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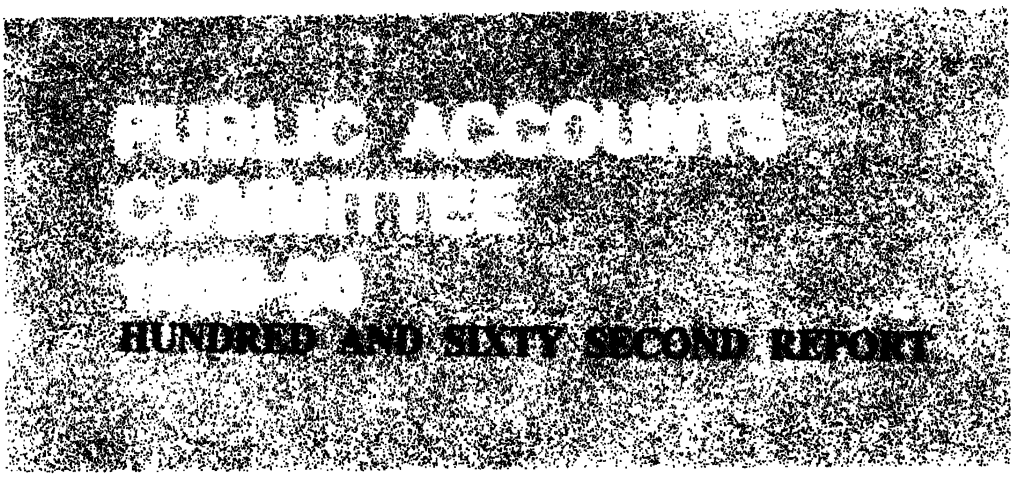
MADRAS ATOMIC POWER PROJECT

DEPARTMENT OF ATOMIC ENERGY



HUNDRED AND SIXTY SECOND REPORT

PUBLIC ACCOUNTS COMMITTEE

(EIGHTH LOK SABHA)
1988-89

MADRAS ATOMIC POWER PROJECT
DEPARTMENT OF ATOMIC ENERGY

Presented to Lok Sabha on 27-4-1989
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LOK SABHA SECRETARIAT
NEW DELHI

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@ Appointed w.e.f. 7-12-1988 *vice* Shri Kalpnath Rai ceased to be a member of the Committee on his appointment as a Minister of State.

INTRODUCTION

I, the Chairman of Public Accounts Committee, as authorised by the Committee, do present on their behalf, this 162nd Report on the Supplementary Report of the Comptroller and Auditor General of India for the year 1985-86, Part II, Union Government (Civil) relating to Madras Atomic Power Project.

The Supplementary Report of the Comptroller and Auditor General of India for the year 1985-86, Part-II Union Government (Civil) was laid on the Table of the House on 11 December, 1987.

3. The construction of the first nuclear power unit in the country incorporating natural uranium fuelled heavy water moderated reactor technology was commenced in Rajasthan with the Canadian assistance in 1964. The Department of Atomic Energy almost at the same time decided to construct two such units at Madras using the same basic reactor technology with indigenous effort. The Madras Atomic Power Project was approved by the Government in 1965. However, the project schedules for Madras Project were based on the schedules prepared for Rajasthan Atomic Power Project despite the fact that site condition and the methodology adopted for manufacture of critical nuclear equipments in case of Madras Project was clearly different from that of Rajasthan Project. The Committee have expressed the view that the Department of Atomic Energy in their anxiety to embark on the Madras Atomic Power Project, commenced the work without taking proper prepatory measures. The Committee felt that proper planning was not made at the pre-construction stage and the project was beset with problems right from the beginning due to inadequate investigations at site, changes and modifications in design during construction and the delayed delivery of various equipments by the indigenous manufacturers with the result that there were heavy overruns of both time and cost.

4. The Committee have expressed their surprise over the fact that the sub-soil problems specific to the site of Madras Project could be known only on excavation at site they have felt convinced that work on such a big project was started without adequate geological investigations and the net result of the lapse was increase in scope of work. The Committee have accordingly recommended the Department to ensure that proper and adequate geological investigations of the Project sites are made before submitting the Project reports to the Government for approval.

5. The Committee have also expressed their concern at the disquieting

picture that has emerged in regard to substantially delayed delivery of nuclear equipments by indigenous sources. The Committee have felt convinced that while the pre-project planning in this case needed thorough acquaintance with the Indian industrial scene, no earnest and systematic effort was made in this regard with the result that indigenous industries failed to deliver the goods in time.

6. The Committee have also expressed their concern over the poor performance of the two units of the Madras Atomic Power Station. They have accordingly desired that effective and timely steps should be taken to get over the mechanical and operational problems of this station with a view to improving its performance.

7. The Public Accounts Committee (1988-89) examined the Supplementary Report of C& AG at their sittings held on 9 January, 1989. The Committee considered and finalised the Report at their sitting held on 24 April, 1989. The Minutes of the sittings form Part II* of the Report.

8. For facility of reference and convenience, the observations and the recommendations of the Committee have been printed in thick type in the body of the Report and have also been reproduced in a consolidated form in Appendix VI to the Report.

9. The Committee would like to express their thanks to the Department of Atomic Energy for the coöperation extended by them in giving information to the Committee.

10. The Committee also place on record their appreciation of the assistance rendered to them in the matter by the office of the Comptroller and Auditor General of India.

AMAL DATTA
Chairman
Public Accounts Committee

NEW DELHI;
April 26, 1989
Vaisakha 6, 1911 (Saka)

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REPORT

CHAPTER I

INTRODUCTORY

1.1 This Report on Madras Atomic Project is the result of an enquiry based on the Supplementary Report of the Comptroller and Auditor General of India for the year 1985-86, Part-II, Union Government (Civil) which is reproduced as Appendix I to this Report.

A. Nuclear Power Profiles

1.2 Indian Atomic Energy Programme was launched in mid 1950s mainly to supplement the limited conventional energy resources to meet the long term power needs of the country and to utilise nuclear techniques in agriculture, industry, medicine and other areas. The broad objectives of the programme are as under:

—Energy security and independence in the long term;

—Installation of new capacity at a rapid rate and at economically Viable costs;

—Safety of station personnel and general public with minimum radiation exposures; and

—Minimum environmental impact.

1.3 The targets of nuclear power generation as contemplated by the Atomic Energy Commission (AEC) in 1954 and as revised downwards by certain agencies subsequently in particular years vis-a-vis the actual achievements in those years were as follows:

Year	As suggested by AEC in 1954	As forecast by Energy Survey Committee in 1965	As proposed by AEC in 1968	Achievements	Remarks
1	2	3	4	5	6
	MWe	MWe	MWe	MWe	
1970-71	600	600	400	420	TAPS-1&2

1	2	3	4	5	6
	MWe	MWe	MWe	MWe	
1975-76	3000	2000	1000	640	TAPS-1&2 and RAPS-1
1980-81	8000	5000	2700 (by 1978-89)	640 (by 1978-89)	-do-

(TAPS: Tarapur Atomic Power Station, RAPS: Rajasthan Atomic Power Station)

It would be seen from the above table that the installed capacity of nuclear power generation in the country was only 640 MWe as against the revised target of 2700 MWe of power by the year 1978-79.

1.4 With the commissioning of RAPS—2 in 1980 and Madras Atomic Power Station (MAPS)-1 and 2 in 1983 and 1985 respectively, the installed capacity could go upto only 1330 MWe. Even this installed capacity has now been reduced to 1230 MWe due to derating of the units of TAPS by 100 MWe.

1.5 Explaining the factors which weighed with the AEC in 1968 for downward revision of the targets of nuclear power generation as contemplated by AEC earlier, the Department of Atomic Energy (DAE) stated that the estimated time frame of five years visualised for setting up of nuclear power plants proved to be difficult to achieve in practice. The other most important factors were the difficulties in achieving effective co-ordination of training and personnel needs, R&D facilities and projects and lack of industrial infrastructure to back-up the programme. According to DAE, the early projects of Tarapur and Rajasthan were constructed with foreign collaboration and the inherent need for external financing and agreement on international safeguards have involved protracted negotiations leading to major delays in the past.

1.6 As regards the reasons for not achieving even the reduced targets of nuclear power generation, DAE stated that it appeared in retrospect that the initial expectation of gestation period was unduly optimistic as lack of industrial infrastructure in the country contributed to delay in manufacture of equipment due to learning process and developmental efforts associated with such a frontier technology. DAE also stated that as per the power profile of 2700 MWe by 1978-79, approval for four new projects amounting to 1700 MWe *i.e.*, MAPP-II (235 MWe), 2 additional 235 MWe Units and 2 Units of 500 MWe each should have been given for construction during the Fourth Plan (1970-75). But as against this, only MAPP-II (235 MWe) and NAPP-1&2 (2×235 MWe) were sanctioned in 1971 and 1974 respectively amounting to a capacity of 700 MWe. Though the profile

envisaged sanction of 2 units of 500 MWe each during the period 1970-75, a policy decision, in the light of experience, was taken to continue with 235 MWe Units for some more time due to infrastructural limitations. It was also decided to modify the designs of 235 MWe units of MAPP type so that designs could suit moderately seismic environment in recognition of the facts that large parts of the country are moderately seismic. Also, it was the objective to incorporate all design modifications and safety standards in a 235 MWe units so that the same could be scaled upto 500 MWe unit size in future.

1.7 DAE informed Audit in March 1987 that the shortfalls under Nuclear Power Programme were, among other factors, due to resource crunches. However, the statement showing the financial outlays under Nuclear Power Programme (Appendix-II) reveals that while the Plan allocations made by the Planning Commission were less than those proposed by the Department, the actual expenditure remained less than even the Plan outlays from IVth Plan to VIIth Plan (1987-88). On enquiry about the basis for this contention of the Department in the context of the fact that the actual expenditure under Nuclear Power Programme from IVth Plan onwards had remained less than the plan allocations, DAE stated that the reasons for expenditure being less than plan outlays in the past have been slow progress in project execution and manufacture of nuclear equipment and delays involved in obtaining environmental clearances, *e.g.*, Kaiga Project. The 1983 nuclear power profile suffered due to the 'crunch' felt during the formulation of the Seventh Five Year Plan. According to the profile, work on 12 units of 235 MWe each and 6 units of 500 MWe each should have been started during the Seventh Plan. However, the Plan allocation of Rs. 1410 crores allowed the Department to accord complete financial sanction only for 4 units of 235 MWe each and part financial sanction for 2 units of 500 MWe each till 1988 when the Planning Commission revised the Plan allocation to Rs. 2010 crores. After this revision, advance procurement action has been sanctioned for four 235 MWe reactor units and six 500 MWe units. As these sanctions were accorded only in July 1988, expenditure was bound to be less than the revised allocation.

1.8 The current (1983) Nuclear Profile of Department of Atomic Energy aims at achieving 10,000 MWe of nuclear power by the year 2000 A.D. The total operating installed capacity at present is 1230 MWe. Nuclear Power plants amounting to a total capacity of 1880 MWe are under construction taking the total to 3110 MWe. In addition, three sites for additional 4×235 MWe, 2×500 MWe, and 4×500 MWe have been approved. It is envisaged that work on 6×500 MWe units would commence during the 8th Plan taking the total committed capacity to about 10,000 MWe.

1.9 The Atomic Energy Commission (AEC) in 1954 had contemplated a target of 8000 MWe of nuclear power generation by the year 1980-81.

However, this target was revised downwards by AEC in 1968 to 2700 MWe of nuclear power generation by the year 1978-79 on the ground that the projections made earlier to were based on assumptions which needed revision in the light of experience. But even this reduced target could not be achieved and the installed capacity of nuclear power in 1978-79 was merely 640 MWe which could go upto only 1330 MWe after the commissioning of Rajasthan Atomic Power Station-2 in 1980 and Madras Atomic Power Station-I and 2 in 1983 and 1985 respectively. Only 3 units of 235 MWe each *viz.* Madras Atomic Power Project-II and Narora Atomic Power Project I & II were sanctioned during the Fourth Plan period in 1971 and 1974 respectively. Even these two projects have been affected substantially by time overruns admittedly due to initial expectation of unduly optimistic gestation period and due to absence of the nuclear grade industrial capability in even such basic areas as welding technology in the country.

1.10 The Committee are inclined to conclude that the AEC in 1968, while envisaging targets of nuclear power generation, had neither fully anticipated the time and effort required for establishing a nuclear power station nor taken into consideration the realities of the industrial situation prevailing in the country with the result that targets of nuclear power generation continue to remain elusive even today. The Committee urge the Government to give thrust to the achievement of the current Nuclear profile of Department of Atomic Energy which aims at attaining 10,000 MWe of power by 2000 AD, keeping in view the experience gained in constructing nuclear power stations and also by making a realistic assessment of indigenous industrial capabilities of the quality required to supply nuclear components for future reactors of different capacities so that the limited plan resources committed on this programme may yield timely benefits to the economy in the vital power sector.

B. *Growth of Atomic Energy Programme*

1.11 The Indian Atomic Energy Programme, chalked out in 1954, has envisaged a four stage growth. The stages were:

— establishment of natural uranium fuelled heavy water moderated thermal reactors (1970-80);
— Building of advanced thermal reactors of 500 MWe (1970-80);
— establishment of plutonium fuelled fast breeder reactors; and
— establishment of thorium cycled fast breeders.

1.12 According to audit paragraph only first stage has been partially achieved. The second stage involving scaling up process of the existing technology has not been attempted on the ground as yet. The third and fourth stages are still at experimental levels.

1.13 Outlining the background of nuclear power programme, the Secretary, Department of Atomic Energy (DAE) informed the Committee during evidence that the original conception of the nuclear power programme in the country was to build reactors using natural uranium as

fuel and heavy water as moderator because the Department wanted to depend on indigenous supply of fuel. Though the country does not have large quantity of uranium, this particular type of natural uranium reactor was chosen because reactors of the kind using heavy water and natural uranium produce plutonium in the spent fuel which is a very important fuel for starting subsequent reactors called fast breeder reactors on the second stage. In the third stage, thorium based reactor system was expected which would use the very large amount of thorium available in the country.

According to the information made available to the Committee, the currently uranium reserves in the country can support the first stage programme upto 10,000 MWe.

1.14 According to DAE, the basic programme for nuclear power as originally envisaged continues to remain unchanged. The Department is pursuing the objective of establishing pressurised heavy water type of reactors in the first phase of the programme. It has also been stated that the Department has been able to finalise the design for advanced thermal reactors of 500MWe capacity without any external assistance. Simultaneously, development work on plutonium fuelled fast breeder reactors and design of the first prototype 500MWe fast breeder reactor is also in progress. A prototype fast breeder reactor of 15 MWe capacity has already been commissioned at Kalpakkam as a step towards the fast breeder reactor technology.

1.15 According to DAE, from the beginning the Department has set self-reliance as an important objective in the development and harnessing of nuclear energy for power generation. It was with this end in view that the Department opted to go in for natural uranium fuelled heavy water reactors in the first phase of the programme utilising in the natural uranium resources available in the country. However, since at the time of taking this decision, only Canada was working on similar type of reactors and even their programme was at an infant stage, the Department decided to construct an enriched uranium light water type of reactor on a turnkey basis at Tarapur to acquire expertise in constructing, operating and maintaining a nuclear power station though it required import of enriched uranium from overseas. The contract for work on Tarapur was executed in May 1964.

1.16 However, at the same time, the Department also entered into an agreement with Atomic Energy of Canada Ltd., for obtaining technology for pressurised heavy water reactors the design of which was demonstrated by them on a prototype and a commercial scale power station was under construction. As a result of this, construction of 2 units of pressurised heavy water reactors was commenced in Rajasthan with Canadian assistance. According to DAE, whatever equipments/materials that could be supplied from within the country, were utilised in the first unit keeping in line with the policy of progressive self-reliance. The indigenous content

was progressively increased from 55 per cent in the first unit to 75 per cent for the second unit and the responsibility for project management and construction rested with Indian engineers. The work on RAPP-I and II commenced in 1964 and 1967 respectively.

1.17 The Committee have been informed that at that stage, Indian industry was not exposed to or in a position to meet the demand of sophisticated technologies. Even in the area of raw material, the manufacture's were not in a position to meet the quality requirement of special materials required for nuclear power units. The welding technology was also in its infant stage. As such a lot of effort was required to build up capability to manufacture nuclear equipment involving welding and heavy fabrications with specialised machining operations to vary rigid quality control requirements. The delivery schedule of second unit of Rajasthan is stated to have been greatly affected by this. The construction programme of the two units of Rajasthan was also affected to a certain extent by design changes which had to be made in the light of the deficiencies observed in operation of the units at Douglas Point, Canada, on which the design of Rajasthan units was based. This also led to certain cost and time overruns for that project.

1.18 DAE also stated that based on the experience gained in construction of Rajasthan units, the Department decided that the two units of Kalpakkam (Madras) would be set up without any external assistance. The responsibility for detailed design, safety review, construction and commissioning was taken up departmentally with maximum participation from Indian industry. Indian consulting agencies were also involved in some of the conventional areas of work. Madras Atomic Power Project (MAPP) was approved in 1965 as the third nuclear power project and sanction for construction of MAPP-I was given in December 1967. Subsequently, work was also undertaken in 1974 on two units of 235 MWe each at Narora (NAPP) followed by similar sized units at Kakrapar (KAPP-1&2), Rajasthan (RAPP-3&4) and Kaiga-1&2.

1.19 According to DAE, the efficacy of the policy followed has been proved and the objectives, by and large, achieved. Nevertheless, there have been some shortfalls in achieving the goals in the prescribed time frame. The main reason for the shortfall has been to get the Indian industry to come up to the needs of stringant specifications and quality control requirements of the nuclear industry. The technological difficulties encountered in the manufacture of critical nuclear equipment like the calandria and end shields delayed the delivery of these equipment to the first project and sequentially affected supplies to other subsequent projects as well. The restrictive attitudes of certain countries and embargo placed on supply of material and equipment intended for nuclear power reactors were also stated to have contributed to delays in execution of the projects.

1.20 DAE also stated that in addition to these factors, there were many

areas in this frontier technology for which specialised work was being carried out for the first time in the country. In these areas, the time and effort required were not fully anticipated at the planning stages and in actuality, more time and cost was required for completion. DAE has also pointed out that even for the developed countries the initial estimates of time for completion of early nuclear power projects was found to be unrealistic and had to be revised upwards in subsequent projects.

1.21 Based on the limited uranium reserves and abundant thorium deposits available in the country, the Indian Atomic Energy Programme drawn in 1954 had envisaged a strategy of first establishing natural uranium fuelled heavy water moderated reactors followed by plutonium fuelled fast breeder reactors using plutonium obtained from the first stage reactors. The third stage would be thorium based reactors. The Department of Atomic Energy is, however, still pursuing the objective of establishing natural uranium fuelled heavy water reactors in the first phase of the programme and the work on fast breeder reactor techonology is only at experimental levels. Currently identified uranium reserves in the country can support the first stage programme of establishing natural uranium fuelled power reactors upto only 10,000 MWe.

1.22 With a view to establishing natural uranium fuelled heavy water moderated reactors in the first phase of the nuclear power programme, the Department of Atomic Energy entered into an agreement with Atomic Energy of Canada Ltd. for obtaining technology for pressurised heavy water reactors and construction of 2 such units in Rajasthan. Accordingly, construction of the first unit in Rajasthan with Canadian assistance was commenced in 1964. The Department of Atomic Energy almost simultaneously decided to set up two units at Madras. This project was approved by the Government of India in 1965. The Department undertook responsibility for construction and commissioning of Madras Atomic Power Project with maximum participation from Indian industry. However, both Rajasthan and Madras Atomic Power Projects were affected by substantial time overruns. The Department of Atomic Energy have tried to justify the delay on the ground that the time and efforts required for certain specialised work in this frontier techonology, which was being carried out for the first time in the country, were not fully anticipated at planning stages and that the initial estimates of time for completion of early nuclear power projects even in the developed countries were found to be unrealistic. The Committee are not convinced by these justifications and are further of the view that the Department of Atomic Energy overestimated the industrial capability and infrastructure available in the country. Since the Department were venturing into a new field, the Committee feel that they should have made thorough enquiries about the capabilities of the indigenous manufactures to decide whether and to what extent they were capable of manufacturing critical nuclear equipments and within what time frame so as to leave little or no scope for the stretch in time scheduled. Considering the

fact that a developing nation like India can ill afford to commit limited financial resources on the projects whose costs are bound to escalate with delays besides entailing loss of production, the Committee hope that the Department of Atomic Energy will draw a lesson from this experience and take adequate precautions in future.

