The Philippine Review of Business and Economics Vol. XIV No. 2 December 1977

A REVIEW OF WORLD ENERGY SITUATIONS: SOME POSSIBLE IMPLICATIONS

By

Lido P. Gonzalo*

ntroduction

The interdependence of the world economy is clearly demon-trated by the current energy crisis. No nation, small or big, dev-loped or developing, is spared from its deleterious repercussions.

The timing was unfortunate for the industrialized nations as it ccurred when demand pressure in these areas was at its height, iving rise to shortages and inflationary anticipations (*OECD Ob-erver*, 1975). The crisis abetted the demand momentum, pushing urther the inflationary spiral. Besides which it also happened at the ime when the world economy has grown accustomed to cheap sup-lies of energy input. Such a situation in the past led to the under-levelopment of alternative energy sources. Thus, when the OPEC tarted to withhold oil supplies and escalated prices, most countries vere unprepared for counter actions.

But a crisis such as this has also its own functions, apart from its ysfunctions. It has ushered in a new era of energy utilization. Final-y, after so many years of neglect, various forms of energy resources vill be the focus of intensive development and research. For aside rom traditional energy sources like petroleum, coal, and natural gas, he world has vast reserves of shale, tar sand, and hydronuclear esources, which could be tapped for their energy potentials.

Although the technology to extract energy from these sources is vailable, the most appropriate technologies, which are both econom-ally feasible and less injurious to the environment are yet to be eveloped. It is therefore expected that within the next 10 to 15 ears, fuel oil will still dominate the energy scene.

---

*Instructor, U.P. School of Economics. This paper is based on an earlier per presented in a DAP Workshop on World Scenarios on November 7, 1976. e research support extended by DAP-PREPF Project is hereby acknowledged.

In view of this, we have to contend with the almost chain reaction consequences of the present crisis. The worldwide inflation, brought about by the rising cost of fuel oil, has given rise to depressed economies in the developed world. This, in turn, led to disruptions in world trade due to the slackened demand for commodities in the world trade streams. As a result, both developed and developing countries stand to suffer losses both domestically and externally. Hence, it is not surprising if we find many nations enmeshed in balance of payments disequilibrium.

Prospects in world trade, especially trade flows from developing to developed countries, depend to a very great extent on the stability of the world energy situation. Currently, most of the industrialized countries are experiencing balance of payments deficits. Their tendency, then, is to pursue a strong export drive and discourage imports. In effect, the exports of the developing countries will suffer slumps, inasmuch as 70% of the LDC's market is found in the developed world (U.N., *Review of International Trade and Development*, 1970). Until such time that the supply of world energy is secure, trade flows between developing and developed countries will be mainly sluggish.

The present crisis has created uncertainties in the present economic orders, uncertainties emanating not only from the vagaries of the OPEC monopoly but also from the prospects of developing alternative forms of energy. Forecasts are made about the future course of events, not so much for the purpose of eliminating these uncertainties, but more for the purpose of understanding alternative futures.

The Growth of World Energy Demand

To essay a guess about the energy situation in the future, it is important that we review the patterns of demand for energy all over the world. The postwar expansion of energy consumption has almost been at an exponential rate. From 2,700 m.t.c.e. (million tons of coal equivalent) in 1950, world energy consumption has grown by approximately 5% a year (Table 1) and reached 6,000 m.t.c.e. in 1968 (Surrey and Bromley, 1973). At this rate of growth, world energy consumption would be 19,000 m.t.c.e. in 1990 and 36,500 m.t.c.e. in the year 2000. The supply, consisting of coal, crude petroleum, natural gas, and non-hydrocarbon energy, more than satisfied aggregate demand in 1972. But the growing dependence on oil by Western Europe, Japan and the U.S. has produced a significant geographic imbalance in the overall supply-demand pattern (Ware and Gross, 1974).

Table 1

Average Rate of Growth of Production of Commercial Energy, World (Percentage)

Year	Total Primary Energy	Coal and Lignite	Crude Petroleum	Natural Gas
1962	5.6	2.3	7.8	9.2
1963	6.1	4.3	7.2	9.0
1964	6.1	3.6	8.0	9.0
1965	4.6	1.3	7.2	7.0
1966	5.7	1.8	8.5	8.9
1967	2.4	−4.4	7.2	7.7
1968	6.6	3.0	9.2	8.9
1969	5.9	2.3	7.6	9.5
1970	7.3	2.9	9.7	10.3
1971	3.8	− .1	5.6	6.5
1972	4.2	1.6	5.4	5.7
1962-1966	5.6	2.7	7.7	8.6
1967-1971	5.2	.7	7.9	8.6
1962-1972	5.3	1.7	7.6	8.3

Source of Basic Data: UN. *World Energy Supplies*. Series J No. 17, 1961 − 1971.

In 1963, petroleum accounted for 36% of total energy produced. In 1971, this percentage share jumped to 43.65%. The opposite trend holds in the case of coal. It accounted for 32% in 1971, compared with 45% in 1963 (Table 2). It is obvious that since the postwar years, there has been a transition from coal to oil age. The use of natural gas is increasing but at a very slow rate. In 1971, it accounted for 21% compared to 16% in 1963.

