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PROJECT PERFORMANCE AUDIT REPORT

INDIA--NANGAL FERTILIZER EXPANSION PROJECT
(CREDIT 357-IN)

December 31, 1981

Operations Evaluation Department

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PRINCIPAL ABBREVIATIONS AND ACRONYMS USED

BHEL	Bharat Heavy Electrical Co.
BHPV	Bharat Heavy Plate and Vessel Co.
CAN	Calcium Ammonium Nitrate
FCI	Fertilizer Corporation of India
FRG	Federal Republic of Germany
GOI	Government of India
HCH	Hydrogen Cyanide
MW	Megawatt
MWH	Megawatt Hour
NFL	National Fertilizers Ltd.
N	Nitrogen
P_2O_5	Phosphorus Pentoxide
P & D Division	Planning and Development Division
PPM	Parts per Million
TPD	Tons per Day
TPY	Tons per Year

PROJECT PERFORMANCE AUDIT REPORT

INDIA--NANGAL FERTILIZER EXPANSION PROJECT (CREDIT 357-IN)

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INDIA-NANGAL FERTILIZER EXPANSION PROJECT (CREDIT 357-IN)

PREFACE

This report presents a performance audit of the Nangal Fertilizer Expansion Project supported by Credit 357-IN. The Credit was approved in November 1973 following four years of discussion with the borrower; it was fully disbursed in September 1976, six months earlier than the closing date.

The Nangal Fertilizer plant, located in the State of Punjab in Northern India, was initially one of the plants operated by the Government-owned Fertilizer Corporation of India (FCI). Following a restructuring of the public sector fertilizer industry in 1978, the unit was placed under the newly created National Fertilizer Ltd. (NFL).

A Project Completion Report (PCR) was prepared by the Industrial Projects Department of the Bank on the basis of information and data gathered by NFL. This report, which provides a factual review of project implementation and operations, is attached. It is preceded by an audit memorandum prepared by OED following a visit to the country in February 1981. Assistance provided during the mission is gratefully acknowledged. The memorandum was prepared on the basis of a review of the PCR, the credit documents, the files and discussions with Bank staff as well as Government and project officials. It reviews the discussions held between the Bank and FCI prior to credit approval and evaluates the operations of the project in recent years. Comments received from the borrower have been taken into account in finalizing the report and are reproduced as Attachment A to the audit memorandum.

PROJECT PERFORMANCE AUDIT REPORT

INDIA--NANGAL FERTILIZER EXPANSION PROJECT (CREDIT 357-IN)

BASIC DATA SHEET
Amounts (in US$ Million)

	Original	Disbursed	Cancelled	As of 08/31/81 Repaid	Outstanding
Credit 357-IN	58.0	58.0	-	-	58.0

Cumulative Credit Disbursement

	1973	1974	1975	1976	1977
Planned (i)	-	7.5	42.5	57.0	58.0
Actual (ii)	3.0	11.2	48.1	58.0	58.0
(ii) as % of (i)	-	149	106	102	100

PROJECT DATA

	Original Credit Dates	Actual or Re-estimated
Board Approval	-	01/30/73
Credit Agreement	-	02/09/73
Effectiveness	-	05/11/73
Credit Closing	03/01/77	09/30/76
Date of Physical Completion	08/75	07/77
Completion Time (in months)	32	55
Time Overrun (%)	-	72%
Total Project Cost (US$M)	100.5	140.1
Cost Overrun (%)	-	40%
Economic Rate of Return	15%	12%

MISSION DATA

	Month, Year	No. of Weeks	No. of Persons	Man-weeks	Date of Report
Identification) Preparation) Preappraisal)	1971/72	8	3	24	
Appraisal	06/72	3	4	12	07/06/72
Subtotal		11		36	
Supervision I	02/72	1	3	3	03/08/73
Supervision II	06/73	1	2	2	08/07/73
Supervision III	10/73	1	1	1	11/03/73
Supervision IV	03/74	2	1	2	05/02/74
Supervision V	07-08/74	2	1	2	09/13/74
Supervision VI	11/74	1	1	1	12/05/74
Supervision VII	08/75	2	1	2	09/29/74
Supervision VIII	07/76	1	1	1	09/09/76
Final Supervision	11/78	2	2	4	12/20/78
Subtotal		13		18	

PROJECT PERFORMANCE AUDIT REPORT

INDIA--NANGAL FERTILIZER EXPANSION PROJECT (CREDIT 357-IN)

HIGHLIGHTS

The project represented an expansion of a nitrogenous fertilizer plant located in the State of Punjab in Northern India. It involved the construction of an ammonia/urea complex with a capacity of 900 tpd--600 tons of ammonia to be used in the new 1,000 tpd urea plant and 300 tons to be utilized by existing units to produce calcium ammonium nitrate.

The project was physically completed in July 1977, almost two years behind schedule due to a combination of factors, including (i) delays in the preparation of detailed engineering and (ii) late delivery of equipment (PPAM, para. 13; PCR, paras. 3.01 and 3.02). Total project cost amounted to US$140 million, 39% over the appraisal estimate (PPAM, para. 14; PCR, paras. 2.04 and 2.05). Continuous production was not achieved until November 1978, because of a number of technical and operational problems that developed after commissioning. Thereafter, repeated failures of a critical waste heat boiler and, to some extent, power outages have kept production down, with capacity utilization averaging about 40% in 1980 (PPAM, paras. 15 and 16). However, capacity utilization has been improving significantly during 1981 following the alleviation of important constraints. But low capacity utilization has eroded the project's competitiveness as well as the overall plant's profit ability (PPAM, paras. 18, 19 and 21). Due to higher output prices, however, the project still shows a satisfactory economic rate of return of 12%.

The following points may be of particular interest:

- delays in project preparation as a result of differences of opinion between IDA and the borrower on the choice of production processes (PPAM, paras. 3 to 11);
- delays resulting from having procurement organized from the general contractor's office located in a different part of India, with which communications were cumbersome (PPAM, para. 13);
- the advantage of having responsibilities for project implementation entrusted with a project manager on site and independent from the management of the existing plant (PPAM, Paras. 12 and 22);
- the larger than anticipated participation of Indian manufacturers in supplying locally produced equipment, in part due to the tight equipment supply on international markets (PPAM, para. 14); and
- failure to close down the plant's uneconomic electrolysis-based ammonia unit implied continued reliance on heavily subsidized use of electricity (PPAM, paras. 17 and 19).

PROJECT PERFORMANCE AUDIT MEMORANDUM

INDIA--NANGAL FERTILIZER EXPANSION PROJECT (CREDIT 357-IN)

1. The Nangal Expansion Project was one of the two fertilizer projects identified by the Government of India for Bank financing, following the Bank's decision in 1969 to consider assisting publicly-owned entities engaged in this particular sector. Protracted discussions on technical matters deferred Bank approval of the credit for about three years. The project, supported by Credit 357-IN of February 1973, was the third Bank operation for fertilizer manufacturing in India. The credit was fully disbursed by September 1976, six months earlier than the closing date.

2. The Nangal fertilizer plant, located in the State of Punjab in Northern India, began production in 1961. At the time of appraisal, it was one of five units operated by the Fertilizer Corporation of India (FCI), a government-owned entity and the largest producer of fertilizers in the country. As a result of the rapid expansion of FCI during the 1970's, the Government established a more decentralized decision-making structure for the sector. As a first step, in 1974, the Government created a new company, National Fertilizers Ltd. (NFL), to implement two new projects located in Bhatinda and Panipat in Northern India. Later, in 1978, it restructured FCI's operations under four separate, geographically-oriented companies; the Nangal Fertilizer Unit was placed under NFL, to which public sector fertilizer manufacturing plants in the northern part of the country were attached (para. 1.08 of the PCR).

Project Preparation

3. The existing Nangal plant in operation at the time of appraisal had a design capacity of 310 tons per day (tpd) of ammonia. Unlike most modern ammonia plants which usually rely on natural gas or petroleum derivatives as feedstock, it was based on water electrolysis. Heavy water, used in the atomic energy industry, was also produced from the hydrogen gas obtained from electrolysis. Ammonia was converted first to nitric acid and then to calcium ammonium nitrate (CAN). Since the electrolysis of water is a highly power intensive process, the company had important energy needs (149 MW); these were being met by the hydroelectric plant of the Bakhra Dam located a few miles from Nangal.

4. The original feasibility study submitted to the Bank in November 1968 proposed the erection of a new plant designed to produce 600 tpd of ammonia and 1,000 tpd of urea, with all the ammonia production feeding into the urea plant. The new plant was to be independent of existing units except for its use of by-product oxygen from the electrolysis plant, which had heretofore been discarded. Reflecting changes in Government policy in the early 1970's regarding the choice of feedstock for the fertilizer industry, ammonia production was to be based on the gasification of heavy fuel oil.

Most of India's earlier plants were based on naphtha, which was becoming increasingly scarce, and Nangal was in fact to be the first heavy fuel-based ammonia plant in the country.

5. The project involved the following four processes:

(i) the gasification of heavy fuel oil by means of partial oxidation to produce the necessary gases to feed into the ammonia synthesis plant;

(ii) the purification of the gases and adjustment of hydrogen-nitrogen ratio prior to ammonia production;

(iii) the ammonia synthesis process which produces ammonia from the ammonia synthesis gases;

(iv) the urea synthesis process.

6. During project preparation, discussions took place between the Bank and FCI on the choice of processes FCI intended to set up at Nangal, a choice which the Bank felt had been made with insufficient attention to technical optimality or capital cost merits. Under bilateral credit, India had earlier acquired licenses covering the synthesis of ammonia and urea for use in other projects[1/]; FCI intended to make use of these licenses at Nangal. The Bank pointed out that the licensor had no commercial experience in partial oxidation (which meant that its ammonia synthesis loop had to be integrated with gas preparation processes from other licensors), and that its urea process was not the best available (in terms of conversion efficiency). Process technology and commercial experience became critical and unresolved issues between the Bank and FCI. However, discussions centered mainly around the choice of the gasification process (which FCI had also already acquired), a choice the Bank criticized on grounds both of technical feasibility and economy.[2/]

1/ These were located in Durgapur and Cochin, where FCI and Fertilisers and Chemicals, Travancore Ltd. (FACT) were setting up naphtha-based ammonia/urea plants.

2/ Gasification technology was at the time undergoing rapid change, as the type of feedstock generally used was changing from hydrocarbons of lower specific gravity (e.g., methane and naphtha) to others of higher specific gravity (e.g., fuel oil and later coal) in response to changes in relative prices. The controversy was not over the partial oxidation technology itself (by which high-specific gravity feedstock is converted into gases for ammonia synthesis), but rather over the particular type of process chosen by FCI within this technology. More specifically, the issues involved were whether enriched or pure oxygen had to be used and at what working pressure should the process operate. While all existing ammonia facilities using heavy hydrocarbons as feedstock were based on a pure oxygen oxidation process, the availability at Nangal of free oxygen from the electrolysis plant led FCI to give preference to an enriched air process, which eliminated the need for an air separation plant--a decision questioned by the Bank. The Bank also believed that using a higher pressure process than the one selected by FCI would result in lower capital and operating costs.

7. Overall project preparation was delayed as the Bank tried to induce FCI to prepare a rigorous economic analysis of all available processes or provide the data necessary for such an analysis which resulted in fairly protracted discussions and correspondence. Eventually, the Bank commissioned two consultants to review the issue; their conclusions were that the process selected by FCI (a low-pressure process working with enriched air) would be acceptable. Although the type of process the Bank favored (a pure oxygen high-pressure process) would have been somewhat superior on economic grounds, it appears FCI had opted for an equally sound process from a technical standpoint, a choice to some extent justified on commercial grounds since the license for it had already been acquired.1/

8. By November 1970, the Bank had in principle accepted FCI's original (September 1968) project proposal, by having approved FCI's choice for the gasification, ammonia synthesis and urea synthesis processes. The only condition the Bank had imposed was that project appraisal await the satisfactory operation for at least three months of the two other projects (Cochin and Durgapur) which were based on the same ammonia and urea processes (excluding gasification)2/. However, a deteriorating electricity supply position at Nangal made changes in the project scope necessary. To avoid tying the project to the availability of oxygen from the power-intensive electrolysis unit which was increasingly affected by power shortages, FCI proposed to separate the project entirely from the existing plant and, in doing so, to increase the size of the new plant to benefit from economies of scale. To this end, FCI expressed the intention to set up an oxygen separation plant and use a pure oxygen gasification process, thus partially reversing its position to coincide with that initially supported by the Bank. Further, by the time a revised feasibility study was prepared in May 1971, the Bank had become very much aware that the high economic cost of electricity was making the electrolysis process uneconomic. A discussion of various project alternatives ensued between the Bank and FCI, with the Bank's position being that the project be linked to the shut-down of the electrolysis plant, a proposal to which FCI formally agreed in 1972.

9. The project, as it was eventually defined, consisted of an ammonia plant with a capacity of 900 tpd--600 tons to be used in a new single stream 1,000 tpd urea plant (the first one of this size in the country) and the remaining 300 tons to be diverted to old units to produce calcium ammonium nitrate. The existing electrolysis and ammonia units were to be shut down, and substantial economic benefits were expected from the release of a large

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1/ FCI also argues that high pressure equipment would, to some extent, have involved greater risks of failure, because the greater sophistication of the equipment called for the use of special alloy steel thereby making local repair work more difficult.

2/ In retrospect, the Bank's position to evaluate the experience of Cochin and Durgapur has proved to be correct. In 1981, fourteen years after implementation of these projects started and about seven years after initial operations, neither of these two plants has ever operated at full capacity.

amount of hydroelectric power as a result of the setting up of a new source of ammonia for the old nitric acid and CAN units. An important consequence of the scaling up of the ammonia plant (from 600 tpd in the original project proposal to 900 tpd) was that FCI's choice of licensor (for the synthesis loop) was not considered by the Bank as fortunate. FCI concurred with this viewpoint and selected a contractor for the ammonia plant following a point system agreed to with the Bank[1/].