CHAPTER II

PROJECT ESTIMATES

A. *The Time Schedules*

2.1 The proposal for constructing MAPP was approved by the Government in June 1965 subject to the requisite foreign exchange being arranged in consultation with the Department of Economic affairs. However, the expectation that the special credit would be available to cover the foreign exchange requirements of the station was not realised and it was proposed that only the first unit of the station (MAPP-I) should be taken up as an immediate commitment with a time interval of about two years being left between unit I and II. Accordingly, a Project report for the construction of MAPP-I was prepared in 1967 and financial sanction for the same was issued in December 1967. The Government subsequently, approved the setting up of second unit of MAPP in April 1971 and the financial sanction for the same was issued in May 1971. The original project schedules fixed the date of criticality as December 1974 for MAPP-I and November 1976 for MAPP-II. But the dates of criticality for MAPP-I and II underwent various revisions and were finally shifted to July 1983 and August 1985 respectively. The details of revision in the dates of criticality for two units are as under:

Revisions	Date of criticality anticipated
1	2
For MAPP Unit-I	
December 1967 (Original)	December 1973
I Revision—May 1970	December 1974
II Revision—August 1971	November 1975
III Revision—September 1972	July 1976
IV Revision—November 1973	June 1976
V Revision—July 1976	December 1977
VI Revision—June 1977	December 1979
VII Final Revision—1982	July 1983

1	2
For MAPP Unit-II	
May 1971	
(Original)	December 1976
I Revision—November 1973	June 1979
II Revision—July 1976	June 1980
III Final Revision	August 1985

It may be seen from the above table that the date of criticality underwent seven revisions in case of MAPP-I and three revisions in that of MAPP-II. The table also reveals that as against the original target dates, there were delays of about 9½ years and 8½ years in attaining criticality of MAPP-I and II respectively.

The detailed reasons for each of the revisions made in the projected dates of attainment of criticality for the two units of MAPP separately, are given at Append. III.

2.2 Earlier, the Estimates Committee in their 129th Report (4th Lok Sabha) on the Department of Atomic Energy while taking note of the revisions in date of completion of MAPP, held the shifting of target dates as indicative of lack of realisitc planning but the shifting of dates went unabated in both the units of MAPP. When asked as to why were no concrete steps taken in deference to the above observation of the Estimates Committee, DAE stated that all steps were taken to minimise the time overrun but the slippages in the project schedules occured because of the various problems which arose on several fronts. According to DAE, planning and implementation of nuclear power projects pose problems not normally encountered in other conventional projects and time and cost overruns are unavoidable when a high technology like nuclear technology is being adapted/developed indigenously. It was also claimed that it was with the commencement of work on MAPP that the major challenge of building a nuclear power station on a totally self-reliant basis was embarked upon and in no other sector of industry was such a bold attempt of establishing self-reliance from the third project itself was made.

2.3 According to audit paragraph, DAE stated (March 1987) that stretch in schedules in both the units had been mainly on account of embargo imposed by the USA and Canada, consequent cancellation of orders, identification of alternative sources in European countries, indigenisation of equipment as an organisation policy and adoption of costly and complex reactor system based on pressurised heavy water design.

2.4 It is hovewer, seen that USA and Canada have adopted restrictive practices in transfer of information as well as embargo on supply of equipment intended for use in nuclear power plants in India only after the

testing of peaceful nuclear device in May 1974 at Pokhran. This trend was also later followed by some other European countries.

2.5 As regards adoption of reactor system based on pressurised heavy water design and indigenisation of equipment, it was stated by Secretary, DAE during evidence that the Department discussed the heavy water reactor system with the Canadians who were then in the process of building a prototype of first pressurised heavy water reactor. Because the Canadians were alone in this particular reactor technology, they looked upon India as a good partner to sponsor heavy water development and to give the technology inputs required to design a reactor in Rajasthan. When these two projects were taken up in 1964, the Department had already decided that the next project would be an Indian design project. The reason why the early planners stressed self-reliance, according to the witness, was two fold. Firstly, it was a large programme and the Department could not finance buying of capital goods on extensive basis from overseas and therefore, the Department had to make things within the country. The second and the most important reason was that it was realised that nuclear technology was much too sensitive an area and that we would not be in a position to get various types of items required by us sooner or later.

2.6 According to the information made available to the Committee, the originally projected schedules of 6 years and 5½ years for completion of MAPP-I and II respectively were based on schedules for RAPP and had envisaged similar time schedules for manufacture of major nuclear equipment based on Canadian experience. On being enquired whether it was not incorrect to follow the same time schedule when the methodology to be adopted for MAPP-I was clearly different from that of RAPP-I, the Secretary, DAE stated during evidence that the potential suppliers like Bharat Heavy Electricals Ltd. Larsen & Tubro etc. indicated the time by which they would be able to manufacture the equipments but they gave relatively short period of time probably not being aware of the actual problems that would be encountered in the manufacturing process. In the opinion of the witness, the suppliers were not trying to mislead the Department but shorter period of time was indicated because the suppliers were doing the job for the first time. During evidence, raising the question whether the Department could have done better by choosing to wait for the technology to reach some stable level, the Secretary, DAE stated that had the Department postponed the project, they would not have been able to get the grip of the technology because the Madras project had shown that the terms of technology transfer in nuclear area would have hardened with or without Pokhran and the Department would not have acquired the technology had they waited.

2.7 On being pointed out that the option was not that the Department waited but it was to make a realistic project schedule, the Secretary, DAE stated that at that time the best planning that the Department could do

was done collectively with the industry. Both the Department and the industry mutually arrived at the forecast for producing nuclear equipments. The witness also stated that the forecast was based on expectations as both the Department and the industry were really going without any actual experience in that particular field.

2.8 On being asked whether the Department assessed the capability of the industries in terms of their technical know-how and equipment, the Secretary, DAE stated during evidence that this was one of the major activities of the Power Project Engineering Division (PPED) which had a procurement group and their task was to go and survey the Indian industries regularly. The procurement group of the PPED was set up in 1967 but in reality, it had begun to functioning 1965 when RAPP-I was started. This group was finding out the potential suppliers. The Committee pointed out that this particular group did not function properly as certain industries found out by this group ultimately failed to deliver the goods and desired to know whether any action was taken to see that the group functioned properly. The Secretary, DAE replied that the group was doing those jobs for the first time and it was easy for the group to say that nobody in the country could make the particular item and that was really what the group had said in a number of cases. In such cases the next question for the group was to find out as to who was the most likely to make the particular item. According to the witness, they had many successes and a few failures but they had to take chance with the most likely candidate.

2.9 The Secretary, DAE also informed the Committeee during evidence that DAE itself took a lot of trouble to upgrade the industrial capability by way of making available new technologies, by way of giving loans to industries to add on to their capital assets and by way of training their people. According to the witness, this process took time to give results because nuclear technology is one of the most demanding technologies.

2.10 When enquired about the expenditure incurred by DAE on building capabilities of the suppliers of major equipments etc., DAE stated that it would not be possible to indicate the expenditure incurred on building up the capabilities as most of the development works were an essential part of the manufacturing process of the critical equipment in question and the Department had not incurred separate expenditure exclusively for such development except in one or two instances like tri-junction welding where separate development contract was awarded.

B. *The Cost Estimates*

2.11 The original projects estimates calculated in 1965 indicated cost of two reactors of 200 MWe each as Rs. 60 crores. The project report for construction of first reactor i.e., MAPP-I was prepared in early 1967 and the cost of this reactor with 200 MWe capacity was calculated as Rs. 61.78 crores excluding the cost of heavy water. The financial sanction for this

amount of Rs. 61.78 crores was issued in December 1967. Subsequently, these cost estimates alongwith those for MAPP-II underwent various revisions together with upgradation of the installed capacity of the two units of MAPP as may be seen from the details given below :

Year	MAPP-I		MAPP-II	
	Reactor Capacity (in MWe)	Cost Estimates (Rs. in crores)	Reactor Capacity (in MWe)	Cost Estimates (Rs. in crores)
1967	200	61.78* (Original sanctioned)	—	—
1971	215	77.09	215	70.63* (Original sanctioned)
1979	—	107.87	—	103.02
1983 (Final Sanction)	235	118.83	235	127.04

*Excluding cost of heavy water.

2.12 According to the information made available to the Committee the initial cost estimates for MAPP-I were worked out on the basis of data for RAPP-I which in turn was based on the following inputs:

(a) Cost information on the nuclear portion furnished by Atomic Energy Canada Ltd. (AECL) who were then involved in the construction of a nuclear power station in Canada.

(b) Cost of the conventional portion was furnished by Montreal Engineering Company a leading firm of Canadian Consultants.

2.13 The RAPP cost estimates and preliminary schedules were prepared by a Joint Indo-Canadian team consisting of technical experts from AECL and Montreal Engineering Co. as also engineers from DAE and some who had joined RAPP directly with outside industrial and power plant experience. The Report of this Joint Indo-Canadian study was prepared in 1965 at a time when AECL itself did not have sufficient experience in exploitation of nuclear power with PHWR type of reactor as their first commercial unit had not yet been completed.

2.14 According to DAE, they had no independent data base at that point of time and had to go by the data furnished by these agencies who were involved in the construction of a similar nuclear power station in Canada which was the first prototype PHWP in the world. It has also been stated that though the initial estimates of MAPP-I & II did not have the benefit of previous cost data, these cost estimates were based on the best

available information at that time and from limited budgetary inquiries obtained from possible suppliers. These budgetary figures, however turned out to be low since suppliers had no experience of such large sized equipment to be manufactured for nuclear service.

2.15 According to DAE, there was no separate power projects organisation when the initial cost estimates of MAPP-I were formulated in 1965-66. The estimates were prepared by the Reactor Engineering Division, BARC with the inputs from experienced engineers who had worked on construction of large research reactor like CIRUS, experience acquired from large projects like TAPP and RAPP which were there under construction.

2.16 Explaining the stages through which these estimates were routed, DAE stated that these estimates were reviewed by Senior Programme leaders who had prior experience of construction of research reactors in Trombay. These estimates were thereafter reviewed by a group of people with experience in administration and financial matters before being submitted to Atomic Energy Commission. The project proposals approved by Atomic Energy Commission were also sent to Planning Commission for their concurrence before submission to Cabinet for approval. After formation of the Power Projects Engineering Division (PPED) in 1967, the cost/time schedule of already sanctioned projects like RAPP-1 & 2 and MAPP-I are also stated to have been reviewed by one more level viz., a Board which included senior programme leaders from BARC, persons with experience in construction of other nuclear power or chemical plants, research scientists, experienced administrators, financial advisers and Director of PPED. DAE also stated that the preparation of the estimates was a joint effort of a team of people and the best available and experienced talent had been used in preparation of the estimates.

2.17 The causes for delay and cost escalations are discussed in the succeeding chapter.

2.18 The Committee are constrained to observe that the Department of Atomic Energy could not prepare realistic project estimates in case of both the units of Madras Atomic Power Project. While the first unit had to undergo as many as seven revisions in the projected date of criticality, the number of revisions made in the case of second unit were three. As against the originally targetted date, there were delays of 9½ Years and 8½ in the first and second units respectively. Similarly, the cost estimates together with upgradation of installed capacity underwent three and two revisions in the case of first and second unit respectively. The Department's plea that they had no independent data base at that point of time and the only method available to them was to extrapolating information available through the project schedule prepared for the Rajasthan Project by a Joint Indo-Canadian study is hardly convincing since the methodology adopted for Madras Atomic Power Project was clearly different from that of the first

unit of Rajasthan Atomic Power Project in so far as manufacture of the critical nuclear components and construction methodology were concerned. The Committee feel that while it may always not be possible to precisely estimate the cost and time frames for accomplishing tasks in the high technology area like nuclear technology at the very beginning of the programme, these estimates have to be correct within reasonable limits and there should not be extraordinary stretch in schedule as have been in this case. The Committee are led to believe that the Department of Atomic Energy, in their anxiety to embark on the Madras Atomic Power Project commenced the work without taking proper preparatory measures.

2.19 Considering the fact that frequent revisions in project schedules were made mainly due to non-delivery of various equipments by indigenous manufacturers, the Committee have an impression that the Department could not appreciate the Indian industrial situation and relied upon the time and cost estimates of the indigenous manufacturers without proper scrutiny of their claims. The Committee would like the Department of Atomic Energy to develop proper organisation and methodology for estimating the capabilities and scrutinising the claims of the indigenous manufacturers.

CHAPTER III

DELAYS AND COST ESCALATIONS

A. *Analysis of Delays*

3.1 The critical path for construction of MAPP passed through the award of civil contract, release of calandria vault for equipment erection, installation of end-shields and calandria, installation of coolant channels, feeders and post feeder work leading to criticality. To suit this installation sequence, deliveries of critical equipment like end-shields, calandria, coolant channels etc. were to be made by certain dates. At various stages of the project, the completion schedule was to be governed by deliveries of coolant tubes, stand by coolers and availability of heavy water.

3.2 Based on the information made available to the Committees, the following table shows the projected dates of receipt of certain equipments on the critical path as originally envisaged *vis-a-vis* the actual dates of receipt of those components/equipments which had sequentially delayed the execution of the project.

Activity on critical path	MAPP-I			MAPP-II	
	As originally envisaged in Dec. 69	Revision in May 70	Actual date of completion of activity	As originally envisaged in May 71	Actual date of completion of activity
1	2	3	4	5	6
Manufacture and delivery of end-shield & Calandria	Dec. 71	Dec. 72*	March 76	NA	Dec. 78*
Installation of end-shield and calandria	May 72	May 73	£	Aug. 74	£
Delivery of coolant tubes, headers, feeders etc.	May 72	—	Sept. 77** Dec. 78***	Aug. 74	Dec. 81**

*delivery of end-shield
**delivery of coolant tubes
***delivery of stand-by coolers

1	2	3	4	5	6
Installation of coolant channels	Dec. 72	Dec. 73	£	Feb. 75	£
Moderater System- Installation of and part piping	Dec. 72	—	£	May. 75	£
PHT System- Installation of — and part piping	Dec. 72	—	Dec.82@	May. 75	Oct. 84@
Post Feeder Work and Commissioning	Dec. 73	Dec. 74	July. 83	Dec. 76	Aug. 85

@Final Review
£ Information not furnished by DAE

It would be seen from the above table that the deliveries of certain items were not made in time thereby affecting the project schedules.

3.3 According to DAE, the proportionate distribution of delays on account of various factors, between original and final completion dates for MAPP-I was as follows:

Items of work	Percentage
Civil works	10
End Shields	30
Coolant Tubes	9
Standby Coolers	8
Increase in duration of post feeder work	5
Balance Instrumentation and Control Works, modifications and changes in design based on RAPS experience.	18
Delayed supply of Heavy Water	20

In the case of MAPP-II, the proportionate distribution of total delays between original and final completion dates was as under:

Items of work	Percentage
End Shields	55
Coolant Channel Assemblies	29
Heavy Water and Balance Instrumentation and control works and design improvements.	16

These figures of proportionate distribution of total delays reveal that the

major factors which affected the completion schedule of the two units of MAPP were: Civil Works, Nuclear equipments and delayed supply of heavy water. These factors are discussed in the following paragraphs:

(i) *Civil Works:*

3.4 In the case of MAPP-I, the tenders for construction of reactor and turbine buildings were received in March 1969 and the evaluation of the tenders was completed by December 1969. The selected tenderer, however, withdrew from the project and the contract after fresh negotiation was awarded to next bidder towards and of February 1970. In case of MAPP-II, the contract for civil work was awarded in June 1971 after the financial sanction for this unit was accorded in May 1971. The projects were to be completed in 35 months but these were completed in April 1979 and May 1983 thus leading to delays of 74 months in the case of MAPP-I and 107 months in the case of MAPP-II.

3.5 When enquired about the basis for calculating the initial period of construction as 35 months, DAE stated that the original time schedule for completion of civil works was fixed taking note of earlier project experience and striving for a certain degree of compression of time for completion. This was made to fit into the overall project schedule but the expected compression in time to complete civil works for the project did not materialise.

3.6 In reply to a question whether the original schedule of 35 months for completion of civil works was not unrealistic in the first instance considering the fact that RAPP experience was not valid for MAPP due to changed site conditions, the DAE informed the Committee that different site conditions had not been the only cause for the original time estimate being exceeded but the design changes and the time required to finalise the civil design to meet new safety criteria, increase in scope of work etc. have also significantly increased the time requirement for completion of civil works.

3.7 According to DAE, the main factors which affected the original time schedule of 35 months for civil works were as follows:

(a) The original schedule of 35 months for civil works was arrived at on the basis of the then available information of the site conditions. It was recognised in the initial stages itself that this schedule would be governed by the design changes being contemplated in the building designs viz. adoption of prestressed concrete for the reactor building, use of diaphragm wall technique for sub-soil structures etc. Such sophisticated civil construction work for reactor buildings with use of prestressed concrete for perimeter wall was being done for the first time in the country.

(b) The original scheduled also did not allow a delay on the availability of structural steel for the reactor building without which the construction work could not proceed. Plates required for fabrication of structural steel

were ordered on Hindustan Steel Ltd. in June 1968 but after making some deliveries in May 1969, HSL advised the project that the delivery schedule for the remaining steel plates was uncertain. Consequently, most of the steel plates were imported thereby causing a delay of about 9 to 12 months in the fabricaction work.

Significant extra work was also required to be done during the construction in view of inadequate support to the diaphragm walls. This aspect could not be known earlier by the soil investigations which were carried out at this site also but the local problems specific to MAPP-I were not known till the excavation was carried out. The changes required to be carried out at the foundation level also influenced the design of the foundation of the main reactor building itself which involved additional time to provide ring raft and rock anchors.

(d) The profile of the dome had to be changed after the detailed design stage. Concreting of dome also got extended due to complexity of dome centering and special structural steel fabrication had to be undertaken. Additional civil work had to be undertaken owing to process design changes and need to reduce radiation field in the boiler room area to limit radiation exposure of maintenance personnel.

(e) The finalisation of the turbine generator design also took more time, as BHEL the indigenous manufacturer had to acquire know-how for the turbin from the UK collaborator and get designs of the generator vetted by the Russian collaborator. Hence the design inputs for civil works of the Turbine building were significantly delayed due to these external reasons.

3.8 When enquired about the selection of site, the Secretary, DAE informed the Committee that Kalpakkam was recommnded for siting of MAPP by a Committee headed by Shri Hayath, the then Chairman of Central Water and Power Commission and included specialists from CW&PC and Department of Atomic Energy. The witness also stated that the Department had done an extensive foundation drilling but problems were encountered due to terrain and the characteristics of the bed rocks. He further added that there was a lot of uncertainty on foundations even with many major projects. He however, admitted that the uncertainty could be reduced by more investigations. When asked whether the Deptt. could know about this aspect before drilling, the Secretary, DAE replied that the rock around that area was of a very variable nature.

3.9 As regards the increase in scope of work, DAE stated that the following factors contributed towards increased scope of work during construction of the reactor building:

(a) The necessity arose for deeper excavation to reach the required rock strata for founding the reactor building raft. The Department also stated that this is an inherent limitation in the current methods of investigation involving the drilling of bore holes at suitable spacing during exploratory stage of the project.

(b) On opening the excavation, the diaphragm wall was found to rest on bouldery strata. As such the wall had to be built up from the bottom using special technique of under-pinning the structure. As this was done in parallel with the construction of the main reactor building foundations, special techniques of controlled blasting had to be resorted to, which took additional time.

(c) These changes also influenced the design of the main reactor building raft involving more time and work.

3.10 DAE also stated that as against a single wall containment of RAPP, the MAPP containment structure of double wall construction took additional time which could not be adequately assessed at the time of invitation of tenders.

3.11 As regards the increase in the scope of work in Turbine Building, it was stated that additional space was provided in the MAPP turbine buildings on the basis of operational and maintenance experience of RAPP. This called for increased floor area thereby increasing the scope of work. The foundation conditions at MAPP also called for adoption of pile foundations for the main building and a raft for the Turbo Generator block. The original time and scope of work estimates were based by and large on RAPP experience and extensions of time had to be made for the changed site conditions. According to DAE, this is inherent to a growing situation where experience is gained with time.

