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LAWRENCE LIVERMORE LABORATORY

University of California/Livermore, California

ELEMENTS OF THE WORLD ENERGY CRISIS

Unclassified

Glenn C. Werth

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ELEMENTS OF THE WORLD ENERGY CRISIS*

A Talk Given at the Watchtower-74 Meeting

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Glenn C. Werth

and

Elliott Green

Based on Material Developed by the Energy Systems Group,
Lawrence Livermore Laboratory, University of California,
Livermore, California

The world energy crisis is a large and complex topic. I hope to highlight the chain of events leading to the crisis, point out which countries are primarily affected and identify what options they may have. This is a large topic and I approach it with humility. There are others who have studied the problem more thoroughly than I, and I welcome their comments and any opposing views.

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*Work performed under the auspices of the U.S. Atomic Energy Commission.

A discussion of energy should start by pointing out the fact that as man has moved from the primitive and hunting stage through the agricultural and industrial stage and on to the technical stage, his consumption of energy has risen enormously (Slide 1). The energy crisis, therefore, is really a crisis of the highly industrialized technological nations. This point is further illustrated in the second slide in which the gross national product per capita is plotted against the total energy per capita. The United States is the largest per capita user of energy and stands far out on the curve. Next are the countries of Western Europe and then, with about the same energy consumption per capita but a lower gross national product, come the Soviet Union and her East European allies. The position of Japan is on the curve and should also be noted.

The consumption and production of these major regions of the world are displayed in Slide 3. The tails of the arrows show the consumption and production in 1953, and the head of the arrows show the situation in 1969. For example, in 1953 North America's production almost equaled consumption as indicated by the position near the 45 degree line. By 1969, however, North America had become a moderate importer of energy. The Soviet Union and her Eastern European allies, "planned economies" in the United Nation's data, were in balance in 1953 and a slight exporter in 1969. On the other hand, Western Europe, in 1953 a slight importer, has since actually cut production and increased consumption by about a factor of two. Asia-Pacific, principally Japan, has also increased consumption.

This changing pattern of energy flow is more dramatically shown in Slide 4, which is restricted to world petroleum flow. North America has become a 25 percent importer of oil; the Soviet Union is a slight exporter and Western Europe and Japan have enormously increased their consumption of imported oil. In this same time period oil has, of course, come from the Middle East, from Central America (including Venezuela), and from Africa. African oil is principally Libyan production. One can see that early in the 50's, the big users of energy were more or less self-sufficient, but since that time there has been a shift to a very large commerce in oil.

The reason for the shift is one of economics. If you were an oil company president with funds to invest in oil exploration and you asked yourself the question, "Where can I get the largest capacity for my dollar?" you would note the information displayed in Slide 5. A $5500 investment would obtain a barrel of daily capacity in the United States. In Canada it would require $4500, in Venezuela $1300, and in the Middle East $300. Thus there is a factor of 20 difference in what it costs to obtain oil between the United States and the Middle East. The reason for this large difference lies in the nature of the oil fields. In the United States a well is drilled, a 3 to 5 meter oil-bearing sandstone is found, and it is considered to be a good oil field. In the Middle East, however, the producing formation is 100 meters thick and extends over a considerable area. With Middle East oil wells costing 5 percent of their U.S. equivalent, investment quickly moved to that region of the world.

The typical cost of Middle East crude is shown in Slide 6. The time period here is 1955 through 1970. The direct cost of production is eight cents per barrel; direct cost is the cost of operating the pumps and maintaining the equipment. Amortization of capital takes an additional ten cents, for a total cost of production of about 18 cents. Apart from inflation, that is still the cost of Middle East production today. During the period from 1955 through 1970 the royalty and taxes amounted to 93 cents.

The posted Middle East crude price was $1.80, which yielded 69¢ for oil company overhead and profit. Transportation to the U.S. was about 45¢, giving a delivered cost of Middle East crude to the U.S. of $2.25. It was quite clear that unlimited availability of this cheap Middle East crude would quickly destroy the U.S. oil industry. At $2.25, Middle East crude was at least $1.00 under the U.S. oil price. The U.S. debated the problem and decided that oil was too basic to national and economic security to allow dependence on Middle East crude. Therefore, the U.S. adopted a policy of oil quotas which limited the import of Middle East oil to a fraction of domestic production, and thus protected the domestic industry.

An interesting result of this policy is shown in Slide 7. Middle East exports to the Western Hemisphere actually decreased slightly from 1960 to 1970. The rest of the world, Western Europe and Japan in particular, took advantage of this cheap Middle East crude oil, and expanded their imports dramatically. In the process they built their economies on this oil. The oil producing countries, of course, received the revenue or profit of 93 cents a barrel. Escalation of the host country receipts started in 1970. These receipts are shown in Slide 8. Kuwait's profit reached $1.6 billion in 1962, Saudia Arabia reached $3.1 billion and so on. Over the years these funds were, in part, used to develop their own countries. These funds have also been used as "foreign" aid to other Arab countries, since the countries having significant oil production constitute only 10 million of the 100 million Arab people in the world. These funds have been used to finance in part the war against Israel and the Palestinian Liberation Movement. It is reported that Libya has been bankrolling the Irish Republican Army.

These revenues were coming in at such a rapid rate that finding adequate investments became increasingly difficult. Since development and investment could not absorb the funds, foreign exchange reserves built up rapidly, as shown in Slide 9. These reserves are basically demand deposits in European central banks. A year ago, when the dollar was weakening, there was considerable suspician that Arab countries, in order to protect their reserves, sold dollars and bought West German marks, Swiss francs and yen. With huge amounts of money involved, such action led to further deterioration of the dollar. Gradually the Arab countries came to realize that their wealth was their oil, that it should be conserved, and that the best conservation program was leaving it in the ground. Last year Libya actually decreased production. Kuwait announced no further increases in production and Saudia Arabia stated that they would only increase production out of friendship for the United States. So, at the time of the 1973 Egyptian-Syrian War against Israel, the stage was set to use oil as a political weapon. It was an opportune time to restrict production, inasmuch as many of the Arab nations had already planned cuts. The production cut shocked the world, but the total embargo against the United States and the Netherlands turned out to be leaky. After assessing this, the Arabs decided that their most important political weapon was price. They raised the host country receipts to $7.00 a barrel which represents a 700 percent increase from the 93 cents that prevailed from 1955 through 1970. The return to more normal levels of production may also have been spurred by the realization that Western nations could take effective countermeasures. Such countermeasures might include a ban on sales of machinery and hardware and a ban on technicians working in the Arab states. Perhaps the most telling argument, however, was that a dramatic reduction in oil production might trigger a world-wide economic recession, which would, in turn, affect the prosperity of the Middle East itself.

And so the world finds itself in the position shown in Slide 10 in which the production is the black hemisphere and the consumption the white hemisphere. The large producing areas are, of course, the Middle East, North Africa and the Caribbean, as well as the USSR and the U.S. The large consuming areas are the United States, Western Europe, the USSR and Japan. So the real problem of the energy crisis is: What are these four large consuming areas going to do? Since these are the large industrial regions of the world, the health of their economies affects the whole world.

First, however, let us take a look at the enviable Mexican situation where production and consumption are in balance. The figures are given in Slide 11. I am certainly no authority on the consumption and production of energy in Mexico but these are figures taken from the standard reference books. They show that domestic production was slightly ahead of consumption and a small export trade resulted. The reserves picture is shown in Slide 12.

Using the usual ratio of reserves to current production, there is a 15.5 years supply of oil and 16.6 years of gas. Coal is in much larger supply. These reserve-to-production ratios are comfortable margins and, on the surface at least, it appears that Mexico will be spared major energy problems through your own foresight and reserves planning.

The world, however, needs to develop other sources of energy. Mexico is to be congratulated on her geothermal development at Cerro Prieto in Baja, California. Figure 13 is a picture of the plant producing 75 megawatts of electrical energy from the heat of the geothermal waters. The United States is just starting the development of geothermal energy; in fact our Laboratory has just received about $400,000 for the development of United States geothermal resources just north of Cerro Prieto. Unfortunately the Salton Sea resource has ten times the dissolved salts of Cerro Prieto. Hence, the techniques that you are using at Cerro Prieto cannot be used at Salton Sea. Nevertheless, we believe that research will find ways of utilizing such water and improving the efficiency of generation. International cooperation in the development of geothermal resources has already started. Our Laboratory hosted a meeting last October attended by representatives from eleven countries, including Mexico. The conference included a field trip to Cerro Prieto. As this international research effort makes progress, the world should see dramatic increases in geothermal energy utilization in the coming years.

Turning now to the Soviet Union, we find crude oil production rising dramatically, as shown in Slide 14. In 1970 the USSR was producing about 350 M metric tons against an estimated reserves of nearly 500 M metric tons, for a production-to-reserves ratio of about 14. The Soviets exported about 25 percent of their oil production. The dollar value of their exports is given in Slide 15. In 1971 about $700 million worth went to western countries and $1 billion to the Eastern European countries. The Soviet Union has difficult selling manufactured goods in Western countries, so she has decided to sell raw materials: oil, gas and mineral resources.

Apparently, these sales are being made to Western countries to earn hard curriencies for machine goods and other capital items. In a sense then, the Soviet Union is a competitor of the Arab countries. Clearly, the dramatic increase in world-wide prices will benefit the Soviet Union. The planned expansion of oil and gas production will come from Siberia. A great deal of technology is needed to develop these fields and, of course, they will come in at a significantly higher cost than production from European Russia.

Let us now turn to the United States. United States' energy flow is shown in Slide 16. The sources of energy are given at the left: petroleum, coal and gas. The width of the lines is proportional to the energy that flows. The units are 10^{15} BTU. 10^{15} BTU is equivalent to 171 million barrels of oil, 41 million tons of coal and a trillion cubic feet of gas. The uses of energy are shown in the middle of the chart. Residential and commercial usage is primarily for space heating. Industrial usage is for space and process heating. The non-energy uses are for petrochemicals, plastics and fertilizers. Finally, the chart shows the useful and rejected energy and is, in a sense, a measure of efficiency of energy utilization. The imported energy in 1971 shows a total of 7.5 units in oil and 1.0 unit in gas. Imports were thus a small fraction of our energy usage in 1970; since then that fraction has approximately doubled. It is significant that we are major users of petroleum, coal, and gas because this gives us flexibility to change from one to another, as the situation warrants. Transportation, however, is vulnerable because it depends exclusively on petroleum.

There are several projections of U.S. supply and demand; one set is shown in Slide 17. The supply projection includes increased production from conventional recovery of oil, gas and coal. The nuclear reactor will become an equally important contributor in the years ahead. Even with increasing supplies, the projected total demand indicates a growing gap, here labeled imports, which has increasingly concerned the U.S. Thus one can see that new technology is needed to increase our supply and to reduce demand. In our view, a vigorous research and development program could reduce the need for imports - as shown on the chart. In the meantime, with the partial embargo of Middle East oil, other measures have to be taken, and one important measure is conservation. The United States has not been conservation conscious during the last 20 years. We now find that, under the embargo, more efficient management can reduce industrial energy consumption 10 percent without affecting productivity. That also seems to be true in homes and in transportation. It is, of course, not completely clear how the crisis will be weathered in the United States, but I am optimistic that, with conservation, there will not be major disruption of the economy.

The U.S. fossil energy resources are shown in Slide 18. The first column is the present situation with our current technology, current prices ($4.00 a barrel for oil at the time the chart was made) and proved recoverable resources. The present fossil fuel reserves amount to 6,800 x 10^{15} Btu (10^{15} Btu), principally because of the large coal reserves. The 1970 usage was 71 x 10^{15} Btu and so the reserve-to-production ratio is about 100.

Prices are going up and so we show in the next column domestic oil at $5.00 a barrel, which permits the offshore fields to be developed. Also included are the undiscovered resources, namely those which have not yet been drilled. These are expected to come in as deeper offshore prospects are explored. If new technology is added, then additional resources are anticipated at these higher prices. The new technologies should approximately double reserves; the United States will have fossil fuel until at least the middle of the next century.

