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PREFEASIBILITY STUDY FOR THE PRODUCTION OF SYNTHETIC OIL FROM COAL INDIA

FINAL REPORT
December 1985

Unido Project No. DP/IND/82/040
Unido Contract No. 84/27/MK

Coal Processing Consultants Ltd

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

INTEROFFICE MEMORANDUM

To: Ms. Tcheknavorian-Asenbauer, Head
IO|CHEM

Date: 3 January 1986

Attn.: Mr. M. Maung

From: D. Gardellin, Acting Head
Purchase and Contract Service
Division of Industrial Operations

Ref.: MK|ho

Subject: Final Report - DP|IND|82|040 - Techno-Economic Feasibility Study for Production of Synthetic Oil from Coal

1. In accordance with the stipulations of paragraph 2.10 (d) of Contract No. 84|89, FLUOR ENGINEERS, INC., USA have provided this Office with thirty (30) copies in English of the final version of their report on the subject project.

2. We are forwarding herewith fourteen (14) copies in English * of the Contractor's report under consideration.

3. We would appreciate your reviewing this report as soon as feasible and your advising this Section of its acceptability.

4. If the Contractor's report is acceptable, copies should be distributed in accordance with the instructions contained in the UNDP Policies and Procedures Manual (UNDP/PPM/TL/2 of 27 January 1978, Section 4.0, paragraph 5, pages 9-14).

5. Please note that:

a) one (1) copy of the Contractor's report is being sent to Registry for their own records, and that

b) one (1) copy is being sent to Mr. E. Rennert who, upon perusal, will transfer it to the Library for micro-filming.

6. We would also appreciate your completing and returning the enclosed copy of the "Evaluation of Contractor's Performance" form.

*

Please note:
- eleven (11) copies sent to UNDP New Delhi 3/1/86
- one (1) copy sent to UNDP New York 3/1/85
- one (1) copy given to Mr. Messian 3/1/86
- one (1) copy sent to Registry 3/1/86
- one (1) copy with Mr. Kohonen
- one (1) copy sent to Mr. Rennert 3/1/86

cc.: Mr. E. Rennert (with one (1) copy of the report under consideratio

Registry (with one (1) copy of the report under consideratio

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India.

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C O N T E N T S

		PAGE NO
	Summary	
1.	Introduction	1
2.	Project Execution	2
2.1	Methodology	4
2.2	Major Activities	5
2.2.1	Initial Briefing	5
2.2.2	Initial Meeting with NPT	5
2.2.3	Comparative Study of Process Technologies	6
2.2.4	Selection of the Foreign Engineering Contractor	8
2.2.5	Study Launch Meeting	9
2.2.6	Project Review Meeting No 1	9
2.2.7	Project Review Meeting No 2	10
2.2.8	Review of Draft Final Report	11
2.2.9	Presentation to Government of India	11
2.3	Adherence to the Project Programme	12
3.	Study Findings	12
3.1	Choice of Coal Feedstock	13
3.2	Process Configuration	13
3.3	Product Slate/Quality	14
3.4	Capital Cost Estimates	14
4.	Conclusions	15
5.	Recommendations	17
	References	
	Tables	

SUMMARY

Based on the recommendations of a number of Indian Committees and Expert Groups, a prefeasibility study regarding the production of liquid fuels from coal was commissioned by the Government of India and the United Nations Development Programme. The aim of the project was to prepare information relevant to setting up a plant producing 1 million tonnes per year of diesel and kerosene. The plant was to be based on indirect liquefaction technology, that is coal gasification followed by synthesis of liquid products.

The United Nations Industrial Development Organisation managed the execution of the study and appointed Coal Processing Consultants to act as technical adviser and to assist in the overall implementation of the study. The National Project Team, based in Calcutta, represented the Government of India.

By a process of competitive tendering, a foreign engineering contractor, Flour Corporation, was appointed to execute the pre-feasibility study. Project and Developments India Ltd, a public sector engineering contractor, was appointed by the Government of India to supply domestic inputs to the study.

In conjunction with UNDP, UNIDO and the NPT, CPC's initial task involved the compilation of the Terms of Reference for the foreign engineering contractor and to assist in the contractor selection process. In parallel with this task CPC performed a comparative study of technologies appropriate to the conversion of coal to liquid fuels.

