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AN EVALUATION OF THE

INDIAN FARMERS' FERTILIZER CO LTD

(IFFCO)

BY

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AND

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AUGUST 1980

MINISTRY OF OVERSEAS DEVELOPMENT
ELAND HOUSE
STAG PLACE
VICTORIA
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THE "INDIAN FARMERS' FERTILIZER CO LTD" (IFFCO) PROJECT AT KALOL/KANDLA

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LIST OF ABBREVIATIONS

BHC	British High Commission in Delhi
BHC/D	Development Section of BHC
CFI	Co-operative Farmers International
CW	Cremer and Warner
DEA	Department of Economic Affairs (GOI)
DGTD	Directorate General of Technical Development (GOI)
EIL	Engineers India Ltd
FPDIL	Fertilizer (Planning and Development) India Ltd
FACT	Fertilizers and Chemicals Travancore Ltd
GOI	Government of India
H & G	Humphreys and Glasgow
H & G (C)	Humphreys and Glasgow (Consultants) Limited Bombay
IFFCO	Indian Farmers Fertiliser Cooperative Ltd
KIL	Kellogg India Limited
MCF	Ministry of Chemicals and Fertilisers (GOI)
MWK	MW Kellogg Corporation (USA)
ODA/ODM	Overseas Development Administration (UK), formerly Ministry of Overseas Development (1964-1970 and 1974-1979)
USAID	United States Agency for International Development
ata	atmospheres pressure absolute
BTU	British thermal unit
CO_2	carbon dioxide
crore	10,000,000 - (ten million)
kg	kilogram
m^3	cubic metre
MAP	mono ammonium phosphate
DAP	diammonium phosphate
HP	high pressure
MDC	maximal daily capacity
MW	megawatt
NPK	Nitrogen - phosphate - potash fertiliser
Rs	Rupees (Indian) about Rs 18 = £1
t	metric ton - 1000 kg
yr	year
DOL	days on line per year
NPV	net present value
IRR	internal rate of return
( )	negative
1974/75 etc	All financial years refer to July-June unless stated otherwise.

PREFACE

Each year the Overseas Development Administration (ODA) commissions a number of ex-post evaluation studies with two aims in mind; firstly, to assess the effectiveness of its aid activities and secondly, to learn lessons for improving the effectiveness of future aid activities.

This evaluation is one such study.

Evaluation studies are undertaken by individuals or by teams especially recruited for their particular knowledge with regard to the subject under study. Sometimes these teams will include personnel from ODA (increasingly teams are a mix of ODA and external personnel).

In all cases the reports and conclusions are attributable to the authors, who are finally responsible for their contents, and not to ODA.

Evaluation Unit
Manpower and Evaluation Department

1. AUTHORS' PREFACE

The sources of information for this report were the Overseas Development Administration files on the IFFCO Project, supplemented by IFFCO files seen in Delhi, and Kalol in Gujarat. A valuable guiding summary was the Cremer and Warner 'Completion' Report.

We interviewed representatives of ODA, of one of the contractors (Humphreys and Glasgow), of Cremer and Warner, in London; of the Ministry of Chemicals and Fertilisers, of the British High Commission, and of IFFCO in Delhi; and other representatives of IFFCO in Kalol.

One of us (FFS) has been involved for many years in all aspects of chemical projects, both large and small. One of these was an ammonia/urea fertiliser project in India, of which he was General Manager, being responsible for design, negotiation of contracts, implementation of the project, commissioning and operation. He is responsible for the technical content of this report. The other (DCWS) is a member of the Economic Planning Staff of ODA, and is responsible for the financial and economic content.

We wish specially to thank all those in IFFCO, both in Delhi and Kalol, who gave us of their time and afforded us so much help while we were in India.

A list of those interviewed and our terms of reference are given in the Appendices.

FFS

DCWS

2. INTRODUCTION AND SUMMARY

This is a report of an ex-post evaluation study of the Indian Farmers Fertiliser Co-operative (IFFCO) fertiliser project completed in 1975 at Kalol and Kandla in Gujarat. The study is one of a series commissioned by the Overseas Development Administration (ODA) to help it assess the effectiveness of its aid activities.

Aid has played an important role in the development of the Indian fertiliser industry, usually taking the form of providing foreign exchange for the licensing of processes, for the purchase of equipment not made in India, and for the services of foreign experts and contractors.

The IFFCO fertiliser project comprises a 910 t/day ammonia plant at Kalol to serve a 1200 t/day urea fertiliser plant also at Kalol. Some 200 t/day ammonia is railed 200 miles to Kandla where with imported phosphoric acid and potash it serves to produce up to 1500 t/day nitrogen/phosphate/potash (NPK) fertilisers.

The total capital cost of the project in 1975 amounted to £52 million (sanction £49.5 million). The foreign exchange content was $19.7 million (£8.2 million) going mainly on the ammonia plant from the USA, and £6.2 million going mainly on the urea plant from the UK.

IFFCO itself was a new company set up to own this project, and with its successful implementation became the largest single fertiliser company in India, accounting for some 10% of fertiliser production. It has just completed construction of a second larger ammonia/urea complex at Phulpur in Uttar Pradesh.

In Part I of the report we follow the project from its inception to the present, summarising its financial and technical implementation, and recording its subsequent technical, financial and economic performance.

The project was successfully implemented although production of urea at Kalol was about seven months late, chiefly because of delays in delivery of two major items of UK equipment. There were however some parallel delays in completion of auxiliary plants and equipment (generally referred to as offsites) on Indian delivery.

The ammonia plant commissioned satisfactorily, and a debottlenecking programme when completed next year will bring plant capacity to 1000 t/day. The urea plant has been satisfactory apart from design faults on the main compressor. These and later problems with the machine, have brought about considerable lost output of urea amounting in all to some 50,000t or about 1½ month's output. However it was possible to take up the bulk of the released ammonia to increase the output of NPK fertiliser.

No problems were encountered in commissioning the NPK plant at Kandla, although this was delayed by four months because of lack of supplies of phosphoric acid. At the modest cost of £1 million it has proved possible to increase the nominal annual NPK capacity from 375,000 to 500,000 t. A second identical NPK stream is now being installed, bringing the nominal NPK capacity to 1 million t/year.

We compare the subsequent technical performance of the key ammonia plant with that of other ammonia plants: it emerges amongst the best for Indian plants and indeed if the less favourable technical environment of the IFFCO plant is taken into account it measures up well with the performance of North American plants. Utilisation of the Kandla plant has been exceptionally high, and the level of production has exceeded the increased nominal capacity in recent years.

The financial performance of both the Kalol and Kandla units has been highly satisfactory; good returns on capital have been recorded and the present financial situation is sound. The achieved levels of capacity utilisation have contributed to a substantial extent to these favourable results, but the GOI's pricing policy has also played a major role in determining the level of profitability. The prices of many of the inputs and outputs of the project have been fixed by the GOI, and the present prices of IFFCO's products are based on a formula which should yield an annual after-tax return of 12% on net fixed assets if the plants are operated at 80% of annual capacity. Assuming that capacity utilisation at Kalol and Kandla remains above this level, the plants should continue to produce a substantial financial surplus.

Our economic evaluation indicates that the net present value (NPV) and internal rate of return (IRR) of the overall project should turn out to be broadly similar to the results of the 1969 ODM appraisal. Our evaluation yields an IRR of about 5%, and the 1969 appraisal gives 6% when calculated on a similar basis. However we have proceeded a step further than the 1969 ODM appraisal by the preparation of separate evaluations of the Kalol and Kandla plants as independent entities.

The results of our evaluation of the Kalol plant are satisfactory. The IRR of Kalol is estimated to be just over 12% (which is currently the "cut-off" discount rate employed by the GOI Planning Commission); and the IRR rises to 17% if the evaluation is recalculated using the 1969 price assumptions for the outputs and main raw material inputs in order to remove the main impact of international price movements during the 1970s.

The results of our evaluation of the Kandla plant, on the other hand, are far less satisfactory. The plant produces no positive IRR and the NPV is -$24 million discounted at 12%; furthermore the NPV is even lower if the main 1969 price assumptions are used in place of our own. However we cannot be sure that our method of valuation of the benefits fully captures the value to the farmer of Kandla's NPK production, and this aspect of our evaluation requires further study which is outside our areas of professional competence. If the Kandla plant is to yield an IRR of 12%, the benefits would need to be 20% higher than we have estimated, leaving all our other assumptions unchanged.

In Part II of the report we discuss the project management, the choice of technology, the supply of raw materials and services, the authorities involved and their role and relationships, drawing out the positive factors which contributed to the technical success of the project. We identify these as the valuable collaboration of IFFCO with the experienced Co-operative Farmers International (CFI), which led to sound choice of proven processes and contractors; the competent leadership and good quality of the IFFCO team, the sound training of operatives and staff; and efficient management. ODA, being without appropriate technical staff for such a project, appointed an experienced external consultant (Cremer and Warner) to carry out the technical appraisal and to serve as monitor through implementation. The arrangement worked well and should serve as a useful model for other sizeable industrial projects for which UK aid is provided.

It would be unusual in a big industrial project if no weaknesses emerged. These included a long delay in signing the major contracts because of supposed problems in site organisation, serious delays in the fabrication in the UK of two major items of equipment for the urea plant, a big under-estimation of the requirement for working capital in the early stages, and failure to bring in phosphoric acid in time because of lack of a firm supply contract.

Finally we draw attention to what we believe is a changed context in India for fertiliser projects and possibly for future UK aid to such projects.

In our opinion one of the best features of the IFFCO project has been the demonstration that with initial assistance a new Indian organisation can acquire sufficient knowledge of, and confidence in, handling a big project, and go on to tackle a second project of similar size without further assistance.

Recommendations

1. A study of the economic value of NPK compounds compared to equivalent volumes of DAP and potash should be made (3.77 line 16).

2. A report on each sizeable ODA aided technical or industrial project should be written (4.58 line 2).

3. ODA should study the changed context of the Indian fertiliser industry in liaison with British contractors and licensors in order to assess the future pattern of UK aid to the industry (4.62 line 30).

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3. PART I : THE PROJECT

3.1 FOREWORD

The 'Completion Report' on the Project, prepared by Mr G H Hayward of Cremer and Warner (CW) who were consultants to the ODM (now ODA) for the Project, was written in July 1978.

It provides a clear factual account of the Project, summarises the capital costs and the sources of finance, and then concerns itself with the outline of the technical implementation, going on to give the production record up to April 1978. It does not deal with economic performance.

We have found it accurate and have drawn freely from it, sometimes to the point of reproduction, there being no point in duplicating effort.

In this first section we give an account of the Project and assess its technical and economic performance.

3.2 HISTORY OF THE PROJECT UP TO EFFECTIVE CONTRACTS IN 1971

Initiative

In the middle sixties Co-operatives were well established amongst farmers in the USA and this extended to fertiliser manufacture and marketing. In 1966 American Farmers Co-operatives approached the Government of India and put forward the idea of assisting Indian Co-operatives to set up a fertiliser project in India. The Government of India (GOI) responded by asking the United States Agency for International Development (USAID) to carry out a study.

The USAID study, completed in August 1967, recommended the establishment of an ammonia/urea/NPK complex at Kandla Port in Gujarat. A deepwater port was necessary for the import of phosphoric acid and potash for NPK manufacture, and of naphtha for ammonia manufacture. The Report put the total cost of the complex at about £50 million, financed as £15 million equity and £35 million debt.

Cabinet Encouragement

In September 1967 the Indian Cabinet approved the issue of a Letter of Intent for the Project, offering rupee participation if USAID would provide the necessary foreign exchange.

In November 1967 an organisation of Indian Co-operatives called the 'Indian Farmers Fertiliser Co-operative Limited' (IFFCO) with membership open to Agricultural Co-operatives in India was set up to implement the Project. It was to be assisted in this by a corresponding organisation of the USA Co-operatives set up at about the same time called 'Co-operative Fertilisers International' (CFI). In July 1968 an agreement between IFFCO and CFI was signed whereby CFI was to provide technical assistance to IFFCO in the implementation of the Project, made possible by a grant of $1 million from the USA Co-operatives.

Definitive Capital Estimate

In May 1968 IFFCO commissioned Chemico to prepare a Definitive Engineering and Investment Cost Report. At the same time USAID carried out a market survey.

The Engineering study indicated that the cost of the Battery Limits and Offsites Plants would be about £41 million, excluding escalation, pre-operating costs and working capital. The Marketing study concluded that there would be no difficulty in selling the Project output of urea and NPK fertilisers through the already established IFFCO member co-operatives, which were already selling some five times this quantity of fertilisers.

The production of ammonia and urea fertiliser was to be based on the use of naphtha as feedstock. However by August 1968 the Indian Oil and Natural Gas Commission had established that at Kalol near Ahmedabad, some 200 miles east of Kandla, sufficient natural gas existed to serve as feedstock for an ammonia plant of the size envisaged for the Project. Studies showed that the use of this gas as feedstock at Kalol instead of naphtha at Kandla would lead to substantial cost reductions. In the light of this IFFCO and CFI revised the Chemico study, and the present shape of the Project emerged, namely an ammonia plant (910 t/day) and a urea plant (1200 t/day) at Kalol, leaving the NPK plant (1400 t/day) to be located at Kandla. Ammonia for the NPK plant would be sent to Kandla by rail. The capital cost of the plants came down from £41 million to £36 million. In February 1969 the Indian Government formally allocated the Kalol natural gas to IFFCO.

British Aid

Initially USAID had intended to provide all the foreign exchange, but by 1968 it became clear that because of cuts in USAID appropriations this would no longer be possible, and alternative funding was sought from US banks, led by the Bank of America. By the middle of 1969 however interest rates in the USA rose to 10½% which was considered by IFFCO to be unacceptably high. As a result alternative sources of foreign exchange finance were sought. USAID was willing and able to provide $15 million (£6.3 million) as direct loan to the Project and so a request was made by the Government of India to the UK Government to meet the balance of foreign exchange by allocating £7 million from UK Overseas Aid to India.

Responding to this request the UK Ministry of Overseas Development (ODM), with the assistance of their technical consultants Cremer and Warner, undertook an appraisal of the IFFCO Project.

The ODM report was completed and submitted to their Projects Committee in December 1969. It showed that the total capital cost of the Kalol and Kandla fertiliser Project would be about £42 million, this figure including escalation, start-up costs, contingencies and working capital. The foreign exchange content would be $17 million (£7 million) mainly for the ammonia plant (USAID) and £7 million mainly for the urea plant (UK aid). Approval of the Project was given by the UK Government in January 1970, subject to certain conditions being fulfilled by IFFCO.

Tenders invited

During December 1969 and January 1970 IFFCO invited pre-qualified contractors to submit tenders for the Kalol and Kandla plants. A principle adopted for pre-qualification was the ability of the contractor to offer plants using proven processes and which were essentially duplicates of plants which had been shown to be successful in operation.

MW Kellogg was asked to tender for the ammonia plant at Kalol. This Company had built three very successful ammonia plants (910 t/day) for the American Co-operatives and had shown a successful record of repeated construction.

In the case of the NPK plant the same principle was followed and Dorr-Oliver were invited to tender. They had just completed the construction of an NPK plant for the Madras Fertiliser Company.

It was not possible to follow exactly the same principle for the urea plant, as although proven processes were offered by UK contractors (Stamicarbon by Humphreys and Glasgow, and Mitsui Toatsu by Power Gas) no plant of the desired size (1200 t/day) had been built. Competitive bids were invited from each of these contractors, and the tenders were carefully evaluated by IFFCO/CFI, who selected Humphreys and Glasgow as contractors for the (Stamicarbon) urea plant and the Kalol offsites.* Discussions then commenced between IFFCO and the chosen contractors to negotiate satisfactory contracts between the parties.

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*Offsites is the general term used for auxiliary plants and equipment.

Site organisation

CFI and USAID had definite views on the contractual arrangements they would like to see during construction, believing that of the two major contractors involved (Humphreys and Glasgow, and MW Kellogg) one should act as prime contractor, taking overall responsibility for all the plants at Kalol. Agreement could not be reached on this and finally IFFCO took on overall management and co-ordination, led by Paul Pothen, and assisted by the CFI team.

Contracts

At the time of the CDM appraisal it was expected that construction might begin in mid-1970. However the argument over site organisation led to considerable delay in placing the contracts with the result that the validity of the tenders, submitted in April/May 1970, expired. Renegotiation of these tenders, at increased prices, and the setting up of the site organisation, took until March 1971. However it proved possible to reduce the delay by three months by negotiating preliminary contracts to enable basic engineering and work on import procedures through DGTD to be started ahead of the main contracts. The ammonia plant contract became effective on 1 July 1971, the urea and Kalol offsites plants contracts on 7 July 1971 and the Kandla contracts by 31 July 1971.

3.3 THE PROJECT AS SANCTIONED IN 1971

We have seen how the Project developed into a two-site project, but we shall discuss later the reasoning which led to its particular technical shape. It may be helpful to bear in mind that the ammonia and urea plants are technically much more complex than the simpler NPK plant which is basically a mixing plant.

Kalol

At Kalol, some 20 km from Ahmedabad in Gujarat, the ammonia/urea complex was built on a greenfield site. It comprises a 910 t/day ammonia plant and a 1200 t/day urea plant, urea storage and packing facilities, ammonia storage and rail loading facilities, and supporting off-sites plants.

The ammonia plant is a single-stream gas-based plant designed by, and engineered and constructed by M W Kellogg. Natural gas is compressed, mixed with steam and reformed at very high temperatures in two stages to give ammonia synthesis gas. The second stage involves air addition thereby introducing the nitrogen. The gas is then cooled, thereby raising steam, and passed over catalysts to convert all the carbon monoxide to carbon dioxide. The carbon dioxide is then scrubbed out, and is used as raw material in the urea plant. The partly purified ammonia synthesis gas remaining is further purified, compressed to 150 ata and circulated over ammonia catalyst at 500°C to produce ammonia which by cooling is condensed out as liquid ammonia.

The urea plant is a single-stream CO_2- stripping plant designed, engineered and constructed by Humphreys and Glasgow from a Stamicarbon process package. It takes in ammonia and carbon dioxide from the ammonia plant and reacts them in a large stainless steel lined reactor at 150 ata and 200°C. Unconverted ammonia and CO_2 is stripped out of the solution by the incoming CO_2 and recycled to the reactor. Urea is crystallised out of the stripped solution, melted, and pumped to the top of a high prilling tower. A spinning bucket sprays the molten urea down the tower and the droplets solidify to spherical prills as they fall down the tower. The prills are conveyed either to the storage silo or to the weighing/bagging machines.

Ammonia is stored in a single skin atmospheric pressure 10,000 t storage tank, and urea in bulk in a 30,000 t silo. The urea bagging plant consisted of six bagging lines each rated at 22.5 t /hr. Humphreys and Glasgow had responsibility for the off-sites.

The main utilities comprise two 43 t /hr boilers raising steam at 60 ata and 405°C, water cooling towers and pumps to handle 95 million gallons/day, tube-wells to supply 5 million gallons/day raw water, and electrical equipment to take 5MW from the grid.

The main raw material and fuel requirements of the site were 165 million m^3/yr natural gas, 82 million m^3/yr associated gas, 80,000 t /yr naphtha and 53,000 t /yr fuel oil.

The expected annual output of ammonia was put at 300,000 t /yr, arrived at in the customary fashion by taking 330 stream days at design daily capacity of 910 t /day. The annual urea plant output was similarly arrived at by taking 330 stream days at design daily capacity of 1200 t /day, and was put at 396,000 t /yr requiring 230,000 t /yr ammonia thus leaving 70,000 t /yr ammonia available for transfer to NPK production at Kandla.

Comments will be made on these assumptions later in this report.

The Kalol site covered 230 acres; the IFFCO township of 280 houses and a bachelor hostel were built on a nearby site of 50 acres.

Kandla

At Kandla Port on the coast some 200 miles west of Kalol the NPK Plant and its offsites were built on a 62 acre site, together with a township of 320 houses and guest house on a site of 30 acres.

The Dorr-Oliver NPK plant takes in as raw materials imported phosphoric acid as 54% solution, imported muriate of potash in bulk, and liquid ammonia in rail tank wagons from Kalol. The process consists of mixing these ingredients, followed by granulation and drying. Several grades of NPK can be formulated, such as NPK 10/26/26, NPK 12/32/16, NPK 22/22/11 and NPK 24/24/0 and the capacity of the two plants provided depends on the proportion of the chosen grades. The most popular is 12/32/16 and

400,000 t /yr of this grade would require 60,000 t /yr ammonia, 134,000 t /yr phosphoric acid as P_2O_5, and 112,000 t /yr muriate of potash as K_2O. Small amounts of urea, filler and coating oil would also be required.

The utilities requirements were small, electric power amounting to 5MW from the grid, 3½ t /hr steam at 10 ata, and some 500,000 gallons/day raw water from tube wells. Two 1500 t ammonia pressure storage spheres were provided, two 5,000 t storage tanks for 54% phosphoric acid, and a 30,000 t NPK bulk storage silo. The NPK bagging plant has twelve lines each rated at 12 t /hr each in 50 kg bags.

Both sites were greenfield sites and IFFCO was an entirely new company. Even though CFI could provide valuable experience through some individuals, the implementation of a project of this size and complexity would be no easy task.

3.4 TECHNICAL IMPLEMENTATION 1971 - 1975

CFI/IFFCO Collaboration

The shaping of the project, its implementation and early operation, owed much to the collaboration with CFI. During the implementation stages the most senior technical management positions were filled by CFI men. The operations manager (W Brooks) responded to the IFFCO Managing Director Paul Pothen, and was responsible for all work at Kalol and Kandla. In addition there were the respective Project Managers at each site, and responding to them were six other senior CFI men. They brought with them direct experience of implementing similar projects.

However this was not to diminish the role of Paul Pothen, a man of wide engineering and project experience. In addition to his leading role he proceeded to attract to IFFCO a team of able men from the developing Indian fertiliser industry who would soon acquire their own confidence.

Ammonia Plant

At Kalol the implementation phase got off to a good start, greatly helped by the preliminary contracts which operated ahead of the main contracts. On the ammonia side lists of foreign equipment were cleared with DGTD by July 1971, most US items were ordered by August 1971 and by October 1971 all US orders had been placed, and even the ordering of spares commenced in December 1971. By February 1972 MWK engineering was substantially complete and by April 1972 such good progress had been made that MWK brought forward their completion date to December 1973 from the contractual date of 30 March 1974.

In August 1972 MWK even talked of finishing in November 1973. However by January 1973 MWK had a setback in deliveries of structural steel for the reformer. Apart from this, good material deliveries were made in spite of growing labour unrest in vendors' works and in Gujarat in general. By August 1973 however MWK announced that completion was now likely to be 1 April 1974. This date was almost held, completion being achieved on 9 May 1974, slightly disappointing after such good early progress but still very creditable for a company without experience in India.

Urea Plant

H & G also got off to a good start on the urea plant with long term items ordered by September 1971, and big items such as the urea reactor, HP vessels, and the CO_2 compressor all ordered by December 1971. However by March 1972 H & G had fallen behind schedule, but no critical milestone delays had occurred. In May 1972 and in June 1972 H & G strengthened their organisation in India and felt that they could still meet their completion date of March 1974.

In December 1972 and January 1973 serious delays emerged in the fabrication of the HP condenser and the lining of the urea reactor, partly stemming from the UK contractor's lack of experience with the specialised liner material and consequent welding difficulties. The reactor should have left maker's works in January 1973 but clearly would now be months late. In May 1973 cracks developed in the reactor body bringing further delay. However by this time the HP condenser was being satisfactorily fabricated. The completion date was now put at June 1974. In October 1973 the HP condenser left maker's works but a further setback occurred when the reactor failed its pressure test, and it was not until January 1974 that it was finally satisfactorily completed. Strikes in the works of Indian fabricators delayed urea plant piping and by February 1974 the completion date was put back further to October 1974. The achieved completion date was 15 October 1974, being seven months late. The lateness of the urea reactor completely over-shadowed the late delivery of many other items of equipment and materials from Indian vendors caught up in the wave of industrial unrest particularly in Gujarat.

Offsites

H & G were responsible also for the Kalol utilities and offsites plants, and they did this largely through H & G (C). Good progress was made on the offsites until about October 1973 and at that time it appeared that the general completion date of March 1974 would be achieved. However delays in delivery of the largely Indian equipment began to develop, particularly towards the end of the year when a state of labour unrest developed in Gujarat. Further afield unrest and strikes in vendors' works began to affect the later piping programmes. In July 1974 the ammonia plant

commissioning was held up because of lateness and the need for some remedial work on the cooling water system. However practically all utilities were available in some degree by August 1974 and any lateness of offsites was concealed by the lateness of the urea plant.

The work by IFFCO itself at Kalol namely railway tracks, natural gas lines, raw water and electricity supplies, the provision of ammonia tank wagons, and of course the housing colony were all finished in time to meet the requirements of the main plants.

Kandla

At Kandla Dorr-Oliver (India) was the main contractor for the NPK fertiliser plant, and they handled all design, engineering, procurement and construction. IFFCO themselves were responsible for site filling, railways, electricity, raw water, housing, and in addition the two 1500 t Hortonspheres for ammonia storage.

Dorr-Oliver kept to programme only until June 1972 when delays first in site piling developed, to be followed by long delays in delivery of steel plate. For some considerable time the revised completion date of February 1974 was held but in January 1974 riots severely disrupted the area. Welding gases in particular were unavailable and the completion date slipped further to March 1974. It was not until May 1974 that completion was achieved. Even so commissioning could not properly begin until July 1974 because of delay in the supply of raw water to the site. The more serious delay was with the two storage spheres for ammonia. The vendor had great trouble in fabricating the steel plate for the spheres and it was not until January 1977 that the first sphere was ready, the second following in June 1977. Meanwhile rail tank wagons were used as storage.

