ARTHUR ANDERSEN &CO

ENVIRONMENTAL SCIENCE AND TECHNOLOGIES TO SUPPORT CANADIAN INDUSTRIES: EARLY OPTIONS VOLUME I: ACTION REPORT

REVIEW DRAFT

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THE LE GROUPE ACS GROUP LTD. LTÉE

May 25, 1990

Mr. Barry Sterparn
Director
Federal Research Directorate
Industry, Science and Technology Canada
235 Queen Street
Ottawa, Ontario
K1A 0H5

Dear Mr. Sterparn:

I am pleased to submit herewith our consulting report on early options for environmental science and technology to support Canadian industry.

We believe that it offers a useful starting point for considering how best to help the Canadian resource-processing, manufacturing, and service sectors move into the new era of sustainable development.

Yours sincerely,

C. David Crenna
Associate

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EXECUTIVE SUMMARY

This report is intended to recommend early science and technology options to meet urgent environmental and public needs and to complement implementation of the Government's Green Plan. The options represent **starting points** and do two things:

- o demonstrate ISTC leadership in the field of environmental science and technology;
- o test approaches to longer-term strategies through pilot projects.

The options **have effectively been chosen** by preceding events. That is, they are driven by international commitments and regulations already **coming into force**, clean-up programs **currently underway**, and science and technologies already **developed to a certain point**. The approach to selection has also been guided by a desire to use **existing Federal programs** and resources to build on **established Canadian strengths** and capabilities.

The selection of options probes the environment-economy dynamics of:

- o protecting Canada's vital interests in economic **sectors under challenge**;
- o meeting the **Federal government's own** environmental science and technology needs;
- o serving **emerging international markets**, following major changes in the world security situation;
- o improving **public awareness of environmental risks**, and the management of information for decisions flowing from environmental science.

The choice of these particular options for early action does not preclude initiatives which might come forward in other sectors (e.g., chemicals, oceans technology). They do imply immediate and secure market opportunities for the Canadian environmental industries. They will also combine to assist sectors under challenge in managing the environmental imperative more competitively.

The early options proposed are:

- o science and technology support to the resource-processing sector, specifically the **pulp and paper industry**, and to **defence industries diversification**;
- o **science and technology support and procurement to "get the Federal house in order"** from an environmental perspective, specifically in recapturing and recycling chlorofluorocarbons (CFCs) used in refrigerants;
- o Canadian environmental science and technology to respond to the urgent pollution-control needs of **the Third World and Eastern Europe**;
- o **better ways to interpret and present** the findings of environmental science, recognizing potential risks to the public at large, and also costs to industry.

For each option chosen, a framework for an action plan has been prepared for consideration. These plans would be fleshed out in cooperation with industry partners and participating Federal departments over the coming three months.

OPTION 1: SECTORS UNDER CHALLENGE

Part A of the **first option** addresses the needs of the **pulp and paper** industry with:

- o concentrated R&D to develop and test **"closed-loop" or "zero-discharge"** systems which eliminate discharge into the environment of all pollutants;
- o application of leading-edge Canadian science and technology in the form of process audits and improved electronic process controls;
- o use of Canadian technology to convert resulting sludge into fuel oil, for use in-plant and for sale.

(This kind of approach may be extended to include chemicals, minerals and mining, the petroleum and steel industries in the slightly longer term, or as substitutes, if the case can be made.)

The proposed **action plan** seeks to establish strategic partnerships on R&D with industries already open to closed-loop systems, science and technology producers, and regulatory agencies. The new partnerships would accelerate work to end the uncertainty about the future of this industry by achieving zero discharge solutions in an orderly manner.

Part B of the **first option** addresses the need to diversify the **defence industries**. The proposed **action plan** assists them first to define and then to realize the potential for using science and technology for pursuing new or improved environmental products and services. These would be selected to build on their existing capabilities, and initially respond to defence-related markets, e.g., pollution-control systems for naval vessels.

Specific areas of obvious **overlap between defence/security science and technology capabilities and environmental capabilities** include: remote sensing and imaging; process-control instrumentation; equipment and training programs for responding to environmental emergencies; environmental monitoring; selected process machinery and equipment.

OPTION 2: GETTING THE FEDERAL HOUSE IN ORDER

The second option "kick-starts" the **CFC recycling industry** across Canada. The proposed **action plan** achieves this by procuring the science and technology that is **needed for major Federal users** in a strategic manner. Through precompetitive R&D, it builds confidence in the new recycling technologies, and permits a target for CFC recapture or recycling by 1992 to be met by Federal operations. The technology chosen will be compatible with replacements for CFCs in the future.