Among the seven major regions of the world, Africa and the Middle East have an overwhelmingly favorable position in terms of energy supply. The ratio of supply to demand in 1972 was 740%. Thus, we can expect this region to be a net exporter of energy for the rest of the century. The only other net exporting region is South America. North America, comprising the U.S. and Canada, is almost self-sufficient in energy (Table 3). But while Canada is in a surplus position, supply in the U.S. is around 90% of demand.

Historically, coal has been the major source of energy for Western Europe. In fact, in 1961 it accounted for almost 90% of energy production but this will likely decline to 24% by 1985 (Ware and Gross, 1974). The North Sea natural gas and crude is expected to figure more importantly in the next decade.

Table 2

Production by Types of Energy Resources
1963 – 1971

Per Cent

	Coal and Lignite	Crude Petroleum	Natural Gas	Hydro and Nuclear Electricity
1963	45.11	36.09	16.66	2.13
1964	44.04	36.74	17.10	2.10
1965	42.66	37.64	17.49	2.22
1966	41.10	38.64	18.00	2.28
1967	38.31	40.46	18.94	2.29
1968	37.04	41.40	19.32	2.25
1969	35.80	41.99	19.94	2.29
1970	34.30	42.97	20.48	2.25
1971	32.99	43.65	21.05	2.30

Source of Basic Data: UN *Statistical Yearbook*, 1972.

Table 3

Total Energy Consumption as Per Cent of Total Energy Production by Region
1963 – 1971

Per Cent

Region	1963	1964	1965	1966	1967	1968	1969	1970	1971
Africa	61.8	51.6	44.7	39.0	36.7	31.6	26.6	24.2	28.0
America, North	108.1	108.7	109.8	109.7	107.8	110.4	111.2	108.9	112.3
America, Central	31.2	30.7	32.2	34.2	34.5	36.7	37.9	40.6	44.4
America, South	155.3	160.4	165.3	164.2	152.5	154.7	159.7	157.7	159.2
Asian Middle East	8.2	7.7	7.9	7.7	7.8	7.7	7.7	8.2	7.7
Asia, except Middle East	146.5	157.8	163.7	170.6	189.2	198.6	206.1	220.7	230.9
Europe except Eastern Europe	169.6	173.3	182.1	195.3	203.7	215.6	229.7	242.5	236.6
Oceania	150.0	151.4	142.9	143.2	143.5	134.6	128.1	109.9	98.8
Centrally-Planned Economies	95.1	95.2	94.9	94.6	94.4	94.8	95.6	95.8	96.1
World	98.0	98.1	98.0	97.4	98.0	98.4	97.6	97.6	98.5

Source of Basic Data: UN, *Statistical Yearbook*, 1972

Eastern Europe has maintained energy self-sufficiency because of vast coal resources. As such, coal was the single largest prime energy source and accounted for 48% of total energy production in 1972 as compared with 66% in 1961. The gradual trend away from coal will continue in the future as huge Soviet natural gas supplies serve as a substitute.

Asia and the Far East, which contain 54% of the world population consume only 15% of total energy supply. Next only to Western Europe, this region is the most deficient in energy supply. In 1972, supply was just 70% of total demand.

World Energy Reserves and Depletion

A. *Oil*

World energy reserves have been increasing through time. In the case of oil, it is interesting and perhaps encouraging to note that the estimates of ultimate reserves have risen by a factor of four to five during the last 30 years (Table 4) (Gaskell, 1974). This is due to new

Table 4

Estimates of World Ultimate Reserves of Crude Oil From Conventional Sources

Year	Source	x10⁹ brl
1942	Pratt, Weeks and Stabinger	600
1946	Duce	400
1946	Pogue	555
1948	Weeks	610
1949	Levorsen	1,500
1949	Weeks	1,010
1953	Mac Naughton	1,000
1956	Hubbert	1,250
1958	Weeks	2,000
1965	Hendricks (USGS)	2,480
1967	Ryman (Esso)	2,090
1968	Shell	1,800
1968	Weeks	2,200
1969	Hubbert	1,350-2,100
1970	Moody (Mobil)	1,800
1971	Warman (BP)	1,200-2,000
1971	Weeks	2,290

Source: T.F. Gaskell, "Future Petroleum Supplies Onshore and Offshore," in K.A.D. Inglish (ed.) *Energy: From Surplus to Scarcity?* (New York: John Wiley and Sons, 1974)

Table 5

Proved Oil Reserves — At End of 1973
(thousand million barrels)

United States		34.7
Canada		9.4
United Kingdom		10.0
Norway		4.0
Other Western Europe		2.0
Japan		—
Australia		2.3
New Zealand		0.2
	Sub-Total	62.6
Western Hemisphere (excluding US and Canada)		31.6
Africa		67.3
Middle East		350.2
USSR, E. Europe and China		103.0
Other Eastern Hemisphere (excluding Australia and New Zealand)		13.1
	Sub-Total	565.2
World Total		627.8

Source: OECD, *Energy Prospects to 1985*, Volume I.

discoveries of additional reserves. The published crude oil reserves at the end of 1973 were 627.8 x 10^9 barrels (brl) of which more than half is in the Middle East (Table 5). In terms of 1972 production, which was about 2,600 million tons, the world reserves are good for another 35 years (Gaskell, 1974; Chandler, 1974). By far the biggest additions to world reserves were those in the Middle East which increased more than sixfold from 52 x 10^9 to 347 x 10^9 barrels in the last two decades (Surrey and Bromley, 1973). The Middle East now contains 61% of world proven crude oil reserves.

