Amirates. This old and divisive problem is part of the reason behind the surprisingly heavy and diversified military buildup in Abu Dhabi, to which a sizeable portion of the oil revenues in that oil-rich shaykhdom has been allocated.

The Gulf is for the most part free at present from major power conflicts. If this situation should continue, local issues can probably be solved on mutually agreeable terms. Perhaps the most outstanding example in this regard was the settlement in 1970 of the long-standing claim of Iran to sovereignty over Bahrayn, the oldest oil-producing shaykhdom in the Gulf. The Gulf states of Iran, Kuwayt and Saudi Arabia, three of the world's most important oil producers, are all looked up to in various ways by the shaykhdoms and Oman as senior experienced members not only of the Gulf community but also of that more specialized community of countries for whom the political and socio-economic impact of petroleum has been profound. In the case of Iraq, the other major oil-producing power in the Gulf, the shaykhdoms and Oman will probably continue to view any Iraqi rôle in area developments with suspicion. This is unfortunate, for Iraq has had a vast array of experience in the field of economic development and the problems arising out of government-oil company relationships -- the most important economic relationship prevalent in the majority of the Gulf states. However, the Gulf-Oman area, being ruled entirely by traditional leaders, is understandably wary of outsiders from states such as Iraq, whose republican and socialist views are known to be hostile to the type of leadership presently found in the Lower Gulf area.

Finally, it is possible that if other foreign interests avoid the temptation to assert themselves in the Gulf, the littoral states will be capable of managing their own affairs. Seen from the perspective of the Gulf states it would be tragic if the Great Powers were to export their differences with each other to this area to play the locally irrelevant but nonetheless dangerous game of superpower confrontation.

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From the foregoing cases, it is apparent that in weighing the future prospects of the impact of petroleum on the politics and economies of the Middle East and North African areas, there is no magic formula whereby the conflicting interests of concession granting

governments and petroleum companies can automatically be reconciled. As a matter of fact, tension and conflict in most cases -- the Lower Gulf and Oman constituting important exceptions thus far -- have been the norm rather than the exception. Moreover, based on the Iraqi example and the ambitious development plans inaugurated in Algeria and Libya, the governments of these and other oil-producing countries in the two areas will most likely take increasingly strong measures to insure that development plan financing, which most likely will continue to rely heavily on revenues earned from oil, will not be allowed to fluctuate. There appears to have emerged among the countries of both areas a consensus that it is bad enough that plan implementation should fall short of its goals, but it is even worse to tie these plans to an unstable source of revenue. In view of these considerations, there appears to be increasing recognition by the states of both areas that the oil sector is of such overwhelming importance to their future development prospects that it should be fully integrated into the overall framework of their economies. In the view of the producing countries, if not of the foreign operating companies, it is clear that the time has come for the isolation of this sector to be brought to an end and for this sector to contribute far more than merely a certain percentage of overall government revenue.

Rapporteur: *John Duke Anthony*

Panel II, Saturday morning, September 30, 1972

Presiding: George A. Doumani, Science Policy Research Division, Congressional Research Service, Library of Congress
Panelists: Afif I. Tannous, U. S. Department of Agriculture (Ret.)
Claire Nader, Associate Director, ORNL-NSF Environmental Program, Oak Ridge National Laboratory
Marvin Zonis, Associate Professor of Political and Social Sciences, University of Chicago

PREPARING FOR ECONOMIC DIVERSIFICATION AND STRENGTH: INTERNAL POLITICAL, ECONOMIC AND SOCIAL STRATEGIES

It is both superficial and misleading to portray the energy crisis as merely the concern of the consumer countries. The present world energy situation poses policy problems for both the producing and consuming countries, both in terms of their domestic priorities and in their international relations.

The United States, for instance, has sixty-one agencies concerned with energy problems, and yet it has no overall energy policy. This lack of a coordinated policy reflects the complexity of the issues involved. The energy crisis is not a crisis based on shortages; it is a pricing crisis. Alternatives to fossil fuels exist, but each has its problems. For instance, geothermal energy offers the promise of clean and limitless energy. However, since it is a highly localized source of energy, it cannot be the basis of a centralized national energy system. Second, oil shale has been mentioned as an energy alternative, especially attractive since there is a large supply in the United States. However, there is a problem of disposing of the leftover shale tailings after the oil is extracted. Furthermore, after the oil is extracted it must be further treated to improve its quality; the process of retorting [extracting the oil] and treating it through hydrogenation both themselves require energy. A third energy alternative frequently mentioned is tar sand. Americans must often be reminded that these supplies are in Western Canada, and cannot be counted as part of the United States' resource supply. Canada has its own energy demands, and the Alberta tar sands simply are not as secure an energy source as many have supposed. Finally, breeder reactors promise a diversification of energy sources; research is now in progress, but fusion and fission remain hopes for the twenty-first century. For the next fifteen years or so, Middle Eastern oil will play a major role in the world energy picture.

This should not suggest that producing countries are without similarly difficult policy problems. After all, the technology transfer from the developed countries to the Arab world is fossil

fuel based, so the producing countries are also consumers, and must also be concerned with continuing adequate supply. But, as producers, these countries face very real dilemmas and difficult decisions which will affect their economy, their society and their political system.

If one considers oil in the context of the total economic development of the Middle East, one must recognize that it affects only a small proportion of the people in the area. It is both accidental in location and finite in supply: it will not be available forever. The most significant aspect of oil within the Middle East is its role as a major source of revenue for development. It is a source of foreign exchange with which to finance development projects, as well as to import luxury items. It provides funds for economic and social programs, and in sufficient amounts that large scale, comprehensive projects can be undertaken. These productive projects have begun to involve the people in even the most remote regions of the Middle East in the process of national development, and thus are changing not only the economy, but also the society of the area.

Because of the large scale of the projects made possible by the oil revenues, the role that agriculture plays in development has often been underestimated. It must be recalled that agriculture has been the major occupation in the Middle East for 10,000 years; it affects the way of life of millions of people, and will continue to be important long after the oil is gone. Indeed, in the Middle East area as a whole, agriculture accounts for a significant proportion of the GNP, and ranks second to oil as a foreign exchange earner.