Following the execution of a similar independent study by Fluor the prefeasibility study was performed on the basis of a plant which combined Texaco gasification technology with Arge synthesis technology. Fluor produced a technically sound, competent report in line with UNIDO requirements, which

confirmed the availability of appropriate technology. Fluor completed their activities within the specified time allocations. However there was a substantial slippage in the overall project programme due primarily to a delay in the appointment of the foreign engineering contractor.

In the event that the results of the pre-feasibility study are sufficiently attractive to the Government of India to warrant proceeding to the next phase of the project then it is recommended that the Indian authorities initiate the formation of a formal company which would organise and control the execution of subsequent phases of the project and eventually be the operators of the coal liquefaction plant.

1. INTRODUCTION

India's current demand for oil and petroleum products amounts to 40 million tonnes per annum (mtpa). This demand is increasing and it is estimated that it will amount to 90 mtpa by the year 2000. The current domestic crude oil production is 32 mtpa and is expected to peak at 35 mtpa in the near future. Thus there will be an increasing resultant deficiency which will have to be met by crude oil imports.

For both economic and strategic reasons it is imperative that India considers ways of minimising its dependence on imported oil. This can be achieved to a small degree by practising energy conservation but will for the main part inevitably require a greater utilisation of indigenous energy resources. In the event that there is no possibility of increasing domestic oil production, conversion of Indian coals, reserves of which amount to 120 billion tonnes, to liquid fuels must be considered. The Indian market demands large quantities of diesel and kerosene and hence manufacture of these products is of prime importance. Although it is unlikely that coal conversion plants will be constructed in India to meet all future demands for diesel and kerosene the installation of a substantial plant capacity will result in a reduction in foreign currency payments and at the same time create a significant number of jobs.

Within India, over the past ten years or more, several Committees and Experts Groups have considered the possibility of setting up a substantial coal liquefaction facility. A distillation of their recommendations suggested the execution of a feasibility study on a coal conversion plant, producing approximately 1 mtpa diesel and kerosene, using commercial or near commercial technology.

At the current time the only commercialised route to liquid fuels involves coal gasification to produce a "synthesis gas" (carbon monoxide and hydrogen) followed by Fischer Tropsch catalytic synthesis of liquid products. India is currently particularly well positioned to utilise processes based on coal gasification since they have first hand experience of the Koppers-Totzek coal gasifiers which are in operation at the fertiliser plants at Talcher and Ramagundam.

Based on the recommendations of the Committees and Expert Groups, the Government of India (GoI) and the United Nations Development Programme (UNDP) commissioned a pre-feasibility study to be performed by a foreign engineering contractor with assistance from Projects and Development, India Ltd (PDIL), a public sector Indian engineering contractor. The study was conducted under the supervision of the United Nations Industrial Development Organisation (UNIDO) who contracted Coal Processing Consultants Ltd (CPC) to act as their technical adviser and as coordinator of the execution of the study.

CPC formed a project team comprising eight technical experts; in addition to the Team Leader there were expert consultants in the fields of coal gasification, synthesis, process evaluation and project planning, some with first hand experience of coal gasification in India. CPC initiated work in their home office on 4 June, 1984. A full project team meeting was held on 7 June, to clarify the project objectives and individual responsibilities and to detail and agree the schedule of CPC activities.

Progress with all aspects of the study has been reviewed in a series of CPC progress reports and detailed notes of meetings. This final report is intended to consolidate and update all

previous CPC documents. Section 2 reviews the execution of the project and highlights the major activities and major changes to the project programme. Section 3 reviews and comments on the main contractor's Study Report. Following the presentation of conclusions in Section 4, technical and administrative recommendations are made in Section 5.

2. PROJECT EXECUTION

The objective of the project was to produce a reliable and detailed pre-feasibility study report for a plant producing synthetic diesel and kerosene from coal. The study report had to conform to the guidelines presented in the UNIDO Manual for the Preparation of Industrial Feasibility Studies[1].

To that end it had to present detailed information on the following:

- Project background and history
- Market and plant capacity
- Material inputs
- Location and site (including environmental impact)
- Project engineering (based on specific conversion technology)
- Plant organisation and overhead costs
- Manpower
- Project implementation
- Financial and economic evaluation

The foreign engineering contractor was responsible for the execution of the study and compilation of the Final Report. PDIL's responsibilities were detailed in the contractor's TOR and included for example:

- Provision of information regarding local inputs, eg land, coal, water, power

- Provision of information regarding local infrastructure, manufacturing capabilities

- Provision of local cost information

- Analysis of market demand and supply data for oil products and coal.