Mechanical Completion

We can sum up the construction phase by noting that the ammonia plant was just over a month late - 34 months against contractual 33 - a very good performance. A whole variety of delays over a range of items, large and small, effectively meant a construction time of 40 months against contractual 33 for the urea and offsites plants at Kalol, and similarly

produced a construction time of 36 months against contractual 27 for the Kandla site.

Commercial Production

The overall time for the implementation of the complete ammonia/urea complex at Kalol was 42 months from the effective date of contract to commercial production - a very creditable performance, even though late, not often bettered in India.

For the Kandla NPK complex lack of phosphoric acid for 4 months meant that commercial production took 40 months from the effective date of contract.

Commissioning

It was convenient to carry this brief history of the implementation of the Project through to mechanical completion. However it is always the aim to carry out as much pre-commissioning as possible before mechanical completion. We therefore retrace our steps somewhat to take up the story of commissioning.

In April 1974 when mechanical completion of the ammonia plant at Kalol and of the NPK plant at Kandla was in sight IFFCO put forward a wildly optimistic forecast of ammonia, urea and NPK output for the period July 1974/June 1975. Discussion of this certainly did bring out the realities of the situation up to the end of 1974 at least.

Firstly some offsites were behind schedule, such as cooling water and boilers at Kalol, ammonia storage at Kalol and Kandla, and ammonia tank wagons, all of which threatened early and sustained production. Secondly production at Kandla would be limited by lack of phosphoric acid if by nothing else. Thirdly even if early commissioning of the ammonia plant was completely successful output could only be sustained until the advent of the urea plant if it could be regularly sold.

Ammonia Plant Commissioned

Some pre-commissioning had been carried out before mechanical completion on 9 May 1974. In June hotspots were found in the auxiliary boiler

ductwork and repairs to refractories had to be made. Further progress had to await completion of and remedial work on the cooling water system and it was not until August that the reformer was lit and commissioning proper started. During August liquid hydrocarbon was found in the natural gas and separators had to be fitted by the Oil and Natural Gas Commission. During September catalyst reduction was successfully carried out and the high pressure synthesis loop tested. Hotspots were found in the reformer ductwork but temporary protection by water cooling enabled ammonia production to be achieved on 5 November 1974. Production continued until 20 November when over 8000 t had been made and put to the 10,000 t ammonia storage tank. The front end was operated to provide CO_2 for the commissioning of the urea plant until 23 November. It was then shut down to await repairs to the urea plant compressor, and meanwhile repairs to the reformer and auxiliary refractories were made.

The commissioning, although not particularly quick, was satisfactory. The test run was completed satisfactorily in March 1975.

Urea Plant Commissioned

By August 1974 pre-commissioning work was being done on the urea plant. Mechanical completion was announced on 15 October 1974. By 17 November the main CO_2 compressor was tested to 100 atmospheres but design faults in the coupling and the flywheel halted further commissioning until December.

Urea was finally produced on 31 January 1975, faults on the compressor trip system having caused several interruptions to commissioning. The ammonia plant only operated for 5 days in February because of fouling of the auxiliary boiler, but it enabled the urea plant to reach 60% capacity. In March output of urea totalled 16,700 t and in April 17,000 t, limited by continued problems in the CO_2 compressor.

A somewhat protracted commissioning - but in retrospect troubles were confined largely to one machine, the main CO_2 compressor.

Although the plant had shown its ability to operate at 100% rate, a compressor restriction operated until June 1976. Immediately after that the plant successfully passed its test run.

NPK Plant Commissioned

Mechanical completion of Train A was 3 May 1974 and of Train B 24 May 1974. However it was not possible to start commissioning until temporary ammonia storage in the form of handling from rail tank wagons became available, together with the supply of raw water, in July 1974. Preliminary trials took place in September. When sufficient phosphoric acid became available in November 1974 Train A was commissioned and made over 1200 t of 10/26/26 in four days. A successful test run was held in December 1974 on Train A. Lack of phosphoric acid prevented the commissioning of Train B until March when monoammonium phosphate (MAP) was substituted for phosphoric acid. Train B had a successful test run in March 1975.

The whole of 1975 was a poor year for NPK production. There were shortages of ammonia and urea, an interruption of six weeks because of cyclone damage to power lines, and above all extremely low demand. It was not until the second half of 1976 that the plant was able to get into its stride. The plant produced 109% of flowsheet output in November 1976.

3.5 FINANCIAL IMPLEMENTATION 1971-1975

The first capital estimate for the project in its present shape was that prepared by IFFCO/CFI in 1969. It amounted to £42 million,* including escalation, start-up costs and working capital, of which the foreign exchange element was £14 million. In late 1969 ODA was asked by GOI to provide £7 million in sterling to cover the foreign exchange costs of the urea and NPK plants and some offsites. ODA carried out its own appraisal of the project in December 1969, assisted by its technical consultant, and accepting the IFFCO/CFI capital estimate. After approval of the project by the UK Government in January 1970 little time was lost in seeking bids for the urea and NPK plants, and indeed in choosing the contractors.

However nearly a year was lost in making further progress because of the strong views of USAID and CFI on site organisation at Kalol in so far as it affected the main contractors MW Kellogg and Humphreys and Glasgow. This turned out to have been more an imagined problem than a real one but by the time it was sorted out the validity of the contracts expired, and because of recent price increases had to be renegotiated. So by the time the contracts became effective in July 1971 the project capital estimate had risen to £49.5 million (Rs 916 million), with a US dollar foreign exchange element of US $20.6 million (£8.4 million). The sterling element remained at £7 million.

It is this capital estimate, valid for July 1971, against which we compare the achieved capital cost of July 1975. We draw heavily on the CW 'Completion Report' for this comparison.

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* Although the rupee sterling exchange rate fluctuated to some extent during the early 1970s, a constant exchange rate of Rs18.5 = £1 has been assumed throughout this section.

Financial Plan

The financial plan for the capital expenditure was as follows:

		Rupees millions	£ sterling millions (rounded)
Share capital	GOI	180	9.7
	Co-operatives	90	4.9
Foreign loans	USAID (US$)	155	8.4
	UK Aid (£)	130	7.0
	Dutch Credit	5	0.3
Rupee loans	GOI	106	5.7
	Ind Dev Bank of India	100	5.4
	Life Ins Corp	100	5.4
	Ind Fin Corp of India	30	1.6
	Unit Trust India	20	1.1
		916	49.5

The Dutch credit covered the Stamicarbon licence fee.

Achieved Expenditure at July 1975

The achieved expenditure at May 1975 was £52.7 million, ie an over-run of £3.2 million (6.5%). The over-run was financed by shareholders' contribution of £0.7 million, with the Life Insurance Corporation and the Industrial Development Bank of India together putting in £2.5 million.

Only £6.2 million of the £7 million UK aid was used up, and US$19.7 million of $21 million dollar aid.

A breakdown comparison of the July 1971 control estimate and the achieved May 1975 project cost is given below:

Comparison of achieved 1975 cost with 1971 estimate

	£ million	
	Estimate 1971	Achieved 1975
Kalol site		
Ammonia plant	11.0	11.4
Urea plant	7.0	8.6
Offsites	7.0	7.3
Other costs	3.0	4.6
Contingencies	1.9	0.2
	29.9	32.0
Kandla site		
NPK Plant	3.6	3.7
Offsites	3.1	3.5
Other costs	3.8	4.3
Contingencies	0.9	-
	11.4	11.5
Project Overheads		
Pre-sanction costs	0.1	0.2
IFFCO costs & seeding programme	3.1	3.2
Interest	3.7	4.4
	6.9	7.8
Working Capital	1.4	1.4
Total	49.5	52.7

At Kalol, the over-run was 7%. Factors contributing to this were increases in import duty, some scope changes, and price inflation of equipment and materials beyond the 12 - 15% allowed for by IFFCO in the control estimate.

At Kandla the over-run was only 1%. There was some under-estimation of civil work costs, and a higher cost of special steel imported for the ammonia storage tanks.

The Project Overhead costs exceeded estimate by about 13%. This was caused mainly by the 7 months delay in the commissioning of the urea plant, caused by the lateness in delivery of the urea reactor. It is reckoned that interest charges were thereby increased by about £0.7 million. There was an under-run in the estimated costs of the seeding programme because of lack of fertiliser supplies. The prompt collection of the equity finance helped keep interest charges down.

Overall, two-thirds of the over-run is accounted for by inflation, change of scope, and reduction of the seeding programme, whilst the remaining one-third was on account of the higher interest charges incurred by the delay to the urea plant commissioning.

As inflation in the early 1970s accelerated faster than anticipated in 1971, the total over-run of only 6.5% was a most creditable performance. However, the provision of £1.4 million for working capital turned out to be grossly inadequate for the early years of operation, and an additional £4 million had to be borrowed for this purpose.

The provision of foreign exchange for the project from two sources (USAID providing dollars for the ammonia plant, and UK aid providing sterling for the urea and NPK plants) did not present any problems apart from the induced (and unnecessary) prolonged argument over site organisation. No difficulties arose in the disbursement of either foreign exchange or of rupees.

3.6 TECHNICAL PERFORMANCE 1975 TO DATE

In Appendix I the monthly output to date is presented in bar chart form with brief comments.

Here however we shall simply set out performance on an annual basis over nearly five years of operation, the years being co-operative years July/June, over the period July 1975 to March 1980.

We remind ourselves that the conventional annual capacity is expressed as 'nameplate daily capacity' x 330, and this was used in the ODM appraisal study.

For the Kalol plants these are:-

	Conventional capacity t/yr
Ammonia	910 x 330 = 300,000
Urea	1200 x 330 = 396,000

For the Kandla NPK plant the capacity depends on the product mix and the nominal figure taken was 375,000 t/yr.

Annual outputs '000 t/yr July/June

	Start up June 75	75/76	76/77	77/78	78/79	79/Mar 80	Target 79/80
Ammonia	63	185	248	263	276	190	261
Urea	56	240	312	305	347	218	310
NPK	60	162	368	517	551	376	510

The millionth t of ammonia was produced on 12 April 1979, that of urea on 25 September 1978, and that of NPK also in 1978.

It should be remembered that the urea plant can only operate when CO_2 is being produced by the ammonia plant. On the other hand the ammonia plant can operate without the urea plant provided that the minimum output of 600 t/day can be disposed of. This interaction needs to be borne in mind when discussing achieved or likely outputs.

The main plants proved to be capable of exceeding their design capacity, and debottlenecking programmes on the ammonia and NPK plants have increased

capacity still further (see below). Nevertheless we believe that even taking this into account the performances displayed above stand up well amongst those of the best-comparable Indian fertiliser plants, especially with regard to output in the early years. In Appendix II we make a more detailed comparison of the IFFCO ammonia plant performance with that of comparable Indian and also American plants, since in an ammonia/urea complex it is the ammonia plant which largely determines urea output.

A second figure of merit can be displayed, namely the number of days in the year on which the plant produces some product, a direct indication of the most important factor determining annual output.

For the years 1975 to date we show days on line/yr (DOL)

Days on line/yr

July/June	75/76	76/77	77/78	78/79	79/Mar 80
Ammonia	275	309	318	308	235
Urea	265	283	281	284	193
NPK	263	306	331	330	233

'Days on line' as defined above are recorded by IFFCO in their monthly reports: it is slightly different from 'stream days' which is a figure calculated by dividing stream hours of actual production by 24 to give equivalent days. Days on line/yr usually exceeds 'stream days/yr' by about 10.

In Appendix II we express the opinion that even when the ammonia plant debottlenecking programme is complete, bringing capacity up to 1000 t/day, the ammonia plant will need to achieve some 315 days on line a year (ie calendar days on which some ammonia is made) to reach the conventional capacity referred to in the appraisal, namely 300,000 t/yr ammonia. To achieve the conventional capacity of 396,000 t/yr urea a similar on-line performance will be required from the urea plant, even though a daily capacity of 1390 t/day has been reached. The nominal design capacity was 1200 t/day of urea.

We have discussed technical performance of the plants as a whole. However it is important to identify aspects of design or performance of individual items of equipment which have turned out to be disappointing.

Ammonia Plant

The ammonia plant has had few process troubles. There were early problems of surging of the air compressor with consequent internal damage, and hotspots on the auxiliary boiler ducts were soon overcome. A third problem arose with two failures of the insulated hot reformer exit manifold. This was traced to old technology and after modification no further trouble has occurred. In December 1976 a failure of the air compressor steam turbine occurred, bringing about a six weeks' shutdown.

Ammonia plant debottlenecking

The design daily capacity of the plant was 910 t/day. After improvements to the cooling water system it proved capable of providing 935 t/day. Recently an Air Liquide Cryogenic system for recovery of purge gas was installed which will raise ammonia capacity to about 965 t/day. The existing ID fan will later be increased in diameter and this modification, expected to be complete in 1981, will raise daily capacity to 1000 t/day. The cost of these and other modifications, together with the installation of a third boiler, will amount to about £4 million of which some £2½ million is foreign exchange, financed by the International Bank for Reconstruction and Development.

Urea Plant

There have been no process problems of any consequence with the urea plant. Some modifications were made to the urea evaporator to bring the biuret content of urea into specification. Some restriction on output occurred up to March 1976 because of problems with the urea reactor level controller.

There was an explosion in the HP scrubber caused by evolved gas being ignited during a shut-down in March 1977. Damage was caused to the internals of the scrubber and the urea plant was out of commission for two weeks.

A major problem however has been with the main CO_2 compressor.
We refer to the use of a single machine for this duty when discussing the choice of technology in Part II. When commissioning the machine the flexible coupling proved to be unable to cope with the vibration load. This was

eventually put right by changing the material and increasing the flywheel inertia. Subsequently cracks developed in cylinder blocks and compressor load had to be restricted from November 1975 until April 1976. After repairs it then operated satisfactorily until April 1979 when a fresh crop of troubles arose. Valve failures led to connecting rod seizures and a mistaken modification to avoid this led to further seizures. No urea was made in June and July 1979 because of cylinder cracks, and nearly a month was lost in November 1979.

It is now hoped that the compressor problems have been solved, but it is estimated that they were responsible for the loss of 50,000 t of urea production. In addition there would have been some imposed loss of ammonia production. However some of the ammonia released by not being consumed in urea production no doubt found financially profitable consumption in additional NPK manufacture and the net result of the lost urea production is difficult to ascertain.

Consideration is being given to purchasing another CO_2 compressor. If so we suggest that alongside any scheme there be considered the debottlenecking of the urea plant to take it up to a capacity matching the maximum amount of CO_2 which will become available from the fully debottlenecked ammonia plant. When not limited by the CO_2 compressor the urea plant has produced 39,700 t urea in a month, and 1390 t in a day.

NPK Plant Debottlenecking

Only minor technical problems have been experienced on the NPK plant. It has proved possible to bring about a major increase in capacity by relatively inexpensive debottlenecking, so increasing it to some 500,000 t/yr compared with the nominal design capacity of 375,000 t/yr, the cost of the modification being about £1 million.

A second identical plant (but no doubt incorporating the modification) is being built in Kandla, and this will bring NPK capacity to 1 million t/yr. Three additional 5000 t phosphoric acid storage tanks are being built - at present there are two 5000 t tanks. Because of shipping and port delays at Kandla this limited storage of phosphoric acid has at times restricted production.

Offsites

We have noted that off-sites were generally late in construction, but that only to a minor degree did this hold back commissioning (except at Kandla) because of the lateness of the urea plant.

This is a not uncommon failing since the importance of the offsites to a project tends curiously enough to be less appreciated than it should. We do not know whether this (and for that matter the serious delay on a crucial main plant item namely the urea reactor) could have been obviated to some extent by more comprehensive and tougher expediting. And although there is much evidence of concern and care taken in arriving at the correct choice of technology we do not know whether this extended to a searching review of the capacity and layout of the offsites. It is admitted that boiler capacity and cooling water capacity should have been bigger to provide more flexibility in operation of the main plants. We understand an additional cooling tower cell has been put in, and a third boiler is now being installed, both with some difficulty because of cramped layout.

The only major failure in offsites was that of the main power transformer in August 1975. Fortunately an identical transformer was located within days. Here again, perhaps there was too much reliance placed in having a single item.

Although far from being alone in this the IFFCO choice of having a single skin 10,000 t ammonia storage tank with no retaining tank or bund would not be shared by everyone.

3.7 ECONOMIC PERFORMANCE

Introduction

The main objective of the project was to produce nitrogenous and NPK fertilizers solely for domestic consumption. India has always been a substantial importer of both types of fertilizer and is likely to remain an importer for some years to come. The project is therefore one of "import substitution", and its economic justification should be assessed on the basis of whether the costs of production at Kalol and Kandla are lower in real resource terms than the costs of importing the fertilizer from outside. In this section we take as our starting-point the economic appraisal prepared by the ODM towards the end of 1969, and compare it with our own economic evaluation which takes account of actual performance during the 1970s and makes revised projections for the future.

1969 ODM Appraisal

Extracts from the 1969 ODM economic appraisal are reproduced in Appendix III and are summarised in the following paragraphs.

In general terms it was argued that the IFFCO project had several important advantages vis-a-vis other fertilizer projects which were under consideration in 1969. Natural gas was recognised as the most cost-effective feedstock for ammonia production, a point which has been greatly reinforced by the dramatic oil price hikes since 1973 (which have had the effect of enhancing the cost advantages of natural gas compared with other feedstocks). Emphasis was given to the expected cost advantages of selecting relatively large ammonia and urea plants (which would yield economies of scale) and of "duplicating" successful ammonia and NPK plants in the USA. On the marketing side (which is outside the scope of this report), advantages were seen in the close links between IFFCO and the co-operatives responsible for fertilizer marketing, and in the relatively wide range of fertilizers to be produced at Kalol and Kandla. Attention was also drawn to the strength of the IFFCO management. As will be evident from other sections of this report, the passage of time has confirmed the validity of these general arguments.

After establishing that the Kalol-Kandla project compared very favourably with other Indian fertilizer projects, the 1969 ODM appraisal sought to

establish the economic viability of the project in terms of its costs and benefits. The methodology employed was based on the "Manual of Industrial Project Analysis in Developing Countries" by Little and Mirrlees which was published by OECD in 1969. This methodology has since been refined and developed, and now forms the basis of the cost-benefit appraisal techniques which are used by the ODA and the Indian Planning Commission. At the time of the appraisal of the Kalol-Kandla project, the method was still new to ODM; but the main thrust of the analysis in Appendix III is considered to be sound.

The basis of the "Little and Mirrlees" technique is to value the costs and benefits in terms of international prices, to discount them at an appropriate rate of interest and then to establish whether the project has a positive or negative net present value (NPV). Drawing primarily on CFI's "Financial Analysis" dated 25 April 1969, the NPV of the project was estimated to be $4.6 million using an 8% discount rate; but our evaluation of the project has revealed a number of apparent errors which need to be corrected before the 1969 ODM appraisal result is compared with our own results. In particular there appears to have been a significant arithmetical error in the discounting process and we disagree with some of the basic assumptions underlying the valuation of the NPK production (paragraph 41 of Appendix IV). Amending the 1969 ODM appraisal to eliminate these errors yields a NPV discounted at 8% of -$13 million and a corresponding internal rate of return of 6.0%.

Economic Evaluation and 1969 ODM Appraisal Compared

Our economic evaluation is set out in detail in Appendix IV. It is based on historical data up to 1978/79 and our own forecasts for the remainder of the life of the project. On these assumptions the NPV of the overall project, discounted at 8%, is estimated to be -$15 million, and the IRR is 4.6%.

This is a similar result to that of the 1969 ODM appraisal as amended above, but the similarity in the aggregate figures conceals quite substantial differences between the estimates of some of the constituent parts which were made in the 1969 appraisal and in our evaluation. These differences can be conveniently divided into two categories: firstly,

there are what might be termed "real" differences such as higher or lower levels of production than expected at the time of the 1969 appraisal; and secondly there are differences in prices.

Among the "real" differences between the 1969 ODM appraisal and our evaluation, the largest were in respect of the level of production at Kalol which was lower than the (rather optimistic) 1969 projections; and the level of production at Kandla which has been higher than expected due to the success of the debottlenecking scheme which was implemented in 1976/77.

The reason for separating out the differences in prices from the "real" changes is that the price movements have been outside the control of the project management, and in some cases outside the control of the GOI. Consequently the impact of price movements on the project is to a large extent fortuitous. During the 1970s there were some very dramatic changes in the prices of some of the project's outputs and raw material inputs. Largely as a result of the oil price rises of 1973/74, the prices of many nitrogenous and compound fertilizers (eg urea and DAP) tripled between 1973 and 1974 and then fell back close to 1973 levels by 1976. There were also, of course, major increases in the prices of the oil-based inputs, and the price of phosphoric acid has exhibited large fluctuations. As the project did not come into commercial production until 1975, it unfortunately missed the period of peak fertilizer prices in 1974, although it is of interest to note that production would have commenced towards the end of 1973 if the project had proceeded according to the schedule envisaged at the time of ODM's 1969 appraisal.

Since these price movements could not reasonably have been foreseen in 1969, it is perhaps fairer and more realistic to compare the 1969 ODM appraisal with an evaluation adjusted to remove the impact of major price movements during the 1970s. This has been achieved by recalculating our evaluation using the prices assumed in the 1969 appraisal for the outputs and the main raw material inputs in place of our own corresponding price assumptions (but leaving all our other estimates unchanged). The result of this "recalculated" evaluation is that the NPV discounted at 8% rises marginally from -$15 to -$12 million and the IRR increases from 4.6% to 5.3%. This suggests that the price movements during the 1970s have

adversely affected the economic viability of the project but only to a small extent. However, as will be pointed out later, the price movements appear to have affected the Kalol plant adversely but have had a favourable impact on the Kandla plant.

In 1969 the Kalol and Kandla plants were treated as one project, but either unit could have been developed independently of the other with only small conceptual modifications. We therefore compiled our evaluation in a form which enables us to prepare separate cost-benefit analyses of each unit. The conclusions reached are summarised below.

Evaluation of Kalol

Our evaluation of the Kalol unit yields an IRR of just over 12%. If the outputs and raw material inputs are valued at the prices assumed in the 1969 ODM appraisal (but all other assumptions remain unchanged), the IRR rises to 17%.

As the "cut-off" discount rate which is currently employed by the GOI's Planning Commission is 12%, these results are satisfactory. If the Kalol plant had been faced with the product prices assumed in the 1969 appraisal the IRR would be well above this "cut off" rate, and the investment decision made in 1969 can therefore be confirmed as being entirely sound. However, price movements since 1969 have moved against the project; and, on the basis of the prices experienced during the 1970s and our own projections for the future, our estimated IRR is only marginally above 12%.

Since Kalol is an efficient and technically successful plant utilising an economic feedstock (ie nearby gas supplies), it is perhaps surprising that the IRR arrived at in our main evaluation is only marginally above the 12% discount rate used by the Planning Commission. Furthermore the IRRs which are being estimated for the new gas-based plants around Bombay are understood to be significantly higher, and it is therefore appropriate to investigate why the IRR for Kalol is not larger. Part of the explanation must lie in the greater efficiency and the economies of scale expected from the new plants, which will benefit from technical advances during the 1970s and which are substantially bigger than Kalol; but another reason why the IRRs of the new plants are higher is thought to be the choice of fuels. At Kalol, fuel oil is used for steam raising and naphtha is used as fuel for

the reformer, whereas the new plants will employ coal and gas respectively. It may therefore be prudent (if this has not already been done) to investigate the economics of moving over to coal-fired boilers at Kalol; and, if further gas supplies become available, replacing naphtha by gas as the reformer fuel.

As part of our evaluation of Kalol, we have subjected our main result to a variety of sensitivity analyses. The greatest uncertainty attaches to the future urea price and the prices of the petroleum-based inputs (ie gas, naphtha and fuel oil). We have valued the gas in terms of the quantity of fuel oil which has the same calorific value, and we have assumed that the price of the petroleum-based inputs will increase by 3% per annum in real terms. If energy prices increase more rapidly, it is probable that this will be reflected, at least to a substantial extent, in urea price rises. The urea price projections are based essentially on estimates of long-run prices which will provide a reasonable return to a European producer investing in a new economic sized gas-based plant. In practice the world urea price is likely to continue to exhibit fairly substantial fluctuations, but our view is that there may be larger fluctuations above our trend prices than below. If there are world shortages of urea there is no theoretical limit above which the price could rise, but in times of a world surplus the price is unlikely to fall below the short-run variable costs of production for any sustained period of time. For these reasons, and barring any sudden technological innovations in urea production, we consider our price projections for Kalol to err on the side of caution rather than being favourable to the project.

Evaluation of Kandla

Our evaluation of the Kandla unit produces a far less satisfactory result, but as will become clear we have less confidence in the accuracy of the Kandla evaluation than that for Kalol. On our calculations Kandla yields no positive IRR and the NPV is -$24 million discounted at the rate currently employed by the Planning Commission, namely 12%. If our price assumptions for the outputs and main inputs are replaced by those employed in the 1969 ODM appraisal, the NPV (again discounted at 12%) worsens to -$38 million, indicating that price movements since 1969 have been favourable to the Kandla project.

