Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology | Centre canadien de la technologie des minéraux et de l'énergie

OVERVIEW OF COMBUSTION RESEARCH AT CANMET

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OVERVIEW OF COMBUSTION RESEARCH AT CANMET

by

G. K. Lee*

ABSTRACT

Current combustion research activities at the Canada Centre for Mineral and Energy Technology (CANMET) reflect the increasingly important role that energy conservation and alternatives to oil are expected to make in meeting our future energy requirements and in reducing our dependence on foreign oil. Widespread use of substitutes for oil, particularly low grade resources such as coal and waste wood will, however, be heavily dependent on the ability of conventional and emerging combustion systems to cope with the disruptive conflicts caused by variations in fuel quality, on requirements for better equipment availability and on the implementation of progressively more stringent environmental constraints.

To minimize these conflicts, Energy, Mines and Resources Canada has embarked on a systematic sequence of research, development and demonstration-scale (R, D and D) initiatives to stimulate the utiization and competitiveness of thermal coal in both domestic and export markets through a number of complementary in-house projects and external contracts, considered to have short- to intermediate-term benefits to industry and society.

Many of the in-house projects are funded in part by industry, whereas the external contracts are either fully funded (100% government funding) or jointly funded (50% government - 50% project proposer).

External contracts and shared-cost projects are an important adjunct to the CANMET in-house effort on combustion because research data can be more effectively transferred to industry and because the commercialization of novel combustion systems can be accelerated significantly.

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Vue d'ensemble de le recherche combustion a CANMET

par

G.K. Lee

RESUME

Les recherches en cours au Centre Canadien de la Technologie des minéraux et de l'énergie (CANMET) reflètent le rôle d'importance croissante que la conservation de l'énergie et les alternatives à l'utilisation de l'huile, sont supposiés jouer en ce qui concerne la demade en énergie et la diminution de notre dépendance sur les pétroles étrangers. L'usage répandu des substituts a l'huile, en particulier les ressources de qualité moindre tels le charbon et les déchets de bois, dépendra: de l' habileté des systèmes de combustion conventionnelle et nouveau à s'adapter à la variation de la qualité de ces carburants; la disponibilité de meilleurs équipements; et de l'implémentation progressive de constraintes environnementales de plus en plus rigoureuses.

Afin de réduire ces conflits, Energie, mines et resources du Canada s'est engagé dans une séquence systématique de recherche, developpement et démonstration (R,D et D), entreprise sans le but d'encourager l' utilisation du charbon thermique sur le marché domestique et sur les marchés étrangers. Le programme se constitue de projets internes et de contrats externes qui fourniront des benifices a court et moyen terme pour l'industrie et la societé.

Plusieurs des projets internes sont subventionnés par l'industrie et les contrats externes sont soit totalement subventionné par le gouvernement ou partiellement i.e. 50% gouvernement 50% organisation.

Les contrats externes sont un complément important aux efforts internes de CANMET sur la combustion car ils faciliteront le transfer de technologie et la commercialisation des nourcaux systèmes de combustions.

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INTRODUCTION

The Canada Centre for Mineral and Energy Technology (CANMET) is the research arm of the Department of Energy, Mines and Resources Canada and is Canada's leading agency for fossil fuel research. Its energy R&D resources for 1983/84 are 416 PY and $41 million.

CANMET maintains a close partnership with Canadian energy industries and electrical utilities by encouraging innovative R&D, often through cost-shared programs. The Branch seeks to develop Canada's petroleum and coal-based resources by improving extraction and upgrading technologies and improving utilization of the primary products. It addresses materials problems associated with pipelines operating in extreme climatic conditions transporting oil, gas and coal to both domestic and export markets. All avenues of technology transfer are used to ensure that federal R&D efforts reach Canadian industry, its intended beneficiary, and an Office of Technology Transfer has been established to assist in this transfer.

This paper a) contains highlights abstracted from the activity objectives, priorities, resources and management structure reported in CANMET Report ERP 83-1 and b) given an overview of the procedure for project implementation and review.

ENERGY TECHNOLOGY ACTIVITY

The primary goal of this activity is to ensure the availability of technology for the extraction, processing, utilization and conservation of Canada's energy resources while at the same time addressing economical technology options and the environmental effects of conversion processes.