These new resourses are primarily coal and oil shale. Since these are solids there is much concern about whether the United States will do the underground and open-pit mining required to recover the resources. The mine dumps and safety problems associated with mining make conventional recovery of these resources unattractive. One of the newer techniques proposed for recovery of the resources is what we call the in situ resource recovery method. Slide 19 shows that recovery concept for coal. In the western part of the United States there are thick, deep coal beds at depths of 300 to 800 meters. We envision drilling a series of holes, loading chemical explosives in those holes, and fracturing the coal. Oxygen and water are pumped down the holes and the coal is burned in place to produce methane, carbon monoxide and hydrogen. In essence then, the coal is gasified in place. The methane is, of course, pipeline-quality gas. The carbon monoxide and hydrogen can either be made into methane or can be made into methanol (a liquid) and used as a transportation fuel. In situ recovery is only in the research and development stage, but we feel that it is the technology of the future for recovery of the energy from coal and oil shale. Mining is avoided and because the earth itself is used as the retort vessel, in situ processes ought to be about half the cost of other methods.

Moving on to non-fossil energy resources, Slide 20 shows that the present uranium situation is limited, but that a 30 percent increase in the price of electricity would permit tapping large amounts of additional uranium ore. In addition to the uranium, the new technology of the high temperature, gas gooled reactor (HTGR) would permit thorium to be used as a fuel. Also, the geothermal development will add sizable reserves. The U.S. is indeed fortunate in having abundant resources.

Next, let us turn to a consideration of the European situation. The energy flow diagram is shown in Slide 21 for the original six nations in the Common Market. Coal is produced within the Common Market, but the major source of energy is imported oil. Oil is basic to industry and to residential home heating.

Slide 22 shows that in 1960, 60 percent of the energy requirement in Western Europe as a whole came from coal, with only 33 percent from oil. By 1970, 60 percent was in oil and 30 percent was in coal. Western Europe built her economy on the cheap Middle Eastern oil costing her about $2.00 a barrel. With the enormous price rises in oil($8.00 a barrel and up) a major change in the European economy will take place; the projections shown here for 1980 will never happen.

The situation by country is shown in Slide 23. West Germany and the United Kingdom are the largest consumers, importing about 45 percent of their energy, the rest being primarily from coal. The North Sea is growing in importance and is a more important producer of oil than the U.S. Gulf Coast. Almost all the oil found so far lies in the British and Norwegian sectors of the North Sea. Hence, by 1980 those countries should be self-sufficient in oil, and in fact, could become oil exporting countries. France and Italy, the two next largest users are critically dependent on imported oil. The Netherlands is the lowest importer of all the European countries principally because of her gas field, and will be less affected by dramatic price increases. The principal option open to the Europeans is a return to coal. A 400 percent increase in oil price allows greater pay for miners, better working conditions, and the working of lower grade deposits. Again, I would encourage the Europeans to consider <u>in situ</u> recovery of coal because it causes less environmental damage and it costs less. It would, however, have to be specialized to match the nature of the European coal beds. Europe of course has good reactor technology. Because the breeder reactor is less dependent on the fuel supply, it is particularly attractive. Consequently, it is no surprise to find that the United Kingdom, France and West Germany all have strong breeder reactor programs. The United Kingdom, the Netherlands, and France have oil technology and, of course, participate in world-wide exploration. The recent enormous oil price increases should stimulate joint exploration ventures with the less-developed nations of the world. The Europeans have the technology, the capital and the motivation to respond.

The Japanese are in the most critical situation. Slide 25 shows the Japanese energy flow, and essentially all of their energy is imported. Imported coal is needed by their steel industry and petroleum provides the remainder of the energy. Note how large the non-energy use is in their economy. Very little energy goes for discretionary transportation, and thus cutbacks directly effect their industrial strength.

The history of energy utilization in Japan is shown in Slide 26. In 1960, 55 percent of the energy was coal and 36 percent oil. By 1970 coal had increased in absolute terms, but only 23 percent of the energy was from coal, while oil provided 72 percent. Clearly, with the international oil price of $8.00 or more, the projected 1980 usage of oil will not come to pass.

Japan has an additional problem shown in Slide 27. A tanker leaves the Middle East every 15 minutes for Japan. The usual route is through the Straits of Malacca. Japan wanted to widen and deepen the Straits. Indonesia and Malaysia said no, declaring them territorial waters subject to closure at any time. In fact any of the straits through the Indonesian Archipelagos could be closed at any time, although the Indonesians said they had no intention of effecting such closures. Therefore, Japan has two problems. Japan has both an insecure supply and a vulnerable supply route.

Japan recognized the vulnerability of imported oil in 1967 and developed a plan to alleviate the situation. An oil tariff was enacted to provide funds to Japanese companies to carry out the activities shown on the chart. By and large this effort has failed. The oil exploration effort, in particular, failed, perhaps because Japan did not have the needed technology. Now, by national policy, she is teaming up with Western oil companies to obtain the needed oil exploration technology. To her chagrin Japan has found that her refineries in Saudia Arabia did not protect her against cutbacks in oil. The pipeline with the Soviet Union is still under negotiation. The United States is selling liquefied natural gas from Alaska but the Canadians have said they want to finance a billion dollar tar sands project through Canadian sources before considering the proposed Japanese project.

Western Pacific Basin energy resources are shown in Slide 29. That area of the world has not been well explored and it would seem that Japanese capital teamed with European or U.S. technology could find significant new resources.

By way of summary, Slide 30 shows that the Soviet Union and the United States can easily take care of their own energy needs. They have not built their economies on Arab oil. The Soviet Union has extensive oil and gas reserves and may want to become an exporter of oil. They do not need western technology for development.

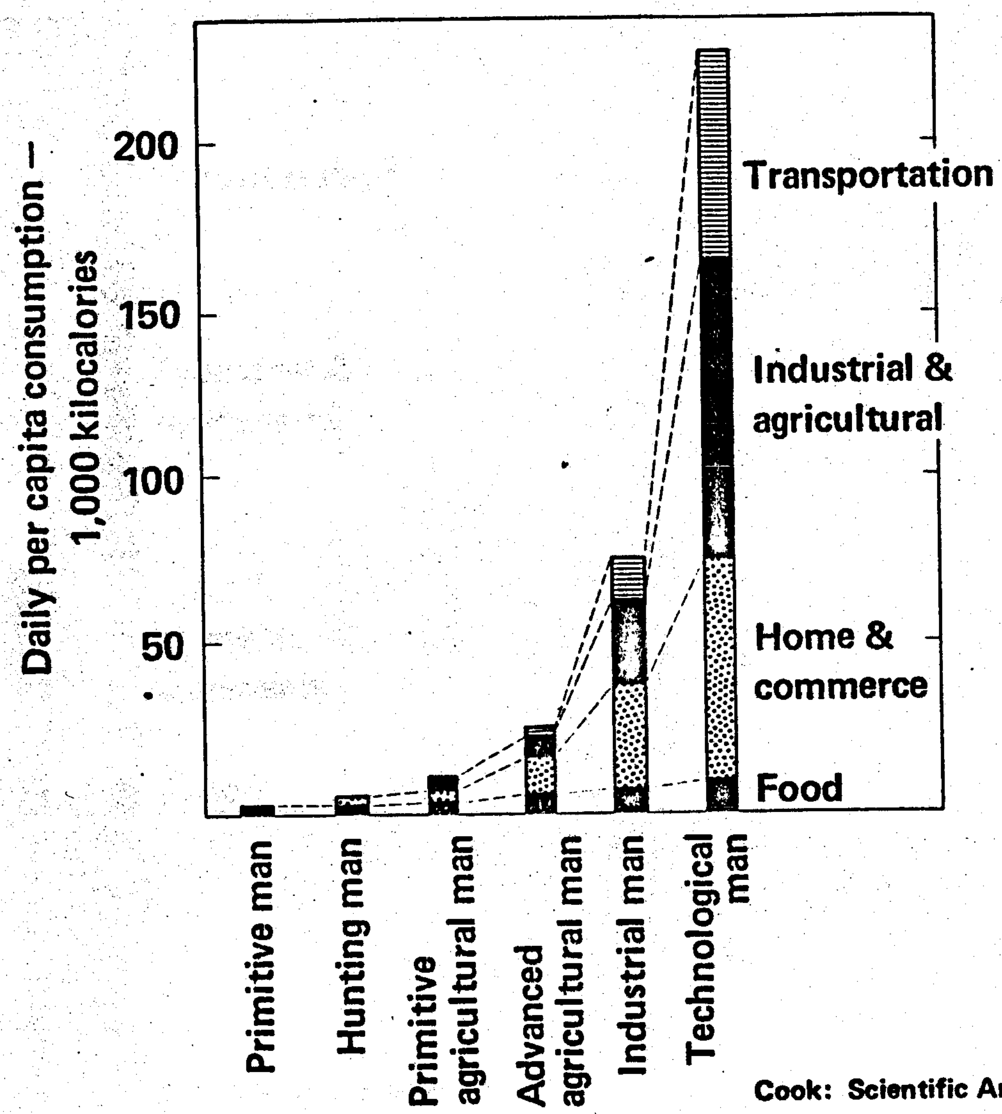
The U.S. has extensive fossil fuel reserves, but needs to develop technology for coal and shale. If this is done the U.S. could become an exporter of energy, or it may prefer limiting production to lessen the impact on the enviornment caused by mining.

Western Europe is in a critical situation with the price of oil up by a factor of four. The Europeans could develop their coal and should, I think, develop in situ methods for recovering the coal. They will also probably participate in world-wide efforts to develop additional oil resources. Reactors, particularly breeder reactors, are promising for Europe.

Japan is in the most critical situation. Her economy will clearly suffer a setback from increased oil prices. In one sense history seems to be repeating itself in Japan's quest for resources from outside her island. Now, however, she has the capital for development, although much of that capital needs to be used internally in improving living conditions. The utlimate answer for Japan may be Herman Kahn's idea of a trade area. This system would provide all nations in the area a share in a secure system of economic growth.

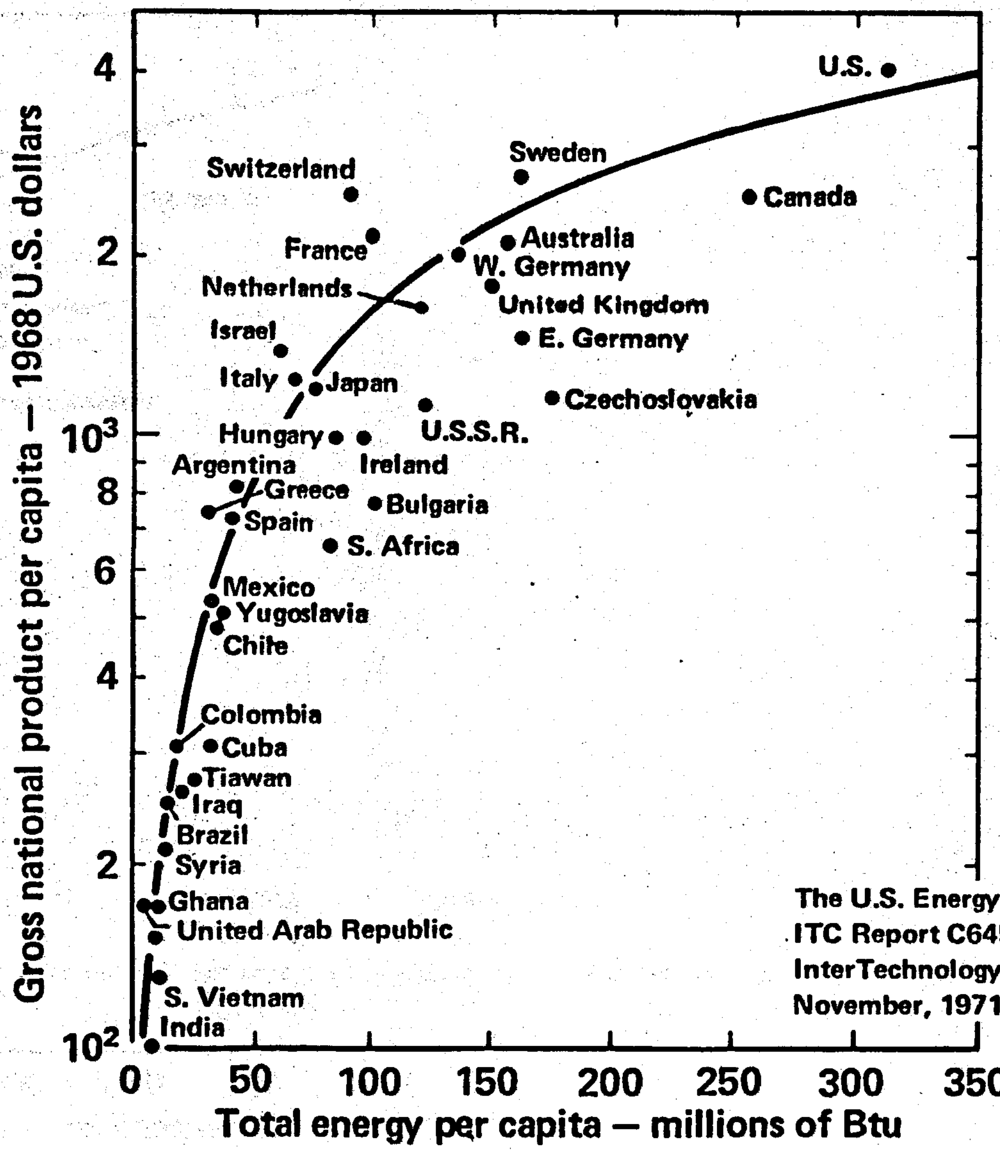
Overall, the severity of the price increase of oil is not yet clear, but in my judgment at least a slowdown in the general world economy will occur.

