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ANNUAL REPORT TO THE IEA CLM EXECUTIVE COMMITTEE
1985-12-10 to 1986-12-09

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To be submitted to the Executive Committee of the IEA Implementing Agreement on Coal-Liquid Mixtures, as a report of information exchange conducted under Annex II "Cooperation in the Exchange of Base Technology Information for Coal-Liquid Mixtures" for 1986.

ENERGY RESEARCH LABORATORIES
DIVISION REPORT
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ANNEX II
COOPERATION IN THE EXCHANGE OF BASE TECHNOLOGY INFORMATION FOR COAL-LIQUID MIXTURES

BACKGROUND

A meeting of the participants of Annex II was held in London, England from June 23 to 27, 1986.

The participating countries and their major designated contractors are:

Canada	- New Brunswick Electric Power Commission Canada Cement Lafarge Ltd. Bruleurs Coen Canada Ltée Maritime Electric Company Ltd. Cape Breton Development Corporation
Japan	- Coal Mining Research Centre (CMRC) Electric Power Development Co. Ltd. Mitsubishi Heavy Industries Ltd. Kawasaki Heavy Industries Ltd. Ishikawajima-Harima Heavy Industries Co. Ltd. Sumito Heavy Industries Ltd. Nippon Steel Corporation Mitsui Engineering and Ship Building Co. Ltd.
The Netherlands	- NEOM (Netherlands Energy Development Corporation)
Spain	- ASINEL (Electric Industry Investigation Association)
Sweden	- Energikonsult Studsvik Energiteknik
U.S.A.	- Combustion Engineering Inc. TRW Inc.
Italy	- ENEL, ANIC Snamprogetti, CSM

Each participant is committed to a program of work in his respective country to meet the agreement criteria of Annex II, and has agreed to participate in a cooperative and equitable exchange of data via structured reporting, meeting/workshop, and site visit procedures. The coordination of all activities is handled through the Annex II Operating Agent (OA). The OA for this reporting period was Canada.

OBJECTIVE

The objective of Annex II is to stimulate the orderly and equitable exchange of technical, economic, and environmental data relating to the research, development and application of coal-liquid mixture (CLM) technology between the participants and to provide a forum for such exchange.

ACTIVITIES DURING 1986

A meeting was held at the offices of IEA Coal Research, London, U.K. on June 24, 1986 which included member country program presentations by designated contractors or delegates. A special topics meeting was also held June 25 on economic aspects of CLM conversions. Since 1984 special topic meetings have been held concomitantly with the technical committee meeting. The meeting on economics was very useful since the CLM technology is approaching maturity in a number of key areas. Also, site visits were arranged to two boiler/burner companies involved in CLM technology development.

It was agreed at the London meeting that the next meeting would be held in Italy at the time of an IEA sponsored workshop on CWF developments.

Former Netherlands delegate Mr. Bino Fortuin was replaced by Mr. T. Krekels of NEOM.

Former U.S. delegate Mr. Cas Foster was replaced by Mr. John Winslow of U.S. Department of Energy/PETC.

Former Japanese delegate Mr. M. Kawaguchi was replaced by Mr. K. Hosaka of NEDO.

Canada was operating agent for 1986 and in 1987 Italy will take over.

PROJECT STATUS SUMMARIES

Canada

Preparation, combustion and characterization of coal-liquid mixtures - progress in 1986.

Objective and Scope

The project comprises seven tasks in the areas of CLM preparation, combustion and characterization which began in 1982. Each task may be adapted to the changing requirements of the Canadian program and is reported on that basis. Some tasks are related to the utility boiler demonstration program and the remainder are industrial applications of coal-water mixture (CWM) technology or part of the in-house and contract support program of the federal government through its various agencies. The seven tasks are:

1. Design, construction and operation of 4 t/h pilot CWM preparation plant.

2. Development of CWM burners for front-wall and tangentially-fired boilers at Chatham, New Brunswick and at Charlottetown, P.E.I. Operation of the boilers on No. 6 oil and CWM for performance assessment.

