



TOGETHER
for a sustainable future

OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.



TOGETHER
for a sustainable future

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as “developed”, “industrialized” and “developing” are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

TECHNIQUES OF DIRECT COAL LIQUEFACTION, PHASE II

DP/CPR/83/002

CHINA

Technical Report*

Mission 20 November - 1 December 1985

Prepared for the Government of the People's Republic of China
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of

J. J. Lacey,
Technical Adviser

United Nations Industrial Development Organization
Vienna

* This document has been reproduced without formal editing.

RESTRICTED

December 6, 1985
English

ABSTRACT

Project DP/CPR/83/002/11-01/32.1.I
November 20 to December 1, 1985

This report covers a trip which included seven (7) days in Beijing, China for the purpose of strengthening and supporting the Chinese government's on-going research and development program in the area of direct coal liquefaction. This work is being carried out at the Central Coal Mining Research Institute (CCMRI) in Beijing. The author of this report serves as a member of a Technical Committee whose duties are:

- a) To review the research and development activities of the project and report, monitor, review and evaluate the progress over a four (4) year period.
- b) To advise on the annual work program with the aim of keeping it in its proper perspective in relation to developments in other countries.
- c) To recommend to the Chinese government, UNDP and the executing agency (UNIDO) on the specific utilization of UNDP funds in the best manner to achieve the project objectives.

This report summarizes the first annual meeting of the above mentioned Technical Committee, and is organized in a daily journal format for the period covered by this trip. Particular emphasis is placed on documenting the approved 1985 Progress Report and 1986 Work Plans for this project. A detailed plan is established for the proposed 1986 R&D work. A determination is made regarding the required UNIDO inputs in terms of Consultants, Fellowships, Study Tours, and Equipment. Milestones are established for monitoring and evaluating work progress for the entire duration of the project.

SUMMARY

This trip covered the period of November 20, 1985 to December 1, 1985 inclusive. The actual time in Beijing, China covered the period of November 23-30, 1985 and was spent at the Central Coal Mining Research Institute (CCMRI). My duties were covered by DP/CPR/83/002/11-01/32.1.I and involved my serving as the Technical Adviser on a committee whose purpose is to review the Chinese government's present research and development program being carried out at the CCMRI.

The overall aim of this program is to proceed orderly from laboratory to commercial scale. It is planned that four or five candidate coals will be evaluated, and a suitable direct liquefaction process selected for commercialization. The overall plan proposed:

- a) To evaluate various types of Chinese coals and select several for hydrogenation.
- b) To investigate the liquefaction characteristics for the candidate coals using autoclaves and continuous process development units (PDU) to obtain quantitative data for the design of larger systems.
- c) To investigate the formation of suitably stable slurry that can be pumped to the reactor without separation.
- d) To carry out experiments on selection and preparation of the hydrogenation solvent.
- e) To develop laboratory methods for the separation of coal liquids to determine their chemical structures.
- f) To evaluate different coal liquefaction catalysts.
- g) To study techniques for upgrading of coal liquids to obtain light, stable products.

This trip report covers the items discussed at the annual meeting of the Technical Committee at which time the 1985 Progress Report and the 1986 Work Plans were discussed and approved. A detailed plan for the 1986 R&D work was established and a determination of the UNIDO inputs needed in terms of Consultants, Fellowships, Study Tours, and Equipment was finalized. Milestones required for evaluating and monitoring the project were also established for the duration of the effort.

TABLE OF CONTENTS

	<u>PAGE</u>
Introduction.....	1
Discussion.....	1
November 20, 1985.....	1
November 21, 1985.....	2
November 22, 1985.....	2
November 23, 1985.....	2
November 24, 1985.....	2
November 25, 1985.....	2
November 26, 1985.....	7
November 27, 1985.....	14
November 28, 1985.....	14
November 29, 1985.....	15
November 30, 1985.....	17
December 1, 1985.....	17
Conclusions.....	18
Recommendations.....	21

INTRODUCTION

The period covered in this report is November 20 - December 1, 1985 inclusive. I served as a member of the Technical Committee established to strengthen and support the Chinese government's present research and development program on techniques of direct coal liquefaction carried out at the Central Coal Mining Research Institute (CCMRI), Beijing. The committee consists of three members; viz., the National Project Director (Mr. Ouyang Yuan), the Technical Adviser and an UNIDO technical staff member. I functioned as the Technical Adviser under job description DP/CPR/83/002/11-01/32.1.I.

In addition to participating in the work of the Technical Committee, the Technical Adviser gives lectures and advice on aspects of coal liquefaction technology which fall within his specialization and are of interest to Chinese research scientists and engineers.

The long-term objectives of this project are the utilization of China's coal resources and the development of industrial-scale technologies for the conversion of lignites and bituminous coals to liquid fuels and chemical feedstocks.

This project (Techniques of Direct Coal Liquefaction) has been listed as one of the key projects in the National Research and Development Program, the major points of which are:

- a) By the end of 1985, to establish laboratories, conduct basic research, evaluate the liquefaction characteristics of Chinese coals and select suitable liquefaction technologies for these coals.
- b) During the period of 1986 to 1990, conduct basic research and scale up to obtain the necessary data for construction of a commercial coal liquefaction plant.
- c) In the third and final stage, the construction of a commercial coal liquefaction plant is planned in the 1990's.

DISCUSSION

This report is organized on a daily journal basis, followed by conclusions and recommendations regarding future work. Wide ranging discussions with many Chinese workers are summarized with particular emphasis on their long range plans and immediate needs.