It is also clear that a closer examination of the ODM appraisal in 1969 would have reached a similar conclusion. If a rough estimate had been made of the costs of the phosphoric acid, potash, ammonia and urea and of the other production costs at Kandla, it would have been discovered that the annual net benefit stream at full production was either negative or only marginally positive, and was inadequate to cover the capital costs let alone to generate any internal rate of return.

In view of this outcome, we have organised our sensitivity analysis so as to determine by how much particular costs and benefits need to be above or below our estimates if the IRR is to be at least 12%. In this exercise we have concentrated on the costs of phosphoric acid, ammonia and urea and on the benefits, since these are the elements in the cost-benefit analysis which are both important and subject to a substantial margin of uncertainty. We have excluded variations in the potash costs since potash is both an input and an output so that a change in the potash price alters the size of the costs and benefits by almost equal amounts; and we excluded variations in non-raw material production costs and capital costs on the grounds that they are known with relative certainty and are less significant in the determination of the IRR. The results of this sensitivity analysis can be expressed as in the table below which gives the percentages by which the costs need to be reduced, or the benefits increased, if the IRR of the Kandla plant is to be at least 12%. The results are given for two periods, namely the life of the project and the years for which we have had to make projections (ie the period over which our estimates are the least reliable).

	Over life of project	Over years 1979/80-1989/90
	%	%
Phosphoric acid costs down by	33	55
Phosphoric acid, ammonia and urea costs down by	25	42
Benefits up by	20	30

Our judgement is that the costs are highly unlikely to prove to be underestimated by the percentages given in the above table (indeed it is possible that our price projections for phosphoric acid, which is the largest input, are too low rather than too high). However there are certain grounds for thinking that our valuation of the benefits may underestimate the true magnitude of the value to the economy of the NPK

produced at Kandla, although it is not possible for us to assess the extent of any such underestimation.

The difficulty which arises in the valuation of the NPK benefits is the lack of suitable "world prices" for the particular grades of fertilizer produced at Kandla. In the absence of such prices we have adopted the same approach as in the 1969 ODM appraisal, which expressed the NPK in terms of DAP and potash (for which "world prices" are fairly readily available). For the conversion to DAP and potash equivalents, we have calculated the volumes of DAP and potash which contain the same amounts of nutrients as the NPK compounds; but we are uncertain whether this method fully captures the benefits to the farmer of the NPK fertilizers. It is obviously desirable to reach a final decision on whether, and the extent by which, the economic value of the NPK compounds exceeds that of equivalent volumes of DAP and potash, but unfortunately a comparison of this kind would take us outside the scope of this study and our areas of professional competence into the fields of agronomy and fertilizer distribution. We can therefore only conclude this aspect of our evaluation by recommending that a relevant study should be made.

If, after further study, it is still concluded that the IRR of the Kandla plant is likely to be below 12%, it is appropriate to ask the question why the plant does not generate an IRR which is satisfactory to the GOI Planning Commission. At least part of the answer may be that the main raw material (phosphoric acid) is imported, and, being an acid, is relatively expensive to transport and store compared with finished fertilizers. It also raises the point whether the additional benefits derived from a granulated rather than a powdered NPK fertilizer are sufficient to offset the extra costs of granulation.

3.8 FINANCIAL PERFORMANCE 1975 TO DATE

Being a development agency, ODA is primarily concerned with the technical and economic viability of projects and their impact on the national economy of the aid recipient. ODA interest in financial viability takes second place to economic considerations, and in industrial projects such as Kalol/Kandla is usually limited to being satisfied that successful implementation and operation will not be vitiated by financial difficulties. This approach differs from that of most banking institutions, for which the capacity of the borrower to repay its debts is of paramount importance. In the case of UK aid the national Governments, and not the end-users, are responsible for servicing any loans, although the ODA often requires specific allocations of aid to be "on-lent" by the Government to the beneficiary on specific terms. However no on-lending terms were stipulated for the Kalol/Kandla project.

The 1969 ODA appraisal drew on the results of the Financial Analysis by CFI and IFFCO dated 25 April 1969 to demonstrate that the project should be financially sound. This confidence in the profitability of the project has been amply borne out by the financial results for the first few years of operation which are presented in Appendix V in the form of profitability statements and balance sheets for Kalol and Kandla separately. A summary and analysis of the results is given below.

	1974/75	1975/76	1976/77	1977/78	1978/79
Kalol					
Profit before interest and depreciation (Rs m)	2.4	148.0	207.9[1]	194.1	183.9
Interest (Rs m)	12.9	54.4	45.0[1]	35.1	37.9
Depreciation (Rs m)	17.5	45.5	46.9	48.6	49.1
Net Profit (Rs m)	(28.0)	48.1	116.0	110.4	96.9
Ratios					
Net Profit/Income (%)	(51.8)	11.0	22.3	21.1	16.4
Return on Capital[2] (%)	-	13.8	19.7	16.6	15.5
Current Ratio[3]	2.6	4.6	11.3	10.3	9.8
Debt/Equity Ratio[4]	78/22	74/26	62/38	54/46	43/57

	1974/75	1975/76	1976/77	1977/78	1978/79
Kandla					
Profit before interest and depreciation (Rs m)	12.7	2.7	164.2[1]	290.6[1]	287.0
Interest (Rs m)	7.9	18.1	20.0[1]	20.0[1]	12.7
Depreciation (Rs m)	6.5	13.6	14.4	14.8	16.0
Net Profit (Rs m)	(1.7)	(34.4)	129.8	255.8	258.3
Ratios					
Net Profit/Income(%)	(1.1)	(8.2)	15.8	21.9	20.3
Return on Capital[2] (%)	-	-	28.1	45.5	30.8
Current Ratio[3]	1.5	1.3	1.8	4.2	5.3
Debt/Equity Ratio[4]	63/37	72/28	46/54	26/74	21/79

Notes

1. Estimated.
2. Profit before interest as a % of total capital employed including long and short-term borrowings.
3. Ratio of current assets to current liabilities at end of year.
4. Ratio between long-term debt and total equity (ie share capital plus retained earnings) at end of year.

Kalol was profitable in its first full year of operation (1975/76) and has generated a good return on capital in every year since then. The high level of profitability has greatly improved the debt/equity ratio (which was probably greater than desirable at the beginning of the period), and has generated a very strong financial position which is reflected in the large current ratio. Kandla operated at a loss in 1975/76, but has since then outstripped Kalol in respect of most major financial indicators.

The financial analysis in Appendix V has been limited to the performance of the Kalol and Kandla plants as we are concerned in this report with an evaluation of these particular projects rather than of IFFCO as an institution. However it is also relevant to point out that the projects have provided IFFCO with a sound financial base on which to proceed with a third (urea) fertilizer plant at Phulpur and to double the size of the Kandla

plant. Financial projections for the whole of IFFCO's operations over the next five years indicate that consolidated net cash flow and profitability should remain satisfactory.

The good financial results of the Kalol and Kandla plants are partly attributable to their sound technical performances which have been noted earlier, but a major factor has been the domestic pricing structure. The prices of urea and NPK fertilizers have been centrally determined and/or subsidised for all or most of the period under review, and major input prices (particularly at Kalol) have also been fixed by Government or GOI agencies.

At Kalol the combination of relatively low feedstock costs and an efficient plant produced in 1976/77 the highest annual profit levels so far achieved by the unit. The small decline in profitability since then was due to the introduction of a lower ex-factory price for urea as from 1 November 1977 (Table 5.5 of Appendix V) under the "Marathe Formula". In essence this "Formula" fixes for each urea plant in India an ex-factory price which will enable the producing unit to earn an annual 12% after-tax return on net fixed assets (as specifically defined) if the unit is operated efficiently at 80% capacity utilisation on an annual basis, namely 80% of nominal daily capacity x 330. Since the IFFCO plant has generally operated above 80% of this capacity, a substantial level of profits continued to be achieved in 1977/78 and 1978/79.

The losses incurred by Kandla in 1975/76 were primarily due to the low level of domestic demand for NPK products, which in turn was largely the result of high prices. Following the emergence of lower phosphoric acid prices in world markets, IFFCO reduced its NPK prices in December 1975 (Table 5.5 of Appendix V), but sales remained low and profit margins unsatisfactory. However in March 1976 the GOI introduced a subsidy of Rs 1,250 per t of P_2O_5 which enabled IFFCO to make another substantial reduction in its NPK selling prices. Assisted by two further downward adjustments in prices in 1977, demand recovered strongly and Kandla production and sales reached high levels well in excess of the nominal capacity of the plant. Consequently the plant became highly profitable. In 1979/80 some reduction in profitability is forecast as NPK fertilizer pricing was brought under the "Marathe Formula" as from February 1979 and the subsidy on P_2O_5 has been reduced.

The GOI has intervened in the pricing of inputs and outputs of fertilizer plants with the objective of promoting the development of the indigenous fertilizer industry and ensuring the financial viability of efficient production units, while at the same time encouraging domestic fertilizer consumption. The rapid growth of the Indian fertilizer industry during the 1970s is testimony to the success of this policy in certain respects, but it is generally recognised that price intervention can carry with it certain dangers. In particular, if investment decisions are taken on the basis of financial prices which diverge significantly from economic prices (which reflect real resource costs to the economy), there is a danger that the allocation of resources might be seriously distorted. It is clear from the economic appraisal of this project that there have been considerable divergences between the financial and economic prices of the outputs and some of the inputs of the Kalol and Kandla plants, and consequently there is the possibility that the financial and economic analyses of the plants can yield different conclusions. While the Kalol project is considered to be both financially and economically profitable, it appears that there must be some doubt about the economic viability of Kandla. In financial terms, Kandla has recently been more profitable than Kalol, and this has encouraged IFFCO to double the size of the plant; but in economic terms the domestic production of NPK fertilizers from imported phosphoric acid is, as we have pointed out in the previous section of this report, open to question.

4. PART II : DISCUSSION

4.1 FOREWORD

There is no question that apart from one or two areas where initial judgement might be questioned or where equipment failure has resulted in considerable lost output, the Project was and is a considerable technical success.

In this section we try to identify the factors which have contributed to this success and note the few areas where things might have been done better. We leave on one side the economic aspects which are discussed in Section 3.7.

We have also looked at the role and activities of the various bodies and institutions involved in the quite complex task of initiating and implementing (in the broadest sense) such projects as this.

We were asked to provide guidelines for future projects of this type. Drawn from an evaluation of this project not all of them would necessarily be valid if the context in which the Project was conceived and implemented had changed. We believe that it has changed and make comment on this in section 4.6.

4.2 TECHNICAL COLLABORATION AND PROJECT MANAGEMENT

The initiative for what is now the IFFCO Kalol/Kandla Project came from the American fertiliser co-operatives who were keen to collaborate with Indian fertiliser marketing co-operatives to assist them in setting up a fertiliser manufacturing co-operative in India. They made a donation of $1 million towards such development and in 1967 set up the Co-operative Fertilisers International (CFI) to arrange appropriate technical assistance to the newly formed IFFCO, set up to implement the Project.

CFI were able to draw upon considerable experience, since included in membership of CFI were producers such as Central Farmers Co-operative who owned very successful fertiliser plants in USA producing over 4 million t/yr fertilisers, including 1 million t/yr of ammonia capacity using the recently developed M W Kellogg 910 t/day ammonia plants.

They were thus well equipped to collaborate with IFFCO and their assistance took the form mainly of supplying key experts to work with IFFCO in the task of shaping the Project, preparing tender enquiries, examining bids, drawing up contracts etc. They also were able to supervise construction, assist in selecting and training staff, and to supervise initial operation. To this end they designated an Operations Manager who would function under the IFFCO Managing Director, 2 Project Managers, and 6 other Americans in senior management positions to assist IFFCO in the implementation and early operation of the Project.

This CFI group with its experience of the new generation of ammonia plants in the USA and of NPK manufacture was to be of considerable assistance to the very competent team brought together by IFFCO, enabling them in the first place to arrive at sound decisions on the choice of processes and contractors for the IFFCO project and secondly in the implementation of the Project.

Some personal problems arose, particularly at higher levels, and some working relationships deteriorated to the point where some CFI men left the project. There had been plans to continue technical assistance well beyond the commissioning stage, but partly because of the difficulties mentioned above but more so because of the rapidly increasing management skills developed by the IFFCO staff, this proved unnecessary. By May 1975 only 8 expatriates remained and by July 1975 only 2.

After final settlement of the H & G contract at the end of 1976 IFFCO felt quite capable of proceeding without any post-completion technical service from H & G. Moreover when in 1977 IFFCO came up with their Phulpur ammonia/urea project they felt strong enough and confident enough to proceed without foreign technical collaboration of the sort typified by the early IFFCO/CFI collaboration.

3 CHOICE OF TECHNOLOGY

Ammonia process choice

The early sixties saw the first of a new generation of ammonia plants ushered in by M W Kellogg. The first was a 545 t/day single-stream plant based on natural gas and using a rotary synthesis gas compressor. Plants of 910 t/day soon followed.

One of the early 910 t/day plants was built at Donaldsonville for Central Farmers Co-operative. A second identical plant was built for them also at Donaldsonville in 1969. The two plants at Donaldsonville had performed well and it was a short step for CFI to advise IFFCO to choose an MWK 910 t/day ammonia plant identical with those at Donaldsonville. This proved a wise choice - it was at once a step into the new ammonia technology and with several similar plants already in operation this new technology could be said to be proven. A plant identical with those at Donaldsonville was ordered. Not only were Donaldsonville plant drawings used (saving some design charges) but MWK were to do not only the engineering and procurement but also construction, through their Indian subsidiary Kellogg India Limited. This ensured a high degree of identicality between the successful Donaldsonville plants and the IFFCO plant. It was true that MWK did not have experience of construction in India but in the event they carried out construction without difficulty.

Urea process choice

For the urea process the IFFCO choice was similarly sound though it was not to be an identical copy of an existing plant. The classical urea processes were the so-called total recycle processes, offered by Mitsui-Toatsu, Stamicarbon, and Snam-Progetti, having not very great differences between them, and those chiefly in materials of construction and prilling technique. Stamicarbon then introduced the CO_2-stripping process which avoided the use of high-pressure recycle pumps which were difficult to maintain. By the time the choice was to be made USAID had indicated that it would not be able to provide all the foreign exchange for the Project. It was able to provide $15 million which would be sufficient for the (American) ammonia plant. So the UK offered British Aid. Two UK contractors offered sound

urea processes. Power Gas offered the Mitsui-Toatsu total recycle process and H & G the Stamicarbon processes, and both bids were studied by IFFCO.

IFFCO, assisted by CFI, chose the Stamicarbon CO_2 stripping process, having satisfied themselves about this more modern process by visits to plants in Europe and USA. The process did eventually require two modifications, one a changed material of construction in the stripper, the other a safety modification, but these were satisfactorily introduced during construction.

There was at the time no 1200 t/day Stamicarbon single-stream stripping plant in existence and so there was extrapolation in size, a risk that was taken by IFFCO which turned out to be justified. However we do question the judgement of choosing (or accepting) a single reciprocating CO_2 compressor for this plant. Reciprocating compressors do suffer from valve failures and changing valves means an interruption. Moreover any major maintenance on such a big machine is time consuming. It would perhaps have been better even though somewhat more expensive in capital to have gone for two smaller machines. A single machine of the size chosen also represented a considerable extrapolation in size and design, and this was not entirely successful as we have seen.

Humphreys and Glasgow, the contractor offering the Stamicarbon process, had experience of operating in India through their Indian subsidiary H & G (C). It was found during construction that some strengthening of H & G (C) was necessary and this was immediately forthcoming from H & G UK.

We conclude that the IFFCO/CFI choices of appropriate ammonia and urea technology (and of the contractors to implement their choices) were sound, and these choices contributed hugely to the success of the Project. Their choices were endorsed by USAID, by ODA and by the latter's consultants, Cremer and Warner.

NPK process choice

At full output a 1200 t/day urea plant will consume about 700 t/day ammonia, and thus with an ammonia plant capacity of 910 t/day some 200 t/day ammonia would be available for NPK production at Kandla.

The NPK process chosen was that of Dorr-Oliver whose Indian subsidiary was just completing a plant using the same process for Madras Fertilisers Company. It was based on purchased phosphoric acid, with the potash purchased as muriate of potash. The process was simple, being basically one of mixing, granulating and drying, and the use of purchased phosphoric acid obviates the troubles often associated with making phosphoric acid on site from phosphate rock.

The process chosen therefore was simple, and the plant identical in size with one just built in India. The nominal design capacity was 375,000 t/yr but the plant has been debottlenecked to be capable of producing 500,000 t/yr. No serious technical problems were encountered in commissioning or operation. The plant is now being twinned, the requisite ammonia to be purchased and probably arriving by sea.

We conclude that the processes were well chosen, the two guidelines of choice being 'proven' but 'modern'.

4.4 SUPPLY OF RAW MATERIALS AND SERVICES

Gas

The discovery of natural gas near Ahmedabad was a stroke of good fortune for the Project. The use of gas as feedstock to produce synthesis gas allows a cheaper plant and one easier to operate than one using naphtha as feedstock, and local gas is cheaper than naphtha. Another advantage in this particular situation was that the ability to site the ammonia (and hence the urea) plant at Kalol rather than at Kandla reduced the transport distance of urea to most of the consumers, and of course very little cost was involved in getting feedstock to the plant.

There is sufficient gas from the small field to last until 1990; after its exhaustion natural gas will probably be taken from the Bombay High trunk gas line.

A smaller amount of associated gas is also available, of not greatly dissimilar composition. This is being used as fuel on the auxiliary boiler of the ammonia plant and a small amount is used as fuel for the reformer. The bulk of the reformer fuel is naphtha.

Dual purpose burners are being fitted to the auxiliary boiler to allow naphtha to be used as fuel if desired - there is a commitment to supply local industry with some associated gas.

At the time of sanction the gas was priced on calorific value the same as naphtha, namely Rs 3.8/million BTU. At this time fuel oil was priced at Rs 7.2/million BTU. These prices are compared below with basic prices being used by IFFCO in 1980:

	Rs/million BTU	
	1970	1980
Gas	3.8	10.3
Naphtha	3.8	16.9
Fuel Oil	7.2	23.9

Thus the domestic price being paid by IFFCO for its feedstock is now substantially less than if it were using naphtha.

Other Materials and Supplies

The other raw materials used at Kalol are naphtha and fuel oil which are obtained from the Koyali refinery some 100 miles away at Baroda. There are no problems with their supply provided that they are available. They are delivered by rail tank wagon.

The major raw materials for Kandla are phosphoric acid which is imported directly by IFFCO, and muriate of potash which is purchased from the Indian Potash Company but is usually shipped straight to Kandla. In addition ammonia and small quantities of urea are transferred from Kalol. In late 1974 and early 1975 there was an acute shortage of phosphoric acid in the international market which restricted output from the NPK plant and delayed the commissioning of Train B. The situation was relieved by the importation of mono ammonium phosphate (MAP) which was used in conjunction with phosphoric acid until February 1976. Since then supplies of raw materials have been regular, although in recent years the ammonia supplies from Kalol have been supplemented by purchases from other Indian producers in order to achieve higher levels of NPK production than was originally envisaged.

Other supplies used by both plants include spare parts, bags, chemicals and catalysts (at Kalol). No particular difficulties have been encountered in the procurement of these materials.

Power and Water

Both Kalol and Kandla are dependent on the supply of electricity from the grid. Power instabilities and power cuts have proved to be a major hindrance to the smooth running of fertilizer plants (and other industries) in many parts of India, but both of the IFFCO plants have to a large extent escaped these problems. This is mainly due to the relatively good performance of the Gujarat electricity supply organisation, but we note also that the Kalol plant was specially designed to minimise power requirements. By the use of steam drivers for the compressors for the ammonia and urea plants, the electricity demand at Kalol was brought below 5 MW. The demand at Kandla is also about 5 MW.

Raw water is obtained from tubewells on site. It has presented some problems on control of algae and bacterial growth at Kalol, but a considerable (and successful) biochemical effort has been mounted to ring the changes on algicides and bactericides to keep on top of the problem.

Employment

The numbers employed are small in relation to the cost of the plants. The total employment in the two production units in May 1980 was a little under 1,600 which represents a capital cost per employee of some £33,000 (at early 1970s prices). This is simply a reflection of the capital-intensity of fertilizer plants, but our attention was drawn to a particular opinion expressed in the UK that it should be possible to substitute labour for capital in the bagging activities. Our view is that labour-intensive bagging would not be cost-effective at either Kalol or Kandla due to the large volumes of products which must be handled.

Marketing

The project came on stream at a time of exceptionally high world fertilizer prices which were partially reflected in the domestic pricing structure. These high prices suppressed the level of demand and caused temporary marketing difficulties for NPK products from Kandla, which were exacerbated by large imports of DAP by the GOI. Subsequently successive reductions in Indian prices and the run-down of stocks of imported fertilizers resulted in a sharp recovery of demand and by 1977/78 NPK sales exceeded 500,000 t, and the Kandla plant was being operated substantially in excess of nominal capacity. The plant is, as we have seen, now being doubled in size. Meanwhile the demand for urea from the Kalol factory has been satisfactory throughout the period and in recent years has been particularly buoyant.

There has been a general shortfall of railway capacity in India for a number of years and the IFFCO project has not been exempt from these difficulties. Especially over the past few years both Kalol and Kandla have suffered from a shortage of railway wagons for their finished products. This has not generally caused production shut-downs (except

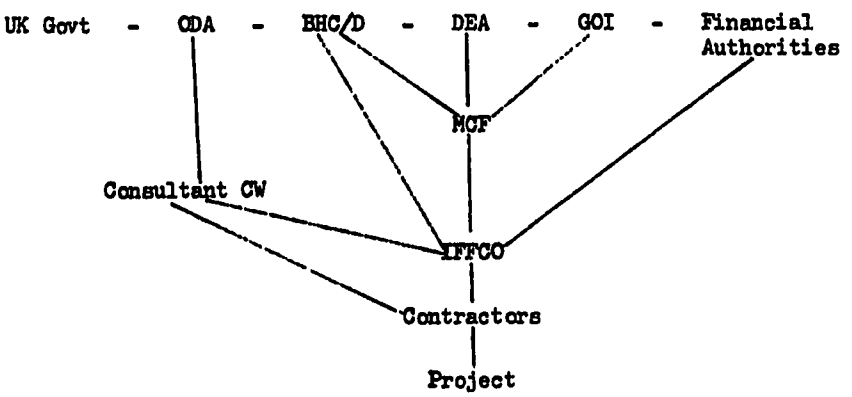
briefly at Kandla), but has resulted in certain marketing difficulties. Some of the smaller markets have not been regularly served, and open wagons have had to be used which are adequate during the dry seasons but result in spoilage during the monsoons.

Being a Co-operative IFFCO is required to serve all the State co-operatives which hold shares in the Company. Some of the States involved are at the far Southern end of the country, and in order to reduce transportation costs IFFCO pioneered two product exchange agreements with the FACT and Mangalore fertilizer companies. Under these agreements FACT and Mangalore provide urea to nearby markets on behalf of IFFCO in exchange for reciprocal arrangements which are fulfilled by Kalol. These agreements have operated well and are being recommended by the GOI to other fertilizer companies.

4.5 AUTHORITIES INVOLVED: THEIR ROLE AND RELATIONSHIPS

Overseas Development Administration (ODA)

ODA is responsible for administering UK aid, which in 1978 amounted to about £700 million, of which over £500 million was bilateral, India receiving about £100 million. In India the aid is administered by the Development Section of the British High Commission (BHC/D) in Delhi. We can set out the various authorities and bodies involved in the IFFCO project as follows:



ODA was brought into the IFFCO project after proposed partial funding by dollar loan from UK banks appeared to be too expensive. In August 1969 GOI therefore sought through the DEA - BHC/D - ODA link £7 million UK aid to be spent mainly to provide the urea plant. ODA (or ODM as it then was) responded by reviewing the work done so far on the project and concluded that the project appeared to be soundly based. It proceeded to appoint an external consultant to assist it in the work of preparing its own appraisal. In November 1969 ODA's consultant (then Gibb-Ewbank) approached British contractors, and later that month ODA participated in a joint mission with USAID, CFI, and Gibb-Ewbank and had discussions with IFFCO. By January 1970 ODA had approved the aid subject to a number of the qualifying conditions. In June 1970 CW (who had superseded Gibb-Ewbank) scrutinised the H & G and Power-Gas bids for the urea plant and Kalol off-sites plants, and ODA drew up the GOI - BHC/D agreement. In July IFFCO chose the H & G bid, and this was endorsed by CW.

In October 1970 ODA agreed to the proposal whereby IFFCO/CFI would manage the project, with H & G implementing the urea plant and offsites, and M W Kellogg implementing the ammonia plant in its own battery limits. Discussions were carried out with CW on the likely disbursement curve for the UK aid. In November 1970 an ODA representative visited India and the project management arrangements were finally agreed.

Because of the delays over this management problem the contracts outran their validity and had to be up-dated. In March 1971 ODA informed DEA that the IFFCO/H & G contracts had been initialled and that it regarded the price rises as justified.

In June 1971 the UK and US aid agreements were signed, and all the contracts were signed by the end of June.

During the construction period the project was monitored by CW who specifically drew ODA attention to matters requiring ODA assistance or support, examples being the need to strengthen the H & G organisation in India, the concern felt about the lack of firm phosphoric acid supply contracts as completion of the NPK plant approached, and a request for additional UK aid (£46,000) for fittings for wagons to move ammonia to Kandla.

In order to illustrate the role of ODA in the IFFCO project it has been necessary to take an historical approach. We believe that ODA fulfilled its function adequately and was well served by BHC/D and by CW in this task.