3.12 According to audit paragraph, one of the reasons for the delay in construction was the changes in the design of the dome. When enquired about the need for changes in the design of the dome during construction, DAE replied that advantage was taken of the deeper excavation to incorporate a pressure suppression pool and make a conceptual change in the vapour suppression system in the containment structure. This was a major design change involving revision to the design conditions at the project sanction stage. This design change alongside the decision to delete rubble packing on the dome also necessitated re-design of the prestressed concrete dome.

3.13 During evidence, the Secretary, DAE informed the Committee that the evolving of safety needs is one very important factor that has, in a sense, affected all nuclear industry around the world. He also stated that the nuclear industry around the world is still a young industry and many of the nuclear power projects in the world were really built in seventies and a number of earlier ones built in sixties were very small. He clarified that as a result of experience gained with regard to making nuclear reactors safe, DAE had to accommodate the global view of nuclear safety by backfitting or retro-fitting and this took time.

3.14 On specific enquiry of the Committee, the Secretary, DAE stated that the two experts committees — one set up by the Nuclear Power

Corporation and the other set up by Atomic Energy Regulatory Board — had done extensive review of the safety requirements of the Indian reactors so as to look at the question whether our reactors are required to be modified in the light of the Chernobyl disaster. Both the Committees had come to the conclusion that this type of accident cannot take place with the basic characteristics of the reactors in the country.

3.15 Yet another change brought about subsequently was the provision of an indoor switchyard for greater reliability of switchyard equipment in the saline atmosphere at MAPP. According to DAE, when the original cost estimate was made in 1965-66, TAPP was not yet commissioned and as such the difficulties that could arise in the switchyard due to saline atmosphere and the special maintenance required were not known. This information was available only by 1971 onwards after Tarapur unit had operated for sometime and switchyard building was a new item of work for MAPP.

3.16 In a note furnished to the Committee, DAE stated that most of the reactor and turbine building civil works were completed before end February 1974 vis-a-vis completion date of end January 1973 envisaged at the time of tender in case of MAPP-I. The remaining work which could not be completed before February 1974 arose out of the need to reschedule the project to accommodate delay in delivery of nuclear equipment. These works were the break out panel work, balance painting works, miscellaneous structural steel work, hatches, concrete floor in some specific areas, grouting under equipment foundation etc. According to DAE the sequential delay in the project completion schedule of MAPP-I attributable to delay in civil works is 10 per cent and civil works have not contirubted to delay in the case of MAPP-II.

3.17 While the first nuclear power unit in the country incorporating natural uranium fuelled reactor technology was in its early stages of construction in Rajasthan with the Canadian assistance, the Department of Atomic Energy decided to construct Madras Atomic Power Project using the same basic reactor technology with indigenous effort. However, the project schedules for Madras Project were based, by a large, on the schedules prepared for Rajasthan Atomic Power Project despite the fact that site conditions and the methodology for manufacture of critical nuclear equipments were clearly different in these two projects. Although it was recognised by the Department in the initial stages itself that the time schedule for Madras Project would be governed by the design changes being contemplated in the building designs, the initial time schedule of 35 months for civil structural works is stated to have been made with a view to striving for a certain degree of compression of time for completion of the project. The Committee feel that proper planning was not made at the preconstruction stage and the project was beset with problems right from the beginning due to inadequate investigations at site, changes and modifications in design during construction and the delayed delivery of

various equipments / items by the indigenous manufactures with the result that there were heavy overruns of both time and cost.

3.18 The Committee are surprised to find that the sub-soil problems specific to the site of Madras Atomic Power Project could be known only on excavation at site thus necessitating deeper excavation to reach the required strata for founding the reactor building raft. The Committee have been informed that extensive foundation drilling was undertaken but problems were encountered due to terrain and variable characteristics of rocks. The plea of the Department that there is an inherent limitation in the current method of investigation involving drilling bore holes at suitable spacing during exploratory stage do not find favour with the Committee and they consider that detailed geological investigations about the rock conditions etc., should have been conducted by drilling more holes at site before undertaking work. The Committee are convinced that the work on such a big project was started without adequate geological investigations and the net result of the lapse was increase in scope of work and resultant cost escalations. The Committee recommend that the Department should ensure in future that proper and adequate geological investigations of the project sites are made before submitting the project reports to the Government for approval.

3.19 The Committee note that the other reasons responsible for delay in completing the civil works were design changes and modifications made during the execution of the project. The profile of the dome was changed after the detailed design stage and additional civil work had to be undertaken owing to process design changes. According to the Department, the design of the dome was changed taking advantage of deeper excavation to make a conceptual change in the vapour suppression system. In the case of Turbine Building, increase in the scope of work was called for due to provision of additional space in the building on the basis of experience gained in operating Rajasthan Atomic Power Station. Similarly, an indoor switch-yard was an additional item of work provided for greater reliability of switchyard equipment in saline atomosphere at Kalpakkam. Taking due note of the facts that the Department of Atomic Energy had limited experience in the execution of the nuclear power projects during early seventies and that the evolving of safety needs have affected nuclear projects around the world, the Committee desire that the Department should keep themselves abreast of the advancements and the latest developments in the field of nuclear technology in the world over with a view to taking these into account at the project formulation stage so that design changes and modifications during the execution of the project may be kept to the barest minimum and that too in the light of subsequent developments, if any.

(ii) *Delayed delivery of nuclear items*

1. MAPP-I

3.20 According to a note furnished by DAE, the major critical items

responsible for a cumulative delay of additional 5 years which shifted the critically date to December, 1979 were as follows:

Description	Delay in months
(i) Delivery of end-shields	36
(ii) Delivery of coolant channel assemblies	10.5
(iii) Delivery of standby coolers which delayed part of piping work	9.5
(iv) Post feeder work upto criticality	4
	60 months

According to the Department, the above activities were sequential and as such the cumulative delay worked out to 5 years. It may however, be seen from the table at the beginning of this Chapter, that the delay in delivery of these items were substantial and ranged between $3\frac{1}{2}$ years to 5 years with reference to first revision in the time schedule.

3.21 The detailed reasons, as furnished by DAE, on the above items are as follows:

End Shields: The purchase order for end-shields was placed on M/s. L&T as early as in October 1969, with a promised delivery date of 15th May 1972. Initially there was delay in the import of raw materials due to difficulties of foreign exchange and nickel industry strike in Canada. At an early stage in the fabrication, the calandria side tube sheet had to be corrected extensively for out of flatness followed by repeated heat treatment for obtaining the necessary impact properties. These two factors accounted for a delay of about 19 months. Subsequently the special weld filler wire showed rust on the surface and a special cleaning process had to be set up to clean the wires and respool them as it was not possible to import additional quantities. It took about seven months to overcome this problem. In addition to these, additional time required for ultrasonic testing of lattice tube to tube sheet welding, increase in depth of lattice tube and other miscellaneous reasons are attributable to the manufacturing difficulties over the contract period. Eventually the end shields were supplied to site in February 1976 and March 1976. There was a delay of about 4 years in deliver of end shields based on the promised delivery date as per purchase order. However, the effective delay attributable to end shields according to DAE is about 3 years (36 months) on the critical path.

Coolant channel Assemblies: Installation of coolant tubes was on the critical path activity following end-sheild and calandria. However, calandria tubes were to be assembled in calandria before its installation. Calandria tubes were manufactured by Nuclear Fuel Complex and its supply to

MAPP-I was completed by January 1976. The coolant tube manufacture could, however, commence only after calandria tubes were manufactured. The coolant tubes were taken up for manufacture in March 1976 and the MAPP-I requirements were completed in September 1977. According to DAE, this- was the first lot of coolant tubes manufactured in India and many problems were encountered in making the tubes. Considerable development work is stated to have been carried out and solutions were found by in-house development. Installation of coolant tubes effectively controlled the project schedule and its delayed delivery affected the critical path adversely.

Standby coolers: In the 1971-73 period, the Department had placed orders for a number of items required for MAPP on Canadian suppliers. Many items were either in an advanced stage of manufacture or about to be delivered when Canadian embargo on export in 1974 created an immediate adverse impact on the work programme at site. In the case of standby coolers, the supply of overlaid and drilled tube sheets got delayed considerably. Since the tube sheet thickness was 200 mm, drilling equipment for close drilling was not easily available and it had therefore been planned that the overlaid and drilled tube sheet would be imported as also the shell and tube materials and the balance work of fabrication of heat exchangers done in India. When the forged tube sheets were ready, to be sent from France (where forging was ordered) to Canada for overlay and drilling, the embargo became effective. The department was left with no alternative but to permit shipment of forgings to India instead. At that time only two agencies in India possessed the numerically controlled drilling equipment which could handle the work and BHEL (Bhopal) was persuaded to take up the work. Their drilling equipment was heavily booked with their own work on feed heaters. Eventually tube sheets were drilled in and the standby coolers were delivered to site during July 1978. The delivery of these standby coolers was linked to providing terminal points for completing PHT system piping which otherwise could have been done in parallel with other activities.

Post feeder work upto criticality: Based on the experience of RAPP-I, it was realised that the duration given in the initial schedule was optimistic and additional 4 months were added to post feeder work activities.

3.22 DAE also informed the Committee that during December 1979, most of the process system work was completed. Primary heat transport and moderator system were in advanced stage of completion by beginning of 1980. Balance reactor and process instrumentation and control installation work was in progress. During the period early 1980 to July 1983, on the basis of operating experience of RAPS-1, with a view to achieve trouble free operation of the station, improved leak tightness of heavy water systems and better recovery of heavy water,

design improvements were undertaken and implemented. If heavy water was available, these improvements would have been deferred to the operating phase.

2. **MAPP-II**

3.23 According to DAE, the initial planning of MAPP-II for ordering of imported raw material coinçided with the Indo-Pak hostilities and considerable delays took place in importing these raw materials due to paucity of foreign exchange. The Department also stated that when ordering out the long delivery items, it was not possible to follow the practice as adopted for MAPP-I, of placing repeat orders on the same manufacturers who were fabricating RAPP-2, MAPP-I components. Besides there was a desire on the part of the Department in 1971-72 to develop more than one competent manufacturing organisation for each of the major nuclear components which meant that the new manufacturer had to go through the learning process on components with the associated difficulties and delays.

3.24 The major nuclear items that delayed the completion schedule of MAPP-II were end-shields and coolant channels and the itemwise reasons for the same are as follows:—

End Shields: MAPP-2 end-shields incorporated one major change namely, the shell material, which in earlier reactors was carbon steel was changed over to austenitic stainless steel for MAPP-2. The procurement of imported raw materials as well as fabrication tender could be floated only after finalising the design improvements. Also before finalising the fabrication tender, the delivery status of imported free issue material was to be reasonably certain. There were delays in import of raw materials due to paucity of free foreign exchange and also special sizes of the materials. Purchase order for end shield fabrication was placed on September 1973 with a promised delivery date of August, 1976. Due to design change and induction of a new manufacturer, a certain amount of development work became inevitable and the end shields were delivered ex-works on July 1978 and December 1978 respectively. The delay in delivery is mainly due to manufacturing problems associated with a new manufacturer and therefore associated development efforts and also the design changes. Transportation by rail also took longer than expected. A total delay of about 58 months is attributable to end shield delivery compared to initial scheduled date of end shield installation.

Coolant Tubes: There was a bunching of orders at the Nuclear Fuel Complex for the production of Zircalogy components. There was a temporary but acute shortage of zirconium sponge. In the interim, even with some import of Zirconium sponge fabrication of coolant tubes for MAPP-2 could not be started before middle of 1979. Changes in manufacturing route also required considerable development works. The delivery of coolant channels could be completed by December 1981. A

delay of about 30 months is attributable to coolant tubes in the critical path after installation of calandria and end-shields.

Balance works and heavy water: Balance reactor and process instrumentation works, design improvements based on RAPS operating experience, improvement of leak tightness of heavy water system and vapour recovery system were carried out as in MAPP-I. On receipt of full quantity, balance commissioning activities were taken up and reactor attained criticality in mid August, 1985. A delay of about 16 months is attributable to these activities.

3. *Installation of main piping systems*

3.25 The work relating to installation of main piping systems consisted of two parts namely nuclear portion and conventional portion. According to audit paragraph, this work was delayed by 71 months and 86 months in the case of MAPP-I and MAPP-II respectively. The time overruns in this case, according to audit, have been attributed to: delay in making available terminal points; delay in supplying valves etc; works not originally planned; and faulty drawing and re-doing of work etc.

3.26 Explaining the delay in making available terminal points and work areas as also in supplying valves etc. DAE stated that the nuclear power plants contain many more piping systems than a coal fired power station. The number of equipment is also more in view of the layout of these systems in limited space. In view of this complex nature, piping work could be taken up sequentially only after terminal points were available. As regards valves, it was stated that the manufacture of valves got affected due to difficulty in getting radiographic castings indigenously.

3.27 When asked whether faulty drawing, dismantling or work etc. did not indicate lack of planning in pre-construction stages, DAE replied that nuclear power plant is a complex system having multiple process systems and that as many as 10,000 drawings are prepared in the headquarters for each reactor. It was also stated that utmost care is taken to avoid omissions in these drawings but some discrepancies in a project of this magnitude could be expected due to number of different agencies involved in preparation/revision of these drawings at various points of time.

3.28 When asked whether the Department accepted that the modifications etc. in piping systems led to increase in the cost of work, DAE stated that certain modifications had to be made due to changes in the design during construction of the project which had resulted in revision of drawing and supply of suitable materials/equipment. DAE also stated that had the piping been deferred till the design and manufacture of equipment was complete, the project would have been further delayed thereby resulting in cost escalations.

3.29 The Committee are greatly concerned at the disquieting picture that has emerged in regard to substantially delayed delivery of nuclear

equipments/items by the indigenous sources. The Committee wonder as to how the Department of Atomic Energy embarked upon building a nuclear power station on a self-reliant basis without meticulously assessing the capabilities of industrial infrastructure available in the country in late sixties and early seventies. While agreeing that the Department could not buy capital goods on extensive basis from overseas, the Committee consider that execution of an ambitious project of this dimension called for both advance planning and dynamic planning to deal with changes in various parameters. The Committee are convinced that while the pre-project planning in this case needed thorough acquaintance with the Indian industrial scene, no earnest and systematic effort was made in this regard with the result that the indigenous industries failed to deliver the goods in time.

3.30 Among the important items which were delivered late thereby affecting the project schedule were "end shields" and "coolant tubes". The end shields were required at the initial stages of the project but the same were delivered after a delay of 4 years in the case of MAPP-I. In the case of MAPP-II, the end shields alone accounted for 55 per cent of the proportionate distribution of total delays between original and final completion dates. The Committee have been informed that a certain amount of development work became inevitable in case of the end shields used in MAPP-II due to change in shell material and induction of a new manufacturer. While a second source of supply would definitely benefit the country in the long run, the Committee cannot but express their unhappiness over this approach and process of experimentation during execution of the project as it had ultimately cost the exchequer heavily due to stretch in schedule.

3.31 The Committee note that the coolant tubes were manufactured by Nuclear Fuel Complex for both the units of Madras Atomic Power Project. However, the manufacture of these tubes for MAPP-I could commence only after the manufacture of calandria tubes at Nuclear Fuel complex. The Committee are not inclined to agree with the plea of the Department that this was the first lot of coolant tubes manufactured in India and considerable development work had to be carried out to overcome certain problems, as the subsequent delivery of this item to the second unit was also substantially delayed and accounted for 29 per cent of the proportionate distribution of total delays. The Committee are not able to understand as to why the Department having control over Nuclear Fuel complex, could not take advance action to make available this item in time. It is obvious that there was deficiency in comprehensive planning of the project and the delayed delivery of this item reveals in-house failure. The Committee consider that it is time for the Department of Atomic Energy to do introspection with a view to obviate repetitions of the experience of this project in future.

(iii) *Heavy Water requirements:*

3.32 The pressurised heavy water type of reactors of 235 MWe established at Madras requires about 230 tonnes of heavy water per reactor as initial charge as moderator and coolant and additionally 9 to 15 tonnes per annum per reactor as replacement for process losses. According to audit paragraph, all systems of MAPP-I were tested and commissioned with light water in December 1981 but the unit had to wait till May 1983 for want of heavy water. This delay of more than 16 months in the commissioning of first reactor, according to audit paragraph, resulted in the estimated revenue loss of the order of Rs. 56.42 crores.

3.33 During evidence, the Secretary, DAE stated that the delay in heavy water production was one of the main reasons for the MAPP getting delayed. According to the witness, when the first reactor was ready for commissioning, heavy water was not available from the production plants as heavy water production lagged behind the targetted production. As such the reactor had to wait for some period of time before the heavy water was made available. According to the Secretary, DAE, the non-availability of heavy water also delayed commissioning of the second reactor.

3.34 In reply to a question about the sources from where heavy water was made available for the units at Madras, the Secretary, DAE stated that the Department had been producing heavy water at Nangal from the early sixties. Since very many reactors were not coming up from that time, the Department had been stock piling the production at Nangal. Then, there had been production at Baroda and Tuticorin. There had been no production at Talcher because of certain difficulties in power supply etc. Insofar as Madras Station was concerned, the witness added that the heavy water was made available through the production at Nangal, Baroda and Tuticorin supplemented by the downgrade heavy water from Rajasthan.

3.35 In response to a specific quarry about delay in making available heavy water for reactors at Madras, the Secretary, DAE stated that fresh heavy water production plants produced either reactor grade or 60 to 70 per cent heavy water and that required furnishing and upgrading in the up-grading plants. But the heavy water from Rajasthan was generally of a low grade and it was that which took time to process. The production of either reactor grade or 60 to 70 per cent heavy water from the production plants was available and it was stockpiled. According to the Secretary, DAE, it was the upgradation of the lowest type of heavy water from Rajasthan that took time. He further added that what had happened was that in their earlier scheme of things they had not foreseen that they would have such a heavy water crunch.

3.36 Asked as to why DAE could not foresee heavy water shortage despite having control over production plants, the Secretary, DAE stated that the Department started putting up heavy water upgrading plants on a crash basis when they were disappointed on the heavy water front both at Tuticorin and Baroda. In these days it took the Department four years to

put up a heavy water upgrading plant. Then it also took sometime to work out the designs which the Department had to develop themselves. According to the witness the very crucial part of upgrading is packing and it took some years for the Department to do their own R&D for packing. Ultimately, the plants became ready in 1980 and the Department started producing the material fairly quickly from 1980 to early 1983. It was also stated that the Department could upgrade the Rajasthan heavy water within sixteen months in the two plants.

3.37 According to audit paragraph a study conducted in 1972 anticipated that indigenous production of heavy water would outstrip the requirements of the nuclear power plants by 1979. This was based upon a plan of action to commission four heavy water plants at Kota, Baroda, Tuticorin and Talcher in addition to already functioning Nangal Plant. These four new plants, which were expected to be completed by 1973-74, could be commissioned only in 1978, 1980, 1985 and 1986 respectively. While accepting the delays and deficiencies in the production of heavy water, DAE stated that these plants were first industrial units scaled up from pilot plant stage and it took quite sometime to identify the scaling up problems and the causes thereof. The original excepted capacities of these plants did not take into account the limitations that would be imposed by the realities of unsteady power, single stream operation and long equilibrium time.

3.38 According to the information furnished to the Committee, heavy water plants are designed to operate within the statutory limits of variations of voltage and frequency in power supply. The variations in the supply of voltage and in the frequency of power supply beyond these limits as well as interruptions in power supply are not expected to occur (except on rare occasions) as the Electricity Boards are to monitor and control these parameters and ensure continuous power supply to the grid. As regards the limitation imposed by single stream operation, it has been stated that there were no double stream fertilizer plants in operation in the country when these projects were taken up for execution. As regards the long equilibrium time, it has been stated that uninterrupted supply of the inputs (including power) is essential for the sustained operation of the plant. Once the equilibrium condition is disturbed due to an interruption in the operation of the plant, it takes considerable time before equilibrium condition is reached again and product withdrawal can commence; this is inherent in the process and automatically leads to loss of production.

3.39 Explaining the steps that are being taken to increase the production of heavy water at these plants, DAE stated that the measures taken to improve the performance of the Heavy Water Plants include modifications to the plants wherever required, streamlining and updating of Maintenance Schedules and Procedures etc. Wherever shortage/uncertain supply of inputs was experienced, measures are stated to have been taken for augmentation of the supply by providing captive units so as to ensure steady supply of the inputs as far as possible.

