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R, D & D IN FLUIDIZED-BED COMBUSTION
THE COAL PROGRAM FOR FY 1980-81 AND BEYOND

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Canadian Combustion Research Laboratory

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by

F.D. Friedrich*

INTRODUCTION

Fluidized-bed conbustion (FBC) is in the forefront of the emerging technologies which are urgently required to permit the displacement of oil by lower-quality fuels such as coal, coal wastes, wood waste and tar sands coke. However, substantial efforts in research, development and demonstration are required before FBC can make its full contribution to the Canadian energy picture. Although fluidized-bed incineration of wood waste and sewage sludge is commercially established, at present in Canada there are no fluidized-bed boilers burning coal.

Potential applications of atmospheric FBC boilers range from heating plants of modest size through large industrial boilers to very large electric utility steam generators. An additional application lies in uncooled combustors providing hot gases for industrial dryers such as are used in coal preparation plants. Pressurized FBC equipment is most likely to find application in advanced, combined-cycle electricity-generating systems. All these areas require demonstration that FBC technology works, and with a variety of fuels. Coals range from lignite to low-volatile bituminous; levels of ash, moisture and sulphur may be high. Other potential fuels are coal washery rejects, wood waste and various industrial wastes.

In order to hasten the application of FBC technology to Canadian needs, EMR has undertaken to support a broad program of demonstration projects in the areas of application just described. The demonstrations, in turn, are supported by contracted and in-house R & D mostly on a pilot scale. CANMET, as the technical arm for EMR's Science and Technology Sector, carries most of the program responsibility via the administrative

functions of the Energy Research Program Office and the technical expertise and research facilities of the Canadian Combustion Research Laboratory (CCRL).

The present report describes the FBC program as it now stands, primarily from the viewpoint of CCRL. Objectives and status of the various projects are presented, together with financial manpower resources allocated for the current fiscal year. The report includes a review of probable resource requirements as projects progress, and thus forms a basis for future planning.

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FLUIDIZED-BED COMBUSTION IN THE CANMET ENERGY PROGRAM

The program of the Canadian Combustion Research Laboratory on research, development and demonstration in fluidized-bed combustion falls mostly within the CANMET Energy Research Program, and specifically within Activity 3.3; Energy Research and Technology Development. This corresponds to the office of Energy Research and Development code 2.4 on Coal and Peat.

Since, in the Canadian context, fluidized-bed combustion is viewed primarily as an emerging technology for the combustion of coal, most of the effort, 6.85 person-years is directed into Sub-Activity 3.3.4; Coal Technology, Sub-Activity 3.3.4.6; Combustion.

The objective of this work, as stated in the CANMET 5-year program plan[1], is "to decrease the consumption of premium liquid and gaseous fuels in Canadian industrial and utility applications by introducing and demonstrating fluidized-bed combustion technology to Canada, specifically by 1985, by completing a project for construction of a fluidized-bed heating plant at CFB Summerside, PEI". The program plan further states "Demonstrations of fluidized-bed combustion technology at CFB Summerside are supported by in-house and contract pilot-scale trials to determine the potential for fuel flexibility and emissions containment. Futher demonstrations are anticipated in utility and industrial use of coal rejects and under conditions applicable to industrial cogeneration of steam and electricity".

Specific goals identified in the CANMET program plan are as follows:

- "On-going R & D support by in-house and contracted pilot studies on fuel flexibility and emissions control during FBC of coals and petroleum coke.
- Completion of construction and demonstration of the CFB Summerside FBC heating plant.
- Completion of FBC coal dryer burning coal rejects for drying heat and plant heating.
- Initiation of FBC demonstrations for utility use of coal rejects and in industrial applications".

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[1]Staff, Energy Research Program Office; Program Plans, 1980-1985, Report No. ERP 80-1 Jan. 1980.

A smaller amount of work on fluidized-bed combustion, 0.25 person-years, is directed into Sub-Activity 3.3.7; Renewable Energy Technology, Sub-Sub-Activity 3.3.7.1; Combustion and Conversion. The objectives of this work are:

1. to accelerate improvements in wood-firing systems in industry, and
2. to provide advisory support for the ENFOR program administered by the Conservation and Renewable Energy Branch.