There are several reasons to believe that agriculture will continue to play a role in the development of this region. First, and perhaps most important, is the fact that the large majority of tribal and village people of the area organize their lives around this economic system. Second, there are still areas which can be cultivated when irrigation systems are developed, thus there is a great potential for expansion of crop lands. Third, crop yields may be increased through pest control, improved seeds, and better marketing and storage facilities. It is suggested that yields could be doubled by the application of methods of modern technology. Fourth, investment in livestock can be greatly increased.

All these possibilities require sound national planning, and all require the involvement and active participation of the people of the area. However, since agricultural development cannot be imposed on a rural population, a coordinated policy of national education, local initiative in the design, implementation and administration of needed development projects, and centralized budgeting of oil revenues for balanced regional development is indicated. Since a

sound agricultural base is essential for the future development of the area, the governments of the Middle East must encourage popular participation in, and identification with, national development goals.

Implicit in this call for popular participation in development is the need to recognize the fact that human resources play a major role in the process of technological change. When one asks why human resources are not being better utilized in the Arab world, several problems must be recognized, among them debilitating diseases which plague large portions of the population and for which there are inadequate medical facilities and personnel; a growing population which makes increasing demands on the underdeveloped and poorly coordinated social services of the country; scarce housing which confounds and is confounded by the population explosion; a poor educational system which is not geared to national objectives; and unmodernized agriculture reflected in the massive underemployment in rural areas, and inadequate transportation and marketing systems linking areas of the country.

Policies aimed at developing human resources must be designed both to educate and to employ people. Bottlenecks created by the lack of coordination between the expanding educational system and job market have been responsible not only for economic problems but also for political upheavals. Among the factors which obstruct the better utilization of human resources, the present education and training systems in the Middle East must be included. These countries have a stratified educational system typified at the top by elite and mass universities; and educational hierarchy based on wealth rather than ability is simply not in the interest of these countries, but the lack of clear development objectives has made reform of the old system of education difficult. Even when there are established national development goals, efforts at reform are fragmented and agencies of government lack a coordinated program. One result of this lack of coordinated effort has been the brain drain and the underutilization of existing talent within the country. Bright young students continue to favor the social sciences and humanities, their training in which cannot be utilized in their own country; while they leave to find jobs elsewhere, the country must import labor from abroad to fill the technical jobs created by national development projects.

A second problem area is the near crippling dependence of Arab states on foreign experts. Foreigners design and even run development programs; the Arab states delegate authority and responsibility to foreigners, and this dependence on others for problem definition as well as solution leads to inefficient and inadequate development schemes. A third problem, related to the application of Western objectives to the local situation is the indiscriminate use of Western

education models. Western education is meaningless to rural, agricultural societies; by redesigning the education system to fit the local requirements, the country can increase the absorption of technology. Such absorption is crucial, for these countries must utilize their indigenous talent lest they lose it.

Development problems are complex, and Arab governments must guard against too narrow a definition of these problems. They must see development projects in the broadest possible perspective and bring together the talents of diverse specialists in designing comprehensive development plans.

The economic and human problems, the problems associated with setting development priorities and designing coordinated policies to achieve these goals, the problems involved in balancing rapid development and popular participation -- all are problems highlighted by Iran's experience in recent years. Iran's rate of growth has been rapid and rising; the economy has been expanding, employment and wages are growing, and the fruits of modern civilization -- cars, radios, televisions, etc. -- are enjoyed by ever larger numbers of people.

This prodigeous growth is not due entirely to oil. The relative political stability of recent years and the intelligence of the Persian people have also been important factors. Nevertheless, oil has been the key, and oil revenues are growing and will continue to grow. The role of agriculture in GNP is declining while industry's share is rising, though it should be noted that agriculture, forestry and fisheries are still the largest sector of the economy, involving two-thirds of the population.

However, it is not a sufficient guarantee of Iran's continued stability and growth to ensure the continued flow of its oil. To date, Iran's small elite has benefited most from the growing oil revenues, and corruption at the top of the social and political hierarchies has been ignored. A great deal of attention and resources have been devoted to the visible aspects of Iran's national strength: military power is a major aspect of the Shah's program, and the size of the army and the gendarmerie has been greatly increased; heavy industry has been emphasized since it symbolizes modernization.

At the same time that the Shah has built Iran's international prestige, he has launched a major campaign against internal anarchy and urban guerrillas. The instruments of repression are more prevalent than ever, and large funds have been devoted to building criss-crossing networks of domestic espionage. His concern for domestic security is, to some extent, justified, for, along with the economic growth recorded above, there has been growing dissatisfaction

and frustration. The problem may be characterized as one of imbalance. Despite the growing oil revenues, nutrition in Iran is worse than in most other Middle Eastern countries; many are malnourished. The skew in the distribution of incomes is also great, and it is little wonder that the rising food prices prompted the February 1972 food riots. In short, much of the new wealth has not trickled down to the people. While GNP doubled between 1962 and 1971, employment only increased twenty-three per cent. The government is more powerful and secure than ever before. The people are doing better than in the past, but the improvement has not met their expectations. There is a growing dissatisfaction because the benefits of development have not "trickled" fast enough. Further economic growth will depend on policies adopted now -- especially in areas of education, transportation, and distributional programs. The "showy" projects in heavy industry and international posturing may only serve to emphasize to the Iranian people the gap between the national objectives, as articulated by political leaders, and the realities of their everyday lives.

The will of the power structure in all the states of the region is the key to continued development. It is crucial that those politically responsible be committed to change at an adequate pace and in appropriate directions.

Rapporteur: *Roxann Van Dusen*

Panel III, Saturday morning, September 30, 1972

Presiding: Richard J. Ward, Vice President, R. L. Hines Associates, Inc.