Research and development needs, in order or priority, are listed below:

1. Recovery and upgrading of bitumen and heavy oils.

2. Utilization of synthetic products as transportation fuels.

3. Combustion of coal under environmentally acceptable conditions.

4. Coal as a feedstock for liquid fuels and as energy source for bitumen processing.

5. Improved productivity and reduced health and safety risks in the recovery and processing of fossil fuels.

6. Characterization of rock properties for permanent storage of nuclear wastes.

7. Conservation strategies for better utilization of oil, gas and wood.

8. Materials for new process technologies and off-shore oil and gas structures and

9. Technology transfer to industry in support of policy initiatives.

The above priorities reflect Departmental strategies that are being directed toward the national goal of oil self-sufficiency by the 1990's. While liquid fuels from bitumen and heavy oil remain a high priority, the important role of coal in replacing oil and in meeting future energy demands is recognized.

SUB-ACTIVITIES

The Energy Technology Activity is divided into five sub-activities: Conservation, Petroleum Supply, Coal, Nuclear and Renewable Energy. A breakdown of CANMET's submission for FY 83/84 by sub-activity is given in Table 1.

Each Sub-activity is divided into technologies making 42 technologies in total. Each technology consists of a number of projects. An algorithm has been developed specifically for the Energy Technology Activity to rank the technologies. This Algorithm requires a judgement on each of five factors:

1. relationship between the Technology and the objectives of the Activity and Sub-activities;

2. impact of the anticipated contribution to the overall energy program of each Technology;

3. R&D effort to be invested to achieve the objectives of the Technology;

4. scientific merit of the projects that form the Technology, in terms of innovation, technology transfer possibilities, and potential for future development; and

5. probability of success of the projects included in the Technology, on the basis of available resources and project difficulty.

Management System

Most of the R&D effort at CANMET is classified as "mission-oriented". CANMET uses a matrix management system in which program management (the Research Program Office) interacts with laboratory line mangement in planning, programming and evaluation of R&D efforts within the program activity structure. The relationship of the Energy Technology Sub-activities to responsiblity centres within CANMET is shown in Table 2.

The Research Program Office has responsibility for planning and designing programs with laboratory directors acting in advisory capacities. The Research Program Director is assisted by three assistant program directors, whose responsibilities cover the five sub-activities within the Energy Technology Activity. These officers formulate program objectives, develop strategies and select the appropriate technical responses to perceived R&D needs. In addition, they are responsible for monitoring work progress and program evaluation, including contracted-out R&D.

Technology leaders are laboratory personnel who interact with the assistant program directors for the purpose of administering program affairs in the performing laboratories and who assist in selecting the most cost-effective group of projects to met a particular Technology objective. Allocation of resources between sub-activities is the responsibility of the Research Program Director. Laboratory directors and managers are responsible for implementing operational plans, work performance and control. Reports are prepared for the Research Program Office on a regular basis describing the project status.

CANMET management receives formal advice and recommendatins on research priorities from the National Advisory Committee on Mining and Metallurgical Research, NACMMR, - a representative body formed by Order-in-Council to advise the Minister of Energy, Mines and Resources Canada. The committee provides a national perspective on R & D needs and its recommendations are taken into account in formulating energy research plans.

CANMET, through the Research Program Office, contracts a considerable amount of research to the private sector. In addition, the department enters into research agreements with universities and International agencies for performing certain R & D which coincides with program activities. Unsolicited proposals co-ordinated by Supply and Services Canada may also be funded where these support the Energy program objectives.

TECHNOLOGIES

As shown in Figure 1, the 5 sub-activities are divided into 42 technologies which are in turn sub-divided into 86 projects. Each project, depending on its scope and complexity, consists of one or more project elements. A list of the 42 technologies is given in Table 3 and an illustration of the format sheet used to define the broad objectives, the description, the resources and the expected outputs for the Conventional Combustion Technology of the Coal Sub-Activity is shown in Table 4.

The five-year plan is updated each year with an additional year being added to compensate for the year completed. The annual update provides an opportunity to modify technology objectives, to expand or decrease resources and to re-structure major outputs to accommodate any policy or strategy changes dictated by evolving world or national energy conditions.

