FINANCING ASPECTS OF NUCLEAR POWER IN INDIA

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Abstract

This paper addresses economic scenarios and trends toward deregulation in India. Growth of the power sector must precede economic growth. Nuclear power growth, now at a rate lower than the average growth of other power, is expected to accelerate over the next two decades. Capacity growth would be funded through equity and debt in the ratio of 1:1. While a substantial portion of the equity capital would be mobilized internally, the initial flow of equity for this growth must come from the Government. The debt capital is to be substantially funded by the domestic capital market and part would flow from external sources.

1. INTRODUCTION

Development of infrastructure is a prerequisite for growth of a developing economy. As a critical part of infrastructure development, power must achieve a high rate of growth to support this. Nuclear power has been identified as a clean and economically viable source of energy, which can contribute significantly to economic development. However, nuclear power needs more capital investment than conventional thermal power. A developing country is faced with a scarcity of capital and therefore must plan a long-term strategy for financing. This paper illustrates the Indian experience in the financing strategies of nuclear power programs.

2. THE INDIAN ECONOMY

India has a developing economy with a gross domestic product (GDP) of (rupees) Rs.12756 billion (US $ 300 billion) at current prices and has been growing at an average rate of about 5 per cent in the last two decades. The average growth rate of the economy in the last five years has been 6.7 per cent. It is poised to grow at the rate of about 7 per cent in the coming years.

The contributions to the economy from the different sectors during 1996-97 at current prices are shown in Table I.

<p>| TABLE I. SECTORAL CONTRIBUTIONS TO GDP |</p>
<table>
<thead>
<tr>
<th>Sector</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>27</td>
</tr>
<tr>
<td>Industry</td>
<td>31</td>
</tr>
<tr>
<td>Service</td>
<td>42</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
</tr>
</tbody>
</table>

2.1. Direct savings in the Indian economy

India’s current savings rate at about 26 per cent of GDP, is relatively high compared to other developing countries and can be further increased through tighter fiscal policies and
strong structural reforms. Components of the savings include, currency, deposits with banks and financial companies, claims on government, investments in shares and debentures and contractual savings like pension funds, provident funds, etc. Household savings play an important role in boosting growth in the economy. Private corporate saving has also shown a steady increase over the last 20 years though it remains at below five per cent of GDP. Gross saving is expected to increase at about 28 per cent by the year 2000. A part of these savings are directed to the capital market, which includes the equity and the debt market.

2.2. The Indian capital market

The Indian capital market has been instrumental in the economic growth of the country by channeling domestic savings to industrial investment. During the 1980s, the Indian capital market emerged as an important source of funds for corporations in both the private and public sectors. During the period 1988-95, the total volume of capital issues rose nearly five-fold. While in the 80s, the debt instruments played a dominant role in mobilizing resources, during the 90s, the trend has changed and equities emerged as a more popular instrument in resource mobilization. However, during the last 3 years, debt instruments have again become popular. The debt market is expected to grow substantially in volume and will provide debt capital for growth of the power sector, including nuclear power.

3. ENERGY POLICY OF INDIA

The energy policy of the Government of India aims to ensure adequate energy at a minimum cost, achieve self-sufficiency in energy supplies and protect the environment from adverse impact by utilizing energy resources judiciously. The main elements of the energy policy are:

- Accelerated exploitation of conventional domestic energy sources viz.: coal, hydro, oil and nuclear power.
- Energy conservation and management with a view to increasing energy productivity.
- Optimizing the utilization of existing capacity in the country.
- Development and exploitation of renewable sources of energy to meet the energy requirements of rural communities.
- Intensification of research and development in the field of new and renewable energy sources.
- Organization of training for personnel engaged at various levels in the energy sector.

4. POWER SECTOR IN INDIA

Electricity is the single most critical infrastructural input for economic growth of the country. In India, electricity is a resource involving complex decision making that lies in the concurrent jurisdiction of the center and the states. As a result of substantial growth of the power sector, the cumulative generating capacity of the country has increased to about 90000MW(e), supported by a vast network of transmission and distribution systems. The hydro share of electricity generation has decreased from about 54 per cent in 1947 to about 25 per cent now. This is expected to decline further during the Ninth Five Year Plan (1997-2002). The present share of different sources in electricity generation is given in Table II.