3.40 The Committee regret to observe that the Department of Atomic Energy could not ensure timely supply of requisite quantity of heavy water to both the units of Madras Atomic Power Project. The commissioning of the first unit alone was delayed by more than 16 months due to non-availability of heavy water which, according to Audit, meant an estimated revenue loss of the order of Rs. 56.42 crores. Considering the fact that the Madras Atomic Power Project was already running behind the schedule, the non-availability of heavy water at appropriate time shows nothing but another facet of poor planning in the Department of Atomic Energy. The Committee are not able to understand as to why the Department, with their intimate knowledge about the heavy water stocks and production, could not take advance action to meet the heavy water requirements of the two units of this project specially after the four new heavy water plants could not become functional within the time frame as was originally anticipated. The Committee feel that the heavy water crunch for this nuclear power project would not have arisen had the Department taken timely measures in developing technical know-how for heavy water up-grading plants. It is obvious that the planning on heavy water front was not done with adequate care with the result that the time schedule of the Madras Atomic Power Project was affected adversely. The Committee hope that the Department of Atomic Energy would evolve a suitable strategy to prevent deficiencies in the programme for indigenous production of heavy water with a view to avoiding slippages in the future nuclear power projects.

B. Analysis of increased costs

3.41 From the information given in the audit paragraph and the data subsequently furnished to Committee, the following picture emerges in respect of the revisions made in the cost estimates from time to time for the two units of MAPP separately.

Year	Total estimated cost (Rupees in crores)	Foreign exchange component	Brief Reasons for increase
1	2	3	4
1967	61.78 (Original sanctioned)	13.89	—
1971	77.09	15.36	—Indigenisation of costs —Site conditions —Design changes —Increase in net power output from 200 to 215 MWe.

1	2	3	4
1979	107.87	12.50	—Capitalisation of certain expenditure on fuel and heavy water etc. —Additional facilities & modifications —Increase in scope of work —Increased provision for housing —General escalations in costs.
1983	118.83	12.50	—Inclusion of new items of machinery & equipment —Stretch in schedule —Additional housing —Increased provision for fuel and heavy water charges
		FOR MAPP-II	
1971	70.63 (Original sanctioned)	15.17	—
1979	103.02	13.10	Same as for MAPP-I
1983	127.04	13.10	—Provision for additional heavy water upgrading plant, coolant tubes, and fittings. —Escalation and stretch in schedule.

The above information reveals that cost of the Project had to be increased mainly on account of indigenisation of the project, subsequent design changes and modifications including increased scope of work and delay in completion of the project.

3.42 According to DAE, the increase in cost of MAPP-I and MAPP-II with reference to the original estimates on account of the factors enumerated above can be allocated as follows:

	MAPP-I	MAPP-II
	(Rs. in crores)	
Escalation, stretch in Schedule and indigenisation	46.76	41.89
Increase in scope of work, new work and design changes	10.29	14.52
Total increase in cost:	57.05	56.41

3.43 According to audit paragraph, the cost of indigenous components

had registered an increase of more than 100 per cent. The major portion of the increase was on Reactors Boiler System, Electrical Power System etc. These increases have been attributed to changes in design and scope and additional facilities which had not been thought of originally. Clarifying this position, DAE stated that MAPP was the first atomic power station which was built and commissioned entirely as a national effort and that the changes in design and scope were made due to the following factors:

a) The main reason was the insufficient cost data base that was available at the time of preparation of the initial cost estimates. Indigenous manufacturing experience in this field was almost non-existent at that time. Therefore, the initial cost estimates had to be based on certain assumptions.

b) In view of the Three Mile Island accident in the United States, the safety systems had to be reviewed and design changes incorporated. This aspect could not have been foreseen in the initial planning stages. Addition of Diesel Generators had to be provided for each unit as a result of safety review in addition to other design change.

c) Design changes had to be progressively incorporated to reduce heavy water losses, reduce the need for maintenance in active area thereby reducing "man-rem" exposure to Operations and Maintenance Personnel.

d) In the light of the operating experiences of steam generators in nuclear power units, increasing emphasis was laid on maintaining the water chemistry of the Boiler Feed Water, on units using sea water for condenser cooling. Design was therefore made to back fit a full flow condensate polishing system to maintain stringent feed water quality.

e) The initial estimate was based on the experience of Rajasthan Atomic Power Project. However, the site conditions in Madras Atomic Project which was a coastal power station necessitated changes. Some new features like an indoor switch yard had to be provided in the design to increase the reliability.

f) Based on operating experience at RAPP the capacity of the upgrading plant had to be increased by installing additional units.

3.44 The initial project estimates for MAPP calculated in 1965 had indicated a foreign exchange component of Rs. 22 crores out of the total project cost of Rs. 60 crores. When asked as to why the foreign exchange component in the project estimates was so high despite emphasis on indigenisation, DAE stated that even though great emphasis was laid on indigenisiation of materials and equipment for construction of MAPP, it was necessary to import some items like raw materials which were not

being made in the country. The raw materials were to be issued to manufacturers by the Department and this was the starting point for the down stream activities of manufacturers. The foreign exchange component finally stood at Rs.12.5 crores and Rs.13.10 crores out of the total revised estimates of Rs. 118.83 crores and Rs. 127.04 crores for MAPP- I and II respectively. According to DAE, it was possible due to rigorous indigenisation efforts and items covered under import were crucial for manufacture of major nuclear components like calandria, end-shields, steam generators etc. In addition, certain special components were also imported.

3.45 In reply to a quarry of the Committee on the number of cases wherein recourse to import had to be taken to procure equipments which could not be manufactured indigenously and the cost overrun involved in such cases in Indian rupees and foreign exchange, DAE stated that the major items of equipment/material which were initially ordered in the country but had to be imported subsequently were: (a) End fitting forgings, (b) Primary heat transport pumps and (c) structural steel materials. The cost overrun in respect of these items was as follows:

Equipment/Item	Cost overrun	
	In Rs.	In F.E.
1. End fitting forgings	79.25 lakhs	DM. 31.70 lakhs
2. Primary heat transport pums	170.00 lakhs	French Frances 126,90,000
3. Structural Steel plates	12.00 lakhs	—
4. Some miscellaneous itmes	2-3 lakhs	—

3.46 Yet another area which affected the cost schedule was the design changes made during execution of the project. When asked as to why the designs could not be standardised or decided upon till the work was due for being taken up, DAE informed that an early start had to be made with a view to establishing capabilities in the frontier technology area. DAE also stated that it was a deliberate decision to commence construction work on MAPP in parallel with evolving designs in some areas and aspects. According to the Department, standardisation of design can be made after adequate experience in construction and operation of nuclear power stations is gained and that RAPP was still under construction by the time MAPP was planned and thus experience was limited.

3.47 Audit sub-paragraph 4.1 has highlighted certain heads of expenditure where substantial increases had been registered as against the original estimates. Such items of expenditure mainly relate to civil and structural work including housing; consultancy; commissioning; reactors; boilers and auxiliaries; and turbine generator. The reasons for substantial increase in the cost as against the original estimates are as follows:

Civil Structural Works including Housing

3.48 The details of plant layout were originally based on RAPP. Subsequently, at the stage of detailed engineering for MAPP, many design changes in the layout had to be incorporated to suit site conditions and to improve O & M features. Further, many significant design changes in the civil structures to improve the performance (viz. incorporation of prestressed concrete reactor building to improve the containment) had to be incorporated. These design changes had significantly increased the scope of civil works which resulted in increase in costs. The reactor building structural steels which had been originally envisaged to be fabricated indigenously were to be imported from USA which also resulted in increase in the costs.

3.49 Provision for housing was made in line with the number of O & M staff expected to be employed and the percentage of satisfaction guidelines prevalent during that period. Higher percentage satisfaction in respect of housing was required and the number of O & M staff was also increased which resulted in increase in the number of houses, thereby increasing the cost.

3.50 Costs of material like cement and steel escalated substantially in the seventies particularly after 1973-74 oil crisis which also caused increase in the cost of civil works.

Reactors, Boilers and Auxiliaries, Turbo Generators

3.51 Many of the equipment related to the nuclear systems were manufactured indigenously. Due to the learning efforts required in establishing various manufacturing procedures required for such critical equipment, the costs of such equipment were substantially more than the original estimates. Further, there were certain design changes in certain equipment such as steam generators, to increase the performance which also contributed to the increase in cost. The scope of Turbo generator and Auxiliaries was increased to include one set of spare turbine rotor as well as condenser polishing unit.

The price escalation prevalent in seventies particularly after the 1973-74 oil crisis coupled with increase in gestation period of the project have resulted in increase in cost on account of inflation.

Commissioning

3.52 The commissioning costs included cost of heavy water loss during commissioning. Since the heavy water price had escalated substantially, the costs of heavy water loss during commissioning also went up.

In the original estimates, the cost of power required for commissioning activities was adjusted towards the credit due to power that would be generated by station before it attains commercial operation. However, in the final estimates of MAPP-I and II, cost of power required for

commissioning activities was also included in the cost of commissioning thereby increasing the provision for commissioning. A separate provision was made towards "credit" due to sale of power generated by the unit till it attained commercial operation.

Consultancy

3.53 There were many design changes to be incorporated in the systems, due to changes in safety criteria. The efforts required for engineering and analysis were substantially increased on account of such design changes, thereby increasing the costs of consultancy.

The scope of work had increased in various systems such as civil engineering, nuclear systems etc. due to improvement required in the lay outs and system design for better performance. This increase in scope of work resulted in increase in engineering efforts.

In addition to the above, the consultancy charges had gone up substantially due to inflation and also due to stretch in the gestation period of the project.

3.54 The increase in costs in the above-mentioned heads were mainly on account of the following:—

(a) Increase in the scope of works due to design changes necessitated by site conditions as well as safety criteria.

(b) Inflation in prices prevalent in the seventies particularly after 1973-74 oil crisis coupled with increase in the gestation period.

3.55 The audit paragraph has also pointed out that due to slippage in Schedules of MAPP-I and II, the associated facilities which have come up earlier than their corresponding main systems had to be maintained at a cost. When enquired about the total maintenance expenditure on such systems/facilities till the commissioning of the project, DAE stated that the total maintenance expenditure on the five systems/facilities till the commissioning of MAPP-I was only Rs.7.22 lakhs. As the five systems/facilities mentioned are common facilities, they were put to operation from January 1984 when MAPS-I was declared commercial. It was also stated that these facilities had to be completed much before project criticality date to facilitate erection of various equipment in building like service building, pump house etc. In respect of Environmental Survey Laboratory, this facility had to be completed much ahead of porject criticality to collect data on environment in advance which were used for checking the designs.

3.56 When asked as to why dynamic project monitoring could not be undertaken to avoid facilities being created before those were necessary, DAE informed the Committee that based on the project schedule, detailed schedules for various activities were worked out and that activities were taken up. Many of the activities initiated in the early stages of the projects, particularly in the conventional areas, progressed as per the schedule.

However, the project got delayed due to the delay in delivery of some critical equipment/components and heavy water etc. and consequently, the overall completion date of the project got shifted. It was therefore, unavoidable that some of the facilities taken up in the earlier stages of the project got completed a little earliar than thay were actually required based on the revised completion date of the project. DAE also informed the Committee that due to dynamic monitoring, the activities which were to be initiated in the latter stages of the project, got rescheduled as per the revised completion date of the project.

3.57 The Committee note that there has been steep escalations in the cost of the two units of Madras Atomic Power Project. As against the original project estimates, the project cost of MAPP-I has gone up from Rs. 61.78 crores to Rs. 118.83 crores and from Rs. 70.63 crores to Rs. 127.04 crores in MAPP-II thus registering an increase of 91 per cent and 79 per cent over the originally sanctioned estimates in the two units respectively. However, the foreign exchange component stands at about 10 per cent of the total cost in each of the two units. The Committee have been informed that the increases in the cost of two units are attributable mainly to price escalation, stretch in schedule, indigenisation, increase in scope of work and design changes. The increase in cost of the projects due to price escalations, stretch in schedule and indigenisation worked out to Rs. 46.76 crores and Rs. 41.89 crores for MAPP-I and II respectively. While commending the effort of the Department at indigenisation, the Committee deprecate the expenditure incurred on the project due to stretch in schedule. The Committee would like to know the expenditure incurred due to stretch in schedule in the two units separately.

3.58 The other areas where the original estimates of costs have registered steep escalations are increase inscope of work, new work and design changes. The increase over the original estimates due to these factors is Rs. 10.29 crores and Rs. 14.52 crores in MAPP-I and MAPP-II respectively. Considering the fact that MAPP-II essentially followed MAPP-I, the Committee would like to know the specific reasons for proportionately more expenditure incurred in MAPP-II on account of increase in scope of work, new work and design changes.

The Committee would also like to emphasise the need for realistic planning at the Project formulation stage so as to leave little scope for cost escalations on account of subsequent design changes and new works.

CHAPTER IV

PERFORMANCE AND TARIFF STRUCTURE

A. *Performance*

4.1 The first unit of MAPP attained criticality on 2 July, 1983 and the second unit on 12 August, 1985. The commercial operations at these two units started on 27 January, 1984 and 21 March, 1986 respectively. In other words MAPP-II took 221 days compared to 209 days taken in case of MAPP-I from criticality to commercial operation. According to DAE, the marginally higher period in case of MAPP unit II was mainly due to (a) rectification of all minor deficiencies noted in the operation of unit I and (b) stabilisation of Unit II at higher power level prior to its being declared commercial.

4.2 Based on the audit paragraph and the information furnished by DAE, following are the details of targets and actuals of gross power generation alongwith plant load factor etc. In respect of the two units of MAPP.

Year	Targets	Actual power generation	Excess (+) / Shortfall (−) vis-a-vis targets	Plant load factor %
	(In million Kwh)			
1983-84				
Unit-I	—	448*	—	—
Unit-II	—	—	—	—
1984-85				
Unit-I	1150	1071	(−) 79	51-45
Unit-II	—	—	—	—
1985-86				
Unit-I	1250	1292	(+) 42	60.95
Unit-II	420	446*	—	—
1986-87				
Unit-I	1090	769	(−) 321	37.4
Unit-II	1070	929	(−) 141	45.1
1987-88				
Unit-I	1290	1134	(−) 156	54.9
Unit-II	1290	902	(−) 388	43.7

*Includes infirm power from the date of criticality.

It would be seen from the above table that there had been substantial shortfalls in achieving the targets of power generation at both the units

except in 1985-86 when target was exceeded by 42 million units in the case of Unit-I. The table also reveals that the plant load factor of both the units had also remained less than the norm of 62.78 per cent given in the tariff norms.

4.3 According to audit paragraph, the project authorities stated that it is the usual practice to fix a lower target during initial 2 or 3 years anticipating test problems. Since no major equipment overhaul etc. had taken place in 1985-86, the performance in Unit-I was marginally better than targeted.

4.4 Explaining the reasons for lower power generation in both the units, DAE stated that the shortfall in generation in 1987-88 in both the units of MAPS was due to blade failures in the HP stages of the turbines of both the units and LP stage blade failure of the MAPP-2 turbine.

4.5 As regards the steps being taken to improve the power generation at MAPP, DAE stated that apart from modifications to the governing system of turbines, repeated blade failures in the high pressure turbine of both units are being investigated in consultation with BHEL/GEC. The changes to the turbines' interstate draining system, as recommended after detailed investigations, are being carried out. Further, grid has also been requested to maintain frequency at proper values to prevent possible blade failures.

4.6 The audit paragraph has brought out that while the administrators of the unit had assumed 56 days (1344 hours) as the annual shutdown period, the actual shutdown in respect of Unit-I during the years 1984-85 and 1985-86 was 2607 hours and 2126 hours respectively. The extra outages resulted in loss on generation of 275 million units of power and at the average cost of 40 paise per unit the revenue loss due to forced outages would amount to Rs. 11 crores. According to the information furnished by DAE, the following are the details of outage-period for the years 1986-87 and 1987-88 in respect of the two units.

(Period in hours)

	1986-87		1987-88	
	Unit-I	Unit-II	Unit-I	Unit-II
Total elapsed time	8760	8760	8784	8784
Total shutdown time	4311	3283	3289.7	4176.8
Total operation time	4449	5477	5494.3	4607.2
Availability factor	50.8%	62.5%	62.5%	52.4%

4.7 The reasons for forced outages, as furnished by DAE, are as follows:

For the year 1986-87

Unit-1 2795.9 HRS. Generator transformer not available due to breakdown. During this time annual shut down jobs were completed. Unit-2 2047.2 HRS. were spent in dislodging the stuck fuel after necessary

approvals and system normalised. During this period annual shutdown jobs were completed.

For the year 1987-88

Unit-1 After annual shutdown jobs were over by 1248.00 HRS, noticed hair line cracks on the HP rotor of the turbine. The period (1409.1 HRS) till it is replaced is classified as a forced outage. Unit-2 2722.3 HRS. were spent for rehabilitating damaged HP rotor and repairing LP rotor blades. During this period annual shutdown jobs were completed.

4.8 During evidence, the Secretary, DAE stated that the plant load factor for Madras Units I and II had been much lower than what the Department had anticipated. Firstly, there was serious vibration problem and it took a long time for BHEL to resolve it. Then, there were five blade failures in Madras Units. According to the witness, when the Department asked BHEL as to why that had happened, BHEL said, "We got the turbine design from General Electric Company in U.K. and we got the generator from Hardwar etc.". According to the Secretary, DAE, the loss on this count to the Government was of the order of Rs.70 to Rs. 80 crores on production. He further stated that the Department was very unhappy with the performance of BHEL machines and the services rendered by BHEL were very unsatisfactory.

4.9 When enquired whether the turbine generators were not made earlier by BHEL, the Secretary, DAE informed the Committee during evidence that it was for the first time that BHEL made a nuclear turbine generator. It was stated that the Department evaluated the quality aspect very closely but depended-upon BHEL in the design review area as the issue like critical speed, vibration and detailed analysis of blade reasonance could be handled by only the best equipped turbine manufacturers.

4.10 The Secretary, DAE also informed the Committee that a big risk was really taken by the Department by entrusting the job to BHEL. At that point of time, if the Department had to buy a nuclear trubine, there would have been embargo problems. That was why the Department had to go to BHEL. When asked whether DAE had gone to arbitration with BHEL for doing the job badly that they had undertaken, the witness informed the Committee that the matter is being reviewed at the level of Prime Minister's Secretary and of the Minister of Industry. It was also stated by Secretary, DAE that the suppliers (BHEL) also had a certain guarantee as performance for design with U.K. designers but the guaranteed sum was obviously related to the money paid for know-how which was not a large amount.

4.11 The witness also stated that the Department had gained from the experience of Kalpakkam. What the Department is proposing now is to tell BHEL that in case of 500 MWe the first two machines will not be made in India but in Germany by the Company located there. Those machines would be tested there and BHEL people would have training there and

then have the tight technology transfer and not just training and documentation.

4.12 In reply to a specific query of the Committee about the fuel rod getting struck resulting in outages, the Secretary, DAE stated that that was an unusual problem. It happened in the fuel transfer operation when one of the fuel elements from the reactor after its discharge got struck. According to the Secretary, DAE, similar problem had not occurred in any of the other nuclear power units in Canada either and the Department had to take some special steps to overcome that problem.

4.13 The two units of the Madras Atomic Power Station started commercial operations on 27 January, 1984 and 21 March, 1986 respectively. Although lower targets of power generation are stated to have been fixed during the initial 2 or 3 years due to test problems, the Committee are perturbed to find that except in case of Unit-I in 1985-86, the actual generation of power in both the units upto the end of 1987-88 has always remained below the prescribed targets. The shortfall was more pronounced in Unit-I during 1986-87 and in Unit-II during 1987-88. The HP stage blade failures in the turbines of both the Units besides LP stage blade failure in the turbine of second unit are stated to be the main cause for lower power generation during 1987-88 at Madras Atomic Power Station. The Committee have been informed by the Secretary, Department of Atomic Energy during evidence that the performance of these machines manufactured by BHEL as well as services rendered by them are vary unsatisfactory and this matter is being reviewed at the level of Prime Minister's. Secretary and the Minister of Industry. The Committee would like to know the outcome of this review. The Committee would also like the Department to examine the prospects of claiming compensation from the manufacturers of critical nuclear components, be they come from public sector, for the supply of defective components by them so that the poor consumer is not made to pay for the failure of the manufacturers in such a vital sector as power.