2.1 Methodology

Having reviewed the project requirements with UNIDO, NPT and PDIL, CPC organised the production of the Terms of Reference (TOR) for the foreign engineering contractor. Then, in order to provide information to assist in the selection of the process technology, which would form the basis of the pre-feasibility study, CPC performed an independent Comparative Study of Process Technologies.

The foreign engineering contractor was selected by a process of competitive tendering against the TOR. The contractor's initial task involved the execution of a further Comparative Study of Process Technologies. Following this, a coal, plant location and process configuration which, would form the basis of the study, were agreed by all parties.

Progress during the study was reviewed at project review meetings. The contractor submitted monthly progress reports to all parties whilst CPC monitored progress and submitted to UNIDO a series of progress reports which coincided with the achievements of major objectives within the programme.

The contractor's findings were presented in a Draft Final Report which was modified in the light of comments from NPT, PDIL, UNIDO and CPC to form the Final Report.
Detailed comments on the major activities within the project are given below.

2.2 Major Activities

2.2.1 Initial Briefing

The CPC Study Team Leader attended a briefing meeting at the UNIDO offices in Vienna on 15 June, 1984. During this meeting discussions were held with representatives of both the technical and contract departments, regarding the background to the project, CPC's Terms of Reference and topics for subsequent discussion with the NPT and PDIL.

2.2.2 Initial Meeting with NPT

This meeting, held in the Calcutta offices of the NPT between 25 and 29 June, 1984, was arranged in order to:

- Discuss the project objectives
- Develop a detailed Work Plan for the NPT, PDIL, the foreign engineering contractor and CPC
- Prepare the Terms of Reference and Request for Proposal Document required for inviting tenders from foreign engineering contractors

Details of the discussions and agreed documentation were presented in a CPC Progress Report [2]. The UNDP was represented by its Resident Senior Programme Officer at some of the discussions. In addition to the discussions a visit was made to one of the proposed plant locations near Durgapur.

Following the conclusion of this meeting and subsequent communications between CPC and UNIDO, the Request for Proposal and Terms of Reference were issued to ten foreign engineering contractors.

Bearing in mind the intense communication between CPC and UNIDO regarding the issue of the tender documents, CPC were advised that it was not necessary to attend a debriefing meeting in Vienna as specified in CPC's Terms of Reference.

The Work Plan developed in conjunction with the NPT and UNIDO specified a 50 week programme from the issue of tender documents to submission of the foreign engineering contractor's Final Report. The Work Plan however contained activities which although considered essential by NPT and CPC were not catered for in CPC's Terms of Reference. The additional activities were associated with:

- Extension of the review meeting in Vienna to include tender evaluation discussions

- Project Launch Meeting in India, to brief the foreign engineering contractor

- Site selection and project review meeting in India

- Further project review meeting in India

- Extension to the Draft Final Report Review Meeting in Vienna

NB Some of these requirements were further modified as the project progressed. Such modifications are stated below.

2.2.3 Comparative Study of Process Technologies

Discussion with UNIDO and NPT resulted in the adoption of the following basis for the Comparative Study.

- The gasification potential of two coals, specified by the NPT, to be evaluated

- The gasification technologies assessed to be commercially proven or expected to be proven in the near future

- The synthesis technologies assessed to be Fischer-Tropsch processes such as Arge or Synthol

- The process configurations to be self-sufficient in power

- The process configurations to be designed to produce one million tonnes per annum of C_5^+ hydrocarbons

- Light gas (methane, ethane) to be reformed and recycled to the synthesis stage

The detailed objectives of this study were satisfied by adopting the following approach. First six gasifiers, three commercially proven and three approaching commercialisation, were reviewed in detail. The two coals, Singrauli and Raniganj, proposed by the NPT, were then assessed with respect to their gasification potential. Based on the foregoing information three gasifiers (Lurgi, Texaco and Koppers-Totzek) were selected for further consideration. Fischer-Tropsch synthesis technologies were then reviewed and Arge and Synthol chosen for detailed evaluation. Various process configurations combining the selected gasification and synthesis technologies were then evaluated; mass and energy balances together with capital cost data were presented for four. A summary of the results is given in Table 1.

