CANMET

Canada Centre for Mineral and Energy Technology

Centre canadien de la technologie des minéraux et de l'énergie

Energy Research Laboratories

Laboratoires de recherche sur l'énergie

BUSINESS PLAN 1993-1996
ENERGY RESEARCH LABORATORIES

April 1, 1993

Energy, Mines and Resources Canada

Énergie, Mines et Ressources Canada

Canada

THE ENERGY OF OUR RESOURCES • THE POWER OF OUR IDEAS

L'ÉNERGIE DE NOS RESSOURCES • NOTRE FORCE CRÉATRICE

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Divisional Report 93-30 (TR)

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Business Plan 1993-96

1. Mission

The Energy Research Laboratories (ERL) conducts R&D to improve the efficiency and environmental acceptability of processing and utilizing hydrocarbon-type fuels, and to improve energy conservation methods and end-use efficiency.

Technological innovation is vital to enhance Canadian productivity and to achieve environmental goals. ERL's program strongly supports CANMET's overall objective, which is to perform both pre-competitive and commercially related R&D in partnership with industry. In this regard, cost-shared R&D is an important element which helps to ensure rapid technology transfer and increases the prospects for commercialization.

Following the introduction of a "team building" program across ERL, the division has adopted total quality management (TQM) concepts and continuous improvement to help it attain the goals and live the values in the EMR Mission Statement.

2. Objectives

- To sustain the future competitiveness of, and to expand market opportunities for Canadian industry by advancing knowledge and by developing more advanced technologies for the efficient recovery, upgrading, and use of Canada's energy resources, such as bitumen, heavy oil, natural gas, coal and biomass.
- To improve public health and safety by developing energy-efficient technologies that minimize environmental impact (particularly the greenhouse effect and acid rain); specifically, by developing cleaner fuel processing technologies, improving fuel utilization processes, and improving the quality and performance of fuel products and energy systems through contributions to national and international standards.
- To support the development and implementation of government policies related to security of energy supply and the environment.

3. Structure of the R&D Program

About 45 percent of ERL's effort is devoted to improving industrial productivity and competitiveness, 40 percent to the protection of people and the environment, and 15 percent to policy, standards and regulations. This is a significant change from the past when ERL devoted approximately 60 percent of its efforts to productivity, 30 percent to protection and 10 percent to policy. New projects have been implemented with specific environmental goals and many of the productivity and policy projects embody environmental goals and components.

ERL will continue to adhere fairly closely to CANMET's guidelines for the type of research performed. About 15 percent of its efforts will be devoted to exploratory research, 50 percent to strategic research, 30 percent to incremental development, and 5 percent to certification and testing services.

Table 3.1: Distribution of R&D Effort by Type of Activity

	Planned 1991-1992	**Actual** 1991-1992	**Planned** 1992-1996
Productivity	60%	40%	45%
Protection	30%	45%	40%
Policy	10%	15%	15%

Table 3.2: Distribution of R&D Effort by Type of Research

	Planned 1991-1992	**Actual** 1991-1992	**Planned** 1992-1996
Exploratory	10%	8%	15%
Strategic	45%	48%	50%
Incremental	35%	32%	30%
Certification and Testing	10%	12%	5%

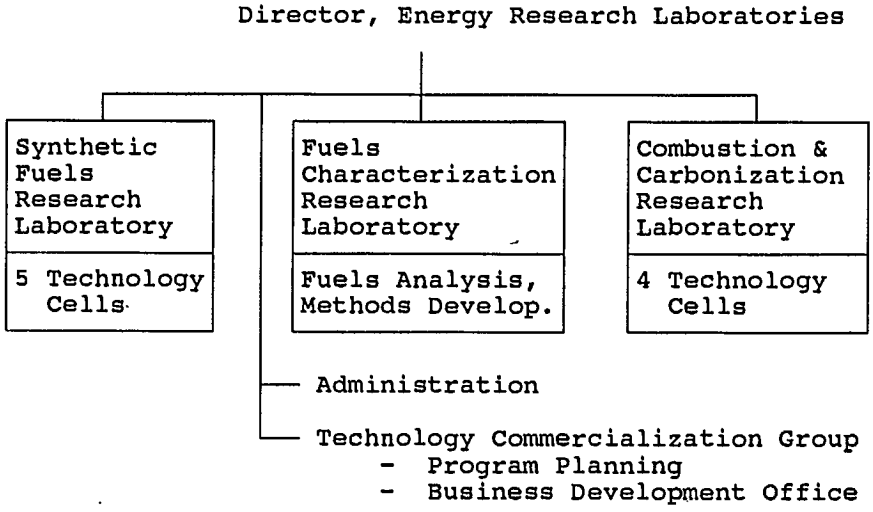
ERL's program parallels Canada's pattern of energy resources and utilization. About 40 percent of the R&D addresses combustion or use of fossil fuels and wastes, and improving the efficiency of energy systems. Another 40 percent is devoted to improving the extraction and upgrading of Canada's hydrocarbon resources: oil sands, heavy oils and natural gas. The program is weighted toward heavy oil recovery and upgrading because of the enormous resource base and its strategic importance. The program also includes projects to obtain the best possible value from the large gas reserves of western Canada. The remaining 20 percent focuses on analytical support, standards development and support of policy development.

Fully two thirds of ERL's R&D is funded through the Program on Energy Research and Development (PERD) of the interdepartmental Panel on Energy R&D. This support is vital. The federal government, through PERD, is ERL's major client for energy R&D.