During the past decade, ultimate reserves have settled down at around 2,000 x 10^9 barrels — or about 300,000 million tons, and it is probable that this represents a good estimate that will not change much in the future (Gaskell, 1974). This is because, during the past 25 years, extensive exploration in many parts of the world has taken place and drilling has probed structures to the 10,000 to 20,000 feet depths below which economic oil accumulations do not appear to exist (Gaskell, 1974).

The consensus among petroleum geologists appears to be that three-quarters of the reserves yet to be found will be in a few areas —

he U.S.S.R. and China (over a third), the Middle East (about one-eventh), North America including Alaska (about a fifth), and Latin America (about a tenth) (Surrey and Bromley, 1973). If this is cor-ect, the Soviet Union could become a bigger source of crude oil over he coming decades.

Currently, the shallow continental shelves are the sites of intensive oil exploration on the belief that, if oil accumulations are found on and, it is more likely that similar oil fields exist offshore on the helves adjacent to land (Gaskell, 1974). It is estimated that the combined oil content of the continental shelves and the land coastal plains is about 75% of the world's oil.

The depletion of world crude oil reserves depends upon the future growth of demand as well as recovery factors. If world oil demand continues to grow at 7 1/2% (Table 1) a year, then the ratio of proved reserves to annual production would fall to 10 by 1978. By he year 2000, some 1100 x 10^9 barrels of new reserves would have o be found to prevent the ratio falling below 10.

At the rate the U.S. is consuming her oil reserves at about 5.4 billion barrels annually, the approximate lifespan of her oil eserves is about 20 years (Table 6 and 7). Given the minimal reserves of Western Europe of about 20 billion barrels and an annual con-umption of 4.7 billion barrels, these reserves will be exhausted in ive years. It is also clear from Table 6 that the U.S.S.R. and China vill have no future problems in oil supply for the rest of the century Rocks and Runyon, 1972).

Although most of the advanced industrialized countries exhibit a consumption rate of 4-5% per annum, the world's oil consumption ate remains at 7-8% per annum due to growing demand from rapidly leveloping countries, like Mexico and Spain, and industrialized coun-ries like Japan. The sales of oil products to these countries rise at he rate of 10-20% (Gaskell, 1974).

The problem of supply availability also depends on recovery actors. Current oil production techniques have normally low effi-iencies. The rate of recovery on normal flow may be as low as 15% of oil in place and as high as 50% (Gaskell, 1974). With the improve-nent of new production techniques like, gas, water and steam injec-ions into the rock reservoir, recovery rates can be increased. The videspread application of these more costly recovery methods, vhich could increase recovery factors by perhaps 10%, would just

Table 6

Approximate World Oil Reserves by Geographic Region

Region	Billion of Barrels	Per Cent of Total
United States	100	6
Western Europe	20	1
Africa	170	10
South America	190	11
Middle East	740	40
Other Regions	90	5
USSR and China	490	27
	1,800	100

Source: Lawrence Rocks and Richard P. Runyon. *The Energy Crisis* (New York: Crown Publishers Inc., 1972)

Table 7

Lifespan of Oil if Each Region Were Forced to Rely on Its Own Resources (Billions of Barrels)

Region	Reserves	Annual Consumption	Annual Growth Rate in Consumption	Approximate Lifespan (constant rate)
United States	100	5.4	5%	20 years
Western Europe	20	4.7	10%	5 years
Japan	negligible	1.7	17%	—

Source: Lawrence Rocks and Richard P. Runyon. *The Energy Crisis* (New York: Crown Publishers Inc., 1972)

increase recoverable reserves by the same proportion (Surrey and Bromley, 1973). The use of new geophysical techniques, which allow drilling at depths of more than 10,000 feet offers a lot of promise in the recovery of offshore oil. This is, however, constrained by high production costs.

B. *Coal*

Since 1930, world inventories of coal resources have been put at $8{,}000 \times 10^9$ metric tons. Estimated total reserves have changed comparatively little in the past 60 years (Surrey and Bromley, 1973). The 1968 World Power Conference Survey of Energy Resources indicated that measured world reserves of hard coal are 460×10^9 metric tons and measured reserves of soft coal are 270×10^9 metric tons (Table 8). Given a recovery factor of 50% and the present rate of growth of world coal consumption of 3% (Table 9), the reserves would last 100 years in the case of hard coal and 300 years in the case of soft coal.