The British High Commission in Delhi (BHC) and Government of India

The Development Section of the British High Commission in Delhi (BHC/D) is the link between ODA and the Government of India (GOI). It responds to GOI requests for aid and it is also the channel through which the amount and nature of likely British aid is indicated to GOI. An important GOI link with BHC/D is through the Department of Economic Affairs (DEA), but BHC/D has many contacts with other Ministries, public sector organisations etc in administering the many and varied forms of aid.

It may be useful here to summarise in simple form the mechanism of the planning process of the GOI for the fertiliser sector.

The Planning Commission makes major projections of fertiliser needs using inputs from the Ministry of Agriculture. This of course may have to be subject to some constraint by the overall plan.

These projections are taken over by Sector Planning, in this case the Working Group on fertilisers. At this point the Ministry of Chemicals and Fertilisers (MCF) provides its input, namely the projections of fertiliser production expected from installed capacity, or capacity being installed, if the projection span warrants. It also works out the corresponding feedstock requirements for this production. In the light of the Planning Commission's projected future demands the MCF will put forward its proposals for new capacity.

The Working Group produces projections such as N consumption trends, production capacity, feedstock requirements and policy, schemes under consideration, additional capacity to be planned, capital requirements etc. In addition it feeds back to the Planning Commission data on infrastructure, manpower, requirements of working capital, yearly investment etc.

In this way new plant capacity is identified, and its phasing, capital costs, and foreign exchange requirements determined. These data go out to the DEA which examines the availability of funds by dialogue with the World Bank, other aid authorities, and Governments offering aid.

When foreign exchange funding is identified the MCF becomes the instrument to direct such funds into identified projects and becomes ultimately (after due appraisal and approval) the sanctioning body for a project through its approval of draft construction and supply contracts between owners and contractors.

If ODA has offered aid to say a fertiliser project it makes its own appraisal and also imposes conditions before approval, some of which may involve GOI. As the link between ODA and GOI, BHC/D makes an important contribution to this phase.

When a fertiliser project of the size and shape of the IFFCO project under review gets under way the question of monitoring arises. Technical and financial monitoring is crucially necessary to identify and deal with delays in implementation, or over-run in expenditure, which if not tackled can seriously jeopardise the success of the project. This of course is primarily the concern of the owner but is far from being of little concern to the authorities providing finance in general, or aid in particular such as ODA.

The owner, or his contractor, is likely to carry out fairly sophisticated technical monitoring (which in this context includes monitoring of the financial plan for the project) and if confidence can be reposed in the reporting of this, can serve the other interested parties. This is usually the situation in big projects such as the IFFCO project. It may not be the case in smaller or more diffuse projects.

BHC/D has an obvious interest in monitoring projects, and indeed has a responsibility to ODA in this respect, as being closer to the project in space and in time.

At present, apart from non-technical monitoring (which for many projects is perfectly satisfactory) and monitoring of civil engineering projects, it and ODA must rely on owner-, or contractor-monitoring, unless as in the IFFCO project under review, an external technical consultant was employed not only to assist in appraisal but to carry out technical monitoring of the implementation of the project on behalf of ODA. The performance of this consultant in respect of the IFFCO project is briefly discussed below, but the desirability of technical assistance and technical monitoring is of general validity for projects with appreciable technical content.

It does not matter who does the monitoring so long as he functions efficiently enough to satisfy the needs of the bodies concerned, and is accepted by them. In some circumstances where other aid donors are involved joint donor monitoring may be arranged. If this is not possible then it would seem desirable to appoint to all ODA-aided projects of high technical content an external consultant able to provide continuity of technical monitoring, the value of which we think was demonstrated by the example of Cremer and Warner in the IFFCO project.

IFFCO

We were impressed by the IFFCO people we met, and this impression was by no means confined to their most senior people. We were also struck by the thoroughness of their appraisal of the Project from the earliest stages as evidenced for example by the series of Financial Appraisal Papers. No doubt at this stage good advice was given by CFI but the necessary work put in by IFFCO is impressive.

If we had a criticism of these early stages it would be on the delay of several months which were lost as a result of the argument (chiefly put forward by USAID and CFI) on site organisation. Whilst agreeing that a single authority was essential during implementation, the solution, namely to have the owner carrying out this role, was too long in being propounded. In the event IFFCO performed this role (assisted by CFI) with credit, which opinion one would temper only by wondering whether more pressure could have been exerted on the broader areas of expediting delivery of materials and equipment, in addition to that exerted on main plant items.

IFFCO said that there were no real difficulties on site during construction, apart from those caused by delays, and co-ordination procedures worked satisfactorily. They were satisfied with the performance of the main contractors.

IFFCO was conscious of some of its advantages at the time of the Project. It was a young organisation, with good leadership, with the senior team very competent and highly committed, and experiencing a great deal of professional satisfaction with its work. They developed good relations with all levels of staff which is possibly slightly earier in Gujarat than in some other parts of India.

One of the best features of the IFFCO project has been the demonstration that with initial assistance a new organisation can acquire sufficient knowledge of, and confidence in, handling a big project, and that it was very quickly capable of going on to tackle a second project of similar size within two or three years of completing the first, providing from its own resources the necessary people. Indeed IFFCO have gone further and are now into a third and even bigger fertiliser project, as big as any being undertaken anywhere. Of course this has become possible also

because of the recent growth and development of the Indian chemical process industry. This is discussed later in this report.

We were also impressed by their attitude to training. Thorough active (in contrast to passive) training is essential in setting up fertiliser manufacturing projects. IFFCO are quite clear about this and this is demonstrated by the training at Kalol for the Phulphur project. For example young graduate engineers are receiving 1½ years training at Kalol before going on to Phulpur, and Phulpur junior operatives receive a year's training at Kalol first.

We thought that housekeeping at Kalol although generally good, could be even better. However the wearing of helmets was somewhat patchy, as was the use of goggles for certain operations and areas. Similarly the marking of escape-gas-mask areas left something to be desired. There was not time to examine safety records, but the monthly reports seen at Kalol showed detailed examination of even minor accidents.

The housing colony at Kalol was particularly pleasant.

Consultants

Although two technical consultant groups were involved in the IFFCO project (Gibb Ewbank for a very short time, followed by Cremer and Warner) in reality the work was done by one man who moved from Gibb Ewbank to Cremer and Warner when the latter group was appointed. He was supported occasionally by a senior partner of Cremer and Warner (CW). There was thus a fortuitious continuity which we feel was a great value.

The consultant group was appointed by ODM in November 1969 and made the first approaches to UK contractors, shortly afterwards taking part in a combined project mission to India. Although no doubt some internal ODM technical assistance could have been organised it was unlikely to be able to match in suitability that which could be provided by a competent commercial specialist group. In any case it probably would not have been likely to provide continuity throughout the planning, implementation and early operation of the project, a point to which we attach importance. We believe it was a sound decision to appoint the consultant.

His main immediate task was to assist ODM in the appraisal of the Project to enable them to make their recommendation to the Minister of Overseas Development about granting UK aid. This involved reviewing the various feasibility studies that had been made, and the technical assumptions behind them.

The second task was to examine the competitive bids for the urea plant put forward by Humphreys and Glasgow and by Power Gas, and make comment to ODM. After H & G had been selected the draft contracts had to be examined and amended where necessary.

When construction started CW entered into its monitoring role, receiving monthly construction and financial reports, commenting when necessary to ODM or BHC/D, and at times actively assisting in expediting work being carried out in UK, particularly the urea reactor and HP exchanger which ran into fabrication difficulties. They made six-monthly visits to site and had progress discussions with IFFCO, H & G, ODM and BHC/D as necessary. In addition to warning ODM of delays CW also made a contribution in bringing about resolution of problems which occasionally developed between IFFCO and the contractors. CW for example at one stage successfully recommended the strengthening of the H & G organisation in India.

A particularly important warning was sounded by CW in 1974 when it was found that phosphoric acid supplies were unlikely to be available in the quantities required, and that it looked as if plant modification would be necessary to enable monammonium phosphate to be used instead. Strong recommendations were made about the need for firm long term contracts in place of separately negotiated shipments.

Appraisal and monitoring are essential tasks, and in the absence of in-house staff of the particular experience for this work, the use of professionals is the only way of providing the necessary skills and continuity. The cost, relative to the cost of the project, or even to the amount of UK aid involved, is extremely small.

CW also produced a 'Completion Report'. This was a fairly detailed document dealing with the implementation and operation of the Project. It did not deal with the economic and financial performance.

We understand that the World Bank prepares a detailed report on and evaluation of every project it finances. We think that a report on each sizeable ODA aided technical or industrial project should be written. It need not be quite so detailed as the CW 'Completion Report' on the IFFCO project, but must be sufficiently so to give a clear account of how it was implemented, how it turned out, and perhaps by later addition or review, how it performed. Again by comparison with the amount of aid involved, its cost would really be quite small. It could conveniently be prepared by the technical consultant to the project who also would have monitored it. An economic addition to it and to any later review could be provided by appropriate ODA staff.

A summing up

In this discussion, we have made observations on various aspects of the project, and on the activities and role of the various bodies and authorities involved. We conclude with a brief summing-up of the main features which in our opinion contributed to the success of the IFFCO Project:

1. IFFCO's valuable collaboration with the experienced CFI.
2. Good leadership of a good and dedicated IFFCO team.
3. Careful IFFCO/CFI appraisal leading to sound choice of processes and contractors.
4. Sound training of staff and operators.
5. Efficient and continued good management.

A most important feature of the Project as a whole was the experience and confidence so rapidly gained by IFFCO, sufficient, as noted above, to enable them to proceed to a second (and even a third) project without the need for further collaboration of the IFFCO/CFI type, and to do very much more of the project management themselves.

On the other side of the balance sheet however there were some weak features, mainly in the implementation. For example there were the very serious delays in fabricating the urea reactor and the HP condenser, the

extremely late delivery of the reactor making the urea plant seven months' late. Without investigation it is not possible to do more than pose a question. To what extent was detailed investigation made into the manufacturers' equipment and experience needed for the fabrication of such big and complex items?

Moreover some of the off-sites were just as late, and indeed later, and we doubt whether all this could be put down to the labour difficulties besetting the Indian suppliers and fabricators. Should there have been tougher expediting? Were the suppliers' other work loads sufficiently examined before accepting either their offered delivery dates or their agreement with the requested delivery dates? Such questions cannot be answered so long after the events, but should be borne in mind in future projects.

. A third weak feature was the very big underestimation of working capital (Rs 2½ crores estimated, Rs 10 crores required) which necessitated additional bank borrowings and temporary transfer of Phulpur funds.

Finally it should be noted that failure to negotiate firm supply contracts for phosphoric acid delayed the start-up of the NPK plant, even though a sight of such firm contracts was a condition of granting aid. Over the period 1970-71 ODA staff gave out several reminders about this. IFFCO apparently had a draft contract but it was never signed because of difficulties over a wider inclusive Indo-Iranian agreement which the two governments failed to achieve. Both ODA and IFFCO should have presented their justified concern to GOI with even more determination.

6 THE CHANGED CONTEXT IN INDIA

It is some ten years since the IFFCO plant was conceived. We believe that the context in which that plant was implemented has changed, and any lessons that might be drawn from that experience must be considered in the new context.

We can distinguish three phases of the Indian fertiliser industry in that time. The first phase saw the introduction of naphtha-based ammonia plants of size 600 t/day to 1000 t/day and mainly serving urea plants (Visak, Kanpur, Kota, Goa, Madras). Apart from Kanpur these were plants of the modern single stream rotary compressor type. They were built by a variety of contractors, H & G, Power Gas, Chemico, Kellogg, Chiyoda etc. On the urea side Mitsui-Toatsu were prominently represented, and in addition there were Chemico and Stamicarbon. The pattern usually was one of the foreign contractor offering a turn-key contract, doing the design, engineering, procurement and construction. Construction was often handled through an Indian subsidiary of the main contractor.

The next phase came in when concern was expressed about the increasing dependence on naphtha, even though the refining pattern in India, together with the relatively low demand for petrol, made relatively more naphtha available. At that time heavy sulphur fuel oil was half the price of naphtha, partly brought about by its cheapness on the world market through reduced demand stemming from environmental considerations. And so a crop of plants appeared (Haldia, Nangal, Sindri, Patinda, Panipat) using the Shell and Texaco processes. Again foreign design, engineering and procurement packages were frequent. There was perhaps a little more Indian engineering participation during this phase.

Apart from World Bank aid which is untied, national aid meant for the contractor/licensor that trade followed the flag. Some countries were more 'successful' than others in this depending on how complete a package could be offered. The UK for example could not offer big rotary compressors or some of the bigger reactor vessels as plants grew larger.

It looked at one point as if a number of coal-based plants would emerge as a third stage, but in the event only two have been built and have not yet been fully commissioned.

We define the third stage as that now emerging. The discovery of offshore oil and gas now makes it possible to base the current expansion of the fertiliser industry on gas-based plants, and the situation appears to be that some ten plants are envisaged between now and 1990, all gas-based and of capacity 1350 t/day ammonia, serving 1100 t/day or 1500 t/day urea plants. IFFCO has set up a company to build two 1350 t/day ammonia plants serving four 1100 t/day urea plants on one site at Hazira, and Rashtrya Chemicals and Fertilizers are setting up two 1350 t/day ammonia plants serving three 1500 t/day urea plants at Thal. The remaining six 1350 t/day ammonia plants have not yet been allocated. Gas for these plants will be supplied from a centralised gas-gathering and distribution scheme.

The pattern of implementing these schemes differs from that of the earlier plants. The Indian chemical process industry has developed rapidly in the last few years. It can now offer much more equipment built in India under collaboration with foreign manufacturers, for example Pignone compressors built by BHPV. Indian companies (EIL, FPDIL, Development Consultants etc), now offer design engineering, procurement, and management services. The old pattern of relying on foreign contractors' packages has given way to much more independent Indian management of projects, with Indian companies increasingly doing the engineering design, and managing construction. Foreign licensors and contractors will still be involved but the content of future contracts will change. These new fertiliser projects are massive and will present a very big challenge to the developing Indian process industries and management resources, particularly when one contemplates the intended momentum of this new phase in the expansion of the Indian fertiliser industry. These projects are also very costly, the Hazira and Thal schemes running into several hundred million pounds. We think that this alone may bring about changes in the required pattern of international aid to the Indian fertiliser industry. We think that the ODA should study the situation along with British contractors and licensors, possibly seeking the views of authorities and individuals in India, in order to assess realistically what might be the future pattern of UK aid to the Indian fertiliser industry, and the opportunities for UK participation, in the best interests of both parties.

THE 'INDIAN FARMERS' FERTILIZER CO LTD' (IFFCO)

PROJECT AT KALOL/KANDLA

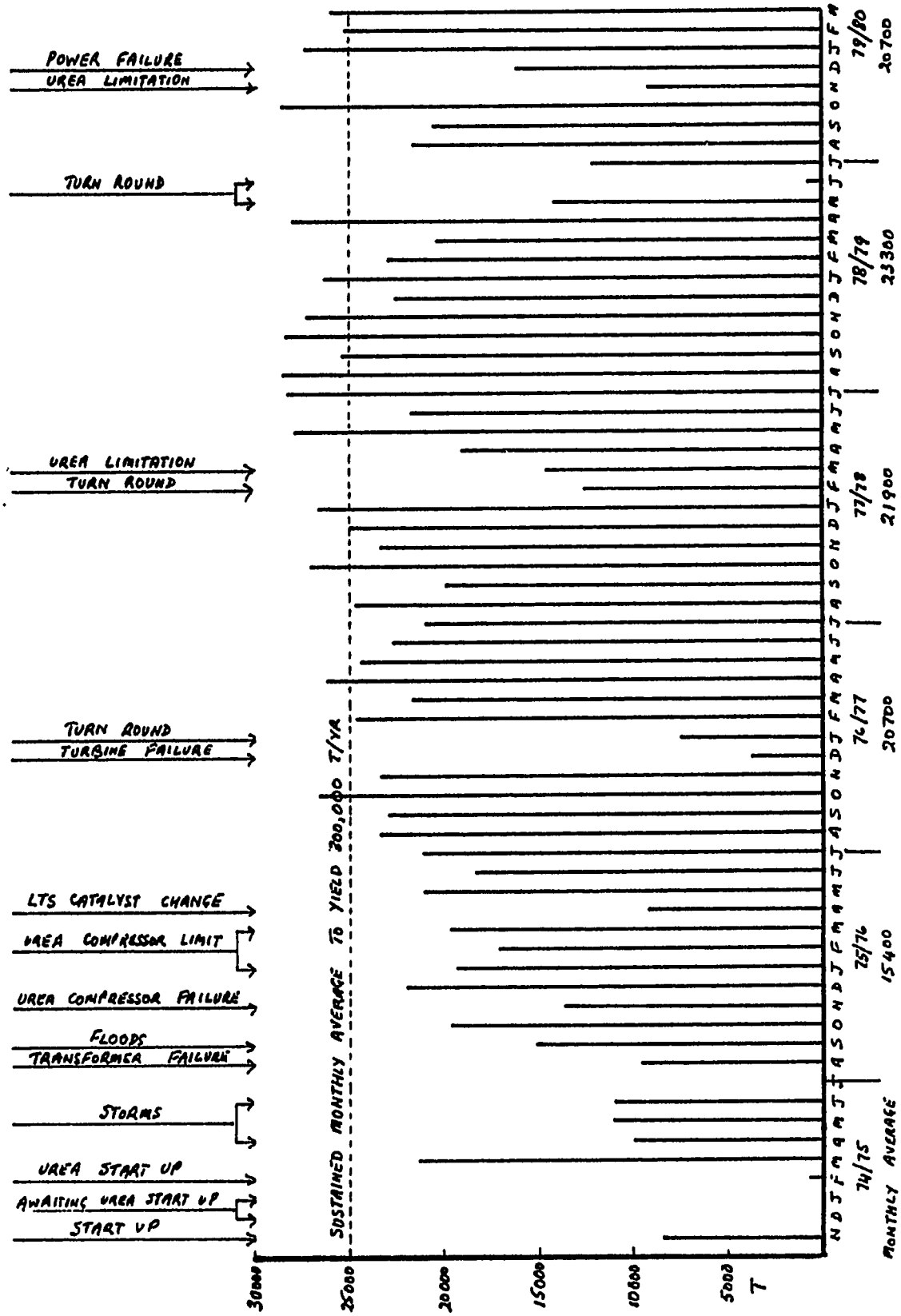
AN EX-POST EVALUATION

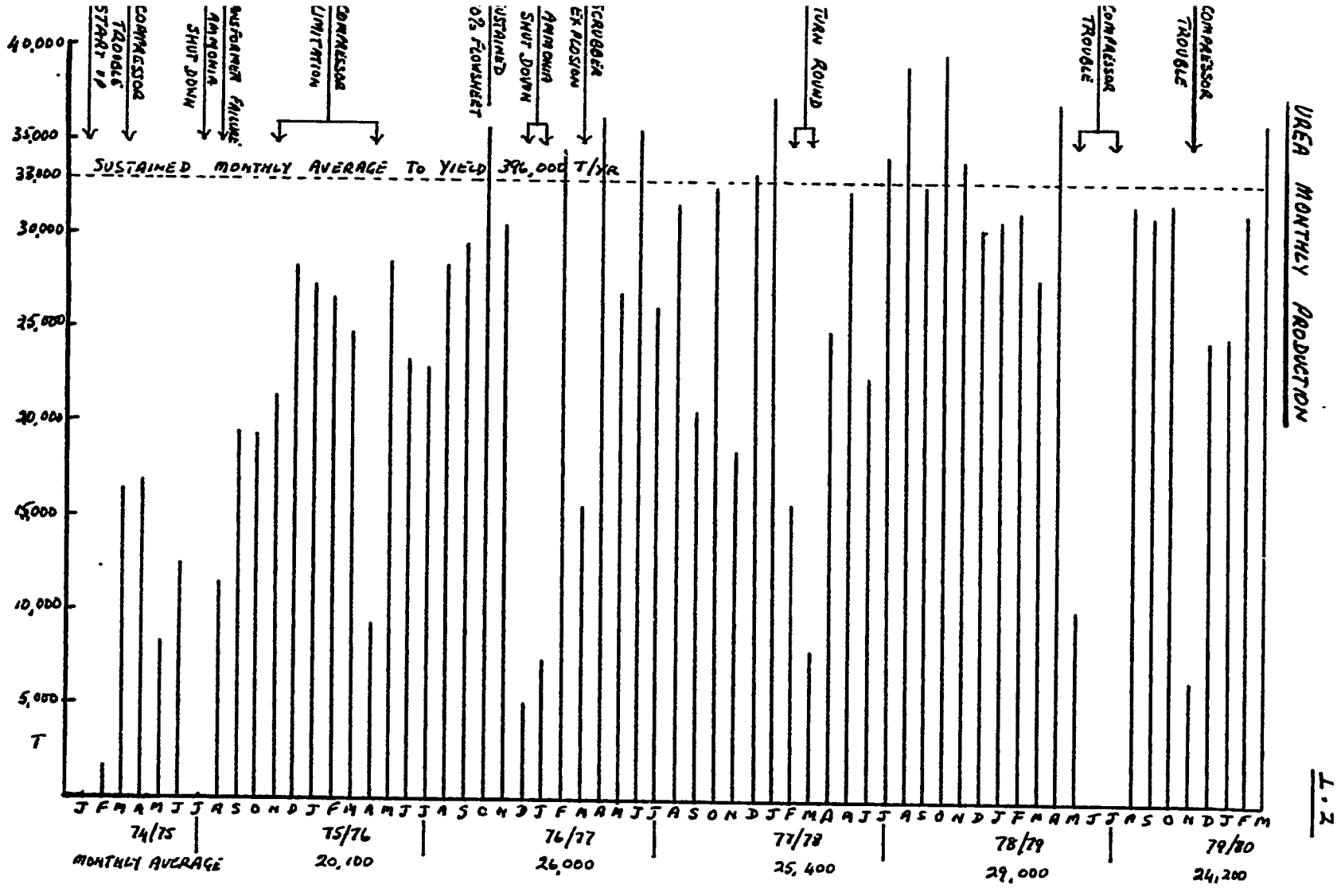
APPENDICES

APPENDIX I

MONTHLY PRODUCTION DATA

AMMONIA MONTHLY PRODUCTION

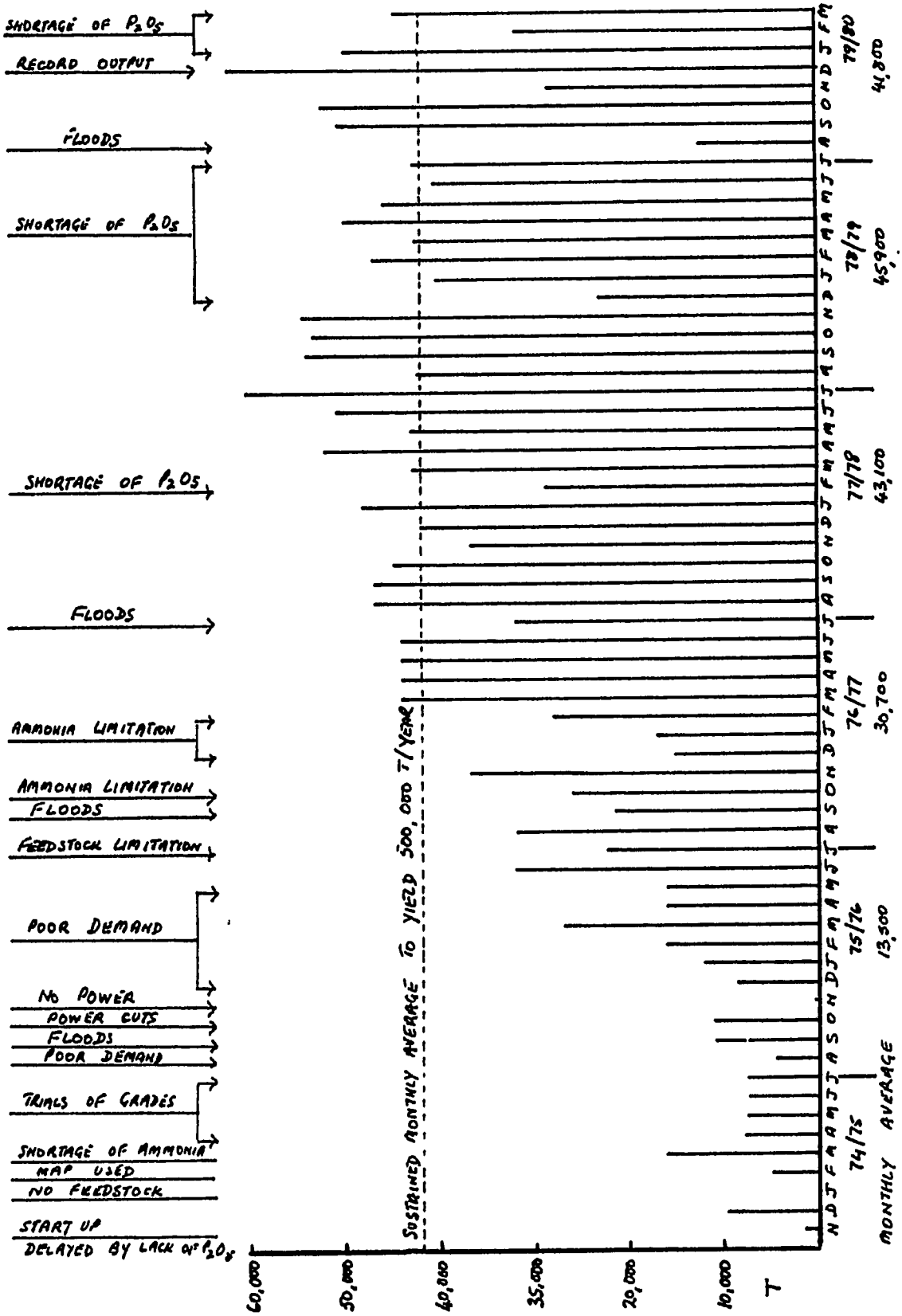



UREA MONTHLY PRODUCTION
40,000
35,000
33,800
30,000
25,000
20,000
15,000
10,000
5,000
T
SUSTAINED MONTHLY AVERAGE TO YIELD 396,000 T/YR
START UP
COMPRESSOR TROUBLE
SHUT DOWN
AMMONIA
WEIGHMETER FAILURE
COMPRESSOR LIMITATION
SUSTAINED O2 FLOWSHEET
AMMONIA SHUT DOWN
SCRUBBER EXPLOSION
TURN ROUND
COMPRESSOR TROUBLE
COMPRESSOR TROUBLE
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M
74/75
MONTHLY AVERAGE
75/76
20,100
76/77
26,000
77/78
25,400
78/79
29,000
79/80
24,200

1.2

NPK MONTHLY PRODUCTION

I.3



APPENDIX II : COMPARATIVE PERFORMANCE OF IFFCO WITH OTHERS

In any nitrogenous fertiliser complex the performance of the ammonia plant is crucial. It is the most sophisticated plant in the complex and it will usually be the case that the output of the fertiliser produced will be determined by the performance of the ammonia plant.