CPC's report[3], submitted in August, 1984, contained the following conclusions:

- Arge based process configurations possessed significant advantages over Synthol based processes

- Of the Arge based processes considered, the Lurgi configuration had advantages over Texaco configurations in terms of capital cost and efficiency. In addition the technical risk associated with the Lurgi system was less. However all these advantages were considered to be small.

- Raniganj coal should be used as the feedstock for the detailed study

- The detailed study should include the provision of dedicated product refining facilities. (CPC reviewed the possibility of pipelining raw distillate to an existing refining facility at Haldia and highlighted a number of significant disadvantages in the proposal.)

2.2.4 Selection of the Foreign Engineering Contractor

CPC attended a meeting in the offices of UNIDO in Vienna together with representatives of the NPT, PDIL, UNDP and UNIDO, from 3-6 September, 1984, to evaluate tenders from the seven engineering contractors listed below - three contractors failed to respond to the invitation to tender.

Humphreys & Glasgow (UK)
lurgi (FRG)
Krupp-Koppers (FRG)
Kellog Rust (USA)
Lummus (USA)
Fluor (USA)
Davy-McKee (UK)

CPC performed an independent technical appraisal of the tenders (4) and following discussion with NPT, PDIL, UNIDO and UNDP it was recommended that the contract for the execution of the pre-feasibility study be awarded to Fluor. All outstanding queries regarding Fluor's scope of supply were satisfactorily resolved by 27 September, 1984.

2.2.5 Study Launch Meeting

The Launch Meeting was held in the Calcutta offices of the NPT on 10-11 December, 1984 and was attended by representatives of the NPT, PDIL, UNDP, UNIDO, Fluor and CPC. The meeting had the following objectives:

- To produce a final agreed version of the foreign engineering contractor's Terms of Reference

- To produce an agreed detailed schedule of tasks for PDIL, Fluor, NPT and CPC

- To define the project communication requirements

The meeting successfully achieved these objectives; the project schedule is given in Table 2.

2.2.6 Project Review Meeting No 1

It was originally intended that this meeting, held in the Calcutta offices of the NPT from 18-22 March, 1985, would have the following objectives:

- To review the Fluor Report of the Comparative Study of Process Technologies and choose the basis for the detailed pre-feasibility study

- To visit potential sites for the coal liquefaction plant

However during preparation for the meeting Fluor suggested and CPC agreed that site information could be provided by PDIL in response to a Fluor questionnaire. On this basis UNIDO agreed to the elimination of the site visits from the schedule.

The meeting was attended by representatives of NPT, PDIL and Fluor, although it was not possible for UNIDO to authorise expenditure for CPC to attend the meeting. CPC did however make a detailed comparison of the results of the Fluor and CPC comparative studies and submitted comments to the meeting.

Although there were a number of differences in the basis for the evaluations the overall conclusions of the Fluor and CPC Comparative Studies were similar; both studies favoured the use of Arge technology, Fluor were marginally in favour of Texaco gasification technology whereas CPC were inclined towards use of Lurgi gasifiers.

The meeting decided to proceed with the TEFS on the basis of Raniganj coal the Texaco/Arge configuration. In reply to CPC's concern regarding the operating temperature required to achieve adequate slag viscosity in the Texaco gasifier, Fluor stated that preliminary discussions with Texaco indicated that Raniganj coal could be successfully processed. On this basis CPC agreed with the choice of Texaco/Arge for the pre-feasibility study.

In addition it was agreed that the synthetic crude product would be refined in a dedicated refinery.

2.2.7 Project Review Meeting No 2

This meeting was held in the Irvine offices of Fluor from 12-16 August, 1985. It was attended by representatives of the NPT, PDIL, UNDP, UNIDO and CPC and had the following objectives:

- To review the general progress towards preparation of the pre-feasibility study

- To review in detail the information generated by Fluor related to the process configuration, infrastructure details, cost data and economic evaluation

- To review the scope and format of the Final Report

- To prepare for the presentation of the Final Report to the Government of India

All the objectives of the meeting were achieved[5]. In fact many draft sections of the Final Report had been prepared by Fluor, in some cases with assistance from PDIL, and were available at the meeting. It was therefore possible to make detailed comments on the contents and format of the report; significant alterations were recommended.