THE R & D PROGRAM FOR COAL

Objectives

The stated objective of the R & D program on FBC is to support demonstration programs by pilot studies on fuel flexibility and emissions control. This deserves some elaboration. Essentially, it is proposed to develop a data base to guide designers of full-scale FBC equipment for the various Canadian coals, coal wastes, tar sands cokes, wood waste and other wastes which are likely to be utilized by means of FBC technology.

The questions which designers might ask are many and varied; they may relate to fluidized-bed combustion in general, or they may be specific to certain fuels and sorbents. The following is only a partial list of information which will likely be required, perhaps for a large number of coals and other solid fuels.

- At what bed temperature do ash components begin to fuse?
- What are the optimum relationships among bed temperature, superficial fluidizing velocity, excess air level and combustion efficiency?
- What are the effects of fuel size consist, bed size consist and bed depth on combustion performance?
- What fraction of the ash is elutriated and how does this affect bed inventory?
- If coarse coal is fired, will large ash particles accumulate to the point of interfering with fluidization?
- What is the size consist and composition of elutriated material?
- To what extent can elutriated carbon loss be reduced by fly ash recycling?
- Are fine fly ash particles likely to cause deposition problems on convective heat transfer surfaces?

- What are optimum area or volumetric heat release rates and how widely can they be deviated from to achieve turndown?
- What are the sulphur-neutralizing characteristics of various limestones and dolomites, and how are they affected by size consist, bed conditions, and additives?
- To what extent is fuel sulphur neutralized by fuel ash constituents?
- What are the proportions of sulphur neutralization accomplished in the bed and in the freeboard regions?
- What is the level of nitrogen oxide emissions and how is it affected by bed conditions and fuel nitrogen component.?
- What is the fate of heavy metal constituents in the fuel?
- What proportion of the thermal input may be extracted from the bed?
- What are typical heat transfer rates to immersed heat exchange surfaces, and how are they affected by tube bundle configuration?
- To what extent can coal and wood waste be burnt in the same bed, and how is combustion performance affected?
- What materials problems are likely to occur in terms of corrosion and erosion, and how can they be solved?
- What are the limiting factors in terms of maceral composition, ash content, moisture content, calorific value and size consist, which govern the combustion and dust collector performance of waste materials from coal preparation plants?

Although R & D conducted elsewhere in the world can be expected to contribute a substantial part of the desired information, the Canadian situation is sufficiently unique with respect to both fuels and applications, that the speed with which FBC technology impacts on the Canadian energy picture will depend in large measure on the rate at which Canadian R & D responds to the need for information. A parallel can be drawn with conventional PF combustion technology which, despite many decades of development and full-scale aplication around the world, has R & D needs in Canada alone that the pilot-scale facilities of CCRL are hard-put to meet.

Approach

To produce the massive body of required information as outlined in the foregoing section will require a correspondingly massive R & D effort

extending over many years and encompassing several agencies. CANMET can be expected to play a leading role, both because of the existing pilot-scale facilities at CCRL and because of CANMET's mandate to contract out desirable R & D to suitably equipped agencies.

The manner in which information is gathered will have to be varied to suit specific needs and circumstances, but an excellent starting point is provided by the pilot-scale facilities existing or under construction at CCRL, at Queen's University and at B.C. Research. These facilities can best be utilized as tools for industrial-style experiments in which input parameters are varied while appropriate output parameters are measured, both sets of parameters being selected as priorities dictate. The input and output parameters of most probable concern are listed below, but the list is by no means exhaustive.

Input Parameters

Fuel:
- type
- ash content
- moisture content
- size consist
- feed arrangement
- petrography
- sulphur content

Bed Conditions:
- temperature
- depth
- size consist of bed material
- heat release rate per unit of area or volume
- superficial fluidizing velocity
- excess air level

Sorbent:
- source
- analysis
- size consist
- Ca/S ratio
- effect of sorbent additives

Heat Exchanger:
- tube size and arrangement
- materials
- metal temperature

Output Parameters

Emissions:
- sulphur oxides
- nitrogen oxides
- elutriated carbon
- other combustibles
- heavy metals and other trace elements
- fly ash; quantity, size consist and sulphur capture

Bed Ash:
- size consist
- build-up of oversize
- sintering and slagging
- inventory trends
- sulphur capture
- uses and disposal