It is important therefore that we compare the IFFCO ammonia plant performance with that of other ammonia plants. In this section we make only passing reference to urea and NPK plant performance.

Comparison with other Indian ammonia/urea plants

The most up-to-date data on performance of Indian nitrogenous fertiliser plants are given in a World Bank report of June 1979. D G Rao, Technical Adviser to the Indian Ministry of Chemicals and Fertilisers, published a collection of performance data at the Fertiliser Association of India Seminar in 1978 (Proceedings Tech-I/1). The World Bank Report reproduces and extends these data. The 'installed (annual) capacity' has reference to the ammonia plant capacity. 'Capacity utilisation' is defined as annual output x 100/'installed capacity'.

We give a display of annual 'capacity utilisation' drawn from the above data which refer to the private and joint sectors and the best of the public sector plants, for the years ending March 1976 to 1979. It affords visual comparison with IFFCO data.

Table I : % Capacity Utilisation for ammonia plants

	ending Mar	1976	1977	1978	1979
Public					
FCI Trombay		98	126	106	106
FCI Namrup		102	104	100	100
	Total	100	115	103	103
Private					
SCI Kota		72	79	79	76
IEL Kanpur		89	94	98	93
Zuari Goa		66	72	85	88
CFL Vizag		60	80	73	81
	Total	74	80	86	77
Joint					
MFL Madras		88	78	77	92
GSFC Baroda		73	80	81	77
SPIC Tuticorin		50	66	71	56
MCFL Mangalore		-	64	60	76
	Total	71	69	73	73
Co-operative					
IFFCO Kalol		69	93	99	104

The conventional definition of 'installed capacity' is given by the expression 'installed capacity' = 'nameplate (design) daily capacity' x 330 days. However for the display given above it is possible from a knowledge of actual nameplate daily capacity to deduce that for some reason 'installed capacity' has been defined as 'nameplate daily capacity' x 282 days. In Table I above, the IFFCO data has been calculated similarly, and so the Table is self-consistent, enabling comparison of plant performance one with another to be made.

The IFFCO data are for the IFFCO year July/June. With the exception of the Tuticorin and Mangalore plants, all the plants were commissioned rather earlier than was the IFFCO plant. To a degree therefore this should place the IFFCO plant somewhat at a disadvantage in comparison. In spite of this the IFFCO plant stands up well in comparison with the private and joint sector plants, as well as with the two best public sector plants.

D G Rao in his paper also gives 'days worked' for some of the Indian plants for the years 1976/77 and 1977/78.

The average for the best seven plants comes out at 316 'days worked'. It is not clear whether these are 'stream days of 24 hours' or 'calendar days on which some product was made'. The average figures for IFFCO Kalol over three complete years 1976/77-1978/79 is 312 'calendar days on which some product was made' or about 302 'stream days of 24 hours'.

Comparison with American Plants

The most recent survey of the performance of US ammonia plants is that of G P Williams published in 'Chemical Engineering Progress' September 1978. It presents data covering the period 1969-1976. For the two later periods in the survey namely 1973/74 and 1975/76 a total of 30 plants ranging in size from 600 t/day to 1500 t/day were involved, accounting for the bulk of North American production.

Performance of the 'average' ammonia plant comes out at about 50 days downtime, downtimes being measured from the time the plant ceases to produce ammonia until it resumes. Whenever the plant ceases to produce ammonia it is reported as a 'shut down'.

For the period 1969 - 1976 we have the following display:

Table II : US plants : Stream days/yr

Period	1969/70	71/72	73/74	75/76
Number of Plants	22	27	30	30
Downtime (days)	50	45	49	50
Stream days	315	320	316	315
Number of shutdowns	10	9	11	11

These periods are arithmetically averaged from the performance of all the plants for the periods concerned. The range of downtime experienced by individual plants can be quite large, from as little as 10 days to as much as 110, and the industry's arithmetic averages in the table above exaggerate somewhat the downtime experienced by most plants. In the last two periods 20 out of the 30 plants had downtime not exceeding the arithmetic average of 50 days.

We would not be far wrong in saying that the IFFCO performance denoted by stream days of 297, 305 and 302 for the last three years, achieved in a much less favourable environment, is commendable. Part of the more favourable environment in the USA is the ability to achieve short turnrounds by the use of skilled contract labour. The Donaldsonville ammonia plants, which were copied for the IFFCO project, achieve turnrounds which lose only about 11 production days. There is also almost a complete absence of power failures.

Conventional Capacity

We have seen that the conventional annual capacity is arrived at by the expression: Annual capacity = nameplate (design) daily capacity x 330. This is often used at the appraisal stage to calculate ultimate output and hence ultimate profitability.

The real relationship between daily capacity and achievable annual output is rather more complex than is usually assumed.

The daily output of a plant will certainly have an upper limit and equally certainly is unlikely to stay constant. An ammonia plant employs several catalysts which are subject to decline in activity, and one may find that the plant output can progressively decline as a result. Similarly heat exchangers may become progressively dirty with time, which may also reduce plant output. Ambient and cooling water temperatures vary with the seasons and this will change heat transfer performance. Machines such as pumps and compressors may decline in performance for mechanical reasons such as valve wear and changes in clearances.

Apart from the above-mentioned progressive changes, complex plants like ammonia plants may suffer minor upsets, recovery from which may take some hours (but often requiring a reduction in plant rate) until stability is achieved.

Only if the design is such that margins are sufficient to make up for all these consequent shortfalls in output can the specified daily capacity be confidently used in assessing likely annual output.

Even the definition of time on line requires to be carefully defined. For some it is the number of hours (converted to 'equivalent days) that the plant is producing product. For others it is defined as those calendar days on which some product is made.

We can see that the simple formula: Annual output = daily capacity x days on line a year is quite inadequate without considerable definition.

Moreover on a complex plant a minor mechanical or instrument failure resulting in a major upset (or a short stoppage) might result in an appreciable time, perhaps a day, being needed to get the plant back to full steady output. On a large plant a fault on a big machine may bring the plant off production for a day or two and to get such a plant on line again may well take two or three days at below design daily output. The simple formula for annual output is seen to be too simple, particularly if we wish to use it predictively.

A useful expression which modifies the conventional formula: Annual output = design daily capacity x 330 is as follows:-

Annual output = Maximal daily capacity x days on line x F

'Maximal Daily Capacity' (MDC) is the maximal daily output which can be achieved under the best conditions.

'Days on line a year' (DOL) is the number of calendar days on which some product is made, and is most reliably determined historically. If it has to be estimated this is best done by estimating the number of days of no production. This will be made up of:

a. days off for planned maintenance

b. days off for unplanned maintenance

c. days off for regular shutdown period for process reasons

'F' is a factor less than unity which is introduced to allow for the inevitable periods when the daily output falls below 'maximal daily capacity' whether progressive, or resulting from plant upsets, or resulting from the process of building up to full output after a plant restart.

The formula becomes more accurate for predictive purposes when actual production data have become available for the plant or for similar plants. It is then possible to be more confident about the expected 'days on line a year', and past data can be used to derive values of F.

Where we have knowledge of maximum daily capacity for the period in question we use it.

For the IFFCO ammonia plant we have the following data:

Table III : IFFCO ammonia plant : derived F factor

	1976/77	1977/78	1978/79
Annual output '000 t	248	263	276
DOL	309	318	308
MDC	910	910	935
F	0.88	0.91	0.96

We would say that the value of 0.96 for F is rather high and may be due to a combination of favourable factors in that year. We can interpret the increase in the value of F as due to better and steadier operations as experience and skills increase. But the use say of F = 0.95 to predict output for 1979/80 whilst appearing reasonable at the time would have been vitiated by the 'external' factor of the limitation of ammonia output because of compressor trouble on the urea plant. So care is needed in the case of an ammonia/urea complex where there is interaction between the plants. For shorter term predictions, knowledge of planned shutdown will allow reasonable estimates to be made of likely days on line for the short term.

Ammonia output prediction

A longer term prediction of annual ammonia output for the IFFCO plant after 1981 when the urea plant should not be limiting ammonia production, and after the I D fan has been enlarged, might reasonably be in the region of:-

MDC x DOL x F = annual output

1000 x 315 x 0.91 = 285,000 t/yr

Note that this suggests that it is most unlikely that the conventional capacity (name-plate daily capacity x 330 = 300,000 t/yr) could even be approached without having debottlenecked the ammonia plant almost by 10%.

It will be realised that annual output will vary from year to year and that such calculations only serve as a useful guide.

We find support for such an approach in some production data for the Central Farmers' ammonia plants at Donaldsonville, enabling us to calculate a value of F for these plants.

	Output '000 t		
Year	No 1 Plant	No 2 Plant	DOL
69/70) 70/71) 71/72)	324 average	333 average	About 345

The maximal daily capacity noted was about 1035 t/day. We then have:

MDC x DOL x F	=	Annual output t
1035 x 345 x F	=	328,000
∴ F	=	0.92

We note here that the conventional capacity of 910 x 330 = 300,000 t/yr was exceeded, partly because days on line exceeded 330 but also because the plants turned out to have a maximal daily capacity some 14% greater than nameplate daily capacity. It is not clear why such a maximal daily capacity is not reached by the supposedly identical IFFCO Kalol plant.

Urea output prediction

As far as urea is concerned, provided that it can be managed that to a high degree the urea plant is available on the days that the ammonia plant is at least supplying CO_2, then if we take the plant to be capable of achieving 1350 t/day with certainty (it is said to have produced 1390 t/day on one day in March 1977) then the conventional annual capacity of 396,000 t/yr of urea can be reached if values of F = 0.93 can be sustained : for 1978/79 F averaged 0.93.

MDC x DOL x F	=	Annual output
1350 x 315 x 0.93	=	396,000 t/yr

Actually since NPK is the preferred product rather than urea since it is more profitable, the production of 285,000 t/yr ammonia would permit 500,000 t/yr NPK 12/32/16 to be produced, leaving sufficient ammonia for 350,000 t/yr urea.

APPENDIX III : EXTRACTS FROM 1969 CDM ECONOMIC APPRAISAL

SUMMARY OF CONCLUSIONS

1. The project has several important advantages vis-a-vis other fertilizer projects under consideration in India:

a. The proposed raw material for ammonia and urea, natural gas is technically the easiest raw material to use. In terms of real costs and benefits for social cost/benefit analysis in India, the Kalol ammonia plant would have capital and operating cost advantages over all other ammonia projects in India.

b. The scale of the ammonia and urea units proposed at Kalol has been planned so as to be close to the limits of the present technology, while still retaining the important benefits of duplicating existing plants. The result is a scale for ammonia and urea plants which is more than 50% larger than all other plants existing or planned in India, with undoubted economies of scale.

c. Unlike most other projects in India, the Kalol-Kandla project should obtain important economies - in capital costs, in time saved in achieving capacity operation and in operating costs - from "duplicating" existing ammonia and NPK projects. The possibility of duplication exists - in the future - for the major Indian public sector producer, the Fertilizer Corporation of India, but has not otherwise been considered for private sector projects. EPS believes that, conservatively estimated, the "duplications" envisaged will be worth several million dollars in net present value. Importantly, the duplication strategy is a new and perceptive response to the growing problem of maximising Indian procurement at least cost, in terms of both quality and price.

d. EPS considers, in spite of the huge unfitted potential for fertilizer consumption in India, that marketing problems will be a key constraint for some of the existing plants or projects in India. This project however, has an almost captive market through the co-operative marketing organisation which already handles the bulk of existing sales.

e. The planned product-mix for this project - urea manufactured at Kalol, DAP manufactured at Kandla, plus a small but flexible combination of these two with potash - has two advantages over most other projects. First, a full range of balanced nutrients will be available from the start, whereas most other projects offer only nitrogen as the first stage. Second, the choice of urea and DAP as basic vehicles for nitrogen and phosphate has been justified by marketing experience over a wide range of agronomic conditions in India: a number of existing plants are at a major disadvantage in being obliged to offer only other, less flexible, nitrogenous or phosphate fertilizers.

f. This project offers a strong combination of Indian and International management experience which has yet to be found in existing plants and is not in prospect in other projects.

2. For these reasons, only some of which are quantified in the cost/benefit analysis, EPS believes that this project is the best fertilizer project of any on offer in India. However, it might be wondered whether any fertilizer project is economically justified in India, a country which is relatively poorly endowed with fertilizer raw materials. The social cost/benefit analysis shows that, on very conservative

assumptions, which treat this project as a marginal competitor for India's scarce economic resources and which price all inputs and outputs at international prices, the project has a $4.6mn net present value at an 8% discount rate. The conclusion is that India is economically justified in developing its own production of nitrogenous (and phosphatic) fertilizers in spite of the existence of resource-based international suppliers, eg Persian Gulf suppliers.

INDIAN CAPITAL COSTS

3. In the social cost/benefit analysis, Indian equipment costs, as given in the project report, have been reduced by 27.5% to obtain an approximation to the internationally traded price of the same equipment. This corresponds to the fairly widely held view that the present import duty on capital equipment, 27.5%, realistically measures in broad terms, the extent to which Indian domestic capital equipment costs are above foreign prices cif Indian ports. Representatives of this project's promotors believe that this is the case. Evidence to support this view was also obtained by the CDM mission in November 1968, which discussed in some detail the costs of three or four similar fertilizer projects. (It may be noted that in cases where the Indian activity consists of fabricating directly imported raw materials or components, the project report treats the imported raw material or component costs as foreign exchange costs.)

4. A similar conversion factor (0.75) was applied to other project costs shown as rupee costs in the project reports. This factor was applied to the total of these costs after the exclusion of: (i) import duty and sales tax (approximately 10 per cent) on imported plant and equipment costs; (ii) financing charges during construction. Some estimate was available from the original - now superseded - project report of the breakdown of different Indian cost items. It was assumed that 50 per cent of construction costs in India are for unskilled labour, or labour otherwise unemployed. A factor of 0.5 was applied to this assumed 50%. A similar assumption was made about Indian costs in design, engineering and procurement.

5. In fact, therefore, the treatment of capital costs in this project appraisal is close in practice to a straight shadow price of 25% on foreign exchange. This seems appropriate as a preliminary operation. A more sophisticated examination of Indian costs would be likely to lower further this traded good value, but since this project justifies itself in cost/benefit terms without this further analysis, the sophistication does not seem to be necessary. In discounted present values, capital costs represent some 20% of total costs over the life of the project.

LIFE OF PLANT AND TERMINAL VALUE

6. In the central assumption, the plant has a 15 year life from Year 6 when it reaches capacity operation. This assumption was made on the advice of CDM's technical consultants for this project, who said that in the industry it is assumed that plants of this type could expect to have 15 years effective operating life. If, alternatively, it were assumed that: (i) the plant had a further useful life of 20 years beyond Year 21, (ii) all other operating costs and sales values remained unchanged, and (iii) no allowance need be made for special capital renewal, then, the net present value of the project would rise by some $16 million (at an 8% discount rate) after adjustment for the lower terminal value of the plant.

THE PRICING OF INPUTS

(a) Phosphoric acid

7. The most important item of operating costs is imported phosphoric acid, which contributes almost half the total traded good value of operating costs. EPS has adopted a price for phosphoric acid delivered to the Kandla site of $146 per metric ton. Phosphoric acid is a highly corrosive liquid which has only recently begun to be shipped internationally in bulk. Shipment has been primarily on bulk long-term contract and special terminal facilities and even special tankers are required. India has not hitherto imported phosphoric acid in bulk. This makes it difficult to establish an international price cif Kandla. The project report adopts a cif Kandla price of $139.3 per metric ton, and adds $11.8 for wharfage and $0.5 for landing charges. (It also adds 25% as import duty.) EPS has taken the cif Kandla price and added, rather arbitrarily, some $7.0 per metric ton as the traded good equivalent of the project report's $12.3 for wharfage and landing charges. The assumption here is that these charges represent, substantially, unskilled labour (and to a smaller extent under utilised infrastructive) which would otherwise be underemployed over the life of the project.

8. However, the Madras fertilizer project, which will be the first Indian plant to use phosphoric acid, has negotiated a long term contract at a cif Madras price of $133.5 per metric ton ($5.8 below the project report price for Kandla), and this is also the price adopted in the USAID appraisal of Trombay expansion and Kandla as appropriate prices cif Bombay and Kandla respectively. These are all prices based on the assumption of supply from Mexico or the US Gulf Ports, the principal existing source of international supply. IFFCO is currently negotiating, with official Government of India support, for bulk supply from Bandur Shapur in Iran. The main attraction of this source would be very low freight charges, $11-12 per metric ton, as against some $24 per metric ton for supply from Mexico or the US. So again, the project report's pricing assumption (taken over into this appraisal) is significantly cautious. On the other hand, CDM's technical consultants have suggested that some of the very low reported prices which are influencing current thinking may represent distress prices to keep plants employed. If IFFCO does reach agreement with the Iranian suppliers, as seems likely, the saving in freight costs should add $8mn. to net present value. If IFFCO obtained the reported Madras price ($133.5) rather than the project report price ($139.3), that would add $3.8mn. to net present value.

(b) Potash

9. The second most important cost item is potash, which represents some 14% of total traded goods costs. The project report takes a cif Kandla cost of $48.78 per metric ton, which is increased to $53.78 by handling charges to the site. In adjusting to traded good value, the handling charges are reduced by 40% as most of these charges are for unskilled labour.

(c) Natural gas

10. EPS has taken as the economic price of Kalol's natural gas, the cost of that amount of naphtha that would be needed to produce an equivalent amount of ammonia (and urea). The naphtha equivalent is valued at a relatively high assumed cif import price for naphtha of $20 per metric ton. These are restrictive assumptions. They imply that, if the natural gas were not used for this project, it would be feasible to use it in another chemical plant (producing ammonia or methanol*)

* The Kalol gas is largely methane: it would not be usable for ethylene derivatives.

where it would replace naphtha as feedstock. In the near term future, however, it is not clear that there are alternative users for the Kalol natural gas who would pay to use it as feedstock, if all their inputs and outputs were similarly priced as "traded goods", as ODM's guiding principles require. The analysis of capital costs and management efficiency of the present project suggests that there are no alternative ammonia projects which could afford to pay as much for natural gas and still show an acceptable rate of return. So, to an important degree, if the use of natural gas were ruled out for this project for economic reasons, it is likely that it would be ruled out for the same reasons for other ammonia plants. This proposition is plausible so long as this project represents the most efficient use for natural gas in the area. Ultimately, however, technical improvements in efficiency are likely to favour later plants. Given the delay in developing new processes on a commercial scale, one should probably assume that only in the 1980's will there be a significantly better feedstock use for this gas.

11. To the extent that this is so, it seems plausible that the next best economic use for the natural gas would - at least during the 1970's - be a fuel use - plausibly in steam raising for a thermal power station. The economic price would be determined by the available alternative fuel - probably fuel oil - suitably priced to reflect its real cost. If this were the appropriate comparison, natural gas would be priced into the Kalol-project some 15-20% lower than the naphtha equivalent price - with a saving in expected annual costs of $1.0 mn. and an improvement in net present value of some $6.6 mn (at an 8% discount rate). (Even this "economic" price would be substantially above the price that Kalol seems likely to have to pay for natural gas in practice.)

(d) Other operating costs

12. Other costs contribute about 20% of total annual costs at normal capacity operation. Some 25% of these other operating costs are for fuel, naphtha and for fuel oil, which is priced in this appraisal at (relatively high) traded good prices of $20 and $18 respectively per metric ton. A further 22% is contributed by maintenance material costs, which the project report takes as 2% of initial capital costs for battery limit units and off-sites, but which has been raised to 3% of total initial fixed capital costs in this appraisal. Almost 28 per cent is contributed by costs of bags and miscellaneous supplies. These are rupee costs for which no easy traded good value is derivable: they are rather arbitrarily converted by a 0.7 factor. Utility costs represent about 7% and the operating results are, therefore, not sensitive to the assumptions made about them.

PRICING OF OUTPUTS

13. Urea

EPS has assigned a price for urea bagged ex-Kalol of $55 per metric ton over the life of the project. This would correspond to a cif Kandla or Bombay price of about $50 per metric ton. India is at present paying very much more than this for its, largely aid-financed, imports. World urea prices have, however, been falling and are expected to fall through to the middle 1970's as new export-oriented natural gas-based capacity comes on stream in the major ldc petroleum-producing countries.

It, therefore, seems appropriate to impute a price to this project, at which India could obtain marginal but substantial quantities in the 1970's and which does not involve any protection against ldc exporters. In its 1969 appraisal report on the Goa project, the IFC staff argued that India could probably hope to obtain Persian Gulf supplies at $50 per metric ton cif West coast ports. It is clear, however, that IFC and others do not think that India's traditional suppliers in North America and Western Europe could get their prices below some $65 per metric ton cif Indian ports in the late 1970's. USAID in its cautious economic appraisals of Trombay and Kalol-Kandla imputed urea prices at or above $70 per metric tons. In practice, the IBRD/IFC staff have done the same. This would add some $56 mn to the net present value of this project.

DAP and potash

14. This economic appraisal adopts the USAID, evaluation of likely price trends. Over the life of the project AID assumes a DAP price of $87.0 per metric ton and a potash price of $50.0 per metric ton. The DAP price is well below the project report's $100.0 per metric ton, which reflects expected price levels within India.

TIME SCHEDULE AND ASSUMED NORMAL OPERATING RATE

15. The project's promotors have assumed for cash flow purposes that construction will require 36 months from signature of contract to mechanical completion. Start-up trials and commercial production would, therefore, begin in the fourth year. The assumed date of contract signature is now mid-1970. An assumption of 36 months would be normal for the major ammonia and urea plants and contractors are willing (if forced) to guarantee 36 month completion dates. Mechanical completion inside 36 months has recently been achieved on three fertiliser projects in India. In fact, however, there are good hopes that this project can reduce this construction time:

i. A large amount of detailed preparation has taken place over the past two years.

ii. With contractors largely designated already, detailed project preparation work will take place over the next six months to mid-1970.

iii. The important element of duplication (primarily in ammonia and NPK plants) should yield time savings both in planning, procurement and erection.

The promotors hope that effective completion in 30 months will be achieved. In the case of the NPK plant at Kandla, a 36 month completion assumption would be generous in any case, and it would be appropriate to assume no more than 30 months. We have not done so, because on present project assumptions there would be no raw material (ammonia or urea) from Kalol to use with the imported materials at Kandla. However, the project promotors are actively considering the possibility of arranging temporary nitrogen imports at Kandla to allow some production before the completion of Kalol: at this stage an arrangement seems possible. So the output and benefit assumptions for 1974 seem conservative.

27. The project is assumed to take three years to build up to capacity operation, with a build-up assumption of 50%, 70% and 90% for the first three operating years. These are normal, fairly cautious, operating assumptions for fertiliser plants of

this type, and have been bettered by some recently established plants in India. The project's promotors believe that they can get a better performance build-up than assumed. In planning the project, they have been willing to eschew some savings in capital and operating costs to obtain proven reliability in the three plant designs. In the case of the (difficult) ammonia plant, the planning strategy has been to duplicate (in very similar climatic conditions) a plant which reached capacity operation within weeks and has operated beyond capacity since.

17. The assumption of normal operation at full capacity might seem optimistic. However, normal is taken to be 100% of rated capacity for 330 days, leaving 35 days for annual maintenance. Moreover, rated capacity is conservatively estimated. The concept is of that capacity that the contractors and process licensors are prepared to guarantee.

EXPECTED RESULTS AND SENSITIVITY ANALYSIS

18. Expected Results. The national economic cost/benefit analysis has been set up with very cautious technical and economic assumptions. The calculations show, even on these restrictive assumptions, a $4.6 million net present value at an 8% discount rate.