4. Organization

ERL comprises three research laboratories, a technology commercialization group and administrative staff. The three laboratories are: the Synthetic Fuels Research Laboratory (SFRL), the Combustion and Carbonization Research Laboratory (CCRL) and the Fuels Characterization Research Laboratory (FCRL). SFRL addresses recovery and upgrading of heavy oils and bitumens, secondary upgrading, catalysis, conversion of natural gas to liquids, utilization of upgrader residues and other processing wastes and hydrogenation of coal. CCRL addresses combustion mechanisms and modelling, equipment control and development, control of emission of pollutants from combustion efficiency in energy conversion and energy systems, gasification, and the production and use of metallurgical fuels. FCRL addresses fuel and feedstock analysis and take a lead role in establishing new national and international analytical standards. The Technology commercialization Group deals with strategic program planning and co-ordination, program assessment, and marketing and business development.

Figure 4.1: Organization of Energy Research Laboratories



5. Marketing Strategy

Clients and Market Niches

Oil and Gas Industry

ERL supports research in extraction and upgrading of heavy crude oil and oil sand bitumen, residue utilization and the development of catalysts. This research aims to improve industry's competitiveness in the production of synthetic fuels and chemical feedstocks while responding to environmental concerns. ERL addresses new ways of modifying fuels to improve air quality and eliminate production wastes.

Research is being conducted that will expand the role of natural gas in meeting national energy and environmental needs by using processes that have less environmental impact than those for oil or coal. Beyond using natural gas as a high-grade fuel, ERL's program emphasizes the opportunities to convert it to transportation fuels, fuel additives and petrochemicals. We are joining with industry in research in catalysis and catalytic processes for the conversion of natural gas and its components (methane, ethane and condensates).

Industry-wide rationalization has continued to reduce substantially the size and capabilities of key research laboratories in the Canadian oil and gas industry. ERL has responded by initiating co-operative programs to develop and share expertise and services. Indeed, ERL has formed, to date, seven consortia, with another three under negotiation. Industry has shown a strong interest in ERL's research program for upgrading using bitumen/water and heavy oil/water emulsions. Interest is also growing in ERL's programs studying reactor hydrodynamics, the reactivity of feedstocks for catalytic hydrocracking and catalytic processes. ERL is exploring the applicability of its programs to smaller and medium-sized oil companies. ERL is developing its position, together with the Alberta Research Council and Syncrude Canada Ltd., in the proposed Oil Sands Research Centre in Western Canada.

Coal and Steel Industry

Canada exports about 28 million tonnes of coking coal annually (principally to Japan and other Pacific Rim countries) and uses about eight million tonnes domestically in metallurgical processes. ERL provides technical support to the coal and metals industries by developing technologies that improve fuel quality and efficiency in thermal and metallurgical processes; lower the environmental impact of producing and utilizing carbonaceous materials; increase the use of pulverized coal injection (PCI) in the iron-making blast furnace and other metallurgical processes; and improve the coking behaviour of coals to produce high-quality coke while ensuring safe and efficient industrial operation.

A major strategic advance in iron-making technology around the world is the injection of coal into the blast furnace through the tuyères. To this end, ERL has now commissioned a facility to simulate the injection process and investigate combustion reactions and their effect on blast furnace operations.

Electric Utilities

Since coal is the primary energy source for 18 percent of Canada's electric power (79 percent in Alberta, 73 percent in Saskatchewan and 60 percent in Nova Scotia), ERL aims to provide technology to minimize the emission of pollutants associated with coal-fired generation. ERL co-operates with electric utilities to develop technologies that reduce the formation of acid gases (NOx and SOx) in the combustion process and capture the gases with furnace sorbents.

Integrated gasification combined-cycle (IGCC) technology promises higher efficiencies and substantially lower emissions in the generation of electricity from coal. ERL continues to support the development of this technology through the testing of coals and gas clean-up systems suitable for Canadian use, although competition from natural gas may affect time horizons for IGCC in Western Canada, especially Alberta.

ERL is also working with electric utilities to understand better the environmental and economic merits of utility-based combined heat and power (CHP) or cogeneration so that siting policy may be considered in light of total energy rather than solely electricity production. ERL has developed a modelling capability to simulate integrated energy systems.

Integration of Energy Technologies

ERL is providing impetus in the area of technology development, dissemination and commercialization to accelerate the integration of energy systems with electricity production, including combined heat and power, and district heating and cooling. The goal is a marked improvement in energy efficiency and reduction of CO_2 and other emissions. Indeed, this thrust is a component of the federal government's Green Plan, which has allocated new resources amounting to $8 million for a six-year period (1991 to 1997) for integration of energy technologies.

ERL is also committed to developing new engineering and scientific capability in the growing field of integrated technology through production of technology transfer materials and cooperative work with the private sector and other government departments.

Other Environmental and Energy-Related Industrial Needs

ERL is focusing on the development of technologies that use industrial process wastes and upgrades them to use as fuel or petrochemical feedstock. These include products from sewage treatment processes, waste products from pulp and paper processes, municipal wastes, hydrocarbon and water emulsions, waste oils, and plastics. ERL's specialized analytical services are used to examine quality and test the performance of carbonaceous fuels and chemical feedstocks derived from wastes. Also, ERL plays a national role on behalf of the Canadian fuel industry in formulating national and international fuel standards.

Co-operative Research and Development

ERL has nine R&D consortia, either active or being formed, (7 in oil and gas technologies, 2 in coal) involving some 30 companies, which provide industry with a very effective means of leveraging R&D funds. Consortia allow industry to create business opportunities rather than just license foreign technology and also allow Canadian industry to focus on common industry-wide problems such as export market development and solutions to environmental constraints.