2.2.8 Review of Draft Final Report

Fluor's draft Final Report was reviewed independently in CPC's home office. The report was found to be very competent technically, although it was criticised in some areas in terms of clarity of presentation. Recommendations were made regarding in particular the organisation of the sections on Financial and Economic Evaluation and the Executive Summary. These comments were subsequently remotely discussed with UNIDO and Fluor.

2.2.9 Presentation to Government of India

Subsequent to submission of the Final Report to UNIDO, a presentation of its findings to Government of India officials was planned. The form of this presentation was discussed at the Project Review Meeting in Irvine, where it was recommended that a representative of the NPT should lead the presentation. Representatives of Fluor and PDIL would then expand on the detailed technical and costing aspects of the study, whilst CPC would be present to support their own recommendations.

2.3 Adherence to the Project Programme

The general scope of work and timetable for the project was specified at the time of CPC's appointment. However as the project proceeded the detailed activities and timetable were modified, as a result of detailed discussions. In particular the initial meeting between NPT, PDIL and CPC (see Section 2.2.2) and the Study Launch Meeting (see Section 2.2.5) resulted in the compilation of modified project programmes.

According to the project schedule issued after the initial meeting between CPC and the NPT, the programme duration from the issue of the Request for Proposal documents to the issue of the Final Report was 50 weeks. In fact a total of 70 weeks was actually required; the major causes of this increased timescale were:

- a fourteen week delay, compared with the original schedule, between tender evaluation and the project launch in Calcutta

- delays in the execution of project review meetings due to problems in communication between all the parties and in the selection of convenient meeting dates

The activities undertaken by Fluor, ie the execution of the comparative Study of Process Technologies and the detailed pre-feasibility study were completed within the allotted times.

3. STUDY FINDINGS

Through the execution of the independent Comparative Study of Process Technologies and a detailed knowledge of the process technologies it is possible for CPC to make the following comments on the results of the study performed by Fluor.

3.1 Choice of Coal Feedstock

Three coals were nominated for consideration as feed-stock for the liquefaction plant. The lignite was dismissed from detailed consideration since as a feedstock it is generally less attractive than the other 2 nominations: Raniganj and Singrauli coals. However it would be possible if necessary to utilise the lignite in future coal liquefaction plants. CPC agree with the choice of Raniganj coal as the feedstock for the proposed plant but would stress that the results should be generally applicable to Singrauli coal.

3.2 Process Configuration

CPC's evaluation of gasification technology resulted in a slight preference for conventional Lurgi, fixed bed gasification technology. This resulted from apparent minor advantages compared with the Texaco in terms of capital cost and thermal efficiency and the fact that the slagging characteristics of the Raniganj coal need to be clearly identified in relation to processing in the Texaco system.

Some preliminary tests have been performed by Texaco on Raniganj coal in parallel with although not in conjunction with this study. These test results apparently indicate the Raniganj is a suitable feedstock for the Texaco gasifier although CPC have not been able to directly assess the results.

With regard to the Fischer-Tropsch synthesis of carbon monoxide and hydrogen into liquid fuel and chemicals, since the study was confined to commercially available technology there are no alternatives to the Arge and Synthol processes. The Arge process has the major advantage that is produces a product slate better suited to the project objective of

maximum diesel/kerosene yield. In addition it produces only small amounts of C_1/C_2 gases. Some development is required in terms of increased reactor throughput in order to reduce the number of vessels required to provide the projected plant output. This development is in hand by the process licensor and the scale-up potential is demonstrated by the current utilisation of high throughput methanol synthesis reactors which are similar in design concept. In order to meet the project objective of high diesel/kerosene yield it would be necessary to hydrocrack the wax which is a major product of the Arge process. This step has not been commercially proven although the level of technical risk is assessed as small and the diesel produced will be of high quality.

The NPT originally suggested that the liquefaction plant should generate crude liquid products which would then be supplied to an existing refinery (Haldia) for upgrading into saleable products. Having reviewed the current capabilities of the Haldia refinery, CPC suggested that the proposed scheme was impractical for a number of reasons. Fluor's study was conducted on the basis of a dedicated refinery for upgrading crude products.