Day 1 - Wednesday, November 20, 1985

After such planning and preparation, a visa for China was obtained. It was necessary to have an invitation from the Chinese government in order to obtain this visa. Once this was taken care of, the Chinese embassy in Washington, D.C. issued the visa. Hence the

RESTRICTED

December 6, 1985
English

trip began by flying from Pittsburgh to San Francisco for an overnight stay in order to make the necessary connection for Beijing the next day.

Day 2 - Thursday, November 21, 1985

The flight to Beijing was via Tokyo. The day was spent flying over the Pacific and reading the various background reports for this project.

Day 3 - Friday, November 22, 1985

Arrived in Tokyo late in the day for scheduled layover at the Tokyo airport.

Day 4 - Saturday, November 23, 1985

Flew from Tokyo to Beijing and was met at the airport by Mrs. Pang of CCMRI and driven to my hotel. Mrs. Pang Weizhen is an engineer with CCMRI working in their Office of International Cooperation. She was extremely helpful during my entire stay in Beijing and greatly aided me in all my administrative duties. After a short orientation session, we took a tour of Beijing and I returned to my hotel.

Day 5 - Sunday, November 24, 1985

Spent the day organizing this report and reading the background files on this project. My Chinese hosts were kind enough to provide some sight-seeing opportunities in the Beijing area.

Day 6 - Monday, November 25, 1985

The first order of business was to meet with Mr. A.W. Sissingh, the Senior Industrial Development Field Adviser for UNDP. He was very helpful in all the financial matters regarding the per diem arrangements for my stay in Beijing. His assistant, Ms. Wang Limin, a UNDP Program Officer was especially helpful.

After completing the required UNDP administrative details, we went to CCMRI to begin our technical meetings and plan our agenda for the week.

Since some of the organizations that we are dealing with in China are vast and spread out over the entire country, a short introduction of the players that we dealt with would seem to be in order. Since this is a "coal project" it naturally falls under the Ministry of Coal Industry (MCI). The Director of MCI is Mr. Yu Hongen. One of the many organizations in MCI is the Central Coal Mining Research Institute (CCMRI) headquartered in Beijing. CCMRI is the R&D arm of the MCI. CCMRI's Director is Mr. Fan Weitang and its Deputy Director is Yu

Xiang. CCMRI is responsible for all coal research in China and is funded by MCI. CCMRI is organized into sixteen (16) institutes, viz.,

1. Beijing Research Institute of Mine Construction - Special and conventional shaft sinking techniques, drifting and support.
2. Beijing Research Institute of Coal Mining - Ground pressure, mine support, mining techniques under special conditions.
3. Beijing Research Institute of Coal Chemistry - Coal analysis, coking, coal gasification, coal liquefaction, and combustion technique.
4. Research Institute of Economy - Coal economics and management.
5. Branch of Geology and Exploration - Coalfield geology, mine geology, hydrogeology, and exploratory technique.
6. Tangshan Branch - Coal preparation, hydraulic mining, mine surveying, and coal mining techniques for special conditions.
7. Shanghai Research Institute - Mining machinery, and electrical equipment.
8. Taiyuan Branch - Mining machinery, and powered support.
9. Fushun Research Institute - Mine safety technique, and surface mining technique.
10. Chongqing Research Institute - Prevention of coal and gas outburst, and prevention of dust explosion.
11. Nanjing Research Institute - Conventional shaft sinking and drifting techniques.
12. Research Institute of Blasting Technology - Explosive materials, and blasting methods.
13. Hangzhou Research Institute - Environmental protection, and coal utilization.
14. Changzhou Research Institute of Automation - Mine automation and mine communication.
15. Changzhou Development and Manufacturing Centre - Building of prototypes and testing facilities, and small lot production of new products.
16. Computer Center - Application of computers in coal industry.

December 6, 1985
English

The discussions pertinent to the organization of the Central Coal Mining Research Institute were handled by Mr. Yu Xiang the Deputy Director of the Institute. The Central Coal Mining Research Institute is made up of 16 institutes located throughout the coal mining areas of the country. These institutes employ 7,800 people of which approximately 1,500 are located in Beijing. Generally the title of the institute indicates its location with the following exceptions:

<u>Organization</u>	<u>Location</u>
Research Institute of Economy	Beijing
Branch of Geology and Exploration	Xian
Computer Center	Beijing

Deputy Director Yu noted that coal preparation research was carried out at the Tangshan branch of the Institute, and he recently arranged for Mr. Al Deurbrouck of PETC to visit this Institute.

Since the UNIDO project involves coal liquefaction, it will be handled by the Beijing Research Institute of Coal Chemistry (BRICC). The Director of the BRICC is Mr. Dai Hewu. All coal liquefaction work in China is done by the BRICC. Its Deputy Director, Mr. Wu Chunlai gave a brief introduction to the history and the organization of the BRICC. It was founded in 1956 and is composed of seven (7) labs and one (1) section as follows:

1. Coal Analysis Lab
2. Coal Properties Lab
3. Coal Gasification Lab
4. Coal Liquefaction Lab
5. Coal Combustion Lab
6. Coking Lab
7. Special Processes Lab
8. Design Section

The larger "labs" (coal liquefaction, gasification) are staffed with about fifty (50) people, while the smaller "labs" have as little as ten (10) people. Overall BRICC employs 270 people composed of:

Senior Engineers -----	15
Engineers -----	80
Associate Engineers -----	100
Technicians -----	<u>75</u>
TOTAL -----	270

We next discussed the plan for the remainder of the week. These discussions were led by Mr. Ouyang Yuan, the National Project Director and a member of the Technical Advisory Committee for the UNDP funded coal liquefaction project. He briefly summarized the objectives, the accomplishments to date, and the plans for the future. He also

RESTRICTED

December 6, 1985
English

introduced Dr. Wang Yinren who founded the BRICC in 1956. Dr. Wang now acts as the Chinese consultant to the Technical Committee. During all meetings of the Technical Committee, the following were present:

- o Mr. Ouyang Yuan - National Project Director
- o Dr. Wang Yinren - Consultant
- o Mr. J.J. Lacey - U.S. DOE (UNIDO)
- o Mr. Wu Chunlai - Deputy Director, BRICC
- o Mrs. Pang Weizhen - Office of International Cooperation CCMRI

The proposed weekly schedule included a tour of the BRICC labs Monday, followed by Technical Committee meetings on Tuesday, Wednesday, and Thursday. On Friday it was planned to hold the annual Tripartite Review Meeting with representatives from:

1. Ministry of Foreign Trade
2. Ministry of Coal Industry
3. UNDP
4. UNIDO

As time allowed during the week, I was given the opportunity to lecture on aspects of direct coal liquefaction.