10. As noted, the main reason for the delay in preparing the project was the protracted discussion over the choice of technical processes. The project represented the Bank's second involvement in public sector industry in India and was assessed against the background of FCI's poor operating record in the past. Project preparation also suffered from sensitivities at the time on the part of FCI to any hint of outside interference.

11. In this regard, another important subject of discussion during project preparation revolved around FCI's intention to maximize its involvement as project engineer (through its Planning and Development [P&D] Division) and prime contractor, without due consideration of the costs and risks involved. As the PCR notes (paras. 5.02 and 5.05), difficulties in integrating the various know-hows acquired under license into well-organized ammonia plants was a major factor in the slow implementation and production build-up of the plants FCI built during the sixties[2/]. In view of this, the Bank considered unacceptable FCI's original proposal by which the company's P&D Division was to take full responsibility for the unproven[3/] project engineering, and insisted that FCI accept some technical backup from more qualified engineering firms. A compromise on this was eventually reached, whereby FCI's P&D Division agreed to receive limited assistance from two experienced

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1/ As will be seen, FCI had by that time accepted the Bank's suggestion that it contract an engineering company to prepare the basic design of the ammonia plant. The ammonia contractor was to provide for gasification following the process selected by FCI (using pure oxygen), with the rest of the process being his own design. As part of this compromise, the Bank agreed to the use of the urea contractor/process previously selected by FCI.

2/ At the time of appraisal, FCI projects were running at between one and three years late in construction time and many were operating at between 50% and 70% of capacity.

3/ The 600 tpd ammonia reactor design initially chosen by FCI had not yet been proven for capacities of 600 tpd or over. The contractor eventually selected to design the 900 tpd ammonia plant was engaged at the time in implementing an ammonia plant with capacity of 1,215 tpd in Western Europe, and was to base its design of the Nangal plant on a similar combination of processes.

foreign engineering companies. These were to be responsible for the basic design of the ammonia plant (treated as a single unit from gasification through synthesis) and the urea plant, while P&D was to retain full responsibility for the detailed engineering and procurement of equipment.[1/]

12. The difficulties experienced by FCI in meeting timetables and cost limits prompted the Bank to ensure also that adequate implementation arrangements were provided for. While agreeing to FCI's P&D Division acting as prime contractor, the Bank insisted that substantial responsibilities for the supervision of erection be subcontracted to the foreign firms responsible for preparing the basic engineering of the plant. The Bank was also instrumental in having FCI appoint a project manager to coordinate project implementation on site.

Project Implementation

13. The project was physically completed in July 1977, almost two years behind schedule. The time overrun was due mainly to (i) delays in the preparation of detailed engineering; (ii) late delivery of equipment owing to the tight situation of the market in the aftermath of the 1973/74 oil crisis; and (iii) storm damage to the urea reactor during shipment (PCR, para. 3.02). Procurement also suffered from the large distance separating Nangal from FCI's P&D Division located in Sindri in the State of Bihar, which suggests that the project would have benefitted from having procurement work delegated to the project unit. Partly for its inexperience and that of the engineering contractor with large fuel-oil based plants, FCI experienced difficulties in stabilizing production after commissioning; the plant was stabilized in November 1978, 16 months after physical completion (PCR, para. 3.03). Overall, however, most of the difficulties experienced during implementation were beyond FCI's control. Within its area of competence the company's performance was satisfactory, the appointment of a project manager on site proving particularly helpful to coordinate the actions of FCI's P&D Division, contractors and foreign firms acting as consultants.

14. The project was implemented at a total cost of Rs 1,177 million (US$140.1 million equivalent), which represents a cost overrun of 61 percent in rupee terms and 39 percent in US dollar terms over appraisal estimates. Because of the tight equipment supply situation on international markets, Indian manufacturers were able to contribute to the supplying of equipment to a far greater extent than was anticipated, winning 35 percent of equipment contracts allotted under international competitive bidding (against 10 percent

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1/ In fact, P&D's work was under-written by the consultant engineers Uhde, Lurgi, Shell-Topsoe Consortium since they were contractually responsible for the supervision of the detailed engineering.

expected at appraisal)[1]. As a result, foreign exchange costs were lower than anticipated, amounting to US$48 million, as compared to US$58 million (the amount of the loan) expected at appraisal.

Nangal's Operating and Financial Performance

15. During construction, Nangal's production performance was affected by power shortages which limited the output of its old power-intensive ammonia unit. Continuous production of the new facilities started in 1979. The following table depicts the production record of Nangal's old and new facilities:

	Capacity Utilization (Percent)						
	1975/76[a]	1976/77	1977/78	1978/79	1979/80	1980/81	April-Sept. 1981
Old Plant							
Ammonia	98	95	57	72	61	51	44
CAN (25% N)	97	101	69	88	80	65	52
New Plant							
Ammonia	-	-	2	32	38	38	56
Urea (46% N)	-	-	2	37	44	47	79

/a Fiscal years run from April 1 to March 31.

16. Repeated failures of a waste heat boiler in the ammonia synthesis loop lie, up to a point, behind the disappointing performance of Nangal's new facilities[2]. The defective boiler is now being bypassed, which results in energy losses and limits the output of the new synthesis loop to 55 percent of capacity. The ammonia plant has been running on two (out of three) gasifiers, part of the gas mix produced being diverted to the old ammonia plant

1/ Response from overseas on some major items (e.g., the steam generation plant and heavy fabricated vessels and columns) was particularly poor; considerable orders were then placed on Indian heavy equipment manufacturers such as Bharat Heavy Plate and Vessel Co. (BHPV) and Bharat Heavy Electrical Co. (BHEL).

2/ NFL points out that the underutilization of capacity in 1980/81 was mainly due to the irregular supply of raw materials, as a result of which the plant was shut down for about 120 days. With more regular supplies during April-September 1981, and despite the fact that the waste heat boiler was under repair, capacity utilization improved considerably (see table in para. 15).

for synthesis. In turn, urea production until very recently had been restricted for lack of CO_2 recovered from ammonia production. But late in 1981, Nangal modified the CO_2 recovery unit and was able to ensure sufficiently high purity carbon dioxide recovery as to load the urea plant at 100% even when two gasifiers are in line[1/]. Concerning the defective boiler, which is proprietary equipment of the company that engineered the ammonia plant, no long-term solution to its repeated failings has yet been identified[2/]. The Bank could have followed up more closely on this issue.

17. An important objective of the project was to set up an entirely new ammonia production facility permitting the closing down of the old electrolysis and ammonia units; the new ammonia plant was indeed so dimensioned that it was to provide sufficient ammonia to feed both the old CAN plant and the new urea plant. Despite overwhelming economic arguments, the decision to close down the old electrolysis plant has so far been postponed. In 1978, NFL entered into a seven-year agreement with the Punjab State Electricity Board (which controls the Bakhra Dam power plant) for the supply of an average of 98 MW (i.e., 66 percent of the requirements of the electrolysis plant). This limits the extent to which it can divert the gas produced in the new heavy fuel oil gasifiers for synthesis in the old ammonia plant. While this in itself does not limit overall ammonia production, it does restrict urea output for lack of CO_2 (a by-product of the new ammonia plant but not one of the old plant)[3/]. Ammonia and urea production has remained, however, well within the limits imposed by the boiler failure and the non-closing of the electrolysis unit. This has been due to a combination of mechanical breakdowns and lack of raw materials; raw material shortages were responsible for 114 days of stoppage in 1979/80 and 113 between April and December 1980.

18. Because of low capacity utilization, production costs of urea (and CAN produced on the basis of ammonia from the new plant) were in 1979/80 38 percent (13 percent for CAN) above equivalent CIF prices of imports:

1/ Comments Received from Borrower, Attachment A.

2/ NFL states that it has been in consultation with the proprietary suppliers and came to the conclusion that stress corrosion was the cause for the boiler's failings. As an interim measure, Nangal's workshop reconstructed the boiler using 2-1/4 chrom and one moly tubes. This material is reportedly not susceptible to corrosion. Steps have also been taken to improve scavenging at the tube sheets. The repaired boiler was commissioned in November 1981. To work out a long-term solution, a study was commissioned with Messrs. Haldor, Topsoe and FPDIL. For details, see Attachment A.

3/ As only two-thirds of ammonia production was to be converted into urea, it was unnecessary to optimize CO_2 recovery; as a result, the ammonia plant has to run at about 80% to generate sufficient CO_2 to meet the requirements of urea production at full capacity. Below that level, at most 83% of ammonia produced in the new plant can be converted into urea. If the ammonia plant operates at 55% of capacity (its present ceiling), urea production cannot exceed 69% of capacity.

Unit Production Costs in 1979/80
and at 90 percent capacity (Rs MT)

	Urea		CAN	
	1979/80 (Actual)	At 90% Capacity (Estimate)	1979/80 (Actual)	At 90% Capacity (Estimate)
Variable cost	638	638	414	414
Fixed cost	1,904	967	948	607
Total	2,542	1,605	1,362	1,021
(as % of CIF equivalent)	(138)	(87)	(113)	(85)

Nangal's competitiveness should, however, considerably improve as fuller use is made of additional capacity; actual data for 1979/80 suggest that the company should break even with the CIF price of imported urea when production reaches 77 percent of capacity.

19. Costs of production of ammonia and CAN produced in the old facilities are considerably lower (Annex 1 to this memorandum); these, however, reflect the highly subsidized price the company is paying for electricity it uses to operate its electrolysis plant[1/] and the fact that fixed assets have by now been fully depreciated. The substantial benefits expected to be derived from the closing down of this unit (the present value of which is estimated in the PCR [para. 4.12] at US$155 million) have so far not materialized. There is little indication at this point that they will do so for a number of years, as NFL apparently intends, for reasons other than economic, to keep operating a plant which has been very well maintained and is also (owing to the subsidized price of electricity) the most profitable of its units.

20. A common sales department distributes the production of the three plants operated by NFL. NFL's marketing effort has focussed on the states of Haryana, Rajasthan and Punjab where fertilizer consumption per hectare is

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1/ NFL is charged Rs 98/MWH for the electricity it uses in its electrolysis unit, i.e., less than half the normal industrial rate of Rs 230/MWH charged for other industrial uses. In 1979/80, power expenses on account of the electrolysis plant amounted to Rs 72.3 million (US8.9 million equivalent for an average of 91 MW); these represented 76 percent of production costs in the old ammonia plant. Power requirements per ton of ammonia produced through the electrolysis route amount to about 12,000 KWH; estimating the opportunity cost of thermal power at Rs 250/KWH, this represents a cost of Rs 3,000/ton of ammonia. On this basis, the economic cost of ammonia produced by electrolysis was Rs 3,355/ton in 1979/80, about twice the CIF value of imported ammonia.

about the highest in the country. In 1979/80, NFL's overall production accounted for 56 percent of the consumption of nitrogeneous fertilizers in those three states, which in turn exceeded NFL's capacity by about 10 percent. NFL is thus confident that despite the Government's policy to encourage competition among fertilizer producers it will be able to keep disposing of its production within a reasonably short radius from its plants so as to minimize sales expenses. Marketing costs have in the past averaged Rs 10/ton, considerably less than those of other producers in the country.

21. The financial performance of the Nangal unit has deteriorated sharply since the new plant came on stream. This deterioration was due to low capacity utilization of the new facilities as well as lower productivity in the old ones. Total revenue includes direct income from sales complemented by transfers from the Government based on retention prices. Since retention prices (ex-factory prices + transfers) are calculated by the Government so as to ensure a minimum return on producers equity when plants are operated at 80% capacity, Nangal's net profit position reflects more than anything else the poor capacity utilization of its facilities.

Nangal Unit--Summary Income Statements (Rs Million)

Year ending March 31	1976	1977	1978	1979	1980
Total income	264.4	346.7	492.0	591.2	824.3
Net profit	98.9	69.6	31.3	(22.9)	12.0
(As percentage of sales)	(37%)	(20%)	(6%)	(-4%)	(1%)
(Forecast at appraisal)	(7%)	(7%)	(14%)	(18%)	(16%)

Conclusions

22. The project was appraised at the onset of the Bank's involvement in the financing of public sector fertilizer industry. Project preparation, especially decisions concerning the selection of technical processes, role of local (public sector) engineering firms and level of local supply of equipment, was marked by prolonged discussions between the Bank and the borrower. To a large extent, these reflected the fact that the Bank's thinking regarding procedures for the selection of technical processes was still evolving at the time. The difference of viewpoints between the Bank and FCI that prevailed over the first years of project preparation were slowly resolved and evolved into a closer understanding. Because of FCI's past operating record the Bank had misgivings about the project (in particular about the fact that it involved an unproven integration of sub-processes) and insisted that adequate implementation arrangements be adopted. The setup that was eventually agreed upon between the Bank and FCI proved highly successful: it allowed FCI to keep responsibility for project implementation as well as for its P&D Division to undertake a major share of the engineering work; at the same time, it ensured that critical assistance from foreign engineering companies be made available. Within this general framework, which allowed for a substantial strengthening of the P&D Division's capability, the role of the project manager as overall coordinator on site was highly critical.

23. The key step in bringing to an end the protracted discussions between FCI and the Bank during project preparation was the decision to close down the electrolysis plant. It is somewhat ironic to note that this decision now appears to have been postponed for at least a number of years notwithstanding the highly uneconomic use of power which is allowed to continue, although there is no technical or economic reasons why the electrolysis unit should not be closed[1/]. The expectation that the project was to permit the release of a large amount of hydroelectric power for more economic uses was thus not fulfilled although this should not be interpreted as a shortcoming of the project. To utilize its excess ammonia capacity (55 percent of the capacity of the old plant or 170 tpd) NFL is contemplating setting up a methanol plant at Nangal; the Punjab State Industrial Development Corporation is also considering setting up a soda ash plant. These projects, which the Bank declined to finance on economic grounds, are not expected to be ready for at least three years. In the meantime, a 5,000-ton ammonia storage unit is being set up to allow for sales and transfer to other fertilizer units.