Table 5.1: R&D Consortia at Energy Research Laboratories

Consortium or R&D Club	Target Industry Membership by Size
Canadian Carbonization Research Association	Large integrated steel producers Small/medium coal producers
Canadian Coal Gasification R&D project	Medium/large electric utilities
Heavy Oil Emulsion Upgrading	Medium/large integrated petroleum producers Medium/large heavy oil & bitumen producers
Feedstock Reactivity	Medium/large integrated petroleum producers Medium/large heavy oil & bitumen producers
Distillate Upgrading	Medium/large catalyst producers Medium/large oil refiners
Natural Gas Conversion	Medium gas utilities Medium/large gas producers
Catalysts for the Conversion of Canadian Residua	Medium/large heavy oil & bitumen producers Medium/large integrated petroleum producers Medium/large catalyst producers
Fluid Dynamics	Medium/large heavy oil & bitumen producers
Recycling of Waste Plastics as a Refinery Feedstock	Small/medium plastics processors Medium/large oil refiners Medium/large plastics resin producers Small/medium waste recyclers

ERL is strengthening its ties with research organizations and technical and engineering consultants. ERL's world-class R&D facilities and expert scientific and technical staff are a valuable resource and are available for use by other research organizations in both the public and private sectors. Memoranda of Understanding (MOU) have been signed by CANMET with both the Alberta and Saskatchewan Research Councils and methods are being explored to increase our cooperative research. An MOU has also been signed with the Association of Consulting Engineers of Canada which will strengthen their capacity to conduct specialized work both within Canada and internationally.

Networking

ERL represents Canada on over 20 international committees, and enters into co-operative agreements with other countries (particularly through the International Energy Agency (IEA)) to share technology advancements in areas of particular interest to Canada. The information gained by participating in international activities is shared through the Coal Association of Canada and the Canadian Electrical Association. ERL is also active on joint projects with foreign governments directly, as with the U.S. Department of Energy, as well as through the IEA. This networking capability continues to play a very important role in capitalizing on international technological opportunities, which are transferred to the private sector, in marketing Canadian capability, services and products, and in fostering a better appreciation of Canadian capability.

Stronger linkages with energy policy development are being forged. ERL also networks with other technology-based federal government departments. It is expanding its liaisons with the policy-making and program-delivery departments responding to the Competitiveness and Environmental agendas. ERL has contributed to the thrusts of the Green Plan and will participate in its implementation.

ERL is now developing projects with links to other divisions of CANMET. The coal gasification project, for instance, includes input from both the Metals Technology Laboratories and the Mineral Science Laboratories. In a recent and ongoing development, ERL and the Western Research Centre (WRC) of CANMET are cooperating with the Alberta Research Council, Syncrude Canada Ltd., and other interested parties to establish an Oil Sands Research Centre (OSRC). It is expected that the proposed centre will be a major node in a research network devoted entirely to the extraction and upgrading of oil sands bitumen to synthetic fuels and petrochemicals.

Marketing Outputs

Table 5.2: Major Marketing Activities at ERL

Activity	Target Date
Update Fact Sheets on main technology areas	1993
Produce Fact Sheets on principle services offered by ERL	1993
Produce Fact Sheets on selected ERL success stories	on-going
Produce Business Opportunity Documents and marketing plans for selected technology areas	on-going
Produce prospectuses for new consortia	on-going
Conduct in-house and contracted-out market research studies	on-going
Produce/co-sponsor 3 to 5 seminars/workshops per year	on-going
•Heavy Oil Upgrading, co-sponsored with Alberta Chamber of Resources and AOSTRA	April 1993
•IEA Coal Combustion Science and Flame Modelling, co-sponsored with Canadian Electrical Association, Alberta Research Council and Alberta Office of Coal Research and Technology	June 1993
•Integrated Community Energy Systems/Urban Energy Solutions, co-sponsored with:	
-Canadian Energy Research Institute in Vancouver	May 1993
-PEI Energy Corporation in Charlottetown	June 1993

6. Program Plans and Outputs

Strategic R&D Thrusts

ERL focuses on technology to make Canada's energy industry more competitive and more environmentally acceptable. ERL's technical expertise covers bitumen and heavy oil recovery, upgrading and conversion; natural gas conversion to liquid fuels and petrochemical feedstock; coal utilization, combustion and use as a metallurgical fuel; energy-efficient systems; and energy conservation. In many of these fields, Canadian industry is facing unstable or declining real prices, increasing costs, and strong social pressures to reduce pollution and waste. ERL constantly modifies its programs and products to respond to industry's technical problems. Technologies are developed to make processes more competitive and cleaner. The main strategic thrusts, however, are in the research and development of technology at the pre-competitive stage.

ERL addresses issues of global warming (caused mainly by the build-up of atmospheric CO_2), acid rain, ozone depletion, and municipal and industrial waste. More emphasis is being applied to energy efficiency. Improving efficiency in the production and use of fuels is the most effective way to minimize emissions of pollutants, lower operating costs and improve productivity. ERL will continue to develop energy technologies that minimize acid gas and CO_2 emissions,
especially from the combustion of coal as well as carbonaceous residues from bitumen upgrading. Integrated energy systems, especially advanced combined heat and power associated with district heating or cooling offer significant opportunities for improvement in energy efficiency. Integrating energy systems will provide other major benefits, including security of energy supply, ability to switch fuels, utilization of industrial and municipal waste heat, and cost-effective use of renewable energy resources.