Heat Exchanger:
- heat transfer rates
- corrosion
- erosion
- abrasion

As each project element is raised, a suitable scope of work can be prepared using appropriate parameters from the foregoing list, whether the work is carried out in-house at CCRL or contracted to another agency. Initially project elements will be formulated to meet the needs of current demonstration projects and to generate information which it is anticipated will be required in hastening the application of FBC technology to Canadian needs. As these applications become more widespread, it can be expected that industry, i.e., users and suppliers of FBC equipment, will play a greater role in identifying R&D needs, as has happened in CCRL's R&D program for conventional combustion technology. Project elements will than have to reflect changes in priority.

Projects, Elements and Tasks for FY 1980-81

The CCRL R&D program for 1980-81 encompasses two projects with the following breakdown of elements, milestones and resources.

Project 334606; pilot-scale fluid bed

Objective: To develop and extrapolate fluid-bed technology to burn low-grade Canadian coals and coal rejects in steam-generating and process heat application under acceptable environmental conditions.

Resources: 5.8 person-years
$180 k direct funding
$ 35 k contract funding

Project element 334606-01; design parameters

Objective: to determine critical design parameters for successful combustion of a variety of coals or coal rejects.

Milestones:
1. Trial burns in Mark 1 fluid bed with Line Creek coal and Onakawana lignite.
2. Report on 1.
3. Correlation trials with Mark 2 fluid bed using Luscar coal
4. Combustion trials with Devco coal.
5. Report on 4.
6. Finalize IEA fluid-bed data exchange.

Project element 334606-02; CCRL Mark 2 combustor

Objective: To install and debug new fluid-bed combustor at CCRL and conduct evaluations.

Milestones:
1. Erect new fluid-bed.
2. Complete refractory lining and cure refractory.
3. Install coal feeder, bunker and instrumentation.
4. De-bugging in adiabatic mode.
5. Install in-bed cooling

Project element 334606-03,
fluid bed diagnostic and control sensors

Objective: To determine the applicability of differential temperature sensors to fluidized-bed combustion as a means of anticipating defluidization and for detecting other changes in bed operating characteristics.

Milestones:
1. To build and commission a 100 mm diam continuous fluidized-bed combustor.
2. To determine the operating variables that significantly affect the extent of anticipation of defluidization of the bed.
3. To design, build and test a DT sensor with variable anticipation of defluidization.
4. To instrument CCRL Mark 2 FBC.
5. To commission instrumentation in 4.

To the foregoing elements will be added, if possible, a contract to Stake Technology for testing their proprietary feeder with coal.

Project 334607; fluid-bed mechanisms

Objectives: To elucidate the mechanisms of in-situ sulphur and nitric oxide neutralization during combustion using additives to the coal feed and by changes in combustion parameters.

Resources: 0.2 person-years
$90 k contract funding in 1979-80
est. $70 k contract funding in 1980-81

Project element 334607-01; Queen's University

Objective: To erect and de-bug a CCRL Mark 2 pilot-scale fluid-bed at Queen's University and to conduct two trial burns for elucidating Devco coal-Havelock limestone SO_2 neutralization reactions.

Milestones:
1. Erect new fluid bed
2. Complete refractory lining and cure refractory
3. Install coal feeder, bunker and instrumentation
4. De-bugging in adiabatic mode
5. Install in-bed cooling
6. Trials with two coals and one limestone.

In addition to the above work designated for CCRL, the Energy Program Office has designated a person-year in the Physical Metallurgy Research Laboratories for materials research relating to fluidized-bed combustion. There is also in progress a CANMET contract to B.C. Research and B.H. Levelton Associates Ltd., for corrosion research in the pilot-scale FBC at B.C. Research.

THE DEMONSTRATION PROGRAM FOR COAL

Objectives

The key objective of EMR's FBC demonstration program has already been stated; i.e., "to decrease the consumption of premium liquid and gaseous fuels in Canadian industrial and utility applications by introducing and demonstrating fluidized-bed combustion technology to Canada". Since EMR has no authority by which it can require industry to employ FBC technology, the means for "introducing and demonstrating" must be through clarifying the advantages and reducing the perceived risk of adopting the new technology. This is done through funding of contracts for design studies, economic analyses and installation of full-scale equipment.