3.3 Product Slate/Quality

Although CPC's comparative evaluation did not assess fully integrated schemes which included for example oligermerisation of olefins and wax hydrocracking, the general applicability of technology to these requirements was assessed in terms of the distribution of products and product quality. The results of these assessments confirm the accuracy of Fluor's predictions.

3.4 Capital Cost Estimates

CPC's comparative evaluation did include capital cost estimates for a number of process configurations, based on

cost data derived from conceptual studies of coal conversion plants published in the US for US plant locations. Cost estimates related to gasification, gas cleaning, shift reaction and synthesis plant were generated and were intended to provide guidance on the relative costs of the process option considered.

CPC's estimate of the cost of the Lurgi/Arge option coincided exactly with Fluor's estimate, presented in their comparative study. CPC estimated that the Texaco/Arge configuration would cost an extra 10% whereas Fluor anticipated that it would cost 5% less.

Detailed examination of capital cost data presented in their Final Report illustrates the rigorous procedures adopted by Fluor in compiling the plant capital cost. The plant cost of $1.94 billion compares with CPC's initial estimate of $2.01 billion, which it must be stressed was estimated on the basis of a considerably less well defined process configuration.

4. CONCLUSIONS

1 It was considered to be necessary during execution of the project to adjust the detailed content of the programme. In particular it was decided to introduce project review meetings associated with major project milestones. This decision resulted in the efficient production of the Final Report in a situation complicated by the interaction of six parties, ie UNDP, UNIDO, NPT, PDIL, Fluor and CPC.

2 With reference to the execution of the total project a substantial programme slippage resulted from a delay in the appointment of the foreign engineering contractor and delays in major project review meetings associated with communication difficulties between parties.

3 Fluor has produced a technically sound, competent report and has performed its tasks within the agreed time allocations. The report has been prepared with reference to the UNIDO Manual for the Preparation of Industrial Feasibility Studies.

4 The pre-feasibility study has illustrated that:

- India's requirement for oil products in relation to its indigenous reserves suggests the need for serious consideration of coal to oil conversion processes.

- India possesses abundant supplies of coal suitable for conversion.

- Technology, either already commercially proven or soon to be proven, is available to form the basis of the conversion process.

- Both gasification and synthesis technology is still developing; small improvements in process performance would therefore be available in the future.

- India has the capability to provide a significant contribution to the project in terms of design, construction and plant operating resources and experience.

- In terms of required return on investment the project does not appear commercially attractive at present. However the uncertainty regarding world oil prices and the strategic implications of being dependent on large oil imports suggest that the project should be given serious further consideration.

5. RECOMMENDATIONS

Fluor's report makes recommendations regarding future studies and parallel administrative activities which in principle are endorsed by CPC. The following recommendations are intended to supplement Fluor's recommendations and to suggest an organisational approach to their execution.

In the event that the results of the pre-feasibility study are sufficiently attractive to the Government of India to warrant proceeding to the next phase of the project then it is recommended that the Indian authorities initiate the formation of a formal company which would organise and control the execution of subsequent phases of the project and eventually be the operators of the coal liquefaction plant.

This Operating Company should initially be set up with a budget sufficient to cover the costs incurred over a period of sufficient duration to enable further detailed studies and parallel activities to be completed and further decisions to be made on whether the project is to proceed further or not. The controlling Board of the Operating Company should comprise representatives of the various Indian Government Ministries and State companies with vested interests in such a project. Initial staffing of the Operating Company should take into account the experience gained to date by members of the National Project Team and skills that will be required to investigate ancillary items (such as finance, licenses, environmental matters etc) that will need to be carried out in parallel to the main engineering studies.

The Operating Company would then act as a decision making body to solicit proposals for a detailed engineering feasibility study (DEFS), undertake parallel investigations and present the results of these activities to the Government of India for decisions regarding proceeding to future activities. In conjunction with the execution of the DEFS the Company would

determine the tendering philosophy to be adopted for the mechanical design and construction stage. It would employ and control the activities of the main engineering contractor together with other foreign and Indian contractors and at the same time have Indian and foreign expert consultants reporting to it. During the design and construction stage the Company would expand its management structure and recruit operating staff for the operational phase of the project.