ENERGY CONSUMPTION



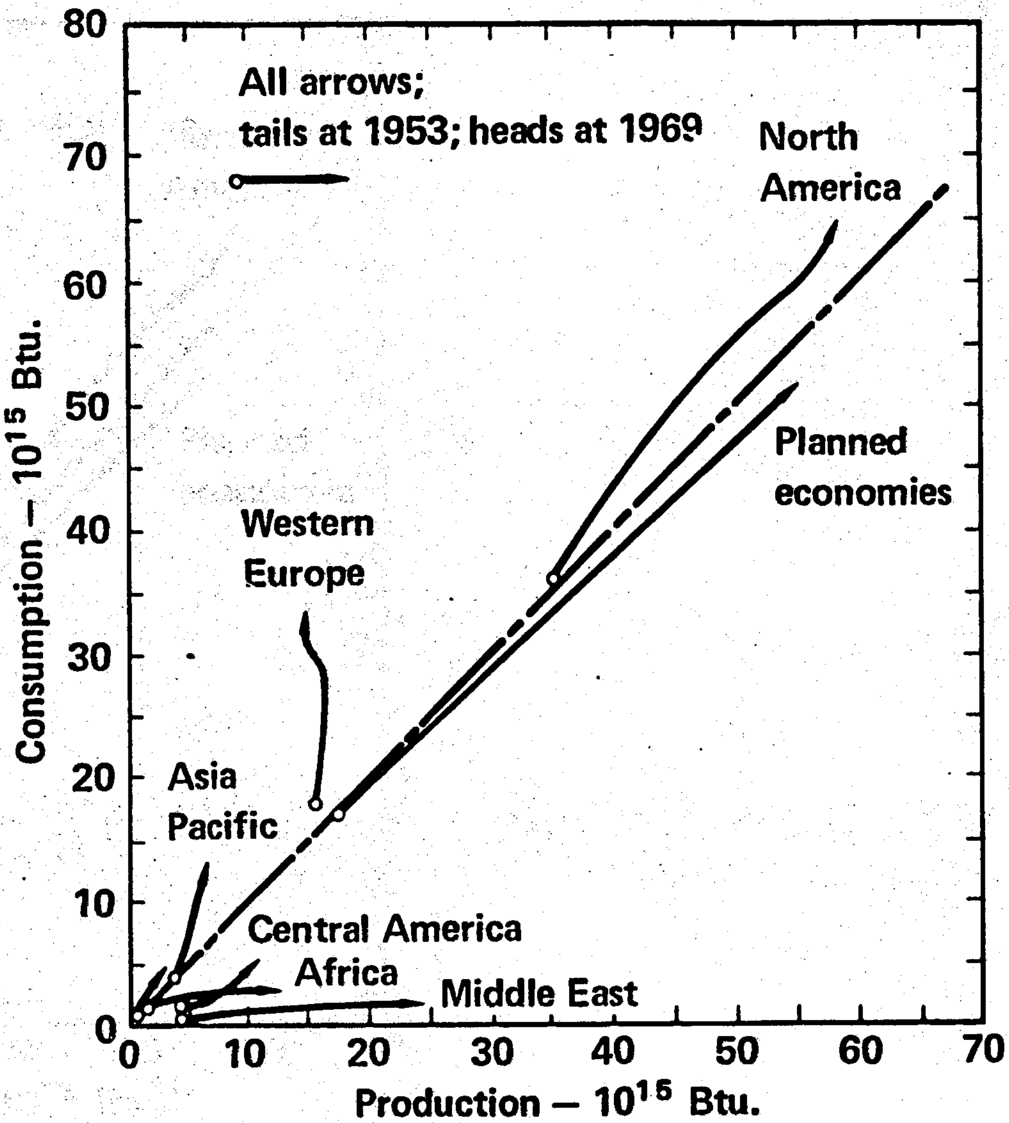
Cook: Scientific American

GROSS NATION PRODUCT AND ENERGY



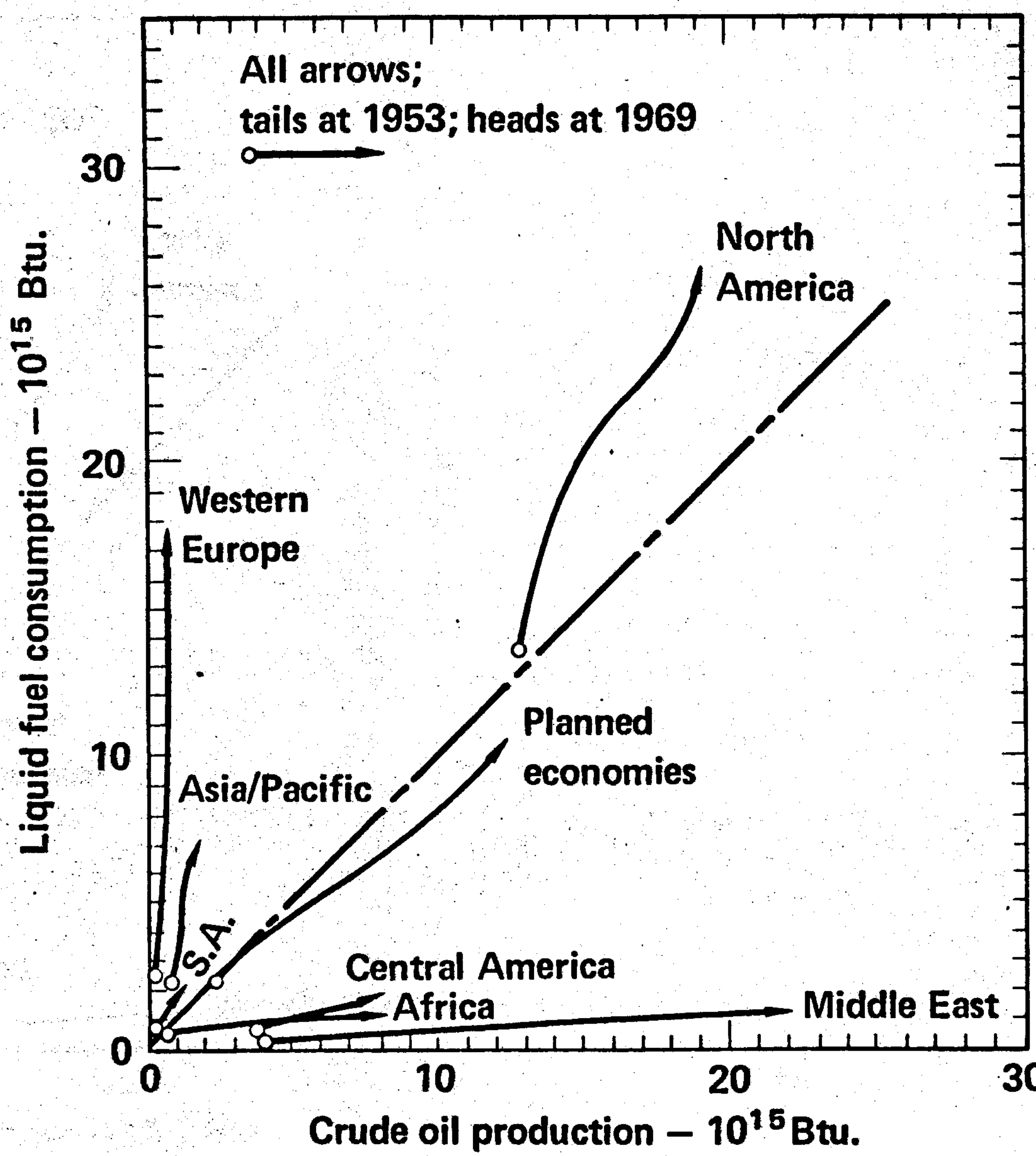
The U.S. Energy Problem, Vol. I
ITC Report C645
InterTechnology Corporation, Warrenton, Va.
November, 1971

WORLD TOTAL ENERGY FLOW



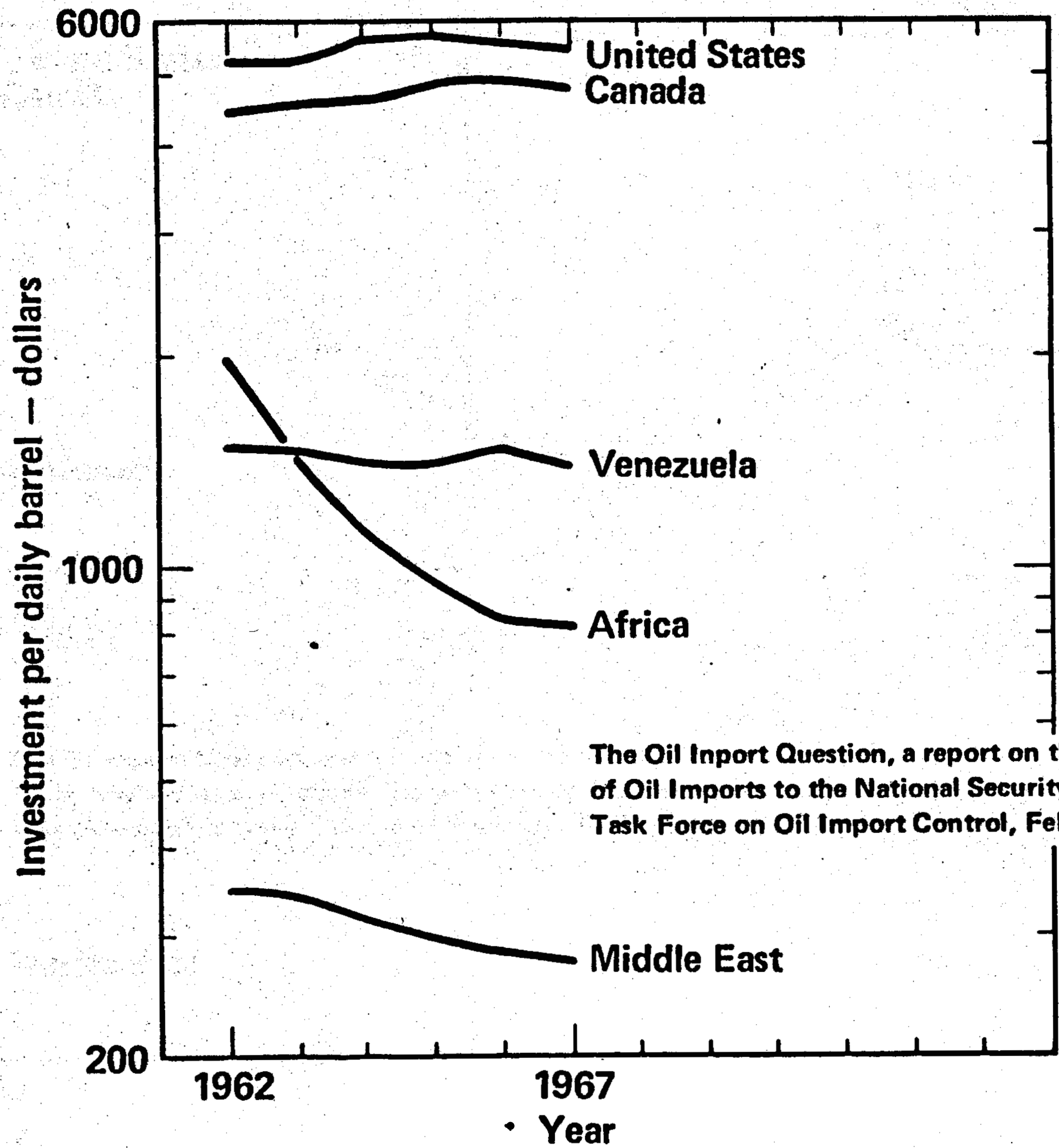
U.N. Statistical Yearbook 1970

WORLD PETROLEUM FLOW



U.N. Statistical Yearbook

GROSS INVESTMENT IN CRUDE OIL PRODUCTION



The Oil Inport Question, a report on the Relationship of Oil Imports to the National Security by the Cabinet Task Force on Oil Import Control, February 1970)