24. The project was efficiently implemented, albeit two years behind schedule due to a combination of factors largely outside the control of the project management team. Since start-up, production has been inhibited by a number of technical difficulties. This should not be construed as a reflection of improper management: the company has been active in dealing with production bottlenecks and the main production constraint that remains largely falls outside its control.

1/ NFL asserts that, according to their records, it made no commitment to close down the electrolysis plant. Rather, the decision was left to FCI "and the Bank had agreed not to insist upon this as a precondition." FCI felt that some power might still be available and the electrolysis plant could be phased out gradually depending on power availability. NFL also maintains that there is financial justification to draw a part of the ammonia production from the old electrolysis plant on the basis of prevailing current costs. For details, see Attachment A.

ANNEX 1

PROJECT PERFORMANCE AUDIT MEMORANDUM

INDIA--NANGAL FERTILIZER EXPANSION PROJECT
(CREDIT 357-IN)

CAPACITY, PRODUCTION AND UNIT COSTS OF PRODUCTION

	Ammonia I (Old Plant)	Ammonia II (New Plant)	Urea	CAN	
Capacity ('000 tons)	101	297	330	318	
Production ('000 tons)					
1975/76	99.0	-	-	308.7	
1976/77	96.1	-	-	328.0	
1977/78	57.8	6.4	7.2	221.1	
1978/79	72.4	95.4	123.3	282.5	
1979/80	62.0	112.1	146.1	254.8	
April-Dec. 1980	40.1	68.0	93.7	150.8	
Unit Costs of Production (Rs/MT in 1979/80)				A/b	B/b
Variable cost	1,154	890	638	516	414
Fixed cost/a	366	2,451	1,904	231	948
Total	1,519	3,340	2,542	747	1,362

/a Includes wages, depreciation, other production costs, interest and overheads.

/b A: On the basis of ammonia produced in the old plant.
B: On the basis of ammonia produced in the new plant.

ANNEX 2

PROJECT PERFORMANCE AUDIT MEMORANDUM

INDIA--NANGAL FERTILIZER EXPANSION PROJECT
(CREDIT 357-IN)

NANGAL UNIT--INCOME STATEMENTS (1978-1980)
(Rs Million)

	Year Ending March 31		
	1978	1979	1980
SALES REVENUE			
Sales	467.5	467.4	544.3
Retention price subsidy	15.5	90.0	263.3
Other income	9.1	33.8	16.1
Total income	492.0	591.2	824.3
COST OF OPERATIONS			
Purchased finished goods	206.2	97.5	76.7
Raw materials	82.8	121.3	184.7
Wages and salaries	32.7	36.7	35.6
Power and fuel	49.0	147.7	179.4
Freight and handling	6.9	11.1	13.3
Excise duty and pool equalization charges	49.5	73.1	69.3
Repairs and maintenance	18.6	27.0	38.5
Depreciation	4.7	55.6	127.1
Central office expenses	7.4	8.6	11.6
Interest	-	32.3	62.9
Other expenses (net)	2.9	3.0	13.3
Total costs	460.7	614.0	812.4
Net profit (loss)	31.3	(22.9)	12.0

ANNEX 3

PROJECT PERFORMANCE AUDIT MEMORANDUM

INDIA--NANGAL FERTILIZER EXPANSION PROJECT
(CREDIT 357-IN)

NANGAL UNIT--BALANCE SHEETS (1978-1980)
(Rs Million)

	Year Ending March 31		
	1978	1979	1980
ASSETS			
Gross fixed assets	1,663.5	1,324.3	1,339.1
Less accumulated depreciation	285.1	57.8	185.0
Net fixed assets	1,378.4	1,266.5	1,154.2
Current assets	185.3	267.2	367.0
Total assets	1,563.7	1,533.6	1,521.2
LIABILITIES			
Current liabilities	118.6	101.3	120.7
Long-term debts	576.1	-	-
Equity	869.0	1,432.3	1,400.5
Total liabilities	1,563.7	1,533.6	1,521.2

ANNEX 4

PROJECT PERFORMANCE AUDIT MEMORANDUM

INDIA--NANGAL FERTILIZER EXPANSION PROJECT
(CREDIT 357-IN)

NFL--INCOME STATEMENTS (1979-1980)
(Rs Million)

	Year Ending March 31	
	1979	1980
REVENUE		
Sales	467.4	821.1
Retention price subsidy	90.1	523.8
Other income	34.4	88.0
Total income	591.8	1,432.9
COST OF OPERATIONS		
Purchased finished goods	97.5	76.7
Raw materials	121.3	390.1
Wages and salaries	40.7	54.8
Power and fuel	147.7	297.4
Freight and handling	11.1	17.5
Excise duty and pool equalization charges	73.1	102.2
Repairs and maintenance	27.1	56.3
Depreciation	58.3	340.0
Interest	32.3	192.6
Other expenses (net)	5.6	47.8
Total cost	614.7	1,575.5
Net profit (loss)	(22.9)	(142.6)

ANNEX 5

PROJECT PERFORMANCE AUDIT MEMORANDUM

INDIA--NANGAL FERTILIZER EXPANSION PROJECT
(CREDIT 357-IN)

NFL--BALANCE SHEETS (1979-1980)
(Rs Million)

	Year Ending March 31	
	1979	1980
ASSETS		
Gross fixed assets	5,345.8	5,724.6
Less accumulated depreciation	84.3	424.8
Net fixed assets	5,261.5	5,299.8
Current assets	642.1	909.1
Total assets	5,903.6	6,208.9
LIABILITIES		
Current liabilities	359.5	433.2
Long-term debts	2,910.3	3,082.2
Equity	2,633.8	2,693.5
Total liabilities	5,903.6	6,208.9

ATTACHMENT A

COMMENTS RECEIVED FROM BORROWER

COMMENTS ON PROJECT PERFORMANCE AUDIT REPORT
ON NANGAL EXPANSION PROJECT (CREDIT 357-IN)

.....

Para 2 (line 7) :

The National Fertilizers Ltd was formed in 1974 and not in 1975 as stated in the text.

Para 11 (last sentence)

Incorporated in PPAM, para. 11, footnote 1.

It has been stated that P&D was to retain full responsibility for detailed engineering and procurement of equipment. In actual fact, however, the work done by P&D was under-written by the consultant engineers, namely: Uhde, Lurgi, Shell-Topsoe Consotium-in as much as contractually they were responsible for supervision of the detailed engineering to ensure its adequacy from their point of view.

Para 15.

NFL has supplemented the figures for capacity utilisation given in the Table forming part of this para. The following figures form the supplementary material:

	Capacity Utilisation (percent)	
	1980-81	Apr-Sept. 1981
Old Plant		
Ammonia	51	44
CAN (25% N)	65	52
New Plant		
Ammonia	38	56
Urea (46%N)	47	79

Incorporated in PPAM, para. 16, footnote 2.

NFL points out that the underutilisation of capacity in 1980-81 is principally due to irregular supply of raw materials, because of which the plant was shut down for about 120 days. This external constraint has however, not been a feature in April-September 1981 and the figures show that, in spite of the waste heat boiler being under repairs, the capacity utilidation has improved considerably.

Para 16: (Last but one sentence)

In regard to the defective waste heat boiler, the company has been in consultation with the proprietary suppliers and has come to the following conclusion:

The failure of the Sandvik Sanicro-30 tubes, forming the boiler elements, has been identified as due to stress corrosion in the crevices between the tube and the tube plate caused by presence of sodium and chlorides. It has also been noted that the design features are such that water circulation in the boiler at the entry zone of the gas is poor and since the heat flux at this point is high, compounded by the fact that there are crevices at the hot end of the tube, there is an acceleration in the deposit formation and attack in this zone. As an interim measure, the Nangal workshop has reconstructed the boiler using 2¼ chrome and 1 moly tubes. This material, it is claimed, is not susceptible to stress corrosion. Steps have also been taken to improve proper scavenging at the tube sheets, ensuring better quality of the feed water and additional monitoring of the quality with newly installed instruments. The repaired boiler is already in commission since November 1981. To suggest a long-term solution, a separate study has been entrusted to M/s. Haldor Topsoe and FPDIL. This study will also incidentally include suggestions for either change of internals or specific equipment to achieve higher capacity utilisation. It has also been mentioned in the paragraph that the urea production is being restricted for lack of CO_2 when only two of the three gasifiers are in commission. This is no longer true. In consultation with M/s Lurgi, Nangal plant has introduced certain modifications in the CO_2 recovery section of the Rectosol unit which ensures sufficient high purity carbon dioxide recovery to load the urea plant at 100% even when only two gasifiers are in line.

Incorporated in substance in PPAM, para. 16, footnote 2.

Incorporated in text, para. 16 of PPAM.

Paras 19 and 23:

A reference has been made to some understanding which the World Bank had on discontinuance of operations on the old Nangal electrolysers once the expansion plant was put into operation. NFL has pointed out that according to their records, there was no commitment on the part of NFL to do this. According to their records, it would appear that the decision to close down the electrolysis plant was left to the FCI and the Bank had agreed not to insist upon this as a precondition. This was done because, at the time of negotiations, the FCI felt that some power may still be available for the electrolysis plant and its phasing out could be done gradually depending upon a review of the availability position. NFL has indicated that the electrolysis plant, even though 20 years old is in fairly good health and with normal maintenance can be expected to operate for another 8 to 10 years. Even when operating this plant, there would be no effect on the urea production because of resultant reduced gasifier loads, since the rectisol CO_2 recovery system has been suitably modified as already commented in previous section. NFL feels that there

Incorporated in substance in PPAM, para. 23, footnote 1.

is a justification on the ground of current costs (purely on financial terms) to draw a part of the ammonia production from the old electrolysis unit as the following production cost figures for the two plants for 1980-81 would show:

		(in rupees/tonne)	
Ammonia	Variable cost	Fixed cost	Total
Nangal old plant	1216.29	552.70	1768.99
Nangal new Plant	934.96	2753.97	3688.93

As it is, around 98 MW of power is made available to NFL off and on and this enables them to produce about 170 tonnes per day of ammonia from this unit. The extra ammonia is intended to be stored in a 5000 te ammonia storage tank which has been sanctioned to them under the Operations Improvement Programme funded by the World Bank. The ammonia pool from this storage would be utilised to improve performance not only in Nangal but also in Bharinda and Panipat by moving ammonia from surplus to deficit plants as and when contingencies arise. The soda ash project of Punjab Industrial Development Corporation, though delayed to some extent for tying up finances, is now already taken under execution and is expected to be ready with in another 30months.

ATTACHMENT B

PROJECT COMPLETION REPORT

INDIA--NANGAL FERTILIZER EXPANSION PROJECT

I. INDIA'S FERTILIZER INDUSTRY

A. Bank Group Involvement

1.01 The Indian fertilizer industry was still in its early stages of growth when in 1967 the Bank Group first became involved to assist in its further development. During the last 10 years, there have been significant developments within the industry and the Government's approach to it and the Bank Group has been associated with many of them. The first two Bank Group operations in the industry were in the private sector with an IFC investment of US$11.5 million in 1967 to the Indian Explosives Company Limited (a subsidiary of Imperial Chemical Industries, of the U.K.) to finance a urea project and another IFC investment of US$18.9 million in 1969 in the Zuari-Agro Company Limited (an affiliate of U.S. Steel Agrochemicals) to produce urea and complex fertilizers. Since then there have been eight other operations - six by IDA and two by IBRD. Of them, six financed additions to capacity of existing plants and one assisted the removal of production bottlenecks by increasing capacity utilization of eight public, joint and private sector fertilizer companies (para. 1.07). IBRD's first operation, approved in 1974, financed a new urea plant of IFFCO, a company jointly owned by the farmers' cooperatives and the Government. Bank Group financial support to the Indian fertilizer industry to date totals about US$473 million. Annex 1 lists the fertilizer projects financed to date by the Bank Group in India and their current status.

B. Industry's Development

1.02 Chemical fertilizer production in India, as a modern industry, began shortly after independence in 1947 as part of the Government's program to make the country self-sufficient in food supply. Government policies vigorously promoted expansion of the industry. Initially this was done via the public, private, joint state and private, and cooperative sectors, but subsequently, emphasis shifted to the public sector primarily through related policies such as pricing, allocations of foreign exchange, restrictions on profits and foreign participations. Although the Government sanctioned many new projects, actual capacity expansion through the late 1960's was slow and capacity sizes of plants were relatively small (below 200 tpd on the average). A philosophy of maximum indigenous input in all phases of the expansion, including engineering and fabrication, often resulted in considerable completion delays, excessive cost overruns and commissioning difficulties, largely because of the inexperience of the local entities with projects that were large and complex relative to then available capabilities. Poor performance, underutilization of capacity and low nutrient content of product mix were also major features of the industry.

1.03 In 1967, when the Bank Group became involved with the industry, total installed capacity of nitrogen (N) and phosphates (P_2O_5) was about 785,000 tpy. A decade later (1977) it was about 3.7 million, or four times as much and is expected to double again to about 7.7 million tpy by 1983, when all the projects, now under construction or planning are scheduled to be completed. While low-nutrient products such as ammonium sulphate (20.5% N), calcium ammonium nitrate (20.5% N) and single superphosphate (16% P_2O_5) formed about three-fourths of the nutrient capacity in 1967, most of the newer capacity has been for the production of urea (46% N) and complex fertilizers. At the same time, Indian plant designs have followed closely developments elsewhere. Ammonia plant sizes have increased from below 200 tpd in 1967 to 900 tpd for plants now being commissioned. A 1,100 tpd naphtha-based ammonia plant is already in operation and four gas-based plants with capacities of 1,350 tpd each are planned. The feedstock pattern for ammonia production, which emphasized the use of naphtha in the late 1960s, has been diversified to include fuel oil, natural gas and coal, with the objective of reducing the country's petroleum import bill and of more fully reflecting its resource base. Present expansion plans are based on natural gas from Assam and the recently-discovered Bombay High Bassein offshore field. In terms of operating efficiency, average capacity utilization, a major problem in the past, has increased to about 73% by 1977 including plants that had recently come on stream and others--mostly of an early vintage--with low utilization. Local capabilities developed in the fields of design, engineering, construction, equipment fabrication and project implementation have helped to reduce the foreign exchange share of project costs, even though there have been delays and cost overruns in some earlier projects. With a total employment of over 60,000 persons in Indian fertilizer plants, the industry has developed a large pool of trained and experienced manpower especially in the middle managerial and supervisory levels. Pricing policy for nitrogenous fertilizers was revised in 1977 to improve ex-factory prices, especially for the more recent higher cost plants, though these prices are still not adequate to attract much local private sector investment or foreign equity participation.