After these detailed discussions of organization and schedule, we were given a tour of the coal liquefaction facilities of the BRICC. I was impressed by their analytical capabilities. Their pilot plant facilities were composed of several continuous process units (CPU), viz.,

1. NEDO Unit (CPU #1) 20 kg/hr coal slurry
2. Xytel Unit (CPU #2) 5 kg/hr coal slurry
3. German Unit (CPU #3) 15 kg/hr coal slurry

All slurry rates include 1/3 coal. The Xytel unit is presently not in use. It proved difficult to operate and too small for their needs. It is being modified for product upgrading service in conjunction with the product from the NEDO and German units. The NEDO unit has operated over 1200 hours (typical run of 3-5 days) on eight (8) different coals. It is presently shut down and being modified to include facilities for:

1. Hydrogen recycle
2. Solvent recycle
3. Computer control
4. Tube type reactor

The German unit (Saarberg-Veba Oil) is under construction and scheduled for operation in January 1986. It is a complete unit from coal grinding and drying to product distillation. It will feature hydrogen and solvent recycle, computer control and a tube type reactor.

The original New Energy Development Organization (NEDO) unit (CPU #1) was built by Mitsui Engineering and Shipbuilding Co., Ltd. of Japan. It has operated well in the "once-through" (H₂ and solvent) mode and proved very valuable in coal screening studies. It is being modified to include H₂ and solvent recycle and will be capable of performing process technology assessment studies. The German unit (CPU #3) will be built with the required capability for technology assessment studies and should prove very valuable during 1986. The Xytel unit (CPU #2) can best be utilized in product (from CPU #1 and #3) upgrading studies. These three (3) units are very powerful tools for future coal liquefaction research in China.

Day 7 - Tuesday, November 26, 1985

The day was spent at CCMRI and we discussed the 1985 Annual Report in the morning and the 1986 Work Plan in the afternoon. The discussions were lead by Mr. Ouyang Yuan and attended by Dr. Wang, Mr. Wu, and Ms. Pang. The first order of business was a summary of the history of the project which Mr. Ouyang indicated as:

1. The effort was established as a key project in the national R&D program for China in 1979.
2. In 1979, the Chinese government provided a new laboratory building, some initial equipment and training opportunities in the field of coal liquefaction for several recent university graduates.
3. In 1980, the project "Techniques of Direct Coal Liquefaction" was funded by UNDP at a level of \$700K and began as Phase I (1980-1983).
4. At the end of 1981 an agreement was signed with NEDO of Japan whereby the Chinese would supply buildings and lab support, and the Japanese would provide a 20 kg/hr slurry feed (1/3 coal) continuous processing unit (CPU #1). The operating results were to be owned by both governments. This unit has been in operation since March 1983 for over 1200 hours on eight (8) different Chinese coals. It proved very valuable in testing coal types, but the lack of H₂ and solvent recycle limited its use in the areas of process technology assessment.
5. In July 1984, an agreement was signed with West Germany (the Saarberg-Veba Oil organization) to provide another continuous processing unit (CPU #3). The agreement had similar terms as the NEDO agreement. The equipment was delivered in May 1985 and operations are scheduled to commence in January 1986. This unit processes 15 kg/hr slurry (1/3 coal) and has the capability of H₂ and solvent recycle.

6. Another unit provided by the Xytel Corp., (CPU #2) was also purchased, installed and operated in a limited manner during this period. This unit processes 5 kg/hr slurry (1/3 coal).
7. Phase I ended in 1983. During 1984, plans were drafted for Phase II which commenced in January 1985 and will run 3 1/2 years.
8. Hence the project history of "Techniques of Direct Coal Liquefaction" can be summarized as:

<u>Year</u>	<u>Action</u>
1979	Original Chinese Work
1980-1983	UNDP Funded Phase I
1984	Planning Year
1985-1988	UNDP Funded Phase II

The Technical Committee will function during Phase II.

The first order of business after the historical introduction was a discussion of the 1985 results in the form of an annual report to the Technical Committee by Mr. Ouyang Yuan, the National Project Director. The objective was to review this report, offer suggested revisions, then approve it in final form for presentation at the Tripartite Meeting on Friday, November 29, 1985. The report was divided into the following sections:

- A. Modifications and Installations
- B. Research and Tests
- C. Consultants
- D. Fellowships
- E. Equipment Procurement

Mr. Ouyang again stated that Phase I of the project was completed by the end of 1983, and the project document for Phase II was signed formally at the beginning of 1985. Research work has continued during this period and the 1985 results were as follows:

- A. Modification and Installation - This work on the continuous liquefaction process development units was extended. These proved valuable in evaluating coals, but limited as regards assessing coal liquefaction process technology. Modifications were required to include facilities to recycle H₂ and the process solvent. These small continuous process development units continue to be the main approach for coal liquefaction research and development. In order to extend coal liquefaction research from evaluation of coal samples to technology process assessment, the No. 1 unit (Japanese-made)

is being modified and No. 3 unit supplied by the Federal Republic of Germany (FRG) is being installed with the required modifications.