The Committee also recommend that effective steps may be taken to get these defects rectified at the earliest so as to avoid the forced and unplanned outages resulting in loss of generation of power entailing revenue losses.

B. *Tariff Structure*

4.14 The audit paragraph brings out that in 1971 the cost of generation of power in MAPP was calculated to be 6.58 paise per unit and the selling rate was calculated as 8.59 paise per unit. However, this could not be achieved because of escalation of project cost and the cost of generation of power was calculated to be 39 paise per unit in 1984-85 — the details of which are given in audit sub-para 6.6.

4.15 According to the information furnished by DAE, the methodology adopted for formulating sale price in 1971 was different from the one adopted presently. The salient difference being that interest was earlier

taken on the net block (depriciated capital at the mid point of the assumed plant life, to have an average return throughout the plant life instead of a declining return, as is applicable presently) and a return of 3% on the capital base calculated after providing for insurance and contingency as against 12% return on investment being allowed now.

4.16 In 1971, the selling rate after adding 3% return on investment was calculated as 8.59 paise per unit and the composite base tariff rate for MPAS as calculated in 1986 worked out to 44.48 paise per unit (detailed calculations are at Appendix IV). According to DAE, this increase is primarily due to cost escalations of the various input factors used in determining the selling rate as shown in the table given below:

	Factors	1971	Prevailing base rate fixed in 86	Remarks
	1	2	3	4
(1)	Plant cost excluding Heavy Water (Rs. Cr.)	143.09	231.38	Increase due to cost escalation arising from inflation, change in scope of work due to design changes, forced indigenisation due to embargo etc.
(2)	Interest During Construction (Rs. Cr.)	20.64	79.09	Increase is due to increase in cost and stretch in schedule.
(3)	Depreciation (Rs. Cr.)	5.93	11.08	Increase is due to increase in capital employed, i.e. (1) & (2) above.
(4)	Capital cost including IDC (net block) (Rs. Cr.)	91.33	275.17	Depreciated capital at the mid point of the assumed plant life taken in 1971 as against depreciated capital in the tariff period at present.
(5)	Working Capital (Rs. Cr.)		21.68	Working capital was not separately accounted for in 1971.
(6)	O&M Charges (Rs. Cr.)	1.66 (Incl. of heavy water make-up charges)	9.60	Increase is due to inflation and also the fact that in 1971 we had no experience of operating a PHWR station and figures were only estimates.
(7)	Heavy Water Inventory (subject to lease charges) (Te)	420	500	Increase is due to the inclusion of HW inventory held by the station outside the reactor which was not included in 1971.
(8)	Heavy Water make-up per annum per reactor (Te)	9	12	In 1971 we had no experience of operational HW losses in PHWR stations. The present rate is based on operating experience gained subsequently.

	1	2	3	4
(9)	Heavy Water Lease Rate (%)	6	8	These reflect the cost of heavy water and the holding costs which have increased by nearly eight times.
(10)	Heavy Water rate (Rs./Kg.)	550	4292	Same as at (9)
(11)	Fuel rate (Rs./KgU02)	575	2291	Cost of fuel has gone up nearly four times.
(12)	Energy output (Mill. Kwh)	2825	2274	The reduction is based on operating experience and is generally the same basis as followed by centrally owned Thermal Power Stations.
(13)	Return on Investment (%)	3 above interest @ 6% and providing for insurance and contingency	12	The higher rate of return was as approved by AEC and the CEA as being a fair return on investment by the Government of India.
(14)	Selling Rate (P/Kwh)	8.59	44.48	The rate of effective November-1988 was 50.39 P/Kwh inclusive of fuel and heavy water adjustment charges.

4.17 The composite base tariff rate of 44.48 paise per unit for MAPPS was decided with the concurrence of Central Electricity Authority as required under Section 22 of the Atomic Energy Act and was made effective from March 1986. This rate is subject to fuel and heavy water adjustment charges and the rate effective November 1988 is 50.39 paise per unit inclusive of applicable fuel and heavy water adjustment charges.

4.18 However, it is seen from the information furnished to the Committee that the actual cost of generation, not including a return on capital but providing for interest payments, works out as under:

1984-85	34.9 P/Kwh	+
1985-86	33.9 P/Kwh	+ for MAPP Unit I
1986-87	46.6 P/Kwh	+ for MAPP Unit I & II
1987-88	401.6 P/Kwh	+

The higher cost of generation during 1986-87 was on account of lower capacity utilisation (capacity factor) primarily for the following reasons:

(a) Unit-I generator transformer failure — about four months

(b) Unit-II Fuel handling problem — about three months

(c) Reduced power operation due to problem with mechanical seals of PHT pumps.

4.19 The tariff structure is expected to ensure a 12 per cent return on the capital invested by the Government. But the audit paragraph points

out that the 39 paise charged from Tamil Nadu Electricity Board (TNEB) for the power supplied from MAPPS, if applied towards various costs, would reveal that the return on investment was about only 3.5 per cent. The DAE stated (January 1987): "cost of generation ensure 12 per cent return if targeted output is achieved. The actual return would depend on the performance during the relevant period".

4.20 When asked about the latest rate of return on investment in MAPPS, DAE stated: "nuclear power generation costs are worked using a rate of return on investment at 12% and a targeted capacity factor of 62.8%. The actual return achieved therefore is a function of the actual capacity factor achieved. During 1986-87 and 1987-88 the actual capacity factor achieved were 41.3% and 49.3% and the return on investment was approximately 3.5% and 8% respectively".

4.21 Based on the Proforma Accounts of 1984-85, the Audit sub-paragraph 6.9 has also pointed out that the final cost of generation of power of 39 paise as calculated in 1984-85 would have been higher due to the following factors:

a) Interest during Construction (IDC) — The total IDC of Rs. 70.74 crores was reduced to Rs. 41.32 crores for calculating the tariff. Had the entire IDC been taken into account, the depreciation would have gone up and consequently the cost of generation of power.

b) The rate of return on capital @ 12% per annum would worked out to 26.98 paise per unit as against 15.88 paise mentioned in the tariff norms because the net fixed assets and working capital would be reckoned as Rs. 21,026 lakhs as per proforma accounts instead of Rs. 15,049 lakhs as taken into account for working out the tariff rate. According to audit this alone amounted to a difference of 11.10 paise per unit.

c) The provision of Rs. 100 lakhs for decommissioning may be inadequate and if the higher amount is provided tariff would also go up. There is no provision for major repairs/disaster management and recent experiences in MAPP and RAPP indicate the likelihood of periodical major repairs.

d) No provision has been made for waste management which is fairly an expensive proposition.

e) while proforma accounts for the year 1884-85 reveals the actual expenditure on fuel and heavy water as 16.16 paise, only 14.78 paise had been provided for the purposes of calculation of tariff.

According to Audit, even without taking into account the factors (c) and (d) mentioned above, the generation cost of MAPP worked out to 55.11 paise in 1984-85 as per the proforma accounts for that year. This was essentially due to variation in IDC as included for tariff purposes and as it was actually to be calculated.

4.22 Some of the factors affecting the tariff structure are discussed in succeeding paragraphs.

(i) Interest during Construction

4.23 In the case of MAPP, the IDC was estimated to be around 60 per cent of the fixed assets including capital overheads and commissioning charges. Despite having reservation in reducing the gestation period with a view to reducing the IDC to a figure which may be considered reasonable for the purposes of fixation of tariff, the Central Electricity Authority (CEA) admitted reduction in IDC as recommended by DAE considering that there was delay in commissioning MAPP-I and it being a pioneering effort. Thus the total IDC of Rs. 70.74 crores was reduced to Rs. 41.32 crores for calculating the tariff which in turn reduced the depreciation and consequently the cost of generation of power.

4.24 On being enquired about the reasons for reducing the IDC, the Secretary, DAE stated during evidence that the Department wanted in their tariff the entire Rs. 70 crores to be loaded on the capital base but the Central Electricity Authority had also received representations from Electricity Boards who were buying electricity from the power station. The Electricity Boards argued that the IDC of Rs. 70 crores arose due to the fact that the power station did not go into operation because heavy water was not available and wanted even a smaller amount of money for the interest element and the Central Electricity Authority agreed to allow Rs. 40 Crores (actually Rs. 41.32 crores) as IDC. According to the witness, the Department had to agree to the arbitration of CEA.

4.25 On being pointed out that the commissioning of the reactor was delayed for about one and a half year and the interest for that period only has to be accrued, the Secretary, DAE informed the Committee that CEA had allowed a total period of three years saying that the one and a half year period was attributable to the heavy water part and the remaining to the embargo problem.

4.26 Ir reply to Committee's querry that the reduction in IDC could be only for one year and not on a permanent basis, the Secretary stated that what was said was that DAE should not penalise the Electricity Boards which in turn sold power to public at large.

A detailed note on IDC was furnished to the Committee by DEA and the same is appended at Appendix V.

(ii) Lease charges on Heavy water Inventory

4.27 In reply to Committee's specific querry whether 8 per cent lease charges on heavy water taken into account for calculating tariff are not less than the prescribed rate of 12 per cent return on investment and amount to a subsidy, DAE stated that heavy water is a non-depreciating asset and its price is only increasing. While the recovery of the entire cost is made for the heavy water lost in operation, lease charges are only for the inventory in atomic power plants. The DAE also stated that the heavy water pool is managed so as to recover the Government rate of interest on the value of inventory and the incidental expenses towards transportation etc. The lease rate of 8 per cent was fixed earlier taking into account the Government rate of interest.

According to DAE, the present lease rate of 8 per cent is under

review and may be revised suitably taking into consideration the interest rates applicable, the cost of holding of inventories and other handling charges.

(iii) Cost of Decommissioning

4.28 As regards audit observation that the provision of Rs. 100 lakhs for decommissioning may be inadequate, DAE informed the Committee that this provision was based on international experience which is limited. This provision is however, proposed to be suitably revised from time to time based on decommissioning experience. According to DAE, the present provision of Rs. 100 lakhs per annum per reactor would yield about Rs. 133 crores at an interest rate of 12% per annum at the end of its economic life of 25 years. It has also now been decided to make a uniform levy of 1.25 paise per unit for decommissioning which would be updated from time to time. The accumulations at 1.25 paise per unit at 12% interest per annum would be about Rs. 190 crores. DAE feels that the accumulations expected from the present provision is likely to be sufficient to meet the decommissioning expenditure at the end of the plant life.

(iv) Provision for Major Repairs and Disaster Management

4.29 The audit have also observed that no provision has been made for major repairs / disaster management and that the non-provision for Capital Repairs required a review especially in view of the recent experiences in MAPP and RAPP which indicate the likelihood of periodical major repairs. When enquired as to why provision for major repairs / disaster management has not been made, DAE stated that at the time of every tariff revision actual expenditure incurred towards any major repairs carried out and those likely to be carried out were taken into account. The details of tariff calculations furnished to the Committee, however, do not provide specific information this aspect although Rs. 750 lakhs have been incurred as major capital expenditure on repairs at MAPS-I and II up-till-now.

(v) Costs of Waste Fuel

4.30 The transfer and storage costs of waste fuel are also not added in computing nuclear power tariff. According to DAE, the spent fuel is proposed to be reprocessed for use in the future fast breeder reactors and as such it would be necessary to allow credit for recovered plutonium in case expenditure towards high level waste management is included. DAE also stated that as neither can be precisely estimated presently, it has been decided not to provide for either in computing nuclear power tariff. DAE also held the view that the waste management costs have not been considered for computation of nuclear power tariff becasue these costs are assumed to be offset by the plutonium and depleted uranium recovered from the spent fuel and stored for use in the future reactors.

4.31 The Committee note that the tariff rate for supply of power by

Madras Atomic Power Project was calculated to be 39 paise per unit in 1984-85. It has however, been observed in audit that the final cost of generation of power would have been higher on the basis of the proforma accounts for that year. According to audit reckoning, only 3.5 per cent return on capital was realised in 1984-85 as against the expected rate of 12 per cent return on capital invested. The Committee have been informed that the desirable rate of 12 per cent return on capital can be ensured if target capacity factor of 62.8 per cent is achieved during the relevant period. The Committee however, find that the actual capacity factor achieved by the Madras Atomic Power Station has always remained far below the prescribed norms and it was only 41.3 per cent and 49.3 per cent during the years 1986-87 and 1987-88 and the rate of return on investment that could be realised in these years was only 3.5 per cent and 8 per cent respectively. The Committee are in no doubt that the desirable rate of return from Madras Atomic Power Station can be achieved only if the optimal level of capacity utilisation is ensured in future. As has already been stated elsewhere in this report, affective and timely steps should be taken to get over the machanical and operational problems of this Station with a view to improving its performance so that the desirable rate of return on capital investment may be ensured in future.

4.32 The Committee have been informed that on the basis of representations made by State Electricity Boards, the Central Electricity Authority agreed to reduce the total IDC of RS. 70.74 crores to Rs. 41.32 crores for capitalisation on the ground that there was delay in commissioning of the MAPP. The Committee consider that this reduction has resulted in recurring loss by understating cost of production of power. Taking note of the fact that even the subsequent atomic power project at Narora has also been affected by substantial time and cost overruns, the Committee would like the Government to take into consideration the actual gestation period of nuclear power projects with a view to calculating the actual IDC so that the actual cost is fully taken into account in determining the selling price.

4.33 The Committee are concerned to note that although the Government have prescribed a return of 12 per cent on capital investment, the Department is levying 8 per cent lease charges on heavy water for the purposes of calculation of tariff. The Committee have now been informed that the present rate of lease charges is under review and may be revised suitably taking into consideration the interest rates applicable etc. The Committee trust that such a review will be completed expeditiously and realistic lease charges prescribed so that the nuclear power costs are not made artificially lower whatever be the price charged on other than economic considerations.

4.34 The Committee further note that while a uniform levy of 1.25 paise per unit is being made to cover decommissioning costs, no provision in the tariff has been made for major repairs. Considering the fact that Rs. 750

lakhs have so far been incurred as major capital expenditure on repairs at Madras Atomic Power Station, the Committee are of the opinion that provision for major repairs must be incorporated in the cost of generation of power. The Committee would like to know the action taken in this regard.

4.35 The Committee are surprised to find that the transfer and storage costs of waste fuel are not added in computing nuclear power tariff on the assumption that these costs would be offset by the plutonium and depleted uranium recovered from the spent fuel. On the other hand, the Committee have also been informed that it would be necessary to allow credit for plutonium recovered from spent fuel in case expenditure towards high level waste management is included and that neither of them can be precisely estimated presently. In the opinion of the Committee, it is financially improper not to include the waste fuel costs in computing the power tariff on the basis of certain assumptions. They consider that this aspect may be examined in detail so as to avoid any loss of revenue to Government exchequer in future.

4.36 The Committee also recommend that the nuclear power pricing policy may be reviewed in the light of observations made in the preceding paragraphs. From the reasons given for under assessment of various costs for determination of return on investment, the Committee note that the reductions in cost were made, more with a view to peg down the rate of power supply to Electricity Boards rather than from acceptable commercial norms of accounting. In such circumstances, the Committee do not approve of the system adopted to modify the accounting principles to meet a particular tariff and recommend that while the accounts may be allowed to present a true and fair state of affairs, the extent of reduction allowed in tariff with reference to operational cost may be clearly exhibited as a subsidy consciously allowed.

4.37 The Committee desire the Government to examine the feasibility of introducing Technical Audit in the scientific Departments with a view to getting the performance of such Departments evaluated in all respects and inform the Committee of the action taken in this regard.

C. *Stores Management*

4.38 The audit paragraph has also brought out specific cases where certain equipments / items were procured at considerable costs but the same were subsequently either not utilised at all or found to be defective and had to be replaced. The details of such equipments / items are discussed in succeeding paragraphs.

(a) Heavy Water Vapour Recovery Unit

4.39 This equipment costing Rs. 2.97 lakhs was imported and issued to the piping section of MAPP in 1974. But this equipment was returned to the stores in 1977 stating that it was deleted from the system due to change

in design. This equipment is still lying idle in stores. According to DAE, this equipment was declared as surplus to the requirement of MAPS and other units of DAE in 1986 and it was put up for disposal through public tender in September 1987. As no bids were received against that tender, the equipment was retendered in August 1988 and again in November 1988 but the item could not be disposed of as the highest bid was only Rs. 8787.87 as against the reserve price of Rs. 3.50 lakhs. The Department, however, propose to invite tenders afresh. The reason for low price offered for this equipment, according to DAE, may be the fact that this item has no alternative use and the price offered may be for the metal value as scrap.

(b) Overburden Drilling Equipment

4.40 It was decided to import an Overburden Drilling Equipment at a cost of Rs. 3.84 lakhs to aid the construction of sea water intake structure. Order for the equipment was placed in December 1972 against which part shipment was received in June 1973 and the second shipment completing the supplies was received in September 1973. However, the drilling work was completed by April 1973 with the help of the conventional equipment of the contractor and as such the imported equipment could not be utilised at all and is lying idle. According to DAE, this equipment was declared as surplus to the requirement of MAPPS and other units of DAE in 1986. It was put up for disposal through public tender in July 1986 but the equipment was not disposed of as the highest offer received was only Rs. 36,110 as against the reserve price of Rs. 1 lakh. This equipment was retendered in September 1986 but the highest offer of Rs. 45,555 was again less than the reserved price. Meanwhile, BARC indicated their willingness to use the equipment but subsequently BARC also intimated that the equipment was not required by them. Hence the equipment was again tendered in August 1988 and the highest offer of Rs. 67,778 against the subject tender which though less than the reserved price fixed, is being recommended for acceptance as the Department is stated to be not likely to get better rate if the equipment is tendered again.

(c) Stainless Steel Tanks

4.41 62 stainless steel tanks were required for storage of helium and heavy water and orders for the same were placed on three firms at a cost of Rs. 7.16 lakhs. The contract included design, fabrication and erection of tanks. The tanks were erected between October 1975 and December 1979 after due clearance by the quality Surveillance wing of the Department. However, 22 tanks were found to be defective and had to be replaced. DAE stated (January 1987) that 22 tanks developed lead as these were not used immediately. Out of these 22 tanks, 4 were disposed of through auction for Rs. 0.30 lakh; 4 were drawn by Nuclear Power Station of MAPS; 1 drawn by IGCAR: 3 despatched to KAPP;

8 deposited in stores as scrap and disposed of for a price of Rs. 27,566 and 2 tanks are still available in MAPS for disposal.

4.42 According to the 'Stores Procedure' issued by Department of Atomic Energy, an item may be considered as surplus if it is found that there have been no demands against an item for a period of two years or if the issues during the previous two years have been very small as compard to the stock balance of such an item (Sub para 7.3.1.1 of the Stores Procedure).

4.43 It is disquieting to note that certain equipments procured in early seventies at considerable costs, could not be utilised at all and are lying idle in stores. Moreover, these equipments were declared surplus only in 1986 obviously at the instance of audit. This clearly indicates that the Stores Procedure was not properly followed thereby resulting in blocking the capital. The Committee would like the Department to pin-point responsibility in these specific cases. The Committee may be apprised of the action taken in this regard.

NEW DELHI;
April 26, 1989
Vaisakha 6, 1911 (Saka)

AMAL DATTA
Chairman,
Public Accounts Committee.

APPENDIX I

(Vide Para 1.1 of the Report)

Supplementary Report of the C&AG of India for the year 1985-86, Part-II, Union Government (Civil)

DEPARTMENT OF ATOMIC ENERGY

MADRAS ATOMIC POWER PROJECT

I. *Introduction*

1.1 The Nuclear profile of the Department of Atomic Energy (DAE) aims at achieving 10,000 MWe by the end of the century. Earlier the profile for the decade 1970—80 aimed at achieving 2,700 MWe by 1978-79. The target had been revised down wards as can be seen from the following table :—

Year	As suggested by Atomic Energy Commission (AEC) in 1954	As forecast by Energy Survey Committee in 1965	As proposed by Atomic Energy Commission in 1968
	MWe	MWe	MWe
1970-71	600	600	400
1975-76	3000	2000	1000
1980-81	8000	5000	2700 (by 1978-79)

(*Source* : A profile for the decade 1970-80 of Atomic Energy and Space Research by Atomic Energy Commission 1970)

At the end of the decade the installed capacity was only 640 MWe. With Madras Atomic Power Stations I and II (MAPS) commissioned in 1983 and 1985 respectively and Rajasthan Atomic Power Station II (RAPS) commissioned earlier in 1980, the installed capacity has gone upto only 1330 MWe and the downward revised target could not be achieved.