While the country faces genuine power shortages in many areas, there are surpluses during the off-peak hours in some regions. The State Electricity Boards (SEB) are at the center
stage of the power sector in India, which has about a 70 per cent share of the generating capacity and almost 100 per cent of the distribution of electricity. Due to heavy subsidies in tariffs provided by the SEB for electricity supply to agricultural and domestic sectors, and due to high losses in transmission and distribution, most of the SEB cannot recover the full costs of electricity supplied, resulting in weak financial positions for them.

The demand for electricity is growing at an annual rate of about 8 per cent. To match this demand with the supply of electricity, it is necessary to direct huge investments toward capacity additions, with matching investments in transmission and distribution. Coal and hydro will continue to dominate electricity generation in the country for the next 20 years with nuclear, natural gas and lignite playing a complimentary role. With the large deposits of thorium, nuclear power with fast breeder technology is expected to be important in the future.

4.1. Deregulation

Economic reforms include deregulation of the power sector. While initiatives are on for channeling private investment into power, mainly in thermal power, such initiatives for investment have not begun in nuclear technologies. Even with these initiatives, the actual investment to date is far short of expectations.

A direct result of deregulation of the power sector is increased costs for power. The business risk of a public sector unit engaged in power production is by and large internalized and therefore not directly reflected in the price of electricity. However, with private investors, a part of the business risk is allocated to other agencies at a cost, which would be reflected in the pricing of electricity. However, with increases in efficiency of operation expected of the private sector, the increase in the cost of electricity may not be significant.

5. NUCLEAR POWER

Since independence electricity generation has grown at an annual compounded rate of about 7.5 per cent and that of nuclear electricity at a rate of about 5.6 per cent since 1973-74. With the limited availability of fossil fuels in the country, there was a need for an alternate source of energy to meet long-term energy demands.

<table>
<thead>
<tr>
<th>TABLE II. SHARE OF DIFFERENT SOURCES</th>
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<tbody>
<tr>
<td>Sources</td>
</tr>
<tr>
<td>Thermal</td>
</tr>
<tr>
<td>Hydro</td>
</tr>
<tr>
<td>Nuclear</td>
</tr>
<tr>
<td>Other</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

A nuclear power station comprising twin reactor units of 2 x 200MW(e) was launched at Tarapur (Maharashtra) in 1964. This station has two boiling water reactor (BWR) units using enriched uranium as fuel and light water as moderator. To be self-reliant in nuclear generation, the Department of Atomic Energy (DAE), opted for pressurized heavy water
reactor (PHWR) technology in collaboration with Atomic Energy of Canada, Limited, and commenced construction of a power station comprising two units of 220MW(e) each at Rawatbhata in Rajasthan in 1964. The PHWR technology used natural uranium as fuel and heavy water as moderator. To achieve long term self-sufficiency, the DAE established facilities for fabrication of fuel and zirconium alloy components, manufacture of precision reactor components and production of heavy water. Efforts were dedicated to develop manufacturers in the country to produce components like calandria, end-shields, steam generators, fueling machines, nuclear pumps and other critical equipment required for nuclear power stations, conforming to international nuclear standards. With these efforts, development of world class manufacturing facilities in public and private sector organizations could be achieved.

India has developed its own standardized PHWR design of 220 MW(e) with major design improvements in safety systems. The construction of reactors at Narora and Kakrapar was based on the standardized PHWR designs. Presently, five operating nuclear power stations, with an installed capacity of 1840MW(e) are in operation. India has more than 120 reactor years of operating experience and operations have been free from incidents of radiation release. Power generated by these reactor units exceeded 120,000 million units by the end of March 1998. Four units of 220 MWe are in advanced stages of construction. Detailed designs for 500MW(e) of pressurized heavy water reactor series have reached an advanced level of completion. Commencement of construction of 2 x 500MW(e) units at Tarapur has started. Sites for establishing an additional 4 units of 500MW(e) each and 4 units of 220 MW(e) each have been cleared and advance action for procurement of critical items has been taken.