OPTION 3: OPPORTUNITIES IN THE THIRD WORLD AND EASTERN EUROPE

The **third option** responds to the need for **coordinating mechanisms** for firms which have environmental science and technologies and services to offer, either the **Third World or to Eastern Europe.** The **action plan** results in the creation of two private sector offices to support the transfer and export of Canadian science and technology, and also in consensus-based strategic plans to guide their activities.

OPTION 4: INTERPRETING AND PRESENTING THE FINDINGS OF ENVIRONMENTAL SCIENCE

The fourth option plan responds to a call for **increased dialogue** among those in universities and research centres who carry out environmental science, those in industry who attempt to grapple with the findings in operational terms, and those who translate the results of science into public awareness (media, science writers) of these issues. The **action plan** facilitates a series of regional symposia to consider the ways in which environmental risks are assessed and communicated. It will also promote R&D to create **better tools for managing environmental information** and assessing environmental risks as part of corporate decision-making.

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1. PURPOSE OF THE REPORT

This report is intended to recommend environmental science and technology projects which should be promoted to meet urgent public needs, and/or which represent early market opportunities for the environmental industries in Canada.

It is the result of a three-step process:

- wide scanning, based on review of the literature, international telephone interviews, personal visits to industry associations, and interviews with Federal officials;
- strategic scanning and grouping into "families" of science and technologies, based on consideration of key drivers and constraints;
- final selection of early options, based on systematic elimination of potential contenders within each of the families for a variety of technical, regional development, market, or public policy reasons, which are specified.

Each of the above steps is documented fully in three volumes:

- Volume III contains the results of the literature review, a review of work in Federal technology centres, interviews with industry association representatives, international contacts and Federal officials;
- Volume II contains a strategic analysis of these findings according to Canada's vital trade and development interests and the environmental imperative; it provides reasons for rejecting certain options;
- this volume, Volume I, contains detailed assessments of recommended early options among science and technology projects.

It is important to stress the perspective of this report. The aim is to put forward starting points, not the final shape of environmental industries or science and technologies in Canada for years to come. The perspective brought to bear is that of the public interest and of comparative economic advantage, not environmental science or engineering per se.

Experts in any given technology may dispute some of the comments made here based on their more detailed understanding of what is involved. The attempt of the paper is to be "roughly right rather than precisely wrong."

A process of consensus-building amongst the various disciplines and interest groups might produce a similar or a very different set of projects as early opportunities. Given the evident fragmentation of both producers and users of environmental science and technology, as illustrated by recent workshops and conferences, this could surely be a lengthy process, and one that might or might not accelerate subsequent action.

2. FACTORS TO BE CONSIDERED BY INDUSTRY, SCIENCE AND TECHNOLOGY CANADA

In deciding on which, if any, of the following areas of science and technology to pursue further, Industry, Science and Technology Canada will wish to consider a number of critical factors.

2.1 Protecting Canada's Sectors Under Challenge

As documented in Volumes II and III, the regulatory basis for much needed environmental science and technology has been established by Federal and Provincial authorities and is already having extensive effects on private investment. Particularly in the **resource-processing sector**, choices among technological options with large financial consequences are faced over the next two years. Wrong choices will inevitably jeopardize Canada's traditional economic strengths as well as the viability of environmental regulation.

A debate on the use of alternatives to the "command and control" model of how to achieve better environmental performance from private industry is now getting underway in North America. But this is very unlikely to result in the repeal of legislation and regulations already in force: the public at large are simply too concerned about their own health and safety, and too lacking in trust in private industry assurances. What is more likely is the development of "market-type" incentives and schemes, such as tradeable pollution rights, which supplement or complement regulatory regimes. The resource sector is likely to be a primary focus of such schemes, because it tends to consume proportionately more "free" environmental goods.

In the meantime, it will be important to develop and implement maximum technological flexibility within the ambit of the command-and-control approach.

In some cases, it may prove most desirable and feasible to move from the existing concepts which imply ever finer measurement of end-of-pipe effluents and the progressive reduction of pollutants in them to "closed-loop" and other zero discharge systems. The latter are among the approaches called "clean technologies". While their logic is compelling in principle, they have been slow to be adopted in practice.