In line with Fluor's recommendations, CPC recommends that in addition to the execution of the DEFS further complimentary investigations be carried out by the staff of the Operating Company into:

- The financing of the total project (sources of funds, credit terms etc)

- The environmental aspects of operating a coal liquefaction plant (obtain permits for land use, water supply, determine labour requirements and availability, prepare an environmental impact assessment etc)

- The availability and terms of process and catalyst licenses from manufacturers.

- A detailed execution plan for the final project implementation that incorporates the tendering philosophy to be adopted.

During the period taken up by the additional investigations recommended, the Operating Company will continue to need specialist support services from both Indian and international experts. It is recommended that the services of these specialist consultant advisors be engaged prior the issue of the Request for Proposals for the main DEFS or the ancillary studies proposed.

As mentioned previously Fluor have recommended the execution of a Detailed Engineering Feasibility Study which would include optimisation of the process/utility configuration. In this context CPC recommends that consideration be given to the possibility of reducing the mineral matter content of the coal. The Texaco gasifier is penalised in terms of efficiency when high ash coals are gasified since the amount of water fed to the gasifier (in the form of slurry feed) has to be increased to maintain the required slurry viscosity.

Future activities should also include the large scale testing of the recommended coal in the preferred gasification system. This will require substantial quantities of coal (>1000 tonnes) to be available, which in turn will require the Raniganj coal field to be developed to a relatively advanced state; the rate of this development will probably be the rate determining step in the coal testing programme.

The reviews of technologies performed by CPC and Fluor illustrated that there are continuing developments in the fields of both gasification and synthesis. Dependent on the timescale for proceeding to the next stage of this project it would be prudent to continue to assess the development and commercialisation of alternative technologies. Of particular interest would be the development of the Shell gasifier and the Mobil synthesis process. To this end it would be appropriate to appoint a small team of scientists/engineers with the specific responsibility to analyse such developments and visit the appropriate companies and installations.

REFERENCES

1 UNIDO Manual for the Preparation of Industrial Feasibility Studies, United Nations, New York, 1978

2 CPC Progress Report No 1, DP/IND/82/040, July 1984

3 CPC Progress Report No 2, DP/IND/82/040, August 1984

4 CPC Interim Report No 1, DP/IND/82/040, April 1985

5 CPC Progress Report No 4, DP/IND/82/040, September 1985

TABLE 1

Summary of process evaluation results

Gasifier	Lurgi	Lurgi	Koppers-Totzek	Texaco
Fischer-Tropsch Process	Synthol	Arge	Arge	Arge
1. Total coal input Million tonnes/ year	8.7	5.9	6.8	5.9
2. Process efficiency (%)	45.2	47.3	38.9	44.9
3. Total cost (Million $(1984))	3210	1838	1914	2013
4. Cost $/kW total product	1100	890	980	1030

TABLE 2

UNIDO PROJECT DP/IND/82/030 - PROJECT SCHEDULE

ACTIVITY DESCRIPTION	1984	1985											
	Week Commencing												
	17/12	14/1	11/2	11/3	8/4	6/5	3/6	1/7	29/7	26/8	23/9	21/10	18/11	16/12
EDIN														
Comparative Study														
Review Meeting/Process Choice/Site Visit														
TEC														
Process Description of Units														
Overall Plot Plant of Facilities														
Staffing Plan for Plant Operation														
Operating Costs														
Plant Capital Costs														
Project Schedule and Manpower Plan														
Financial and Economic Analysis														
Follow-up activities for Execution														
Potential source of project finance														
Definition of information from EDIN	↑													
Submit Draft Report										↑26/8				
Finalise Report												↑28/10		
Submit Final Report													↑25/11	
Review Final Report in India														
Monthly Progress Report														
EDIN/NEI														
Information/Additional information for information for comparative study														
Basic information for TEC / Initial data, site data														
Input to operating costs														
Input to capital costs														
Input to manpower plan														
Input to Financial/Economic Analysis														
Supply of Market Information														
Review Comparative Study														
Review Meeting/Process Choice/Site Visit														
Project Review Meeting (Irvine)														
Review Draft Report														
Review Final Report Presentation														↑ 6/11
NEI														
Interim Reports					↑			↑		↑				
Review Comparative Study														
Review Meeting/Process Choice														
Project Review (Irvine)														
Review Draft Report														
Review Final Report/Presentation														↑ 25/11

* Refers to final date for receipt of (your) ...