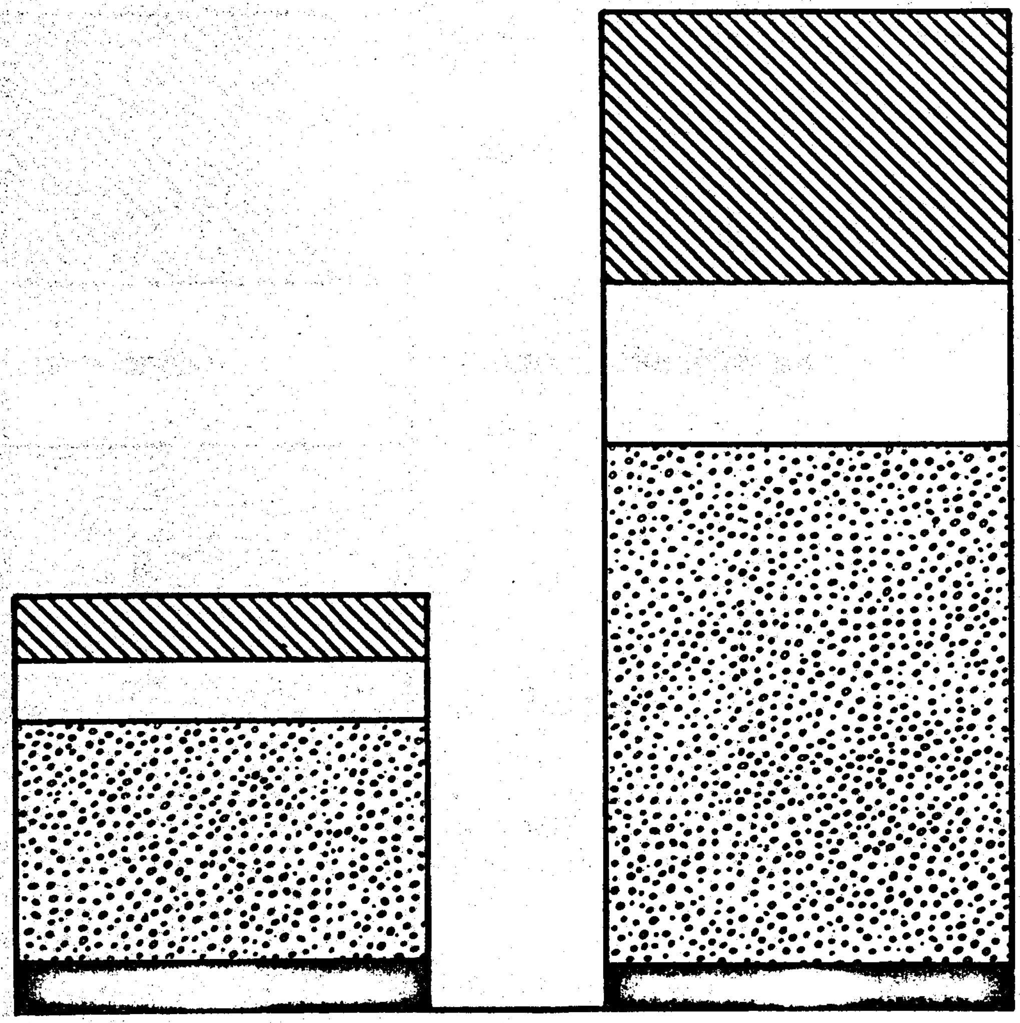
TYPICAL COST – MIDDLE EAST CRUDE

1955-1970, Per Barrel

Direct cost for production	$ .08		
Amortization of capital	.10		
Cost of production	.18	.18	
Royalty	.23		
Tax	.70		
Host country receipts	.93	.93	
Oil company overhead & profit		.69	
Posted price Middle East crude		$1.80	1.80
Transportation to U.S.			.45
Delivered cost Middle East crude			$2.25
U.S. produced oil price			$3.25

The Oil Import Question by the Cabinet Task Force on Oil Import Control, Febrfiary 1973, page 273.

MIDDLE EAST EXPORTS BY DESTINATION 1960 & 1970



Issawi, C., "Oil, The Middle East & The World," Washington Papers, 1972.

OPEC COUNTRY RECEIPTS

(Total Dollars in Millions)

Country	1970	1971	1972	1973
Kuwait	897	1,400	1,657	2,130
Saudi Arabia	1,200	2,149	3,107	4,915
Iran	1,076	1,944	2,380	3,885
Iraq	513	840	575	1,465
Abu Dhabi	231	431	551	1,035
Qatar	122	198	255	360
Other Mideast	150	193	233	
Total Mideast	4,189	7,154	8,747	13,790
Libya	1,295	1,766	1,598	2,210
Algeria	–	350	700	1,095
Nigeria	–	915	1,174	1,950
Venezuela	–	1,702	1,948	2,800
Total Receipt	–	11,887	14,167	21,845

Oil & Gas Journal, October 29, 1973.

Petroleum Press Service, from the Washington Papers, volume, "Oil, The Middle East and the World," by Charles Issawi.

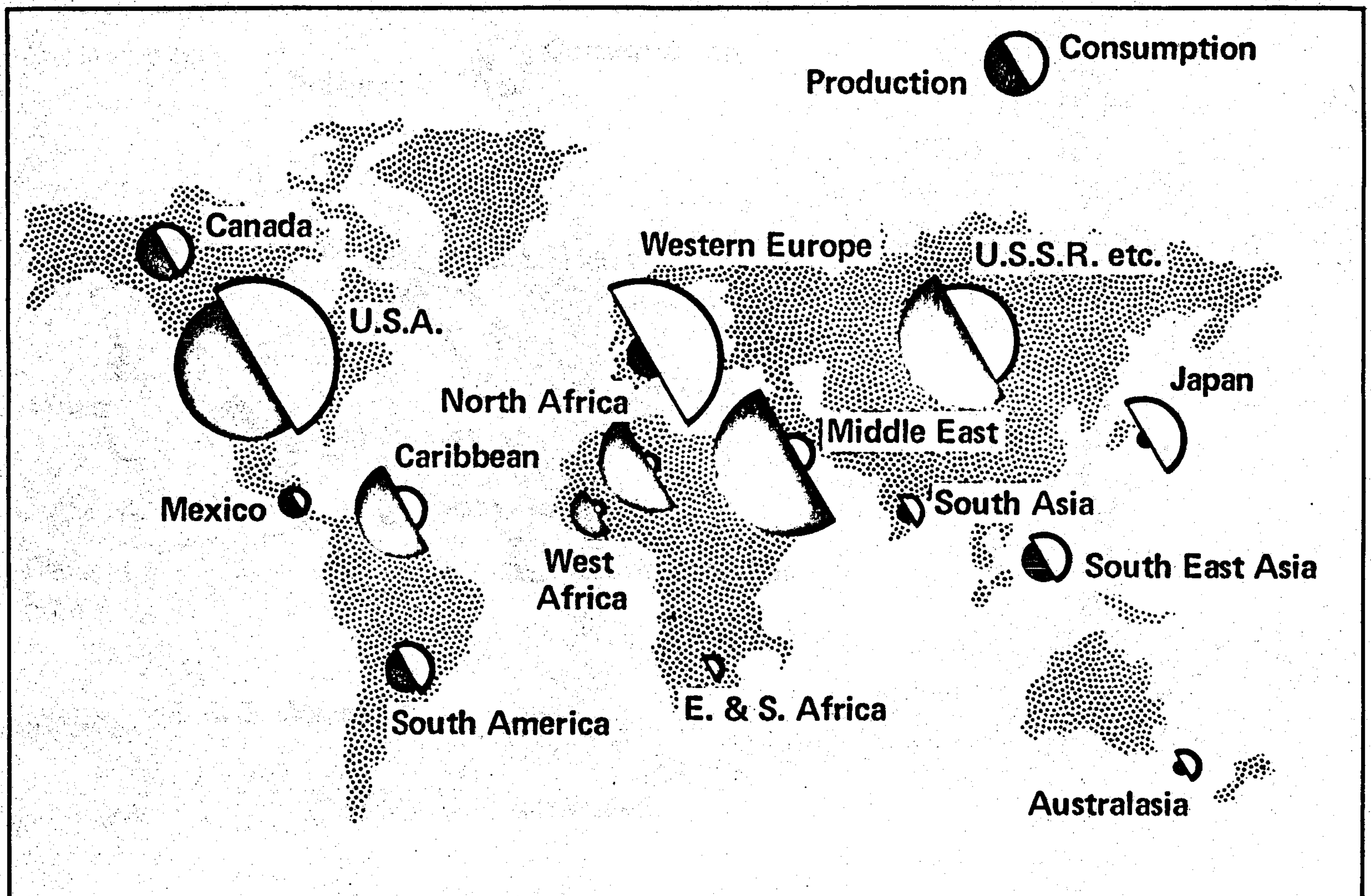
OPEC COUNTRIES FOREIGN EXCHANGE RESERVES

Millions of dollars

Country	6/71	6/72	6/73	7/73	8/73	9/73
Kuwait	110	265	441	515	413	422
Saudia Arabia	793	1777	2965	3505	4200	—
Iran	180	633	931	941	880	727
Iraq	263	505	998	913	928	1000
Abu Dhabi	—	—	—	—	—	—
Qatar	—	—	—	—	—	—
Total Mideast	1346	3180	5335	5874	6421	
Libya	2239	3049	2607	2512	2369	2324
Algeria	200	150	156	222	256	303
Venezuela	617	831	1116	1098	1038	911
Indonesia	102	313	701	720	770	852
Total	4504	7523	9915	10426	10863	

International Financial Statistics, Vol. XXVI, No. 11, International Monetary Fund.

WORLD OIL SUPPLY AND DEMAND 1970



Source: Issawi, C., "Oil, The Middle East & The World," Washington Papers, 1972.