Another sector which faces major challenges for diversification is the **defence industries**, which account for about $3 billion annually in business. These industries include defence electronics, portions of aerospace, ship-building and repair, and manufacturers of specialty vehicles and weapons.

In the case of defence electronics, annual revenues are about $2.4 billion, and export earnings about $1.4 billion. Eighty percent of Canadian shipments are exported. As a result of dramatic changes in Eastern Europe, the North American defence industry is facing major cuts in specific areas.

2.2 Getting the Federal House in Order: Early Opportunities in Government Science and Technology Procurement

The Federal government is the largest single "business" in Canada, with expenditures of $125 billion and over 585,000 civil servants and Crown corporation employees. As the largest commercial landlord, it owns or leases 5.7 million square metres of office space. Its 70,000 buildings and facilities annually consume about 5.7 billion litres of water and 45 terajoules of heat energy, the latter costing over $500 million.

Further, Federal departments and agencies purchase 1,250 motor vehicles in a typical year, adding them to a fleet of over 23,000. These are among 17,000 different categories of consumer, commercial and industrial goods and services. The total value of such purchases from the private sector is over $10 billion.

The Federal government is the largest buyer of travel services in Canada at 288,000 reservations a year, and the largest publisher, with 9,000 printing jobs farmed out. It is also one of the largest purchasers of transportation fuels, at 28 terajoules annually, operating 800 ships and 150 aircraft in addition to its motor vehicles.

Clearly, all this activity has a measurable impact on the environment. Its implication for the Green Plan is that Federal action alone can make a substantial contribution to sustainable development. Its implication for the environmental industries is that the Federal government can play a large and positive role in developing, testing, and placing into widespread use "best practice" environmental technologies.

2.3 Responding to the Needs of Eastern Europe and the Third World

The amount of environmental degradation evident to people in Eastern Europe, and their fears for the future of their own health and that of their children were a significant factor in the revolutions overthrowing Communist governments in Eastern Europe over the past six months. According to European Environment Review, Eastern European economies consume between two and four times as much energy for the same economic output. They consume substantially more fuel to yield the same amount of energy, and they show much higher rates of environmental and health damage.[1]

Early Canadian efforts to assess the need for industrial pollution control technology in Eastern Europe can be put into a context of cooperation on environmental science and technology, as they have been in relation to the Soviet Union.

To the extent feasible, the Canadian approach should be that we will help these countries to advance through R&D directly into clean technologies, rather than confining them to an earlier generation of "end-of-pipe" methods.[2]

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[1] Vol. 2, No. 4 (December, 1988), p. 25.

[2] In the case of the Soviet Union, this may require further relaxation of Co-ordinating Committee on Multi-Lateral Export Controls (COCOM) guidelines on high-technology exports.

Environmental considerations have been a significant factor in Canadian aid to developing countries for some time. In a recent report prepared by the Institute for Research in Public Policy following a series of regional round tables across Canada, Jim MacNeill and associates call for CIDA to support local environmental science institutes and networks, promote urban technologies, develop country plans to mobilize environmental science and technology, and base procurement policies on sustainable development criteria.

Overriding priorities arise out of the relationship between the environment and military security matters. They include linkages between post-war reconstruction in Central America, Namibia, and elsewhere with low-pollution technologies; preparation now to respond in a major way to the environmental disaster created by war in the Sudan and Ethiopia; and the lead role Canada is currently playing promoting direct assistance by industrialized nations for adoption by Third World countries of clean S&T.

2.4 Environmental Monitoring and Measurement as Risk and as Opportunity

While government regulations are the most visible drivers of the environmental industries, these are in turn driven by public concern, often based on the findings of environmental science, as interpreted by the media. As the capacity to detect and monitor toxic substances has grown, the agenda has shifted toward an attempt at a "zero risk" world from some perspectives.

For example, dioxins and furans were previously undetectable, and can now be measured in parts per trillion. There is a need for the creation of fora to bring the stakeholders together, to inform the interface with the public (media, science writers) and otherwise improve the level of debate and information management.

Both the volume and the diversity of environmental data and information have risen exponentially. The largest firms in Canada are quite fully engaged in the process of responding to environmental imperatives, and for the most part, have the means to do so. They can assemble their own confidential synthesis reports for their unique needs. Medium-sized and smaller firms do not have either the resources or the international contacts at their disposal to do so, and must rely more heavily on the published literature. That literature is diffuse and often difficult for the corporate decision-maker to read and use.