It is clear in Table 8 that the U.S.S.R. accounts for more of the world reserves than any other region. This implies that the U.S.S.R. will be a major exporter of oil from coal if coal liquefaction technology can be perfected in the future. At present, Russia is leading

Table 8

Estimated World Coal Reserves (Metric Tons x 10^9)

	Hard Coal			Soft Coal			Hard and Soft Coal		
Area	Measured	Total	Per Cent of Total	Measured	Total	Per Cent of Total	Measured	Total	Percent of Total
North America	114.8	1164.5	17.3	21.6	430.1	20.4	136.4	1594.6	18.1
South America	3.9	26.2	0.4	0.4	10.0	0.5	4.3	36.2	0.4
Africa	41.7	85.5	1.3	—	0.1	—	41.7	85.6	1.0
Asia (excl. China)	20.2	313.6	2.0	2.6	4.7	0.2	22.8	136.8	1.5
China	—	1011.0	15.1	—	0.7	—	—	1011.7	11.5
Western Europe	88.3	96.8	1.4	64.3	67.0	3.2	152.6	163.8	1.8
Eastern Europe	39.1	60.1	0.9	27.3	9.5	4.3	66.4	149.6	1.7
USSR	145.1	4121.6	61.4	104.4	1406.4	66.8	249.5	5528.0	62.7
Oceania	3.3	16.8	0.2	48.4	96.0	4.6	51.7	112.8	1.3
World	456.4	6714.1	100.0	269.0	2104.5	100.0	275.4	8816.6	100.0

Source: A.J. Surrey and A.J. Bromley, "Energy Resources," in H.S.D. Cole, *et.al.* (eds.) *Models of Doom: A Critique of the Limits of Growth* (New York: Universe Book, 1973)

Table 9

Average Rate of Growth of Consumption of Commercial Energy, World

(Percentage)

Year	Solid Fuels	Liquid Fuels	Natural and Imported Gas
1962	2.0	8.1	9.5
1963	4.6	9.2	8.9
1964	2.4	8.6	9.1
1965	1.2	7.7	7.2
1966	2.0	8.3	9.0
1967	5.1	6.4	7.4
1968	5.0	8.8	9.1
1969	3.0	8.0	9.5
1970	1.5	9.7	9.5
1971	−.2	5.7	6.6
1972	1.0	6.7	5.8
1962-1966	2.4	8.4	8.7
1967-1971	2.9	7.7	8.4
1962-1971	2.5	7.9	8.3

Source: UN, *World Energy Supplies*, Series J. No. 17, 1961-1971

the other developed countries in coal conversion technology like, magnetohydrodynamics (Rocks and Runyon, 1972).

Physical reserves of coal are unlikely to represent a limit to world economic growth (Surrey and Bromley, 1973). The real problem lies primarily in the cost of extraction and transport. For the last 30 years coal has increasingly suffered from competition with low-cost oil. But, if the price of oil continues to escalate, the role of coal in power generation will correspondingly increase.

The future of coal conversion technologies, e.g., production of synthetic oil from coal, depends on how major environmental problems posed by coal mining can be solved. It is estimated, for instance, that to produce 2 million barrels per day of synthetic oil, between 200 and 700 million tons of raw material is needed (Clegg, 1974).

C. *Natural Gas*

Estimates of world reserves of natural gas can be seen in Table 10. Large reserves of gas are known to exist in most of the petroleum producing areas of the world. Outside the U.S. natural gas has only recently become a major energy resource. As oil and gas are usually found together, it is reasonable to assume that, in addition to unused gas reserves, large additional quantities will be found in association with future petroleum exploration (Surrey and Bromley, 1973). It is, therefore, impossible at present to estimate total reserves. As a clean

Table 10

Estimated Proved World Reserves of Crude Oil and Natural Gas As At 31 December, 1971

Area	Crude Oil Reserves (barrels x 10^9)	Percent of Total Crude Oil Reserves	Natural Gas Reserves (cubic feet x 10^{12})
North America	49.2	8.6	345.3
of which USA	38.1		
South America	25.2	4.4	55.6
of which Venezuela	13.7		
Western Europe	6.8	1.2	161.1
of which UK	3.0		
Norway	2.0		
Eastern Europe	62.1	10.9	653.4
of which USSR	60.0		
Africa	50.9	8.9	197.6
of which Libya	28.0		
Nigeria	10.0		
Middle East	346.8	60.9	286.0
of which Saudi Arabia	137.0		
Kuwait	75.0		
Iran	60.5		
Iraq	33.1		
Far East	13.4	2.4	23.1
of which China	12.5		
Oceania	13.4	2.4	26.2
of which Indonesia	10.7		
Other Areas	1.7	0.3	4.9
World	569.5	100.0	1753.2

Source: A.J. Surrey and A.J. Bromley, "Energy Resources," in H.S.D. Cole, *et.al.* (eds.) *Models of Doom: A Critique of the Limits to Growth.* (New York: Universe Book, 1973).

fuel, the use of natural gas will continue to expand over the next decade. By 1980, it is estimated by Corbett that natural gas consumption worldwide should have increased by a factor of approximately four (4) as compared with 1960 (Corbett, 1974). Areas already contributing to this development and expected further to increase their consumption of natural gas are Western and Eastern Europe, Japan, Australia, and the U.S.S.R. The U.S., which has pioneered in the use and development of natural gas, would incur supply deficiency of at least 50 m.t.f.c.e. (million tons of fuel oil equivalent) by 1980 (Corbett, 1974). Advances in coal gassification can cover up this supply gap if economic costs can be made competitive with other sources of energy.

The U.S.S.R. with her ample gas reserves has already supplied gas to Eastern Europe. Japan, which is rapidly becoming an important natural gas consumer, is relying on imports of gas from Alaska and Brunei. By 1976, gas supply may also originate from the Persian gulf (Corbett, 1974).