Panelists: Peter K. Bechtold, Associate Professor of Government and Politics, University of Maryland
Oded I. Remba, Professor of Economics and Head of Economics Program, Staten Island Community College
Sevinç Carlson, Member, Senior Research Staff, Center for Strategic and International Studies, Georgetown University

OIL HAVES AND HAVE-NOTS
THEIR RELATIVE DEVELOPMENTAL POSITIONS AND RELATIONS BETWEEN THEM

While similar problems confront the developing economies of both oil "have" and "have-not" nations of the Middle East, their resources and methods of meeting these problems are varied. Generally, in terms of economic development in both categories of states, two important factors must be considered. The first is the necessity for adequate capital and a favorable balance of payments. The second is that the economic development of the "have-not" nations is paralleled by increasing energy demands which drain development funds and create deficits in their balance of payments. Because much attention has been given to some of the more obvious problems of the "have-not" nations in terms of their lack of energy resources, a brief discussion of difficulties facing the "have" nations may be useful. Tremendous oil revenues do not solve all economic problems. Indeed, in some cases, new and more complex difficulties are created. In particular, the manner in which oil revenues are utilized is quite revealing of both the economic and political situation in the country.

Two general categories may be used to examine how the oil "have" countries dispense their resources. The first group of oil-rich countries would include Kuwayt, Saudi Arabia and Libya. These are countries with relatively small populations that have been able to use their oil revenues to develop a more diverse economy. Apart from expenditures on domestic programs, these three have also allocated a portion of their oil revenues for foreign aid. Kuwayt, in addition, has developed its own fund -- the Kuwayt Fund for Arab Economic Development -- and has invested its oil revenues in various other international development organizations as well.

In the second category are such countries as Iran and Iraq. These are oil-rich nations with large rural populations and all the accompanying problems. Of the two, Iran has been more

successful in its attempts to diversify and develop its economy despite the many problems created by the existence of a large tradition-oriented population. Iraq, on the other hand, despite sizeable oil revenues, has been inhibited in its attempts to develop thus far owing to an inefficient land reform scheme, the nationalization of its major industries and continued political instability.

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Turkey, most certainly a "have-not" country in terms of oil revenues, shares similar problems with Iran and Iraq but does not have the benefit of their oil revenues. To compensate, it is forced to depend on foreign aid and loans, both of which must ultimately be repaid. To gain a full understanding of Turkey's present economic orientation, a brief look at its economic history will be useful.

From the collapse of the Ottoman Empire, the Republic of Turkey inherited a heavy foreign debt, almost no economic infrastructure and a system of capitulations. The remnants of the capitulations -- grants of extraterritorial privileges and immunities dating from the seventeenth century -- influenced attitudes toward foreign participation in the Turkish economy long afterwards. Although the capitulations were officially terminated in 1923, the antipathies caused by that system persist down to the present day.

A mixed economic system was adopted in the early days of the Republic. Although the private sector was given some emphasis, its growth was limited by the lack of capital, management and technical know-how, and an entrepreneurial spirit. The shortcomings of the private sector prompted the adoption of a policy of Etatism which allows for active participation by the state in economic development programs while retaining the private enterprise system. In 1927, the Act for Encouragement of Industry provided for the funding of government corporations to be operated as commercial enterprises with public service responsibilities -- for example, providing credit for farmers and conducting training programs for managerial personnel. Etatism was restricted almost entirely to industrialization however. All the other areas of production, including areas in which the state invested (except those under state monopoly), were left open to private enterprise.

Because of the difficulties experienced in obtaining imports during both World Wars I and II industries engaged in the production of consumer goods and other important substitutes received favorable treatment in the immediate post-war period, resulting in the rapid expansion of private industry throughout the late 1940s and 1950s. This period of relative growth -- achieved at the expense of Turkish agriculture -- caused grave economic difficulties,

however, and is today considered one of the greatest mistakes as far as future economic growth in Turkey is concerned.

Planned development as a state responsibility was emphasized in the Constitution of 1961, enacted following the revolution of 1960. Accordingly, a state planning organization was established; since 1962 the organization has prepared two Five-Year Plans. The Third Five-Year Plan is currently under discussion in the Turkish Grand National Assembly. Under the Five-Year Plans, the annual growth rate of the GNP was 6.7 per cent in 1968, 6.3 per cent in 1969, 5.7 per cent in 1970 and 9.3 per cent in 1971. The 1973-77 plan predicts an annual growth rate of 7.9 per cent. Thus it is clear that the Turkish economy is growing -- and along industrial lines -- however slowly.

Two of the most important factors hampering Turkish economic growth thus far have been a shortage of capital and an overdependence on agriculture. In 1970, some 72 per cent of the civilian labor force was involved in agriculture although only 31 per cent of the GNP came from that sector as compared to 27 per cent from the industrial sector and 42 per cent from other activities. The lack of more extensive industrialization to date has permitted the domination of Turkey's economy by agriculture to continue. Other important factors restricting economic development in Turkey are the country's high rate of population growth coupled with increasing unemployment, increased military spending and deficits in the balance of payments. To offset the drain of petroleum import costs on its balance of payments, Turkey has attempted to exploit its domestic oil resources. The first well drilled in Turkey in 1887 was unproductive. Successful strikes did not occur until 1940 and 1951. Foreign participation in developing the country's petroleum industry was encouraged by legislation passed in 1954, which resulted in about 20 foreign companies applying for exploration permits. Unfavorable geological conditions, however, have made exploration efforts thus far quite costly. Adding to the overall cost of production is the fact that the successful strikes which have been made are not connected to existing transportation links.

In 1971, crude oil production in Turkey was 3.4 million tons, nearly a million of which were produced by the Turkish Petroleum Corporation, 1.8 million tons by Shell, about 500,000 tons by Mobil Oil and the remainder by various other companies. At the present time, domestic production meets only 40 per cent of local needs; the rest must be imported. Other energy sources used to satisfy demand are coal, lignite and hydroelectric energy. There is no commercial production of natural gas in Turkey although some liquid petroleum gas and gas produced from hard coal is used for household consumption.