ERL is concentrating on the rational use of energy and the reduction of polluting wastes in many areas of the fuels production and upgrading industry, for example, more efficient use of process heat by integrating stages in the oil upgrading processes, and of hydrogen reduce energy consumption and CO_2 emissions.

Equally important is the management of industrial process wastes, particularly upgrader solid residues and atmospheric emissions of sulphur, nitrogen and polycyclic aromatic hydrocarbons. ERL is taking a lead in ensuring that environmental protection is an important criterion for all new heavy oil technologies. Also, ERL will co-operate with the private sector to provide advice and support to Environment Canada in its development of new environmental legislation affecting transportation fuels. ERL bases its continued development of advanced technologies for the production of cleaner fossil fuels on its established expertise in reaction engineering, process development and catalytic processing.

ERL addresses analytical problems generated by processing non-conventional feedstock, products and wastes. Standard analytical methods are often inadequate and need to be modified through research. ERL participates in the development of international codes and standards to ensure that Canadian resources are properly assessed and competitive in the international market. Leadership in standards activities ensures that environmental aspects, such as toxic trace elements, are considered by industry when standards are prepared.

Recovery of Bitumen, Heavy and Light Oils

In western Canada, bitumen and heavy oil resources are vastly greater than conventional oil resources. As the reserve of conventional light oil continues to decline, a greater supply of heavy oil and bitumen will be required to meet the demand for fuel. ERL supports a co-ordinated, industry-led national program with organizations such as the Alberta and Saskatchewan Research Councils, the Petroleum Recovery Institute, the Alberta Oil Sands Technology and Research Authority and universities. The program addresses high-priority and novel R&D to enhance economical recovery of oil from several large Canadian reservoirs. Environmental protection is emphasized. The re-use of CO_2 recovered from electricity generating stations for enhanced oil recovery (EOR) is also being explored. Contribution to technology transfer and program co-ordination is achieved by holding annual, contractors' review meetings and participating in national multi-client programs and international co-operative forums.

Options are being considered for either transfer or secondment arrangements for this program to Alberta. A decision is pending the outcome of ongoing negotiations among the federal, provincial, and industrial partners of the planned Oil Sands Research Centre.

Major Projects:

Proposals from industry are accepted, on an annual basis, to carry out R&D through the established contract-out program entitled CANMET Energy Conversion Program. Contracts are cost-shared and are for one-year periods. This will continue from 1993 to 1996. About 25 contracts are completed each year; each contract having its own completion date.

Statement of Output	Target Date
development of advanced horizontal well technologies	yearly contracts
development of thermal (steam flooding, in-situ combustion) and non-thermal (hydrocarbon, carbon dioxide, and chemical flooding) enhanced oil recovery processes	yearly contracts
development of methods to improve sweep efficiency, including bacteriogenic mineral plugging, foam and gel blocking	yearly contracts
field trials of novel recovery technologies (foam blocking in steam flooding, bacteriogenic blocking in miscible flooding, chemical treatment to reduce influx of water into gas wells, carbon dioxide as fluid in cyclic stimulations, and water-alternating-gas flooding using methane)	yearly contracts

Bitumen and Heavy Oil Upgrading

To improve the competitiveness of the Canadian oil industry and to capitalize on Canada's vast indigenous heavy oil and bitumen resources, new processing technologies are required that will combine better economics with reduced environmental impact. In particular, technologies need to be developed that will lower the cost of transporting heavy, viscous oils to the refinery and lower the cost of upgrading these heavy oils into clean fuels that will emit less acid gases and CO2.

To address this challenge, ERL has formed research partnerships with industry (industrial research consortia) to explore novel ideas and develop emerging technologies that have commercial potential. Field upgrading to facilitate transportation, high severity hydrocracking, development of new processing schemes and testing of novel catalysts to improve liquid yields are being addressed.

Recently, through negotiations, it has been decided that the delivery of the primary upgrading program will be shifted slowly and smoothly to Alberta. This shift, to be completed during the next 5 years, recognizes that research into bitumen and heavy oil upgrading is more effectively transferred to industry when research and production are close neighbours.

Statement of Output	Target Date
Within the newly formed **Fluid Dynamics Consortium**, develop and demonstrate a single energy, dual beam gamma ray technique to measure gas, liquid and solids hold-ups independently in three-phase fluidized-bed columns	1993
-set up a cold modelling research program with a Canadian university	1994
Within the **Heavy Oil Emulsion Upgrading Consortium**, complete Phase II projects, including an economic evaluation and testing of new additives	1993
-complete evaluation of alternative feedstocks	1995
Within the **Catalysts for the Conversion of Canadian Residua Consortium**, complete evaluation of catalyst properties and processing conditions	1993
-complete preliminary evaluation of micro emulsion catalysts for hydrocracking	1993
-complete studies on non-hydrogenative upgrading technology	1994
-study the effect of very low concentrations of highly dispersed catalysts on the coking propensity of heavy oils and bitumen	1994

Within the **Feedstock Reactivity Consortium**, develop correlations between feedstock reactivity and chemical composition for catalytic upgrading	1993
-develop hot stage microscopy methodology to study coke formation and inhibition	1993
-develop a data package on physical properties of process streams at upgrading conditions	1994
-test feedstock reactivity correlations using a variety of feedstocks	1996
Test a novel processing scheme based on CANMET's Emulsion Upgrading process	1994
-complete reactor performance studies	1995
-complete longer-term pilot-plant process performance studies consisting of:	
-fundamental study on the catalytic upgrading of heavy oils	1993
-coking propensity study of heavy oil fractions	1994
-preliminary assessment of a conversion efficient process for pitch to low boiling distillates	1994
-study on the mechanism and control of catalyst deactivation	1995
Collaborate and exchange information on bitumen and heavy oil upgrading with the U.S. Department of Energy under a Memorandum of Understanding. The Alberta Research Council is also participating in this exchange.	on-going

Synthetic Crude Refining

ERL develops technologies for future production of transportation fuels from Canadian resources. In the short term, Canadian refiners are affected by stricter environmental standards and a deterioration in feedstock quality. In the long term, declining supplies of North American conventional oil represent an opportunity for synthetic crude producers to increase the market share for Canadian heavy oil and bitumen in the production of specification fuels.

