

# The Impact of Oil Price Increases on the Market for Nuclear Power in Developing Countries

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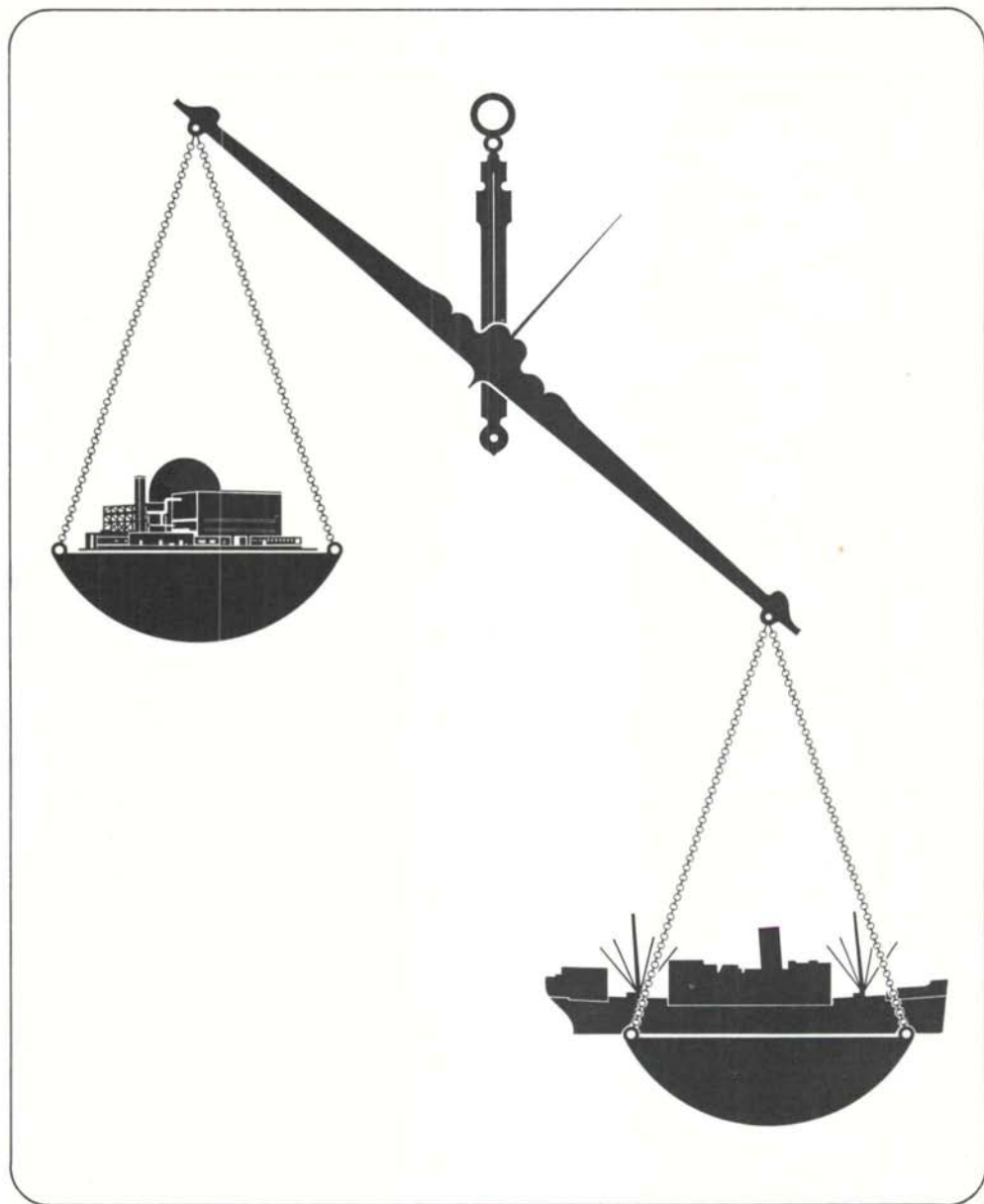
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*In August 1973, the Agency concluded a market survey of nuclear power in fourteen selected developing countries throughout the world. The results of this survey have been reported in fourteen country reports [1] and a general report [2] and also in a summary report presented at the Seventeenth Regular Session of the Agency's General Conference [3]. These results indicate that in the fourteen countries surveyed, about 60,000 MW(e) of nuclear plant capacity might be put into operation during the period 1980 to 1989. Most of this nuclear capacity would be in the form of units of 600 MW(e) or larger since under the assumed economic conditions, nuclear units in the 200-400 MW(e) size range were generally found to be uneconomical compared to oil-fired plants.*

Using the Market Survey results as a basis, a very preliminary evaluation of the potential market for nuclear power in fifty developing countries not covered by the Survey was carried out by Agency staff. The projected total installed capacity of these 50 countries in 1980 amounts to approximately 200,000 MW(e), or about twice that of the 14 surveyed countries. It was found in this extension of the Market Survey results, that during the 1980-1989 period about 200,000 MW(e) of new thermal capacity will be added to the electric power systems of the 50 countries concerned, of which 90,000 MW(e) might be nuclear plants. As in the case of the Market Survey, however, only about 10% of this capacity would be represented by plants smaller than 600 MW(e).