C. Public Sector

1.04. The public sector has taken an increasing role in fertilizer production. In 1978/79, about 49% of the total installed nitrogen capacity of 3.3 million tons per year (tpy) was in the public sector and about 0.2 million tpy in the cooperative sector. Including the cooperative and joint sector capacity of 1.03 million tpy, the public sector directly or indirectly accounts for about 81% of the domestic nitrogen capacity and the share is expected to increase further to about 90% by 1984/85. The large public sector expansion program had mainly been implemented through the Fertilizer Corporation of India (FCI) and the National Fertilizers Ltd. (NFL).

1.05 Four of the 11 public sector plants (Nangal, Trombay, Gorakhpur and Namrup) have generally shown satisfactory capacity utilization rates equal to or better than plants in the private sector, though production at even these plants has at times suffered due to periodic power supply and transport

problems (Annex 2). The original plant at Sindri also showed satisfactory performance until the mid-1970's when the age of the facilities and difficulties in obtaining continued supplies of quality raw materials combined to limit production. The overall unsatisfactory capacity utilization in the public sector plants, occurring during a period of substantial expansion, can in part be attributed to the managerial limitation of FCI, which has led to its restructuring (para. 1.08). Perhaps, more importantly, there were severe technical problems during the commissioning of the new plants (e.g., Nangal Expansion, Sindri Rationalization, etc.) and continuing operating problems at the five older plants (Cochin I, Durgapur, Udyogamandal, Rourkela and Neyveli). Design defects have affected certain of these plants and the foreign firms, where involved, have moved in to rectify these deficiencies. Other problems, however, have resulted from a specific policy of using indigenous resources leading to maximum employment of local engineering and locally-supplied equipment in a technologically-difficult industry. Experience has modified this policy but resolving the resulting technical problems through redesign, replacement and "debottlenecking" programs, has taken time, while problems related to raw materials supply, power, etc. have also, in some cases, constrained operations.

1.06 Problems affecting the performance of the public sector fertilizer plants were studied by a Government committee in 1978 and several remedial measures recommended. Its recommendations, including those for plant modifications and better planning of preventive maintenance, have been adopted. The full impact of these efforts should be reflected in higher capacity utilization gradually during the next two years.

1.07 The Bank has also assisted the Government efforts to improve fertilizer production. As part of the Trombay IV Project (Credit 481-IN) a credit of US$17 million was made available to revamp the Durgapur and Cochin I plants. Further, the Fertilizer Industry Credit of US$105 million, approved in 1975, was specifically designed to improve capacity utilization of the Indian fertilizer industry. The Credit covered a large number of sub-projects involving 11 plants. Since none of these IDA-financed facilities were operational before 1977/78, their beneficial effect on capacity utilization has not yet been fully felt.

1.08 In 1977/78, FCI, the largest public sector fertilizer company, had an installed capacity of 0.92 million tpy of nitrogen (30% of the total in the country) and another 1.25 million tpy of capacity was under construction. As a result of the rapid expansion of FCI during the 1970's, management capabilities of FCI were overstretched. During the past few years, the Government and the Bank have been discussing the need for decentralized decision-making in FCI. As a first step, to improve the organization of the public sector industry and thereby its performance, in 1975 the Government formed a new public sector company -- National Fertilizers Ltd. (NFL) to implement the Bhatinda and Panipat Projects. This approach was successful and a scheme for further restructuring the public sector fertilizer units was

evolved during 1976-77 and formally announced in January 1978. This scheme regroups the units earlier managed by FCI and NFL into four separate geographically-oriented companies. The Nangal Project along with the Bhatinda and Panipat Projects are now under the NFL. The remaining plants and related marketing activities have been assigned to the other three regional companies -- the Rashtriya Chemicals and Fertilizers Ltd. (West), Hindustan Chemicals and Fertilizers Ltd. (East), and FCI (Central). The erstwhile Planning and Development Division of FCI has become an independent company -- Fertilizer (Planning and Development) India Ltd. (FPDIL). The new companies were legally formed in April 1978. The above restructuring is expected to improve delegation of responsibility and authority to the unit/project level and thus ensure better performance.

II. PROJECT IDENTIFICATION, PREPARATION AND APPRAISAL

A. Project Development

2.01 The Nangal expansion project was initiated by the Fertilizer Corporation of India in 1968, and was prepared by its Planning and Development Division. The project was appraised between June and August 1972 and negotiated in Washington in December 1972. It was approved for IDA financing by the Executive Directors on January 30, 1973. The preparation of the project, which lasted 50 months and involved IDA substantially, impacting also on the preparation and execution of latter projects in the sector, is discussed in Chapter V.

B. Project Objectives

2.02 The project was to add a 900 tons per day (tpd) ammonia plant based on the use of heavy petroleum feedstock and use 300 tpd of ammonia to replace ammonia from an old uneconomic hydro-power-based ammonia unit and use the rest of the ammonia for the production of 1,000 tpd of urea.

C. Project Description

2.03 The project included the following production facilities: an ammonia unit having a design capacity of 297,000 tpy; a urea unit with a design capacity of 330,000 tpy and supporting facilities (including storage and utilities) for the new ammonia and urea units. Ammonia production is based on the partial oxidation of fuel oil. Overall process design was the responsibility of Friedrich Uhde GmbH of the Federal Republic of Germany (FRG), which was selected from among several proposals. The process included the following steps: air separation; high pressure, Shell non-catalytic partial oxidation; Rectisol sulphur removal and recovery; shift conversion; Rectisol carbon dioxide removal and recovery; synthesis gas purification by nitrogen wash; Montedison ammonia synthesis; and ammonia separation and storage. The urea production is based on the designs of Montedison for which

FCI already had a license. The plant is a conventional total recycle, single-train unit and includes the following steps: ammonia and carbon dioxide compression; urea synthesis; separation and recycling of unreacted materials; urea solution concentration and prilling; and storage, bagging, and despatch. The project was expected to be mechanically completed in 32 months, which was a rather optimistic estimate. For fertilizer projects subsequently financed by the Bank Group, a longer period (38-40 months) for mechanical completion is assumed.

D. Project Cost

2.04 Total financing for the project (including Rs 37 million of interest during construction) was estimated at Rs 769 million (US$ 105.6 million). The appraisal estimates were based on FCI estimates prepared in cooperation with the contractors who had previous experience with similar projects; and included reserves for physical contingencies equivalent to 10% of equipment, civil works and working capital costs and another 10% for price escalation. Below is a comparison of the appraisal cost estimates with the actual costs:

Comparison of Appraisal Estimates and Actual Project Cost
(in Rs Million)

	Appraisal Estimates			Actual			% Change
	Local	Foreign	Total	Local	Foreign	Total	
Equipment, material, spares	31	293	324	319	341	660	+104%
Freight & handling	9	17	26	36	-	36	+ 38%
Duties & taxes	95	-	95	140	-	140	+ 47%
Engineering designs & license fees plus project management	43	28	71	74	39	113	+ 53%
Erection & commissioning	33	14	47	62	20	82	+ 74%
Civil works	37	-	37	64	-	64	+ 73%
Sub-Total	248	352	600	695	400	1,095	+ 83%
Physical contingencies	26	32	58	-	-	-	
Price contingencies	26	32	58	-	-	-	
Modifications during commissioning	-	-	-	66	1	67	+100%
Working capital	16	-	16	15	-	15	- 6%
Total Project Cost	316	416	732	776	401	1,177	+ 61%
Interest during constr.	37	-	37	121	-	121	+227%
Total Financing	353	416	769	897	401	1,298	+ 69%

E. Analysis of Cost Overrun

2.05 Total actual cost of the project was Rs 1,298 million, 69% higher than the appraisal estimate of Rs 769 million. The increase was mainly due to higher equipment prices and changes in foreign exchange rates, increased duties and taxes, higher outlays for engineering, project management, equipment erection and civil works, equipment modifications during commissioning and increased interest during construction as a result of delays in project implementation. The table below analyzes the cost overrun in various major categories of the project:

Analysis of Cost Overrun

	Rs millions			% Share of
	Local	Foreign	Total	Overrun
Equipment, material & spares	+288	+48	+336	+63%
Freight & handling	+27	-17	+10	+1%
Duties & taxes	+45	-	+45	+9%
Engineering designs & license fees plus project management	+31	+11	+42	+8%
Erection	+29	+6	+35	+6%
Civil works	+27	-	+27	+5%
	+447	+48	+495	+92%
Less: Provisions for price & physical contingencies	-52	-64	-116	-21%
	+395	-16	+379	+71%
Add: Modifications during commissioning	+66	+1	+67	+13%
Less: Additional w. c.	-1	-	-1	-
Total project cost overrun	+460	-15	+445	+84%
Add: Interest during constr.	+84	-	+84	+16%
Total financing overrun	+544	-15	+529	+100%

2.06 The total cost increase amounted to Rs 529 million (or about US$63 million based on the weighted exchange rate of Rs 8.4 to US$1 during the project implementation period). Nearly 70% of the cost overrun was accounted for by

increases in the costs of civil works, equipment and services, while modifications during project commissioning and increased interest during construction accounted for the rest. The bulk of the increase was in the local cost component. There was less than anticipated procurement from foreign sources due to unacceptably long delivery dates and in some cases cancellations by foreign suppliers following the aftermath of the 1973/74 oil price increases (i.e., the very time the project implementation began) which affected projects worldwide.

F. Financing

2.07 Under provisions of the Credit Agreement (Section 3.01), GOI was to onlend to FCI the entire US$58.0 million IDA credit at 8.5% for 15 years including five years of grace, and was to provide Rs.353 million in the form of equity to finance the execution of the project. The provisions also called for any additional funds, as required, to be provided by GOI with at least 50% in the form of equity and the remainder in the form of debt on terms and conditions normally applicable to GOI's loans to FCI. Due to the increased cost of the project, GOI's total contribution actually amounted to Rs 808 million, Rs 455 million more than the appraisal estimate. Seventy-eight percent of GOI's contribution (Rs 634 million) was in the form of equity to FCI, the remainder (Rs 174 million) was in loans at 10.5% annual interest for 10 years including one-year grace, effective February 1978. The terms are similar to other GOI loans to other public sector projects. The debt/equity ratio of 51:49 at project completion was slightly below the 54:46 envisaged at appraisal.

Financing Plan
(Rs million)

		Appraisal	Actual
A.	Equity from GOI	353	634
B.	Long-Term Debt:		
	-GOI onlending of IDA Credit	416	490 /a
	-GOI Direct Loan	-	174
	Sub-Total	416	664
C.	Total of A + B	769	1,298

/a Increase was due to changes in the exchange rate of the Rupee.

III. PROJECT IMPLEMENTATION AND MANAGEMENT

A. Analysis of Time Overrun

3.01 Work on the Nangal project started April 1973 (about three months later than expected at the time of appraisal), and the project was mechanically completed in July 1977, some 23 months behind schedule, and subsequently commissioned after start-up tests early January 1978, a total of 25 months later than the appraisal forecast. The actual implementation schedule is compared with the appraisal estimate in Annex 3.

3.02 The time overrun was mainly due to the longer than anticipated delivery dates for equipment delivery because of the tight international equipment market following the 1973-74 oil crisis. Further, the time originally estimated for process and detailed engineering and to some extent for local equipment and materials procurement was somewhat underestimated, given the local engineering firm's (FCI's Planning and Development Division) lack of adequate previous experience in those areas. Another reason for the delay was the storm damage to the urea reactor during shipment near Lisbon; the reactor had to be returned to the supplier in the Federal Republic of Germany for repairs which delayed the delivery by nearly a year. A major occurrence during the plant commissioning was the explosion in the carbon slurry separator tank due to instrument failure. As a result, the ammonia plant had to be shut down for about three months for repairing the tank. Taking into account the above factors, which were largely outside the control of FCI, the 23-month delay in mechanical completion and a further two-month delay in commissioning the project were not unreasonable.

3.03 Following commissioning, a number of technical and operational problems were experienced and the production could not be stabilized at high levels without intermittent equipment failures until November 1978, particularly because of: (a) a fire breakout in the nitrogen section of the project; (b) carbon dioxide (CO_2) limitation for urea production even when the ammonia plant was operating at high capacity; and (c) the lack of familiarity of the Indian technicians with the operation and maintenance of large fuel-oil-based plants resulting in a longer than normal in-plant familiarizing period. The technical problems were overcome by carrying out certain plant modifications during January-November 1978 with the help of the engineering firms, Uhde and Lurgi. Considering that the Project was the first fuel-oil based fertilizer complex in India and that it was designed by Uhde during the period when the first large-scale fuel-oil-based plant built by Uhde was still under commissioning in the Federal Republic of Germany, those difficulties in stabilizing production at Nangal were not unusual.