The role of CCRL in the demonstration program is substantial and significantly accelerates the transfer of technology from the research stage to commercialization. First, from the background of its technical expertise CCRL advises the Energy Program Office and the Energy Policy Sector on industrial applications where FBC technology can be most beneficial and therefore demonstrations are most desirable. Second, CCRL provides technical input to discussions and negotiations with potential partners in a demonstration, and with contactors for the studies and the hardware. This frequently includes preparation of work statements for contracts. Third,

when a contract or an agreement has been negotiated, CCRL commonly represents EMR as scientific authority or technical liaison officer. The nature of CCRL's contributions is made more clear in the following description of the demonstration projects presently under way.

Summary of Current Demonstration Projects

CFB Summerside project; fluidized-bed boiler

The objective of this project is to put in place at CFB Summerside a heating plant extension containing two fluidized-bed boilers designed to burn high-sulphur coal with supplementary firing of wood chips. These will be the first FB boilers in Canada, and a further objective is to put Canadian equipment suppliers in a position to provide this technology. EMR's partner in this demonstation is the Department of National Defence, (DND) which operates CFB Summerside and will be ultimate user of the boilers.

The project was initiated in 1977 and has proceeded through two phases of conceptual design, one dealing with the FB boiler, the other with the complete plant extension. In both cases parallel contracts were issued to two sets of contractors in order to maintain a strong element of competition and bring two Canadian boiler manufacturers to the point of being able to supply FB boilers. In phase 3, presently underway, two boiler manufacturers are preparing detailed designs and firm price proposals. Tender closing date is January 5, 1981, after which one manufacturer will receive a contract to build the plant extension with one boiler (Phase 4). After construction is complete, an extensive testing and demonstration program (Phase 5) will be carried out, and if boiler performance is satisfactory, the final phase will consist of installation of the second boiler.

Total project cost is estimated at about $10 million, of which EMR will pay approximately 70%, including all costs for phases 1,2,3 and 5. Besides substantial involvement in the initial planning of the project, CCRL participates in the project steering committee, chairs the project technical committee and has provided or is providing the scientific authority for all the contracts connected with Phase 1, 2 and 3. The plant and boiler construction, Phase 4 and 6, will be handled by Defence Construction Ltd., but the demonstration program, Phase 5, which is likely to take place in 1983,

will be an EMR responsibility, and besides requiring a scientific authority from CCRL, should involve substantial test work by CCRL staff at CFB Summerside.

Luscar coal dryer study

The concept of using coal washery rejects as fuel for coal drying has become more attractive as costs of conventional fuels have risen. Uncooled FB combustors such as are already in use for incinerating wood waste and sewage sludge seem well suited to coping with high-ash, high-moisture coal rejects, and in 1976, at the instigation of CCRL, CANMET funded some conceptual design studies and pilot-scale tests. The encouraging results of the pilot-scale tests eventually led to an unsolicited proposal from Luscar Ltd. to cost share with EMR a study related to Luscar's coal preparation plant at Coal Valley, Alberta.

A contract has now been signed for a study which will (a) prepare a conceptual design of an FBC to burn washery rejects and provide heat for the existing coal dryer as well as plant heating, (b) generate a firm price quotation from a supplier for the required FBC and auxiliary equipment, and (c) evaluate the economics of the FBC system; i.e., establish the payback period. The study is scheduled to be completed in the fall of 1980, and may well lead to EMR co-funding a full-scale demonstration, which might cost $5 million.

In this case, CCRL prepared the work statement for the study contract, is providing the scientific authority, and is assisting Luscar in the selection of sub-contractors. The utilization of washery rejects as fuel is viewed by EMR as having very significant potential in that approximately 7 million tons of rejects are generated each year in Alberta and British Columbia.

Nova Scotia Power Commission AFBC utility boiler

The need to substitute coal for oil as fuel for electricity generation is greatest in Canada's maritime provinces. While supplies of indigenous coal are ample, their use via conventional technology is complicated by variable quality and high sulphur content. FBC technology can overcome both these handicaps, but FBC boilers have yet to be demonstrated on a utility scale.