- (1) Modification of hydrogen supply system for CPU #1 was completed. An on-line gas-chromatograph was installed and used during operation. Results showed that conversion and yield of liquid products were higher. The gas product can also be analyzed more accurately and in a timely manner. By the end of 1985, a recycle solvent system will be installed with the assistance of the Japanese. These modifications are required for the assessment of various coal liquefaction process technologies.
- (2) The No. 3 continuous process unit supplied by the FRG was delivered in May and its building has been completed. At this time, the frame structure and all equipment have been installed. Planned start up is January 1986 and the runs with German process technology will be conducted during 1986.
- (3) The No. 2 continuous process unit (Xytel) was installed and shake-down tests were completed. It is planned to use CPU #2 for upgrading of coal liquids produced by the No. 1 and 3 units.

B. Research and Tests

- (1) Tests of the liquefaction characteristics for various types of coal from the Shangtong, Shanxi, Inner-Mongolia and Provinces Yunnan were conducted with autoclaves. It was discovered that bituminous coal from the Shangton Province and Lignite from Yunnan Province gave the best liquefaction results.
- (2) Catalyst screening studies were conducted with autoclaves. Tests were run with 5 types of iron-based catalysts. Activity evaluations indicated that coal pyrite and processed waste of tungsten smelting make suitable disposable catalysts.
- (3) Four test runs with different coal samples were conducted with the No. 1 CPU (NEDO). Several conditions were selected for process technology evaluation, and showed that the bituminous coal from Tung County, Shangton Province gave the best results when processed at 450°C temperature, 250 kg/cm² pressure and one hour residence time. The overall conversion was 86.4% with the oil yield at 56%.

December 6, 1985
English

- (4) Upgrading of the coal-liquids was also conducted. Gasoline with an octane number of 82 and a chemical feedstock with 47.5% BTX (benzene, toluene, xylene) were obtained after hydrogenation and denitrogenation treatment of the minus 200°C cut from the light oil after reforming with platinum. Catalyst and process technology suitable for upgrading of coal liquids were also investigated.
- (5) Eleven (11) items of standard analytical procedure have been edited. Test procedure for H¹ was established last year and procedure for C¹³ has been established this year. Carbon content can also be analyzed. Analysis of the upgraded light oil was made with gas-chromatograph capillary columns.
- C. Consultant - According to the work plan for 1985, no consultants were scheduled. Consultants were sent by NEDO for modification of CPU No. 1, according to the cooperative agreement. Additionally, thirteen (13) consultants were sent by the FRG for installation and start-up of CPU No. 3 according to the joint research program.
- D. Fellowshipolders
- (1) Three (3) separate groups were sent in 1985. A 3-person group (3 people for 2 months each) was sent to Japan for training in upgrading techniques. A 4 person group (4 people for 1 month each) was sent to Japan for training on the application of computers to coal liquefaction research. A 2-person group (2 people for 2 weeks each) was sent to Australia for the "International Coal Science Conference," and study of coal liquefaction.
- (2) A 5 person group (5 people for 1.7 months each) was trained in China on NMR and gas chromatograph/mass spectrometer (GC/MS). This was supported by the Chinese government.
- E. Procurement of Equipment
- (1) Orders were placed for four (4) items according to the project document. They were:

		<u>Due</u>
GC/MS	¥ 280,000	07/86
Surface determinator	\$ 67,000	Delivered
Mass flowmeter	¥ 1,329,200	On Order
GDC data processor	¥ 1,675,800	On Order

RESTRICTED

December 6, 1985
English

- (2) Differential Thermal Analyzer (DTA), ordered by UNDP in Phase 1, had to be sent back to Japan for a second time.
- (3) A set of milling and drying equipment and a product distillation system purchased by the Chinese government were delivered and installed on CPU #3. A trace S and N analyzer was delivered. One small hydrogenation unit (product upgrading) designed by the staff was manufactured.

The DTA provided by Japan has had a long and sorry history at the BRICC. It was originally delivered in June 1981, but returned to Japan in September 1981. It was repaired and returned in February 1984, but sent back a second time in October 1984. It was due back in April 1985, but has not yet been received. The Chinese inquired about its status in July 1985, but as of now (December 1985) the DTA is still among the missing. Since this unit cost \$70,000 in 1981 and has never performed satisfactorily, the Chinese would like to get their money back. I would recommend that this be done and new equipment procured.

This essentially concluded the discussion of the 1985 work. As a sidelight, Mr. Ouyang indicated that all work in direct coal liquefaction in China is the responsibility of the CCMRI and is conducted by the BRICC using about 100 of their 270 people. A small amount of direct coal liquefaction work is done at several universities, and this is coordinated by the BRICC. The universities involved are Qinghua University, Taiyuan Polytechnic College (Shanxi), and Shanghai College of Chemical Engineering.

The afternoon was spent in a discussion of the 1986 Work Plan. Mr. Ouyang did not want to discuss R&D plans for the later years (after 1986) since he mentioned that next year (1986) will be the first year of the Seventh 5 Year Plan for China. Since this plan has not yet been certified, no really firm decisions on research can be made at this time. The present Work Plan does indeed call for the design of a commercial scale plant by 1989. As a result, work must obviously be continued in the areas of processing several coals, screening catalysts, and upgrading the liquid products.