New Sources of Oil

There are untapped reserves of non-conventional hydrocarbons, which will become economical after further technical improvement and if prices of conventional fossil fuels continue to rise. These untapped reserves, which are many times greater than those of traditional fossil fuels, include heavy oil deposits, tar sands and oil shales. Presently, synthetic oil can also be extracted from coal using current conversion technology but at an economic cost less competitive with the production of low-cost oil (Table 11). It is not unreasonable to expect within a decade a breakthrough in low-cost production of synthetic oil from coal.

The oil potential in existing physical reserves of coal is vast. Converting the coal to barrels of oil-equivalent on a thermal basis means that the total known deposits in place are equivalent to 43,000 x 10^9 barrel oil (Table 12) and although recovery cannot realistically be determined at this time, even a very low figure of 10% would give a recoverable reserve of 4.3 x 10^{12} barrel oil — equivalent which is some seven times as large as the currently proven oil reserves (Clegg, 1974).

Heavy oil and tar sand reserves are concentrated in Canada, USA and Venezuela (Table 13). The principal recovery method for heavy oil now being developed involves injection of high pressure steam (Surrey and Bromley, 1973). In the case of tar sand, intense heat is applied to the formation to reduce the viscosity of the tar oil and thus can be pumped out as "conventional" crude oil (Clegg, 1974).

The biggest single deposit of tar sands is at Athabasca, Canada, which is estimated to contain 635 x 10^9 barrels. If only this amount can eventually be recovered it would represent a major addition to proven world oil resources (Surrey and Bromley, 1973).

Table 11

Estimated Rages for Total Crude Oil Costs in the Mid – 1980's (in 1972 dollars per barrel)

Persian Gulf	0.15 – 0.20
North Sea	1.50 – 2.00
United States	
– low-costs category	0.30 – 2.60
– medium-costs category	3.30 – 6.70
– high-costs category	greater than 7.00
High-grade Oil Shales	4.11 – 7.30
Tar Sands (Canada)	3.40 – 3.80
Syncrude from Coal	6.50 – 7.50

Source: OECD, *Energy Prospects to 1985*, Volume I.

Table 12

Oil Reserves in Non-Conventional Sources

	10^9 barrels	10^9 tons
Tar Sands	1,487	
Oil Sands	6,850	
Hard Coal		6,860
Brown Coal & Lignite		2,100

Source: M.W. Clegg, "New Sources of Oil – Oil Sands, Shales and Synthetics," in K. A. D. Inglis (ed.) *Energy: From Surplus to Scarcity?* (New York: John Wiley and Sons, 1974).

Table 13

Heavy Oil and Tar Sands

Country	Area (acres)	Overburden Thickness (ft.)	Volume in-place (10^9 barrels)
Canada	8,000,000	0 – 2600	780
Venezuela	6,000,000	0 – 3000	700
USA	75,000	0 – 2000	2
Malagasy Republic	96,000	0 – 100	2
Others			3
		Total	1,487

Source: M.W. Clegg, "New Sources of Oil — Oil Sands, Shales and Synthetics," in K. A. D. Inglis (ed.) *Energy: From Surplus to Scarcity?* (New York: John Wiley and Sons, 1974).

Long before the development of the international oil industry based upon crude oil, oil shale was produced from deposits in Scotland, France and Germany (UN, 1967). The USA oil shale deposits in Colorado have been estimated to contain 1800 x 10^9 barrels of oil and those in Brazil are thought to contain 800 x 10^9 barrels (Surrey and Bromley, 1973). Assuming a 50% recovery factor and a yield of 10 gallons of oil per ton of shale, the world recoverable reserves from shale would be 6850 x 10^9 barrels (Surrey and Bromley, 1973).

Like tar sand, oil from shale is extracted by the application of intense heat that decomposes the Kerogen content of shale to yield a relatively light "shale oil" (Clegg, 1974). The heat transfer problem in oil shale retorting is relatively large because of the quantities of heat that have to be transferred from hot gases. This process entails large quantities of water, unfortunately major resources are located generally in areas with rather limited water supply.

The technology for the exploitation of these resources for the production of liquid hydrocarbons is, with the exception of some areas of the Athabasca tar sands, still at the research — development — pilot plant stage. The capital investment involved in the production will not be less than $400 million and could be as high as $500-600 for a 100,000 barrels-a-day plant at current costs. This implies that synthetic crude values would have to be at least $5 to $7 per barrel in the USA and even higher in other consumer areas like Western Europe and Japan. Since extensive mining operations are involved in the recovery of tar sands and shale deposits, environmental problems are bound to arise. Environmental problems, unless initially resolved, can constrain advances in the development of appropriate technology and commercialization of production of non-conventional fuels.

Nuclear Energy

The continuing escalation in the prices of fuel oil will surely encourage the development of nuclear energy. In the past, this was one of the most neglected energy alternative, accounting for only 1% of total energy requirement. In the future, however, it will assume a more increasing role. According to an OECD forecast for 1985, nuclear power will provide 10%-13% of primary energy in 1985 in OECD countries (OECD, 1973). This projection is based on the assumption that the cost of oil remains at $9 per barrel (Table 14). According to Frewer, the U.S. will get 19% of her energy supply from nuclear sources by 1990 (Frewer, 1974). Projected nuclear energy supply for most of the industrialized countries can be seen in Table 15. It is apparent that Japan, with her advanced technology, will excel in the development of nuclear energy. The pressure is more intense for Japan as she has negligible energy resources. At present, she imports 80% of her coal and 99% of her oil (Rocks and Runyon, 1972).