ERL research focuses upon the quality of synthetic crude oil and the quality of transportation fuels produced in Canada. Previous experience in catalyst development for hydrogenation, hydrodesulphurization and hydrodenitrogenation is being applied to the hydropurification of transportation fuels. ERL examines transportation fuel reformulation options, membrane separation processes, liquid fuels characterization, and the development of integrated catalytic processes for fuels production. ERL will continue to liaise with synthetic crude producers and refiners, and other groups interested in fuels specification and engine emission standards. ERL maintains a continuous dialogue with other government agencies on fuels environmental issues.

Statement of Output	Target Date
Evaluate advanced catalytic materials for the Distillate Upgrading Consortium	1993
Develop a new integrated hydrocracking-hydrotreating process for producing cleaner transportation fuels	1993
Examine integrated hydrotreating-catalytic cracking technologies applied to synthetic crude gas oils	1994
Evaluate analytical techniques for the analysis of transportation fuels	1995
Improve the quality of fuels derived from synthetic crude oils by developing efficient upgrading/refining routes	1996

Residue Conversion and Utilization

Upgrading heavy oil and bitumen to transportation fuels creates large quantities of low-value by-products (pitches, tars and cokes) that are difficult to store or dispose of safely. Furthermore, they are essentially unmarketable.

ERL is developing new technologies to turn residue into valuable products. Working with consultants in the construction materials sector, ERL provides fundamental assessment of their new products and processes. ERL has initiated a comprehensive program that will assist petrochemical and plastics companies to reclaim and recycle industrial wastes (lubricants, oils, plastics) as clean transportation fuels using adaptations of suitable fuels processing technology.

ERL is assisting petroleum producers, waste oil recyclers and refiners to convert industrial sludges and solid hydrocarbon wastes to liquid hydrocarbons for re-use and landfill volume reduction. Asphalt contractors and transportation agencies (provincial and municipal) benefit from ERL's technological advances in converting residue into superior asphalt cements.

Statement of Output	Target Date
Develop a mathematical model to describe the performance of upgrading and refinery distillate residues in terms of composition and construction materials performance	1993
Establish facilities capable of analyzing in detail waste oils and oils from processed wastes (eg. from co-mingled plastics) and supplying sufficient information for techno-economic assessments	1993
Develop a bench-scale process to convert organic wastes into transportation fuels	1994
Conduct a bench-scale assessment of rubber industry waste oils for use in asphalts	1994
Develop additives to improve asphalt compatibility for recycling aged pavement	1996

Natural Gas Conversion

Natural gas is a complex mixture and its chemical composition varies from reservoir to reservoir. Generally, its main component is methane, but ethane, propane, butane, inert gases and acid gases are often important components. As part of CANMET's natural gas program, ERL's expertise in catalyst development and process engineering will help Canadian industry create new markets for natural gas-derived products. ERL's research consortium on natural gas conversion was established to stimulate development and commercialization of superior technologies to convert natural gas and other light alkanes into marketable liquid fuels and chemicals. Active areas of natural gas R&D include production of raw petrochemicals and fuel octane boosters.

Tighter environmental standards on emissions of carbon and sulphur compounds have challenged the natural gas processing industry to adopt cleaner well-head gas processing technologies. A component of ERL's natural gas program aims to improve the efficiency of gas clean-up methods.

ERL focuses on catalytic chemical conversion of natural gas to fuels, fuel additives and petrochemicals. The Energy Diversification Research Laboratory (EDRL) focuses on other gas technologies such as storage, non-catalytic conversion to hydrogen, and natural gas heat pumps. Close coordination between ERL and EDRL ensures that their programs continue to be complementary and that the technical expertise residing in each laboratory delivers an overall comprehensive natural gas R&D program.

Statement of Output	Target Date
Continue the development of CANMET's Methane to Isobutylene (MTI) conversion technology for octane boosters, in partnership with industrial sponsor	1993
Complete Phase I program for the research consortium on natural gas conversion	1993
Develop and conduct pilot-scale assessment of a process for oxidative coupling of methane	1994
Develop an improved technology for removal of carbonyl sulphide and carbon disulphide from natural gas processing plant emissions	1994
Complete Phase II program for the research consortium on natural gas conversion	1995
Conduct bench-scale assessments of several novel conversion technologies including electrochemical conversion of natural gas	1995

Coal Gasification

Integrated gasification combined-cycle technology (IGCC) converts coal to electricity and reduces emissions of acidic species, particulates, and CO_2 per unit of generated electricity. ERL has promoted the development of this technology through the establishment of the Canadian Gasification R&D Consortium. This group is supported by five utilities, the Alberta Research Council and the Alberta Department of Energy. Research funding is shared equally by CANMET, the Alberta Office of Coal Research and Technology, and industry. CANMET and the Alberta Research Council are the primary R&D performers.