1.2 Apart from the target of 2700 MWe of power by 1978-79 the Indian Atomic Energy Programme had also envisaged a four stage growth. These stages were:

— establishment of natural uranium fuelled heavy water moderated thermal reactors (1970—80);

— building of advanced thermal reactors of 500 MWe (1970—80);

— establishment of plutonium fuelled fast breeder reactors and

— establishment of thorium cycled fast breeders.

However, only first stage has been partially achieved. The second stage which involves scaling up process of the existing technology has not been attempted on the ground, as yet. The third and fourth stages which involve development of new technologies are at experimental levels and their fructification is very much in the future.

1.3 When the targets were laid down the AEC had planned to step up the indigenous production of heavy water and the average lead time in setting up heavy water units was taken to be 4-5 years. This had not materialised and the indigenous production had fallen far behind. The failure on the heavy water production front also led to delays in commissioning of MAPP-I which was otherwise ready. This is dealt with in subsequent paragraphs.

1.4 DAE stated (March 1987) that the nuclear power programme was based on self-reliance and indigenous technology and the shortfalls were mainly due to resource crunches, infancy of indigenous technology and reluctance on the part of foreign vendors to supply components and spares.

1.5 However, it has to be kept in view that the 4 stage programme was chalked out in 1954 and after much experience even the slashed down target has not been achieved nór the necessary technologies fully developed.

2. *Madras Atomic Power Projects I and II*

2.1 Madras Atomic Power Project (MAPP) was approved in 1965 as the third nuclear power project. The original project estimate (1965) indicated cost of two reactors of 200 MWe each (gross) as Rs. 60 crores. In 1967 cost of one reactor (MAPP-I) with 200 MWe (gross) was calculated as Rs. 61.78 crores excluding the cost of heavy water. In 1971, it was revised to Rs. 77.09 crores, together with upgradation of the installed capacity to 215 MWe. The estimate underwent two more revisions— Rs. 107.87 crores (September 1979) and Rs. 118.83 crores (April 1983). Similarly, for MAPP-II (215 MWe), the original estimate of Rs. 70.63 crores (May 1971) had been revised to Rs. 103.02 crores (September 1979) and finally to Rs. 127.04 crores (April 1983). The capacity of MAPP-I and II was finally raised to 235 MWe.

2.2 So also, the dates of criticality for MAPP-I and II have undergone five and three revisions and the dates were finally shifted to July 1983 and August 1985 respectively as below:—

Revisions	Dates of criticality	
	MAPP-I	MAPP-II
September 1969	December 1974 (approval)	—
August 1971	November 1975	November 1976 (approval)
September 1972	July 1976	—
November 1973	June 1977	June 1979
July 1976	December 1978	June 1980
Final revision	July 1983	August 1985

2.3 The dates of commercial operation as distinct from date of criticality was 27th January 1984 for MAPP-I and 21st March 1986 for MAPP-II. As regards date of criticality, there was a delay of about $8^1/_2$ years for MAPP-I as compared to the original target date of December 1974. In the case of MAPP-II, the original date of criticality fixed for November 1976 was finally shifted to August 1985 which meant a delay of 8 years 8 months.

2.4 The Estimates Committee in their 129th Report (4th Lok Sabha), observed about MAPP as under :—

> "The Committee note that the probable date of completion of the project has been revised thrice since it was taken in hand in 1965. From 1970-71, the date has now receded to 1973-74. Constant shifting of target dates indicates lack of realistic planning".

Still, there were five more revisions for MAPP-I. For MAPP-II there were three revisions.

2.5 DAE had anticipated till September 1979 that the total project cost of MAPP-II would be less than that of MAPP-I. However, the sanctions issued in April 1983 showed that the cost of MAPP-II would be more than that of MAPP-I.

2.6 DAE stated (March 1987) that stretch in schedules in both the units had been mainly on account of embargo imposed by USA and Canada, consequent cancellation of orders, identification of alternative sources in European Countries, indigenisation of equipment as an organisation policy and adoption of costly and complex reactor system based on pressurised heavy water design.

3. *Delays and cost overruns—Two illustrative examples*

3.1 In the development of the nuclear power programme, AEC had identified the following factors as responsible for slippage in the earlier units which affected the schedules:—

— delay in selection and acquisition of sites;

— delays in deliveries of major equipments. These have primarily been due to the manufacturer finding the job unprofitable and therefore losing all motivation in completing it;

— shortage of certain raw materials that ultimately needed to be imported;

— need for standardising designs; and

— problems in recruitment, retention and motivation of qualified personnel.

3.2 Despite identification of the reasons for delays and experience gained in setting up similar units, MAPP-I and II were also delayed for similar reasons. Some of the major illustrative items of work where delays had occurred are—

(a) Construction of Reactors and Turbine Buildings

(b) Installation of Main Piping Systems

(a) *Construction of Reactors and Turbine Buildings*

The contract for this work was awarded in February 1970 and June 1971 for MAPP-I and II respectively. The respective costs were Rs. 168 lakhs and Rs. 156 lakhs. The projects were to be completed in 35 months.

Major equipments like Moderator Heat Exchanger, Moderator Pumps and Sea Water Pumps, etc. had not been received from suppliers for Unit I even in December 1976. These had to be installed within the reactor. Similarly in respect of MAPP-II, major equipments like Steam Generators, Water-cooled Thermal Shields, Calandria Vault, Dump Tank, End Shields, Calandria Tubes, Coolant Tubes etc. had not been received till March 1977. Also items of work like closure of break-out panels opening in the perimeter walls and insulation over the domes for both the units remained to be completed. These were completed in April 1979 and May 1983 respectively. In all, there was a delay of 74 months in the case of MAPP-I and 107 months in the case of MAPP-II as against a total construction period of 35 months. The cost escalation was of the order of Rs. 70 lakhs for MAPP-I and Rs. 42.60 lakhs for MAPP-II.

The reasons for the delay are attributed to :

(i) deeper foundation and extra dewatering;
(ii) changes in the design of the dome;
(iii) increase in the quantum of concrete work;
(iv) insufficient supply of cement; and
(v) delay in receipt of major equipments etc.

These reasons indicate insufficient planning and designing and point to in-house failures.

(b) *Installation of Main Piping Systems*

The work consisted of two parts namely nuclear portion and conventional portion. The contract was awarded to the same set of contractors for each portion. The details are :

	MAPP-I	MAPP-II
	(Rupees in lakhs)	
Cost of nuclear portion	114.98	116.21
Cost of conventional portion	66.45	45.78
Total anticipated cost	181.43	161.99
Period of completion	33 months	33 months
Anticipated date of completion	June 1976	March 1978
Actual date of completion	June 1982	June 1985
Total actual cost	244.74	241.10
Additional cost	63.31	79.11
Total delay	71 months	86 months

The delay and cost overrun have been attributed to :

(i) delay in making available terminal points and work areas;
(ii) delay in supplying valves and equipments;
(iii) additional pipelines, supports, etc. not originally planned;
(iv) dismantling of some completed pipelines supports and equipments;
(v) faulty drawing and re-doing of work; and
(vi) faulty material/equipments supplied to the contractor, etc.

Here also the delays can be traced to in-house failures including lack of comprehensive planning in pre-construction stages. The delays had led to cost overrun of Rs. 63.31 lakhs and Rs. 79.11 lakhs for MAPP-I and II respectively.

4. *Analaysis of increased cost due to delays under various heads*

4.1 The increase in cost was particularly significant in some of the sanctioned heads in respect of both MAPP-I and II.

Out of the twenty sanctioned heads, substantial increases had been registered by the end of March 1986 under the heads shown below:—

Sl. No.	Items of expenditure	MAPP-I			MAPP-II		
		Original Estimate	Revised Estimate	Actual Expenditure	Original Estimate	Revised Estimate	Actual Expenditure
						(Rupees in lakhs)	
1.	Building and structures	509.90	1232.00	1231.92	430.00	767.00	757.84
2.	Reactors, Boilers and Auxiliaries	1206.00	2552.90	2613.86	1348.00	3816.89	2744.05
3.	Electrical Power System	252.92	721.15	610.24	355.00	811.08	631.01
4.	Turbine generator and Auxiliaries	887.71	1752.92	1659.50	1150.00	1705.93	1649.38
5.	Instrumentation and Control	317.50	780.84	863.44	320.00	735.66	847.25
6.	Common Processes and Services	225.34	1004.61	1037.62	390.00	795.96	678.92
7.	Construction Plant	285.50	489.95	488.25	183.00	350.00	477 56
8.	Consultancy	230.00	569.30	647.52	335.00	501.80	517.82
9.	Commissioning	56.00	762.50	979.60	125.00	762.50	1226.08

Sl. No.	Items of expenditure	MAPP-I			MAPP-II		
		Original Estimate	Revised Estimate	Actual Expenditure	Original Estimate	Revised Estimate	Actual Expenditure
							(Rupees in lakhs)
10.	Field Management and Superintendence	115.00	350.00	197.76	125.00	350.00	504.48
11.	Housing	150.00	570.00	269.82	77.00	570.00	338.65
12.	Customs Duty	300.00	625.00	792.38	310.00	748.00	565.41
13.	Freight and Insurance	90.00	156.25	186.70	125.00	187.00	109.71
14.	Fuel	170.00	612.00	557.72	140.00	865.00	955.58
	Total:	4795.87	12179.42	12136.33	5413.00	12966.82	12003.74

4.2 The significant reasons attributable to the cost over runs on all 20 heads to the tune of Rs.57.05 crores (92.33 *per cent*) in respect of MAPP-I and Rs. 56.41 crores (79.86 *per cent*) in respect of MAPP-II with reference to 1967/1971 estimates are broadly summarised as under:

(i) Capitalisation of some revenue expenditure;
(ii) Changes in scope of work;
(iii) New works;
(iv) Additional facilities, Building Structures, Equipments, etc.;
(v) Design changes and modification in individual equipments/systems;
(vi) Escalation in cost of components;
(vii) Increased burden of customs duty;
(viii) Stretch in project schedule;
(ix) Increased outlay on Township;
(x) Increased cost of commissioning;
(xi) Design modifications to meet current safety requirements;
(xii) Certain design changes due to scaling up the output from 200 MWe to 235 MWe; and
(xiii) Increased cost due to indigenisation.

4.3 After a critical examination of the cost overrun, it was observed in Audit that while there was marginal decrease in the foreign exchange component which is attributable to the Canadian embargo and the consequent indigenisation, the Indian component of the expenditure had registered an increase of more than 100 *per cent* . It is seen that major portion of the increase was under the heads—Reactor Boilers System, Electrical Power System, Turbine Generator System, Instrumentation and Control System etc. As these increases have been attributed to changes in design and scope and additional facilities, which had not been thought of originally, there appears to have been some inadequacy in the planning of the project. However, expenditure under Commissioning, Common Services, Housing, Consultancy etc. could have been well anticipated and more comprehensively and dependably estimated.

4.4 *Effect of slippage in the schedule*

The long slippage in the schedule of MAPP-I and II led to other fall-outs also. While on the one hand various systems and critical components indigenously ordered got delayed, on the other hand various associated

facilities which were otherwise ordered were coming up one after another from time to time. Such of those facilities/systems which had come earlier in relation to the ultimate schedule, had to be maintained at a cost. Some of these facilities and the expenditure incurred on their maintenance during 1981-82, 1982-83 and 1983-84 are given below illustratively:

Sl. No.	Name of the facility/system	Year of completion/ commissioning	Expenditure on maintenance			Total
			1981-82	1982-83	1983-84	
			(In rupees)			
1.	Pump House	1976	19,773	19,593	26,858	66,224
2.	Travelling water screen	1979	14,963	18,733	46,461	80,157
3.	Demineraliser Plant	1975	21,886	4,439	7,414	33,739
4.	Service Building	1975	61,709	75,536	80,817	2,18,062
5.	Environmental Survey	1974	63,238	1,01,251	1,59,568	3,24,057
	Total:		1,81,569	2,19,552	3,21,118	7,22,239

Similarly, due to 16 months slippage in commissioning MAPP-I, an expenditure of Rs. 48.82 lakhs was incurred, on *pro rata* basis, as establishment charges.

5. *Heavy water requirements*

5.1 The Canadian Deutarium (D_2O) Uranium (CANDU) pressurised Heavy Water Reactors of 235 MWe requires 235 tonnes of Heavy Water per reactor as initial charge as moderator and coolant and additionally 9 to 15 tonnes *per annum* per reactor as replacement for process losses.

5.2 A study conducted in 1972 anticipated that indigenous production of heavy water would outstrip the requirements of the nuclear power plants by 1979. This was based upon a plan of action to commission four heavy water plants at Kota, Baroda, Tuticorin and Talcher in addition to the Nangal plant already functioning from 1962. But the four new plants which were expected to be completed/commissioned by 1973–74 have been commissioned only in 1978, 1980, 1985 and 1985 respectively. Thus the new plants could not become functional within 4–5 years as was originally anticipated and led to delay in commissioning the nuclear power plants.

5.3 In the case of MAPP-I, where all systems were tested and commissioned with light water in December 1981 had to wait till May 1983 for want of heavy water. Thus, the commissioning of the first reactor was delayed by more than 16 months resulting in heavy revenue loss and avoidable extra expenditure in the maintenance of the systems already established. The estimated revenue loss was in the order of Rs. 56.42

crores. The grid, to which power was to be supplied, did not have the benefit of 1447 million units of energy during this period.

5.4 DAE accepted the delays and deficiency in the production of heavy water and stated "These plants were first industrial units scaled up from pilot plant stage. It took quite sometime to identify the scaling up problems and the causes thereof and incorporate corrective measures wherever necessary. The original expected capacities of these plants did not take into account the limitations that would be imposed by the realities of unsteady power, single stream operation and long equilibrium time."

6. *Performance and tariff structure*

6.1 The following are the major events and important activities of both the units:

Events/Dates	MAPP-I	MAPP-II
(i) Criticality	2nd July 1983	12th August 1985
(ii) Synchronisation with the grid	23rd July 1983	20th September 1985
(iii) Commercial operation	27th January 1984	21st March 1986
(iv) Infirm power generated (MU)	245	403
(v) Infirm power sold (MU)	203	335
(vi) Rate for infirm power (p/kwh)	25+2*	32
(vii) Revenue realised for infirm power (Rupees in lakhs)	508+37	1062
(viii) Commercial power generated (MU)		
27th January 1984 to 31st March 1984	203	—
1st April 1984 to 30th September 1984	732	—
1st October 1984 to 31st March 1985	339	—
1st April 1985 to 31st March 1986	1292	43.03
(ix) Commercial power sold (MU)		
27th January 1984 to 41st March 1984	173	—
1st April 1984 to 31st March 1985	935	—
1st April 1985 to 31st March 1986	1128	35
(x) Rate for commercial power (p/kwh) (in paise)		
27 January 1984 to 30th September 1984	39 + 2*	—

	Events/Dates	MAPP-I	MAPP-II
	1st October 1984 to 31st December 1984	39	—
	1st January 1985 to 31st January 1986	42.01	—
	1st February 1986 to 20 March 1986	43.03	—
	21st March 1986 to 31st March 1986	43.03 (provisional)	43.03 (provisional)
(xi)	Revenue earned for commercial power (Rupees in lakhs)		
	27th January 1984 to 31st March 1984	548+7.48*	—
	1st April 1984 to 31st March 1985	3581+115*	—
	1st April 1985 to 31st March 1986	4911 (provisional)	153

*Central Excise Duty. It was withdrawn from 1st October 1984.
(*Source*: Monthly Performance Reports and Records from Accounts Wing.)

6.2 As can seen from the above, the criticality of MAPP-I was reached on 2nd July 1983 and for MAPP-II on 21 August 1985. The commercial operations had started on 27th January 1984 and 21st March 1986 respectively. Even as regards time taken from criticality to commercial operation the time taken for MAPP-II was marginally more than MAPP-I.

6.3 The following were the targets and actuals of gross power generation for both the Units.

Year	Targets		Gross generation	
	Unit-I	Unit-II	Unit-I	Unit-II
	(In million units)			
1983-84	—	—	448**	—
1984-85	1150	—	1071	—
1985-86	1250	420	1292	446**

6.4 There was a shortfall of 79 million units in 1984-85 and in 1985-86 target was exceeded by 42 million units in the case of Unit-I. On the basis of the annual gross generation of 1071 million units in 1984-85 and 1292 million units for 1985-86 the monthly generation can be taken to be 89.25 million units for the first year and 107.66 million units for the second year. The plant load factor was only 51.45 *per cent* in 1984-85 and 60.95 *per cent* for 1985-86 as against the norm of 62.78 *per cent* given in the tariff norms. The project authorities stated that it is the usual practice to fix a lower target during initial 2 or 3 years anticipating testing problems. Since no major equipment overhaul etc. had taken place in 1985-86, the performance in Unit-I was marginally better than targeted.

**Includes infirm power from the date of criticality.

6.5 The administrators of the Unit had assumed 56 days as the annual shutdown period. As against this, the actual shutdown as shown in the Monthly Performance Reports for the last three years has been as under:

	Unit-I		
Year	Outages	Annual shutdown	Extra Outages
		(In hours)	
1983-84	461	—	—
1984-85	2607	1344	1263
1985-86	2126	1344	782

The extra outages resulted in loss in generation of power of 275 million units. At the average cost of 40 paise per unit the revenue loss to the power station due to unanticipate/forced outages would be Rs. 11 crores.

6.6 *Tariff*

The following are the key factors in working out the details for tariff (MAPP-I):

1. Installed capacity	— MW 235
2. Plant load factor	— 62.78% (5500 units/kw)
3. Generation	-- MUs 1292
4. Station use	— MUs 155
5. Sale	— MUs 1137
6. Fuel	— Kg/MU 26
7. Heavy water	— Kg/U_2O Rs. 1000
	— Rs. 4200/Kg.

Cost		Rupees in lakhs/year	Paise/kwh
1. Fuel		336	2.96
2. Heavy water			
(a) Lease 250 MT at 8 *per cent* @ Rs. 4200 /Kg.		840	7.39
(b) Make-up 12 MT/Year		504	4.43
3. Depreciation		548	4.82
4. O & M		300	2.64
5. Provision for decommissioning		100	0.88
6. Return on capital at 12 *per cent per annum*			
(a) On net fixed assets	Rs. 14,109 lakhs		
(b) On working capital	Rs. 940 lakhs		
	Rs. 15,049 lakhs	1806	15.88
		4434	39.00

6.7 In 1971, the cost of generation of power in MAPP was calculated to be 6.58 paise per unit and the rate at which it was to be sold was 8.59 paise per unit. However, this could not be achieved because of escalation of project cost and the cost of generation of power was calculated to be 39 paise in 1984-85.

6.8 The cost of fuel and heavy water as shown in the proforma accounts for the year 1984-85 were as follows:—

Item	Expenditure (Rupees in lakhs)	Cost as per unit of electricity generated (In paise)
Fuel	477	5.10
Heavy Water (lease charges)	720	7.70
Heavy Water (make-up)	314	3.36
		16.16

6.9 While 16.16 paise is the actual expenditure, 14.78 paise had been provided in the norms. However, this difference would be taken care of by the fuel adjustment charges. The final cost of generation of nuclear power would have been different for the following reason also.

(a) In the case of MAPP the Interest During Construction (IDC) was estimated to be around 60 *per cent* of the fixed assets including capital overheads and commissioning charges. Had this been adopted, the tariff rate would have been 43.7 paise per unit at 60 *per cent* capacity factor. The Central Electricity Authority (CEA) had reservation in reducing the gestation period with a view to reducing the IDC to a figure which may be considered reasonable for the purposes of fixation of tariff. However, considering that there was delay in commissioning MAPP-I and since MAPP-I was a pioneering effort, CEA admitted reduction in IDC as recommended by the DAE. The total IDC of Rs. 70.74 crores was reduced to Rs. 41.32 crores for calculating the tariff. Had the entire IDC been taken into account the depreciation would have gone up and consequently the cost of generation of power.