Project and Project Elements

Using the objectives and resources for each technology approved each year by the Program Office, the Laboratories responsible for each technology extend existing projects or initiate new ones to achieve the expected outputs. Project leaders, selected by the lead Laboratory:

a) identify potential performers which typically includes a mix of departmental laboratories, other federal research agencies, industrial organizations and universities;
b) monitor progress in accordance with planned milestones and;
c) provide advance notice of variances in project performance.

The project leaders work closely with the Laboratory Manager who is responsible for ensuring that the available resources are consistent with expected project outputs and that resources are shifted in response to changing priorities.

Each year projects are submitted for the approval of the Director of the Laboratories and the Program Director on a Project Authorization Sheet which provides a detailed breakdown of the project objectives; the distribution of resources; the work plan; project outputs; and potential users of the R & D. Figure 2 illustrates a Project Authorization Sheet used in the 1982/83 operational plan for the Conventional Combustion Technology of the Coal Sub-Activity. Recently this sheet was expanded to identify ways of transferring the results of completed research for use by government or industry as shown in Figure 3.

Projects, for day-to-day control at the Laboratory level, are sub-divided into project elements. As shown in Figure 4, a 1982/83 Project Element Sheet for Conventional Coal Combusion, provides details of the elements of this project by giving the work schedule, and naming the scientific, engineering and technical support required.

Project Monitoring and Review

Project progress is monitored bi-monthly, or more frequently, if necessary, at the Laboratory level by reviewing cash flow, personnel time expended and work status. If slippage in the planned work schedule occurs problem areas are resolved and corrective action taken. When significant variances occur due to external factors such as late delivery of non-stock items, the project personnel are assigned to accelerate other projects. In practice, objectives and timetables can be expanded or changed during the year to accommodate priority unscheduled requests for technology assistance by government or industry.

Effort distribution sheets for each employee showing the time spent on each project are reported bi-monthly and project progress indicating variances, if any, between planned and actual goals is reported quarterly to the Program Office.

PROJECT PERFORMANCE

Completed projects are examined to evaluate their effectiveness in achieving their announced objectives and their usefulness in contributing to national energy self-sufficiency. An example of an evaluation on a completed Conventional Combustion project is described below.

Evaluation of Low-Grade Coal Combustion Project

Background

Over a 20 month period in the late 1970's, the Combustion and Carbonization Research Laboratory of CANMET, in collaboration with a major utility, carried out a series of combustion trials on a high-ash, high-moisture coal from an undeveloped deposit in central British Columbia. The purpose of the trials was to evaluate the combustion, ash deposition and emission characteristics of this coal and utilize the results for the selection of design criteria for large utility boilers. Coal of this low quality (15 MJ/kg) had not been burned previously in industrial furnaces; thus combustion data on this coal was an essential prerequisite to large-scale utilization.

Evaluation

Reference to the work plan and actual results, Figure 5 shows that actual costs of the pilot-scale research component of the project were about $165,000 or about 3% over original estimates. Sixteen milestones were projected; 10 were achieved on time or slightly ahead of time and 6 were slightly delayed, but in no case more than two months. The overall schedule was achieved on time.

Upon completion the experimental project which successfully identified and delineated the key design parameters for a full-scale unit, the pilot-scale results were validated in a 30 MW boiler. The study concluded that steam-generators of capacity up to 750 MWe probably could be projected for the burning of this coal, although prudence should limit the first full-scale installation to a 500 MWe unit.

The utility has now satisfied their concerns about the feasibility of burning this coal on a major scale and the design of a pit-head generating station is under consideration to meet future system demands.

A Canadian firm of consulting engineers participated in this project. As a result, the engineering profession in Canada has been strengthened and is closer to the point where foreign technical assistance will not be required for technologically oriented programs of this kind in future.