KALOL-KANDLA FERTILISER PROJECT - SOCIAL COST/BENEFIT ANALYSIS - MOST UNFAVOURABLE ASSUMPTIONS

($million)

	1970	1971	1972	1973	1974	1975	1976	1990	1991
BENEFITS									
Sales: Urea	-	-	-	5.4	14.0	17.3	21.6	21.6	21.6
DAP + Potash	-	-	-	7.2	18.6	22.9	28.6	28.6	28.6
Terminal value	-	-	-	-	-	-	-	-	22.5
TOTAL BENEFITS	-	-	-	12.6	32.6	40.2	50.2	50.2	72.7
COSTS									
Capital: Project	12.0	31.1	27.0	8.4	-	-	-	-	-
Inventory	-	-	-	2.5	-	-	-	-	-
Materials: Natural Gas	-	-	-	0.9	2.3	2.9	3.6	3.6	3.6
P_2O_5	-	-	-	4.8	12.3	15.2	19.0	19.0	19.0
Potash	-	-	-	1.4	3.6	4.5	5.6	5.6	5.6
Naphtha and fuel oil	-	-	-	0.7	1.8	2.2	2.8	2.8	2.8
Operating costs	-	-	-	2.0	5.2	6.4	8.0	8.0	8.0
CFI costs	-	-	-	0.4	1.0	0.9	-	-	-
TOTAL COSTS	12.0	31.1	27.0	21.0	26.2	32.1	39.0	39.0	39.0
Surplus (or deficit)	(12.0)	(31.1)	(27.0)	(8.4)	6.4	8.1	11.2	11.2	33.7
Discount Factor at 8%	1.0	0.93	0.86	0.79	0.74	0.68	0.63	0.19	0.20
Net present value ($ million)	(12.0)	(28.7)	(23.1)	(6.6)	4.7	5.5	7.1	2.1	6.7

NET PRESENT VALUE = $4.6 million

CDM
December 1969

APPENDIX IV: ECONOMIC EVALUATION

Introduction

1. This evaluation of the project is based on factual information on the costs and benefits for the period up to IFFCO's financial year (July-June) 1978/79, together with forecasts for the remainder of the life of the project. Unlike the 1969 ODM appraisal, cost-benefit analyses have been prepared for Kalol and Kandla separately, as either plant could have been developed as an independent entity.

Methodology

2. ODM's "Guide to the Economic Appraisal of Projects in Developing Countries" 1) has formed the methodological foundation for the evaluation. The numeraire is present net social income measured in terms of convertible foreign exchange of constant purchasing power. For ease of comparison with the original 1969 ODM appraisal, the numeraire has been expressed in the same currency as in 1969, namely US dollars, and the same constant prices, which appear to be 1968/69 prices. All of the benefits and part of the costs can be readily expressed in dollars, but a substantial proportion of the costs are denominated in rupees and, to a lesser extent, pounds sterling. The conversion of rupee and sterling values to constant 1968/69 dollars raises both theoretical and practical problems due largely to the fluctuating exchange rates which have obtained since 1971. The issue can be tackled in a number of ways, and the course selected (as set out below) was determined largely by the availability of data.

3. It was decided that the most appropriate price deflator to use is the dollar price index of industrialised countries' manufactured exports to developing countries which is produced by the World Bank. The index has been transposed to a 1968/69 base and is shown in Table 4.1. All costs and benefits expressed in dollars have been deflated to 1968/69 prices using this index, but rupee and sterling expenditures must first be converted to current dollars. This raises the issue of fluctuating exchange rates.

4. If the movements in an exchange rate only reflect differential rates of inflation (i.e. there are no "real" changes in the exchange rate), the relevant money exchange rate in a particular year can be used to convert rupee or sterling expenditures in that year to current dollars which can then be deflated to 1968/69 dollar prices by the price index mentioned above. This procedure has been used for all sterling expenditures, as the relevant data suggests that there was no major real change in the dollar/sterling exchange rate over the relevant period (i.e. from 1968/69 up to 1971/72 - 1973/74 when the bulk of the sterling costs were incurred) and since the sterling expenditures were small in relation to the total costs and benefits. The dollar/sterling exchange rates which have been used are given in Table 4.1.

5. The rupee costs have also been converted to dollars at the ruling exchange rate in each year (Table 4.1), but in other respects they have been treated differently from the sterling costs. In the first place they have all been classified as "non-traded" goods. For the bulk of the rupee costs this is probably a reasonable assumption, either because the inputs are genuine non-traded goods such as electricity and construction or because they are effectively

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1) Published by HMSO, London 1977.

non-traded due to GOI restrictions on imports; but it is recognised that this is a simplifying assumption which does not strictly hold for the full range of rupee costs over the period under review. The next step was to assign appropriate 'conversion factors' to each main rupee cost item. For the early years of the project (i.e. during the construction period) the choice of 'conversion factors' has been based on information which has previously been made available to the ODA by the GOI Planning Commission and which is considered to be relevant to the early 1970s. For the subsequent period higher 'conversion factors' have in general been applied, as it appears that in a number of instances the international competitiveness of Indian industry and services has increased during the 1970s and in some cases domestic prices have been increasingly subsidised. This conclusion is substantiated by a comparison of some of the relevant Indian wholesale price indices with the international price index and movements in the dollar/rupee exchange rate. The result of this comparison reveals that the Indian rate of inflation in tradeable goods has generally been lower than the rate of increase in the international price index, and that these differential rates of inflation have not been compensated by a corresponding appreciation of the rupee against the dollar.

6. In summary the rupee expenditures have been converted to 1968/69 dollars firstly by applying the relevant 'conversion factor', followed by the ruling dollar/rupee money exchange rate, to express the costs in current dollars, which have then been deflated by the international price index. Since the 'conversion factors' are not known with a high degree of certainty there is a potential measure of error in this approach, but this is unlikely to affect the results to any great extent as the costs which have been estimated in this way are fairly small in relation to the total costs and benefits.

Discount Rate

7. A 12% discount rate has been employed as this is the current practice of the Indian Planning Commission. However, the 1969 ODM appraisal adopted an 8% rate, and the main evaluation results have been recalculated on this basis for comparative purposes.

Life of Project

8. The economic life of the project has been assumed to be about 15 operating years up to 1989/90 (inclusive). After this period both the Kalol and Kandla plants are assumed to close down; and a terminal (scrap) value of 10% of the initial capital cost has been credited to the project in the last year of its life. In line with this scenario, no allowance has been made for special maintenance costs or substantial replacement investment in the later years of the project. In reality the project is likely to be operated for longer than 15 years but at the cost of escalating expenditures on the plants. The choice of 15 years has been made largely on the basis of the "normal life" for process plants of the kinds at Kandla and Kalol. In addition there are doubts whether the reserves of gas near Kalol are sufficient to supply the ammonia plant beyond the end of the 1980s, but in practice this potential difficulty may well be overcome by the availability of gas from the offshore oil and gas fields near Bombay.

9. The 1969 ODM appraisal adopted slightly more optimistic assumptions, namely a project life of about 18 operating years and a terminal value of about 25% of the initial capital costs.

Capital Costs

10. It is convenient to divide the capital costs into three categories: initial foreign exchange expenditures on the original plants, initial rupee expenditures, and additional capital costs incurred after the completion of the original plants.

11. The initial foreign exchange expenditures have been taken from the CW Project Completion Report as shown in Table 4.2. The precise phasing of these costs is not readily available, but estimates are given in Table 4.3 after reviewing the planned drawdown schedules in the 1 May 1971 "Financial Assistance Paper" and after taking account of known delays in implementation.

12. The initial capital costs incurred in rupees have been derived from details provided by IFFCO of their "Final Revision (B)" of the capital costs (which was made in May 1975). The differences between these revised costs and the "Actual Costs" (for which the same breakdown is not available) are small. Table 4.4 gives the costs in both financial and economic prices, together with the 'conversion factors' used to express the financial costs in economic prices; and Table 4.5 gives the phasing of the rupee capital costs (in economic prices) based on the same guidelines as in the case of the foreign exchange expenditure.

13. The total initial capital costs (at economic prices) are given in both current and 1968/69 dollars in Table 4.6. The total in 1968/69 prices is now estimated at about $57 million compared with $78.5 million in the 1969 ODM appraisal. The reasons for this substantial difference of about $21.5 million are not entirely clear as details of the derivation of the 1969 estimate are not available. The 1969 appraisal stated that the financial cost estimates made at that time would probably prove to be on the high side, and this may well be one of the reasons. It is also possible that some of the economic cost estimates made in 1969 were not fully deflated to constant 1968/69 prices and therefore contained an element of the allowances for price escalation during the contract period.

14. Estimates of the additional capital costs which have been (or will be) incurred since the completion of the original plants in 1974/75 are given in Table 4.7. No corresponding estimates were made in the 1969 appraisal. The assumptions behind the Kalol figures are as follows:-

i. Examination of IFFCO's Balance Sheets for 1976 and 1977 reveals additional gross fixed assets amounting to some Rs70 m over and above the cost of the original project at Kalol. A 'conversion factor' of 0.8 has been applied to this figure and the additional costs are assumed for simplicity to fall in 1975/76.

ii. The debottlenecking schemes which are in progress at Kalol are estimated to cost Rs74.4m of which Rs47.4m is foreign exchange (IFFCO's 1978/79 Annual Report). This has been rounded up to Rs75m to include an allowance for other minor items, and the full amount has been debited to 1979/80.

iii. The sums included for 1981/82 and 1984/85 represent approximate estimates for a new CO_2 compressor and replacement items for the ammonia plant respectively.

15. At Kandla a second NPK plant (similar to the existing one) is under construction, but no provision has been made for this on the grounds that it constitutes a separate major project. The only additional capital costs which have been included in this evaluation are Rs25m in 1976/77 to cover the debottlenecking of the Kandla plant and other minor items, and $1m in 1980/81 for additional phosphoric acid storage.

Production

16. Table 4.8 gives details of the outputs of the Kalol and Kandla plants up to 1979/80. For the purposes of this evaluation it has been assumed that sales to outside consumers and stocks held in warehouses outside Kandla/Kalol directly replaced imported fertilizers and can therefore be included in the benefits of the project, but that stocks held at the factory sites constituted part of the project's working capital. Consequently it is necessary to identify the volumes of production which were held as stocks at each plant, and the volumes which were sold to final consumers or despatched to co-operatives' warehouses. It is also necessary to determine the volumes of ammonia and urea which have been transferred each year from Kalol to Kandla.

17. An analysis of the use of past ammonia production is given in Table 4.9. Transfers of ammonia to Kandla have been included in the benefits of the Kalol plant and the costs of the Kandla plant; sales to other consumers have been credited to the Kalol benefits; and the stocks form part of Kalol's working capital. Projections for the future assume a build-up to 285,000 t /yr by 1981/82 2) when the full benefits of the debottlenecking schemes should be realised (see Appendix II for the derivation of this figure). Of this amount, 210,000 t /yr would be used for urea production (assuming that 0.6 t of ammonia are required to produce 1 t of urea which is probably conservative), and the remaining 75,000 t /yr for NPK production at Kandla. Ammonia stocks at Kalol are projected to be 6,000 t which is a little above the average for the past five years.

18. Table 4.10 gives a similar analysis of urea production. The treatment of the despatches and stocks in the cost-benefit analyses is the same as in the case

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2) Ammonia production in 1979/80 and 1980/81 is estimated to be 260,000 and 270,000 t /yr respectively.

of the ammonia production. In the future, urea production is projected to build-up to 350,000 t/yr by 1981/82 3) of which 13,000 t/yr will be utilised at Kandla. Stocks of urea at Kalol are estimated to remain constant from 1981/82 at 15,000 t. The 1969 ODM appraisal assumed a more optimistic long-term production level of 392,000 t/yr.

19. NPK production has been broken down into sales and stocks at plant as in Table 4.11. For simplicity, production from 1979/80 onwards is assumed to be entirely in the form of NPK 12:32:16 and is projected to be 500,000 t/yr. The level of stocks at plant are assumed to build-up to 20,000 t in 1979/80 and then to remain constant. This long-term production level is higher than the 375,000 t/yr assumed in the 1969 ODM appraisal due to the success of the debottlenecking scheme.

Benefits

20. The benefits of the Kalol and Kandla projects are represented by the value at economic prices of the despatches of products from each plant. The volumes of despatches are set out in Tables 4.9 - 4.11 and have been valued at world prices cif Indian port. This method of valuation assumes that the costs of distribution (including product losses) are the same for imported fertilizers as for the products from Kalol and Kandla. Since it is understood that a large part of India's fertilizer imports are landed at Bombay or Kandla, this is probably a reasonable assumption. It is possible that the costs of distribution of IFFCO fertilizers may be raised a little above those of imports by the requirement that IFFCO sells its products to all States which have shares in the company. However an analysis of despatches to each State indicates that IFFCO's sales have been concentrated to a large extent in those States which are likely to have been supplied by imports through Bombay or Kandla in the absence of the IFFCO project (ie. areas in the North-West segment of the country). Furthermore, IFFCO has developed product exchange arrangements with the FACT and Mangalore fertilizer factories under which some of the more distant areas from Kalol/Kandla are served by these factories in exchange for IFFCO supplies on behalf of FACT and Mangalore to areas in the North. As a simplifying assumption any "additional" distribution costs associated with IFFCO's products are assumed to be offset by other miscellaneous benefits which are included in IFFCO's profitability statements but have not been included in the cost-benefit analyses (ie. part of "Other Revenues").

21. The valuation of the urea is straightforward, but the NPK production raises difficulties as it has not been possible to obtain reliable world prices for the particular grades of fertilizer manufactured at Kandla. In the 1969 appraisal the value of the NPK production was expressed in terms of DAP and potash, and the same method has been applied in this evaluation. The underlying assumption we have adopted is that the NPK compounds produced at Kandla are equivalent in value to the corresponding volumes of DAP and potash which contain the same quantities of NPK nutrients. It is possible that this understates the value of the NPK compounds; but we are unable to judge whether, or the extent to which, the NPK fertilizers are of greater benefit to the farmer than DAP and potash, as the necessary comparisons involve a range of agronomic considerations which are outside the scope of this study. This area of uncertainty is discussed further in the context of the sensitivity analysis (paragraph 39).

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3) Urea production in 1979/80 and 1980/81 is estimated at 310,000 and 320,000 t/yr respectively.

22. The 1969 OIM appraisal assumed that 375,000 t/yr of NPK fertilizers were equivalent to 265,000 t/yr of DAP and 109,000 t/yr of potash. These DAP and potash equivalents appear to have been lifted out of the June 1969 USAID appraisal of the project, but it is not understood how they were calculated. In our opinion they are too high. The product mix assumed in the 1969 documents was:

189,900 t	of	NPK	14-36-12
92,800 t	of	NPK	12-32-16
92,800 t	of	NPK	10-26-26

On our calculations this is broadly the same as 375,000 t of NPK 12.5/32.6/16.5, which in turn is equivalent to 227,000 t of DAP and 102,000 t of muriate of potash, 60.5% K_2O (which was the grade of potash assumed in the 1969 reports). These DAP and potash equivalents are below those used in the 1969 OIM appraisal, particularly in respect of DAP.

23. The import prices used for valuing the benefits are given in Table 4.12. The historical figures for 1974/75 - 1978/79 are based on average import prices revealed by India's import statistics, and the projections for the future are generally in line with the World Bank's commodity forecasts prepared at the beginning of 1980. The constant 1968/69 price forecasts which were used in the 1969 OIM appraisal were $55/t for urea, $87/t for DAP and $50 /t for potash.

Kalol Operating Costs

24. The operating costs at Kalol have been divided into two groups. The first group comprises natural and associated gas, naphtha and fuel oil (ie. the main material inputs), which have each been valued directly in terms of world prices. The second group includes all other production costs, which have been valued by the application of conversion factors.

25. The main material costs are shown in Table 4.13. The quantities of each item consumed over the period 1974/75 - 1978/79 are based on actual data provided by IFFCO. The projections of future quantities are derived from the following technical coefficients, which have been drawn from IFFCO's Corporate Plan for Kalol 1980/81 - 1984/85 and have been checked against coefficients achieved in the past:-

i. 656 and 205 m^3 of natural and associated gas respectively per t of ammonia;

ii. 0.249 t of naphtha per t of ammonia; and

iii. 0.120 t of fuel oil per t of urea.

26. The pricing of the gas is based on the assumption that its alternative use is as a substitute for fuel oil in steam generation. In terms of their calorific values, 1000 m^3 of natural and associated gas are calculated to be equivalent to 0.93 and 0.98 t of fuel oil respectively and these coefficients have been used for estimating the economic prices of the gas feedstock. Naphtha and fuel oil prices for the years up to 1978/79 have been based on historical trade statistics, and the projections for future years are generally in line with World Bank statistics produced in early 1980. The GOI's medium-term policy on naphtha is to restrict the licensing of new naphtha-consuming industries so that the domestic supply and demand situation is usually in balance or there is a small surplus for export. However India has been a net importer of naphtha since 1976, and it has been (pessimistically) assumed that net imports will

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continue for the remainder of the project's life. The prices of fuel oil and naphtha have been projected to increase by 3% per annum in real terms from 1979/80.

27. Details of other operating costs at Kalol up to 1978/79 are given in current rupees in Table 4.14. The costs at financial prices have been expressed in economic prices by the application of 'conversion factors' (which are assumed to be unity unless there is good reason to suppose otherwise). In 1979/80 these costs are estimated at $4.0 million in 1968/69 economic prices, which is marginally higher than the costs in recent years, rising to a constant level of $4.5 million/yr based on IFFCO's corporate plan for the next five years.

Kandla Operating Costs

28. The quantities and values (in economic prices) of raw materials consumed at Kandla are detailed in Table 4.15. The quantity projections assume that the output of the plant will be 500,000 t/yr of NPK 12:32:16 (paragraph 19 above) and are based on input coefficients provided by IFFCO. The price projections for potash, urea and ammonia are drawn from Table 4.12 and represent landed import prices. The impact on the Kandla project of valuing the ammonia and urea at the real costs of production (at Kalol) are discussed later (paragraph 38). The future price of phosphoric acid has been related to the World Bank's projections for triple superphosphate (TSP), and it is generally assumed that the phosphoric acid price at factory will be twice the TSP price, fob US Gulf. This relationship has roughly held for parts of the first five years of operation, but in 1976/77 and 1977/78, and at the time of our visit, the phosphoric acid price was substantially higher. Future phosphoric acid prices may therefore be higher than projected in this evaluation thereby increasing the costs of the Kandla plant.

29. The 1969 ODM appraisal assumed a phosphoric acid price of $146/t which is markedly above the price projections used for this evaluation. The corresponding potash price was taken to be $51.78/t, which is again higher than our present projections and is also marginally higher than the $50/t which was used in 1969 to value the benefits. The reason for using a lower potash price to value the benefits than the price used to value the costs is not understood, although the reverse would have some justification as the potash consumed is in powder form and is imported in bulk and the NPK product is granulated and sold in bags.

30. Table 4.16 gives details of the other operating costs incurred at Kandla in current rupees over the first five years of production. The costs are given in both financial and economic prices. In 1978/79 these "other costs" averaged about $7/t in 1968/69 prices, and on this basis they are assumed to amount to $3.5 million/yr from 1979/80 onwards (in 1968/69 prices).

Working Capital

31. In economic terms working capital mainly comprises the physical stocks of raw materials, finished goods, spare parts and other stores; the real resource costs of financial working capital are relatively small.

32. Details of the working capital at Kalol and Kandla are given in Tables 4.17 and 4.18 respectively. No allowance has been made for stocks of spare parts and tools as the capital costs include substantial amounts for these items. At both plants, therefore, the main components of working capital are the stocks of finished goods, which have been valued at world prices. The amounts of other working capital are estimated from the current assets in IFFCO's balance sheets.

/ Results

Results of Evaluation

a. Kalol

33. The costs and benefits of the Kalol plant as calculated in the previous paragraphs are summarised in Table 4.19. The net present value (NPV) of Kalol is estimated at $0.6 million discounted at 12% back to 1970/71, and the internal rate of return (IRR) is 12.3%. The Kalol plant therefore meets the GOI's present economic decision criterion (ie. a positive NPV at a 12% discount rate), although only by a small margin.

34. A variety of sensitivity analyses have been carried out, the results of which are given in Table 4.20. The conclusions which can be drawn are as follows:-

i. The IRR is not particularly sensitive to increases in the capital cost estimates . A 10% increase in the capital costs reduces the IRR to 10.7%.

ii. The gas costs are subject to a relatively large margin of uncertainty as the pricing of the gas depends on its value in the next best alternative use rather than on the direct application of a world price (paragraph 26). An increase/decrease of 10% in gas costs reduces/increases the IRR to 10.3% or 14.1% respectively. If the gas costs are reduced by 50% (eg. as a result of a different method of valuation more related to the costs of production) the IRR rises to 20.0%.

iii. If the historical costs up to 1978/79 are accepted as being essentially accurate, the most important area of uncertainty on the cost side is in relation to future energy prices. An increase/decrease of 10% in the combined costs of gas, naphtha and fuel oil over the period 1979/80 - 1989/90 reduces/increases the IRR to 8.7% or 15.2% respectively.

iv. On the benefit side, the estimates of the value of urea up to 1978/79 are considered to be relatively reliable, but less confidence can be placed in the projections because of uncertainties about the future urea price. If the urea price is increased/decreased by 10% over the period 1979/80 - 1989/90 the IRR rises/falls to 17.4% or 5.4% respectively. As the benefits are larger than the costs, the IRR is,not surprisingly, particularly sensitive to changes in the size of the benefits.

v. The "life" of the project is to some extent a subjective issue, and our assumption of just over 15 years of operation (paragraph 8) may be considered to be pessimistic. If the life is extended by 2 or 5 years, and if it is further assumed that the additional replacement costs associated with the extension are equal in present value terms to the terminal value of the plant, the IRR rises marginally to 12.7% or 13.3% respectively.

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35. Over the past decade since this project was first appraised, there have been major changes in the prices of both the main inputs and the outputs of the Kalol plant. Following the oil price hikes which commenced at the end of 1973, the cost of hydro-carbons has risen dramatically in real terms. Partly as a direct consequence of these events the price of urea also shot up to record heights in 1974, but then fell back to a depressed level in 1976; it is now recovering to a more realistic long-term value given current feedstock costs. In an attempt to isolate the "quantitative" performance of the Kalol plant from these exceptional price movements (which could not have been realistically foreseen in 1969), our price assumptions for gas, naphtha, fuel oil and urea have been replaced by the corresponding prices used in the 1969 OIM appraisal and our evaluation has then been recalculated. The results are presented in Table 4.21 which yields an IRR of 17% and a NPV of $15 million at a 12% discount rate. This NPV is substantially higher than that given in paragraph 33 indicating that price movements during the 1970s have adversely affected the Kalol project.

b. Kandla

36. Our estimates of the costs and benefits of the Kandla plant are summarised in Table 4.22. On the assumptions in the previous paragraphs, the NPV of the Kandla plant is estimated to be -$24 million discounted at 12% back to 1970/71, and the project yields no positive IRR.

37. In the light of this conclusion the sensitivity analysis in Table 4.20 is primarily concerned with the extent to which the costs or benefits need to be changed in order to yield a positive NPV (discounted at 12%). It is clear that the NPV is relatively insensitive to changes in the capital costs (which are also known with comparative certainty), and therefore attention has been focussed on the operating costs and the benefits. If the NPV (discounted at 12%) is to be increased to at least zero (or put another way, if the IRR is to be at least 12%), the costs or benefits need to be reduced or increased by the following percentages:- (derived from Table 4.20)

	Over life of project	Over years 1979/80-1989/90
	%	%
MAP/Phosphoric acid costs down by	33	55
Phosphoric acid, ammonia and urea costs down by	25	42
Benefits up by	20	30

Changes in the potash costs have been excluded from this sensitivity analysis, as variations in the potash price will affect the costs and benefits almost equally and will therefore have a negligible impact on the NPV. Reductions in "other" operating costs (ie. other than raw material costs) have also been excluded on the grounds that they are relatively small and can be forecast with greater certainty than the raw material costs.

38. It will be seen from the table in the above paragraph that the raw material costs need to be lower by very substantial percentages if the NPV (discounted at 12%) is to become positive. Such overestimation of the costs seems highly

/unlikely

unlikely, particularly since it is possible that the major phosphoric acid costs have been under - rather than overestimated (paragraph 28). It might be argued that our valuation of the ammonia and urea input costs at world prices is inappropriate since the products are largely obtained from Kalol (paragraph 28); but Table 4.20 indicates that a reduction of 20% in these costs only increases the NPV from -$24 to -$20 million. Furthermore our evaluation of the Kalol project indicates that the real resource costs of ammonia and urea from Kalol (which should include the costs of transport to Kandla) may not be substantially different from the costs of imported urea (since the NPV of the Kalol plant is estimated to be close to zero at the relevant discount rate of 12% - paragraph 33).

39. Turning to the benefit side of the analysis, the table in paragraph 37 indicates that an increase in the benefit stream of 20% over the life of the project (or an increase of 30% over the period 1979/80 - 1989/90) would be sufficient to yield a positive NPV at a 12% discount rate. One potential cause of an increase in the size of the benefits would be higher DAP prices than those which we have assumed, but it is probable that higher DAP prices will be associated, at least partially, with higher raw material prices so that there would be some increase in the costs as well as the benefits. A far more important area of doubt relates to our valuation of the NPK production in terms of the corresponding volumes of DAP and potash which contain the equivalent quantities of NPK nutrients. As explained in paragraph 21 we do not know whether this method of valuation fully captures the benefits of the NPK produced at Kandla and further study is required before an assessment can be made of the size of "premium", if any, which should be placed on the NPK compound fertilizers.