(b) Similarly, the return on capital calculated at 12 *per cent per annum* would have gone up because the net fixed assets would be reckoned at Rs. 17,867 lakhs instead of Rs. 14,109 lakhs. The working capital would also be Rs. 3,159 lakhs for 1984-85 instead of Rs. 940 lakhs. On Rs. 21,026 lakhs, 12 *per cent* return would work out to 26.98

paise instead of 15.88 paise mentioned in the norms—a difference of 11.10 paise per unit.

(c) The provision for decommissioning is only Rs. 100 lakhs which may be inadequate. If a higher amount is provided tariff would also go up. Also there is no provision for any major repairs/disaster management. Since nuclear power stations are new, technological thrust areas are yet to be stabilised and recent experiences in MAPP and RAPP indicate the likelihood of periodical major repairs, Non-provision for Capital Repairs requires a review.

(d) No provision has been made for waste management which is fairly an expensive proposition. The DAE is of the view that when the waste is processed and plutonium is produced the cost of plutonium so produced would be equal to the cost of storage of used fuel, the processing cost of such fuel etc. Since plutonium production is in the future and the cost can not be precisely estimated at present, the view of the DAE is hypothetical and non-commercial.

However, even without taking into account the cost of waste management and the likely higher cost of decommissioning and capital repairs the generation cost of nuclear power for MAPP-worked out to 59.56 paise in 1983-84 and 55.11 paise in 1984-85, as per the proforma accounts of the respective years. This is essentially due to variation in IDC as included by the department for tariff purposes and as it was actually to be calculated. It is not certain whether the cost of generation of nuclear power is competitive at such rates.

6.10 The tariff structure is expected to ensure a 12 *per cent* return on the capital invested by the Government. However, the 39 paise charged from Tamil Nadu Electricity Board (TNEB) for the power supplied from Madras Atomic Power Station, if applied towards various costs, would reveal that the return on investment is about 3.5 *per cent* as detailed below:—

Fuel cost	— 16.16 paise per unit
Depreciation	— 7.20 paise per unit
O & M	— 3.70 paise per unit
Provision for decommissioning	— 1.07 paise per unit
Total:	— 28.13 paise per unit

6.11 On a capital employment of Rs. 210.26 crores with actual power generation of 935 million units, 5 *per cent* return on capital would mean 11 paise per unit. With power being sold at 39 paise and cost of generation being 28 paise, only 5 *per cent* return was realised. The return would be lower (say 3.5 *per cent*) if the same 12 *per cent* return on the investments

made for heavy water production is also calculated since such a calculation would increase in fuel cost mentioned above.

6.12 The DAE stated (January 1987), "cost of generation ensures 12 *per cent* return if targeted output is achieved. The actual return will depend on the performance during the relevant period." Thus it would be seen that 12 *per cent* return is theoretical and depends upon actual performance matching up the theoretical projections.

7. *Other interesting points*

7.1 *Unplanned purchase of Lead Acid Batteries*

Two sets of Lead Acid Batteries for MAPP-II costing Rs. 11.56 lakhs were ordered in July 1973 for delivery before July 1974. The delivery date was amended thrice to August 1975, July 1976 and September 1976. The batteries were actually received in May 1976 and September 1976.

The Lead Acid Batteries, if stored in dry, uncharged condition in a cool, dry and sealed place without any chance for ingress of moisture, will have a life of 24 months. This is universally stipulated in National Standards, and Specifications. The guarantee period for the batteries stipulated by the manufacturers was 12 months from the date of commissioning or 18 months from the date of despatch whichever was earlier.

Due to a long dry storage of seven years the batteries could not be commissioned and had to be got reconditioned at a cost of Rs. 5.18 lakhs in September 1984. The batteries, thereafter, were commissioned in June 1985.

Ordering batteries as early as July 1973 was injudicious especially in view of the short life of the batteries. Not only there was blockade of capital of Rs. 11.56 lakhs due to unplanned purchase but there was also an additional expenditure of Rs. 5.18 lakhs in reconditioning those batteries.

DAE stated (January 1987) that had the order for the batteries been placed in 1983 the cost would have been around Rs. 29 lakhs and the Department had benefitted by early ordering. This is incorrect and subsequent escalation in prices was fortituous.

7.2 *Infructuous expenditure on 22 stainless steel tanks*

For storage of helium and heavy water, 62 stainless steel tanks were required and orders were placed on 3 firms in July 1971, November 1971 and October 1975 at a cost of Rs. 7.16 lakhs. The contract included design, fabrication and erection of tanks.

The tanks were erected between October 1975 and December 1979, after due clearance by the Quality Surveillance Wing of the Department. However, 22 storage tanks were found to be defective and had to be replaced with carbon steel tanks. The expenditure incurred on these

defective tanks was Rs. 5.51 lakhs. Out of these 22 tanks, 4 were disposed of through auction for Rs. 0.30 lakh. The disposal of the remaining tanks is not known (January 1987).

DAE accepted the facts and stated (January 1987) that 22 tanks developed leak as these were not used immediately. The balance 18 tanks are being examined by the Survey Committee to assess their suitability or otherwise for disposal.

7.3 *Infructuous expenditure on the import of Heavy Water Vapour Recovery Unit and blockade of capital*

One number Heavy Water Vapour Recovery Unit costing Rs. 2.97 lakhs was imported (January 1974) and was issued (August 1974) to the piping section of MAPP. But the same was returned to stores (October 1977) stating that the item was deleted from the system due to change in design.

An expenditure of Rs. 2.97 lakhs incurred towards procurement of the unit has become infructuous and the equipment is lying idle in store (March 1987) for the past 13 years; no alternative use to it has been identified.

DAE stated (January 1987) that it had been decided to dispose of the Unit through public auction as it is not required by other units.

7.4 *Blockade of capital on the import of overburden drilling equipment*

To aid the construction of sea water intake structure, it was necessary to construct a circular coffer dam comprising of piles founded in hard rock and a peripheral curtain grouting etc. Since the work was to be executed in sea depth of about 8 metres and also needed a casing pipe to be sunk, an Overburden Drilling Equipment was required and it was decided to import the machinery at a total cost of Rs. 3.84 lakhs. The equipment was received in January 1973 and taken into stock in October 1973. However, the drilling work was completed by April 1973 with the help of the conventional equipment of the contractor.

Thus, the imported equipment could not be utilised at all and is lying idle.

DAE stated (January 1987) that action is being taken to ensure that the equipment is disposed of to the best advantage of the Government.

8. *Summing up*

— As against the targeted installed capacity of 2700 MWe of nuclear power by 1978-79, the installed capacity by 1986, was only 1330 MWe.

— AEC had a four stage nuclear power programme. However, there

has been slippage and even the attainment of target of first stage has been partial.

— The MAPP was approved in 1965 as the third nuclear power project. The experience gained in setting up the RAPP was to stand in good stead since the technology was comparable. However, the gestation period was more for MAPP-I and II as compared to other earlier nuclear power projects.

— Original project estimate for MAPP was Rs. 60 crores for setting up two units of 200 MWe each. The installed capacity was finally increased to 235 MWe per unit and the cost had gone upto Rs. 119 crores and Rs. 127 crores for MAPP-I and II respectively.

— The date of criticality for both the reactors were revised many times. This was so despite the experience gained and the observations of the Estimates Committee in its 129th Report (4th Lok Sabha).

— Due to slippage in schedule, associated facilities which had come up earlier than their corresponding main systems had to be maintained at a cost. During the 16 months delay in commissioning MAPP-I, Rs. 48.82 lakhs was incurred only as eatablishment charges.

— Despite the long gestation period the cost of foreign components for MAPP-I did not escalate appreciably but the cost of indigenous components moved up very high.

— AEC had identified the various causes for the time overrun in setting up the units of RAPP. Despite the identification of the reasons delays due to changes in design, receipt of major equipments, insufficient supply of cement, need for deeper foundations etc. continued. The reasons indicate lack of comprehensive planning and point to in-house failures.

— The profile for the decade (1970–1980) anticipated the average lead time of 4–5 years for setting up Heavy Water Plants. This hope has not materialised and the indigenous production of heavy water had fallen far behind schedule.

— Absence of ready stock of heavy water also led to a delay of 16 months in the case of MAPP-I and meant a loss of 1,447 million units of energy valued at Rs. 56.42 crores.

— A 1972 appraisal anticipated the production of heavy water to outstrip the demand by 1979. However, the four plants at Tuticorin, Talcher, Baroda and Kota failed to come up within the targeted time and production was far below the demand.

— An analysis of the cost overruns indicated that out of 20 sanctioned heads 14 registered substantial increase. Reasons indicated were change in scope, additional items of work, escalation in the cost of

components, design changes, increased burden of customs duty, increased outlay on township etc. These indicate inadequacy in the planning of the project.

— The loss on account of outages in MAPP in 1984–85 and 1985–86 was 275 million units and revenue loss was Rs. 11 crores.

— At the time when the project proposal was under consideration the cost of generation of power was calculated to be 6.58 paise per unit. However, the cost of generation of power at MAPP is now calculated as 39 paise per unit. In calculating this, the Interest During Construction (IDC) amounting to Rs. 29.42 crores, incurred in the last three years, has been excluded. If the entire IDC had been included, the cost of power generated would work out to 59.56 paise in 1983–84 and 55.11 paise in 1984–85.

— After including the entire Interest During Construction the return on capital employed works out to 5 *per cent* (approx.) as against the anticipated 12 *per cent*. If 12 *per cent* return on the investment of heavy water is also calculated, the return on capital employed would further be lowered to say 3.5 *per cent*.

APPENDIX II

(*Vide* Para 1.7 of Report)

Statement showing the Financial outlays under Nuclear Power Programme proposed by the Department, Approved by the Planning Commission and the Actual expenditure

(Rupees in Crores)

Plan Period	Proposed by Department*	Approved by Planing Commission**	Actual Expenditure**	Remarks
1	2	3	4	5
1951-56 (Ist Plan)	—	—	—	There was no plan component during the first 2 plan periods
1956-61 (IInd Plan)	—	—	—	—
1961-66 (IIIrd Plan)	Not available	51.00	31.06	Scheme wise-details at page 11A and 11B
1966-67 (Annual Plan)		36.75	48.96	
1967-68 (Annual Plan)	Information not available. However Dept. proposed 241.90 crores for the period 66-67 to 70-71 for IV Five Year Plan	39.50	29.89	
1968-69 (Annual Plan)		25.74	31.68	
1969-74 (IVth Plan)	218.80	136.11	132.89	Plan was terminated in 1978-79
1974-79 (Vth Plan)	302.14	183.64	168.80 (upto 1978)	
1978-79 (Annual Plan)	62.20	46.98	45.69	

*Scheme-wise details not available

**Scheme-wise details shown at pages 11 and 12

1	2	3	4	5
1979-80 (Annual Plan)	70.68	56.15	55.40	
1980-85 (VIth Plan)	829.72 523.72 alt.	497.06	461.92	
1985-90 (VIIth Plan) upto 87-88	920.00	736.00	626.45	(Expenditure upto 87-88)

APPENDIX III

(*Vide* Para 2.1 of Report)

Detailed reasons for revisions made in the projected dates of attainment of criticality for the two units of MAPP

Madras Atomic Power Station Unit-1

Revisions	Date of criticality anticipated	Reasons for delay
1	2	3
December 67 (At time of sanction) May 70	December 1973 December 1974	(a) Negotiation between the manufacturer and the collaborator for the know-how for the turbine generator could not be finalised in time and as such firm delivery schedule for turbine generator was not available. This also delayed preparation of layouts and design of the associated equipment.
		(b) It took a longer time to select the contractor for main plant civil works, in view of the special nature of the work. MAPP used a prestressed concrete reactor building, the first such experience in the country. In addition, even after all formalities were completed, no agreement could be reached on the construction schedule between the selected tenderer and the Department. This resulted in further delay in negotiating once again with the next acceptable bidder. Hence civil works contract could be awarded only by February 1970.

1	2	3
		(c) Deliveries from the supplier of steel plates required for reactor building structural steel were suspended after part deliveries as the supplier informed that the delivery of balance steel had to be imported causing delay in structural steel fabrication. This also posed a constraint in planning the construction sequence.
		(d) Delays in the supply of imported raw materials owing to difficulties experienced in procurement against foreign credits allocated to the project.
August 71 Sept. 72 Nov. 73	November 75 July 76 June 77	(a) Components for RAPP-2 and MAPP-1 were ordered in some instances on the same suppliers for reasons of getting attractive prices. Manufacturers of components for unit-2 of RAPP which was undertaken in the country for the first time was delayed due to technical problems normally associated with learning of a new technology. These delays had in turn affected deliveries of similar components of MAPP. Components falling in this category were calandria, end shields, steam generators, etc.
		(b) Turbine generator of this size (235 MWe) was being manufactured for the first time in the country. Fabricator got the designs of turbine and generator from two different sources and there were some unforeseen difficulties in matching them.
		(c) Difficulties experienced in the manufacture of sophisticated heavy water pumps ordered on a Indian firm who was not successful in meeting the requirements, necessitated the import of these pumps at a later stage.

1	2	3
		(d) Difficulties experienced in the import of equipment and materials intended for nuclear services from North American source, finally culminated as a total embargo after May 1974. These orders had been placed in North America (USA & Canada) on commercial consideration on the basis of competetive price and better delivery. The project had to locate alternate suppliers abroad or develop indigenous manufacturing capability. This process delayed the project by about 1½ years to 2 years.
July 76	December 78	The criticality date had to be revised to December 1978, for the following reasons: (a) The delays in the supply of equipment such as bleed cooler and calandria ranged from 9 to 26 months from the respective allowed delivery dates. (b) Piping contract expected to be completed by end 1977 could not be executed in time. (c) Delivery of coolant tubes was delayed beyond 1976. (d) Some imported valves which were in critical path were not available by April 1977.
June 1977	December 79	The Schedule completion date was expected by 1979, in view of the delay in the delivery of the equipment mentioned above. Major areas of delay were the following: i) Delay due to civil works 12 ii) Delay due to end Shields 36 iii) Estimated dealy due to delivery of coolant channels 10.1 / 2 iv) Delayed delivery of stand-by cooler which delayed part of the piping work 9.1 / 2 v) Post feeder work upto criticality 4

1	2	3
Final	July 83	In addition to the factors mentioned above non-availability of heavy water from indigenous sources was the major constraint for attaining criticality. There was a delay of about two years on account of this and the reactor attained criticality on the 22nd of July, 1983.
		Madras Atomic Power Station Unit-2
May 1971 sanctioned November 1973 July 1976	December 76 June 79 June 80	(a) The main reasons for the delay in respect of Unit-2 were also similar to those mentioned under MAPP-1. Manufacture of nuclear equipment for Unit-2 was affected by the delays in the supply of equipment for Unit-1. At the crucial time for procurement of raw materials in 1971, release of foreign exchange was delayed in the wake of Indo-Pak hostilities. During the review in 1977, it was observed that deliveries of various nuclear equipment such as calandria, coolant tubes, standby coolers, heavy water pumps, end shield no. 2, fuelling machines slipped further to the extent of 5 months to 12 months. These delays caused a set back in the piping completion. The completion schedule was mainly governed by the delivery of coolant tubes, which was affected by the labour problems, power cuts etc. The progress of fabrication of the moderator heat exchanges was affected by the labour situation at manufacturer's works during 1977-78 and the design modifications arising out of vibration problems encountered in similar heat exchangers at RAPS-1. The forgings required for fuelling machine were ordered on a French firm. After considerable effort and time to develop welding of type 403 stainless steel, the firm delivered the forgings by March '79 and fuelling machine was available in March 1982.

1	2	3
Final Revision August 85	a)	Criticality was shifted to 12.8.85 due to the following factors: a) Delayed deliveries of coolant tubes and moderator pumps. b) Non availability of heavy water from indigenous sources.

APPENDIX IV

(Vide Para 4.16 of Report)

Detailed calculations of base tariff decided for MAPS effective March, 1986

MAPS TARIFF (BASE RATE)

			MAPS COMPOSITE RATE (PREVAILING)
Installed Capacity	(MWe)		470
Capacity Factor	(%)		62.78%
Generation per annum	(MU)		2585
Auxiliary Consumption	(MU)		311
Energy Sales per annum	(MU)		2274
Fuel Rate	(Rs. per Kg U02)		2291
Fuel Consumption/MU gen.	(Kg U02)		26
Heavy Water Inventory	(Tonnes)		500
Heavy Water Makeup	(Tonnes)		24
Heavy Water Rate	(Rs. per Kg)		4292
Heavy Water Lease Rate	(%)		8.00%
Capital Cost indcluding IDC.	(Rs. Lakhs)		27517
Fuel Inventory	(Rs. Lakhs)		893
Stores Inventory	(Rs. Lakhs)		700
Normal Debtors	(Rs. Lakhs)	575	
Total	(Rs. Lakhs)		29685

	Annual Charges (Rs Lakhs)	p/kwh
Fuel Consumption	1539	6.77
Heavy Water Lease	1717	7.55
Heavy Water Makeup	1030	4.53
Depreciation	1108	4.87
O & M Charges	960	4.22
Return @ 12 %	3562	15.66
Provision for Decommissioning		0.88
Total		44.48

Note: 1. The above base rate is subject fuel and heavy water adjustment charges.
2. The rate effective November 1988 was 50.39 p/kwh inclusive of fuel and heavy water adjustment charges.

APPENDIX V

(Vide Para 4.26 of Report)

Note on Interest during Construction

1.0 In the case of Government departmental undertakings, there is no equity financing of capital costs. All capital expenditure is treated nationally as loan to the undertaking. During the construction phase no interest is actually paid by the undertaking, but after a project is commissioned, during the operational phase interest at the rate notified by Government from year to year on the capital at charge is credited to Government in the proforma accounts.

2.0 For the purpose of tariff formulation only, the interest on money drawn from Government during construction at the rates applicable for the year of drawal is accumulated on a compounded basis upto the date of commercial operation and then capitalised. This capitalised interest or IDC is added to the actual total capital expenditure on the project upto the date of commercial operation. In formulating nuclear power tariff a return of 12% on capital employed has been accepted. Thus the capitalised IDC also earns a return of 12% per annum.

3.0 Depreciation of the Fixed Assets including IDC is allowed at approximately 3.6% per annum under the Electricity (Supply) Act, 1948 for computation of tariff.

4.0 In the computation of tariff, the return on capital is calculated on the value of assets net of depreciation. Thus the return in absolute terms would decline from year to year, though the rate of return (12%) would remain the same.

5.0 In the case of public sector undertakings governed by the Companies Act, Government provides equity financing of capital projects to the extent of 50% of the project cost. The remaining 50% is financed by loan either from the Government or from other sources. In releasing budgetary assistance for capital expenditure on projects, the equity is released first. For computing interest during construction, in the case of such companies, the interest actually payable or paid by them is accumulated on a compounded basis and capitalised when the project goes into commercial operation. This procedure is also followed by NTPC.

After commercial operation, interest on outstanding loans has to be paid at the rates applicable when the loans were drawn. This

interest has to be met from the return on investments allowed in the tariff.

6.0 In MAPP, while it operated as a departmental undertaking, interest had to be credited to Government on the total assets less accumulated depreciation at the rates notified by Government for the relevant years.

7.0 With the formation of NPC the net assets of the Operating Stations including MAPS were to be transferred to the Corporation, half as equity and half as loan from Government. The rate of interest on Government loan is to be calculated at the rate of interest on Government loans prevailing at the time when the loan was deemed to have been given to the Company. *i.e.* the year of actual utilisation. The interest rates notified by Government between the years 1965–66 and 1985–86 ranged from 4% to 8%. For MAPS, the interest on the loan portion works out to approximately 6.3% which is payable to Government by the Nuclear Power Corporation. This is the weighted average of the interest rates in force during the period of construction in respect of the loan portion of the net assets.

8.0 The return on equity, in case of MAPS after paying the interest on the loan portion and providing for depreciation would be around 18% at the normative capacity factor used for tariff purposes. This could be paid to Government as dividend or be reinvested in ongoing projects of NPC. During the first six months of 1988–89 for which results are available the return on equity on an annualised basis works out to 27.18% because of the higher capacity factor achieved during this period. The provision P & L Account for the period 1.4.88 to 30.9.88 is given below.