To help meet local consumption needs, most of Turkey's oil comes from neighboring Iran and Iraq. To facilitate the flow of oil from the former an agreement was reached in the late 1960s to construct a pipeline linking Iran to a Turkish Mediterranean port; however, various obstacles have prevented its final approval. In the interim, because of its geographic proximity, Iraq has continued to supply the greater portion of Turkey's imported oil. Turkey and Iraq have also agreed to construct oil and gas pipelines linking their countries, but no action has come of these negotiations. As well, Turkey has arranged for the purchase of petroleum byproducts from several of the oil "have" states; in one case, Turkey agreed to purchase fertilizers from Kuwayt. For the foreseeable future, Turkey will most likely continue to be faced with the dilemma of whether to explore and develop its own oil resources at great expense and against considerable odds or to import an increasing amount of oil in spite of the problems surrounding importation.

* * *

Like Turkey, Israel can be classified as a "have-not" country when compared to the oil rich states of the Middle East. It possesses neither hydroelectric potential nor coal or lignite; some potential for solar energy on a small scale exists, however, and is being developed and utilized at the present time. No decision is known to have been made to develop nuclear energy in the country. Although the Israeli economy is dependent on petroleum, local production of petroleum and natural gas at present fulfills only three per cent of the domestic demand.

Despite more than 200 drillings at the cost of tens of millions of dollars to foreign and domestic companies, both offshore and on, results have been disappointing. No new discoveries have been made, despite the appearance of classical oil patterns which theoretically should have yielded positive results and even though recent discoveries of prolific petroleum accumulations in neighboring areas to the south and north of Israel place it in the center of a probable trend line. Foreign investors have therefore discouraged the Israeli government from further investment in this endeavor.

Current production in the on and offshore fields in the Sinai, now totalling six million tons annually, is about 30 per cent higher than the post-1967 annual production rate and is more than adequate to meet Israel's domestic requirements. Transportation of the petroleum is mainly through a pipeline -- from Eilat on the Gulf of Aqaba to Ashkelon on the Mediterranean -- which was completed in 1970 at the cost of $100 million. There has also been a rapidly

expanding tanker fleet, much of which operate under foreign flags for security as well as commercial reasons. Israeli capacity for petroleum processing has continued to grow; a 4.5 million ton capacity refinery is under construction at Ashdod. This new facility, scheduled to be completed in 1973, will enable the country to export several million tons of refined fuels. Israel will continue to invest in the expansion of all phases of its petroleum industry and some $500 million has already been envisaged for financing various portions of the industry -- particularly tankers and refineries. Investments are also continuing in other oil-rich countries beyond the Middle East, e.g. in British companies producing in the North Sea region.

However, Middle Eastern countries cannot be divided into categories of "have" and "have-nots" on the basis of petroleum resources alone. The development potential of any country depends also on human resources, on economic infrastructure and on geographic factors. In these categories Israel has many of the same types of resources found in some of the more wealthy countries. As a result, it has been able to develop a balanced and diversified economy largely without the benefits of petroleum. In addition, Israel can list as a unique economic asset about $10 billion received in financial assistance from 1950 to 1970 from the sale of State of Israel bonds, payment of West German reparations, contributions from world Jewry, loans and grants from the US government and money injected by private foreign investors into the Israel economy.

At the present time, Israel's biggest economic problem is its balance of payments deficit, caused by a sharp rise in public consumption -- especially in the area of expenditures for defense, which account for one fourth of the annual budget -- and in a rise in cost of living prices generally. Amidst these assets and problems, Israel, like oil-rich countries in the area, is confronted with the need to decide how best to allocate its domestic resources between private and public consumption on the one hand, and investment for growth and foreign exchange on the other.

Nonetheless, something positive can be said in terms of future development of a well-balanced economy for Israel and the other oil "have-not" countries. If excessive reliance on the exhaustible resource or complacency born of non-created wealth are common pitfalls of most Middle Eastern oil producing countries, then it is perhaps a blessing in disguise not to have to deal with that situation. On the other hand, hardly anyone in Israel would regard the country's present very limited oil resources as a blessing; almost any government official would regard a major discovery of petroleum or natural gas as a very real blessing. Currently, despite its geographic and political isolation from other countries in the Middle East (apart from

Iran) which could serve as energy suppliers, Israel has developed a valuable self-sufficiency. Many factors make this self-sufficiency necessary, two important ones being that qualification for World Bank capital investment requires an economically feasible project and that the recipient country must be able to repay the loan.

Despite its limited petroleum resources, and in contrast to other countries in the area, Israel is rapidly becoming an advanced industrialized economy. Evidence for this can be seen in the distribution of its labor force, in current technology research projects, in the range of its industrial production, in the country's intensive and mechanized agriculture, in the advanced welfare programs for the population and in the involvement of both public and private interests in the economy as a whole. For example, the Israeli labor force is unique in that only 8.5 per cent of its members is engaged in farming, compared to 25 per cent employed in industry and over 50 per cent in services. Israel's industrial capacity, moreover, has been bolstered by the development of science-based industries which are connected with the country's educational centers. Many of the growing industries, e.g. the chemical and plastics factories, are closely related to local defense industries. Further efficiency stands to be achieved through the computer and electronic equipment presently being installed in many public and private enterprises. In terms of agriculture, Israel is at present a net food exporter and is capable of meeting almost all its domestic demands with the exception of wheat, meat, fats and oil. In terms of national output and job distribution, the private sector in the Israeli economy accounts for 60 per cent of production and employment, with the public sector and the labor or Histradut sector providing about one-fifth each. Although government control of foreign exchange investment and national planning dominates the agricultural sector of the economy, the liberalization of tariffs and trade barriers has helped to bring about a decrease in direct government controls.

The Israeli experience would thus seem to offer some relevant examples to other Middle Eastern countries facing similar problems of economic development. For example, Israel can point to the achievement of balance and integration in the economic sector of agriculture, industry, mining and trade and commerce. To accomplish its current favorable state of economic affairs, the traditional bias in favor of agriculture had to be overcome. Diversification and industrialization of the economy has been made possible by diverting manpower and resources elsewhere, though not neglecting agricultural development.

