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System Effects of Reactor Size and Cost

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NUCLEAR CAPACITY EXPANSION IN MEXICO:

SYSTEM EFFECTS OF REACTOR SIZE AND COST

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INTRODUCTION

Mexico's electrical generation capacity could more than double over the next ten years--from about 15 GWe currently to as much as 35 GWe in 1990. While new capacity additions will be predominantly oil-fired in the 1980's, nuclear power will become increasingly important in the 1990's.

This study investigated the appropriate size of new, nuclear capacity additions by assessing the implications of installing different size reactors into Mexico's electrical grid. Included in the assessments of reactor sizes are estimates of electrical generation costs and comparisons of the "effective load-carrying capability" of a 10 GWe nuclear capacity expansion.

LEVELIZED LIFE-CYCLE COSTS

Nuclear generating costs for different reactor sizes (100, 400, 627, 929, and 1139 MWe) were calculated with the POPCYCLE[1] computer code. The economic parameters used in the levelized life-cycle cost calculations are shown in Table I. Three key parameters influential in comparing generating costs are capital costs, construction lead times, and capacity factors--all parameters with large uncertainties. While this analysis tried to put the capital costs on a common basis, the costs were obtained from engineering studies from a number of sources and are only very approximate. The analysis assumed smaller plants could be built faster than large units; for example, a 10-year construction time was assumed for 1139-MWe units and only six years for 100-MWe units. While there is some statistical evidence that capacity factors may decrease somewhat with reactor size, the uncertainties are so large that this analysis assumed a constant value of 70%.

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TABLE I

Economic Parameters[a] Used in
Levelized Life-Cycle Cost Calculations

Parameter	Value
Plant lifetime	30 yr
Bond interest rate[b] (deflated)	5%/yr
Taxes[c]	0
Cost of converting U_3O_8 to UF_6	5.43 \$/kg of U
Separative work cost	144 \$/kg SWU
Uranium tails composition	0.2%
U_3O_8 price	35 \$/lb
Capacity factor	70%
Fabrication losses	1%
Fuel-fabrication cost	249 \$/kg HM[d]
Spent-fuel disposal cost	237 \$/kg HM

	1139 MWe	929 MWe	627 MWe	400 MWe	100 MWe
Capital cost with IDC	\$1743 x 10^6	1556 x 10^6	1226 x 10^6	800 x 10^6	319 x 10^6
Decommissioning cost	\$141 x 10^6	129 x 10^6	104 x 10^6	70 x 10^6	28 x 10^6
Fixed O&M charges/yr	\$29.9 x 10^6	25.3 x 10^6	18.4 x 10^6	9.7 x 10^6	8.6 x 10^6
Construction lead time in years	10	9	8	7	6

[a] 1982 dollars.

[b] Plant is assumed to be financed entirely by bonds.

[c] The plants were assumed to be government owned and operated so no taxes or insurance costs were included.

[d] HM = heavy metal.

The results (Figure 1) indicate that reactors in the 100 MWe range could have a substantial generation cost penalty. However, compared to the large uncertainties in the data assumptions, there isn't a significant difference in generation cost among the other reactor sizes.

EFFECTIVE LOAD-CARRYING CAPABILITY

The expansion of an electrical generation system must be planned as an integrated entity. One method of evaluating the impact of adding new units to a system, originally proposed by Garver,[2] is to calculate what is called the effective load-carrying capability (ELCC). Basically, the ELCC is that portion of the capacity addition that can meet an increase in system load while maintaining a constant system-reliability standard and is calculated as follows:

$$x_{n+1} = \alpha_{n+1} - m \times \ln\left[\left(1 - L_{n+1}\right) + L_{n+1}e^{\alpha_{n+1}/m}\right] ,$$

where x_{n+1} = the ELCC of the capacity addition,

n = the number of units on the system,

α_i = the rated capacity of the i^{th} unit,

L_i = the forced-outage rate of the i^{th} unit, and

$m = \sum_{i=1}^{n} \alpha_i L_i$.

For this study, we assumed that Mexico's grid is interconnected by 1992 and that because of the large uncertainty in forced outage rate dependence on size, the mean 14.3% is the forced outage rate for all unit sizes. The result of the ELCC calculations indicated that capacity addition requirements are not a function of reactor size.

CONCLUSIONS

Because of large uncertainties in values of capital costs and capacity factors, there is no compelling evidence regarding cost-scale economies in the range of 600 to 1139 MWe. Although larger units tend to increase reserve requirements, this system effect is relatively unimportant. Therefore, other considerations besides costs (for example, economic development objectives) might be employed by Mexico's energy planners to select reactor sizes.

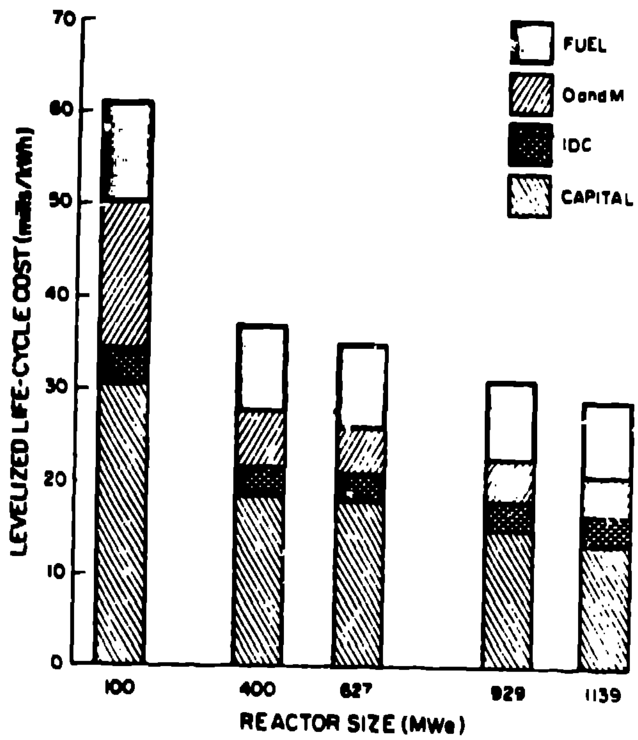

Figure 1. Levelized life-cycle costs based on engineering estimates.

REFERENCES

1. R. W. Hardie, "POPCYCLE: A Computer Code for Calculating Nuclear and Fossil Plant Levelized Life-Cycle Power Costs," Los Alamos National Laboratory report LA-9127 (February 1982).

2. L. Garver, "Effective Load Carrying Capability of Generating Units," IEEE Trans. Power Appar. Syst. 85(8), 910-918 (1966).