MADRAS ATOMIC POWER STATION

Provisional Profit & Loss Account for the period 1.4.1988 to 30.9.1988

(Rs. in Lakhs)

ITEMS	88–89 1.4.88 to 30.9.88
1	2
Income	6418.18
Operating Expenditure	3753.81
Profit before Int. & Depreciation	2664.37

1	2
Interest	338.00
Depreciation	405.00
Decommissioning Provision	164.75
Net Profit	1756.62
Equity Capital	12927.02
Return on Equity (Annualised)	27.18%

9.0 If the accounts for the previous years are recast based on the company accounting principles referred above the return on equity for the previous years would have been as under:

1984–85	19.8%
1985–86	25.2%
1986–87	2.7%
1987–88	12.5%

APPENDIX VI

Statement of Observations and Recommendations

S. No.	Para No.	Ministry/ Deptt.	Observations/Recommendation
1	2	3	4
1.	1.9	Atomic Energy	The Atomic Energy Commission (AEC) in 1954 had contemplated a target of 8000 MWe of nuclear power generation by the year 1980-81. However, this target was revised downwards by AEC in 1968 to 2700 MWe of nuclear power generation by the year 1978-79 on the ground that the projections made earlier were based on assumptions which needed revision in the light of experience. But even this reduced target could not be achieved and the installed capacity of nuclear power in 1978-79 was merely 640 MWe which could go upto only 1330 MWe after the commissioning of Rajasthan Atomic Power Station-2 in 1980 and Madras Atomic Power Station-1 and 2 in 1983 and 1985 respectively. Only 3 units of 235 MWe each *viz.* Madras Atomic Power Project-II and Narora Atomic Power Project I & II were sanctioned during the Fourth Plan period in 1971 and 1974 respectively. Even these two projects have been affected substantially by time overruns admittedly due to initial expectation of unduly optimistic gestation period and due to absence of the nuclear grade industrial capability in even such basic areas as welding technology in the country.
2.	1.10	-do-	The Committee are inclined to conclude that the AEC in 1968, while envisaging targets of nuclear power generation, had neither fully anticipated the time and effort required for establishing a nuclear power station nor taken into consideration the realities of the industrial situation prevailing in the country with the

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			result that targets of nuclear power generation continue to remain elusive even today. The Committee urge the Government to give thrust to the achievement of the current Nuclear profile of Department of Atomic Energy which aims at attaining 10,000 MWe of power by 2000 AD, keeping in view the experience gained in constructing nuclear power stations and also by making a realistic assessment of indigenous industrial capabilities of the quality required to supply nuclear components for future reactors of different capacities so that the limited plan resources committed on this programme may yield timely benefits to the economy in the vital power sector.
3.	1.21	Atomic Energy	Based on the limited uranium reserves and abundant thorium deposits available in the country, the Indian Atomic Energy Programme drawn in 1954 had envisaged a strategy of first establishing natural uranium fuelled heavy water moderated reactors followed by plutonium fuelled fast breeder reactors using plutonium obtained from the first stage reactors. The third stage would be thorium based reactors. The Department of Atomic Energy is, however, still purusing the objective of establishing natural uranium fuelled heavy water reactors in the first phase of the programme and the work on fast breeder reactor technology is only at experimental levels. Currently identified uranium reserves in the country can support the first stage programme of establishing natural uranium fuelled power reactors upto only 10,000 MWe.
4.	1.22	-do-	With a view to establishing natural uranium fuelled heavy water moderated reactors in the first phase of the nuclear power programme, the Atomic Energy entered into an agreement with Atomic Energy of Canada Ltd. for obtaining technology for pressurised heavy water reactors and construction of 2 such units in Rajasthan. Accordingly, construction of the first unit in

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			Rajasthan with Canadian assistance was commenced in 1964. The Department of Atomic Energy almost simultaneously decided to set up two units at Madras. This project was approved by the Government of India in 1965. The Department undertook responsibility for construction and commissioning of Madras Atomic Power Project with maximum participation from Indian industry. However, both-Rajasthan and Madras Atomic Power Projects were affected by substantial time overruns. The Department of Atomic Energy have tried to justify the delay on the ground that the time and efforts required for certain specialised work in this frontier technology, which was being carried out for the first time in the country, were not fully anticipated at planning stages and that the initial estimates of time for completion of early nuclear power projects even in the developed countries were found to be unrealistic. The Committee are not convinced by these justifications and are further of the view that the Department of Atomic Energy overestimated the industrial capability and infrastructure available in the country. Since the Department were venturing into a new field, the Committee feel that they should have made thorough enquiries about the capabilities of the indigenous manufactures to decide whether and to what extent they were capable of manufacturing critical nuclear equipments and within what time frame so as to leave little or no scope for the stretch in time schedules. Considering the fact that a developing nation like India can ill afford to commit limited financial resources on the projects whose costs are bound to escalate with delays besides entailing loss of production, the Committee hope that the Department of Atomic Energy will draw a lesson from this experience and take adequate precautions in future.

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5.	2.18	Atomic Energy	The Committee are constrained to observe that the Department of Atomic Energy could not prepare realistic project estimates in case of both the units of Madras Atomic Power Project. While the first unit had to undergo as many as seven revisions in the projected date of criticality, the number of revisions made in the case of second unit were three. As against the originally targetted date, there were delays of 9½ Years and 8½ in the first and second units respectively. Similarly, the cost estimates together with upgradation of installed capacity underwent three and two revisions in the case of first and second units respectively. The Department's plea that they had no independent data base at that point of time and the only method available to them was to extrapolating information available through the project schedule prepared for the Rajasthan Project by a Joint Indo-Canadian study is hardly convincing since the methodology adopted for Madras Atomic Power Project was clearly different from that of the first unit of Rajasthan Atomic Power Project insofar as manufacture of the critical nuclear components and construction methodology were concerned. The Committee feel that while it may always not be possible to precisely estimate the cost and time frames for accomplishing tasks in the high technology area like nuclear technology at the very beginning of the programme, these estimates have to be correct within reasonable limits and there should not be extraordinary stretch in schedule as have been in this case. The Committee are led to believe that the Department of Atomic Energy, in their anxiety to embark on the Madras Atomic Power Project commenced the work without taking proper preparatory measures.
6.	2.19	-do-	Considering the fact that frequent revisions in project schedules were made mainly due to non-delivery of various equipments by indigenous

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			manufactrurers, the Committee have an impression that the Department could not appreciate the Indian industrial situation and relied upon the time and cost estimates of the indigenous manufacturers without proper scrutiny of their claims. The Committee would like the Department of Atomic Energy to develop proper organisation and methodology for estimating the capabilities and scrutinising the claims of the indigenous manufacturers.
7.	3.17	Atomic Energy	While the first nuclear power unit in the country incorporating natural uranium fuelled reactor technology was in its early stages of construction in Rajasthan with the Canadian assistance, the Department of Atomic Energy decided to construct Madras Atomic Power Project using the same basic reactor technology with indigenous effort. However, the project schedules for Madras Project were based, by a large, on the schedules prepared for Rajasthan Atomic Power Project despite the fact that site conditions and the methodology for manufacture of critical nuclear equipments were clearly different in these two projects. Although it was recognised by the Department in the initial stages itself that the time schedule for Madras Project would be governed by the design changes being contemplated in the building designs, the initial time schedule of 35 months for civil structural works is stated to have been made with a view to striving for a certain degree of compression of time for completion of the project. The Committee feel that proper planning was not made at the preconstruction stage and the project was beset with problems right from the beginning due to inadequate investigations at site, changes and modifications in design during construction and the delayed delivery of various equipments/items by the

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			indigenous manufactures with the result that there were heavy overruns of both time and cost.
8.	3.18	Atomic Energy	The Committee are surprised to find that the sub-soil problems specific to the site of Madras Atomic Power P.oject could be known only on excavation at site thus necessitating deeper excavation to reach the required strata for founding the reactor building raft. The Committee have been informed that extensive foundation drilling was undertaken but problems were encountered due to terrain and variable characteristics of rocks. The plea of the Department that there is an inherent limitation in the current method of investigation involving drilling bore holes at suitable spacing during exploratory stage do not find favour with the Committee and they consider that detailed geological investigations about the rock conditions etc. should have been conducted by drilling more holes at site before undertaking work. The Committee are convinced that the work on such a big project was started without adequate geological investigations and the net result of the lapse was increase in scope of work and resultant cost escalations. The Committee recommend that the Department should ensure in future that proper and adequate geological investigations of the project sites are made before submitting the project reports to the Government for approval.
9.	3.19	-do-	3.19 The Committee note that the other reasons responsible for delay in completing the civil works were design changes and modifica tions made during the execution of the project. The profile of the dome was changed after the detailed design stage and additional civil work had to be undertaken owing to process design changes. According to the Department, the design of the dome was changed taking advantage of deeper excavation to make a conceptual

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			change in the vapour suppression system. In the case of Turbine Building, increase in the scope of work was called for due to provision of additional space in the building on the basis of experience gained in operating Rajasthan Atomic Power Station. Similarly, an indoor switch-yard was an additional item of work provided for greater reliability of switchyard equipment in saline atmosphere at Kalpakkam. Taking due note of the facts that the Department of Atomic Energy had limited experience in the execution of the nuclear power projects during early seventies and that the evolving of safety needs have affected nuclear projects around the world, the Committee desire that the Department should keep themselves abreast of the advancements and the latest developments in the field of nuclear technology in the world over with a view to taking these into account at the project formulation stage so that design changes and modifications during the execution of the project may be kept to the barest minimum and that too in the light of subsequent developments, if any.
10.	3.29	Atomic Energy	The Committee are greatly concerned at the disquieting picture that has emerged in regard to substantially delayed delivery of nuclear equipments/items by the indigenous sources. The Committee wonder as to how the Department of Atomic Energy embarked upon building a nuclear power station on a self-reliant basis without meticulously assessing the capabilities of industrial infrastructure available in the country in late sixties and early seventies. While agreeing that the Department could not buy capital goods on extensive basis from overseas, the Committee consider that execution of an ambitious project of this dimension called for both advance planning and dynamic planning to deal with changes in various parameters. The Committee are convinced that while the pre-

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			project planning in this case needed thorough acquaintance with the Indian industrial scene, no earnest and systematic effort was made in this regard with the result that the indigenous industries failed to deliver the goods in time.
11.	3.30	Atomic Energy	Among the important items which were delivered late thereby affecting the project schedule were "end shields" and "coolant tubes". The end shields were required at the initial stages of the project but the same were delivered after a delay of 4 years in the case of MAPP-I. In the case of MAPP-II, the end shields alone accounted for 55 per cent of the proportionate distribution of total delays between original and final completion dates. The Committee have been informed that a certain amount of development work became inevitable in case of the end-shields used in MAPP-II due to change in shell material and induction of a new manufacturer. While a second source of supply would definitely benefit the country in the long run, the Committee cannot but express their unhappiness over this approach and process of experimentation during execution of the project as it has ultimately cost the exchequer heavily due to stretch in schedule.
12.	3.31	-do-	The Committee note that the coolant tubes were manufactured by Nuclear Fuel Complex for both the units of Madras Atomic Power Project. However, the manufacture of these tubes for MAPP-I could commence only after the manufacture of calandria tubes at Nuclear Fuel complex. The Committee are not inclined to agree with the plea of the Department that this was the first lot of coolant tubes manufactured in India and considerable development work had to be carried out to overcome certain problems, as the subsequent delivery of this item to the second unit was also substantially delayed and accounted for 29 per cent of the proportionate distribution of total delays. The

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			Committee are not able to understand as to why the Department having control over Nuclear Fuel complex, could not take advance action to make available this item in time. It is obvious that there was deficiency in comprehensive planning of the project and the delayed delivery of this item reveals in-house failure. The Committee consider that it is time for the Department of Atomic Energy to do introspection with a view to obviate repetitions of the experience of this project in future.
13.	3.40	Atomic Energy	The Committee regret to observe that the Department of Atomic Energy could not ensure timely supply of requisite quantity of heavy water to both the units of Madras Atomic Power Project. The commissioning of the first unit alone was delayed by more than 16 months due to non-availability of heavy water which according to Audit, meant an estimated revenue loss of the order of Rs.56.42 crores. Considering the fact that the Madras Atomic Power Project was already running behind the Schedule, the non-availability of heavy water at appropriate time shows nothing but another facet of poor planning in the Department of Atomic Energy. The Committee are not able to understand as to why the Department, with their intimate knowledge about the heavy water stocks and production, could not taken advance action to meet the heavy water requirements of the two units of this Project specially after the four new heavy water plants could not become functional within the time frame as was originally anticipated. The Committee feel that the heavy water crunch for this nuclear power project would not have arisen had the Department taken timely measures in developing technical know-how for heavy water up-grading plants. It is obvious that the planning on heavy water front was not done with adequate care with the result that the time schedule of the

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			Madras Atomic Power Project was affected adversely. The Committee hope that the Department of Atomic Energy would evolve a suitable strategy to prevent deficiencies in the programme for indigenous production of heavy water with a view to avoiding slippages in the future nuclear power projects.
14.	3.57	Atomic Energy	The Committee note that there has been steep ascalations in the cost of the two units of Madras Atomic Power Project. As against the original project estimates, the project cost of MAPP-I has gone up from Rs.61.78 crores to Rs.118.83 crores and from Rs.70.63 crores to Rs.127.04 crores in MAPP-II thus registering an increase of 91 per cent and 79 per cent over the originally sanctioned estimates in the two units respectively. However, the foreign exchange component stands at about 10 per cent of the total cost in each of the two units. The Committee have been informed that the increases in the cost of two units are attributable mainly to price escalation, stretch in schedule, indigenisation, increase in scope of work and design changes. The increase in cost of the project due to price escalations, stretch in schedule and indigenistation worked out to Rs.46.76 crores and Rs.41.89 crores for MAPP-I and II respectively. While commending the effort of the Department at indigenisation, the Committee deprecate the expenditure incurred on the project due to stretch in schedule. The Committee would like to know the expenditure incurred due to stretch in schedule in the two units separately.
15.	3.58	-do-	The other areas where the original estimates of costs have registered steep escalations are increase in scope of work, new work and design changes. The increase over the original estimates due to these factors is Rs. 10.29 crores and Rs.14.52 crores in MAPP-I and MAPP-II respectively. Considering the fact that MAPP-II

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			essentially followed MAPP-I, the Committee would like to know the specific reasons for proportionately more expenditure incurred in MAPP-II on account of increase in scope of work–, new work and design changes. The Committee would also like to emphasise the need for realistic planning at the project formulation stage so as to leave tittle scope for cost escalations on account of subsequent design changes and new works.
16.	4.13	Atomic Energy	The two unit of the Madras Atomic Power Station started commercial operations on 27 January 1984 and 21 March 1986 respectively. Although lower targets of power generation are stated to have been fixed during the initial 2 or 3 years due to test problems, the Committee are perturbed to find that except in case of Unit-I in 1985-86, the actual generation of power in both the units upto the end of 1987-88 has always remained below the prescribed targets. The shortfall was more pronounced in Unit-I during 1986-87 and in Unit-II during 1987-88. The HP stage blade failures in the turbines of both the Units besides LP stage blade failure in the turbine of second unit are stated to be the main cause for lower power generation during 1987-88 at Madras Atomic Power Station. The Committee have been informed by the Secretary, Department of Atomic Energy during evidence that the performance of these machines manufactured by BHEL as well as services rendered by them are very unstatisfactory and this matter is being reviewed at the level of Prime Minister's Secretary and the Minister of Industry. The Committee would like to know the outcome of this review. The Committee would also like the Department to examine the prospects of claiming compensation from the manufactures of critical nuclear components, be they come from public sector, for the supply of defectlve components by them so that the poor

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			consumer is not made to pay for the failure of the manufacturers in such a vital sector as power. The Committee also recommend that effective steps may be taken to get these defects restified at the earliest so as to avoid the forced and unplanned outages resulting in loss of generation of power entailing revenue losses.
17.	4.31	Atomic Energy	The Committee note that the tariff rate for supply of power by Madras Atomic Power Project was calculated to be 39 paise per unit in 1984-85. It has however, been observed in audit that the final cost of generation of power would have been higher on the basis of the proforma accounts for that year. According to audit reckoning, only 3.5 per cent return on capital was realised in 1984-85 as against the expected rate of 12 per cent return on capital invested. The Committee have been informed that the desirable rate of 12 per cent return on capital can be ensured if target capacity factor of 62.8 per cent is achieved during the relevant period. The Committee however, find that the actual capacity factor achieved by the Madras Atomic Power Station has always remained far below the prescribed norms and it was only 41.3 per cent and 49.3 per cent during the years 1986-87 and 1987-88 and the rate of return on investment that could be realised in these years was only 3.5 per cent and 8 per cent respectively. The Committee are in no doubt that the desirable rate of return from Madras Atomic Power Station can be achieved only if the optimal level of capacity utilisation is ensured in future. As has already been stated elsewhere in this report, effective and timely steps should be taken to get over the mechanical and operational problems of this station with a view to improving its performance so that the desirable rate of return on capital investment may be ensured in future.

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18.	4.32	Atomic Energy	The Committee have been informed that on the basis of representations made by State Electricity Boards, the Central Electricity Authority agreed to reduce the total IDC of Rs. 70.74 crores to Rs. 41.32 crores for capitalisation on the ground that there was delay in commissioning of the MAPP. The Committee consider that this reduction has resulted in recurring loss by understating cost of production of power. Taking note of the fact that even the subsequent atomic power project at Narora has also been affected by substantial time and cost over-runs, the Committee would like the Government to take into consideration the actual gestation period of nuclear power projects with a view to calculating the actual IDC so that the actual cost is fully taken into account in determining the selling price.
19.	4.33	-do-	The Committee are concerned to note that although the Government have prescribed a return of 12 per cent on capital investment, the Department is levying 8 per cent lease charges on heavy water for the purposes of calculation of tariff. The Committee have now been informed that the present rate of lease charges is under review and may be revised suitably taking into consideration the interest rates applicable etc. The Committee trust that such a review will be completed expeditiously and realistic lease charges prescribed so that the nuclear power costs are not made artificially lower whatever be the price charged on other than economic considerations.
20.	4.34	-do-	The Committee further note that while a uniform levy of 1.25 paise per unit is being made to cover decommissioning costs, no provision in the tariff has been made for major repairs. Considering the fact that Rs. 750 lakhs have so far been incurred as major capital expenditure on repairs at Madras Atomic Power Station, the Committee are of the opinion that

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			provision for major repairs must be incorporated in the cost of generation of power. The Committee would like to know the action taken in this regard.
21.	4.35	Atomic Energy	The Committee are surprised to find that the transfer and storage costs of waste fuel are not added in computing nuclear power tariff on the assumption that these costs would be offset by the plutonium and depleted uranium recovered from the spent fuel. On the other hand, the Committee have also been informed that it would be necessary to allow credit for plutonium recovered from spent fuel in case expenditure towards high level waste management is included and that neither of them can be precisely estimated presently. In the opinion of the Committee, it is financially improper not to include the waste fuel costs in computing the power tariff on the basis of certain assumptions. They consider that this aspect may be examined in detail so as to avoid any loss of revenue to Government exchequer in future.
22.	4.36	-do-	The Committee also recommend that the nuclear power pricing policy may be reviewed in the light of observations made in the preceding paragraphs. From the reasons given for under-assessment of various costs for determination of return on investment, the Committee note that the reductions in cost were made, more with a view to peg down the rate of power supply to Electricity Boards rather than from acceptable commercial norms of accounting. In such circumstances, the Committee do not approve of the system adopted to modify the accounting principles to meet a particular tariff and recommend that while the accounts may be allowed to present a true and fair state of affairs, the extent of reduction allowed in tariff with reference to operational cost may by clearly exhibited as a subsidy consciously allowed.

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23.	4.37	Atomic Energy	The Committee desire the Government to examine the feasibility of introducing Technical Audit in the scientific departments with a view to getting the performance of such Departments evaluated in all respects and inform the committee of the action taken in this regard.
24.	4.42	-do-	According to the 'Stores Procedure' issued by Department of Atomic Energy, an item may be considered as surplus if it is found that there have been no demands against an item for a period of two years or if the issues during the previous two years have been very small as compared to the stock balance of such an item (sub-para 7.3.1.1 of the Stores Procedure).
25.	4.43	-do-	It is disquieting to note that certain equipments procured in early seventies at considerable costs, could not be utilised at all and are lying idle in stores. Moreover, these equipments were declared surplus only in 1986 obviously at the instance of audit. This clearly indicates that the Stores Procedure was not properly followed thereby resulting in blocking the capital. The Committee would like the Department to pinpoint responsibility in these specific cases. The Committee may be apprised of the action taken in this regard.

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