Israel has also been able to develop its manpower to suit the needs of the economy through specialized colleges, thereby avoiding an oversupply of skills in any one field. Vocational training programs have also been emphasized. Moreover, the development of cooperative regional agricultural settlements around urban centers has permitted the maximum use of resources in both areas.

Finally, one may ask what kind of economic cooperation is feasible and foreseeable between Israel and her neighbors, presuming an end to the current Arab-Israel conflict. As a partial answer to this question, it would seem that Israel could offer to the Arab states the programs and plans which it has found successful in meeting some of the multi-faceted challenges of Middle Eastern geography, such as advanced methods of irrigation, drainage, soil conservation and use of fertilizers. In all these areas, the development of the country's youth through training and services abroad has been one of the most important benefits. Moreover, a limited number of joint Arab-Israeli ventures have been attempted inside Israel. For example, a type of de facto Palestinian Common Market, which has developed out of five years of Israeli occupation in the West Bank and the Gaza Strip, now employs some 40,000 Arab workers in Israel in construction and agricultural work. Furthermore, greater utilization of the skills of Jewish residents in Arab cities might prove useful to the Arab countries.

Two things, however, should be said in regard to the overall prospects for cooperation. First, Israelis attempt to romanticize the benefits possible from regional cooperation and, second, Arabs tend to exaggerate the possibility of Israeli economic domination and expansion should programs of cooperation be attempted. Realistically, although many schemes have been proposed, there has been very little real inter-Arab economic cooperation. Also working against future cooperation would appear to be the economic, technological and cultural gap between Israel and the Arab countries. Moreover, based on past experience, the types of projects Arab entrepreneurs are interested in investing in do not meet Israeli needs.

Finally, it is important to keep in mind the fact that Israel and the Arab countries have developed their own distinct patterns of trade and development over the past twenty-five years and that any possibilities of real cooperation were certainly greater fifteen years ago than they are today. Israel's foreign trade today is mostly with advanced countries of Europe and the US, though a small amount of trade is with Asian and African countries.

It is true that both Israel and the neighboring Arab countries would benefit enormously from some sort of a peaceful settlement. Specifically, the reduction of military expenditures

and the end of the destruction of their respective countrysides would have a major impact on the economies of both sides. Perhaps of even greater importance for the future is that such a settlement would make regional cooperation a more feasible possibility, particularly for such joint projects as labor exchange, trade and tourism. However, hopes should not be raised too high for just as the lack of cooperation has had only a marginal long term effect on the economies of Israel and the Arab countries, so cooperation may also have only a marginal economic effect.

* * *

Cooperation among the countries of the Nile River valley is a much more feasible prospect, although the current economies, growth potential, and problems facing them are uniquely different. The Sudan, for example, stands in sharp contrast to Libya, with its rapidly growing urban areas, and to overpopulated Egypt, with its financial deficits and troublesome military problems. Although it is the least known of the three, Sudan is the largest country in Africa and the Middle East, encompassing some one million square miles of territory. Sharing a common border with two Arab and six African countries, it serves as a bridge between Muslim North Africa and Asia and Black Africa. Its potential in terms of geopolitical importance is as well known as the north-south political conflict which inhibits its potential growth.

The country's north-south dichotomy, so familiar to many, is a great oversimplification of the intricate diversity of the Sudan. The Sudan is demographically complex: it has some 597 ethnic groups speaking 56 major dialects. The three southern provinces, which contain one-fourth of the total population of the country, may be characterized as mostly Negroid, some 25 per cent of whom are Christian, between three and five per cent of whom are Muslim and the remainder Animists. The people of the six northern provinces, most of whom are Sunni Muslims, are mixed: Semitic, Hamitic and Negroid. The north, while tied more closely to the Arab world, constitutes a symbiosis of Arabism and Africanism. In both north and south, however, the racial and religious groups are seldom pure and hostilities based on various differences abound.

The Sudanese economy is in dire straits, being based on a single cash crop of long staple cotton and its byproducts on which the country has traditionally depended for more than 90 per cent of its foreign exchange. The demand for the crop, however, is declining because of world market fluctuations and the availability of synthetic substitutes. The Sudan has also been cut off from its former markets due to the closure of the Suez Canal, and it may be correct to say that this has caused greater hardships in the Sudan than in practically

any other Arab country. Trade is also inhibited by the present state of the communications and transportation network. In the whole of the Sudan there is only one paved road; other roads, such as they are, are little more than gravel and dirt tracks. There is one narrow-gauge, single track railroad in the country. This lack of transportation and communication facilities has considerable influence upon the political situation and upon Sudan's possibilities for economic growth.

Despite these infrastructural deficiencies, the Sudan has a number of strong economic assets. While neighboring Libya and Saudi Arabia have large capital surpluses and an excess of energy resources in the form of easily exported petroleum, both are plagued by the lack of water in strategic regions. The Sudan, by contrast, has adequate water supplies in most areas. Additionally, the Sudan offers several complementary resources or services to the economic assets and needs of her Arab and African neighbors. For example, it has abundant land for agricultural development in the southern and western regions and alongside its major rivers. On the other hand, it lacks manpower. Egypt is just the opposite: it lacks land but has an oversupply of manpower. Sudan and Egypt both, however, have adequate water for agriculture, irrigation and hydroelectricity. Both also have abundant sunshine although production costs of solar energy to satisfy even local demands make development of this source of energy prohibitively expensive at the present time. The alternative to petroleum energy in the Sudan -- and perhaps in Egypt also -- is therefore hydroelectricity. However, in order to realize the potential of this resource, a vast and costly network is needed to transport the energy. For example, there is now no effective link from the Rosaras Dam on the Blue Nile, immediately north of the Sudan-Ethiopian border, to the areas of greatest consumption elsewhere in the country. As a result, in lieu of other forms of energy, kerosene and butane gas continue to be used to satisfy local consumption.