The detailed plans include the following steps, again in the same format as the Work Plan, viz.,

- A. Research Work
- B. Equipment Procurement
- C. Consultants
- D. Fellowships
- E. Study Tours
- F. Technical Committee

Each item was discussed in significant detail in order to finalize every part as follows:

A. Research Work

- (1) Autoclave screening of various disposable catalysts for coal liquefaction and coal liquids will continue.
- (2) After modifications are made to CPU #1 (NEDO), two (2) more Chinese coals will be screened.
- (3) Use CPU #3 (FRG) to evaluate one (1) Chinese coal and assess the German technology.
- (4) Use CPU #2 (Xytel) to upgrade the coal liquids produced by CPU #1 and CPU #3.
- (5) Install the GC/MS to be delivered in July 1986 and apply it to analyzing coal liquids.

B. Equipment Procurement

- (1) Accept delivery of the GC/MS in July 1986, install it in the third quarter and operate it in the fourth quarter of 1986. The GC/MS will be used for the analysis of liquefaction products. It was budgeted at 359K, but ended up costing 420K. As a result, other equipment procurements (automatic distillation system and precision liquid densitometer) were cancelled.
- (2) Surface Determinator (catalyst pore size) will be delivered in November 1985, installed in December 1985 and be operating in January 1986. Again although budgeted at 30K, its delivered price was 65K.
- (3) Data Processor for liquid chromatograph will be delivered, installed and operating in first quarter of 1986.
- (4) High Pressure Gas Mass Flow Meter for small upgrading units will be delivered, installed and operating in the first quarter of 1986.
- (5) The automatic distillation system was cancelled for lack of funds, but purchased with Chinese government funds.
- (6) The precision liquid densitometer was cancelled for lack of funds.
- (7) Microcomputer for CPU #3 (FRG) was cancelled due to lack of funds. The available funds will be used to modify the CPU #2 (Xytel) computer for use on the CPU #3.

December 6, 1985
English

- (8) High pressure pump and reactor for small upgrading units will be placed on order in early 1986.

C. Consultants

- (1) Technical Committee (Post 11-01) meeting is scheduled in Beijing in November 1986.
- (2) Catalytic Hydroliquefaction (Post 11-51) for two (2) weeks in March 1986 should be filled up by Prof. Yujo Sanada, Faculty of Engineering, Hokkaido University, Japan.
- (3) Techniques of Two-Stage Coal Liquefaction (Post 11-52) for two (2) weeks in early 1987 should be filled by Mr. T.M. Torkos of PETC, USA.
- (4) Separation and Structural Analysis of Coal Liquids (Post 11-53) for two (2) weeks in August, 1986 should be filled by Prof. Zhang Qichun, University of British Columbia, Canada.
- (5) Kinetics of Liquefaction Reactions (Post 11-54) for two (2) weeks in late 1987 should be filled by Dr. Ingo Romey, Bergbau Forschung, West Germany.
- (6) Liquefaction Reaction Engineering (Post 11-55) for two (2) weeks in early 1987 should be filled by Dr. John A. Ruether of PETC, USA.
- (7) Upgrading Techniques of Coal Liquids (Post 11-56) for two (2) weeks in April 1986 should be filled by Dr. Etsuro Nakamura, Deputy Director of the National Research Institute for Pollution and Resources, Agency of Industrial Science and Technology, Japan.

D. Fellowships

- (1) Training on Structural Analysis Techniques of Liquefaction Products (Post 31-01) for four (4) people for three (3) months in May, June, and July 1986 should be at PETC, USA.
- (2) Training on Processing and Utilization of Coal Liquid Products (Post 31-02) again for four (4) people for three (3) months in September, October, and November 1986 should be in the Government Industrial Development Laboratory, Hokkaido Agency of Industrial Science, Japan.

- (3) Training on Scaling-Up Techniques of Liquefaction Processes (Post 31-03) for four (4) people for six (6) months is postponed until 1988.
- (4) Training on Modifications of Continuous Process Units (Post 31-04) has been scheduled for 1987. It is four (4) people for one (1) month.

E. Study Tours

- (1) Techniques of Direct Coal Liquefaction (Post 32-01) for four (4) people for three (3) weeks to Japan was completed in 1985.
- (2) Two-Stage Liquefaction Techniques (Post 32-02) for four (4) people for three (3) weeks is planned for early 1987 and will include the USA, particularly PETC.
- (3) Super-critical Extraction Techniques (Post 32-03) should be changed to cover only Liquid Solvent Extraction Techniques. It is scheduled for four (4) people for three (3) weeks in September and October 1986 in the UK.
- (4) Study status and development trends in coal liquefaction (Post 32-04) for five (5) people for one (1) month for mid-1988 in Europe (West Germany, Poland, and Russia).

F. Technical Committee

- (1) The committee will consist of:
 - (a) National Project Director (Mr. Ouyang)
 - (b) UNIDO Official (Mr. Maung)
 - (c) Technical Adviser (Mr. Lacey)
 - (d) Chinese Consultant (Dr. Wang)
- (2) The tasks will be:
 - (a) Review progress on project
 - (b) Advise on project activities
 - (c) Make recommendations to China and the UN
- (3) The committee will meet again in Beijing in November 1986.

This concluded the formal discussions. We next discussed the proposed involvement of Mr. Torkos (Two-Stage Liquefaction) and Dr. Ruether (Reactor Engineering) of PETC for early 1987. It was recommended that Study Tour (Post 32-02) precede their visit to China. After the Chinese Study Tour at PETC, Mr. Torkos (Post 11-52) and

RESTRICTED

December 6, 1985
English

Dr. Ruether (Post 11-55) will be able to prepare the correct lectures for their joint visit to China.

We next discussed the Polish Direct Coal Liquefaction PDU. It should be ready for testing in June 1986 and in operation by November 1986. The scheduled Chinese visit (Post 32-04) in mid-1987 would be appropriate. The visit to the USSR may be difficult to arrange, but should be attempted.