3. Coal-water mixture derating assessment of oil-designed utility boilers.

4. Industrial or fluidized bed combustion of coal-water mixtures.

5. Spherical agglomeration applied to CLM or pulverized coal.

6. Development of ceramic CLM burner tip and assembly.

7. Coal-liquid mixture combustion parameters.

The objective of the program is to provide information on the preparation, handling, transportation, combustion and utilization aspects of CLM to allow the fuel to replace oil and gas whenever it is economic. Specific targets are the Atlantic utility sector which depends on offshore oil, industrial boilers and process combustors across Canada which are using oil and gas. The program also seeks to encourage the use of CLM in the utility and industrial sectors through progressively larger demonstrations of the technology and in collaboration with industry.

Accomplishments

Upgrading of the CWM production plant to 6 tonnes/h (task 1).

Improved instrumentation and quality control of CWM manufacturing (task 1).

Manufacture of specification CWM for Charlottetown CWM demonstration (Task 1).

Selection and installation of commercial CWM burners in Charlottetown Unit No. 10 (task 2).

Operation of the Charlottetown boiler on CWM and establishment of capacity limitations and preliminary assessment of performance (task 2).

Commercial CWM fired AFBC installed at the fuel manufacturing plant for heating purposes (task 4).

Commercial conversion of wet process cement kiln (task 4).

Industrial development of coal reject-based agglomerates as an industrial free replacement for oil (task 5).

Final combustion optimization of 55 GJ/h ceramic atomizer/burner at Chatham (to be installed at Charlottetown for testing as part of the demonstration). Tests conducted on both CWM and oil using the same atomizer (task 6).

Study completed on CWM ash deposition using a convective pass simulator rig (task 7).

Japan

Objective and Scope

The Japanese project on highly loaded coal-water mixture (HCWM) has been conducted by EPDC to expand use and to simplify handling of coal. R&D on HCWM since 1980 covers all processes from mine site to boiler and is divided into six tasks:

1. slurry preparation
2. pipeline transportation
3. storage
4. coal cleaning
5. shipping
6. combustion

The R&D work subsidized by the government began in 1982 as a joint project with heavy industry manufacturers and surfactant suppliers. Pilot plant tests will be continued to obtain necessary data for the next demonstration stage.

Accomplishments

In 1983 a 1.5 t/h slurry preparation plant was set up. Storage, ship transport and coal cleaning test facilities were installed in March 1985. Elemental pilot-tests using these total systems began in June 1985.

Major accomplishments were:

1. Preparation
   Preparation of CWM, which holds static stability for 4 weeks, has become possible by adding a stabilizer (below 0.03%).
2. Storage
   Discharging of CWM, after 4 weeks of settled storage, was accomplished without difficulty.
3. Pipeline transportation
   Although slurry viscosity often causes difficulties in long distance pipe transportation, an 80-m continuous slurry circulation loop with 4-B piping has provided 50 to 80 h of continuous running.

4. Coal cleaning
   Deashing rate was about 35 to 45% after flotation, with a combustible material recovery of 95%. No significant difference was found in the fluid characteristics between the deashed and the non-deashed slurry.
5. Shipping
   According to ship motion tests slurry was found stable for both vibration and heaving. However, settling of coal particles has occurred in rolling.

Combustion of CWM is being conducted using test rig furnaces from heavy industry manufacturers.

Meanwhile, EPDC plans to undertake a total system test based on a mock advanced coal chain system, using the same CWM for such practices as preparation, storage, pipe transportation, secondary storage, ship transportation and tertiary storage.

Furthermore, a feasibility study will be undertaken in 1987, in which a demonstration test program will be drafted.

Spain

No report as of April 16, 1987.

Sweden

General situation

The low price of oil has caused a decrease in oil substitution activities in industry. This has led to a significant decline in business opportunities for the CLM producers. No boilers were converted to CLM during 1986. It has even been difficult for the CLM producers to supply fuel to existing customers at agreed prices without a loss or, at least, generating enough revenue to cover capital costs for CLM production facilities.

Government R&D spending on CLM has also declined. As a result of the commercial situation and because of a shift in the government's R&D policy to concentrate more on basic energy research with an emphasis on universities only three companies are competing on the domestic CLM market.

However, to guarantee the survival of the CLM industry the government has allocated funds for technological development, mainly to two companies that are active in marketing CLM technology as a Swedish export product.

Projects

The two projects that were defined as Sweden's contribution to IEA-CLM,

Annex II, have been completed. There will be no direct continuation of either the Sundbyberg boiler test or of the Studsvik materials research project. The main activity that the Swedish government reports as its part of the IEA cooperation is the general results of the national CLM commercialisation efforts.