Table 1 - Resource allocations by sub-activity, 1983-84

	PY	$X 10^6$
Conservation	8	1.8
Petroleum Supply	97	10.9
Coal	151	19.0
Nuclear	28	1.1
Renewable Energy	13	1.4
Support Services	119	6.8
Total	416	41

Table 2 - Relationship of energy technology sub-activities to CANMET responsibility centres

Program Sub-activity	ERL[1]	PMRL[2]	MSL[3]	MRL[4]	CRL[5]
Conservation	x		x		
Petroleum Supply	x	x			x
Coal	x	x	x	x	x
Nuclear			x	x	
Renewable Energy	x		x		

[1]Energy Research Laboratories

[2]Physical Metallurgy Research Laboratories

[3]Mining Research Laboratories

[4]Coal Research Laboratories

Table 3 - Energy sub-activities and technologies

CONSERVATION

- Residential heating systems
- Energy conservation in industrial processes

PETROLEUM SUPPLY

- Treatment of bitumen/oil emulsions and effluent waters
- Extraction of bitumen from mined oil sands
- In-situ recovery of bitumen and heavy oils
- Development and improvement of CANMET hydrocracking for upgrading bitumen, heavy oils and residuals
- Support of commercialization of CANMET hydrocracking processes
- Thermal oil shale conversion and catalytic residuum conversion processes
- Improved process development by characterization of synthetic crudes and their distillate products
- Development of novel industrial separation processes
- Catalytic refining of synthetic crude distillates to specification transportation fuels
- Conversion of natural gas to liquid fuels
- Materials for hydrocarbon processing
- Materials for oil and gas pipelines
- Materials for offshore structures

COAL

- Coal reserve assessment
- Coal mining
- Strata mechanics
- Coal mine atmospheres
- Coal mining safety certification
- Coal preparation
- Fine coal cleaning
- Carbonization
- Gasification
- Evaluation of liquefaction processes for Canadian coals

Table 3 - Energy sub-activities and technologies (cont'd)

- Development of novel liquefaction and pyrolysis processes
- Development of co-processing technology of coal with bitumen, heavy oils and residual
- Construction and operation of a coal and bitumen/heavy oil co-processing pilot plant
- Conventional Combustion
- Fluidized-bed ombustion
- Coal-liquid mixture fuels
- Combustion technologies for pollution abatement
- Materials for coal utilization and conversion

NUCLEAR

- Uranium reserve assessment
- Uranium mine evaluation
- Geomechanics in nuclear waste disposal
- Conventional uranium extraction
- Alternative uranium extraction

RENEWABLE ENERGY

- Wood-fired residential heating
- Biomass utilizaiton in industry
- Materials for advanced energy conversion systems

Table 4 - Conventional combustion technology

Objectives

To produce data on the conventional combustion performance and emission characteristics of Canadian coals destined for power generation in domestic and export markets. Specifically;

by 1985	to produce a catalogue of combustion performance and emission characteristics of commercially-important Canadian coals, and updating annually thereafter;
continuing	to determine the significant performance characteristics, with respect to electricity generation applications, of coal from newly developed deposits; and
continuing	to determine the effects of coal cleaning on the flame, heat transfer and emission characteristics of thermal coals for utility and industrial applications.

Description

The need for evaluation of the combustion performance of Canadian coals has been amply demonstrated by industrial and utility demands for the services of the Combustion and Carbonization Research Laboratory over the past ten years. The demand is expected to increase over the next ten years as new coal sources come on stream and as attention turns to lower grade resources. The need for combustion performance data must be met if coal is to make its full contribution to energy self-reliance in the production of electricity and industrial heat, and if healthy export markets are to be maintained.

Users of conventional coal technology need data on a number of parameters such as grindability characteristics, flame stability, slagging, fouling, heat transfer, pollutant emissions and the performance of stack gas cleanup systems. Much of this information can be generated using existing, proved R & D facilities at CCRL. However, the specialized combustion evaluation trials commonly demanded by coal suppliers and electric utilities must be supplemented by more fundamental R & D aimed at understanding mechanisms and developing better technology for both increased efficiency of utilization and reduction of emissions. Development of a strong technology also enhances the opportunities for export of Canadian coal and equipment for its utilization.

Table 4 - Conventional combustion technology (cont'd)

In the limited areas where suitable private-sector facilities presently exist, some of the required information can be generated by contract. Examples are grinding tests with Canadian coals, and flame radiation modelling. Cost-shared programs for field trials in full-scale utility boilers may be required to verify scale-up factors for pilot-scale results.