ERL investigates the gasification of coals for Canadian electric utilities in an entrained-bed pilot plant where gaseous, liquid and solid emissions are quantified. Results are used for feasibility studies to select and optimize gasification processes for IGCC technology and to identify the suitability of different Canadian coals as feedstocks for different gasifiers. The research will help Canadian coal producers market their coals for gasification purposes.

Research on hot gas clean-up focuses on the development and use of low-cost solids as sorbents for removing acidic species before gasification products are burned or used in fuel cells. Activated carbon produced from Canadian and foreign coals are being investigated for their sorbent properties for environmental applications.

Statement of Output	Target Date
Establish process parameters for entrained bed gasification of coal	1993
Investigate the feasibility of IGCC technologies for utility industries	1993
Develop a process to produce and evaluate the properties of activated carbon from Canadian coals	1993
Develop analytical methods to quantify trace contaminant emissions for flue gas specifications and IGCC plants	1993
Develop models and simulation software to optimize performance of IGCC plants	1994
Evaluate methods to purify feedstock gases for use in high-temperature fuel cells	1994
Investigate the suitability of ceramic filters for particulate removal from hot gases	1995
Investigate the preparation of carbon black by partial gasification of coal	1995

Metallurgical Fuels and Carbon Science

ERL's unique expertise and facilities in metallurgical fuels and carbon science research are used in co-operation with the Canadian Carbonization Research Association (CCRA) to improve fuel quality, energy efficiency and conservation in the coal and steel industries. CCRA is a non-profit research group with members from the Canadian steel and metallurgical coal industries. The doubling of metallurgical coal exports in the past decade is attributable to the joint technical efforts of ERL with CCRA which has demonstrated the high quality of Canada's coking coals.

In response to advances in iron and steelmaking technologies, ERL is constructing facilities and modelling processes to simulate new and environmentally acceptable cokemaking and ironmaking processes. Coal injection into blast furnaces is being investigated. However, coal injection will replace only a portion of the blast furnace coke requirement and thus research to produce better, stronger coke by more environmentally benign coking processes is required. The properties of Canadian coals need investigation as to their suitability to the new technologies.

Statement of Output	Target Date
Model and establish devolatilization and combustion properties of Canadian coals under simulated blast-furnace tuyère conditions, and establish properties and reactivities of chars generated under these conditions	1993
Determine the influence of mineral forms in coal on energy efficiency, gasification, and hot strength characteristics of cokes made from high and low-quality coal blends	1993
Develop models to simulate coking processes	1993
Develop agglomeration and carbonization technologies to improve environmental aspects of utilizing and handling metallurgical coals	1993
Assess the coking properties of Canadian coals as a function of the cleaning methods employed in their production	1993
Assess and develop alternative environmentally benign cokemaking processes	1994
Assess suitability of pitch residue materials as enhancer to Canadian coking coals	1994
Investigate methods to produce "super coke" for new blast furnace technologies utilizing very high levels of coal injection	1995
Develop methods of analysis and standards which are indicative of actual coke quality	on-going

Advanced Combustion Technologies

ERL conducts research to characterize and evaluate fuel quality and combustion performance on a wide range of conventional and speciality fuels including coal, oil, natural gas, biomass and biomass-derived fuels, petroleum coke, emulsions and other non-conventional fuels, and fuel additives. Research is directed at optimizing fuel efficiency and reducing pollutant emissions through bench and pilot-scale combustion tests. These tests evaluate heat transfer and emission characteristics and validate computer simulations of combustion processes. ERL's combustion research facility includes pilot-scale research boiler, tunnel furnace, circulating and bubbling fluidized-bed combustion (FBC) furnaces, reactivity furnace and residential combustion appliances. ERL provides effective combustion R&D support to Canada's electrical utilities, and industrial, residential and commercial clients. ERL's modelling expertise continues to assist in reducing experimental costs and provides clients with a better means of assessing fuels and burner performance under varied operating conditions in commercial applications. The development of advanced simulation and combustion process control software will also allow for increased efficiency of energy utilization through improved furnace and system performance and reduced operating cost.

Input and guidance is also provided to Canadian and international standards committees to allow for the introduction of new fuels and technologies in an efficient, safe and environmentally acceptable manner.

Statement of Output	Target Date
Develop a computer model for in-furnace SO_2 and NO_x removal	1993
Evaluate the combustion performance of different bitumen emulsion formulations	1993
Identify parameters influencing FBC combustion performance of coke and pitch residues from bitumen upgrading for co-generation applications	1993
Evaluate combustion performance of both opportunity fuels and on oils derived from alternative feedstocks	1994
Assess fuel-staged low-NOx burners	1994
Update CANSPECS protocols for the determination of performance characteristics of methods of analysis for coal and coal residues	1994
Develop a low-NO_x natural gas burner	1994
Develop technologies to utilize biomass in residential and commercial heating systems	1994
Develop retrofit combined space and water systems	1994

Assess flyash collection and characterize with respect to trace elements	1995
Develop a natural gas radiation and NO_x predictive model	1995
Develop a portable CARS (Coherent Anti-Stokes Raman Spectroscopy) measurement system to be used as a research tool in field trials	1995
Develop a data base and enhance test procedures for an entrained flow reactor	1995
Develop advanced simulation and expert systems for coal, oil and gas combustion processes	1995
Develop protocols and test procedures to assess the source and fate of pollutants in power plants burning fossil fuels	1996
Improve the performance of fluid bed combustion systems with respect to applicability, combustion efficiency and minimizing environmental impact	1996

Integrated Energy Technologies

Linking electricity production with industrial processes and space heating enables the recovery and utilization of otherwise wasted or rejected heat. Through combined heat and power production, or co-generation, it is possible to decrease energy use and the resulting emissions by as much as 40 percent. Furthermore, by integrating cooling systems in buildings with central chillers, it is possible to increase overall efficiencies by using low-grade heat or steam at central power plants to drive the chillers. System efficiencies can also be increased by ensuring access to lower temperature heat sinks such as lakes, rivers or groundwater. Central cooling systems facilitate the use of new chiller technology that does not use CFCs and can alleviate summer peaking problems by replacing electrically driven chillers. Load management is also enhanced by the more diversified requirements of large central heating and cooling systems.