The nuclear reactor is still the most powerful supplier of energy as compared with conventional power sources. The uranium fuels used in existing reactors release about 20,000 times as much heat as can be obtained from the equivalent weight of coal, and in the more efficient breeder reactors now being developed this ratio will be as high as 1,500,000 to one (Hammond *et.al.* 1973). Furthermore, given a breakthrough in fusion technology, which is not unlikely to occur within the rest of the century, mankind is assured of uninterrupted supply of electricity and power over a billion years (Surrey and Bromley, 1973). Pacesetting development in this area is the USSR which has developed the most advanced fusion reactor in the world — the Tokamak.

Table 14

Percentage Shares of Different Forms of Energy in Overall Energy Consumption of OECD Regions in 1980 and 1985

	1980						1985					
% of TPE (1)	Coal	Oil	Natural Gas	Nuclear	Hydro/ Geo-thermal	Elec-tricity (2)	Coal	Oil	Natural Gas	Nuclear	Hydro/ Geo-thermal	Elec-tricity (2)
USA												
Base Case	18.0	47.6	26.9	5.9	1.5	(14.0)	19.7	45.3	23.4	10.2	1.4	(16.4)
$ 9 Case	21.8	39.7	30.3	6.5	1.7	(15.1)	22.5	34.5	26.7	14.1	2.1	(18.4)
Canada												
Base Case	10.2	51.9	21.7	5.5	10.7	(17.5)	12.5	48.8	20.4	8.5	9.8	(19.3)
$ 9 Case	8.9	48.0	22.7	6.1	14.2	(19.7)	8.3	40.4	24.0	10.0	17.3	(23.9)
EEC												
Base Case	13.2	65.9	14.7	5.1	1.0	(12.4)	9.6	64.8	14.9	9.7	0.9	(14.0)
$ 9 Case	19.6	49.1	23.4	6.8	1.1	(14.1)	15.8	47.3	23.3	12.5	1.0	(17.3)
OECD Europe												
Base Case	13.0	66.0	12.8	5.7	2.5	(13.5)	9.6	64.2	13.5	10.5	2.2	(14.9)
$ 9 Case	18.9	50.0	21.1	7.6	2.8	(16.0)	14.8	47.8	21.5	13.5	2.4	(17.8)
Japan												
Base Case	10.7	75.1	4.0	8.5	1.6	(11.9)	9.0	72.9	4.9	11.9	1.3	(11.6)
$ 9 Case	12.7	69.5	6.1	9.8	1.9	(12.3)	13.1	64.3	6.6	14.4	1.6	(13.3)
Australia (3)	38.2	42.3	18.0	—	1.5	(10.7)	40.0	40.0	18.6	—	1.3	(10.8)
New Zealand (3)	14.0	43.0	21.9	—	21.1	(30.4)	14.8	33.1	31.0	—	21.1	(36.8)
Total OECD												
Base Case	15.4	57.4	18.8	6.0	2.3	(13.7)	14.8	55.6	17.3	10.2	2.1	(15.2)
$ 9 Case	19.3	47.3	23.6	7.1	2.7	(15.2)	18.3	43.4	22.0	13.4	2.8	(17.7)

(1) Total Primary Energy Requirements
(2) As a percentage of total final consumption
(3) One case only
*Base case projection assumes that the petroleum prices prevailing are the pre — October, 1973 prices.

Source: OECD, *Energy Prospects to 1985*, Volume I.

The success of breeder reactor technology is a major step towards conquering energy supply problems between now and 1985, especially among advanced countries with projected supply deficit. Between now and 1980, breeder reactors are expected to rise in USA, USSR, Great Britain, France, Germany and Japan (Hammond *et.al.*, 1973). The economy of breeders lies in the fact that it can produce more fissionable material than it can consume and can utilize 50% to 80% of uranium resources.

Nuclear technology is not free from limitations. The management of radioactive waste from reactor is still one of the biggest problem that must be solved, before reactors can be fully socially accepted as energy supply source. The transport of enriched uranium (plutonium) from diffusion plants to reactor site, which can be an opened target for hijack is another major worry. The chances of a major reactor accident are also by no means insignificant. The acceptability of nuclear technology in the future depends to a large extent on how soon these problems can be eliminated or controlled.

Conservation and Efficiency in Energy Usage

Frewer has estimated that the potential energy savings in the U.S. in 1990 will be 9 million barrels daily (Frewer, 1974). This can be attained if conservation and efficiency measures are observed. These can be in the form of smaller and more efficient automobile, use of more car pools, more passengers per airplane, increased insulation standards, more efficient appliances and lower levels of lighting.

An analysis of the fossil fuel consumption in the US, Japan, and Western Europe shows that about half of the total supply is wasted in the process of conversion of fuels into more convenient forms of energy and in transportation of energy (Alkema and Newland, 1974). The reason for these losses are the low inherent efficiency of power generation and of transportation (internal combustion engines) and to a lesser extent efficiency losses in industrial processes.