The installation of a sufficient power generation base of PHWR using natural uranium resources available in the country as Stage-1 of the nuclear power program, will provide inputs and impetus for utilization of plutonium in fast breeder reactors (FBR) as Stage-2. The long range potential of nuclear energy in India depends on utilization of Thorium, whose known resources in the country exceed 360,000 tons, which, when used in the breeder reactors, will be equivalent to about 600 billion tons of coal. With the establishment of a 40 fast breeder test reactor (FBTR) at Kalpakkam, a beginning has been made for the second stage of the program. Set up of one unit of a 500MW(e) prototype fast breeder reactor (PFBR) is also planned and the design is fast progressing. India has attained total self-reliance in design, construction, operation and maintenance of nuclear power plants. It has also mastered fuel cycle technologies from mining to fabrication of natural uranium fuel, fabrication of enriched uranium fuel, reprocessing technology, fabrication of plutonium and thorium based fuel required for its future program. The related waste management facilities have also been satisfactorily developed.

5.1. Safety aspects

Safety is given utmost importance during design, construction and operation of the nuclear power plants in the country. These aspects are continuously reviewed by the Atomic Energy Regulatory Board (AERB), an independent body, constituted by the government. Nuclear power plants in India have established a good record of operational safety; there has been accident-free operation for more than 120 reactor years and there has been no injury or casualty due to radiation. Gaseous and liquid releases from the nuclear power stations have been a small percentage of the limits authorized by the AERB. Industrial accident frequency and severity rates for the nuclear power stations in operation and under construction are far
below national levels. Codes and standards followed in India conform with international standards including those of the International Atomic Energy Agency (IAEA) and the International Commission on Radiation Protection (ICRP).

5.2. Regulatory environment

There are three distinct regulatory phases: (1) site selection, (2) construction and commissioning and (3) operation of the station. During site selection, the agencies involved in regulation are the Ministry of Environment and Forest, the AERB and the Central Electricity Authority (CEA). During construction and commissioning, the AERB is the regulating agency. During the operation of the station, the AERB, CEA and the Department of Atomic Energy (DAE) regulate activities. While the AERB regulates operations from the standpoint of public safety, the CEA and DAE regulate the distribution of power and pricing issues.

5.3. Attitude of the government and the public

The government of India has extended a high level of support to nuclear power. This support has been translated in terms of budgetary support to the program year after year. Until 1987, the Government met the entire expenditure for the nuclear power program. With the formation of the Nuclear Power Corporation of India Limited (NPCIL) in 1987, part funding for the program started flowing from the capital market as debt capital. However, the entire equity capital for the nuclear power projects continued to come from the Government. During the Eighth Five-Year Plan period (1992-97), the flow of funds from the Government as equity capital was significantly lower than required, due to financial constraints. However, from 1997 onwards, the trend has changed and the flow of funds from the Government has increased.

The public at large in India, has supported nuclear power, as it is perceived as a source of energy with substantial potential available at reasonable prices. However, there are pockets of population critical of nuclear power particularly on safety issues. The limited public opposition is not considered a hurdle for the growth of nuclear power in this country.

5.4. Capital cost of nuclear power projects

The costs of completed nuclear power reactor units shown in Table III have increased unit after unit. If the inflation effect is removed, costs of PHWR until NAPS is fairly stable however, the costs of units from NAPS onwards show large increases from the earlier series.