CONSUMPTION – PRODUCTION – MEXICO 1970

(Millions metric tons coal equivalent)

	Consumption	Domestic production	Imports	Exports
Oil	36.2	36.2	–	–
Gas	22.0	23.1	.5	1.6
Coal	2.0	1.6	.5	–
Hydro/nuclear	1.9	1.9	–	–
TOTAL	62.1	62.8	1.0	1.6

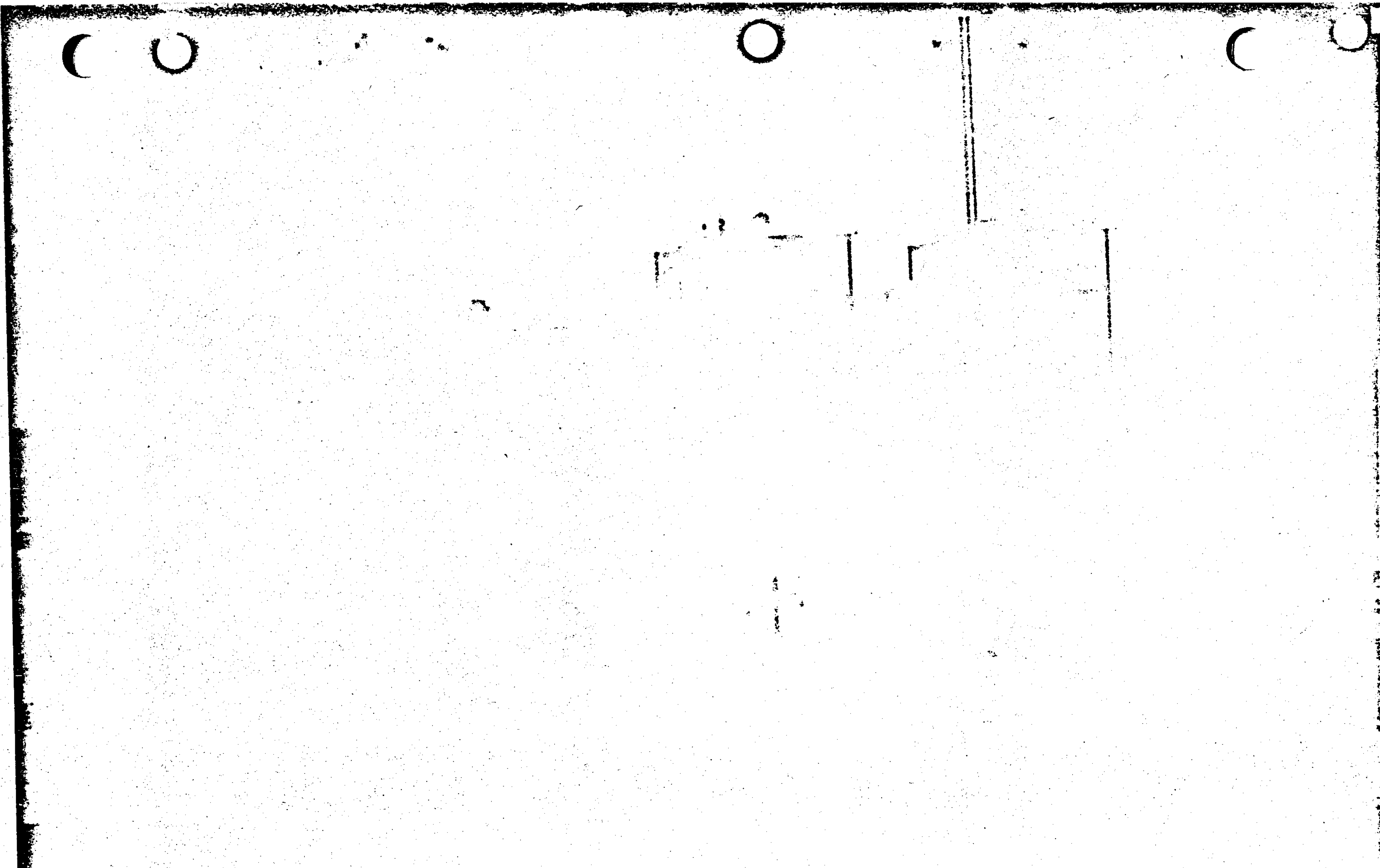
Source: United Nations, World Energy Supplies 1961-1970, Series J, No. 15.

ENERGY RESOURCES – MEXICO – 1970

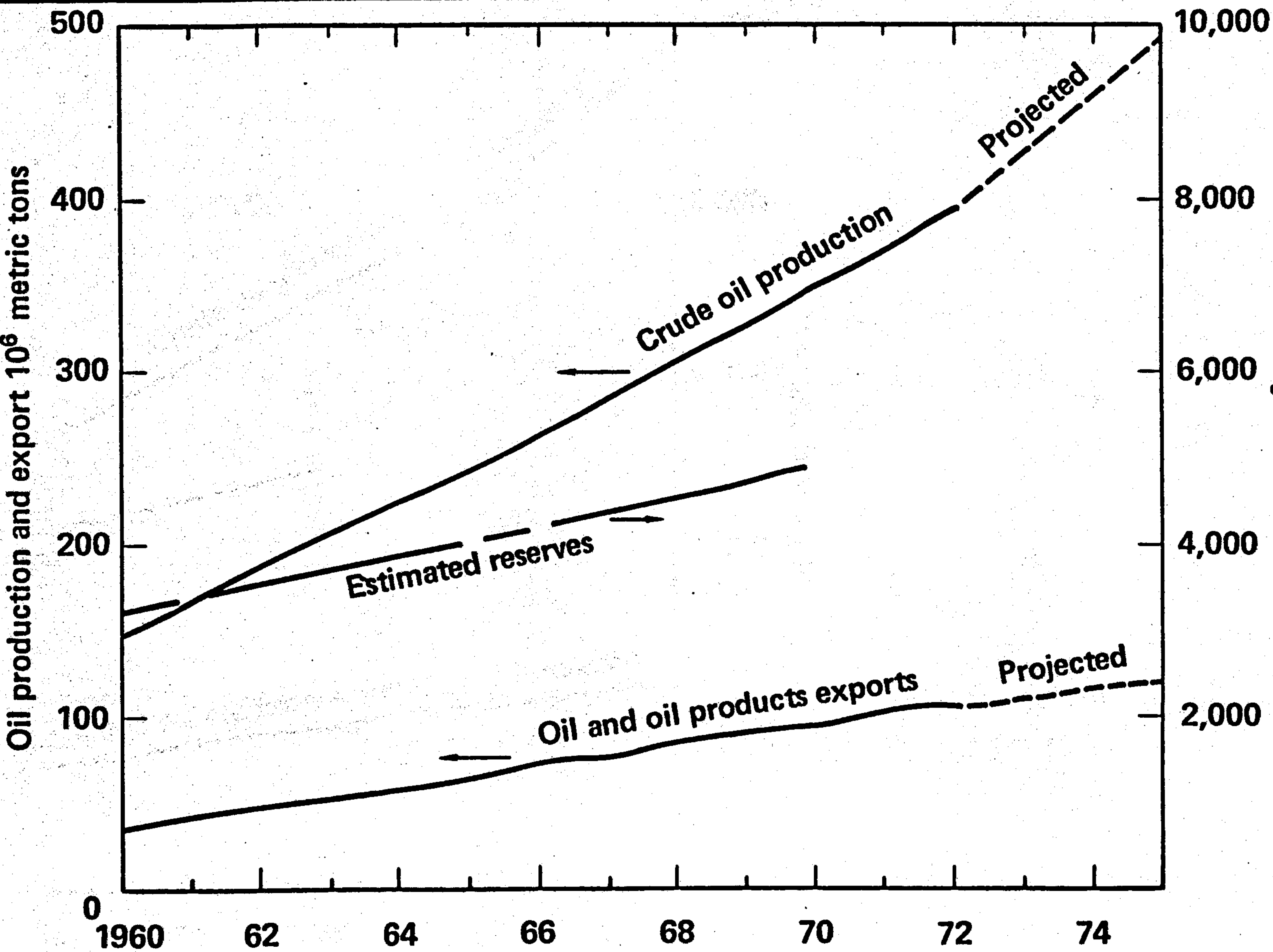
(Millions metric tons coal equivalent)

	Date	Reserves	Domestic prod.	Reserves/production
Oil	1972	551	37.1	15.5
Gas	1971	395	23.1	16.6
Coal	1971	Proven: 182 Inferred: 3284	1.6	Proven: 121 Inferred: 2300
TOTAL		1128	61.8	

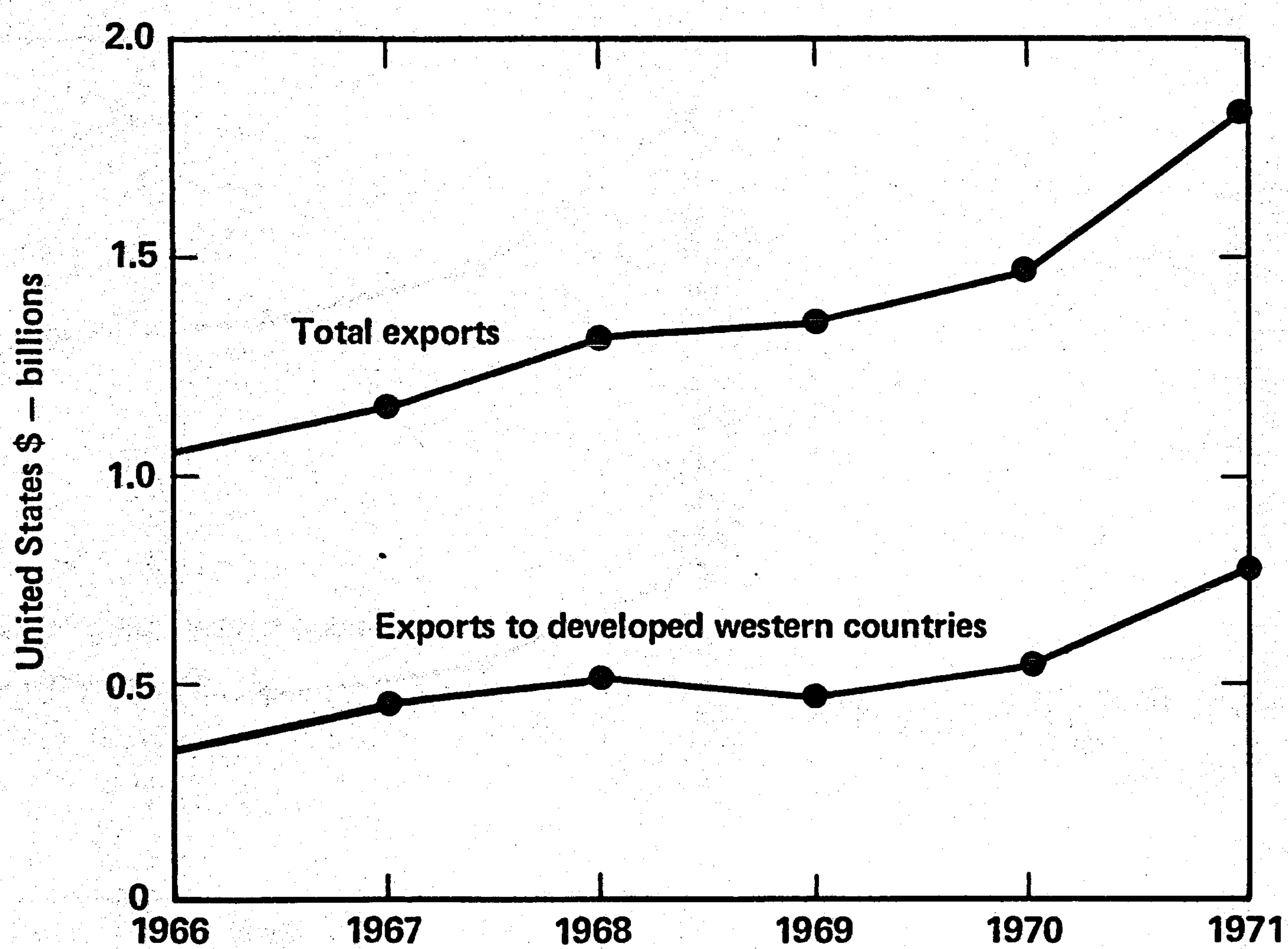
Sources: 1. DeGolyer & MacNaughton, Twentiety Century Petroleum Statistics, 1973.
2. U.N. Statistical Yearbook, 1972.