Projected saving potential can, however, be pulled down by the increasing share of electricity in total energy demand. The use of electricity for domestic — commercial heating is just 30% efficient as against 70% efficiency of gas or oil for similar action. Where the growth of nuclear generating capacity will not meet the growth of electricity demand until perhaps well beyond 1990, that will mean the continued growth of inefficient fossil-fuel-based power generation (Alkema and Newland, 1974).

In the transportation sector, more energy can be conserved if the use of private vehicles is discouraged and shift is made towards a mass transit system. Energy — efficiency of various types of vehicles can be seen in Tables 15 and 16.

There is a need to rethink anti-pollution policies as to their energy implications (Alkema and Newland, 1974). The introduction of high-octane non-leaded gasoline will result in a lower efficiency as additional refining losses are involved in its manufacture. Also exhaust gas purification is quite energy consuming. Estimates are that in the US, gasoline consumption will go up by some 15-20% for this reason alone. If introduced worldwide, it might waste some 2-3 millions of barrels a day by 1985.

The Oil Crisis and the Developing Countries

When the OPEC declared an oil embargo right after the Arab-Israeli war of 1973, a new era in international oil trade opened.

Table 15

Energy-Efficiency for Inter-City Passenger Traffic

	Passenger-miles/gallon	Btu/passenger mile
Buses	125	1,090
Railroads	80	1,700
Automobiles	32	1,250
Aircraft	14	9,700

Source: H. J. Alkema and E. V. Newland, "Increased Efficiency of the Use of Energy Resources," in K. A. D. Inglis (ed.) *Energy: From Surplus to Scarcity?* (New York: John Wiley and Sons, 1974).

Table 16

Energy-Efficiency for Inter-City Freight Transport

	Ton-miles/gallon	Btu/ton-mile
Pipelines	300	450
Waterways	250	540
Railroads	200	680
Trucks	58	2,340
Aircraft	4	37,000

Source: H. J. Alkema and E. V. Newland, "Increased Efficiency of the Use of Energy Resources," in K. A. D. Inglis (ed.) *Energy: From Surplus to Scarcity?* (New York: John Wiley and Sons, 1974).

There was a transition from a buyer's market to a seller's market (Chandler, 1974). Since then the OPEC has started to wield increasing power over the control of supply and render the oil companies ineffective in the face of threats of nationalization of oil industries by producing countries.

The embargo and the consequent increases in oil prices have changed the tempo of growth in the affected industrialized nations from that of continued growth to one of deceleration or stagnation. The joint inflation and recession ran virtually out of control, generating undesirable economic repercussions in almost all parts of the world. The developmental efforts of the less-developed countries have been stunted since they have to wrestle with the balance of payments problem brought about by the disequilibrium in their current account as a result of higher import bills. Initially, however, the corresponding increases in the prices of their primary exports have helped them stem the tide of the initial effects of higher oil prices (*IMF Annual Report*, 1973). But this export price bonanza is expected to dwindle because the continuing recession in the developed nations will consequently lead to considerable cutbacks in their imports from the developing countries, sending the prices of primary exports down (UN, 1974).

Ultimately, then, the less-developed countries will be confronted with a two-pronged problem, that of higher import bills and a decline in the price and quantity of exports. Higher prices for imported oil is compounded by higher prices for imports of capital goods from the developed countries as a result of cost-pushed inflation in these areas.

According to Odell, the developing countries as a whole have higher petroleum consumption rate than the developed areas. The elasticity of oil demand with respect to income (GNP) is about 2, which means that for every 1% increase in income, petroleum consumption increases by 2% (Odell, 1974). Table 18 shows the estimated petroleum requirement at assumed rates of growth of the developing countries by 1980 made by the United Nations. It is not likely that these petroleum requirements can be met unless these countries are willing to drain foreign exchanges reserve, which is expected to decline within 1975-1980, if international trade does not pick up.

In the long run the more-developed countries are more resilient in adjusting to the current crisis than the developing ones. They have the advantage of modern technology and well-organized R and D that could pursue immediate development of alternative energy resources and efficient demand management to moderate the side effects of the energy problem. In short, they have more alternatives than the developing countries.

The current situation does not seem to augur well for the LDCs unless external assistance is extended to them. Foreign assistance from the developed countries, which are adversely affected by the oil crisis, are not likely to flow in until such time when they have effected sustained economic recovery. However, in the sphere of trade, the developed countries can help the LDCs by extending them more liberal trading schemes. They should provide more accommodations for the exports of the LDCs, especially manufacturing exports.

Table 17

Petroleum Requirements in 1980
(Millions of Tons)

Socio-Economic Group of Countries	Low	Medium	High
Developed Countries[a]	2,149	3,051	3,937
(Assumed rate of growth, per cent 1969-1980)	(3.2)	(6.6)	(9.1)
Centrally planned Economies[b]	692**	692	692**
(Assumed rate of growth, per cent, 1968-1980)**	**	(8.4)	**
Developing Countries			
Inland Consumption	367	461	535
(Assumed rates of growth, per cent 1968-1980)	(5.1)	(7.1)	(8.4)
Bunkers[d]	84	105	121
(Assumed rates of growth, per cent, 1968-1980)	(5.1)	(7.1)	(8.4)
World*	3,292	4,309	5,285

Notes: *Excluding centrally planned Economies of Asia
**only a medium figure was submitted

[a]North America, Japan, Western Europe (OECD), Australia, Israel, New Zealand, South Africa

[b]U.S.S.R.