Resources $K (PY)	83/84	84/85	85/86	86/87	87/88
A-Base	150(3+2)*	150(3+2)	150(3+2)	150(3+2)	150(3+2)
Energy R & D	800(8)	850(8)	950(8)	950(8)	950(8)
Total	950(11+2)	1000(11+2)	1100(11+2)	1100(11+2)	1100(11+2)
Contract $ (included in above)	108	128	178	178	178

*2 unfunded PY'

Major Outputs

1. First edition of catalogue of combustion and emission characteristics of commercially-important Canadian coals (1985).

2. Improved technology for producing pulverized-coal flames with heat transfer characteristics tailored to specific industrial requirements, (1987).

3. Improved methods for predicting coal combustion performance from bench-scale test data (1987).

CANMET RESEARCH PROGRAM STRUCTURE

1982-83

ENERGY					ACTIVITY
CONSER-VATION	PETROLEUM SUPPLY	COAL	NUCLEAR	RENEWABLE	SUB-ACTIVITY
2	14	18	4	3	TECHNOLOGY
8	29	48	5	6	PROJECT
					PROJECT ELEMENT

FIGURE 1

PROJECT AUTHORIZATION SHEET/
FEUILLE D'AUTORISATION DE PROJET

FISCAL YEAR/83/84
ANNEE FINANCIERE

PROJECT TITLE/
TITRE DU PROJET ERO - EXPANDED USE OF COAL FOR UTILITY BOILERS

PROJECT LEADER/
CHEF DU PROJET G. K. LEE

ASSISTANT DIRECTOR/
DIRECTEUR ADJOINT FD Friedrich

TECHNOLOGY/TECHNOLOGIE CONVENTIONAL COMBUSTION

SUB-ACTIVITY/SOUS-ACTIVITE COAL

ACTIVITY/ACTIVITE ENERGY TECHNOLOGY

PROJECT CODE/
CODE DU PROJET 4340- 51

OBJECTIVE/OBJECTIF:

To evaluate the reactivity, combustion, slagging and fouling properties of coals from newly developed mines and coal blends for use in thermal power generation.

STARTING DATE/
DATE DE COMMENCEMENT: 1981

EST. COMPLETION DATE/
DATE D'ACHEVEMENT PREVUE: 1988

RESOURCES FOR THE CURRENT FISCAL YEAR/
RESSOURCES POR L'ANNEE FINANCIERE EN COURS

IN-HOUSE (PY'S AND DOLLARS)/
RESSOURCES "MAISON" (PY'S ET DOLLARS): ERD 4 PY, $110K Capital:$100K Operating

CONTRACTS/CONTRATS:
BUDGET: $40K
CONTRACTS:
SPC Contract $15K, CMH Furnace Modelling contract $25K
Gulf Canada $137.5K upgrading thermal coal (50:50 Coal Conversion Program)

MAJOR PROJECT OUTPUTS WITH COMPLETION DATE/
PRINCIPALES PRODUCTIONS A LA DATE D'ACHEVEMENT:

1) Tests on two coals in pilot-scale boiler		May 83
	Report	Aug 83
2) Tests on two coals in pilot-scale boiler		Sep 83
	Report	Dec 83
3) Tests on two coals in pilot-scale boiler		Nov 83
	Report	Feb 84
4) Extensive baseline tests		Mar 84
5) Laser/visual flow studies		Sep 83
6) Design, procurement and installation of holographic grating spectometer		Dec 83
	Report on 5/6	Jan 84
7) Installation and commissioning of CMH furnace		Sep 83
	Modelling Contract	Dec 83
8) Report on 7		Mar 84
9) Contract report on upgrading of thermal coal.		Apr 83
		Mar 84

APPROVAL/APPROBATION	DATE/DATE
PROJECT LEADER /CHEF DE PROJET	25/3/83
ASST. PROGRAM DIRECTOR/ DIRECTEUR ADJOINT DU PROGRAMME	
PROGRAM DIRECTOR/DIRECTEUR DU PROGRAMME	
LEAD LABS/LAB. PRINCIPAUX	
DIRECTOR-GENERAL/ DIRECTEUR GENERAL	