The discovery of oil would obviously be of great benefit to the Sudanese economy. Exploration of Sudan's mineral resources is now in process but on a limited scale due to a lack of diversity in the country's economic infrastructure and the inability of the government to finance exploration projects itself. However, in view of the existence of other energy sources in the country which could be developed in the interim at relatively less cost, it would be a mistake for Sudan to wait for foreign companies to carry out exploration projects for petroleum, especially when the likely outcome of such ventures is at present unknown.

Sudan's certain economic assets are to be found in three other areas -- animal husbandry, the fishing industry and agriculture.

In the western and southern regions, cattle are numerous and healthy. Likewise, there is an abundance and variety of fresh water fish which could be exported. The lack of refrigeration and canning facilities, however, limit the potential of the fishing industry at this time. In the vegetable and fruit growing areas of the south and along the Nile, there is spectacular agricultural potential. An amazing variety of fruit and vegetable crops could be grown, but current production is concentrated only in a few privately owned enterprises on the banks of the Blue Nile. Given adequate investment, production of meat, fruit and vegetables could easily be tripled.

Before the Sudanese economic potential can be realized, however, it would seem that certain specific changes must occur. First, efforts must be made to insure political stability in the south. Second, necessary investment must be secured in the three areas of potential development outlined above. Third, sufficient markets must be arranged. Land is cheap and of good quality in the Sudan and water is abundant, but marketing remains a problem. The great fruit and vegetable growing areas of the south, for example, are easily accessible to ready markets in Libya and Saudi Arabia, neither of which can meet their own food needs. Specifically, in Saudi Arabia the Hijaz is much closer to the Sudan than those areas which presently supply it with fresh produce. The Saudis have the money and the Sudanese have the land and produce.

Concerning the problem of adequate investments, there is evidence that some of the oil-rich countries of the area have an incentive to invest in such low-profit, oil-poor countries as the Sudan. For example, the Kuwayt Arab Development Fund sponsored its first project in the Sudan. Other investment possibilities would appear to exist through assistance from Libya, should a similar fund be developed there. It may also be true that once the capital surplus countries have exhausted the possibilities of high-profit programs elsewhere, they will begin to turn to areas yielding lower profits but which can perhaps offer substantial political returns. However, before all this is possible a significant attitudinal change will have to occur among the Sudanese themselves -- in both the government and private sectors. In short, a new economic man must be created.

Finally, can the development of Sudan's most obvious asset -- agriculture -- be considered feasible, given the existing resources? The answer would seem to be yes. By way of illustration, consider the fact that the roughly 1000 miles between Aswan and Cairo support 36,000 Egyptians at the present time. If all the Sudanese people were settled along the White Nile, the Blue Nile and three other major rivers (currently about one-half of Sudan's population lives along the rivers), approximately five million people could be supported for each 1000 miles of river land. In addition, the land is more fertile and there is much

more available in the way of water and other natural resources. Moreover, Sudanese cultivators have an advantage over Europeans in that they have large amounts of fertile acreage which may be bought at lower prices. Finally, although it is true that the Sudan has a shortage of necessary manpower, neighboring Egypt could contribute manpower for irrigation and labor for intensive agriculture.

Rapporteur: *Nan Burroughs Anthony*

Last session, Saturday morning, September 30, 1972
Presiding: Parker T. Hart, President, The Middle East Institute

CONCLUDING ADDRESS

Charles Issawi
Ragnar Nurske Professor of Economics,
Columbia University

Mine is billed as the Concluding Address, but I shall not be so presumptuous as to conclude what so many experts, far more qualified than I, have said. I shall try to summarize their main findings. This, fortunately, demands no originality, but before beginning I would like to make one small contribution. I have always thought the subject of Middle East Oil lent itself to poetic treatment and that the Persian poets provided excellent models for this purpose. Many years ago, in 1950, I started a poem patterned on Firdawsi's Shahnameh, called Naftnameh. The first couplet ran as follows:

ʾĀyidāt-i-Duwlat az Shirkat-i-Naft,
Kumak kardand Barnāmih-i-Sālih Haft*

But at that point the industry was nationalized, revenues dried up and the SYP was discontinued, so my poem came to an abrupt end.

More recently I decided to try again, this time taking as my model the quatrains of Omar Khayyam (whose real name I have discovered to have been Omar Zayyat, Omar the oil-maker). Here it is:

The world can roil
And the world can boil
But it can't do without
Middle East oil.

We can work and toil.
We can dig the soil.
But we have no substitute
For Middle East oil.

More precious than pearl,
More exciting than girl,
This and much more
Is Middle East oil.

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* Government income from the Oil Company
Was helpful to the Seven-Year Plan

But there are knots to uncoil
And plots to foil
If we are to continue getting
Middle East oil.

The first overriding fact, brought out by A. J. Meyer and the speakers on Friday morning's panel, is that demand for energy in general is going to continue to grow in the foreseeable future -- at say five per cent per annum, as estimated by Mr. Emerson. The second is that oil will have to provide the greater part of the huge increment. A. J. very rightly pointed out that we are all responsible for the rather scandalous waste of energy that is characteristic of the United States and other advanced societies, and gave some telling examples. Elsewhere I have given some other examples. But I believe A. J. would agree with me that while much ought to be done to reduce this waste, the likelihood is that not much will be done. As Mr. Carlsmith reminded us, the amount spent on research on the demand for energy is only a tiny fraction of that spent on research on the supply side.

What then are the prospects for supply? Dr. Hubbert's very interesting paper had, on me at any rate, a very humbling effect. Compared to the time span of man's recorded history, the era of the fossil fuels seems very brief indeed. Of course he did indicate how tentative all estimates of energy resources are -- one suspects that the main differences between the various figures can be traced to the state of digestion of the compilers, or the quarrels they had that morning with their wives. But whichever figures we take some facts seem clear: that, compared to present levels of output, the resources of oil and even coal are not very great; that production and consumption have been growing at exponential rates, and that such rates of growth cannot be sustained for very much longer. Indeed in the United States we seem to have passed our peak and to be on the other side of the hump -- an experience very familiar to all of us Middle Easterners who have tried to ride a camel.