PLANT AT CERRO PRIETO

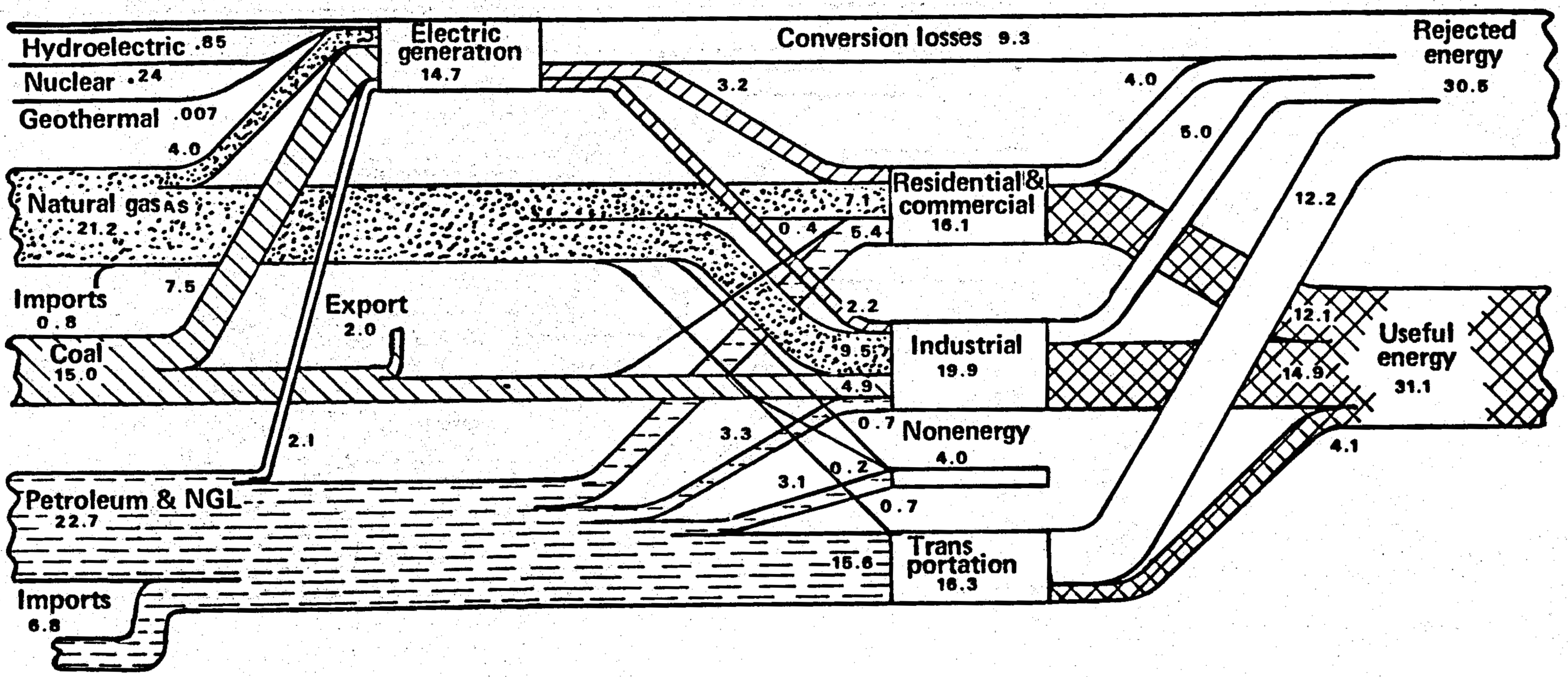

500
400
300
200
100
0
10,000
8,000
6,000
4,000
2,000
Oil production and export 10^6 metric tons
Oil reserves 10^6 tons
1960
62
64
66
68
70
72
74
Crude oil production
Projected
Estimated reserves
Oil and oil products exports
Projected

SOVIET EXPORTS OF CRUDE OIL AND PETROLEUM PRODUCTS



ENERGY FLOW PATTERNS IN THE U.S.A.—1970

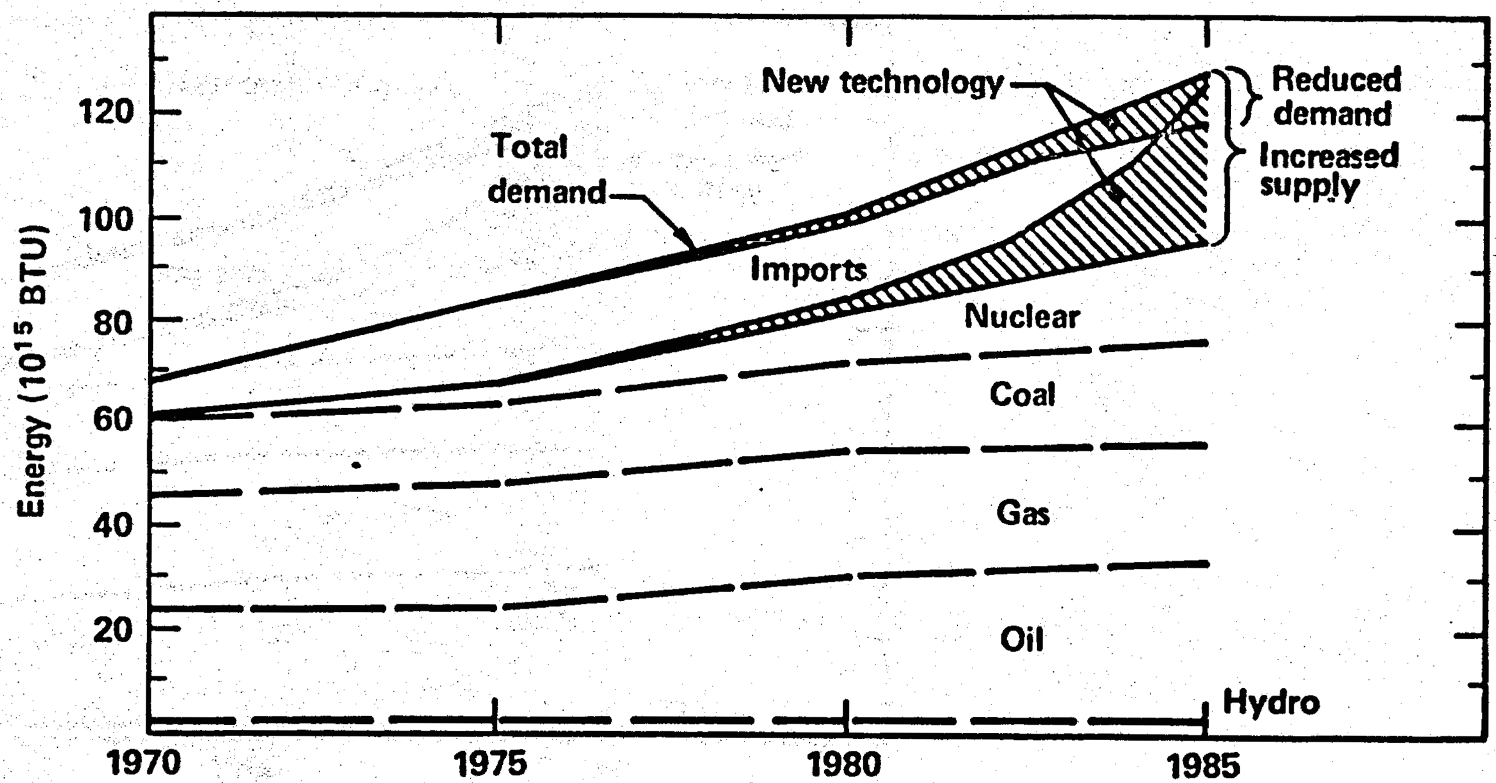
Total Consumption = 67.5 × 10^{15} BTU



Note: All values × 10^{15} Btu (2.12 × 10^{15} Btu = 10^6 bbl/day oil)

U.S. ENERGY SUPPLY AND DEMAND

NPC Case II Projection



UNITED STATES FOSSIL ENERGY RESOURCES

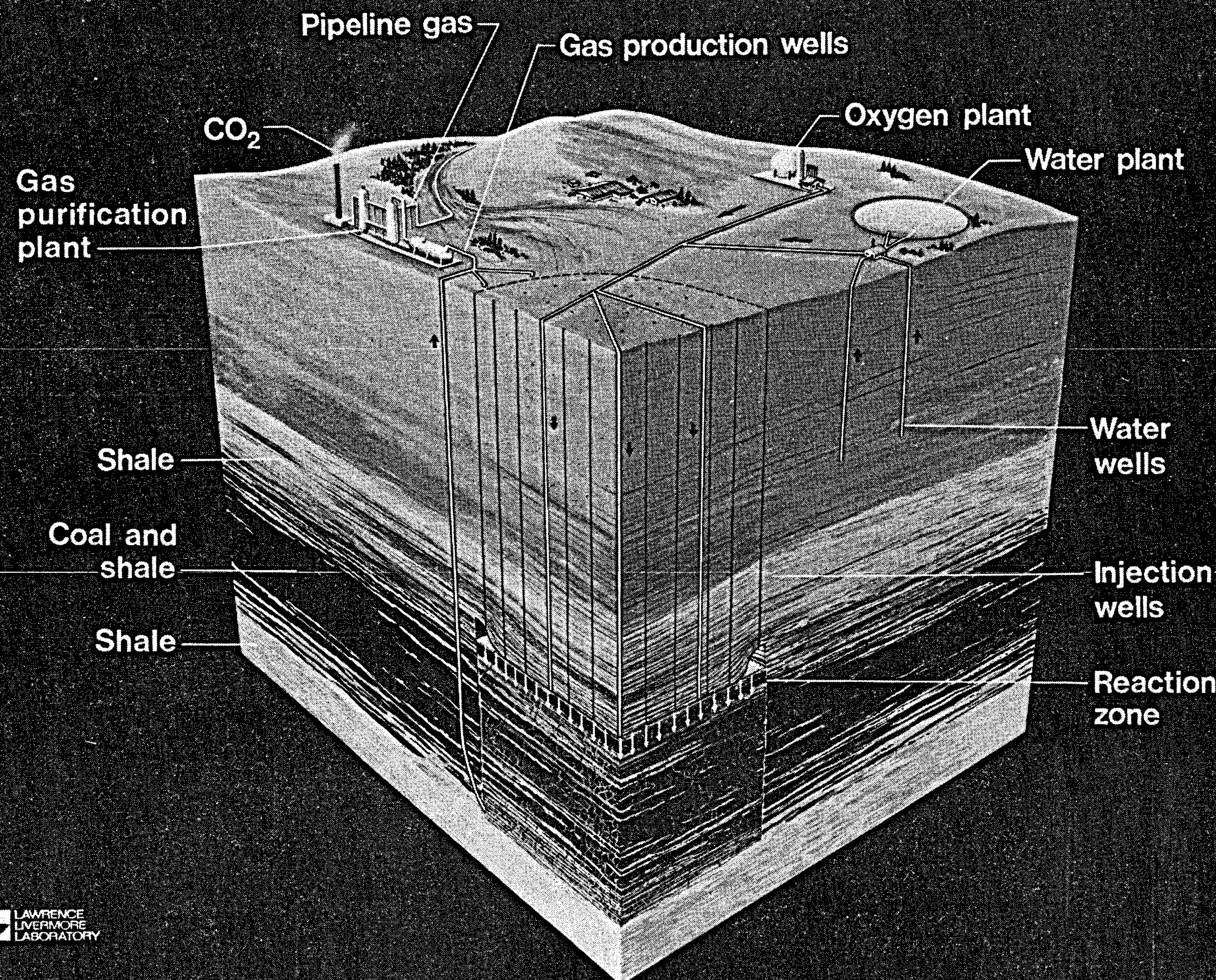
U.S. energy use in 1970 = 71 X 10^{15} BTU

Resources	Present Current technology Current prices[a] Proved recoverable resources	Increase Current technology Higher prices[b] Includes undiscovered resources	Increase New technology Higher prices[b] Includes undiscovered resources	Approximate Total
Coal	6,200	–	9,300	15,500
Petroleum & natural gas liquids	300	2,600	290	3,200
Oil shale	–	–	1,900	1,900
Natural gas	290	2,100	500	2,900
Heavy oils & tar sands	N.E.	N.E.	420	420
Total fossil fuels	6,800	4,700	12,400	23,900

