

DEPARTMENT OF ATOMIC ENERGY

ESTABLISHMENT OF NUCLEAR POWER STATIONS UPTO
END OF 1978-79 AND OUTLAY THEREON.

In the paper "Installation of Nuclear Power Stations during the Fourth Plan Period" sent to the Planning Commission in June 1964, the Department of Atomic Energy had set forth in detail their proposals for the installation of 1.2 Million Kilowatts of nuclear power by the end of March 1971 made up of as under:-

(A) <u>Projects spilling over from Third Plan Period</u>	
(i) Tarapur (2 reactors of 190 MWe each) Atomic Power Project.	380 MWe
(ii) Rajasthan (1st Unit) Atomic Power Project.	200 MWe
(B) <u>Fourth Plan Projects</u>	
(iii) Rajasthan (2nd Unit) Atomic Power Project.	200 MWe
(iv) Madras (2 reactors of 200 MWe) Atomic Power Project.	400 MWe
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	1,180 MWe

2. The work on the Tarapur and Rajasthan Atomic Power Stations are in full swing while that on the first 200-MWe reactor Unit of the Madras Atomic Power Station is getting into stride. The Tarapur Station is scheduled to be turned over for commercial operation some time in April 1969 and the sent over power - 380 MWe - will be shared equally by the Maharashtra and Gujarat States. The first 200 MWe unit of the Rajasthan Atomic Power Station is scheduled to be commissioned some time during 1970-71 while the second 200 MWe unit is scheduled to deliver power to the State by 1972.

3. At the time of including the Madras Atomic Power Project in the erstwhile Fourth Plan, it was expected that the foreign exchange cost of the project would be met by a suitable project credit from France. This expectation did not, however, materialise and consequently it was decided to undertake the construction of this Station in two phases with the object of reducing the foreign exchange content of their costs and meeting it from the various Non-Project Credits available to Government. Work on the first unit of the Station, which will be of 200 MWe size, has already commenced and that unit as scheduled will be commissioned some time in 1972. Thus by end of 1973, 980 MWe of nuclear power would flow into different regional grids.

4. An outlay of Rs.115.00 crores (approximately) on the above mentioned projects is expected to spill over to the Fourth Plan period (1969-74).

Madras Atomic Power Project (2nd Unit):

5. Government had already approved the establishment of a second 200 MWe Unit at Kalpakkam as part of the erstwhile IVth Plan. However, since installation of large size units will result in lower Capital investment per kw, the Department is examining the feasibility of putting up a large size unit (500-600 MWe) at Kalpakkam. Taking into account the estimated deficits in generating capacity in the Southern Region in 1978-79, the Working Group on Power of the Planning Commission has recommended installation of 700 MWe of nuclear power by the end of the Vth Plan period in addition to the 200 MWe unit, which will be available from the first unit of MAPP. This 700 MWe may comprise the 500 MWe unit at Kalpakkam and a 200 MWe unit in the Southern part of the Southern Region.

5.1 The Sub-Committee of the Working Group is also of the opinion that subject to detailed studies on the absorption of power at high-load factor, the new Station in the Southern part of the Southern Region could be upto a 300 MWe unit.

6. NEW STATIONS TO BE INSTALLED DURING 1969-78 (UPTO END OF THE VTH PLAN PERIOD)

6.1 Power Demand Estimates

The Annual Power Survey Committee on the basis of a detailed study on the industrial, agricultural and other developments in progress, has, in their latest (Fifth) Annual Report indicated that the gross load by 1970-71 would be 13.57 million KW. Projecting this figure on the basis of the average rate of increase in demand in the past and allowing for the spurt in demand in the agricultural sector, the Working Group on Power of the Planning Commission considers that it would be reasonable to assume a 15% increase annually in the power demand during the Fourth Plan period beyond 1970-71 and a 12% annual increase during the Vth Plan period (1974-79). Computing on this basis, the power demand in 1973-74 is estimated at 20.5 million KW. The Fifth Annual Power Survey Committee has, however, in their report, put the estimated power demand at 19.7 million KW. Allowing a 12% annual increase during the Fifth Plan period on the figure of 19.7 million KW, the Working Group has put the power demand in 1974 at 34.36 million KW.

6.2 The total installed capacity by the end of March 1969, when the new Fourth Plan is scheduled to commence, is put at 15.5 million KW. This is expected to be augmented by about 7.5 million KW by the end of 1973-74 from stations currently under construction. In other words, the generating capacity by the end of 1974 is expected to increase to 23 million KW. About 2.8 million KW of power is also expected to spill over beyond 1973-74 into the Vth Plan from stations which are currently under construction and will be commissioned during the Fourth Plan period.