Through the mechanism of the Oil Substitution Agreement, EMR is supporting the Nova Scotia Power Commission (NSPC) in groundwork studies aimed at putting in place a demonstration FBC utility boiler, probably 150 MWe in size. At present a consulting engineering firm is carrying out a small contract to evaluate the relative merits of several alternative sites. This work should be completed by mid-1980. Establishment of the best site will determine which coal and which sorbent are available, and will also establish the size of the proposed boiler. A decision must then be reached on whether to proceed with the next step, which would be to contract out the preparation of a conceptual design and duty specification that would form the basis for calling tenders for contruction. Efforts are being made to set up a liaison with the Tennessee Valley Authority, which already has projects under way to commission a 20 MWe AFBC pilot plant by 1983 and a 200 MWe demonstration plant by 1986.

NSPC is acting as lead agency in the proposed Canadian demonstration, and would be the ultimate owner and operator if the plant is built. CCRL is serving as technical advisor on behalf of EMR, and can be expected to have substantial input at the conceptual design stage.

Industrial FBC boiler demonstration

Canadian industry constitutes another market sector where FBC technology could contribute to oil substitution. Typically, industrial boiler requirements fall between heating plant boilers and utility boilers in terms of capacity and steam conditions, but a high degree of reliability is demanded and there is frequently a requirement to burn industrial waste as well. For example, the pulp and paper industry, which is the largest component of the industrial sector, commonly requires boilers that can co-fire wood waste.

To accelerate the application of FBC technology to the industrial sector, EMR has announced a Request for Proposal in the March 1980 issue of Research and Development Bulletin published by Supply and Services Canada. The announcement indicates EMR's willingness to financially support a demonstration, and invites teams of users and suppliers to submit proposals for the design and installation of an FBC boiler at a specific site. The proposed boiler should have a capacity of about 100,000 kg/h of steam, should

burn coal and possibly wood chips, and should displace oil-fired equipment. Preliminary proposals are to be submitted by June 1, 1980. These will be reviewed, and those submitting the most promising proposals will be invited to submit a more detailed proposal, probably by October 1, 1980. A review of these in turn will, it is hoped, lead to a cost-shared contract with one team to design, install and demonstrate a full-scale industrial FBC boiler in an industrial plant. The demonstration boiler might cost $40 million.

The extent to which CCRL will be involved in this demonstration is not clear at present. There has already been a contribution to defining the nature and scope of the desired project, and there will certainly be substantial involvement in reviewing the proposals that are received. However, if CCRL is to take the lead in drafting work statements and providing a scientific authority for subsequent contracts, additional staff will be required.

Pressurized fluidized-bed combustion and gasification

The research, development and demonstration work described up to this point has all been concerned with atmospheric fluidized bed combustion. EMR also supports work on PFBC and on fluidized-bed gasification.

In the case of PFBC, since 1975 EMR has co-funded with the British Columbia Hydro and Power Authority (B.C. Hydro) a series of studies aimed at developing more efficient coal-to-electricity cycles. With B.C. Hydro acting as lead agency, early studies reviewed the options presented by AFBC, combined-cycle gasification and combined-cycle PFBC. These studies concluded that the last of these options offered the best potential. Further studies were then undertaken to evaluate alternative PFBC combined cycles and prepare conceptual designs for a demonstration plant. This resulted in a proposal for a PFB combustor providing hot gas to drive a 70 MWe gas-turbine-generator set. B.C. Hydro are presently reviewing the desirability of proceeding with the detailed design of the demonstration. If this project goes forward it will likely have substantial financial support from EMR, and CCRL will likely be required to provide EMR's technical representation.

EMR is also cosponsoring with Saskatchewan Power Corporation (SPC) studies of advanced coal-to-electricity cycles based on lignite. At present, the option of a 300 MWe combined cycle based on gasification is being reviewed. If a fluidized-bed gasifier is selected, CCRL might again be called upon for technical input, and if the gasifier concept is dropped in favour of fluidized-bed combustion, a much greater involvement could result.

Projects, Elements and Tasks for FY 1990-81

The demonstration program in which CCRL is involved for 1980-81, and which can be expected to continue for some years, consists of three projects with the following breakdown of elements, milestones and resources.

Project 334605; Summerside fluid-bed

Objective: To design and demonstrate the feasibility of FBC technology for steam raising using Maritime coals and wood at CFB Summerside.