Fig. 2 - Project authorization sheet

PROJECT CODE / CODE DU PROJET 4340-51

FISCAL YEAR/ 83/84 / ANNEE FINANCIERE

BACKGROUND/RENSEIGNEMENTS PRELIMINAIRES:

Complementary to 434002, this project addresses the use of coal from newly opened mines by the electric power generation industry. Evaluation is made of the grinding, handling, combustion performance, slagging, fouling, and emissions of a wide range of Canadian coals from lignites to bituminous in rank. In response to the industry's need for early diagnosis of coal performance in utility boilers, new diagnostic procedures are being developed which will enable test matrices to be optimized, thereby reducing the cost and time needed for test and evaluation purposes.

TECHNOLOGY TRANSFER/TRANSFERT DE TECHNOLOGIE:

TECHNOLOGY	I - Coal combustion evaluation for utility boilers.
CLIENT	The Canadian coal industry in support of the export market and the domestic utility sector when using coals of unknown quality in equipment designed for high-quality coal.
REQUIRED ACTION BY CLIENT	Re-orientation of marketing strategies to include R&D on coal evaluation and scale-up parameters from laboratory-scale rigs.
TRANSFER METHOD	a) b) c) Discussions, reports and presentations. d) Publications at conferences or in journals. g) Shared-cost projets. j) Cost-recovery projects. k) Personnel training.
TIME SCHEDULE	Continuing
OTHER FACTORS	Canadian coal exporters are often required to provide pilot-scale operation data on the performance of their coals. Additionally, such information is valuable to domestic industry when switching from oil to coal, particularly low-grade coal.

Fig. 2 - Project authorization sheet (cont'd)

CRITERIA FOR TECHNOLOGY TRANSFER AT CANMET

In reviewing the Technology Transfer components of the 82/83 project authorization sheets, it was apparent that some clarification would be helpful in establishing criteria or parameters for a technology transfer strategy. Such a strategy should include a description of the technology package, the client, the impact of the adoption of the technology on the client, and the appropriate method for transferring the technology to the client. Clearly not all elements can be described or defined equally well for all of CANMET's 200 projects.

Nevertheless, it is felt that a serious attempt should be made to define these elements as best as possible for each project at the very start of the planning cycle. This will ensure a minimum of surprises, once a project is completed, and hopefully will maximize the benefits generated by a project. There are six factors that need to be addressed:

1) Technology: What is being transferred to the client? Can we define the technology package resulting from the R&D project?

   Current technology packages in CANMET includes:

   a) NPD: new process development to produce existing product, e.g. hydrometallurgical process for Ni/Cu;

   b) MP: modified process to produce existing product, e.g. improving separation of bitumen from oil sands;

   c) NP: new or improved product development using a modified or new process; this category includes modifications to existing equipment; e.g. photovoltaic devices and low NO_x burner;

   d) I: generating information for dissemination, such as test data and guidelines; for example, mineralogical testing of ore samples and SO_2 emission guidelines;

   e) S: developing standards, specifications and testing methods.

2) Client or User: At what target is the technology package directed? Which group of firms, agencies or regions will apply, adopt and implement the technology?

   A client may be the primary entity which is typically contracted by CANMET to effect Technology Transfer, e.g. PROTO Mfg. contracted to build the X-ray stress diffractometer prototype, CGA for low BTU burner, PetroCanada for Hydrocracking process or a company which contracts CANMET to do cost-recovery work.

3) Beneficiary: Who will ultimately benefit from the technology, once it is implemented?

   These could include oil companies which use offshore drilling platforms fabricated with tougher steel, or iron ore mine workers who benefit when recommendations of health and safety studies are implemented. It is implicit that the Canadian public should be the ultimate beneficiary.

   An attempt should be made to identify how the client/user or beneficiary needs will be met by the technology.

.../2

Fig. 3 - Criteria for technology transfer at CANMET

4) Impact on Client or User: What impact will the adoption or implementation of the technology have on the client or user? Will it require a capital investment of several hundred million dollars to build a new plant? Will it require less than 10 million dollars for plant modification, and add-on facility or a process change? Or will it require no major outlays, only a change in operation procedures?