This is mainly due to inclusion of financing costs of borrowed funds and to changes in design to incorporate the latest safety features. The main reasons for increases in the capital costs are:

- Inflation.
- A stretch in the gestation period and the consequent increase in overhead and financing.
- Increases in the scope of projects due to incorporation of the latest operational and safety features.
- Foreign exchange variation.
### TABLE III. COST OF COMPLETED NUCLEAR POWER STATIONS (Rs in Million)

<table>
<thead>
<tr>
<th></th>
<th>Cost (book value)</th>
<th>Cost at 1998 rupee value</th>
<th>Cost / MW As % of RAPS-1 cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base IDC Total</td>
<td>Cost Base IDC Total</td>
<td>With IDC W/O IDC With IDC W/O IDC</td>
</tr>
<tr>
<td>TAPS 1,2</td>
<td>930 - 930 9580</td>
<td>- 9580 - 29.9 -</td>
<td></td>
</tr>
<tr>
<td>RAPS 1</td>
<td>730 - 730 8430</td>
<td>- 8430 - 42.1 - 100</td>
<td></td>
</tr>
<tr>
<td>RAPS 2</td>
<td>1030 - 1030 8530</td>
<td>- 8530 - 42.6 - 101</td>
<td></td>
</tr>
<tr>
<td>MAPS 1</td>
<td>1190 - 1190 8060</td>
<td>- 8060 - 36.7 - 87</td>
<td></td>
</tr>
<tr>
<td>MAPS 2</td>
<td>1270 - 1270 6580</td>
<td>- 6580 - 29.9 - 71</td>
<td></td>
</tr>
<tr>
<td>NAPS 1,2</td>
<td>6530 1080 7610</td>
<td>22920 2260 25180 57.2</td>
<td></td>
</tr>
<tr>
<td>KAPS 1,2</td>
<td>9560 4110 13670</td>
<td>23110 6820 29930 68.0</td>
<td></td>
</tr>
</tbody>
</table>

Of the above, the dominant reasons for increases in the capital costs have been inflation and extended gestation periods. Since the formation of NPCIL, debt capital mobilized from the domestic capital market is also used to start new projects. The interest on the debt capital during construction is included in the capital costs of the projects. Since the gestation periods of nuclear power projects are long, interest during construction is of the order of 30 per cent of the capital cost. The capital cost of the new nuclear power projects is estimated at about Rs.60000 per Kwe at 1998 prices, based on a twin unit station of a unit size of 500MW(e) and a capital debt equity ratio of 1:1.

A lot of attention is focused on cost reduction of nuclear power projects. Considering that they have a long gestation period and about 50 per cent of the total capital costs are time related, such as overhead, escalation and interest during construction, NPCIL has set out to standardize the designs to enable serial unit construction. With this strategy it is expected that the capital costs of nuclear power projects, in real terms, could be reduced significantly.

#### 5.5. Tariff and pricing issues

Electricity generated is supplied to the State Electricity Boards (SEB) in the region. For this purpose, a bulk power supply agreement is signed between the generating company and the concerned SEB. With clearance of the Central Electricity Authority, the Government specifies the tariff for bulk power and that is based on a ‘cost plus’ principle. While a two-part tariff system is followed for thermal and hydropower, a single part tariff system is adopted for nuclear power. In case of the two-part tariff, fixed and variable costs per unit are separately identified. While variable costs are charged to all the units sold, fixed costs are charged only for normative generation of units above which an incentive is charged for each unit in place of fixed charges. However, a single part tariff system charges a uniform tariff for all units sold.

The element due to the capital charge in the tariff is accounted on the book value of the assets. Due to the high level of inflation experienced in most developing economies, including India, the real term value of the capital charge in the tariff diminishes year after year. Thus, the internal generation of resources after meeting the debt servicing obligations, to be used as equity capital for new projects, diminishes in real term value.
Regarding institutional aspects, the Government enacted legislation to set up an independent tariff regulatory structure at the center and the states. These regulatory authorities are expected to be in position within the next few months and will enhance investor confidence in the power sector. In the long run, this will facilitate mobilization of resources for power development on a much larger scale in the public and private sectors. A time related 'availability tariff' system is expected to be operational soon for bulk power supply. This will promote safe and reliable operations of the regional power grids.

5.6. Financing

Like in any other developing country, the Government of India has funded the growth of nuclear power in this country. Until 1987, the Government provided the entire appropriation for nuclear power. Considering the projected growth of nuclear power and the limitations of funding through this route, the Government decided that part of the resources for the program should be mobilized from the domestic capital market. With this in mind, the Nuclear Power Corporation of India Limited (NPCIL) was set up as a company under the Department of Atomic Energy.