Resources: 1.0 person-year
$32 k direct funding
$930 k contract funding

Project Element 334605-01; Dominion Bridge

Objective: To complete detailed design of heating plant and FB boiler including firm price proposal under Phase 3.

Milestones:
1. Sign contract for Phase 3
2. Review progress every two months
3. Final report on Phase 3
4. Contractor presentation
5. Evaluation for selection of contractor for Phase 4.

Project Element 334605-02; Foster Wheeler Ltd.

Objective: To complete detailed design of heating plant and FB boiler including firm price proposal under Phase 3.

Milestones:
1. Sign contract for Phase 3
2. Review progress every two months
3. Final report on Phase 3
4. Contractor presentation
5. Evaluation for selection of contractor for Phase 4.

Project element 334605-03; Foster Wheeler sulphur control studies

Objective: To evaluate the effectiveness of Havelock limestone in neutralizing sulphur during AFBC of Devco coal.

Milestones:
1. Conduct pilot-scale trials
2. Monitor experiments
3. Contract report
4. Evaluate report
5. Input data into Phase 4.

Project element 334605-04; construction of FB boiler and plant

Objective: To liaise with DCL/DND during selection of prime contractor for Phase 4 and to provide technical advice during construction of the boiler and plant.

Milestones:
1. Selection of Phase 4 contractor
(further milestones in succeeding years)

Project 334608: innovative power cycles

Objective: To evaluate the feasibility of fluid-bed power cycles fired with coal as requested by the Energy Policy Sector.

Resources: 0.3 person-years
$6 k direct funding
Contract funding through Oil Substitution Agreement, Federal-Provincial Agreements or Canadian Electrical Association.

Project element 334608-01; scientific services and consultations

Objective: To evaluate proposals for innovative cycles for power generation using coal.

Milestones:
1. Review guidelines for conceptual design and costs of FB utility boiler for NSPC
2. Review site options recommended for 1
3. Solicit proposals for an industrial FB steam boiler-100 000 kg/h
4. Evaluate 3
5. Continuing consultations with B.C. Hydro on PFBC
6. Review of SPC gasification combined cycle studies
7. Evaluate AFBC proposal initiated by NSPC under the Oil Substitution Agreement.

Project 334609: fluid-bed coal dryer

Objective: To conduct site-specific conceptual and economic studies for a demonstration fluid-bed combustor fired with coal rejects to supply heat for coal drying and space heating.

Resources: 0.2 person-years
$35 k contract funding

Project element 334609-01; Luscar Ltd.

Objective: To prepare a conceptual design and cost analysis for a demonstration-scale combustor to dry coal and to provide space heating.

Milestones:
1. Complete work statement
2. Sign contract
3. Monitor progress
4. Report progress
5. Evaluation and decision to continue
6. Technical input to funding strategy if decision to proceed.

FBC IN THE RENEWABLE ENERGY TECHNOLOGY SUB-ACTIVITY

Background

Although CCRL activities relating to renewable fuel sources are

extensive, the portion concerned with FBC technology is presently restricted to (a) advisory support to EMR's Conservation and Renewable Energy Branch and the ENFOR program, and (b) pilot-scale test work associated with the commitment to burn wood as a supplementary fuel in the CFB Summerside project. Some effort is also directed into consultative services to industrial installations already utilizing FBC technology for incineration of wood waste.

Canada's forest products industry could take a large step toward energy self-sufficiency by fully utilizing waste wood and bark for steam production. FBC technology offers several advantages and a step toward commercialization has already been taken by suggesting wood waste as supplementary fuel in the Industrial FBC Boiler Demonstration previously described. It is anticipated that FBC combustion of wood waste will be an area of increasing CCRL involvement.

Project, Elements and Tasks for FY 1980-81

Project 337102; industrial technology

Objectives: To accelerate improvements in conventional wood-firing systems in industry, to evaluate new burner concepts and to provide advisory support for the ENFOR program.

Resources: 0.3 person-years
10 k direct funding
Note: The scope of both the objectives and resources identified above go beyond the area of FBC.

Project element 337102-01; emerging combustion systems

Objective: To evaluate co-firing of wood and coal in a pilot-scale fluid-bed.