6.3 Based on the load forecasts indicated in the Fifth Annual Power Survey Committee's Report, which has been accepted by the Working Group on Power, the deficit in generating capacity by 1973-74 is estimated at 4.45 million KW and by 1978-79 at 17.7 million KW. The region-wise break-up of

these figures are indicated in cols.5 and 8 of Annexure II to this note. To meet the deficits by 1973-74 and in the Vth Plan, the Sub-Committee on Power Planning of the Working Group has recommended the installation of 2,000 to 2,500 MWe of nuclear power - the balance being covered by thermal and hydro schemes - by the end of 1978-79. The Sub-Committee has also indicated that of this 400 MWe is to be installed during the IVth Plan period and the remaining 1500-2000 MWe during the Vth Plan period. The region-wise break-up of these is indicated in Annexure III to this note.

6.4 PRIORITIES FOR NEW STATIONS

The Sub-Committee of the Working Group on Power has proposed the following priorities for putting up new Atomic Power Stations during the IVth and Vth Plan periods.

Order of priority	Region	Capacity (MWe)	Date by which the Station is required to be ready	Remarks
1	Western	400	1973-74	(One Station - Possibly expansion of Tarapur Atomic Power Project).
2	Southern	500-600	Early Vth Plan	Madras Atomic Power Project (2nd unit) with higher capacity.
3	Northern	400-600	Vth Plan	New Station
4	Southern	300	"	Another Station in the Southern part of the region
5	Western	400-600	"	New Station
		<u>2,000-2,500</u>		

6.5 It has already been established that nuclear power is already competitive with power produced in thermal stations in areas of high-cost fossil fuels. In recommending the Regions for establishment of new atomic power stations, the Sub-Committee has kept this fact in view. In suggesting the inter-se priority to be accorded to the Stations to be set up during the IVth and Vth Plan, consideration has been given by the Sub-Committee to the desirability of meeting the power demand of the region by installing additional units in the power stations already under construction e.g. Expansion of the Tarapur Atomic Power Project and installation of a 500 MWe unit at Madras in place of the second 200 MWe unit, as such a course would not only result in lower capital cost but also the speedier completion of the projects, due to utilisation of the existing infra-structure.

The sites for the establishment of nuclear power stations have to satisfy a number of technical criteria and their proper selection is of considerable importance. The Department proposes to set up for each Region concerned a small Group comprising the representatives of all interests, which could study the Region's requirements and make recommendations regarding the areas considered suitable for locating atomic power stations. A Steering Group for the Northern Region has already been established on this basis and commenced its studies. Similar Groups are proposed to be constituted for other Regions concerned.

7. TYPE OF STATIONS

7.1 The Indian atomic energy power programme envisages that in the subsequent stage, fast or thermal reactors using thorium and plutonium will be adopted as they would permit on the one hand harnessing of our enormous thorium resources and on the other reduction of the cost of nuclear power.

However, such reactors have necessarily to be preceded by a programme of natural uranium reactors in an earlier stage in order to produce the plutonium which will be required to fuel them initially. The most economical type of natural uranium fuelled reactor is the one moderated by heavy water of the CANDU type and it was for this reason that it was decided to establish such reactor units at Rajasthan and Madras.

7.2 It is recognised that the capital costs of the CANDU type reactors, which are being put up in Rajasthan and Madras are at present relatively high though fuelling costs are low on account of good neutron economy. It has been estimated that use of boiling light water as coolant instead of pressurised heavy water may lead to reduction in the capital cost by about 10%. Preliminary designing of a 300 KWe boiling light water cooled heavy water moderated natural uranium fuelled reactor has been taken up on hand. After the completion of the Second unit of the Madras Atomic Power Station, which will have natural uranium, heavy water moderated and heavy water cooled reactor, it is expected that subsequent stations to the end of the Vth Plan period will have to be based on CANDU type Boiling Light Water design.

7.3 As already stated earlier, the second stage of the Indian atomic energy power programme will be based on breeder power reactors. Studies have been initiated on the development of fast reactors using plutonium as fuel and thorium or uranium as fertile materials. For this purpose, a Fast Reactor Centre with the following facilities is being established near Kalpakkam, the site of Madras Atomic Power Project.

- (i) Facilities like Heat Transfer Laboratory, Fuel Fabrication and Reprocessing Laboratory etc.
- (ii) A prototype Fast Reactor with about 10 MWe capacity to give experience to Indian scientists and engineers for designing and constructing Fast Breeder Power Reactors and
- (iii) A Zero Energy Fast Facility for studying the physics design of large breeders.

The capital cost on the establishment of the Centre is expected to be of the order of Rs.15.00 crores, which is included in the Research & Development programme of the Department.

The programme is expected to be completed in about 7-8 years from now and it would be possible to embark on the construction of Fast Breeder Power Reactors towards the end of the Vth Plan period.

8. SIZE OF STATIONS TO BE BUILT.

Experience in foreign countries has shown that capital and operating costs will be reduced considerably, if large capacity - 500 to 1000 MWe nuclear power stations are built. Subject to the capability of the grids to accept larger units, the efforts of the Department will be directed towards establishing reactor units of 500-600 MWe range. Regarding the turbo-generators required for these larger units, it is understood that both HEIL and BHEL are examining the feasibility of manufacturing larger units with their collaborators, as well as with other European turbine manufacturers. In case it is not possible to obtain larger size turbo-generator units in India, we may be obliged to install two smaller size turbo units with each large size reactor units. Further reduction in cost is possible, if agro-industrial complex is established around such large atomic power stations. These complexes will provide the requisite base load at minimum transmission cost. If such stations are established in India, they would not only provide the necessary impetus for agricultural and industrial development but also provide cheap power for other uses as surplus power could be fed into the grid and sold at cheap rate. The feasibility of setting up such stations in the country during the next ten years is under examination.