With the incorporation of NPCIL, it was recognized that funds for construction of new power stations would be mobilized from different sources, such as: government funds in the form of equity capital, the internal generation of money through the sale of electricity and loans from the domestic capital market. It was also recognized then, that all new nuclear power projects should be built with a debt equity ratio of 1:1.

Since the inception of NPCIL, the company has been able to mobilize funds from the capital market every year. So far, the total direct investments in the nuclear power stations, including the projects under construction, is about Rs.95 billion, which is equivalent to about Rs.200 billion at 1998 rupee value. Out of the total direct investments made so far, about 33 per cent have been mobilized from the domestic capital market, mainly through the issue of bonds. Permission to issue bonds, either by a public issue or by private placement, is given by the government each year, depending on the outlay of the approved capital budget. The issue of bonds by private placement has been found cheaper than the public issue. Therefore, NPCIL has adopted this route for most of its bond issues.

To help NPCIL mobilize debt capital at cheaper interest rates, each year the Government permitted issuance of 'tax free' bonds for part of the amount. Until 1991, the Government determined the interest rates, which were 13 per cent for taxable bonds and 9 per cent for tax-free bonds. Until 1991, NPCIL had no difficulty in mobilizing the entire amounts, however, after 1991, the capital market changed and demands for the bonds diminished. To improve marketability, the Government deregulated the interest rates and tenor of the taxable bonds and left them to NPCIL to decide based on the market but interest rates of the tax-free bonds had an upper limit of 10.5 per cent. Even with these steps, there were difficulties in marketing the bonds from 1991 to 1993. A credit rating of the bonds was done by a reputable credit rating agency to further improve marketability. Further, it was decided to enlist the bonds in the National Stock Exchange, to ensure liquidity for the investors in NPCIL bonds. With these steps, demand increased and funds have been mobilized each year in sufficient volume and at reasonable cost.
6. PROJECTED GROWTH OF NUCLEAR POWER

The present installed capacity of nuclear power in India is 1840MW(e). There are 4 units of 220 MWe each in advanced construction, with completion in about 2 years. Nuclear power capacity is expected to grow to about 20,000MW(e) by the year 2020 (Figure 1) i.e., at an annual compounded growth rate of 11 per cent. This is significantly higher than the average growth rate of the total power sector during that period. The share of nuclear capacity is expected to grow from the present level of about 2 to about 5 per cent by the year 2020. This additional capacity during the next two decades would be pressurized heavy water, light water and fast breeder reactors. A detailed plan for the period to 2020 is not yet complete, however, one for the next decade indicates an additional capacity of about 4800 MW(e).

6.1. Fund requirements

Projected capacity additions in nuclear power for the next 22 years require more than Rs.1000 billion at 1998 rupee values, equivalent to about 23 billion US dollars of 1998. In addition, 15 billion rupees would be needed for additional fuel fabrication facilities. It is expected that the installed heavy water capacity would support projected additions. The investment during the 9th Five-Year Plan 1997 to 2002) would be Rs.66 billion, for which there are detailed plans. To meet the target of 20000 MW(e) by 2020, the investment beyond 2002 must be augmented from Rs.13 billion per year during the 9th plan period to Rs.52 billion.

FIG. 1. Projected growth of nuclear power.
6.2. Debt equity structure

Considering the development of the nuclear power industry in the country and operational constraints, it was decided that new projects should be implemented with a conservative debt equity structure of 1:1. This ratio was adopted to reduce interest during construction. The lower ratio would help reduce fluctuations in the internal generation of resources with respect to variations in the performance of the nuclear power stations.

6.3. Projected sources of funding

Projections of fund requirements and likely sources are shown in Figure 2. With a conservative debt equity structure for funding projected capacity additions, the required capital would be about Rs.500 billion. Of this, a substantial portion, of the order of Rs.350 billion, could be generated internally by operating nuclear power stations. The balance of Rs.150 billion is expected from the Government through budgetary support. While Government funds towards equity capital would flow during the first 10 years, the internal generation of resources could be utilized in the later years. Considering the present constraints of nuclear power regarding the flow of material and technology from external sources, capital for the projected growth is not expected from external sources. Considering the regulatory environment in the nuclear power sector, it is uncertain whether equity capital could be mobilized from the domestic capital market as well.