   Attempts should be made to identify the impact, e.g. if investments outlays or changes in operating practice will be required for implementing the technology. In most projects, the impact will only be an estimate with varying degrees of confidence.

5) Transfer Method: Given the technology package, the nature of the client and the kind of impact the adoption of the technology is likely to have, what is the appropriate, specific approach to transfer that package to the client?

   It should be noted that there is no one right way of transferring technologies, and that each technology/client combination requires almost a custom-made strategy or approach. Nevertheless, we can identify several approaches or methods already used in CANMET.

   a) Informal or formal discussions
   b) CANMET research reports
   c) CANMET seminars and presentations
   d) Publications in journals and presentations at conferences
   e) CANMET patents and subsequent licensing
   f) Cost-sharing projects involving PDU or pilot plant constructed and operated by CANMET or partner
   g) Fed./Prov. incentives program which may create applications for CANMET technology
   h) Fed./Prov. regulations which require CANMET input in formulation or application
   i) CANMET cost-recovery projects
   j) Other, such as staff exchange and training programs.

6) Time Schedule: Over what time period do you expect the transfer to take place (e.g. 6 months to 1 year, 1 to 2 years, 3 to 5 years, 5 to 10 years, etc...).

Fig. 3 - Criteria for technology transfer at CANMET (cont'd)

PROJECT ELEMENT SHEET/FEUILLE D'ELEMENT DE PROJET

RESP. CENTRE/CENTRE DE RESPONSABILITE	160	FY/AF 1983
PROGRAM/PROGRAMME	Energy Technology	ELEMENT CODE/ CODE DE L'ELEMENT
SUB-ACTIVITY/SOUS-ACTIVITE	Coal	
TECHNOLOGY/TECHNOLOGIE	Conventional Combustion	
PROJECT/PROJET	Expanded use of coal for utility boilers	4340-51-01
PROJECT ELEMENT/ELEMENT DE PROJET	Combustion properties of newly developed coals	

PROJECT ELEMENT OBJECTIVES/OBJECTIFS DE L'ELEMENT DE PROJET

To evaluate the combustion, slagging and fouling properties of coals from newly developed deposits in utility boilers

WORK PLAN/MILESTONES/DECISION POINTS PLAN DE TRAVAIL/BORNES POINTS DE DECISION	OFFICER FONCTIONNAIRE	INIT.	COMP. DATE DATE D'ACCOM.
1) P.S.B. boiler preparations	HW		April 83
2) Tests on two coals in pilot-scale boiler	HW		May 83
3) Report on 2)	HW		Aug 83
4) Tests on two coals in pilot scale boiler	HW		Sept 83
5) Report on 4)	HW		Dec 83
6) Tests on two coals in pilot scale boiler	HW		Nov 83
7) Report on 6)	HW		Feb 84
8) Extensive baseline comparative tests	HW		Mar 84

PROGRESSIVE STATUS CONTRACT/PROJECT
ETAT DE PROGRES DE CONTRAT/PROJET

MONTH MOIS	PROGRESS IN RELATION TO SCHEDULE PROGRES VIS-A-VIS L'HORAIRE	% OF WORK COMPLETED / % OU TRAVAIL ACCOMPLI	* PER-FOR-MANCE/ ACCOM-PLISSE MENT	** S.A. ACTIVITIES NATURE AND LENGTH (HOURS) NATURE ET DUREE (HEURES) DES ACTIVITES	CUMULATIVE EXPENDITURE APPROVED BY S.A. DEPENSE ACCUMULEE	EXPENDITURE FORCAST THIS F.Y. PREDICTION DES DEPENSES	NO. OF FOOTNOTES NO. DES NOTES EN BAS DE PAGE
APRIL							
MAY							
JUNE							
JULY							
AUG.							
SEPT.							
OCT.							
NOV.							
DEC.							
JAN.							
FEB.							
MAR.							