9. OUTLAY DURING IVTH AND VTH PLAN PERIOD.

According to the present estimates, the capital cost of nuclear power stations, if we go in for large size (500 MW or above) reactor units is expected to be of the order of Rs.2,300/- per K.W. at current level of prices. Allowing a 10% increase for escalation, it would, perhaps, be prudent to assume a capital cost of Rs.2,500/- per KW. On this basis, establishment of 2,500 MWe by the end of the Vth Plan period, the optimum figure recommended by the Sub-Committee B of the Working Group on power planning would involve an investment of Rs.625.00 crores. According to the priorities indicated by the Sub-Committee, the new station in the Western Region is required to be ready by 1973-74, the second unit of Madras Atomic Power Project with larger capacity by early Vth Plan period and the remaining stations during the Vth Plan. On the assumption that the construction of each of the station would take 5 years to complete, the phasing of the investment of Rs.625.00 crores would be as under:-

(i) IVth Plan period	...	Rs.241.25 crores.
(ii) Vth Plan period	...	Rs.376.25 "
(iii) Spill over beyond Vth Plan	...	Rs. 7.50 "
Total:		<u><u>Rs.625.00 crores</u></u>

The year-wise phasing of the above outlays is indicated in Annexure IV.

As already mentioned in para 3 above, an amount of Rs.115.00 crores representing the balance of outlay on the Nuclear Power Stations currently under construction will spill over to the IVth Plan period. Thus the total outlay on Nuclear Power Stations during the IVth Plan period, if the programme for the installation of an additional 2500 MWe is accepted, will be Rs.356.98 crores, or, say Rs.360.00 crores.

10. FOREIGN EXCHANGE REQUIREMENTS

The foreign exchange requirement for import of raw materials, components etc. required for fabrication of critical parts of the Station may be placed at a maximum of 20% of the overall cost i.e. Rs.125 crores of which Rs.40-50 crores would be required during the IVth Plan period and the balance during the first two years of the Vth Plan period.

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DEPARTMENT OF ATOMIC ENERGY

ANNEXURE I

Statement showing the Outlays required on Nuclear Power Stations during the Fourth Plan period (1969-74).

Name of Project	Sanctioned Estimated Cost to end of 1967-68	Expenditure incurred to end of 1967-68	Estimated Expenditure during 1968-69	Spillover to Plan IV	Remarks
<u>A - Sanctioned Projects:</u>					
1. Tarapur Atomic Power Station	8269.00	7822.14	450.00	..	including fuel
2. Rajasthan Atomic Power Station (Ist Unit)	5250.00	3300.48	1150.00	799.52	including fuel (199.55) and excluding Heavy Water
3. Rajasthan Atomic Power Station (IInd Unit)	5816.00	136.76	600.00	5079.24	including fuel (170) and excluding Heavy Water
4. Madras Atomic Power Project (I Unit)	6178.37	133.93	350.00	5694.44	including fuel and excluding Heavy Water
				<u>11,573.20</u>	

ANNEXURE II

Statement showing the estimates of deficit in the in the power requirements in various regions during 1973-74 and 1978-79. (Figures in MWe)

	1973-74 (end of IVth Plan Period)				1978-79 (end of Vth Plan period)		
	Estimated Load	Estimated installed capacity	Estimated effective capacity (70% of col.3)	Deficit	Estimated Load	Estimated effective capacity	Deficit
1	2	3	4	5	6	7	8
Northern Region	4,952	5,754	3,875	1,077 (1,250)	8,815	4,957	3,858 (4,500)
Western Region	4,788	5,311	3,691	1,097 (1,350)	8,562	4,906	3,656 (4,500)
Southern Region	5,016	6,047	4,333	683 (900)	9,105	5,128	3,977 (4,900)
Eastern Region	3,746	4,545	3,028	718 (850)	6,557	3,738	2,869 (3,600)
North Eastern	184	256	156	28 (100)	327	220	107 (200)
Total	18,686	21,913	15,083	3,603 (4,450)	33,366	18,949	14,417 (17,700)

Note: Figures in brackets under col.(5) and (8) represent deficit in installed capacity.

ANNEXURE III

Tentative allocation of Sources of Power
for meeting the deficits in 1973-74 and 1978-79.
(Figures in MW)

Region	Addl. Generating Capacity required to be installed by 1973-74.	Addl. Generating Capacity required to be installed by 1978-79		
		Hydro	Thermal	Nuclear
Northern	1250	1050	200	—
Western	1350	900	50	400
Southern	900	700	200	—
Eastern	850	650	200	—
N. Eastern	100	100	—	—
	4450	3400	650	400
				17700
				12500
				3700
				1500 (2100)