B. Procurement

3.04 As noted above, equipment procurement fell right into the period of the 1973-74 oil crisis. Due to the impact of the crisis in the form of increased international demand of oil companies on equipment suppliers, responses to bid invitations were limited in general. Typically, against 20 or so invitations per item or package, only between three to five technically acceptable responses (or even less) resulted. In a few cases, only one offer was received. To avoid additional project delays that would have arisen had

rebidding been undertaken and in the face of then dramatically rising equipment prices, some single offers were accepted by the FCI, after consultation with IDA, whenever the prices and delivery times were relatively reasonable. As a result of the poor bid responses and unacceptably long delivery dates from overseas, a considerable number of orders had to be placed with Indian heavy-equipment manufacturers such as Bharat Heavy Plate and Vessel Company (BHPV) and Bharat Heavy Electrical Company (BHEL) who were already themselves laboring under heavy workloads from other customers. Indian equipment suppliers had been expected at appraisal to win about 10% of the equipment contracts under international competitive bidding; as a result of the procurement difficulties, Indian suppliers fulfilled 35% of the contracts financed by IDA. A list of countries of suppliers and contractors and the values of contracts won is shown in Annex 4.

C. Project Management

3.05 Project construction management showed considerable ingenuity in minimizing delays. Critical items and men were 'borrowed' from other FCI projects under construction; and donkeys and additional manual labor were used when the foreign supplier of a heavy earthmoving equipment cancelled the order at the last minute, thus minimizing the resulting delays. The prime contractor for the project was FCI's Planning and Development Division. Major responsibilities relating to basic process design, supervision of detailed engineering and erection and procurement of critical items were subcontracted to various Indian and process consultants. Process design, supervision of detailed engineering and erection of the ammonia plant were assigned to a consortium of firms (Uhde, Lurgi and Mineraltechnick, of the Federal Republic of Germany, and TOPSOE, of Denmark) headed by Uhde after competitive bidding. Similar work relating to the urea plant was subcontracted to Tecnimont of Italy, a subsidiary of Montedison with whom FCI had process licensing agreements. Work on the offsite facilities were subcontracted mostly to Indian companies. In accordance with Section 2.03 (b) of the Project Agreement, FCI appointed a suitably qualified, experienced project manager with adequate authority, staff and facilities. FCI was generally satisfied with the performance of most of the contractors.

D. Disbursements

3.06 Disbursements of the IDA credit of US$58.0 million were closed September 1976. There were no cancellations. Other than in 1973 when the tight equipment supply situation required substantial advance deposits to ensure supply, the appraisal disbursement estimates have been fairly close to the actual, as shown below:

Disbursements
(in US$ millions)

Calendar Years	1973	1974	1975	1976	1977	Total
Appraisal Estimates	-	7.5	35.0	14.5	1.0	58.0
Actual	3.04	8.24	33.85	12.87	-	58.0

The largest sources of supply under the Credit were the Federal Republic of Germany (42.4%), India (34.6%), Italy (8.4%), the U.K. (4.8%) and Japan (3.7%), accounting for about 94% of the disbursements. Annex 4 shows the currencies in which the Credit was disbursed.

IV. OPERATING PERFORMANCE AND ECONOMIC ASPECTS

A. FCI Restructuring

4.01 As indicated (para. 1.05), FCI has been restructured as of April 1, 1978. The restructuring essentially divested the old FCI of some of its operating units regrouping them into four separate geographically oriented companies. Its Planning and Development Division has also been spinned off into an independent company -- the Fertilizer (Planning and Development) India Limited. As a result of this restructuring, the Nangal Unit now belongs to the National Fertilizers Limited (NFL). NFL also has two other plants, each of 511,000 tpy of urea, at Bhatinda and Panipat in northern India. Both plants, which are similar in size to Nangal's expansion unit, were mechanically completed by NFL in 40 months, slightly (two months) behind schedule.

B. FCI's Operating Performance

4.02 Prior to its restructuring in 1977/78, FCI had eight fertilizer operating units (Annex 2). The capacity utilization in these public sector plants has been comparable in recent years to the units in the private and joint sectors, if the performance of one of FCI units--Durgapur-- is not taken into account. The poor performance at Durgapur (which started production in 1974) has been mainly due to design defects and equipment failures which delayed commissioning of this plant and its stabilized operation. The Durgapur Plant has also been affected by inadequte power supply from the West Bengal State grid. Even with certain modifications carried out, Durgapur operated at only 25% in 1978/79. Further plant modifications are now being made based on a Tecnimont (Italy) survey. Besides, an in-plant power generation unit being installed with IDA financing at Durgapur will help improve the power supply situation. The average capacity utilization in the FCI plants was 79% in 1976/77 but it decreased in 1977/78 to 63% mainly because of the declining performance of the Sindri unit due to the age of the plant (it was established in the early 1950's) and power shortages which affected the Nangal and Namrup plant operations.

4.03 In spite of fairly impressive performance by most of FCI units, (para. 1.05), FCI's overall financial position continued to be unsatisfactory until its restructuring because of the Government pricing policy. Fertilizer prices had been kept pegged at unremunerative levels--often at below international prices, to ensure that the basic agricultural input was available to the farmer at an attractive price. A more realistic pricing policy was adopted only in November 1977. Also, to maximize the domestic availability of fertilizers and to avoid unemployment of the operating labor, the Government continued to operate the Sindri Unit whose operation had become uneconomic

because of the age of the plant and the inadequacy of the fertilizer price fixed by the Government prior to 1977 even to meet the variable costs. Further, as already noted, it has not yet been possible to stabilize production in the Durgapur plant.

C. Compliance with Covenants

4.04 The current ratio of FCI was less than the agreed level of 1.2:1 during 1972-75 (Nangal's current ratio was, however, above the agreed limit during this period as shown in para. 4.05) but subsequently the ratio improved to the agreed level with Government assistance. But for the current ratio covenant violation during 1972-75, FCI has complied with all the IDA covenants.

D. Nangal's Operating and Financial Performance

4.05 Nangal's operations which until now have been entirely dependent on power supply from the nearby Bhakra Dam, were adversely affected by power shortages during the project period. The unit's capacity utilization averaged 77% during the 1972/73-1977/78 period. Annual production ranged from a low of 51% in 1974-75 when there were severe power shortages, to 101% in 1976-77 when there was adequate power supply. The unit's operating management is satisfactory. Operating results during the six-year period showed net annual income averaging Rs 54 million per year. Measured against sales, the average net annual income has been about 21% - approximately what had been estimated at appraisal. Following is a summary of the unit's performance during the period based on its income and balance sheet statements for the period shown in Annexes 5 and 6:

Nangal Fertilizer Unit - Performance Indicators

	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78
Capacity Utilization	67%	77%	51%	97%	101%	70%
Profits as % of Sales	20%	27%	30%	37%	20%	7%
Current Ratio	9:1	7.5:1	4.3:1	4.2:1	2.2:1	1.6:1

4.06 As stated in paragraph 4.05 and evidenced by the results of its operations shown in Annex 5, Nangal's operating management was satisfactory throughout the project period. With ammonia for the CAN plant now being supplied from the ammonia unit of the project, and thus free from the severe power shortages of the past, the CAN plant can be expected to operate at close to capacity. The management and operators working on the expansion facility now appear familiar with its technology. In 1978/79 (the first fiscal year of stabilized production), 95,365 tons of ammonia and 123,343 tons of urea were produced, accounting for 32% and 37% capacity utilization in the ammonia and urea plants respectively. The capacity utilization in both plants is expected to reach 70% in 1979/80, and 90% in 1980/81 and onwards.

4.07 Projections for future operations (1979/80-1989/90) are shown in Annexes 7 and 8. The projections assume that the electrolysis ammonia plant would be closed down after 1979/80, and that the CAN plant would be supplied

with 300 tpd of ammonia from the expansion unit. Other assumptions used for the projections are shown in Annex 9. The assumptions are based on 1978 prices which show marked increases as compared to the appraisal assumptions. Following is a comparison of the appraisal price assumptions with the 1978 prices:

Comparison of Appraisal Product Prices with 1978 Prices

	Appraisal Assumption Rs	1978 Rs	% Change
Exfactory Prices (per ton)			
Urea	879	1,741	+ 98%
CAN	510	849	+ 66%
Raw Materials (per ton)			
Feedstock (fuel oil)	190	933	+391%
Coal	95	181	+ 90%
Limestone	38	53	+ 53%
Power			
For expansion plant (MWH)	105	200	+ 90%
For electrolysis plant (MWH)	28.4	93.2	+228%
Bags			
Bags for CAN (per bag)	2.6	3.2	+ 23%
Bags for Urea (per bag)	2.6	3.6	+ 38%

4.08 The changes in raw material prices shown above reflect the changes that have occurred since the 1973-74 oil crisis. As can be expected, imported feedstock as well as energy costs have gone up more than other inputs. The ex-factory prices for urea and CAN are based on a formula introduced by the Government in November 1977 for the main nitrogenous fertilizers produced in the country. The formula aims at providing a reasonable return on investment for the fertilizer industry. It calls for ex-factory retention prices that allow each operating unit a 28% before tax or a 12% after tax return on net worth 1/ (whichever is higher) at 80% capacity utilization. So as to allow a company the full benefits of any tax incentives it can receive, the Government applies that return which gives the company the higher retention price. The retention price, which is based primarily on net worth, debt service, and fixed and variable costs as defined by the formula, is re-calculated every two years. Nangal's recent retention price for urea was Rs 1,741 per ton. The price was determined in 1977 on the basis of estimates of the cost to complete the expansion unit--estimates which turned out to be substantially lower than the actual completion costs. In line with the formula's requirements, Nangal's urea retention price is due for further adjustment in FY1980, to reflect its actual net worth based on the final completion costs. Annex 10 presents a recalculation of Nangal's probable retention price taking into

1/ Approximately 50% of total financing required as defined under the pricing formula.

account its net worth, debt service, variable and fixed costs and other factors prescribed by the GOI formula. The recalculation shows that Nangal's urea retention price for the next two years would be about Rs 2,250 per ton, an increase of Rs 509 per ton. This compares with Rs 2,130 per ton for NFL's Bhatinda plant and Rs 2,112 per ton for the Panipat plant.

E. Financial Rate of Return

4.09 The re-evaluation of the project's financial rate of return is based on the fixed investment cost of the project at completion, the forecast operating cost in 1978 prices and the value of the urea produced by the project's facilities based on the GOI retention price formula. The re-evaluated financial rate of return is about 18.4% compared to the appraisal estimate of 18.1%. The financial rate of return re-evaluation assumes that Nangal does not pay any taxes as taxes are levied on the parent company's overall income and NFL is expected to exercise its tax incentives. It also assumes that in line with the objective of the retention price formula, Nangal would reinvest the large cash flow during the initial years of operation of the project, since if no reinvestment occurs, the unit's decreasing net worth (as defined by the retention price formula) with decreasing net fixed assets would reduce the return and thereby also the retention price (and consequently revenues). Details of the financial rate of return re-evaluation are shown in Annexes 11 and 12.

F. Economic Rate of Return

4.10 The economic rate of return was re-evaluated 1/ for both the base case (i.e., the project without benefits from closing down the electrolytic plant), and the project with benefits from energy savings resulting from closing down of the electrolytic plant. The delivered prices of imported urea and CAN at the plant were used to estimate the benefits from the project's output. Capital and maintenance costs were adjusted to remove transfer charges. Tradable raw material inputs were valued at their international equivalent or market cost, while the high-sulphur, heavy-ash content coal used by the plant for generating steam (which is not internationally tradable) was valued at 50% the nominal ex-colliery price plus freight and handling to reflect its economic value. The details of the assumptions are shown in Annex 9. Details of the rate of return calculations are presented in Annex 13 and summarized below.

4.11 The base case for the project's economic analysis at appraisal was the project without closing down the existing power-intensive ammonia plant. The appraisal economic rate of return for the base case was 14.6%. On the basis of the re-evaluation calculations, the economic rate of return for the base case is 11.8%. The decrease in the return is largely due to (a) the increased international prices for fertilizers since appraisal having

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1/ On the basis of the Bank commodity price forecasts of August 1978 which were prepared before the most recent petroleum price increases.

been offset substantially by the increased capital costs resulting from the delays in implementation; (b) increased prices for fuel feedstock and other raw materials; and (c) the foregone added value of the 100,000 tpy of ammonia that would have to be sold to other fertilizer plants for processing if the existing electrolytic plant is not closed down. The foregone added value is estimated to be about 40% its CAN equivalent.

4.12 Project with Benefits from Energy Savings: An important objective of the project was to enable the closing down of the existing power-intensive ammonia plant. The project, which is based on heavy fuel oil, was designed to enable the closing down of the ammonia section of the existing plant, by feeding about 100,000 tpy of ammonia to the CAN plant. The replacement of the ammonia from the electrolysis plant by equivalent amount from the project releases about 149 MW of energy to other users in the area. The opportunity cost for power, based on thermal plants 1/ currently under construction, is estimated to be about Rs 230/MWH. Based on updated costs, the re-evaluated economic rate of return for the project, including the values for the power savings and the maintenance avoided from closing down the electrolysis plant, is estimated to be about 30.9%. This compares with the appraisal estimate of 22% evaluated on the same basis. The substantial increase in the return is due to the sharp increase in the opportunity cost of power and the maintenance of the electrolytic plant (now 18 years old) avoided by closing it down. Based on the opportunity cost of power discounted at 10% opportunity cost of capital over the 12 years of the project's economic life, the value of the 149 MW released by the existing electrolytic ammonia plant as a result of the project would amount to about Rs 1.3 billion or about US$155.0 million. The associated maintenance cost of the plant, estimated at an economic cost of some Rs 18 million per annum, will save the equivalent in present value of Rs 72 million (or US$8.6 million) over the same period.