[d]Calculated from UN *World Energy Supplies Statistical Papers*, UN Publication, (Series J. No. 13, Sales No: E. 70. XVII. 19). In 1968, Sales of bunkers in developing countries amounted to 46.03 million tons.

Source: United Nations. *Petroleum in the 1970's. Report of the Ad Hoc Panel of Experts on Projections of Demand and Supply of Crude, Petroleum and Products.* (New York: UN Headquarters, 1971).

This would somehow help the LDCs improve their balance of payments position.

The more likely solution to the plight of the LDCs would come from the OPEC countries which are expected to run a surplus of $60 billion at the end of 1975 and a cumulated surplus of $250 billion to $500 billion from 1974-80- (OECD, 1973). Currently, the surplus of the OPEC has been reflowed to most oil-importing countries. However, this is being done in the most strategic manner to get optimum returns. Thus, the petrodollar has found its way into the capital markets of the U.S. and Europe (*The Economist*, 1975).

To the extent that the OPEC fund could be used to finance current consumption or real investment, this reflow could have cushioned the demand-dampening effect of the higher bill for oil import in these areas. However, domestic policies to dampen inflationary pressures and the depressed state of the economies provide little incentive for using the inflow of the OPEC fund to increase real investment or consumption (*Report of the U.S. President*, 1975). But if the same capital surplus could be reflowed to the LDCs in the form of capital loans, it may yet prove to be the much needed shot-in-the-arm for their weakening economy.

The surplus of the OPEC depends also on the absorptive capacity of the member countries. Most of these countries are underdeveloped and backward and have an economic structure that does not permit easy absorption of this extra capital. As of now, they can be divided into two groups — the high absorbers and the low. The latter is typified by the small countries, like Saudi Arabia and Kuwait. Considering their size, these countries are not expected to increase their absorptive capacities for many years to come. However, in the case of the high absorbers, as their absorptive capacities increase in the long run and their imports expand and diversify, the availability of the OPEC surplus dwindles. It is, therefore, inevitable that the less developed oil-importing countries will continue to suffer a balance of payments deficit vis-a-vis the OPEC as there are no corresponding increases in the demand for their exports. Because of these conditions, the effect of the surplus on a good portion of the international economy in the short run is deflationary (OECD, 1973).

Energy and the Developed Countries

Among the developed countries, the USSR is the most endowed with energy resources. Table 18 compares the energy potential between the USSR and the USA. It is expected that before the century ends, the USSR will emerge as a new oil power. She has also gained advances in the technology for alternative energy resources. Although at present her oil consumption is just 60% of that of the US, in the future this rate will continue to increase. The stability of her energy situation is one factor that will contribute to massive advances in her economy, and thus, before the year 2000, she would overtake the United States' material standards of living (Rocks and Runyon, 1972).

Table 18

Comparison of Russia and United States' Natural Resources

Total Resources	Russia	United States
Oil (billions of barrels)	400	100
Gas (trillions of cu. ft.)	3,000	1,000
Coal (billions of tons)	4,000	1,500
Hydroelectric (billions of watts)	240	160
Uranium (tons)	1,000,000	660,000

Sources: Lawrence Rocks and Richard P. Runyon. *The Energy Crisis* (New York: Crown Publishers Inc., 1972.)

A surprise-free projection shows that the U.S. will have an energy supply gap of 16 million barrels daily by 1980, 20 million by 1985 and 23 million by 1990. Western Europe will have supply gap of 21, 27 and 34 million barrels respectively for similar periods. Likewise Japan will have a supply gap of 11, 16, and 10 million barrels daily also for similar periods (Frewer, 1974). If we assume that oil will be used to fill up this gap, noting that oil is the most convenient fuel, these countries will increasingly compete for Middle East oil. Alaskan oil, which is estimated to be 20 billion barrels, will only last for 5 years at the present rate of U.S. consumption.

What is the limit of oil price increase? The escalation of oil prices depends upon certain factors. First, there is the absorptive capacity of the producing countries. At the present situation wherein controlled supply is definitely less than world demand, increase in production is influenced by the capability of the economy of producing nation to absorb increments in petrodollar surplus (Leeman, 1974). Saudi Arabia, for instance, which has ample reserves and limited absorptive capacity, does not have much pressure to increase production, thus maintaining oil price at the high level. In the case of Iran, the pressure for production increase is higher as it has a bigger population and a comparatively more diversified economy. But there is also the problem of maintaining high oil price, and in effect, stimulating the quest for and the development of alternative energy resources which in the long run can lower prices of oil. This has immediate impact on Saudi Arabia's production. Since Saudi Arabia has the biggest reserves in the Middle East which could be rendered less valuable in the future as compared with its present worth, it is not an optimizing policy to maintain high prices at controlled production (Penrose, 1974). The Middle East producers are therefore confronted with the problem of maintaining an appropriate trade-off between future price of reserve and current prices of oil.