The sensitivity of the above results to variations in assumed oil prices and other economic parameters was evaluated in the Market Survey as well as in the extension of the Survey. These sensitivity studies showed that although the potential market for nuclear power is relatively unaffected by variations in economic conditions, the market for plants smaller than 400 MW(e) increases rapidly under conditions which tend to favour the construction of nuclear plants (i.e., higher oil prices). The reason for this is that 600 MW(e) or larger nuclear plants, when operating as base load plants, were found to be competitive with oil at 1 January 1973 prices, whereas the smaller nuclear plants were not.

The 1 January 1973 world oil prices used in the Market Survey and its extension, however, represent a thing of the past. On 23 December 1973, the six major oil producing countries in the Persian Gulf raised the posted price of light Arabian crude oil to \$11.65 per barrel. This precipitated a wave of even greater price increases by other oil producing countries throughout the world, who announced oil prices from \$14/bbl. to \$19/bbl. In the United States, the price of domestic crude oil jumped overnight to \$7/bbl. and at least one oil company was offering to pay \$10/bbl. for oil from new or



uncommitted sources.\* The era of cheap oil, therefore, came abruptly to an end and at the same time introduced the possibility of a greatly improved outlook for the economic competitiveness of nuclear plants in the 100 MW(e) to 400 MW(e) size range.

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\* Traditionally, the price of residual oil burned by utilities has been about 95% of the estimated price of delivered crude. Whether this same relationship will continue to hold in the light of very high crude prices is uncertain.

In order to evaluate the impact of high oil prices on the potential market for small and medium nuclear plants in developing countries, "break even" oil prices (i.e., oil prices at which power costs in nuclear and oil fired plants would be the same) were estimated from economic data developed in the Market Survey. Table 1 shows what these "break even" prices are as a function of plant size for plants in the 100 MW(e) to 400 MW(e) size range. It is seen that under the assumed economic conditions these small nuclear plants become competitive at oil prices in the range of \$3/bbl. to \$6/bbl. which are low compared to present day standards. In other words, the drastic change in oil prices completely reversed the previously unpromising outlook for small nuclear plants.

A detailed examination of the future electric power system expansion programmes in the developing countries of the world has only been carried out for the Market Survey countries plus several other countries who have sponsored their own studies.

<b>TABLE 1. Economics of Nuclear and Oil-Fired Plants</b>					
<b>PLANT SIZE MW(e)</b>	<b>100</b>	<b>150</b>	<b>200</b>	<b>300</b>	<b>400</b>
<b><u>Unit Cost, \$/kW<sup>a</sup></u></b>					
PWR	812	675	588	485	425
Oil-Fired	<u>311</u>	<u>284</u>	<u>262</u>	<u>227</u>	<u>207</u>
Differential	501	391	326	258	218
<b><u>Operating &amp; Maintenance, \$/kW (month)<sup>a</sup></u></b>					
PWR	1.26	0.91	0.71	0.52	0.42
Oil-Fired	<u>0.61</u>	<u>0.45</u>	<u>0.36</u>	<u>0.28</u>	<u>0.24</u>
Differential	0.65	0.46	0.35	0.24	0.18
<b><u>Nuclear Fuel Cycle<sup>b</sup></u></b>					
mills/kWh	1.93	1.91	1.89	1.84	1.79
<b><u>Oil-Fired Plant Heat Rate</u></b>					
kcal/kWh	2290	2270	2263	2259	2253
<b><u>Break Even Oil Prices<sup>b</sup></u></b>					
¢/10 <sup>6</sup> kcal	410	337	293	245	216
¢/MBtu	103	85	74	62	55
\$/barrel	6.12	5.03	4.37	3.66	3.22
<b><u>Basis</u></b>					
<sup>a</sup> Average of the 14 Market Survey Countries					
<sup>b</sup> These are the levels of oil prices at which nuclear electricity is already competitive. The calculations are based on 8% interest rate, 30 years plant life, 80% plant factor. It will be seen that even for a relatively small plant size of a 100 MW(e), nuclear power becomes advantageous for oil prices above \$6.12 per barrel.					