Day 8 - Wednesday, November 27, 1985

The day was spent at the CCMRI in a review of the detailed plan for the R&D work for 1986. The discussions on Tuesday (11/26/85) and the decisions reached were in agreement with the Project Document, but the preliminary published work plan for 1986 contained several errors. This Work Plan was revised to agree with the Project Plan and the decisions made on Tuesday, November 26, 1985. It was agreed that the Work Plan will be corrected and presented at the Tripartite Review Meeting on Friday, November 29, 1985. Special emphasis was placed in assuring that the Work Plan specifies the UNIDO inputs needed in terms of Consultants, Fellowships, Study Tours, and Equipment.

As regards monitoring and evaluating work progress for the entire duration of the project, it was decided that the Technical Committee will meet yearly in November to review the past year's work and plan the upcoming year's schedule. At this time the past year's progress report can be prepared and approved. The upcoming year's work plan can also be decided upon and approved at these November meetings. These approved reports can then be presented at the Tripartite meeting. The latter is normally held at this time of the year.

We again discussed establishing close communications with the direct coal liquefaction work being conducted in Poland. This work is very similar to the Chinese effort and each side can profit from an active information exchange. It was recommended that any Chinese study group (Post 32-04) that is in Europe should include Poland on its agenda. The best time to go would be in early 1987, after the Polish PDU has been in operation. I will maintain a communication link between these two UNDP funded projects in the area of direct coal liquefaction.

Day 9 - Thursday, November 28, 1985

The day was spent at CCMRI finalizing the 1985 report and the 1986 work plans. Particular emphasis was placed on defining the research plan for 1986 and make it flexible enough to agree with the Chinese Seventh 5-Year Plan due to be certified in early 1986, probably in January. With a broad base for the research plan for 1986, it will be possible to later define similar plans for 1987 and 1988 that conform to the overall goals in the latest 5-Year Plan.

RESTRICTED

December 6, 1985
English

As regards Consultants, Fellowships, and Study Tours, these were finalized for inclusion in the 1986 Work Plans. It was possible to specify these inputs by name, organization and date (month and year). These areas have proved very valuable to the Chinese and the project has benefitted accordingly. It is obvious to see in the Chinese effort and equipment the positive contribution of the various consultants and the net benefit obtained from the fellowship program. The study tours have proven worthwhile in keeping the Chinese aware of and abreast of current worldwide technology.

Considerable time was devoted to a discussion of the Equipment Procurement plans. Much of the equipment has been delivered and the material pending delivery has at this time firm prices associated with it. Accordingly it was possible to assess the current status of the UNDP budget in light of the fact that several pieces of equipment came in over the budgeted amount (e.g., GC/MS). It was recommended not to make any additional purchases until all the previously ordered equipment has been delivered and a final audit of the remaining funds is prepared.

Day 10 - Friday, November 29, 1985

The Tripartite Meeting was held today attended by:

- o Mr. Ouyang Yuan, CCMRI
- o Mr. Wu Chunlai, CCMRI
- o Mrs. Pang Weizhen, CCMRI
- o Mr. A.W. Sissingh, UNDP
- o Ms. Wang Limin, UNDP
- o Mr. J.J. Lacey, UNIDO (DOE)

The purpose of this meeting was the annual review of this project "Techniques of Direct Coal Liquefaction." Phase II of the project was signed in February, 1985 and this was the first annual review. Subsequent reviews will be held in November 1986 and 1987. Although Phase I is history, there were a few loose ends to be considered. Dr. Pugmire had been an invited consultant to the CCMRI and lectured on "Application of NMR", but has not yet submitted a trip report to UNIDO, Vienna. It was determined that no report had been submitted either to CCMRI or UNDP, Beijing. Mr. Pugmire will be contacted to obtain his final report and close out this aspect of Phase I.

Another item left over from Phase I was the Differential Thermal Analyzer (DTA) which has never performed in a satisfactory manner and has been returned to the Japanese manufacturer on two occasions. It was recommended that the Chinese contact the manufacturer to recover the purchase price and possibly additional funds due to the loss of research effort attributed to the non-performance of this equipment.

On the subject of Phase II, the 1985 progress report was read, discussed, and approved by the Technical Committee. Considerable

RESTRICTED

December 6, 1985
English

progress was made during 1985 particularly in the areas of equipment modification. The approved 1985 Progress Report is attached.

As regards the 1986 Work Plans, considerable discussion was devoted to ensuring that these plans were reasonable as regards schedule and that they were broad enough to be in agreement with the Chinese Seventh 5-Year Plan due for certification in January 1986. Particular emphasis was placed on specifying, in considerable detail, the required UNIDO inputs regarding:

1. Equipment
2. Consultants
3. Fellowships
4. Study Tours

For equipment, it was recommended that, due to currency fluctuations, that purchases be curtailed until after delivery of all presently scheduled material. A general accounting is needed to take into account the actual delivered purchase price of all the equipment presently on order. It would appear that, even with certain changes already in place, the present equipment budget is nearly fully utilized.

On the subject of Consultants, Fellowships and Study Tours, the plans are rather ambitious and call for implementation of some aspects early in 1986. The Chinese were requested to get the appropriate job descriptions into UNIDO as soon as possible. Also it was stressed that they should not fall behind in this area and thereby generate a surplus of funds. This may indicate no need for these funds and they may be diverted elsewhere to other projects worldwide. The Technical Committee approved the 1986 Work Plans, a copy of which is attached to this report.