G. Environmental Aspects

4.13 The environmental aspects of the operation are well under control and meet the standards established by the Indian Standards Institution. No ammonia is discharged into the atmosphere. Liquid effluents containing small amounts of absorbed ammonia are well treated before discharging into the Sutlej River. The effluents which require treatment before discharge are ammoniacal effluents, occasional hydrogen cyanide (HCN), contaminated carbon slurry, ash in the form of ash slurry and oil spillage. The ammoniacal effluents from the urea plant and waste water stream from the CO-shift conversion containing 500-1,000 ppm of ammonia are treated with lime slurry to adjust the hydrogen-iron concentration (pH) and are then sent for air stripping in a forced draft stripping tower. After stripping, the ammonia content is reduced to 50-100 ppm and then discharged into the factory sewer and further diluted with returned circulation water from both the old and expansion plants before ultimately being discharged into the river. To take care of any

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1/ Because of rapidly increasing power demand in Northern India and with no hydro facilities available to satisfy this demand, marginal increases are being satisfied by more expensive thermal plants.

occasional discharge of carbon slurry containing 50-60 ppm of HCN from the ammonia plant, a carbon slurry pond with a capacity of 22,000 m^3 is available. The carbon slurry effluent is first treated with ferrous sulphate solution to remove the HCN and then is drained to the carbon slurry pond. It is further treated by diluting it with returned circulating water before discharging to the river. Ash disposal in the form of ash slurry from the steam generation plant is pumped to the ash slurry pond near the river where the water, after settlement of the ash, is discharged to the river. Oil contaminated drain water is treated by decantation and subsequent absorption in oil separators provided at different places in the plants.

H. Employment

4.14 As in many projects in developing countries, the old Nangal facility was overstaffed for social reasons. At the time of appraisal, it employed over 3,800 persons, including 1,200 for township and general services. The Nangal Expansion Project has helped reduce the overstaffing problem in the old plant. Further, partly due to the restructuring of the old FCI, and partly due to retraining of some existing staff and job realignments, Nangal's current labor force (3,560) is actually less than at the time of appraisal. About a third of the present labor force is employed by the expansion project, a level comparable with similar operations in Asia.

I. Nitrogen Consumption and Supply

4.15 As shown in the table below, while nitrogen consumption and supply in India have grown since project appraisal, they have not matched the appraisal expectations:

India -- Comparison of Appraisal Estimates of Nitrogen Consumption and Supply with Actuals
(in' 000 tons of N)

	Appraisal Estimates			Actual		
	Consumption	Domestic Production	Imports	Consumption	Domestic Production	Imports
1972-73	2,300	1,370	930	1,839	1,054	665
1973-74	2,650	1,740	910	1,829	1,050	659
1074-75	2,960	2,090	870	1,766	1,186	884
1975-76	3,320	2,465	855	1,990	1,535	996
1976-77	3,720	3,230	490	2,457	1,857	750
1977-78	4,160	3,670	490	2,913	2,000	758

A basic reason for actual consumption not matching projections is believed to be the impact of the oil crisis on the prices of nitrogenous fertilizers. The decline in nitrogen consumption during 1972-73 and 1974-75 was also partially

the result of poor monsoons during those years. Consumption growth in the past three years has, however, been very strong, averaging 18% per annum compared to an average 11.7% annual growth forecast at appraisal. With regard to domestic production, while there have been substantial growth from nearly 1.1 million tons of nitrogen in 1972-73 to 2.0 million tons in 1977-78, due to delays in project completion and lower utilization capacity, growth fell short of appraisal expectations. Annual growth in domestic production over the last three years has shown substantial improvement as performance of installed capacity has improved and new and larger plants have come on stream. The annual growth in the last three years has averaged 19.3% compared to appraisal estimates of 20.9% over the same period.

J. Nangal's Fertilizer Market

4.16 Nangal's fertilizer market region comprises the northern Indian states of Punjab, Himachal Pradesh, Haryana, Rajasthan, Jammu and Kashmir, and the Delhi area. Nitrogen consumption has increased in that region by 44% during 1972/73 and 1977/78 as shown in the table below:

Consumption of Nitrogen (in '000 tons)

	1972-73		1977-78	
	Appraisal	Actual	Appraisal	Actual
Punjab	253	237	422	320
Haryana	94 /a	94	176 /a	150
Rajasthan	63	57	132	90
Jammu and Kashmir	6	10	17	10
Himachal Pradesh	4	4	13	7
Delhi area	/b	4	/b	6
	420	406	760	583

/a Including Delhi.
/b Included under Haryana.

Source: NFL

The unit's production has not been enough to meet demand in the area, and has been supplemented with supplies from other plants and imports. Due to the continuing deficit in production, Nangal is expected to be able to sell whatever it can produce even with two new plants (Bhatinda and Panipat) supplying the market area plus the State of Uttar Pradesh.

V. IDA's ROLE

A. Dialogue with Government

5.01 The preparation and appraisal of the Nangal project covered about four years and involved seven IDA missions. The FCI proposal of November 1968 for the Nangal fertilizer capacity expansion was one of the first public sector fertilizer projects to be presented to the Bank. Earlier Bank Group involvement in fertilizer projects through IFC had been limited to private sector projects. Between 1960 and 1967, the Bank had turned down three GOI requests for financing public fertilizer projects on grounds of public control, lack of foreign technical participation and unacceptable bidding procedures. It would appear that the inordinate delays during the preparation and appraisal of the Nangal Expansion Project were mainly due to unfamiliarity of the Indian project authorities with the IDA appraisal requirements, and the insistence of GOI/FCI to use maximum indigenous inputs without due consideration of experience and efficiency, on the one hand, and IDA staff's unfamiliarity, in the preparation stage, with the Indian fertilizer public sector. The unfamiliarity of both sides with each other's modus operandi, coupled with the forceful personalities, particularly on the Indian side, resulted unnecessarily in time-consuming discussions of issues some of which were not critical to the project design. The issues, positions and time taken to resolve/discuss them have been adequately documented in an evaluation of the project's preparation carried out under OED's supervision in 1974. In some respects, however, the delay in preparation with its attendant discussions, enabled IDA to assist GOI/FCI in developing projects in a more critical way, including rigorous economic analysis, and to develop a better understanding between IDA and the Indian public sector fertilizer units resulting so far in Bank/IDA participation in financing of eight large operations. IDA involvement in the Nangal project was also significant in the following areas: (a) arrangement for engineering services, (b) project scope, and (c) project implementation management.

5.02 In the early 1960s, possibly influenced by foreign exchange constraints which stood in the way of rapid fertilizer capacity build-up, the GOI decided to rely heavily on local engineering services and equipment supplies. Beginning in 1964, the Planning and Development (P&D) Division of FCI, was strengthened to build two fertilizer plants per year based on minimum foreign engineering assistance. The P&D Division acquired process licenses for various technological areas. The reluctance of several foreign engineering firms to part with technology precluded process selection based entirely on merits. The ammonia plants were engineered with process licenses from different process licensors for the gasification, purification and ammonia synthesis sections. The integration of the various know-hows acquired under license into well-organized ammonia plants appeared to have been beyond the local capabilities at that time and has been a principal cause in the slow build-up of production and low capacity utilization in the past decade. Initial attempts with two naphtha based units--Cochin I and Durgapur resulted in ammonia plants which are yet to operate at desirable levels.

B. Arrangements for Engineering Services

5.03 FCI's proposals of 1968 for the Nangal Expansion project had envisaged engineering arrangements similar to those used at Cochin and Durgapur. FCI entered into process license arrangements with Shell (the Netherlands) for fuel oil gasification, Lurgi (FRG) for Rectisol gas purification, and Tecnimont (Italy) for ammonia synthesis. P&D Division was to integrate the above know-how and engineer the full ammonia plant. In the background of the experience at Cochin and Durgapur and the even more complicated nature of the ammonia plant when fuel oil instead of naphtha is used, this arrangement would, in the view of IDA, have resulted in an inadequately engineered plant. IDA involvement ensured that the overall engineering responsibility for the ammonia plant was entrusted to a consortium (Uhde/Lurgi/Topsoe) selected after evaluation of several proposals, which had behind it experience gained in designing and building VEBA Chemie's large fuel oil based ammonia plant in the Federal Republic of Germany, a plant similar to the one proposed for Nangal, while still utilizing P&D Division's engineering capabilities for detailed engineering.

C. Project Scope

5.04 Due in part to the long period of project preparation and appraisal, the project scope underwent considerable change. In formulating the original project scope, FCI was strongly influenced by two factors: (a) their concern that in the long run naphtha prices would become substantially higher than fuel oil prices and, (b) the availability of large surpluses of oxygen from the existing facilities at Nangal. The combination of the two factors favored a fuel oil based ammonia plant based on enriched air partial oxidation. The existing plant facilities had been well maintained and been operating at rated capacities. The ammonia plant in FCI's first proposal was, therefore, sized to match the available surplus oxygen--600 tons per day. During 1971 and 1972, when the project was under appraisal, the existing Nangal plant suffered heavy losses in production due to power cuts caused by regional shortage in power. Both IDA and FCI staff realized that it would not be prudent to link the expansion plant to the surplus oxygen from the existing plant whose operating levels will be affected by power availability. The economics of basing the ammonia plant on enriched air partial oxidation as compared to a self-contained ammonia plant were also doubtful. FCI, therefore, made a revised proposal which included an independent 600 tpd ammonia plant which would have its own captive oxygen plant. At the suggestion of IDA staff, the ammonia plant capacity was further changed to 900 tpd to obtain the benefits of the economies of a larger capacity plant. The continued shortage of power and projected estimates of power supply and demand indicated that the existing facilities may continue to operate only at 60% or below of their capacities and even then their power would have to be supplied to the plant at well below its economic cost. The existing downstream facilities would also operate at well below their capabilities. IDA staff, therefore, considered that the project economics would improve if the electrolytic hydrogen-based ammonia is fully replaced with ammonia from the new partial oxidation plant enabling closing down of the uneconomic electrolytic ammonia plant, while permitting the existing downstream CAN plant to continue to operate at rated capacity. A final revision of the project scope to include 900 tpd of ammonia and 1,000 tpd of urea was suggested by IDA and accepted by FCI and GOI.

D. Project Implementation Management

5.05 Another area in which IDA made a substantial contribution was in project implementation management. The implementation arrangements in the 1960's and early '70s in the Indian public sector projects were inadequate to ensure timely and efficient completion of the projects. While the P&D Division performed the engineering and procurement services for the project, it did not report to nor was accountable to either the Project Manager or FCI's Project Director. As a result of the divided responsibility, co-ordinated project implementation was lacking. In discussions with FCI and GOI, IDA ensured that a competent FCI senior engineer was appointed Project Manager and was delegated adequate decision-making and coordinating authority (Section 2.03(b) of Project Agreement). The selection of a senior engineer from P&D further made project management more effective. In discussions with the engineering firms for ammonia and urea, P&D Division and the project group, an adequate project reporting system was developed which enabled early identification of problems and resulted in timely action.

E. Lessons Learned

5.06 One occurrence that had a major impact on the project was the oil crisis of 1973-74 which caused considerable delays in equipment procurement. By its nature, however, no applicable lessons can be derived from the experience. Outside of this, most of the applicable lessons learned in the project have been incorporated into subsequent fertilizer projects. The most important of these related to the transfer of appropriate technology. The problems encountered in the preparation of this project were largely due to the borrower's and FCI's desire for a rapid technology transfer without the necessary preparation to effect the transfer. While it is important to recognize the increasing expertise of local engineering facilities, perhaps of even greater importance, as was recognized in the preparation of this and other subsequent public sector fertilizer projects, is an adequately engineered plant based on designs and construction of proven expertise. FCI's experience with its Cochin and Durgapur plants relying on integration of various know-hows by local engineering facilities suggests that such an approach, which was originally recommended by FCI for the Nangal plant, was well avoided.

Industrial Projects Department
August, 1979

INDIA - NANGAL FERTILIZER EXPANSION PROJECT

INDIA - FERTILIZER PROJECTS FINANCED BY THE BANK GROUP

	Date of Loan/Credit	Amount of Bank Group Financing (US$ Million)	Project Capacity ('000 nutrient tons	Mechanical Completion Dates Original	Mechanical Completion Dates Current	Completion Delay (months)	Remarks
A. International Finance Corporation							
1. IEL - Kanpur Project	4/67	11.5	200 N	3/70	3/70		Operating at over 90% of capacity.
2. Zuari - Goa Project	3/69	18.9	171 N 42 P_2O_5	4/72	6/73	14	Operating at about 85% of capacity.
B. International Development Association							
1. FACT - Cochin II Project	7/71	20.0	40 N 114 P_2O_5	3/74	10/76	31	Acid plants operating satisfactorily. Complex plant being stabilized for the remaining one grade (17-17-17).
2. FCI - Gorakhpur Expansion Project	1/72	10.0	51 N	8/74	12/75	16	Commissioned and operating satisfactorily.
3. FCI - Nangal Expansion Project	2/73	58.0	152 N	8/75	7/77	23	Commissioning tests began July 77 and was commissioned Jan. 78.
4. FCI - Trombay IV Project	5/74	50.0/a	75 N 75 P_2O_5	6/77	12/78	13	Mechanically completed and commissioned.
5. FCI - Sindri Expansion Project	11/74	91.0	129 N	11/77	2/78	8	Mechanically completed and being commissioned.
6. Various Companies - Fertilizer Industry Credit	12/75	105.0	222 N 31 P_2O_5	12/78	3/80	16	Affected by delays in project preparation and approvals.
C. International Bank for Reconstruction and Development							
1. IFFCO - Phulpur Project	1/75	109.0	228 N	10/78	8/79	10	Progressing satisfactorily after initial delay of one year caused by change in feedstock.

/a Includes US$17.0 million for Plant Operation Improvement Project (POIP).