ERL's program was funded originally through the Panel on Energy R&D (PERD), but has been augmented recently by the federal government's Green Plan. The program focuses on developing more efficient and cost-effective technologies to assemble and manage thermal energy loads through state-of-the-art district heating and cooling and, through analysis, identifying opportunities for systems integration. Through joint projects with electric utilities, provinces and municipalities, ERL also seeks to increase the awareness for opportunities available through a total, integrated energy planning approach.

Funding for this program is as follows:

K$(FTE)	92/93	93/94	94/95	95/96
Base	63(1)	63(1)	63(1)	63(1)
PERD	258(1)	258(1)	258(1)	258(1)
Green Plan	939(2)	934(3)	1158(3)	1520(3)
Total	**1260(4)**	**1255(5)**	**1479(5)**	**1841(5)**

Statement of Output	Target Date
Develop and commercialize friction-reducing additives for district heating and cooling pipelines (PERD)	1993
Develop and demonstrate an integrated multi-utility control system for load management, performance monitoring and remote meter reading based on telephone, cable television, FM-radio or "hard-wire" communication options (PERD)	1993
Complete a manual on district energy systems for low density communities (PERD)	1993
Complete heat loss/gain software and design guides for district heating/cooling pipelines for use by design engineers (PERD)	1993
Produce a promotional manual for the application of district or community energy systems for municipalities, building owners, utilities and others (Green Plan)	1993
Produce summary report on district cooling technology options as a tool for community system design (PERD)	1994
In co-operation with provincial and municipal governments, conduct a range of pre-feasibility studies on community integrated-energy systems (Green Plan)	1994
Develop methods and design guidelines to account for thermal interactions of buried piping in energy (heating and cooling) and other municipal systems (PERD)	1995
Produce a comprehensive design and operating manual for ice slurry cooling systems based on laboratory work and field trial monitoring (PERD)	1995
Prepare a report on the use of "exergy" or second law analysis as a tool for municipal energy planning using district energy as a means of buying and selling energy within the community (Green Plan)	1995

7. Management Initiatives

In keeping with the METS initiative to establish total quality management as a way of life in CANMET, ERL is establishing its own representative Quality Council to focus our activities for continuous improvement. This council has responsibility for links with the sector effort and will identify processes for improvement at the divisional level. A priority of the Council, and indeed of management, will be the reduction of divisional overhead by examining methods to increase operating efficiencies. The first area to be examined will be the requisition process in ERL. Others will be chosen at the rate of about three per year.

A marketing strategy developed for the division is now being implemented. The Business Office is playing a stronger role in the identification of potential clients through the use of available industry listings and databases. It will also provide a set of well-defined services to the ERL Technology Cells. In 1993, the role of the Technology Commercialization Group in ERL will be reviewed with a view to strengthening the marketing component.

The proposed Oil Sands Research Centre (OSRC), as part of CANMET's expansion in Western Canada, will have a marked influence on future directions of ERL's programs, especially as related to synthetic fuels. ERL and the Western Research Centre of CANMET will interact to mutual advantage as planning for the OSRC progresses. Over the next 10 years or so, it is anticipated that delivery of the upgrading portion of ERL's program will be shifted to western Canada.

A major management challenge remains to articulate clearly a near-term vision for the research programs of ERL. This vision must be consistent with the longer term vision as expressed in the document "CANMET 2007", yet provide a framework to focus our research activities in light of continuing budget reductions and the ultimate transfer of some portions of the division's program to the west.

As CANMET becomes more business-like, the need for improved project management skills, coupled with stronger implementation of the Management Information System (MIS), is required. Following extensive staff training, management attention in 1993 will focus on full implementation of an effective system.

The need to revitalize the scientific cadre and to increase staff from under-represented groups remains a priority. The flexibility provided by the new concept of a single operating budget will permit ERL to hire new people to support incremental projects.

8. Financial Resources

TABLE 8.1: Resource Allocations by Category of Expenditures

$K	1992-93	1993-94	1994-95	1995-96
Salaries	8639.8	8735.9	8747.0	8573.0
Employee Benefits	1339.2	1090.1	1091.7	1064.0
Operating	2959.7	3199.6	3194.6	3194.6
Contracts	4420.0	4764.5	5177.3	5740.3
Capital	1790.0	2243.2	2243.2	2340.8
Contributions	987.0	812.0	737.0	490.0
Incentive Bonus[a]	1751.6	2333.8	2333.8	2333.8
Total	**21887.3**	**23179.1**	**23524.6**	**23736.5**
Full Time Equivalents	158	157	157	153

Notes: a) incentive bonus is distributed according to operational needs.