(CODES)* PERFORMANCE S.satisfactory U.unsatisfactory
** S.A. ACTIVITIES M-meeting T-telephone O-other

*ACCOMPLISSEMENT S.satisfaisant N.non-satisfaisant
** ACTIVITES R. rencontre T.telephone A.autre

FOOTNOTES/
NOTES EN BAS DE PAGE:

Fig. 4 - Project Element Sheet

PARTICIPANTS/TRAVAILLEURS	MY/AP	PARTICIPANTS/TRAVAILLEURS	MY/AP
M. W.	0.15	D. F	0.30
G.N. B.	0.20	E.G.	0.30
P.M.J. H	0.10	R. J	0.10
R.O.S. 2	0.10	F.L.	-
ENG 3	0.30	D.D.4	0.20
J. W	0.30	S.I.	0.05
B.C.	0.30	Secretary	0.05
D.G.	0.30		
A. S.	0.30		
C. H	0.10		
TOTAL	2.15	TOTAL	1.00
		TOTAL MY'S/AP'S	3.15

SUPPORT REQUIRED OF OTHER RESP. CENTRES (LABORATORY AND TYPE OF SERVICE)/
LE SUPPORT D'AUTRES CENTRES DE RESPONSIBILITE (LA LABORATOIRE ET GENRE DE SERVICE:

AMENDMENTS/CHANGEMENTS: DATE:

APPROVAL/APPROBATION: DATE:

RESP. CENTRE MANAGER/
GERANT DE CENTRE DE RESPONSIBILITE:

PROJECT LEADER/
CHEF DU PROJET:

Fig. 4 - Project Element Sheet (cont'd)

WORK PLAN - JOINT UTILITY/CANMET RESEARCH PROJECT
PILOT-SCALE RESEARCH PHASE

	1976 A	S	O	N	D	1977 J	F	M	A	M	J	J	A	S	O	N	Hours	Cost
Estimated																		
SE RES 3	7	7															100	$ 6,360
SE RES 2			84	84	28	28	28	28	28	28	28	28	28	28	28	28	504	25,990
EN ENG 3			150	100													250	10,160
EG ESS 7			300	400	100	100	25	25	25	25							1,200	40,000
EG ESS 3			500	400													900	19,980
GT 3			150	150	150												450	9,010
			Professional Services														3,404	111,530
			Emergency Repairs and Supplies															7,000
			Analytical Services															31,350
			Contingency (overtime, bonus, etc)															10,110
			Sub-total for Pilot-scale Research															$160,000
Actual (including approx 150 overtime hours, straight time basis)																		
SE RES 3			58	7									12	30	49		156	9,930
SE RES 2			126	116	31	28	12	11	32				92		11		459	23,670
EN ENG 3			169	95	11												275	11,180
EG ESS 7			582	334	119	226	144	24	4						62	45	1,336	44,540
EG ESS 3			520	312	12		2	7									853	18,930
GT 3			139	93	4												236	4,720
CH 4				44	52	60	21	65	25	77	51	10	35				430	22,170
EL 5				2	7												9	300
			Professional Services														3,754	135,500
			Emergency Repairs and Supplies															7,000
			Analytical Services															20,510
			Contingency, overtime, bonus, etc(approx)															1,980
			Total Costs															$165,000

Time costs are on a full cost-accounting basis, i.e., including all personnel benefits and allocation of departmental administrative and management costs.

Full-scale boiler validation of data was estimated to cost about $5,376 in addition to the foregoing This plan antedates the introduction of the CANMET project management system in 1977.

Figure 5

WORK PLAN - JOINT UTILITY/CANMET RESEARCH PROJECT
PLANNING SCHEDULE FOR COMBUSTION STUDIES

ACTIVITY	1976 A	M	J	J	A	S	O	N	D	1977 J	F	M	A	M	J	J	A	S	O
1. Pilot-Scale Research																			
Develop work plan and budget																			
Develop research plan																			
Select coals																			
Procure and deliver coals																			
Design probes and boiler ancillaries																			
Procure equipment and material																			
Fabricate probes and ancillaries																			
Modify pilot-scale boiler																			
Exploratory combustion experiments																			
Combustion performance trials																			
Analytical work																			
Interim data evaluation																			
Progress reports																			
Final evaluation																			
Draft report and review																			
Final report preparation and printing																			
2. Full-Scale Boiler Validation of Data																			
Site selection																			
Develop test plan																			
Procure and deliver coal																			
Site modification																			
Boiler combustion trial																			
Post-trial evaluation																			
Report on field trial																			

Figure 5 (cont'd)