After the meeting a detailed tour was arranged to review the mechanical progress of the following continuous process units:

1. CPU #1 Japan (NEDO)
2. CPU #2 USA (Xytel)
3. CPU #3 Germany (Saarberg)

The NEDO unit was being actively worked on to modify it for operation with H₂ and solvent recycle. The Japanese had three (3) people (1 engineer and 2 technicians) on-site at CCMRI participating in these modifications. The USA unit will be modified for product oil upgrading work processing the production from CPU #1 and #2 when they are operating. There was an extremely large effort on CPU #3 by the Germans (1 engineer and several technicians) and progress was evident.

After the tour, the Technical Committee concluded the meeting by agreeing to stress communications during 1986 and meet again in Beijing in November 1986.

RESTRICTED

December 6, 1985
English

Day 11 - Saturday, November 30, 1985

A morning meeting was arranged with Mrs. Pang of the CCMRI to discuss the mechanics of obtaining a visa for China in the most efficient manner. She recommended that once UNIDO and DOE approval is obtained, my next contact should be with the CCMRI to insure that an invitation is forthcoming and a visa is issued in plenty of time. She recommended that this invitation be obtained about two (2) months before commencing travel. After this meeting, Mrs. Pang was kind enough to accompany me to the Beijing airport and facilitate my customs clearances. I then flew to Tokyo for a scheduled overnight stop.

Day 12 - Sunday, December 1, 1985

The day was spent in transit flying from Tokyo to Pittsburgh, Pa. via New York. The long flight afforded the opportunity to make the final revisions to this report.

CONCLUSIONS

During my stay in Beijing (November 23-30, 1985) I participated as a member of the Technical Committee whose goal is to strengthen and support the Chinese Government's on-going R&D program in "The Techniques of Direct Coal Liquefaction" being carried out at the Central Coal Mining Research Institute (CCMRI), Beijing. The Technical Committee has been established for the duration of the project (3.5 years) to facilitate its successful implementation.

As the Technical Adviser (Job Description DP/CPR/83/002/11-01/32.1.I), my duties during the committee meetings were:

- 1) To review the R&D activities being carried out under the project and to report, monitor, review and evaluate.
- 2) To advise the Chinese Government through the National Project Director on the Annual Work Plan to keep the program in its proper perspective in relation to developments in other countries.
- 3) To recommend to the Chinese Government, UNDP and UNIDO on the specific utilization of UNDP inputs in the most efficient way to achieve the project objectives.

This particular project, "Techniques of Direct Coal Liquefaction", has been listed as one of the key project in the National Research and Development Program for China. The major milestones are:

- 1) By the end of 1985, establish laboratories, conduct basic research, evaluate the liquefaction characteristics of Chinese coals and select suitable liquefaction technologies for these types of coal.
- 2) During the period from 1986 to 1990, continue conducting basic research, scaling up the results and obtain the necessary data for the design and construction of a commercial coal liquefaction plant.
- 3) The long term goal is the construction of a commercial coal liquefaction plant in the 1990's.

This project is part of an overall Chinese plan for the utilization of the country's coal resources and the development of industrial-scale technologies for the conversion of lignites and bituminous coals of high volatile and sulphur contents to liquid fuels and chemical feedstocks. These resources, which are normally not suitable for other purposes such as power production or steel making, can then be utilized in a manner more compatible with the present and future modes of transportation, as well as industrial and domestic fuel needs.

RESTRICTED

December 6, 1985
English

Based on the results of the Technical Committee meetings, the project's immediate objectives are being satisfied. These are as follows:

- 1) To evaluate various types of Chinese coals and select those that are amenable to hydrogenation;
- 2) To investigate the liquefaction behavior of the selected coals in autoclave experiments and continuous process development units (PDU) to obtain quantitative data necessary for the design of larger systems;
- 3) To investigate the formation of a stable slurry that can be transported through pumps and pipes to the reactor without phase separation;
- 4) To carry out experiments on selection and preparation of the hydrogenation solvent;
- 5) To develop laboratory methods for the separation of coal liquids and determination of their chemical structures and properties;
- 6) To evaluate different coal liquefaction catalysts;
- 7) To study techniques for upgrading of coal liquids to obtain light, stable and useful products.

The Government's R&D programme is well-planned and should carry the work from the laboratory to commercial application. By the end of this project, 4-5 candidate coals will have been thoroughly evaluated and a suitable direct liquefaction process selected for commercialization.

China's Seventh Five (5) Year Plan will be certified in January 1986. As far as the project "Techniques of Direct Coal Liquefaction - Phase II" was concerned, it was concluded that the Work Plans must take into account their tentative nature until the latest Five (5) Year Plan is approved. A detailed plan for the 1986 R&D work was determined; however, it is too soon to formulate similar plans for the years 1987 and 1988. Nevertheless it was possible to specify with some accuracy the required UNIDO inputs as regards:

1. Consultants
2. Fellowships
3. Study Tours
4. Equipment Purchases

As regards project monitoring, it was concluded that the Technical Committee should meet annually in November to review and approve the year's Progress Report and determine the Work Plan for the coming year. The Technical Committee meetings should be scheduled to be held in conjunction with the yearly Tripartite Meeting.

RESTRICTED

December 6, 1985
English

It was further concluded that there is significant progress being made in the area of direct coal liquefaction throughout the world. The Chinese must keep abreast of the long range, high risk type of research being conducted in the USA, particularly in the area of two stage liquefaction. The liquid solvent extraction work in the UK must also be followed closely. Several large scale process development units (PDU) are being operated in Japan, Germany, Russia, Australia, and Poland. As regards Poland, it was stressed that this is another UNDP sponsored project that shares many characteristics with the Chinese effort. Both projects have similar goals and are at the same stage of development using virtually the same technology. I will ensure that there is an exchange of technical information between these projects and urged the Chinese to include the Polish PDU in one of their planned study tours.