[a]About 0.50/MCF (gas); $4.00/bbl (oil); 10 mills/KWHe

[b]Up to 1.00/MCF (gas); $5.00/bbl (oil); 12 mills/KWHe

IN SITU COAL GASIFICATION CONCEPT



GLC-7210-6384A

UNITED STATES NON-FOSSIL ENERGY RESOURCES

U.S. energy use in 1970 = 71×10^{15} BTU

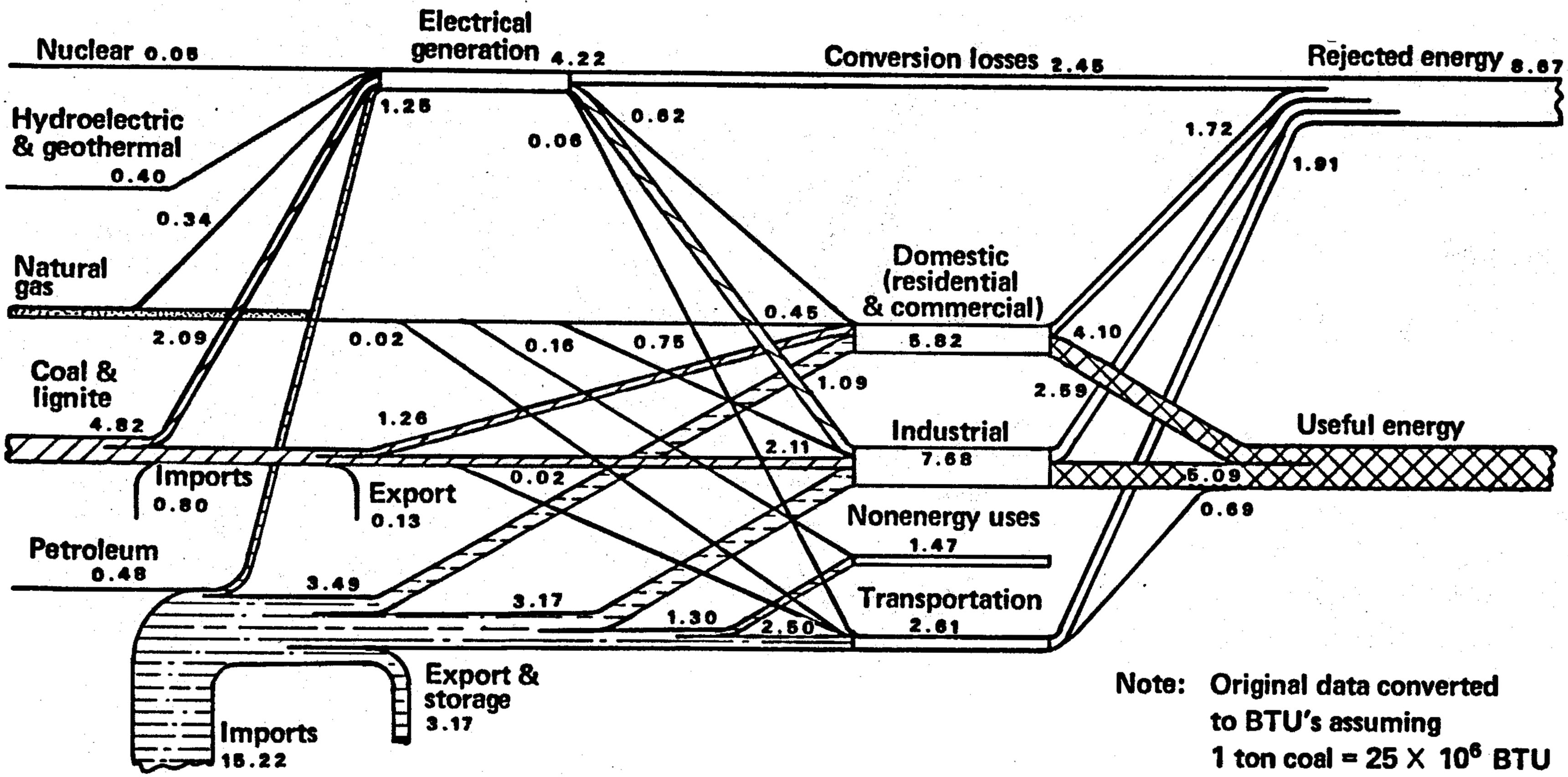
Resource	Present Current technology Current prices[a] Proved recoverable resources	Increase Current technology Higher prices[b] Includes undiscovered resources	Increase New technology Higher prices[b] Includes undiscovered resources	Approximate Total
Uranium	150	5,700	–	5,900
Thorium	–	–	9,600	9,600
Geothermal	10	7	500 - 5,000	500 - 5,000
Solar	(Southwestern U.S.) = ~0.5 kw/m^2			

[a]About \$8/lb U_3O_8, 10 mills/kwhr.

[b]Up to \$50/lb U_3O_8, 13 mills/kwhr.

COMMON MARKET ENERGY FLOW—1970

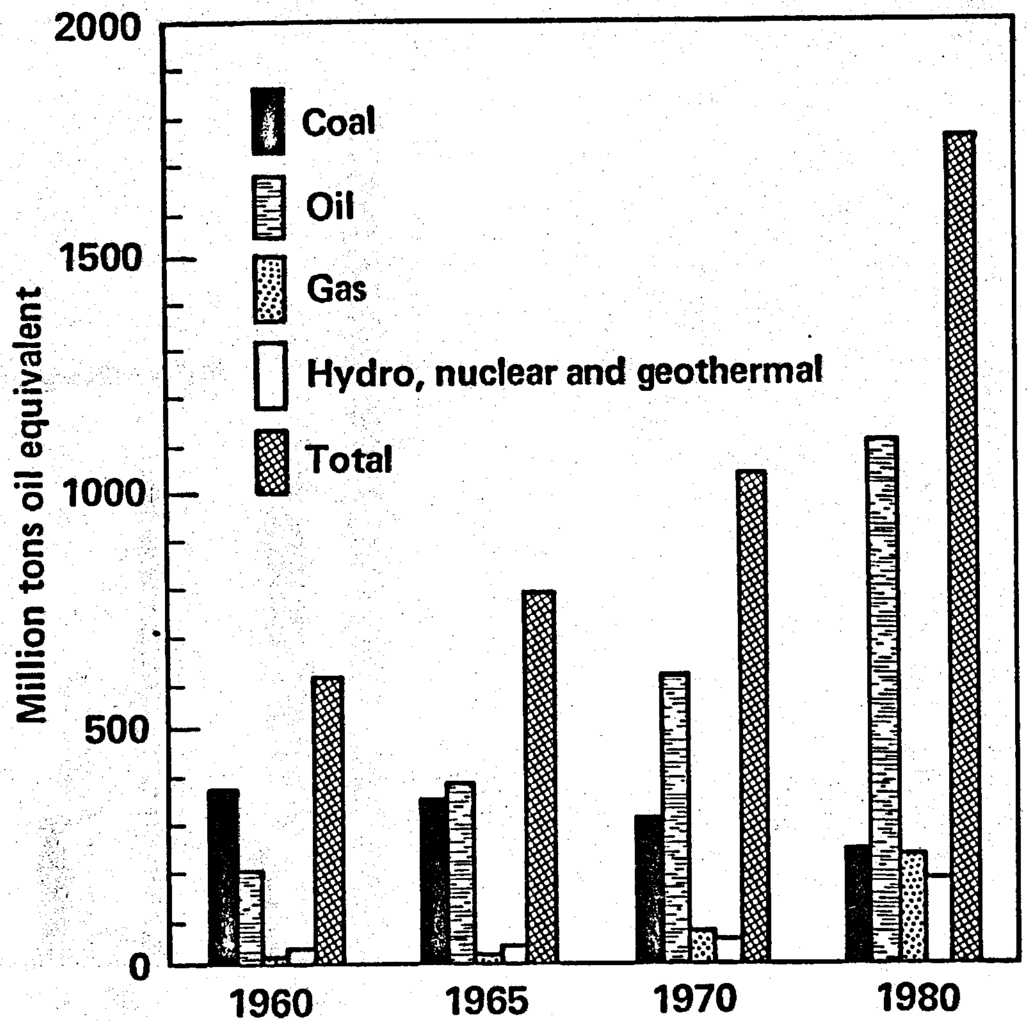
Total Internal Consumption 20.06 X 10^{15} BTU (6 of Original)



Note: Original data converted to BTU's assuming 1 ton coal = 25 X 10^6 BTU

Note all units 10^{15} Btu (2.12 X 10^{15} Btu = 10^6 bbl/day oil
(Ref: Energy Policy Division, Commission DES Communates Europeenes)

PRIMARY ENERGY REQUIREMENTS IN OECD EUROPE (1960 to 1980)



OIL The Present Situation and Future Prospects, A Report by the OECD Oil Committee, Paris, 1973.

OECD EUROPEAN AREA ENERGY SITUATION – 1970

Million metric tons coal equivalent

Country	Total energy consumed	Total energy produced	Percentage imported
W. Germany	317.1	174.3	45.0
United Kingdom	299.1	163.7	45.3
France	193.0	59.3	69.3
Italy	144.1	26.4	81.7
Netherlands	66.2	49.0	26.0
Belgium-Luxemburg	59.6	11.6	80.6
Sweden	50.7	5.2	89.7
Spain	49.9	16.0	68.0
Denmark	28.8	–	99.9
Austria	25.3	10.7	58.0
Switzerland	21.4	3.9	81.4
Finland	19.6	1.2	94.0
Norway	18.7	7.6	59.2
Greece	11.2	2.9	74.4
Ireland	8.8	2.5	71.8
Portugal	6.6	1.0	85.0
Iceland	.9	.2	79.1