At this point we should remember the very wise remarks of Mr. Dole, regarding the United States' belief that we can make up our deficiencies from other sources "on our terms and at our prices." Of course we can't: there are the competing claims of other consumers -- Europe, Japan, Soviet Union, eventually China -- who may be able to offer better terms, both economic and political.

Are there no other sources of energy that can be used? As various speakers, notably Mr. Carlsmith, pointed out: there are. Nuclear energy will become increasingly important and shale and tar sands will be exploited. But all these alternatives are available only at a high cost, and will take a long time to develop.

Let us then, with Dr. King, take another and closer look at oil sources. Not surprisingly, he points out that the giant fields are in the Middle East, North Africa and in the Muslim areas of the Soviet Union. I say not surprisingly because that was predicted in Issawi's Law of 1951 which stated: "Where there are Muslims there is oil, the converse is not true." He expects the Soviet Union to have a surplus by 1980, which could go to Japan and perhaps the United States -- other experts are not so sure, and foresee a deficit due to to rising consumption. The North Sea will meet a significant fraction of Europe's needs of oil and gas, as will West African oil. The Arctic, Indonesia and other sources will play their part, as will more exploration in the continental shelves and slopes and secondary and tertiary recovery. But, as far as one can see, the bulk of the increment in world oil consumption will have to be provided by the Middle East and North Africa.

But, as Friday afternoon's very able panelists reminded us, oil is not just a question of deposits but of economics and politics. Mr. Emerson reminded us that to find the 500 billion barrels we shall need between 1970 and 1985 will demand immense sums of money, and that "Investors cannot be coerced into making an investment. They must be wooed." But he also predicted -- rightly, I am sure -- that energy costs will increase appreciably -- in other words consumers can be raped.

Dr. Mallakh reminded us of the economic and political complexities of the situation. There was not an identity of interests between all producing countries, nor was their behavior identical. He thought that we had exaggerated the insecurity of Arab oil and the irrationality of Arab governments and seemed to imply that the latter were reasonably rational. And much of what appeared to be economically irrational was politically motivated -- for example Libya's nationalization of British Petroleum -- and was in response to what was regarded as an anti-Arab policy on the part of the United States and Britain.

Why Britain and not the United States? There is an Arabic proverb which says: "He couldn't deal with his mother-in-law so he took on his wife."

Mr. Stauffer gave us a very spirited critique of United States energy policy, or the lack of one, pointing out its numerous and profound inconsistencies and contradictions. What we seemed to have achieved was "a high price with minimum security" -- not the best terms for an insurance policy.

Examining the possible dangers facing foreign sources of oil imported into the United States, he thought a deliberate boycott

unlikely, but physical destruction of the facilities much more probable. This could occur as a result of a civil war in Venezuela, a conflict in the Persian Gulf or a resumption of the Arab-Israeli war.

Mr. Akins indicated some of the dimensions of the United States' problem by pointing out that, whereas in 1970 we imported 3.2 million b/d, the estimate for this year was 4.6 million, for 1973 six million and for 1980 a minimum of 12 million b/d. This would cost at least $10 billion net, i.e. after deducting the return flow of profits and payments for increased exports. He reminded us that since 1967 we had been living in a sellers' market, and that the ascendancy of the producers would probably continue through the 1980s. The old concession system, which had done good service in its day, was no longer acceptable to producer governments, and new forms of cooperation would have to be devised.

I shall not attempt to do justice to Mr. Yamani's very frank and informative address, which is still fresh in your ears and whose implications you are, I am sure, still pondering. He proposed 51 per cent participation, as the only alternative to nationalization. Participation would create a community of interests between producers and consumers. Producers would then have an incentive to invest some of their surplus revenues in marketing their share of oil, putting up in the consumer countries facilities for this purpose. Consumers would benefit by the links and stability created. One would hope that the re-formed (and hopefully reformed) companies would be able to carry out, in the world markets, some of the functions now performed by the international oil companies, though there would of course still be room for the latter. He concluded by proposing a commercial agreement between the United States and Saudi Arabia, giving preferential treatment in this country to Saudi oil and oil capital.

As for this Saturday's panels, they dealt with the impact of the oil on the region. Since my numerous talents do not include ubiquity, I was not able to follow all three discussions simultaneously. I got the impression that, as the Arabic saying goes -- each was singing his own tune, which is not surprising since each has a very interesting tune to which to sing. Dr. Zonis was struck by the fact that in Iran rapid growth in GNP had not been accompanied by economic diversification or economic and social justice. Dr. Bechtold was impressed by the potentialities of coupling the agricultural resources of the Sudan with the capital and markets provided by Libya. Mr. Dinsmore was struck by the flexibility shown by the Gulf Arabs and their response to the new world created by oil and oil wealth. Mr. Remba pointed out that Israel has begun to play a significant role in world oil markets, through pipelines, tankers, refineries and overseas

exploration. Mrs. Carlson reminded us that Turkey -- not a major producer but in every other respect one of the most important countries of the region -- was facing the same kind of problems as Iran and some of its other neighbors. Dr. Alnasrawi gave us a thorough study of the impact of oil on the economic development of Iraq. This had been smaller than might have been expected, partly because of the enclave nature of the oil industry in the economy of Iraq -- and indeed in other countries -- and partly because of the poor implementation of the successive development plans.

Mr. Ottaway drew our attention to a very interesting political and social phenomenon: the rise of a bureaucratic and technocratic class in Algeria, and pointed out that oil had had a moderating effect on its outlook and policy. Lastly, two speakers reminded us that there is more to the Middle East than oil. Dr. Tannous studied the impact of oil on the agriculture of the region, which is still the source of livelihood of by far the greater part of the population and, in all but the major oil producers, is still the largest segment of GNP and the main supplier of exports. And Dr. Nader raised some important questions regarding the attempt to develop the human resources of the region, discussed the bases on which such attempts had been made and evaluated their degree of success.