TABLE 8.2: Resource Allocation by Source of Funds

$K	1992-93	1993-94	1994-95	1995-96
A-Base	6449.4	6383.7	6383.7	6175.0
PERD	12747.6	13527.8	13649.6	13707.2
Green Plan	938.7	933.8	1157.5	1520.5
Incentive Bonus	1751.6	2333.8	2333.8	2333.8
Total	**21887.3**	**23179.1**	**23524.6**	**23736.5**

TABLE 8.3: Resource Allocation by Program

		1992-93		1993-94		1994-95		1995-96	
Recovery of Bitumen, Heavy and Light Oils	K$[FTE]	304	[3]	300	[3]	300	[3]	300	[3]
	Contracts	1600		1300		1300		1300	
	Contributions	440		390		390		390	
Bitumen and Heavy Oil Upgrading	K$[FTE]	2275	[24]	2450	[25]	2390	[24]	2330	[23]
	Contracts	380		600		600		600	
Synthetic Crude Refining	K$[FTE]	1790	[19]	2020	[19]	2020	[19]	2020	[19]
	Contracts	400		350		350		400	
Residue Conversion and Utilization	K$[FTE]	792	[7]	1070	[9]	1070	[9]	1090	[8]
	Contracts	150		260		350		400	
Natural Gas Conversion	K$[FTE]	872	[7]	1110	[9]	1200	[10]	1200	[10]
	Contracts	280		420		450		450	
	Contributions	40		0		0		0	
Coal-Oil Coprocessing	K$[FTE]	705	[8]	-		-		-	
	Contracts	50		-		-		-	
Coal Gasification	K$[FTE]	739	[6]	687	[6]	690	[6]	690	[6]
	Contracts	220		210		210		210	
Metallurgical Fuels and Carbon Science	K$[FTE]	1578	[19]	1605	[19]	1605	[19]	1605	[19]
	Contracts	100		100		100		100	
Industrial Combustion[a]	K$[FTE]	1393	[14]	-		-		-	
	Contracts	230		-		-		-	
Advanced Combustion Technologies[a]	K$[FTE]	1277	[12]	3693	[35]	3660	[35]	3610	[34]
	Contracts	300		900		977		1140	
	Contributions	360		337		262		-	
Energy Conservation[a]	K$[FTE]	803	[9]	-		-		-	
	Contracts	120		-		-		-	
Integrated Energy Technologies	K$[FTE]	522	[4]	647	[6]	656	[6]	640	[5]
	Contracts	590		625		840		1140	
	Contributions	147		85		85		100	
Management and Administrative Support	K$[FTE]	1678	[26]	1686	[26]	1685	[26]	1687	[26]
Totals	K$[FTE]	14728	[158]	15268	[157]	15276	[157]	15172	[153]
	Contracts	4420		4765		5177		5740	
	Contributions	987		812		737		490	
	Incentive Bonus[b]	1752		2334		2334		2334	

Notes: a) Industrial Combustion and Energy Conservation Technologies have merged into Advanced Combustion Technologies.

b) The incentive bonus results from calculated performance indicators. It is variable and will be distributed among the above program areas according to their needs and "earnings" contribution.

9. Performance Monitoring

The indicators in the following tables have been established to help assess performance and monitor industry's participation in ERL's program.

TABLE 9.1 Generated Revenue by Type

$K	Planned 1991-92	Actual 1991-92	Planned 1992-93	Planned 1993-94	Planned 1994-95	Planned 1995-96
Goods and Scientific Services	580	502	370	640	640	640
Financial Contributions	1400	1700	1600	1800	1900	1900
Licensing Revenues	0	3	5	5	5	5
Revenues from Other Government Departments	50	79	55	55	55	55
Total Revenue Generated	2030	2281	2030	2500	2600	2600

TABLE 9.2 Client-Share of Joint Research by Type

$K	Planned 1991-92	Actual 1991-92	Planned 1992-93	Planned 1993-94	Planned 1994-95	Planned 1995-96
Client-Share of Task-Shared Work	5000	5596[a]	5000	6000	7000	7000
Client-Share of Cost-Shared Work	6000	15172[a]	5400	5725	6040	6135
Total Leveraging	11000	20768	10400	11725	13040	13135

Note: a) Exclusive of IEA and other international agreements

TABLE 9.3 Secondments and Interchanges

Full time Equivalents	Planned 1991-92	Actual 1991-92	Planned 1992-93	Planned 1993-94	Planned 1994-95	Planned 1995-96
To Industry	2	1.7	1	2	2	2
To Others	-	0.8	1	1	1	1
Total From ERL	**2**	**2.5**	**2**	**3**	**3**	**3**
From Industry	3	2.4	2	3	3	3
From Others	-	0.0	1	1	1	1
Total To ERL	**3**	**2.4**	**3**	**4**	**4**	**4**

In addition to the above indicators, ERL will highlight the following three projects/programs to be the object of mid-year and year-end review by senior management.

Consortium on Heavy Oil Emulsion Upgrading
CANMET and seven industrial clients have joined to investigate the direct upgrading of heavy oil/water emulsions without prior and costly water separation. These emulsions are produced by enhanced oil recovery (EOR) techniques such as steamflooding. The upgrading process will integrate emulsion breaking, in-situ production of active hydrogen and catalytic hydrogenation of the heavy oil.

AOSTRA/CANMET Project to Hydrotreat Synthetic Crude from Oil Sands
A joint cost-shared project with the Alberta Oil Sands Technology and Research Authority (AOSTRA) will assess hydrotreating options to convert heavy oil liquids from the AOSTRA-Taciuk Processor (ATP) into high-quality synthetic crude oil.

New District Cooling System Technologies
A new thrust in technology development of integrated energy systems will support new low temperature and ice slurry generating, transport and storage technologies. High efficiency, non-CFC cooling methods will be demonstrated at ERL which is constructing North America's first ice slurry district cooling system. This project is a component of Canada's Green Plan.