U.N. Statistical Yearbook 1972

OECD EUROPEAN AREA COAL SITUATION

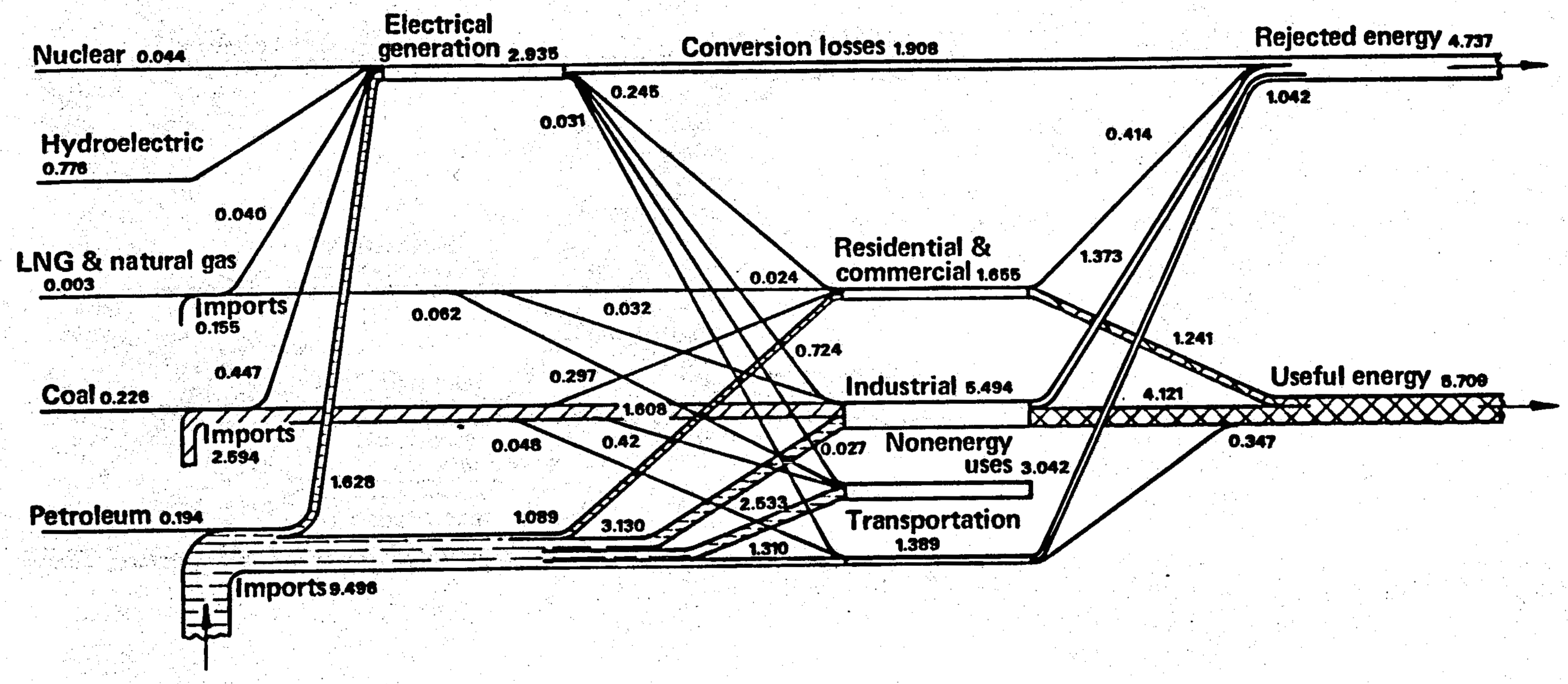
Million metric tons

Country	Coal reserves	Production 1961	Production 1970	% of total
W. Germany	132,000	174.0	144.2	45.5
United Kingdon	15,500	193.5	144.6	48.3
France	2,830	54.1	39.0	20.2
Italy	524	1.5	1.0	6.9
Netherlands	2,394	12.6	4.3	6.5
Belgium-Luxemburg	1,796	21.5	11.4	19.0
Sweden	90	.2	—	—
Spain	3,610	14.8	12.2	24.4
Denmark	50	.8	—	—
Austria	146	2.9	1.8	7.2
Switzerland	—	—	—	—
Finland	—	—	—	—
Norway	166	.4	.5	2.5
Greece	1,575	.8	2.5	22.6
Ireland	48	2.2	2.4	27.0
Portugal	52	.5	.3	4.1
Iceland	—	—	—	—

U.N. Statistical Papers, Series J, No. 15, World Energy Supplies.
U.N. Statistical Yearbook — 1972.

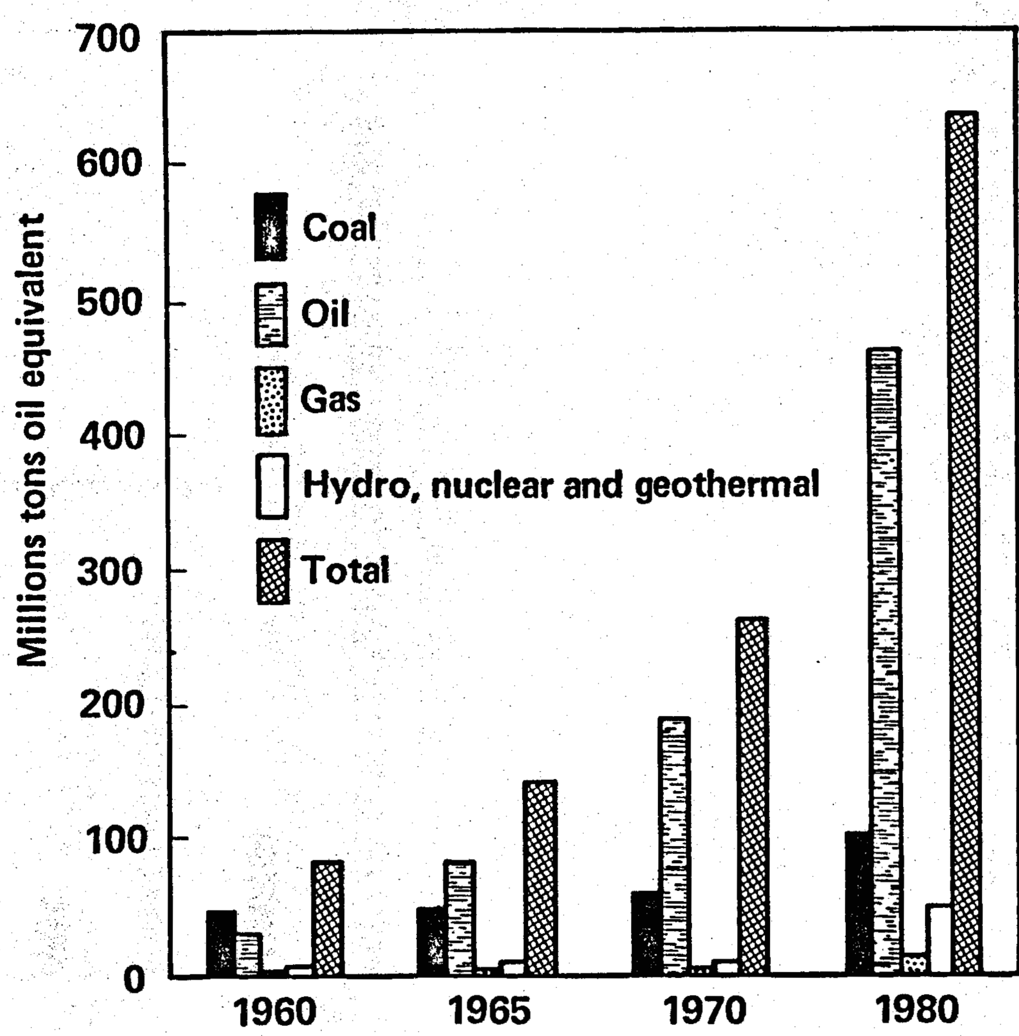
JAPANESE ENERGY FLOW—1970

Total consumption = 13.5 X 10^{15} Btu



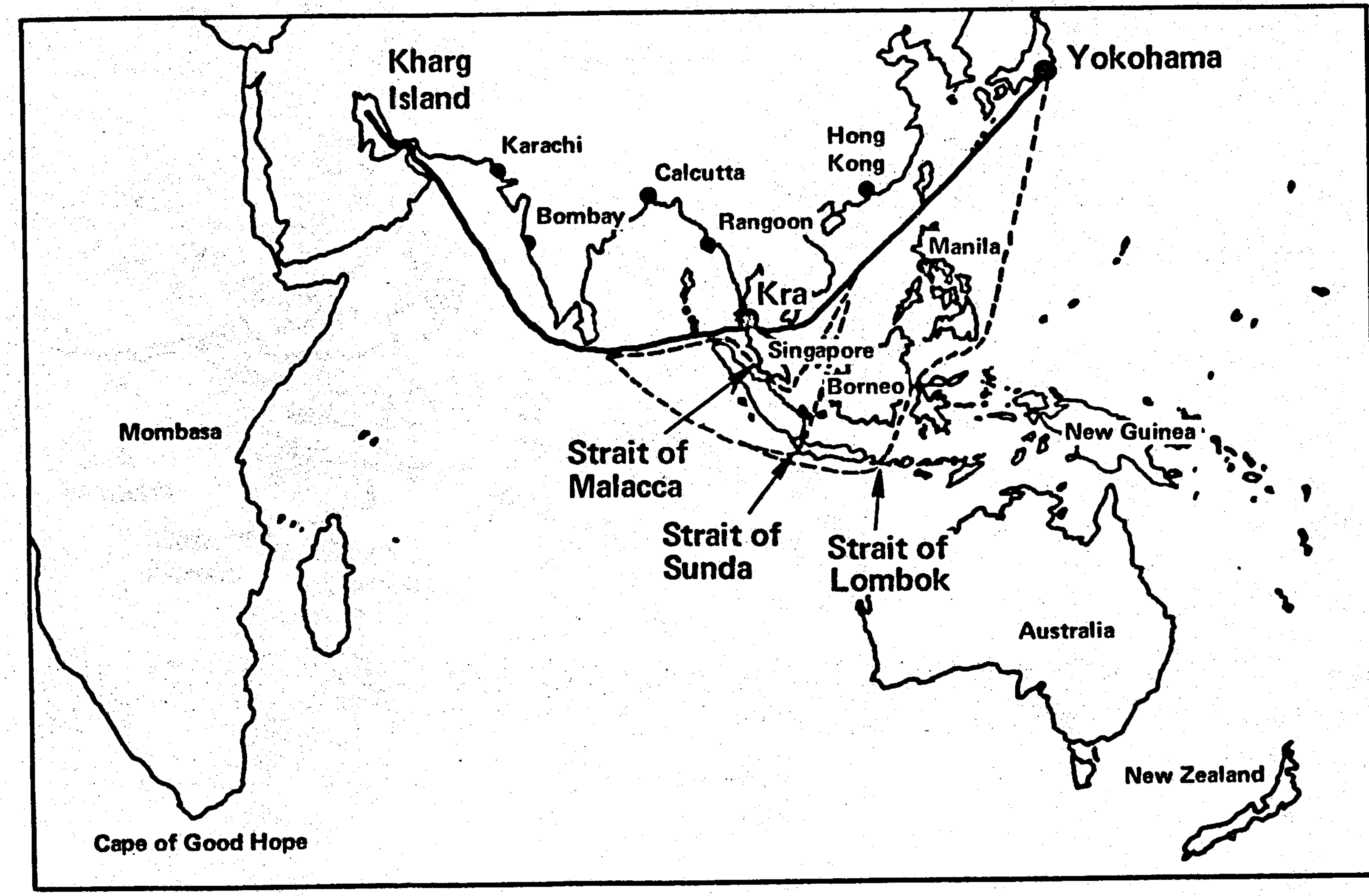
Note all values 10^{15} Btu (2.12 X 10^{15} Btu = 10^6 bbl/day oil)
(Ref: National Research Institute; Tokyo, Japan)

PRIMARY ENERGY REQUIREMENTS IN JAPAN (1960 to 1980)



OIL The Present Situation and Future Prospects, A Report by the OECD Oil Committee, Paris, 1973.

OIL SUPPLY ROUTES TO JAPAN



"Preliminary Survey Report — Kra Canal Complex," TAMS & RRNA September 1, 1973.

JAPANESE NATIONAL PROGRAM FOR OIL

In 1967 Japan adopted a ten-year plan to obtain 30% of oil needs through Japnese companies.

Established an "Oil Development Corporation."
Revenue from a tariff on oil imports.
Now have 25 projects

1. Oil Exploration
   - Near Japan
   - South China Sea
   - Sumatra
   - Indoneasia
   - Thailand
   - Australia
2. Refining
   - Financed one refinery in Saudi Arabia
3. Pipeline
   - Negotiate with USSR for pipeline
4. Liquefied natural gas
   - Contract for gas from Alaska
5. Tar Sands
   - Want to negotiate for Canadian tar sands

M. Sakisaka, "Energy Demand, Resources, and the Environment – Prospects for the Japanese Economy"

WESTERN PACIFIC BASIN ENERGY RESOURCES

Million metric tons

Country	Coal Reserves	Coal 1971 production	Oil Reserves	Oil 1971 production
China	1,011,700	390 (est.)	–	24*
Australia	111,600	68.3	241	11.9
Japan	20,981	33.6	3	.8
Indonesia	2,845	.2	1,459	43.8
New Zealand	1,216	2.1	4	.1
South Korea	1,190	12.8	–	–
N. Vietnam S. Vietnam	1,000	–	–	–
Burma	286	–	5	.8
Thailand	235	.4	–	–
Philippines	88	–	–	–
Malaysia	–	–	110	3.3
Laos	–	–	–	–
Cambodia	–	–	–	–
Taiwan	–	–	–	–

*1970

U.N. Statistical Yearbook — 1972

SUMMARY OF POSITIONS – 1971

(Energy figures in million metric tons of coal equivalent)

Area	Energy position: Consumption	Energy position: % of World	Energy position: % Imported	Built economy on Arab oil	Reserves
Soviet Union	1112.2	15.3	-12.4	no	Oil & gas
United States	2327.6	32.1	12.8	no	Coal & oil shale
Western Europe	1384.5	19.1	57.8	yes	Coal
Japan	341.9	4.7	85.5	yes	None*
Total	5166.2	71.2			

World Consumption: 7259.8

* Reserves are listed but exploitation not considered credible by Japanese.

Source: Energy Statistics Only – U.N. Statistical Yearbook – 1972

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