In addition, a specific project was initiated in 1986 under the auspices of IEA-CLM, in which Sweden and the USA will study the possibilities of using chemically cleaned coal as a feedstock for CWM. A first report will be issued in time for the 1987 IEA-CLM meeting. Preliminary results indicate that chemically cleaned coal is a difficult feedstock. However, it has certain positive features that motivate further R&D efforts to enable the CLM industry to turn it into a marketable fuel.

Future activities

No change is foreseen during 1987 in the CLM R&D policy of the Swedish government. The only reason for a possible increase in funding is a sizeable escalation in oil prices.

United States

Combustion characterization

Objective and Scope

This research project, which began in September 1982, is intended to provide sufficient data on CWM chemical, physical and combustion properties to assess the potential for commercial firing in utility and large-scale industrial boilers and furnaces designed for oil firing. The project is divided into six tasks:

1. Selection of candidate fuels
2. Bench scale characterization tests
3. Preparation of CWM for tests
4. Atomization and burner tests
5. Ash deposition performance tests
6. Commercial application and economics

In addition to developing technical data, the project will evaluate the economics of CWM production using beneficiated coals. The costs of beneficiation will be weighed against the reduced operating costs which result from improved performance.

A final report on the effort is anticipated in the spring of 1987.

Accomplishments (Task 6)

Laboratory Testing

- Examined effect of coal type (5 coals), slurry processing (5 manufacturers) and levels of beneficiation on performance.

- Combustion testing performed at 4 M Btu/h to quantify ash effects and at 50 M Btu/h to establish combustion performance.

- Atomization tests on each slurry to establish flow settings.

- Slurry fuel parent coals test-fired in a dry, pulverized state to provide baseline data.

Oil-Designed Unit Selections (7) for Retrofit Evaluations

-	Utility:	Close-coupled screen	600 MW
		Box	400 MW
		Close-coupled arch	850 MW
-	Industrial:	Shop-assembled	100,000 lb steam/hr
		Modular, field-assembled	400,000 lb steam/hr
-	Process Heater:	Vertical cylindrical	71×10^6 Btu/hr
		Horizontal cabin	142×10^6 Btu/hr

Economic Evaluation

- Incremental costs and savings were determined as a result of the use of CWM as a substitute for oil.

- Payback period defined for each unit based on capital and O&M costs.

Summary and Conclusions

- Coal-water mixtures (CWM) can be fired in oil-designed systems with current technology.

- Significant load-reductions will be necessary if operating problems are to be avoided.

- Predicted load limits are 100% for the process heaters and 30-50% for the others.

- Beneficiation costs of some fuels can be easily justified by more economical operations of the utility units.

- Analysis shows the close-coupled arch is the best candidate for CWM conversion.

- Several cases would be economic at a $1.50/ M Btu price differential (2-3 year payback).

Systems component characterization

Objective and Scope

This project addresses the supply of fuels to the developers of advanced combustion system technologies. The project objectives are to examine the U.S. coal resource base and to select from that base, a suite of coals that has sufficient resources and specifications such that they would be viable candidates for firing in future commercial installations; fully characterize the parent coals and CLM; and supply the coal-based fuels to specific contractors in quantities required for testing.

The project is expected to last three years. Topical reports on the resource base analysis and fuel characterization will be issued, as well as a comprehensive final report.

Accomplishments

This project began in the autumn of 1986. The resource base has been narrowed and initial coal selections will soon be made.

The Netherlands

Preparation and combustion of highly loaded coal-water slurry.

Objective and Scope

The two offices responsible for government sponsored R,D&D work on energy in the Netherlands partially executed to the following CWM-related topics:

1. Slurry preparation.
2. Use of CWM in an industrial type boiler or kiln.
3. Characterization of CWM.
4. Furnace tests to assess the sulphur capture potential of adding limestone/lime to a CWM flame.

This work was based on the prevailing opinion of the government in 1985 that CWM, if fired in an environmentally acceptable way, has a good potential for replacing oil and gas as an alternative fuel in industry and in the long term has domestic application.