![Financing of Nuclear Power Program](image)

**FIG. 2. Projected sources of fundings.**

The debt capital for future growth amounting to about Rs.500 billion, is expected to be mobilized essentially from the Indian capital market. The Indian debt market during the last three years has grown at a phenomenal average rate of about 50 per cent and during 1997-98, the market attained a mobilization volume of about Rs.310 billion. It is expected that the
future debt market will grow at about 20 per cent in the short run and about 12 per cent over the longer term.

Various options available to mobilize the debt capital for growth of nuclear power are:

- Issue of bonds in the domestic debt market.
- Syndicated term loans from banks and financial institutions.
- External commercial borrowing.
- Issue of bonds in the international markets.
- Credit extended by the suppliers.

Mobilization of funds through bond issue in the domestic market is a popular route to mop up resources. Interest rate of the bonds would be determined by prevailing market conditions at the time of mobilization. To increase the marketability, a credit rating of each issue is necessary. The credit rating of the NPCIL bonds is expected to improve to achieve the highest credit rating in a few years. It would therefore be possible for NPCIL to mobilize the required quantum of funds from the capital market at reasonable costs.

Considering the long gestation of nuclear projects, it is desirable to obtain long term funds. The main sources of long-term funds are pension and provident funds, which can be attracted through issue of long-term bonds in the domestic market. In the recent past, NPCIL issued bonds with a maturity of 10 years. It is expected that, with the growth of the debt market in the country, it would be possible for NPCIL to issue future bonds with more than 10 years maturity. It is also expected that, to help the nuclear power sector mobilize resources at reasonable costs, the Government of India would extend permission to issue tax-free bonds.

It is possible to obtain long term loans from banks and financial institutions for specified projects after evaluating financial viability. In a syndicated loan, it would be feasible to pre-determine the schedule of draw of funds depending on projected requirements for the project. The credit evaluation and the associated documentation for a syndicated loan would be more rigorous and voluminous. It would be necessary to secure the loan with some of the company assets. Normally, the cost of a syndicated loan is higher than funds mobilized through issue of bonds.

Funds could also be mobilized through external commercial borrowing (ECB) normally having a maturity of up to 7 years. The cost would be in the region of 100 to 150 basis points over a benchmark interest rate such as the London International Borrowing Rate (LIBOR). Since borrowing is in the foreign exchange, interest payments as well as repayment must be in the foreign exchange. Therefore, ECB exposes the company to the risks associated with foreign exchange variation but could be preferred provided the exchange rate of the rupee is reasonably stable. It is expected that once the exchange rate stabilizes, a part of the debt capital for nuclear power programs would flow from the ECB, provided costs are lower than domestic borrowing after adjusting for the projected exchange rate variation.

The international bond market presents an opportunity for funding nuclear power projects since it provides long term finance of maturity of more than 10 years. However, the ability of the company to gain access to the international bond market depends primarily on the credit rating of the country and the company. Therefore, this could be considered only after the credit rating of the country improves.
Another source of funding is credit from foreign suppliers of equipment or plants, where suppliers arrange long term financing through institutions in their country. Many countries have government supported financing arrangements to promote export and these could fund the supply on credit. Interest rates and repayment terms could be negotiated as part of the contract for the supply. Like other forms of external debt, this source will also expose the company to the risks of exchange rate variations.

7. CONCLUSIONS

The Indian nuclear power program is based on pressurized heavy water reactors. The nuclear power program has been funded mainly by the Government of India through its national budgets. Until now, the nuclear power sector has grown at a moderate rate, lower than the average growth rate of the power sector in general. However, it is poised to grow at a higher rate to achieve a long term target of 20000 MWe by the year 2020. Funding for the projected growth is about Rs.1000 billion, of which about 50 per cent will be mobilized as debt from the domestic capital market. The balance of funding as equity capital is expected to come from budgetary support of the Government as well as the internal generation from operating nuclear power stations.