40. As in the case of Kalol we have recalculated our evaluation replacing our main raw material and output price assumptions by those used in the 1969 ODM appraisal, in order to remove the impact of international price movements since 1969. Substituting the prices used in 1969 for phosphoric acid, potash, ammonia, urea and DAP for the corresponding prices in our evaluation reduces the NPV discounted at 12% (back to 1970/71) from -$24 to -$38 million. The price movements since 1969 appear therefore to have affected the Kandla project favourably.

c. Comparison with 1969 ODM Appraisal

41. Extracts from the 1969 ODM appraisal are reproduced in Appendix III. Although the estimated NPV of the overall project (ie Kalol and Kandla combined) is shown on the last page of Appendix III to have been estimated at $4.6 million discounted at 8% (back to 1970), we have discovered a number of apparent errors which require correction before the 1969 ODM appraisal result is compared with our evaluation. Firstly, there appears to have been an arithmetical error in the discounting process, as the NPV discounted at 8% on our calculations is $11.5 million and not $4.6 million. Secondly, we have identified two apparent errors in the estimation of the benefits in the 1969 appraisal, the major one relating to the DAP and potash "equivalents" for the NPK compounds (paragraph 22) and the other relating to a discrepancy between the price used to value the potash inputs and that used to value the potash outputs (paragraph 29). It is estimated that the net effect of these two errors is that the benefits of the NPK products were overvalued by about 13.5%. If the NPK benefit stream is adjusted by a factor of 0.881 (ie. 100 ÷ 113.5), the 1969 NPV becomes - $13.1 million discounted at 8% and the IRR is 6.0%. It is these amended results which we have compared with our evaluation.

/42.

42. Using our estimates of the actual costs and benefits up to 1978/79 and our projections for the remainder of the life of the project, our evaluation of the overall project yields an NPV of - $14.6 million using the same discount rate as that employed in the 1969 appraisal, namely 8% (discounted back to 1970/71), and the IRR is 4.6%. This result is not substantially different from the outcome of the 1969 appraisal as amended in paragraph 41. However, the similarity in the aggregate figures disguises a number of significant differences between the estimates made in 1969 and our own estimates of the constituent parts. In particular the capital costs were lower than estimated in 1969; the output of the Kandla plant has exceeded expectations by a large margin; but urea production has been lower than predicted. Raw material requirements (per t of outputs) and other operating costs, on the other hand, have been broadly in line with the estimates made in 1969.

43. The difference between the results of the 1969 ODM appraisal and our evaluation can be attributed partly to "real" changes (eg. production being higher or lower than projected) and partly to international price movements. Since international price movements are largely outside the control of the project management, it is of interest to compare the 1969 ODM appraisal with our evaluation having removed as far as possible the impact of these relatively fortuitous price effects. This can be achieved by using the data in Table 4.21 and 4.23, which give our evaluation results on the basis of the price assumptions used in the 1969 ODM appraisal for the outputs and main raw material inputs (paragraphs 35 and 40). On these assumptions our "recalculated" evaluation yields an NPV of - $12.2 million discounted at 8% and an IRR of 5.3%, which is again close to the amended 1969 ODM appraisal result in paragraph 41.

44. Finally, the sensitivity of this "recalculated" evaluation result has been tested for changes in the life of the project. Our own assumptions about the life of the project in paragraph 8 were more restrictive than those used in the 1969 ODM appraisal (of paragraph 9); but if our assumptions are brought into line with the 1969 ODM appraisal by extending the life from just over 15 to 18 years of operation, the NPV of our "recalculated" evaluation, discounted at 8%, rises from - $12.2 million to - $7.9 million and the IRR rises from 5.3% to 6.5%.

Summary of Main Results

45. The central or "base case" results of our evaluation of the Kalol and Kandla plants are given below:-

	NPV at 12% $ million	IRR %
Kalol		
- using our own price assumptions	0.6	12.3
- using the 1969 price assumptions for gas, naphtha, fuel oil and urea	15.0	17.2
Kandla		
- using our own price assumptions	- 24.4	1)
- using the 1969 price assumptions for phos acid, potash, ammonia, urea and DAP	- 37.9	1)

Note

1) No positive IRR

46. The comparison of the 1969 OIM appraisal and our evaluation can be summarised as follows:-

	NPV at 8% $ million	IRR %
1969 OIM appraisal of Kalol and Kandla [1]		
- uncorrected	4.6	3)
- corrected for apparent errors	- 13.1	6.0
1980 evaluation of Kalol and Kandla [2]		
- using our own price assumptions	- 14.6	4.6
- using the 1969 price assumptions for outputs and main inputs and		
life of 15 full operating years	- 12.2	5.3
life of 18 full operating years	- 7.9	6.5

Notes

1) The 1969 OIM appraisal assumed a project life of just over 18 operating years.

2) Our evaluation assumes a life of just over 15 operating years unless stated otherwise.

3) Not calculated.

TABLE 4.1 - INTERNATIONAL PRICE INDEX AND EXCHANGE RATES

Year July-June	Exchange Rates $ per Rupee 1)	$ per £ Sterling 2)	International Price Index 3)
1968/69	0.133	2.40	100
1969/70	0.133	2.40	106
1970/71	0.133	2.42	116
1971/72	0.133	2.48	127
1972/73	0.130	2.48	147
1973/74	0.128	2.38	180
1974/75	0.123	2.28	215
1975/76	0.115		233
1976/77	0.113		244
1977/78	0.118		273
1978/79	0.122 4)		313
1979/80	0.123 4)		349 4)

Notes

1. The rupee exchange rate has been based on an IMF series for the fiscal year April-March adjusted to give estimates for the financial year July-June.

2. The sterling exchange rate has been based on the UK CSO "Financial Statistics" for calendar years, adjusted to give estimates for July-June.

3. The international price index is the World Bank's cif index of US dollar prices of industrialised countries' manufactured exports (SITC 5-8) to developing countries, interpolated to cover the relevant financial years and transposed to a 1968/69 base.

4. Estimates.

TABLE 4.2 - INITIAL CAPITAL COSTS IN FOREIGN EXCHANGE

		$ million	£ million
Kalol			
- ammonia plant, battery limits	17.124		
- other engineering & equipment costs in $	0.040		
- CFI costs (estimated breakdown)	1.200		
- urea plant, offsites & other costs in £			5.279
Sub-total		18.364	5.279
Kandla			
- NPK plant & offsites, $ costs	0.828		
- other engineering & equipment costs in $	0.009		
- CFI costs (estimated breakdown)	0.512		
- £ costs			0.947
Sub-total		1.349	0.947
Total		19.713	6.226

Source: CW Project Completion Report, July 1978

TABLE 4.3 - ESTIMATED PHASING OF INITIAL FOREIGN EXCHANGE CAPITAL COSTS

	Dollar Costs		Sterling Costs			Total
	% of Total	$ million	% of Total	£ million	$ million[1)]	$ million
Kalol						
1971/72	30	5.51	25	1.320	3.27	8.78
1972/73	58	10.65	40	2.111	5.24	15.89
1973/74	10	1.84	30	1.584	3.77	5.61
1974/75	2	0.36	5	0.264	0.60	0.96
Total	100	18.36	100	5.279	12.88	31.24
Kandla						
1971/72	55	0.74	40	0.379	0.94	1.68
1972/73	30	0.41	50	0.473	1.17	1.58
1973/74	12	0.16	10	0.095	0.23	0.39
1974/75	3	0.04	-	-	-	0.04
Total	100	1.35	100	0.947	2.34	3.69

Note

1. £ have been converted to $ using the exchange rates in Table 4.1.

TABLE 4.4 - INITIAL CAPITAL COSTS IN RUPEES

	Financial Costs (Rs m)	Conversion Factor (No)	Economic Costs (Rs m)
Kalol			
Land & site preparation	3.5	1.0	3.5
Ammonia & urea plants, and offsites			
- Indian equipment, spares & civil works/ construction	142.5	0.7	99.8
- Engineering & supervision	38.4	1.0	38.4
- Import duties & sales taxes	67.0	-	-
- Other	20.0	0.8	16.0
Works outside contracts			
- Railways	13.7	0.75	10.3
- Township	13.6	0.8	10.9
- Other	24.4	0.8	19.5
Project management & contingencies			
- Net start-up costs	18.1	0.8	14.5
- Other	13.9	0.8	11.1
Estimated allocation of overheads			
- Financing costs	62.4	0.1	6.2
- Head office etc.	10.0	0.8	8.0
Total Kalol	427.5		238.2
Kandla			
Land & site preparation	9.3	1.0	9.3
NPK plant and offsites			
- Indian equipment, engineering and civil works/construction	103.9	0.8	83.1
- Import duties & sales taxes	7.3	-	-
- Other	4.2	0.8	3.4
Works outside contracts			
- Railway facilities & equipment	15.4	0.75	11.6
- Township	12.8	0.8	10.2
- Other	37.5	0.8	30.0
Project Management	1.2	0.8	1.0
Estimated allocation of overheads			
- Financing costs	20.0	0.1	2.0
- Head office etc	3.5	0.8	2.8
Total Kandla	215.1		153.4

Source: IFFCO

TABLE 4.5 - ESTIMATED PHASING OF INITIAL RUPEE CAPITAL COSTS

	Year	% of Total	Rs Million	$ Million
Kalol				
	1971/72	10	23.8	3.17
	1972/73	50	119.1	15.48
	1973/74	30	71.5	9.15
	1974/75	10	23.8	2.93
	Total	100	238.2	30.73
Kandla				
	1971/72	30	46.0	6.12
	1972/73	50	76.7	9.97
	1973/74	15	23.0	2.94
	1974/75	5	7.7	0.95
	Total	100	153.4	19.98

Note

1. The conversion from rupees to dollars has been made using the exchange rates in Table 4.1.

TABLE 4.6 - CAPITAL COSTS OF INITIAL PLANTS AT ECONOMIC PRICES

$ million

	1971/72	1972/73	1973/74	1974/75	Total
Kalol, Current $					
- foreign exchange costs[1]	8.78	15.89	5.61	0.96	31.24
- rupee costs[2]	3.17	15.48	9.15	2.93	30.73
- total	11.95	31.37	14.76	3.89	61.97
Kandla, Current $					
- foreign exchange costs[1]	1.68	1.58	0.39	0.04	3.69
- rupee costs[2]	6.12	9.97	2.94	0.95	19.98
- total	7.80	11.55	3.33	0.99	23.67
Kalol, 1968/69 $ [3]	9.41	21.34	8.20	1.81	40.76
Kandla, 1968/69 $ [3]	6.14	7.86	1.85	0.46	16.31

Notes

1. From Table 4.3
2. From Table 4.5
3. Current $ deflated by the international price index in Table 4.1

TABLE 4.7 - ADDITIONAL CAPITAL COSTS AT ECONOMIC PRICES

	Year	Current Rs million	Current $ million	1968/69 $ million
Kalol	1975/76	56	6.44	2.76
	1979/80	75	9.23	2.64
	1981/82		5.00[1)]	1.43
	1984/85		3.00[1)]	0.86
Kandla	1976/77	25	2.83	1.16
	1980/81		1.00[1)]	0.29

Note

The current costs incurred from 1979/80 onwards are expressed in 1979/80 dollars.

TABLE 4.8 - KALOL/KANDLA PRODUCTION DATA 1974/75 - 1979/80

Metric Tons '000

	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80 1)
Kalol:-						
Ammonia	62.9	185.1	248.1	263.2	276.2	261.0
Urea	56.4	241.0	312.1	305.0	347.4	310.0
Kandla (NPK):-						
10 : 26 : 26	15.6	22.0	73.1	81.2	79.2	55.6
12 : 32 : 16	25.8	105.5	295.3	435.8	471.8	454.4
22 : 22 : 11	8.7	-	-	-	-	-
24 : 24 : 0	9.9	34.5	-	-	-	-
Total	60.0	162.1	368.4	517.0	551.0	510.0

Source: IFFCO

Note

1. The 1979/80 figures are targets for the year. Actual production was:-

Kalol as at 19 May 1980:-	Ammonia	227,500t
	Urea	264,400t
Kandla as at 21 May 1980:-	10:26:26	48,600t
	12:32:16	408,000t

TABLE 4.9 - USE OF AMMONIA PRODUCTION 1974/75 - 1978/79

Metric Tons '000

	1974/75	1975/76	1976/77	1977/78	1978/79
Used at Kalol for					
- urea production	n.a	146.2	183.3	177.8	202.5
- offsites	n.a	1.3[3]	1.5	1.7	1.7
Sub-total	34.5[1]	147.5	184.8	179.5	204.2
Despatches to					
- Kandla plant	9.9[2]	17.7[2]	45.9	71.8	68.3
- other consumers	10.8	23.5	19.3	7.2	6.2
Sub-total	20.7	41.2	65.2	79.0	74.5
Change in Kalol stocks	7.7	(3.6)	(1.9)	4.7	(2.5)
Total Production	62.9	185.1	248.1	263.2	276.2

Notes

1. Estimated on basis of about 0.61t ammonia per 1 t of urea production.
2. Balancing figure (but also checked against Kandla consumption of ammonia from Kalol over the period).
3. Estimate

TABLE 4.10 - USE OF UREA PRODUCTION 1974/75 - 1978/79

Metric Tons '000

	1974/75	1975/76	1976/77	1977/78	1978/79
Despatches to					
- Kandla plant[1]	8.6	15.2[2]	12.7	13.1	11.8
- consumers/warehouses	39.5	221.8	300.0	287.9	350.6
Sub-total	48.1	237.0	312.7	301.0	362.4
Change in Kalol stocks	8.3	4.0[2]	(0.6)	4.0	(15.0)
Total Production	56.4	241.0	312.1	305.0	347.4

Notes

1. Despatches to Kandla plant are balancing volumes, but agree well with details of consumption of urea at Kandla.
2. These figures have been marginally adjusted to agree with Kandla urea consumption data.

TABLE 4.11 - ANALYSIS OF NPK PRODUCTION 1974/75 - 1978/79

Metric Tons '000

	1974/75	1975/76	1976/77	1977/78	1978/79
12 : 32 : 16					
- sales/warehouses	16.5	114.5	280.2	429.8	484.4
- stock movement	9.3	(9.0)	15.1	6.0	(12.6)
10 : 26 : 26					
- sales/warehouses	10.4	27.1	64.5	87.2	80.2
- stock movement	5.2	(5.1)	8.6	(6.0)	(1.0)
24 : 24 : 0					
- sales/warehouses	4.8	39.6	-	-	-
- stock movement	5.1	(5.1)	-	-	-
22 : 22 : 11					
- sales/warehouses	1.0	7.7	-	-	-
- stock movement	7.7	(7.7)	-	-	-
Total Production	60.0	162.1	368.4	517.0	551.0

Note

Some of the figures have been massaged a little to make them consistent with the data on production and despatches.

TABLE 4.12 – IMPORT PRICES FOR CALCULATION OF ECONOMIC BENEFITS

US $ per Metric Ton

	Actual					Projections 1)										
	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90
Urea – current $/t	276 2) 3)	277 2) 3)	128 2) 3)	149 2) 3)	162 2) 3)	238	243	247	255	270	285	300	302	305	307	310
– 1968/69 $/t	128	119	52.5	54.6	51.5	64.9	66.2	67.3	69.5	73.6	77.7	81.8	82.3	83.1	83.7	84.5
Ammonia – 1968/69 $/t 4)	115	107	47.3	49.1	46.6	58.4	59.6	60.6	62.6	66.2	69.9	73.6	74.1	74.3	75.3	76.1
DAP – current $/t	282 2)	319 2)	161 2)	175 2)	165 2)	280	297	300	315	330	345	365	367	369	371	373
– 1968/69 $/t	131	137	66.0	64.1	52.7	76.3	80.9	81.8	85.5	89.9	94.0	99.5	100	101	101	102
Potash 5) – current $/t	90.2 2)	97.0 2)	77.6 2)	77.6 2)	86.2 2)	135	140	140	140	140	140	142	144	146	149	152
– 1968/69 $/t	42.0	41.6	31.8	28.4	27.5	36.8	38.2	38.2	38.2	38.2	38.2	38.7	39.2	39.3	40.6	41.4
NPK – 1968/69 $/t 6)																
12:32:16	93.6	97.1	52.4	50.3	43.4	59.7	62.8	63.4	65.8	68.2	70.6	74.0	74.5	75.2	75.4	76.2
10:26:26	85.6	88.3	50.0	47.7	41.8	57.1										
24:24:0	103.2	103.1														
22:22:11	102.4	102.1														

Notes

1. The projections in "current dollars" are in 1980 prices and have been deflated by a factor of 3.67 to give 1968/69 dollars.
2. The import prices of urea, DAP and potash in current dollars have been calculated from the values and volumes of imports given in "Fertilizer Statistics" produced by the Fertilizer Association of India. The import statistics relate to financial years April-March, but have not been adjusted. The prices have been converted from rupees to dollars using the IMF exchange rates for the financial years April-March.
3. The historical urea prices are assumed to relate primarily to imports in bags, but it is known that there have also been some bulk imports. $3/t in 1974/75 rising to $6/t in 1978/79 has been added to the cif import prices to cover handling and storage at port and any bagging costs.
4. In the absence of reliable data, the ammonia price is assumed to be 90% of the urea price. Differential transport costs are assumed to be insignificant.
5. Pure muriate of potash (100% KCL).
6. The basis for the valuation of the NPK compounds is that:–

   1 t of 12:32:16 contains 595 kg DAP and 254 kg KCL
   1 t of 10:26:26 contains 483 kg DAP and 412 kg KCL
   1 t of 24:24:0 contains 446 kg DAP and 311 kg urea
   1 t of 22:22:11 contains 409 kg DAP, 235 kg urea, and 174 kg KCL.

   A further $5 per t at 1968/69 prices has been added to cover the costs of handling and bagging.

TABLE 4.13 – MATERIAL INPUT COSTS, KALOL 1974/75 – 1978/79

	← Actual →					← Projections →			
	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83–1989/90
Gas consumption, quantity									
– natural gas million m^3	51.2[1]	149.1	168.5	180.6	178.4	171	177	187	187 p.a.
– associated gas million m^3	22.5	69.8	67.3	67.9	61.0	53.3	55.4	58.4	58.4 p.a.
Naphtha									
– quantity '000 t	16.2	44.8	55.5	60.0	65.1	64.7	67.2	71.0	71.0 p.a.
– current price $/t[2]	124	135	135	134	135	300	300	309	3)
– value 1968/69 $ m	0.9	2.6	3.1	2.9	2.8	5.3[4]	5.3[4]	6.0[4]	3)
Fuel Oil									
– quantity '000 t	6.5[1]	26.5	36.2	36.6[1]	37.1	37.2	38.4	42.0	42.0 p.a.
– current price $/t[4]	70	71	77	86	85	125	165	170	3)
Gas as Fuel Oil Equivalent[6]									
– natural gas '000 t	47.6	138.7	156.7	168.0	165.9	159.0	164.6	173.9	173.9 p.a.
– associated gas '000 t	22.1	68.4	66.0	66.5	59.8	52.2	54.3	57.2	57.2 p.a.
Value of Gas & Fuel Oil									
– quantity '000 t of fuel oil	76.2	234	259	271	263	248	257	273	273 p.a.
– value 1968/69 $ m	2.5	7.1	8.2	8.5	7.1	8.4[4]	11.6[4]	12.6[4]	3)

Notes

1. Estimated
2. Naphtha prices for 1974/75 – 1978/79 based on import and export data in annual reports of GOI department of Petroleum and include small allowance for differential handling and internal transport costs. Projections based on 1.4 times the crude oil prices, expressed in constant 1980 prices.
3. Naphtha and fuel oil prices are assumed to increase at 3% p.a. in real terms from 1980/81 onwards.
4. Values in constant 1980 $ have been deflated by a factor of 3.67 to give 1968/69 $.
5. Fuel oil prices for 1974/75 – 1978/79 derived in same way as naphtha prices (Note 2). Projections expressed in constant 1980 prices.
6. Gas expressed as fuel oil equivalent assuming 0.93 and 0.98 t fuel oil per 1000 m^3 of natural and associated gas respectively.

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TABLE 4.14 – OTHER[1] OPERATING COSTS, KALOL, 1974/75 – 1978/79

Rs million

	1974/75		1975/76		1976/77		1977/78		1978/79	
	Financial Prices	Economic Prices	Financial Prices	Economic Prices	Financial Prices	Economic Prices	Financial Prices	Economic Prices	Financial Prices	Economi Prices
Employees Remuneration & Benefits	2.6	2.6	10.6	10.6	10.5	10.5	9.5	9.5	11.6	11.6
Catalysts & Chemicals	1.5	1.5	10.4	10.4	8.0	8.0	11.7	11.7	13.1	13.1
Tools & Stores	} 3.5	3.2	} 12.0[2]	10.8	3.4	3.1	3.1	2.8	2.9	2.6
Spares for Plant & Machinery					12.6	11.3	12.9	11.6	19.8	17.8
Power	} 1.7[2]	1.7	} 9.3[2]	9.3	6.5	6.5	6.1	6.1	7.9	7.9
Water					2.7	2.7	2.7	2.7	2.8	2.8
Bags	3.6	3.6	17.2	17.2	22.3	22.3	22.9	22.9	29.5	29.5
Depreciation	17.5	–	45.5	–	46.9	–	48.6	–	49.1	–
Other Manufacturing Expenses	2.2	2.2	5.6[2]	6.6	7.1	7.1	9.3	9.3	10.0	10.0
Head Offices Expenses	2.8	2.8	8.0	8.0	11.0[2]	11.0	13.5	13.5	3.9	3.9
Total	35.4	17.6	119.6	72.9	131.0	82.5	140.3	90.1	150.6	99.2

Source:– IFFCO, Delhi and Kalol

Notes

1. Operating costs other than costs of Natural and Associated Gas, Naphtha and Fuel Oil.
2. Estimated breakdown of certain aggregate costs.

106.

TABLE 4.13 - MATERIAL INPUT COSTS, KANDLA, 1974/75 - 1989/90

	Actual					Projections										
	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90
Phosphoric Acid																
- quantity '000 t of P_2O_5 1)	14.7	31.5	112.4	151.7	179.6	168	168	168	168	168	168	168	168	168	168	168
- current price $/t 2)	365	446	285	275	301	360	373	379	393	407	421	435	436	437	439	441
- price 1968/69 $/t	168	191	117	102	96.2	98.1	102	103	107	111	115	119	119	119	120	120
- value 1968/69 $ million	2.5	6.0	13.2	15.7	17.3	16.5	17.1	17.3	13.0	18.6	19.3	19.9	20.0	20.0	20.1	20.2
Potash (50% K_2O)																
- quantity '000 t 1)	15.8	39.9	117.4	151.5	166.3	147	147	147	147	147	147	147	147	147	147	147
- price 1968/69 $/t 3)	40.0	39.6	30.3	27.0	26.2	35.0	36.4	36.4	36.4	36.4	36.4	36.9	37.3	37.9	38.7	39.4
- value 1968/69 $ million	0.6	1.6	3.6	4.3	4.4	5.1	5.3	5.3	5.3	5.3	5.3	5.4	5.5	5.6	5.7	5.8
Ammonia																
- quantity '000 t 1)	7.2	15.8	50.9	74.1	81.5	75	75	75	75	75	75	75	75	75	75	75
- price 1968/69 $/t 4)	115	107	47.3	49.1	46.6	58.4	59.6	60.6	62.6	66.2	69.9	73.6	74.1	74.8	75.3	76.1
- value 1968/69 $ million	0.8	1.7	2.4	3.6	3.8	4.4	4.5	4.5	4.7	5.0	5.2	5.5	5.6	5.6	5.6	5.7
Urea																
- quantity '000 t 1)	8.0	15.6	8.0	12.5	12.2	13	13	13	13	13	13	13	13	13	13	13
- price 1968/69 $/t 4)	128	119	52.5	54.5	51.8	64.9	66.2	67.3	69.5	73.6	77.7	81.8	82.3	83.1	83.7	84.5
- value 1968/69 $ million	1.0	1.9	0.4	0.7	0.6	0.8	0.9	0.9	0.9	1.0	1.0	1.1	1.1	1.1	1.1	1.1
Mono-ammonium Phosphate																
- quantity '000 t 1)	5.5	36.6	5.5	-	-	-	-	-	-	-	-	-	-	-	-	-
- current price $/t	463	337	309	-	-	-	-	-	-	-	-	-	-	-	-	-
- current value $ million	2.5	12.3	1.7	-	-	-	-	-	-	-	-	-	-	-	-	-
- value 1968/69 $ million	1.2	5.3	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Value 1968/69 $ million	6.1	16.5	20.3	25.3	26.1	26.8	27.8	28.0	28.9	29.9	30.8	31.9	32.2	32.3	32.5	32.8

Notes

1. The quantities of materials used up to 1978/79 are actual quantities consumed. The projections from 1979/80 onwards assume that the output of the plant will be 500,000t/yr of NPK 12:32:16 and that 1t of this product requires:- 0.335 t P_2O_5, 0.294t potash 60% K_2O, 0.150 t ammonia, and 0.026 t urea.
2. The phosphoric acid prices for 1974/75 - 1978/79 are based on quantities consumed and costs to IFFCO net of import duties. The "Current" price projections from 1979/80 onwards are all in 1980 prices and have been deflated by a factor of 3.67 to give 1968/69 dollars.
3. The potash prices in Table 4.12 relate to pure (100%) KCl which is equivalent to 63% K_2O. The potash used by IFFCO is equivalent to 60% K_2O so that the prices in Table 4.12 have been reduced by a factor of 1.05 (i.e. 63/60).
4. The prices in Table 4.12.
5. Prices net of import duties, based on data provided by IFFCO.