Industrial Projects Department
July 1979

ANNEX 2

INDIA - NANGAL FERTILIZER EXPANSION PROJECT

Capacity Utilization of Nitrogenous Fertilizer Plants in Operation Prior to 1978[1]

(Percent)

	Unit	Fiscal Year Ending March 31									
		71	72	73	74	75	76	77	78	79	83[2]
A.	Private Sector									Est.	Proj.
	SCI Kota	102	98	116	100	66	72	79	79	76	90
	IEL Kanpur	54	64	78	58	96	89	94	98	93	95
	Zuari Goa	-	-	-	37	79	66	72	85	88	95
	CFL Vizag	76	81	74	68	59	60	80	73	81	90
	Total Private Sector	71	76	86	61	76	74	80	86	77	93
B.	Joint Sector										
	MFL Madras	-	51	64	76	51	88	78	77	92	90
	GSFC Baroda	69	86	94	76	74	73	80	81	77	85
	SPIC Tuticorin	-	-	-	-	-	50	66	71	56	90
	MCFL Mangalore	-	-	-	-	-	-	64	60	76	90
	Total Joint Sector	69	76	81	76	64	71	69	73	73	89
C.	Cooperative Sector										
	IFFCO Kalol	-	-	-	-	17	54	74	95	108	90
D.	Public Sector										
	FCI Plants (Ave.)	71	79	78	68	67	77	79	63	65	90
	FCI Sindri	73	81	73	79	77	67	47	10	53	- /3
	Nangal	68	70	67	77	51	97	101	69	88	- /3
	Trombay	64	82	86	80	84	98	126	106	106	95
	Gorakhpur	85	95	86	80	91	72	85	64	67	90
	Namrup	64	69	80	82	91	102	104	100	88	100
	Durgapur	-	-	-	10	10	24	30	34	25	75
	Barauni	-	-	-	-	-	-	66	50	35	90
	Namrup Exp.	-	-	-	-	-	-	70	72	49	90
	FACT - Udyogamandal	47	49	38	48	46	55	52	61	62	50
	Cochin I & II	-	-	-	9	26	44	53	49	-	80
	SAIL - Rourekela	20	39	41	38	51	64	67	60	57	80
	NLC - Neyveli	46	29	30	21	24	39	61	59	54	80
	Total Public Sector	58	64	62	49	49	61	69	64	52	83
	TOTAL INDUSTRY	63	70	74	58	60	70	73	74	72	87

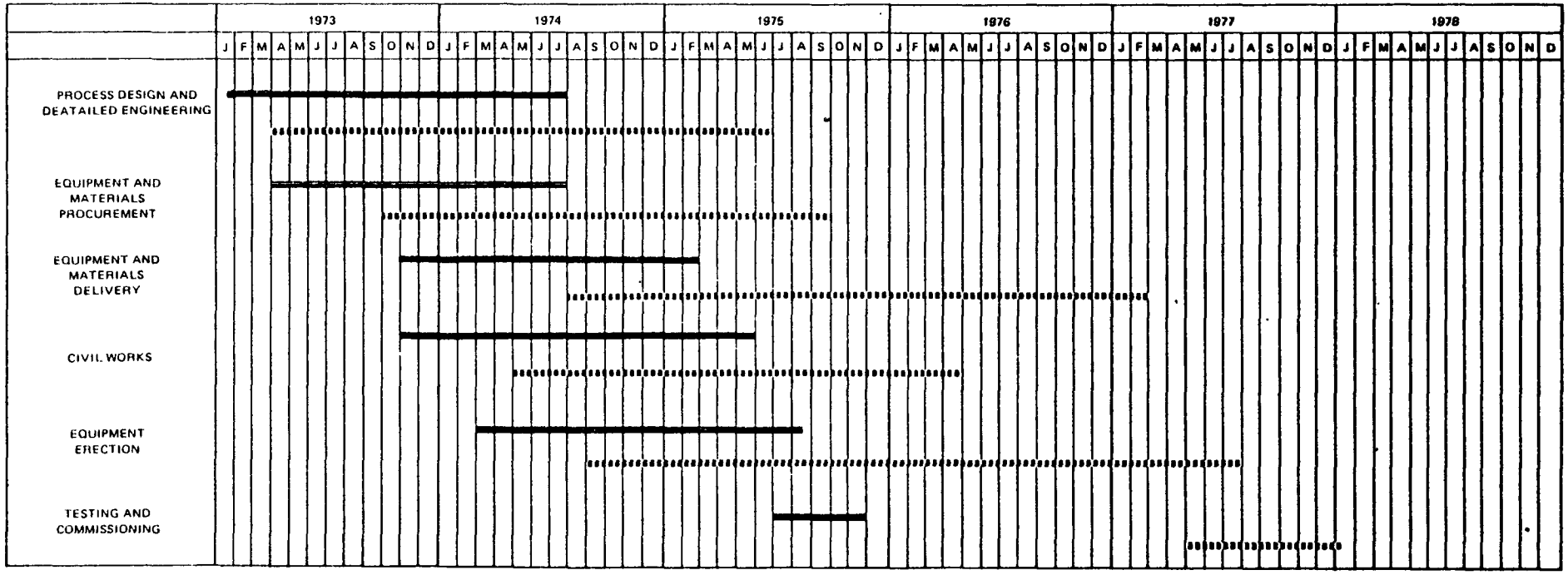
/1 Capacity utilization has been calculated based on available capacity in each year allowing for commissioning date, capacity levels of 50% and 75% in the first and second year after commissioning, and adjusting for industrial nitrogen products.

/2 Expected capacity utilization level taking into account schemes under implementation.

/3 Plants will be shut down with the commissioning of the Sindri Modernization and Nangal Expansion Projects.

Industrial Projects Department
July 1979

INDIA – NAGAL FERTILIZER EXPANSION PROJECT
PROJECT IMPLEMENTATION SCHEDULE – APPRAISAL VS ACTUAL



APPRAISAL
ACTUAL

Industrial Project Department
January 1979

World Bank – 19855

ANNEX 3

ANNEX 4

INDIA - NANGAL FERTILIZER EXPANSION PROJECT

SOURCES OF SUPPLY

Country	US$ Equivalent (in 000s)	% of Credit Amount
Germany (FRG)	24,615	42.4%
India	20,074	34.6%
Italy	4,904	8.4%
United Kingdom	2,767	4.8%
Japan	2,145	3.7%
Austria	868	1.5%
United States	743	1.3%
France	607	1.0%
Switzerland	523	0.9%
Sweden	381	0.7%
Netherlands	267	0.5%
Belgium	106	0.2%
Total	58,000	100.00% /1

/1 Rounded

DISBURSEMENTS BY CURRENCIES (in 000s)

Currency	Amount Disbursed	Rate of Exchange As of 12/31/78 (US$ Equivalent)	US$ Equivalent As of 12/31/78
U.S. Dollars	25,408	1.00	25,408
Canadian Dollars	7,580	1.186	6,391
Australian Dollars	41	1.1505	36
Belgian Francs	10	28.80	-
Danish Kroner	1,664	5.09	327
French Francs	1,410	4.18	337
Netherland Guilders	2,638	1.969	1,340
Pound Sterling	8,487	0.49	17,320
Finnish Markkaa	736	3.926	187
Australian Schillings	2,209	13.3675	165
Swedish Kroner	3,019	4.2955	703
Swiss Francs	114	1.6175	70
Norwegian Kroner	1,233	5.0225	245
Yugoslav Dinars	19	18.6112	-
Italian Lira	1,572	829.75	2
Japanese Yen	2,162	194.60	11
Kuwaiti Dinars	219	3.68	60
			52,601

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ANNEX 5

INDIA - NANGAL FERTILIZER EXPANSION PROJECT

FCI - INCOME STATEMENTS (1972-77)
(in Rs millions)

(Year ending March 31)

	1972-73	1973-74	1974-75	1975-76	1976-77
Sales Revenue (Net)	959.3	1,203.4	1,690.5	1,826.1	2,480.6
Cost of Operations					
Purchased Finished Goods	74.6	244.3	275.9	225.7	440.1
Materials Consumed	295.3	338.6	587.0	754.5	832.2
Repairs and Maintenance	73.0	74.0	109.8	148.7	198.1
Salaries, Wages & Bonus	125.6	159.8	210.6	252.5	273.5
Power and Fuel	116.5	134.7	155.1	272.1	399.8
Freight and Handling	26.8	22.1	32.5	51.3	80.0
Excise Duty	69.6	73.1	92.3	150.4	191.1
Royalties	0.6	0.6	0.9	0.8	0.5
Other Expenses (netted against other income)	(21.9)	(32.5)	33.5	143.1	43.2
Depreciation	111.6	118.7	153.4	164.1	236.0
Total Cost of Operations	871.7	1,133.4	1,651.0	2,163.2	2,694.5
Profits (Loss) on Operations	87.6	70.0	39.5	(337.1)	(213.9)
Interest (Net)	(33.5)	(24.4)	(26.7)	(50.1)	(118.6)
Net Profits (Loss)	54.1	45.6	12.8	(387.2)	(332.5)
Profits on Operations as % of Sales	9%	5.8%	2.3%	(18.4%)	(5%)
Net Profits (Loss) as % of Sales	5.6%	3.8%	1%	(21.2%)	(13.4%)

Source: FCI

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ANNEX 6

INDIA - NANGAL FERTILIZER EXPANSION PROJECT

FCI - BALANCE SHEET STATEMENTS (1972-77)
(in Rs millions)

(Year ending March 31)	1972-73	1973-74	1974-75	1975-76	1976-77
ASSETS					
Current Assets					
Raw Materials and Supplies	281.2	365.8	526.1	731.6	942.3
Accounts Receivable	70.1	97.0	133.7	154.7	248.3
Loans and Advances	58.4	70.9	116.7	151.6	152.4
Cash and Bank Balance	34.4	64.3	22.6	27.4	142.3
Sub-Total: Current Assets	444.1	598.0	799.1	1,065.3	1,485.3
Gross Fixed Assets at Beginning of Year	2,194.0	2,361.2	3,599.8	3,958.8	4,951.9
Less Accumulated Depr.	1,190.0	1,356.9	1,520.8	1,704.9	1,951.6
Net Fixed Assets	1,004.0	1,004.3	2,079.0	2,253.9	3,000.3
Work in Progress	1,943.8	2,722.1	3,096.7	4,239.9	5,390.0
Gross Fixed Assets at Year End	2,947.8	3,726.4	5,175.7	6,493.8	8,391.2
Advances to Contractors and Suppliers	623.3	738.5	789.3	1,374.8	1,483.2
TOTAL ASSETS	4,051.2	5,062.9	6,764.1	8,933.9	11,359.7
LIABILITIES					
Current Liabilities					
Accounts Payable	200.1	31.8	95.3	69.3	67.5
Trade Deposits and Deposits from Contractors	74.7	64.6	83.1	126.7	187.2
Current Portion of Long-Term Debt	166.9	217.6	254.0	269.9	435.1
Other Current Liabilities	62.3	403.8	552.5	429.9	539.5
Sub-Total: Current Liabil.	504.0	717.8	984.9	895.8	1,229.3
Long-Term Debt					
GOI	839.0	804.8	1,234.7	2,355.7	4,215.0
State Bank of India	128.0	126.4	5.9	269.2	-
USAID	77.4	59.2	36.2	14.3	-
Others	503.0	517.7	468.9	372.1	285.6
Total Long-Term Debt	1,547.4	1,488.1	1,745.7	3,011.3	4,500.6
Less: Current Portion	166.9	217.6	254.0	269.9	435.1
Long-Term Debt (Net)	1,380.5	1,270.5	1,491.7	2,741.4	4,065.5
Share Capital & Reserves					
Share Capital	1,984.1	2,906.2	4,126.4	5,287.5	6,055.8
Reserves	182.6	168.4	161.1	9.2	9.1
Sub-Total: Share Capital & Reserves	2,166.7	3,074.6	4,287.5	5,296.7	6,064.9
TOTAL LIABILITIES	4,051.2	5,062.9	6,764.1	8,933.9	11,359.7

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ANNEX 7

INDIA - NANGAL FERTILIZER EXPANSION PROJECT

NANGAL UNIT - INCOME STATEMENTS DURING PROJECT IMPLEMENTATION PERIOD (1973-78)
(Rs millions)

(Year ending March 31)	ACTUAL					
NANGAL I - Old Plant	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78
CAN. PLANT (tpy)						
Installed Capacity			318,160			
Actual Production	213,502	246,350	160,986	308,656	320,077	221,088
Production as percentage of Rated Capacity	67%	77%	51%	97%	101%	69%
	(Rs millions)					
Sales Revenue	133.74	159.74	168.17	264.35	346.66	466.21
Cost of Operations						
Purchased Finished Goods	-	3.20	19.25	-	23.85	206.23
Raw Materials Consumed	19.21	18.32	15.20	36.32	74.03	82.84
Salaries and Wages	15.30	18.28	21.96	25.16	25.01	32.68
Electricity	25.82	30.06	18.88	37.10	78.62	49.03
Freight and Handling	3.81	4.94	3.85	8.43	10.06	6.91
Excise Duty & Transfer Payments	15.11	18.12	15.41	30.25	34.61	23.67
Repairs and Maintenance	12.47	14.40	13.42	18.21	20.43	18.61
Depreciation	4.87	4.47	4.46	4.74	4.63	4.67
Central Office Expense	1.91	2.71	1.94	3.07	4.08	7.38
Interest on Short-Term Loans	-	-	-	-	-	-
Other Expenses (netted against other income)	0.24	1.62	2.70	2.09	1.70	2.87
Total Cost of Goods Sold	98.74	116.10	117.07	165.37	277.02	434.89
Profits on Operations	35.00	43.63	51.10	98.94	69.64	31.32
Interest Payable on L-T Debt	-	-	-	-	-	-
Net Profits	35.00	43.63	51.10	98.94	69.64	31.32/1

/1 Because of the transfer of Nangal from FCI to NFL, Nangal is expected to make adjustment for accrued leave and gratuity earned by its staff while part of FCI, on a cash basis, to the 1977-78 income. This adjustment is expected to result in a loss on that year's operations.