Accomplishments

A. In a joint effort between the government and two interested private companies a research project was executed by the International Flame Research Foundation (IFRF) of IJmuiden. In this project the combustion of three different coal-water fuels was studied with the introduction of lime or limestone as a sulphur absorbing agent. The

trials took place in 1985 and a report was prepared in 1986. Initially, results were not very encouraging because it proved difficult to achieve desulphurization higher than 30%. More satisfactory results were obtained using special sorbents and injection methods. A detailed paper will be presented by Mr. J.T. Krekels at the IEA-Annex II meeting in Rome on May 8, 1987.

B. Ankersmit BV-project

NEOM provided the funds to Ankersmit to undertake of an engineering study for a production plant for CWM-fuel. Ankersmit is a chemical company with expertise in grinding and mixing. They also have experience with chemicals for stabilization and dispersion. They have, on a pilot-plant scale, produced CWM products with superior combustion qualities. The latter was established in comparative tests at the IFRF at IJmuiden. The production plant designed by Ankersmit can produce cheaper CWM-fuel than most other processes. The plant is designed for 40,000 tonnes per year to be realized at the Winterswijk Chemical Complex of the company. Part of the product should be fired in an industrial dryer at the Winterswijk plant also. Because the plant can be realized at an existing complex, without coal-beneficiation the plant is estimated to cost less than $1 million.

At the present price of oil the project cannot be justified economically by Ankersmit. Therefore, it will be necessary for NEOM to provide the required investment funds to realize the project. A decision on this project will be made in the spring of 1987.

C. Frans Swarttouw BV

The Frans Swarttouw Stevedsking company handles 6 million tonnes per year of imported coal and petroleum-coke at the Rotterdam port for transport to Holland and the German-Ruhr area. By screening for special coal qualities, 500,000 tonnes per year of fine coal is separated. The company is undertaking extensive studies for the optimal utilization of these fine-products. CWM production and pulverized fuel (PF) are the main alternatives. The company is in direct contact with Nycol A.B. in Sweden for these studies. Also, a certain degree of cooperation with Ankersmit is involved. Obviously NEOM would be interested in cooperating with Swartthouw and Esso with respect to the Colombian coal situation. This could be effected in another CWM demo plant at the Rotterdam port (see 2 below).

Final Remarks

1. Introduction of CWM in Holland can only be expected in industrial applications for the first decade.

Electricity generation has opted for coal as such or probably coal-gasification. Domestic usage for this century will be governed by gas. The expression for this is that Holland is governed by a gassyndrome!

So the only chance for CWM is in industrial application, probably with export opportunities to Western Germany. However, a serious competitor is German lignite. It is available in pulverized form at low prices in Holland and Western Germany (transport by silocars from the production area near Cologne).

2. NEOM is the Dutch state owned energy development company. It was founded in 1976 by the Dutch Ministry of Economic Affairs. This certainly required much courage by the government because Holland is a very small state with an abundance of natural gas deposits and above-all governed energetically by a number of powerful multi-national oil companies such as Shell, Esso, BP and others. Nevertheless, NEOM BV in its 10 years has booked remarkable performances and was also one of the first to sign the agreement on cooperation for coal-oil mixtures promotion with the IEA in 1981, an agreement which one year later was transformed into the CLM agreement.

   The controversy between a company like NEOM and the multi-national oil companies is obvious. The former has as its major task to develop and demonstrate new energy technologies and diversification of fuels. However, the oil companies ask the government to develop first the market for new technologies, after which they would prefer to develop the technology themselves. They also are not interested in international cooperation. For this very reason NEOM is not in a position to have any substantial support from any of the oil multi-nationals at this time. This situation is rather disappointing as both Shell, Esso and BP have their own coal activities.
   The situation of Esso-Holland is especially typical, because the company has realized a major new coal mine in Colombia, South America, with several billion dollars of Dutch development aid money. The mine (El-Cerrejon coal mine) will produce 14 million tonnes of superb quality coal per year in a short time with a sulphur content of only 0.6% (after froth-flotation 0.45% is attainable) and low mineral content. This coal could be of the utmost importance in the production of CWM fuel.

   It should be expected that the Dutch government might 'freeze' the CLM development in 1987. We expect however, that this will be for a relatively short time, primarily to be governed by the international crude oil price.

Italy

Preparation, combustion and characterization of coal liquid mixtures - progress in 1986.

Background

Activities on coal water mixtures began in 1979. Research activities have been mainly performed by:

- ENERL - (National Energy Board) and ANIC (Petrochemical Company) - development of burners and research on combustion.