TABLE 4.16 – OTHER [1] OPERATING COSTS, KAMPALA 1974/75 – 1978/79

Fr million

	1974/75		1975/76		1976/77		1977/78		1978/79	
	Financial Prices	Economic Prices	Financial Prices	Economic Prices	Financial Prices	Economic Prices	Financial Prices	Economic Prices	Financial Prices	Economic Prices
Employees Remuneration & Benefits	2.2	2.2	5.6	5.6	6.5	6.5	7.5	7.5	8.6	8.6
Chemicals	0.1	0.1	0.2	0.2	0.2	0.2	0.4	0.4	0.6	0.6
Filler	0.1	0.1	0.4	0.4	0.7	0.7	1.0	1.0	1.0	1.0
Tools & Spares	0.9	0.8	0.9	0.8	1.1	1.0				
Maintenance	–[2]	–	2.4[2]	2.2	11.0[2]	10.5	13.1	11.8	19.7	17.7
Fuel Oil							4.5	4.5	4.7	4.7
Power	1.7	1.7	5.9	5.9	8.0	8.0	4.7	4.7	5.2	5.2
Water							0.2	0.2	0.5	0.5
Wages	2.8	2.8	13.8	13.8	23.0	23.0	37.4	37.4	43.0	43.0
Depreciation	6.5	–	13.6	–	14.4	–	14.5	–	16.0	–
Other Manufacturing Expenses	0.3	0.3	5.0[2]	5.0	7.0[2]	7.0	7.5	7.5	10.5	10.5
Head Office Expenses	2.3	2.0	8.0	8.0	11.0[2]	11.0	22.4	22.4	6.6	6.6
Total	17.4	16.8	55.8	41.9	83.7	68.8	120.5	104.4	116.4	98.4

Source: IDCC

Notes

- Operating costs other than costs of Ammonia, Urea, Phosphoric Acid, Potash and MAP.
- Estimated breakdown of certain aggregate costs.

TABLE 4.17 - WORKING CAPITAL, KALOL (ECONOMIC PRICES)

	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82-89/90
Urea - '000 t [1]	8.3	12.3	11.7	15.7	0.7	8.0	15.0	15.0
- 1968/69 $m [2]	1.1	0.4	(0.8)	0.2	(0.8)	0.5	0.5	- [3]
Ammonia - '000 t [1]	7.7	4.1	2.2	6.9	4.4	5.0	6.0	6.0
- 1968/69 $m [2]	0.9	(0.4)	(0.3)	0.2	(0.1)	0.1	0.1	- [3]
Other - 1968/69 $m [4]	0.1	0.2	-	-	-	0.3	-	- [3]
Total	2.1	0.2	(1.1)	0.4	(0.9)	0.9	0.6	- [3]

Notes

1. End-year stock levels at Kalol.
2. The stock levels have been valued in 1968/69 $ using the prices in Table 4.12, and the figures shown give the changes in the value of the stocks each year.
3. From 1980/81 onwards the stock levels of urea, ammonia and raw materials etc are assumed to remain constant. For simplicity, no allowance has been made for increases in the real value of these stocks, but against this no allowance has been made for a positive terminal value of the goods in 1989/90.
4. Stocks of raw materials and other goods are small, as are the real resource costs of financial working capital. The figures give additions to this "other" working capital.

TABLE 4.18 - WORKING CAPITAL, KANDLA (ECONOMIC PRICES)

	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81-1989/90
K Stocks, '000 t [1]							
12:32:16	9.3	0.3	15.4	21.4	8.8	20.0	20.0
10:26:26	5.2	0.1	8.7	2.7	1.7	-	-
Other	12.8	-	-	-	-	-	-
ange in Value NPK tocks - 1968/69 $ m [2]							
12:32:16	0.9	(0.8)	0.8	0.3	(0.7)	0.8	- [3]
10:26:26	0.4	(0.4)	0.4	(0.3)	(0.1)	-	-
Other	1.3	(1.3)	-	-	-	-	-
ange in Other Working Capital 1968/69 $ m [4]	6.7	(4.7)	(0.9)	1.3	(0.1)	0.5	- [3]
tal	9.3	(7.2)	0.3	1.3	(0.9)	1.3	- [3]

tes

End-year stock levels.

The stock levels have been valued in 1968/69 $ using the prices in Table 4.12, and the figures shown give the changes in the value of NPK stocks each year.

The value of working capital has not been increased in line with the real rise in prices after 1979/80, but against this no allowance has been made for a positive terminal value of the stocks in 1989/90.

Mainly stocks of raw materials based on the values in IFFCO's balance sheets.

TABLE 4.19 – COST-BENEFIT ANALYSIS, KALOL, 1980 PRICE ASSUMPTIONS

1968/69 US Dollars million

	1971/2	1972/3	1973/4	1974/5	1975/6	1976/7	1977/8	1978/9	1979/80	1980/1	1981/2	1982/3	1983/4	1984/5	1985/6	1986/7	1987/8	1988/9	1989/90
Capital Costs																			
– original plants[1]	9.4	21.3	3.2	1.8															
– additional investments[3]					2.0				2.6		1.4			0.9					(4.1)[2]
Operating Costs																			
– gas, naphtha & fuel oil[4]				3.4	9.7	11.3	11.4	9.9	13.7	16.9	18.6	19.2	19.7	20.3	20.9	21.6	22.2	22.9	23.6
– other[5]				1.0	3.6	3.8	3.9	3.9	4.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Working Capital[6]				2.1	0.2	(1.1)	0.4	(0.9)	0.9	0.6									
Total Costs	9.4	21.3	8.2	8.3	16.3	14.0	15.7	12.9	21.2	22.0	24.5	23.7	24.2	25.7	25.4	26.1	26.7	27.4	24.0
Benefits																			
– urea[7]				6.2	28.2	16.4	16.4	13.8	19.6	20.7	23.6	24.3	25.3	27.2	28.6	28.8	29.1	29.3	29.6
– ammonia[8]				2.4	4.4	3.1	3.9	3.5	4.3	4.6	4.5	4.7	5.0	5.2	5.5	5.6	5.6	5.6	5.7
– Total				8.6	32.6	19.5	20.3	22.3	23.9	25.3	28.1	29.0	30.3	32.4	34.1	34.4	34.7	34.9	35.3
Net Benefits	(9.4)	(21.3)	(8.2)	0.3	16.3	5.5	4.6	9.4	2.7	3.3	3.6	5.3	6.6	6.7	8.7	8.3	8.0	7.5	11.3

Notes

1. Table 4.6.
2. Terminal value of plant at 10% of original plant capital costs.
3. Table 4.7.
4. Table 4.13.
5. Table 4.14 and paragraph 27.
6. Table 4.17
7. Despatches in Table 4.10 valued at price in Table 4.12.
8. Despatches in Table 4.9 valued at price in Table 4.12.

NPV discounted at 10% back to 1970/71 = [illegible] million
Internal rate of return = [illegible]

TABLE 4.20 - SENSITIVITY ANALYSIS RESULTS, 1980 PRICE ASSUMPTIONS

	NPV at 12% $m	IRR %
Kalol		
Base Case	0.6	12.3
Sensitivity analysis:-		
Capital costs up 10% over whole period		10.7
Gas costs up 10% over whole period		10.3
Gas costs down 10% over whole period		14.1
Gas costs down 50% over whole period		20.0
Gas, naphtha & fuel oil costs up 10% over years 1979/80 - 1989/90		8.7
Gas, naphtha & fuel oil costs down 10% over years 1979/80 - 1989/90		15.2
Benefits up 10% over years 1979/80 - 1989/90		17.4
Benefits down 10% over years 1979/80 - 1989/90		5.4
Extend life by 2 years deleting terminal value		12.7
Extend life by 5 years deleting terminal value		13.3
Kandla		
Base Case	(24.4)	1)
Sensitivity analysis:-		
Capital costs down 20%	(21.6)	1)
MAP/Phos acid costs down over whole period by:-		
10%	(17.0)	1)
20%	(9.5)	5.7
30%	(2.1)	10.7
MAP/Phos acid costs down 1979/80 - 1989/90		
30%	(11.2)	5.9
40%	(6.8)	3.6
50%	(2.4)	10.9
Ammonia/urea costs down by 20% whole period	(19.9)	1)
Phos acid and ammonia/urea costs down by:-		
25% over whole period	(0.2)	11.9
40% over 1979/80 - 1989/90	(1.1)	11.5
Benefits up by:-		
10% over whole period	(12.0)	4.1
20% over whole period	0.4	12.2
20% over 1979/80 - 1989/90	(8.2)	7.8
30% over 1979/80 - 1989/90	(0.1)	11.9

Note

1. No positive IRR

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TABLE 4.21 - COST-BENEFIT ANALYSIS, KALOL, 1969 PRICE ASSUMPTIONS

1968/69 US Dollars million

Year	Capital Costs[1]	Operating Costs: Raw Materials[2]	Operating Costs: Other[1]	Operating Costs: Total	Working Capital[3]	Benefits[3]	Net Benefits
1971/2	9.4						(9.4)
1972/3	21.3						(21.3)
1973/4	8.2						(8.2)
1974/5	1.8	1.5	1.0	2.5	1.0	3.6	(1.7)
1975/6	2.8	4.6	3.6	8.2	0.2	15.0	3.8
1976/7		5.2	3.8	9.0	(0.1)	20.4	11.5
1977/8		5.5	3.9	9.4	0.4	20.5	10.7
1978/9		5.5	3.9	9.4	(0.9)	23.6	15.1
1979/80	2.6	5.2	4.0	9.2	0.4	20.2	8.0
1980/1		5.4	4.5	9.9	0.4	21.0	10.7
1981/2	1.4	5.7	4.5	10.2		23.0	11.4
1982/3		5.7	4.5	10.2		23.0	12.8
1983/4		5.7	4.5	10.2		23.0	12.8
1984/5	0.9	5.7	4.5	10.2		23.0	11.9
1985/6		5.7	4.5	10.2		23.0	12.8
1986/7		5.7	4.5	10.2		23.0	12.8
1987/8		5.7	4.5	10.2		23.0	12.8
1988/9		5.7	4.5	10.2		23.0	12.8
1989/90		5.7	4.5	10.2		28.5[4]	18.3

NPV discounted at 12% back to 1970/71 = $15.0 million
Internal rate of return = 17.2%

Notes

1. Same as Table 4.19.
2. Gas valued at $14.5 per 1000 m^3; naphtha at $20/t; and fuel oil at $18/t.
3. Urea valued at $55/t and ammonia at 0.9 x urea price.
4. Includes terminal value of $5.5 million (i.e. $4.1 m being 10% of initial capital costs plus $1.4 m for working capital).

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TABLE 4.22 – COST-BENEFIT ANALYSIS, NATURAL, 19X PRICE ASSUMPTIONS

1965/6 US Dollars million

	1971/2	1972/3	1973/4	1974/5	1975/6	1976/7	1977/8	1978/9	1979/80	1980/1	1981/2	1982/3	1983/4	1984/5	1985/6	1986/7	1987/8	1988/9	1989/90
Capital Costs																			
– original plants[1]	6.1	7.9	1.9	0.5															(1.6)[2]
– additional investments[3]						1.2				0.3									
Operating Costs																			
– phosphoric acid[4]				2.5	6.0	13.2	16.7	17.3	16.5	17.1	17.3	18.0	18.6	19.3	19.9	20.0	20.0	20.1	20.2
– other raw materials[5]				3.6	10.5	7.1	9.6	5.8	10.3	10.7	10.7	10.9	11.3	11.5	12.0	12.2	12.3	12.4	12.6
– other operating costs[6]				0.6	2.1	3.1	4.5	3.8	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Working Capital[7]				9.3	(7.2)	0.3	1.3	(0.9)	1.3										
Total Costs	6.1	7.9	1.9	16.5	11.4	24.9	31.1	29.0	31.6	31.6	31.5	32.4	33.4	34.3	35.4	35.7	35.3	36.0	34.7
Benefits[3]																			
– 12:32:16				1.5	11.1	14.7	21.6	21.0	29.2	31.4	31.7	32.9	34.1	35.3	37.0	37.3	37.6	37.7	38.1
– 10:26:26				0.9	2.4	3.2	4.2	3.4	0.1	–	–	–	–	–	–	–	–	–	–
– Other NPK				0.6	4.9	–	–	–	–	–	–	–	–	–	–	–	–	–	–
– Total				3.0	18.4	17.9	25.8	24.4	29.3	31.4	31.7	32.9	34.1	35.3	37.0	37.3	37.6	37.7	38.1
Net Benefits	(6.1)	(7.9)	(1.9)	(13.5)	7.0	(7.0)	(5.3)	(4.6)	(2.3)	(0.2)	0.2	0.5	0.7	1.0	1.6	1.6	1.8	1.7	3.4

Notes

1. Table 4.6
2. Terminal value of plant at 10% of original plant capital cost.
3. Table 4.7
4. Table 4.15
5. Costs of potash, ammonia, urea and MAP in Table 4.15.
6. Table 4.16 and paragraph 30.
7. Table 4.18
8. Quantities sold or despatched to warehouses in Table 4.11 valued at prices in Table 4.12.

NPV discounted at 10% back to 1970/71 = –$24.4 million.
No positive internal rate of return.

TABLE 4.23 - COST-BENEFIT ANALYSIS, KANDLA, 1969 PRICE ASSUMPTIONS

1968/69 US Dollars million

Year	Capital Costs 1)	Operating Costs: Raw Materials 2)	Operating Costs: Other 1)	Operating Costs: Total	Working Capital 3)	Benefits 3)	Net Benefits
1971/2	6.1						(6.1)
1972/3	7.9						(7.9)
1973/4	1.9						(1.9)
1974/5	0.5	4.9	0.6	5.5	8.5	2.3	(12.2)
1975/6		13.7	2.1	15.8	(6.4)	12.8	3.4
1976/7	1.2	26.1	3.1	29.2	0.8	24.0	(7.2)
1977/8		36.5	4.5	41.0	1.3	36.1	(6.2)
1978/9		39.5	3.8	43.3	(1.1)	39.4	(2.8)
1979/80		36.2	3.5	39.7	1.2	34.3	(6.6)
1980/1	0.3	36.2	3.5	39.7		35.0	(5.0)
1981/2		36.2	3.5	39.7		35.0	(4.7)
" "		"	"	"		"	"
" "		"	"	"		"	"
" "		"	"	"		"	"
1988/9		36.2	3.5	39.7		35.0	(4.7)
1989/90		36.2	3.5	39.7		40.9 4)	1.2

NPV discounted at 12% back to 1970/71 = -$37.9 million

Notes

1. Same as Table 4.22.
2. Phosphoric acid valued at $146/t; potash at $51.8/t; ammonia at $49.5/t (i.e. 0.9 x urea price); urea at $55/t; and MAP at same prices as in Table 4.22.
3. NPK products valued using same co-efficients as in Note 6 to Table 4.12, a DAP price of $87/t, potash $52/t (the same as the input price), and urea $55/t. A further $5/t has been added for handling and bagging of import substitutes.
4. Includes terminal value of $5.9 million (i.e. $1.6m being 10% of initial capital costs plus $4.3m for working capital).

APPENDIX V

PROFITABILITY STATEMENTS, BALANCE SHEETS, AND FERTILIZER PRICES

TABLE 5.1 – PROFITABILITY STATEMENT KALOL, 1974/75 – 1978/79

Rs million

	1974/75		1975/76		1976/77		1977/78		1978/79	
Income										
Sales of urea and ammonia	55.1		342.1		474.4		498.0		503.3	
Transfers of urea and ammonia to Kandla	11.7		19.7		26.8		43.3		41.5	
Other revenue	10.7		29.5		14.0		10.1		58.7	
Stock variation	(23.4)		44.8		5.9		(28.8)		(13.9)	
Total Income		54.1		436.1		521.0		522.5		589.6
Expenditure										
Manufacturing expenses										
– gas & naphtha	18.0		56.5		66.9		72.4		74.8	
– bags	3.6		17.2		22.3		22.9		29.5	
– power, fuel oil & water	5.7		32.8		41.5		41.5		43.7	
– employees remuneration	2.6		10.6		10.5		9.5		11.6	
– other production costs	7.2		29.0		28.5		33.7		45.9	
Sub-total		37.1		146.1		169.7		180.0		205.5
Marketing costs										
– marketing overheads	1.7		4.7		11.2		10.1		20.8	
– excise duty	6.2		45.7		54.6		50.7		57.0	
– freight	3.4		28.8		27.9		19.8		25.6	
– pool equalisation charges	–		54.9		37.3		18.7		22.8	
– FICC charges	–		–		–		35.5		70.2	
– interest on bills discounted	0.5		–		0.3		–		–	
Sub-total		11.8		134.1		131.2		134.9		196.3
Depreciation		17.5		45.5		46.9		48.6		49.1
Head Office expenses		2.8		8.0		57.3		13.5		3.9
Interest		12.9		54.4				35.1		37.9
Total Expenditure		82.1		388.1		405.0		412.1		492.8
Net Profit		(28.0)		48.1		116.0		110.4		96.9

Source: IFFCO

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TABLE 5.2 – PROFITABILITY STATEMENT KANDLA, 1974/75 – 1978/79

Rs million

	1974/75		1975/76		1976/77		1977/78		1978/79	
Income										
Sales of NPK	82.4		284.1		642.7		966.1		1084.2	
Subsidy on P_2O_5	–		–		133.1		200.3		171.6	
Other Revenue	0.9		34.0		24.4		24.9		42.9	
Stock variation	75.7		103.9		20.1		(23.5)		(27.7)	
Total Income		158.9		422.0		820.3		1,167.8		1,271.0
Expenditure										
Manufacturing expenses										
– raw materials	114.6		313.8		457.3		601.4		685.0	
– bags	2.8		13.8		23.0		37.4		43.0	
– power, fuel oil & water	1.7		5.9		8.0		9.4		10.5	
– employees remuneration	2.2		5.6		6.5		7.5		8.6	
– other production costs	1.2		8.5		17.5		23.6		30.8	
Sub-total		122.5		347.7		512.3		679.3		777.9
Marketing costs										
– marketing overheads	3.5		2.5		14.4		16.5		35.1	
– excise duty	12.2		49.1		85.9		49.2		52.4	
– freight	4.6		16.9		34.1		119.8		112.0	
– interest on bills discounted	0.6		0.5		0.8		–		–	
Sub-total		20.9		69.1		135.2		185.6		199.5
Depreciation		6.5		13.6		14.4		14.8		16.0
Head office expenses		2.8		8.0		28.6		32.3		6.5
Interest		7.9		18.1						12.7
Total Expenditure		160.6		456.4		690.5		912.0		1,012.7
Net Profit		(1.7)		(34.4)		129.8		255.8		258.3

Source: IFFCO

TABLE 5.3 - BALANCE SHEETS, KALOL 1975 - 1979

Rs million

	30.6.75		30.6.76		30.6.77		30.6.78		30.6.79	
Fixed Assets										
Gross fixed assets	627.9		675.0		672.9		692.5		699.0	
Less accumulated depreciation	19.5		64.2		110.4		157.7		206.2	
Net fixed assets		608.4		610.8		562.5		534.8		492.8
Investments (inter unit)		-		-		-		-		25.3
Working Capital										
Current assets										
- stocks of finished goods	15.2		59.9		66.3		37.5		24.0	
- stocks of spare parts	29.5		41.4		65.4		83.8		124.6	
- stocks of raw materials	-		2.3		2.8		1.8		2.6	
- loans and advances	11.3		6.3		48.9		28.0		29.3	
- debtors	21.3		51.2		42.7		21.3		31.2	
- cash	1.0		8.5		53.2		208.4		180.1	
Sub-total	78.3		169.6		279.3		380.8		391.8	
Less current liabilities										
- bank loans	0.2		-		-		-		-	
- other current liabilities	30.0		37.2		24.8		36.8		39.9	
Sub-total	30.2		37.2		24.8		36.8		39.9	
Working Capital		48.1		132.4		254.5		344.0		351.9
Total Net Assets Employed		656.5		743.2		817.0		878.8		870.0
Financed by:-										
Capital										
Share capital	174.0		174.0		174.0		174.0		174.0	
Retained earnings	(26.9)		20.1		136.2		233.6		320.7	
Sub-total		147.1		194.1		310.2		407.6		494.7
Long-term Loans		509.4		549.1		506.8		471.2		375.3
Total Capital Employed		656.5		743.2		817.0		878.8		870.0

Source: IFFCO

TABLE 5.4 - BALANCE SHEETS, KANDLA 1975-1979

Rs million

	30.6.75		30.6.76		30.6.77		30.6.78		30.6.79	
Fixed Assets										
Gross fixed assets	195.9		205.3		223.2		239.3		277.5	
Less accumulated depreciation	7.5		20.6		35.1		49.6		64.6	
Net fixed assets		188.4		184.7		188.1		189.7		212.9
Investments (including inter unit)		0.2		0.2		0.2		0.2		50.8
Working Capital										
Current assets										
- stocks of finished goods	75.7		179.7		199.3		175.9		148.7	
- stocks of spare parts	34.9		12.1		21.1		31.6		51.6	
- stocks of raw materials	116.7		40.8		24.2		56.4		58.9	
- loans & advances	16.6		7.1		23.3		21.5		57.8	
- debtors	45.0		102.3		128.2		100.1		62.4	
- cash	1.0		11.4		16.1		162.2		380.9	
Sub-total	289.9		353.4		412.2		547.7		760.3	
Less current liabilities										
- bank loans	113.7		201.2		162.3		-		-	
- other current liabilities	79.9		77.6		67.2		131.8		144.5	
Sub-total	193.6		278.8		229.5		131.8		144.5	
Working capital		96.3		74.6		182.7		415.9		615.8
Total Net Assets Employed		284.9		259.5		371.0		605.8		879.5
Financed by:-										
Capital										
Share capital	109.0		109.0		109.0		109.0		109.0	
Retained earnings	(2.6)		(36.7)		93.0		339.7		582.9	
Sub-total		106.4		72.3		202.0		448.7		691.9
Long Term Loans		178.5		187.2		169.0		157.1		187.6
Total Capital Employed		284.9		259.5		371.0		605.8		879.5

Source: IFFCO

TABLE 5.5 - EX-FACTORY UREA AND NPK PRICES, 1974-1979

Date	Urea Kalol	Ex-Factory Price (Rs Per Metric Ton)			
		NPK, Kandla			
		12-32-16	10-26-26	24-24-0	22-22-11
7.11.74		2,500	2,400		
28.12.74	1,030	2,500	2,400		
7.4.75	1,030	3,026	2,400	2,444	
18.7.75	1,107	2,909	2,400	2,314	
15.9.75	1,168	2,909	2,400	2,314	
4.12.75	1,168	2,334	2,073	2,031	2,031
16.3.76	1,168	1,873	1,655	1,700	1,700
8.2.77	1,200	1,640	1,440	1,518	1,535
8.9.77	1,200	1,527	1,353		
1.11.77-79	1,113	1,527	1,353		

Source: IFFCO

APPENDIX VI: THOSE INTERVIEWED

We take this opportunity of thanking all those who very willingly gave us their time. Our thanks are also due to Miss J Holder, Attache (Development) BHC, who made many arrangements, and re-arrangements, for us.

British High Commission: Development Section (Delhi)

Mr M Jay	: First Secretary (Development)

Ministry of Chemicals and Fertilisers (GOI)

Mr D G Rao	: Technical Advisor (Fertilisers)

IFFCO Delhi

Mr D Talwar	: Deputy Managing Director
Dr K S Gill	: Executive Director
Mr B Ramdas	: Executive Director Finance
Mr Jayantha Rao	: Planning Manager
Mr Maha	: Planning Department
Mr K N Parthasarathy	: Deputy Financial Manager

IFFCO Kalol

Mr Joharpurkar	: General Manager
Mr Therat	: Technical Manager
Mr Parikh	: Maintenance Manager
Mr Gupta	: Production Manager

Humphreys and Glasgow

Mr D Young	: Operations Director

Cremer and Warner

Mr G H Hayward	: Staff Consultant

Overseas Development Administration

Mr K Osborne	:)	South Asia Department
Mr V McClean	:)	ODA
Mr D Curran	:)	

APPENDIX VII: TERMS OF REFERENCE

The study will be undertaken with the intention of providing a basis for the ODA and the Government of India to assess the effectiveness of ODA's past aid to the Indian fertiliser industry and to provide guidelines for any future aid to this sector. You will undertake a review of the role of British aid in assisting the planning, implementation and execution of the fertiliser complex at Kalol/Kandla through:

- a study of ODA files
- a study of consultants' reports
- a field visit to the project
- discussions with all bodies and individuals concerned with the planning, implementation and operation of the project.

you will produce a report which will:

- examine the history of the preparation of the project for approval by ODA.
- examine the implementation of the project from the time of its approval in 1971 to the time of its commencing operations in 1976.
- assess the technical performance of the plant since commencement of operations.
- undertake a technical and economic evaluation of the plant and equipment including consideration of the suitability of the production processes chosen and the technologies and materials used.
- analyse the economic and financial performance of the project.
- comment on the adequacy of the supporting infrastructure and services including the supply of inputs to the factory and the transport of the outputs to the distribution centres.
- comment on the role of the various consultants oconcerned with the design, appraisal and management of the plant.
- assess the adequacy of the project management and reporting systems.

You should recommend on ways in which the planning, implementation and operation of the plant could have been improved and provide guidelines for future similar projects.