**TABLE 2. Potential Total Market for Small and Medium Nuclear Plants  
(Plants Commissioned 1980 - 89)**

PLANT SIZE, MW	=	100	150	200	300	400
<b>Country</b>						
Greece						1
Columbia						1
Turkey						2
Chile					4	4
Egypt						6
Pakistan						5
Israel					1	5
Iran					1	5
Peru					2	5
Cuba				1	5	1
Thailand					2	5
Malaysia				4	4	
Ghana			4			
Uruguay			2	5		
Kuwait			3	5		
Iraq			4	3		
Singapore				3	4	
Indonesia				5	3	
Morocco	2		4			
Algeria	3		3	1		
Jamaica	3		3	1		
Nigeria	3		3	1		
Lebanon	3		1			
Cameroon	2					
South Viet-Nam	2					
Bangladesh	2		4	3		
Syria	2		3			
Iceland	3		2			
Costa Rica	3		2			
Panama	3		2			
Dominican Republic	3		2			
Ecuador	3		2			
Albania	3		1			
Sri Lanka	3		1			
Bolivia	3					
Uganda	3					
Tunisia	3					
Zambia	3					
Saudi Arabia	2					
Guatemala	2					
Liberia	2					
El Salvador	1					
Burma	1					
Sudan	1					
Total		61	46	32	26	40

Nevertheless, a rough indication of the total potential market for small reactors can be obtained from the system expansion schedules developed in the extended study which is still in draft form. In this case, projections of each countries' future power needs were made using procedures developed for the Market Survey; however, because of lack of data it was not possible to treat hydro in detail. Instead, the assumption was made that future hydro capacity additions would be in the same ratio to thermal capacity additions as found for the 14 Market Survey Countries. The resulting thermal plant schedules, therefore, are only approximate and cannot be considered definitive for any specific country. Table 2 based on these schedules shows the number of thermal plants of a given size that might be ordered during the next decade for commissioning during the 1980 decade. Just how many of these plants will be nuclear, of course, depends on the long range oil prices and the willingness of reactor manufacturers to develop and sell such plants.

Plant Size MW	Potential Number of Plant Orders	Total Capacity MW	Total Nuclear Plant Investment \$ Billions	Approximate Sale Value of Nuclear Steam Supply System \$ Billions
400	40	16,000	6.8	1.4
300	26	7,800	3.8	0.8
200	32	6,400	3.8	0.8
150	46	6,900	4.6	0.9
100	61	6,100	5.0	1.0
Total	205	43,200	24.0	4.9

Table 3 shows the economic incentive for the development of small and medium nuclear plants. If the long term oil price remains above \$6 - \$7 per barrel, all nuclear plant sizes above 100 MW(e) would be competitive with oil-fired plants, resulting in a total investment costs in the range of  $\$24 \times 10^9$ . Although the cost of the nuclear steam supply systems of these plants amounts to about 20% of the total plant investment (including indirects and interest during construction), Table 3 shows that the total sale value of the NSSS equipment amounts to about \$5 billion. With a potential market of this size, reactor manufacturers should give serious consideration to the development of nuclear plants in the 100 MW(e) to 400 MW(e) size range.

The data for small nuclear plants can be combined with the Market Survey and extended study results for plants in the 600 MW - 1000 MW size range to obtain an indication of how the total market for nuclear plants would be influenced by oil prices. The results shown in Table 4 indicate that at oil prices above \$6.00 per barrel ( $400 \text{ } \$/10^6 \text{ kcal}$ ) the total nuclear market amounts to more than 400 units with an installed capacity of almost 200,000 MW(e), representing one-third of the total electrical

capacity of the countries concerned. The total investment in these plants would amount to about \$75 billion, of which \$12.5 billion would represent the cost of the nuclear steam supply systems.

**TABLE 4. Effect of Oil Prices on Total Nuclear Market in Developing Countries (Plants Commissioned 1980 - 1989)**

Effective Oil Price, \$/bbl.	No. of Nuclear Plants	Total Capacity, GWE	Total Plant Investment, \$ Billions	Sale Value of Nuclear Steam Supply System, \$ Billions
2.50	135	103	33	5.0
3.60	273	171	59	9.5
4.40	314	183	65	10.5
5.00	360	190	70	11.5
6.10	421	196	75	12.5

#### References

- [1] Country reports are available on: Argentina, Bangladesh, Chile, Egypt, Greece, Jamaica, Korea, Mexico, Pakistan, Philippines, Singapore, Thailand and Turkey (available from the IAEA on restricted basis).
- [2] Market Survey for Nuclear Power in Developing Countries – General Report (available from the IAEA).
- [3] Summary Report – GC(XVII)/506 August 1973. See also O.B. Falls: "A Survey of Nuclear Power in Developing Countries" IAEA Bulletin, Vol. 15, No.5, pp 27-38, 1973.