We further concluded that now is the appropriate time to begin an economic survey of direct coal liquefaction with the overall goal of evaluating the feasibility of constructing commercial coal liquefaction plants in China. I supplied some information on this subject to the National Project Director and will continue to send more pertinent material to him upon my return to PETC.

RECOMMENDATIONS

Based on the discussions with the staff of the CCMRI and the BRICC the following recommendations seem to be in order:

1. The autoclave work should be directed at catalyst screening studies since several representative coals have been selected for liquefaction. The problem now would be to determine an active catalyst that is abundant and inexpensive for use in a disposable mode in their continuous units.
2. Modifications to the NEDO unit (CPU #1) should be completed as soon as possible. These modifications will convert this unit from a once-through operation to a more process oriented operation featuring solvent recycle and circulation of the H₂ rich recycle gas. It will then be possible to perform process technology assessments since an equilibrium recycle solvent will be generated.
3. The Xytel unit (CPU #2) has proven difficult to operate and rather small for their purposes. Their plans to convert this unit to a product oil upgrading facility is recommended. Although their plans are to modify the control computer from CPU #2 and use it on CPU #3, this may prove rather difficult to accomplish and should be re-evaluated at a later date.
4. The FRG unit (CPU #3) should prove to be a valuable processing tool for technology evaluations. It was designed and built for recycle (H₂ and solvent) operation and is in the final stages of construction. It is a very impressive unit complete in all respects from coal grinding to product distillation. Start-up and operation of this unit should be given top priority in early 1986.
5. The GC/MS is scheduled for delivery in July 1986 and efforts should be made to insure that it is indeed delivered at this time. This is a valuable (and expensive) piece of equipment that will prove very useful in analyzing coal liquids. The operation of CPU #1 and #3 combined with the upgrading potention of CPU #2 will require that this GC/MS is operating in 1986.
6. Equipment purchases in general have been on-time; however, there have been several instances where the delivered cost was significantly higher than the budgeted estimate. I would recommend that an effort be made to obtain more realistic quotes for the larger equipment items and include these estimates in the Work Plan.
7. The DTA unit ordered from Japan was delivered in June 1981 and has not performed satisfactorily. It has been returned to the manufacturer twice with no results. At present it is back in Japan and no progress is being reported. I would recommend that this

RESTRICTED

December 6, 1985
English

unit remain in Japan and that the purchase price be refunded to the Chinese.

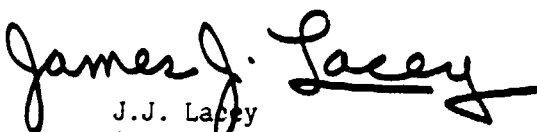
8. The plans for Consultants, Fellowships, and Study Tours were well developed into 1988. I would recommend that every effort be made to arrange the scheduling in order to obtain the maximum benefit. For example the Study Tour on Two-Stage Liquefaction (Post 32-02) should take place as early as possible in 1987 and schedule an extended visit at PETC to consult with Mr. Torkos and Dr. Ruether. Then these two consultants can then visit China together to discuss two-stage liquefaction (Post 11-52) and reactor engineering (Post 11-55) a little later in 1987.
9. As regards Fellowships, I would recommend that this type of training be at an institution where a free exchange of information is possible, e.g., the Pittsburgh Energy Technology Center in the USA. Industrial installations due to their restrictions on patent information may not be able to discuss many aspects of direct coal liquefaction, e.g., Chevron in the USA.
10. On the subject of Study Tours, I would recommend that these be concentrated at the installations where large scale operations involving direct coal liquefaction are taking place. Again one must be assured of a free exchange of information. Some plants that I would recommend would be as follows:
 1. Polish Pilot Plant, Katowice
 2. German Pilot Plant, Bottrop
 3. NEDC Pilot Plant, Japan
 4. Australian Pilot Plant, VictoriaOther plants, would include those in Russia. Every effort should be made to visit several plants when in one geographic area (e.g., Europe).
11. The Study Tour on super-critical extraction (Post 32-03) should take place in the UK should take place as scheduled in September/October 1986; however, it should concentrate on Liquid Solvent Extraction Techniques.
12. One area that should start receiving emphasis is the conduct of economic surveys and the study of direct coal liquefaction technology to evaluate the feasibility of constructing commercial coal liquefaction plants in China after 1990. Progress in this area should be reported upon in 1986.
13. After the next 5 year plan has been approved (early in 1986), the Work Plans for this project should be revised to include the years 1987 and 1988, particularly in the area of planned Research Work. I would recommend that these Work Plans be extended as soon as possible in early 1986.

RESTRICTED

December 6, 1985
English

14. Due to currency fluctuations, the delivered price of several pieces of equipment has been larger than budgeted. Since the present UNDP equipment budget is practically spent for this project, it is recommended that no further equipment be placed on order until the presently requisitioned material is delivered, firm prices established and an accurate accounting performed on the remaining funds.
15. Since the 1986 Work Plans call for Consultants, Fellowships, and Study Tours in early 1986, it is recommended that the Chinese submit the documentation (Job descriptions, etc.) to UNIDO for these efforts as soon as possible. It was stressed that they adhere to the Work Plan in order to proceed in an orderly manner, particularly as regards the expenditure of funds for these areas.
16. The Technical Committee should meet on an annual basis near the end of the calendar year to review the progress during the year and approve the work plans for the coming year. The Technical Committee should meet at a time convenient to the annual Tripartite Meeting. I would recommend that the next meeting of the Technical Committee be scheduled for November 1986.

Finally, it was concluded that my next trip should be in November 1986 and the visit should be arranged to include the yearly Tripartite Meeting. At this time a more accurate status of project cost and schedule should be possible.



J.J. Lacey
Associate Director
Office of Research and Development
December 6, 1985

Attachments

1985 Annual Report
1986 Work Plans