I promised to summarize faithfully, and this I have done. Is there anything to be said in conclusion? Only this, that the excellent papers presented at this conference -- and which I hope will soon be published so that we can give them the attention they deserve -- have demonstrated with great clarity and cogency what we had all known vaguely before. The world's energy needs are growing rapidly. The only available source of surplus energy in the immediate future is the Middle East and North Africa. The impact of oil is having a deep, and on the whole beneficial, effect on Middle Eastern economies and societies. Here is a perfect case for a mariage de convenance. But nations, like young people, are not swayed by considerations of convenience alone. There will be many gusts of passion, many quarrels, and much suffering and anguish and tears on both sides before things settle down to the pattern of mature, easy, domestic relations which mutual interests so obviously dictate.

WORLD ENERGY DEMANDS AND THE MIDDLE EAST

26th Annual Conference of the Middle East Institute
in Conjunction with Georgetown University

At the Georgetown University Law Center
Washington, D. C.
September 29-30, 1972

Program

Friday, September 29

8:30 to 9:30 am Registration

9:30 am Opening Remarks — Moot Courtroom

Parker T. Hart
President, The Middle East Institute

10:00 am Presiding: *Parker T. Hart* — Moot Courtroom

Keynote Address

A. J. Meyer
Associate Director, Center for Middle Eastern Studies, Harvard University

10:45 am Plenary Panels — Moot Courtroom

Panel I

PRESSURES OF ENERGY DEMANDS ON RESOURCES

Presiding: *Hollis M. Dole, Assistant Secretary, Mineral Resources, U.S. Department of the Interior*

M. King Hubbert, Research Geophysicist, U.S. Geological Survey - Survey of Total World Energy Resources

Robert E. King, Consultant - Fossil Fuels

Roger S. Carlsmith, Director of Energy Team, Oak Ridge National Laboratory and Associate Director, ORNL-NSF Environmental Program - Alternative Sources of Energy

12:30 pm Luncheon Break

2:30 pm POLITICS OF OIL DEMAND AND SUPPLY Moot Courtroom

Panel II

John D. Emerson, Energy Economist, Energy Economics Division, The Chase Manhattan Bank (Mr. Emerson will also preside) - *Nature and Background of the Bargaining Process*

Ragaei El Mallakh, Professor of Economics, University of Colorado - *Interests and Policies of the Producing States*

Thomas R. Stauffer, Research Associate, Center for Middle Eastern Studies, Harvard University - *Implications for United States Policy*

4:15 pm PROSPECTS FOR COOPERATION BETWEEN OIL PRODUCERS, MARKETERS AND CONSUMERS: THE ISSUE OF PARTICIPATION AND AFTER Moot Courtroom

Presiding: *Peter F. Krogh, Dean, School of Foreign Service, Georgetown University*

James E. Akins, Director of the Office of Fuels and Energy, U.S. Department of State

7:00 pm Dinner Session
Army-Navy Town Club
Farragut Square and Eye Street, N. W.

8:00 pm Dinner

Toastmaster: *Francis O. Wilcox, Dean, School of Advanced International Studies, The Johns Hopkins University*

Banquet Speaker: *Christian A. Herter, Jr., Special Assistant to the Secretary and Director of the Office of Environmental Affairs, U.S. Department of State*

Saturday, September 30

9:15 am — Moot Courtroom

PROSPECTS FOR COOPERATION BETWEEN OIL PRODUCERS, MARKETERS AND CONSUMERS: THE ISSUE OF PARTICIPATION AND AFTER (Cont.)

Presiding: *Parker T. Hart*

Ahmad Zaki Yamani, Minister of Petroleum and Mineral Resources, Kingdom of Saudi Arabia

10:00 am — Simultaneous Panels: WHAT ARE THE IMPLICATIONS OF SPIRALING ENERGY DEMANDS ON THE FUTURE OF THE MIDDLE EAST?

Panel I — Classroom 3

The Economic and Political Impact of Oil upon the Middle East and North Africa

Presiding: *Vincent M. Brown, Executive Director, National Petroleum Council*

Abbas Alnasrawi, Associate Professor of Economics, University of Vermont - *Iraq as a Case Study*

David B. Ottaway, The Washington Post - *North Africa, Focus on Algeria*

Lee F. Dinsmore, U.S. Foreign Service (Ret.) - *Persian Gulf and Arabian Peninsula*

Panel II — Classroom 6

Preparing for Economic Diversification and Strength: Internal Political, Economic and Social Strategies

Presiding: *George A. Doumani, Science Policy Research Division, Congressional Research Service, Library of Congress*

Afif I. Tannous, U.S. Department of Agriculture (Ret.) - *The Promise of Oil in Agricultural Development*

Claire Nader, Associate Director, ORNL-NSF Environmental Program, Oak Ridge National Laboratory - *Human Resources*

Marvin Zonis, Associate Professor of Political and Social Sciences, University of Chicago - *Iran as a Case Study*

Saturday, September 30 (Cont.)

Simultaneous Panels

10:00 am

Panel III — Moot Courtroom

Oil Haves and Have-Nots
Their Relative Developmental Positions
and Relations Between Them

Presiding: *Richard J. Ward, Vice President, R. L. Hines Associates, Inc.*

Peter K. Bechtold, Associate Professor of Government and Politics, University of Maryland - Sudan as a Case Study

Oded I. Remba, Professor of Economics and Head of Economics Program, Staten Island Community College - Israel as a Case Study

Sevinç Carlson, Member, Senior Research Staff, Center for Strategic and International Studies, Georgetown University - Turkey as a Case Study

12:00 noon — Moot Courtroom

Concluding Address

Charles Issawi
Ragnar Nurske Professor of Economics, Columbia University

Adjournment of Conference

Parker T. Hart

3:00 pm

Reception at Middle East Institute
1761 N Street, N. W.