Milestones:
1. Equipment fabrication
2. De-bugging
3. Burn trials

4. Data evaluation
5. Report
6. Advisory support to related renewable energy projects.

Project element 337102-03; advisory support to ENFOR/CREB

Objective: To evaluate proposals of R,D & D projects and to prepare position statements on results of completed contracts.

Milestones:
1. Evaluation of studies contracted on biomass through CREB or ENFOR
2. Advisory support for ENFOR and CREB federal/provincial agreements.

PROGRAM SUMMARY AND REVIEW OF RESOURCES

Although CAMNET's involvement in FBC technology is relatively recent, good progress has been made in developing a program covering both R & D and demonstration. Achievable objectives have been defined and the resources presently available have been allocated as seems most appropriate. The present status can be summarized as follows:

R & D Resources and Projects

Resources: 6.0 person-years
$180 k direct funding
$290 k contract funding

Projects: Sub-activity 3.3.4, Coal Technology,
Sub-sub-activity 3.3.4.6, Combustion

Project 334606 - Pilot-Scale Fluid-Bed
Element 334606-01 - Design Parameters
Element 334606-02 - CCRL Mark 2 Combustor
Element 334606-03 - Fluid Bed Diagnostic and Control Sensors
Project 334607 - Fluid-Bed Mechanisms
Element 334607-01 - Queen's University

Demonstration Resources and Projects

Resources: 1.5 person-years
$38 k direct funding
$965 k contract funding

Projects: Sub-activity 3.3.4, Coal Technology,
Sub-sub-activity 3.3.4.6, Combustion

Project 334605 - Summerside Fluid-Bed
Element 334605-01 - Dominion Bridge Co. Ltd.
Element 334605-02 - Foster Wheeler Ltd.
Element 334605-03 - Foster Wheeler Sulphur Control Studies
Element 334605-04 - Construction of FB Boiler and Plant
Project 334608 - Innovative Power Cycles
Element 334608-01 - Scientific Services and Consultation, re:
(a) NSPC FBC utility boiler
(b) FBC industrial boiler
(c) B.C. Hydro PFBC project
(d) SPC gasification combined cycle
Project 334609 - Fluid Bed Coal Dryer
Element 334609-01 - Luscar Ltd.

Renewable Energy Resources and Projects

Resources: 0.25 person-years

Projects: Sub-activity 3.3.7, Renewable Energy,
Sub-sub-activity 3.3.7.1, Combustion and Conversion

Project 337102 - Industrial Technology
Element 337102-02 - Emerging Combustion Systems
Element 337102-03 - Advisory Support to ENFOR/CREB

Future Resource Requirements

Objectives are under frequent review and can readily be refined or added to as dictated by the course of events. As the projects presently in hand progress, additional manpower resources will be required if the very substantial investments are to be protected by a reasonable level of supervision. The following is an estimate of these requirements to 1985.

1. CCRL pilot-scale fluid bed - For optimum utilization of the new facility, this project requires two additional person-years, preferably one technologist and one engineer or research scientist.
2. R & D contracts to outside agencies - Additional major contracts ($100 k/year or more) should receive scientific authority staffing of 0.2 person-years each.
3. CFB Summerside project - The testing and demonstration phase of this project, which is likely to be under way from Jan./83 to Apr./84, will require a substantial test crew. Because of its special expertise, CCRL will be expected to contribute at least three person-years during the heating season. Some of these can be drawn from present staff, but only at the expense of existing programs.
4. NSPC FBC utility boiler - If this project proceeds as hoped, at least 0.1 person-year of scientific liaison shluld be allocated during the design stage, which will probably be in 1981 and 1982.
5. Industrial FBC boiler demonstration - If CANMET remains as the lead agency, the scientific authority function will require at least 0.5 person-year, probably from 1981 to 1985.
6. Luscar FBC-fired coal dryer - Presuming this project proceeds to demonstration, the scientific authority function will also require 0.5 person-years, probably during 1982 and 1983.
7. B.C. Hydro PFBC demonstration - If the demonstration proceeds 0.1 person-years as scientific liaison should be provided. The time frame is uncertain at present.
8. SPC combined cycle power power generation and industrial technology (renewable energy) - Developments in these areas are not sufficiently defined to estimate additional manpower requirements at this time.