Source: Nangal Unit

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ANNEX 8

INDIA - NANGAL FERTILIZER EXPANSION PROJECT

NANGAL - BALANCE SHEETS DURING PROJECT IMPLEMENTATION PERIOD (1973-78)

(Rs/million)

Year Ending March 31	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78
ASSETS						
- Fixed Assets	336.97	346.29	412.60	735.33	1,271.17	1,434.44
- Additions during the year	9.32	66.31	322.73	535.84	163.28	229.04
- Gross Fixed Assets	346.29	412.60	735.33	1,271.17	1,434.45	1,663.48
- Less Accumulated Depreciation	260.85	264.29	268.81	274.14	279.58	285.07
- Net Fixed Assets	85.44	148.31	466.52	997.03	1,154.87	1,378.41
CURRENT ASSETS LOANS & ADVANCES						
- Current Assets:						
- Finished Goods Inventory	0.36	0.27	0.44	6.31	3.92	5.14
- Raw Material Inventory	0.31	0.38	0.57	0.34	0.25	1.70
- Spares & Loose Tools	23.24	23.16	25.04	27.60	25.03	26.01
- Accounts Receivable	5.69	4.16	6.41	21.76	24.32	25.84
- Operating Cash	0.07	0.08	1.72	13.45	1.32	0.04
- Remittances	394.32	453.43	489.26	198.82	219.15	116.47
	423.99	481.48	523.44	268.28	273.99	175.00
- Loans & Advances:						
- Advances recoverable in cash or in kind or for value to be received.	2.61	3.30	5.11	4.57	4.77	10.12
Sub-total	426.60	484.78	528.55	272.85	278.76	185.32
TOTAL ASSETS	512.04	633.09	995.07	1,269.88	1,433.63	1,563.73
SHARE CAPITAL & LIABILITIES						
- Share Capital	220.64	284.64	533.45	771.86	811.86	868.30
- Reserve Fund	238.33	280.66	331.56	430.38	487.91	0.71
Long-Term Debts						
- Secured Loan	0.34	3.24	0.01	-	6.52	-
- Unsecured Loan/Deferred Credits	5.42	-	5.86	3.66	-	576.10
Current Liabilities						
- Current Liabilities	47.31	64.55	124.19	64.84	127.26	118.62
TOTAL LIABILITIES	512.04	633.09	995.07	1,269.88	1,433.63	1,563.73

Source: Nangal Unit

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INDIA - NANGAL FERTILIZER EXPANSION PROJECT

Assumptions for Financial and Economic Analysis

	Financial	Economic
1. Exchange Rates		
January 1973	Rs. 7.26 = US$1.00	
average between 1973-78	Rs. 8.4 = US$1.00	
December, 1978	Rs. 8.6 = US$1.00	
2. Revenues per Ton		
a) urea (46% N)		
(i) current retention price	Rs. 1,741.0	Import price: cif Kandla = US$175.0
		X 8.6
		Rs 1,505.0
(ii) approximate future retention price/1	Rs. 2,250.0	plus: port handling 35
		rail freight 100
		Delivered price-Nangal Rs 1,640
		handling at Nangal 35
		ex-factory 1,675
b) CAN (26% N)		
Retention price	Rs. 869.0	Based on same unit price per ton of N as urea Rs 850.0
		plus: handling & freight 170.0
		Rs 1,020.0

/1 See calculation in Annex 10

3. Costs

c) Power

i) Electrolysis Plant

Rate up to 98 MW	Rs 58.59/MHW	
plus: generation duty	20.00	
	78.59	
plus: 25% electr. duty	14.65	
	Rs 93.24/MWH	
Rate > 98 MW	68.59/MWH	
plus: generation duty	20.00	
	88.59	
plus: 25% electr. duty	22.15	
	110.74	

ii) Expansion Plant

Rate	Rs 140.80/MWH
plus: gener. duty	20.00
	160.80
plus: 25% electr. duty	40.20
	201.00

d) Maintenance

i) Old Plant

Electrolysis Plant only Rs 20.0 million

Opportunity Cost Rs 230.0/MWH

Annual plant requirement at full capacity

149 MW
X 360 days
X 24 hrs.
1,287,360
X Rs 230

Annual opportunity cost Rs 296 million

Contracted annual power requirements

20 MW
X 360 days
X 24 hrs.
172,800
X Rs 230
Rs 39.7 million

Financial costs less 5% sales tax, less 30% duty on assumed 20% foreign content of maintenance materials

Fin. Cost	Rs 20.0 million
less: 5%	1.0 million
	19.0 million
less: 30% duty on 20% foreign content	1.14
	Rs 17.86 million

e) Raw Materials			
Feedstock - heavy fuel oil ex-refinery	Rs. 722.83/ton	ex-refinery	722.83
Sale and other taxes	45.22	freight & handling	164.00
Freight	161.00		886.83
Handling	3.00		
	Rs. 932.05		
Coal - ex-colliery	Rs. 64.80	ex-colliery	49.0[/1]
freight	92.00	freight	92.0
welfare	2.00	handling charges	4.25
handling charges	4.25		145.25
	Rs 163.05		
f) Other Expenses	Market Costs	Market Costs	
		less: sales tax (5%)	

/1 The coal used for generating steam at Nangal is of a high sulphur and ash content and is not internationally tradeable. As in the original appraisal report, the economic price is based on evaluation of inputs required to produce the additional amounts of coal at the social costs. For this purpose, 50% of the ex-colliery price is estimated to be the unskilled labor content, and therefore is priced at 50% of the nominal wage.

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ANNEX 10

Page 1 of 2

INDIA - NANGAL FERTILIZER EXPANSION PROJECT

Recalculation of Nangal's Urea Retention Price

		Rs million	
i)	Estimated net fixed assets at March 31, 1979	1,341.0	/1
	less: estimated non-urea producing assets	350.0	/2
		991.0	
ii)	add 4 months working capital employed in urea production	60.0	/1
iii)	total capital employed in urea production	1,051	
iv)	less: outstanding long-term debt associated with urea production	533.0	/3
v)	total net worth used in urea production	518.0	
vi)	28% (before tax) return on net worth used in urea production	X .28	
		145.0	
vii)	add: interest on long-term debt associated with urea production	56.0	/4
viii)	add: estimated worker's bonus	10.0	
ix)	(a) variable cost associated with urea production at 80% capacity	208.0	/5
	(b) fixed cost associated with urea production at 80% capacity	185.0	/6
x)	Sum of vi) thru ix) = fair ex-factory realization to Nangal of urea	Rs. 594.0 million	
xi)	divided by production volume of urea at 80% capacity (330,000 X .8)	264,000 tons	
xii)	Nangal's probable retention price for urea beginning April 1, 1979	Rs. 2,250 ton	
	less price until March 31, 1979	1,741.0	
	additional benefits per ton	509.0	
	additional annual benefits (Rs 509.0 X 297,000 tpy)	Rs. 151.2 million	

/1 Estimates from Nangal unit.

/2 Township, CAN plant, and one-third of project ammonia unit based on proportion of ammonia supplied to CAN plant.

/3 In consideration for the transfer of Nangal unit from FCI to NFL, GOI required NFL to issue equity shares amounting to Rs 715 million and to accept a long-term obligation of Rs 576 million payable over 10 years at 10.5% with one year's grace. NFL has transferred this debt to Nangal. The estimate above is that portion of the debt estimated to be associated with urea production.

/4 Interest on item iv) on terms indicated in Footnote 3.

/5 Based on cost of goods sold estimates for 1980 shown in Annex 9 and adjusted for 80% urea production and only two-thirds of ammonia production transferred to urea unit:

	Rs millions
Fuel Oil	24.0
Heavy Stock Fuel	121.0
Coal	36.0
Consumable Stores	5.0
Bags	22.0
Total Estimated Variable Costs	208.0

/6 Based on operating expenses estimates (fixed costs) for 1980 shown in Annex 9, but excluding interest on short-term borrowing, taxes and duties. Proportion of depreciation unrelated to urea production (26% as per ratio in net fixed assets) has also been excluded; only two-thirds of maintenace materials and salaries, respectively, were included in fixed costs (based on the ratio of ammonia production transferred into urea production).

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INDIA - NANGAL FERTILIZER EXPANSION PROJECT

NANGAL - INCOME STATEMENT FORECAST
(Rs Millions)

Fiscal Year Ending March 31	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
PRODUCTION												
Urea (tons)	123,343	229,500	297,000	297,000	297,000	297,000	297,000	297,000	297,000	297,000	297,000	297,000
As % of rated capacity	61	70	90	90	90	90	90	90	90	90	90	90
CAN (tons)	151,720	286,000	286,000	286,000	286,000	286,000	286,000	286,000	286,000	286,000	286,000	286,000
As % of rated capacity	95	90	90	90	90	90	90	90	90	90	90	90
Sales	344	643	760	760	760	760	760	760	760	760	760	760
COST OF GOODS SOLD												
Limestone and soap stone	2	4	4	4	4	4	4	4	4	4	4	4
Fuel Oil	13	27	27	27	27	27	27	27	27	27	27	27
Heavy Stock	113	157	203	203	203	203	203	203	203	203	203	203
Coal	23	36	41	41	41	41	41	41	41	41	41	41
Consumable Stores	7	11	11	11	11	11	11	11	11	11	11	11
Bags	13	37	40	40	40	40	40	40	40	40	40	40
Sub-total: Cost of Goods Sold	171	272	326	326	326	326	326	326	326	326	326	326
Gross Profit	173	371	434	434	434	434	434	434	434	434	434	434
OPERATING EXPENSES												
Power /a	57	39	39	39	39	39	39	39	39	39	39	39
Salaries, Wages & Benefits	18	39	41	43	45	47	50	52	55	57	59	62
Maintenance Materials	16	33	34	36	38	40	42	44	46	48	51	53
Selling & Admn. Expenses	2	5	5	5	5	5	5	6	6	6	7	7
Taxes and Duties	5	9	9	9	9	9	9	9	9	9	9	9
Interest on short-term Borrowings	9	17	17	17	17	17	17	17	17	17	17	17
Depreciation	63	126	126	126	126	126	126	126	126	126	126	126
Sub-total Operating Expenses	170	268	271	275	279	283	288	293	298	302	308	313
Operating Profit (-)	3	103	163	159	155	151	146	141	136	132	126	121
Interest on long-term Debts	29	52	46	41	35	29	23	17	12	6	1	-
Net Income - (-)	(26)	51	117	118	120	122	123	124	124	126	125	121

/a Power for 1978-79 includes Rs. 38 million for the electrolysis plant.

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INDIA - NANGAL FERTILIZER EXPANSION PROJECT

Re-Evaluation of the Financial Rate of Return

(in Rs millions in 1978 terms)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Benefits																	
Current Retention Price Rs. 1741/ton for Urea & Rs. 849/ton for Can	-	-	-	-	-	344	643	760	760	760	760	760	760	760	760	760	760
Additional benefits with adjustment of Urea retention price to Rs. 2250/ton	-	-	-	-	-	-	117	151	151	151	151	151	151	151	151	151	151
Total Benefits with adjusted retention price for urea		-	-	-	-	344	760	911	911	911	911	911	911	911	911	911	911
Costs																	
Fixed Investment Cost	67	246	564	115	159	11	-	-	-	-	-	-	-	-	-	-	-
Working Capital	-	-	-	-	-	15	-	-	-	-	-	-	-	-	-	-	(15)
Costs of Goods Sold	-	-	-	-	-	171	272	326	326	326	326	326	326	326	326	326	326
Other Operating Costs	-	-	-	-	-	107	142	145	149	153	157	162	167	172	176	182	187
	67	246	564	115	159	304	414	471	475	479	483	488	493	498	502	508	498
Net Benefits with Current Retention Price for Urea	(67)	(246)	(564)	(115)	(159)	40	229	289	285	281	277	272	267	262	258	252	262
Net Benefits with adjusted urea retention price	(67)	(246)	(564)	(115)	(159)	40	346	440	436	432	428	423	418	413	409	403	413

Internal Rate of Return at Appraisal: 18.1%
Internal Rate of Return with Current retention price: 12.1%
Internal rate of Return with adjusted retention price: 18.4%

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ANNEX 12

INDIA - NANGAL FERTILIZER EXPANSION PROJECT

RE-EVALUATION OF ECONOMIC RATE OF RETURN
(in Rs millions)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Production (in '000s)																	
- Urea	-	-	-	-	-	123	230	297	297	297	297	297	297	297	297	297	297
- Can	-	-	-	-	-	152	286	286	286	286	286	286	286	286	286	286	286
Benefits (in Rs. Millions)																	
- Urea	-	-	-	-	-	207	384	498	498	498	498	498	498	498	498	498	498
- Can	-	-	-	-	-	155	292	292	292	292	292	292	292	292	292	292	292
Savings from Closing Down Electrolysis Plant																	
Savings from release of 149 MW of energy	-	-	-	-	-	157	296	296	296	296	296	296	296	296	296	296	296
Savings from Avoidance of Maintenance of Electrolysis Plant	-	-	-	-	-	-	18	18	18	18	18	18	18	18	18	18	18
Total Benefits						519	990	1,104	1,104	1,104	1,104	1,104	1,104	1,104	1,104	1,104	1,104
Costs																	
Fixed Cost Investment	56	220	448	115	159	11											(15.0)
Working Capital	-	-	-	-	-	15											
Operating Costs:																	
- Feedstock - heavy fuel	-	-	-	-	-	80	149	193	193	193	193	193	193	193	193	193	193
- Coal	-	-	-	-	-	18	37	37	37	37	37	37	37	37	37	37	37
- Other Raw Material Imports	-	-	-	-	-	31	78	78	78	78	78	78	78	78	78	78	78
- Power	-	-	-	-	-	40	40	40	40	40	40	40	40	40	40	40	40
- Other Operating Expenses	-	-	-	-	-	39	82	85	88	92	96	101	105	110	114	120	124
Total Costs	56	220	448	115	159	234	386	433	436	440	444	449	454	459	463	469	457
Net Benefits	(56)	(220)	(448)	(115)	(159)	285	604	671	668	664	660	644	650	645	641	635	647

Economic Rate of Return excluding benefits from closing electrolysis plant = 11.5%
Economic Rate of Return including benefits from closing electrolysis plant = 30.8%
Appraisal estimate of economic rate of return excluding benefits from electrolysis plant = 14.6%
Appraisal estimate of economic rate of return including benefits from electrolysis plant = 22%

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