- SNAMPROGETTI - development of coal water mixtures and the analyses of CWM characteristics and rheology.

- CSM (Metallurgical Experimental Centre) - utilization of CWM instead of fuel oil, in blast furnaces.

Other Italian companies such as ANSALDO, AEM-MI, and AGIP Carbone performed various activities on CWM development and on industrial demonstration projects:

- 100 MBTU burners have been developed: tests on a loop have been carried out and the technology for long distance transport of CWM has been developed. Production plants of 100,000 tonnes per year have been realized.

Objective and Scope

The Italian program has the following objectives:

1. Operation of CWM production pilot plants for:

   - optimization of production costs;
   - test functionality of installed materials and components;
   - production of CWM from various coals;
   - understanding the know-how for the construction of larger plants.

2. Combustion tests on small industrial boilers for:

   - selecting industrial burners;
   - atomizers, wear and life;
   - effect on combustion efficiency of parameters such as air combustion temperature; fuel pre-heating, atomizing media;
   - appraisal of instrumentation and component behaviour.

3. Development of CWM long distance transportation technologies to optimize transportation parameters.

4. Fuel boilers retrofitting:

   - optimization of combustion efficiency;
   - derating evaluation;
   - ash characteristics;
   - problems related to a prolonged operation of the plant.

5. Coal water mixtures utilization in the steel industry.

6. Environmental aspects - evaluation of benefits with respect to the use of heavy oil and pulverized coal.

The purpose of the program is to substitute wherever possible fuel oil with CWM, mainly in the electrical sector (large boilers) where fuel oil energy consumption still prevails with respect to other fuels.

Other objectives are production, supply flexibility and reduction of environmental impact.

Accomplishments

A. SNAMPROGETTI'S ACTIVITIES

Various R&D research programs and industrial projects on CWM technology were performed during 1986 or are in progress. The aim is to improve CWM technology in production, transportation, combustion, equipment development and to improve the overall economics through the reduction of costs incurred in CWM preparation and handling.

The most important activities are:

- Systematic research aimed at comprehending of all physical and chemical phenomena which affect the slurry ability of the coals to optimize formulations and slurry preparation procedures capable of successfully processing a wide range of coals including low-rank coals.

- Development of low cost additives by using cheap and accessible raw materials.

- Development of CWM transport via pipeline over long distances (over 2000 km) and for very large throughputs (over 15 Mta of coal). This activity includes the feasibility study for the Kuzbass-Ural coal pipeline system (USSR).

- Development of equipment specifically designed and optimized for the slurry process. This activity includes the design of an advanced mill of large capacity for the wet micronization of the coal.

- Development of CWM combustion technology aimed at designing reliable equipment (burners and fuel feeding systems) for industrial applications and developing new desulphurization techniques.

- Start-up of the ENICHEM ANIC pilot plant at Porto Torres (10 t/h CWM), designed by SNAMPROGETTI.

- Completion of the basic and detailed design for the pilot-commercial coal slurry pipeline Belovo-Novosibirsk and slurry preparation complex (USSR). This project is based on the SNAMPROGETTI process and includes:

  - slurry production plant with a capacity of 3 Mta of coal;
  - 6 m diam. and 256 km long pipeline with three main pumping stations;
  - retrofitting of the power station at Novosibirsk, consisting of 6 units of 220 MW each.

B. ENEL'S ACTIVITIES

The coal-water slurry activity is in progress.

Progress has been made in understanding the chemical-physical properties of the structure of the "system" made by water, coal particles and tensioactives. Low-cost dispersants and stabilizers for the preparation of the slurry have been identified.

- Developments related to CWM atomization were:

  1. The study of atomization phenomena with special emphasis on the effect of CWM characteristics on atomization quality.

  2. Use of the results to optimize the development of large-scale industrial burners.

- A startup test of a burner set (4 burners) at No. 2 S. Gilla unit has been completed.

  A 15 MWe capacity has been reached. The new burners performed well.

- Problems occurred on the CWM burner supply system because the performance of the automatic regulation valves installed on the burners was inadequate.

  Other problems occurred related to the operation of auxiliary systems outside the CWM systems such as pre-heaters, boiler evaporation and bundles. When these problems are resolved tests will resume.