There is no Canadian equivalent of The Environmental Professional, an excellent U.S. periodical devoted to synthesis and the management perspective. Nor is there as comprehensive a Canadian magazine as Environmental Science & Technology in the United States.

2.5 Scope for Action by ISTC

The purpose of the early options projects is twofold:

- to demonstrate that Industry, Science and Technology Canada is prepared to take a leadership role and implement its mandate in support of critical science and technology issues;

- to learn from trying different approaches to be able to shape a long-term science and technology strategy, consistent with the Environmental Industries Sector Initiative and the Federal Green Plan.

No new policy instruments are needed to implement the early options. Those which exist now include:

- research contracts;
- S&T procurement;
- grants to universities;
- S&T brokering;
- Environmental Technology Development Program;
- Forest Industries R&D and Innovation;
- repayable loans to support industrial modernization and application of new science and technology;
- Phase III funding under the Environmental Industries Sector Initiative.

3. CONSIDERATION OF PROPOSED EARLY OPTIONS

3.1 Format for Presentation of Options

For each of the projects proposed for early action or early attention as a major market opportunity, the following subjects are addressed below:

- o What It Is: basic description of the proposed project, technology, or science activity;

- o Rationale for Choice: why this science, technology or type of project has been selected from amongst all of the other possibilities, including consideration of some or all of the following aspects as relevant...

  - the legislation, regulation, environmental action plan, resource loss or consumer interest which is pushing the need for the science/technology along;

  - why the project in question has not been undertaken already, what the constraints are to earlier action have been;

  - why the project is proposed as an <u>early</u> opportunity rather than being left to other, longer-term mechanisms, or imported, etc.;

  - the number of users, units which could be sold, etc., within Canada, to the extent these are known;

  - the number of relevant Federal facilities requiring action, volume of potential purchases to get the Federal house in order, etc.

- o Canadian S&T Capabilities: a brief assessment of the feasibility of the project from the perspective of some or all of these factors ...

  - existing Canadian-based firms which have established market positions, and/or R&D capabilities, and/or production capabilities;

  - comparative and competitive advantages arising from Canadian advances in research, highly qualified personnel, access to the U.S. market under the FTA, etc.;

  - extent to which Canadian capabilities are or could be overshadowed by those in other countries;

  - location of the most like producers of the science and technology.

- o Action Plan: the specific kinds of actions which it is proposed ISTC would take to accelerate action to develop the needed technology, refine the needed science, or exploit the potential market opportunity;

- Contacts/Sources: individuals interviewed or consulted through public statements.

3.2 Summary of Options

In relation to the sectors under challenge, action is proposed on:

- science and technology work leading to application of "closed-loop" systems in the pulp and paper industry, including process audits and improved electronic controls for wastewater processing systems, and oil from sludge;

- converting some of Canada's defence industry science and technology capability to environmental purposes.

Responding to the imperative to get the Federal house in order is a project on science and technology leading to government procurement of equipment and services to recycle chlorofluorocarbons used in domestic and commercial refrigeration and in automotive air conditioners.

Turning to the urgent needs of the Third World and Eastern Europe, there are proposed environmental industries science and technology liaison offices on opportunities for export to Eastern Europe and the Third World.

Finally, in relation to the interpretation and presentation of environmental science findings, symposium of scientists and the users of their results is proposed, followed by R&D to develop better management information tools for assessing environmental risks as part of day-to-day corporate decision-making.

Each of these is addressed in turn in the sections which follow.

4. EARLY OPTIONS: SCIENCE AND TECHNOLOGY FOR SECTORS UNDER CHALLENGE

PART A: THE RESOURCE-PROCESSING SECTOR

4.1 What It Is:

Part A of the first early option addresses the resource-processing industry under greatest immediate challenge, pulp and paper with:

- o R&D most critical to application of "closed-loop" or "zero-discharge" systems which eliminate discharge into the environment of all pollutants;
- o application of leading-edge Canadian science and technology in the form of process audits and improved electronic process controls;
- o use of Canadian technology to convert resulting sludge into fuel oil, for use in-plant and for sale.

(This kind of approach may be extended to include chemicals, minerals and mining, the petroleum and steel industries in the slightly longer term, or as substitutes, if the case can be made.)

4.2 Rationale for Choice:

The pulp and paper industry contributes about $14 billion annually to Canada's GNP and employs some 80,000 Canadians. The industry appears to be at particular risk because of the combination of environmental and other challenges which it faces: new standards which call for virtual elimination of dioxins and furans; environmental assessment processes on all new pulp mills; paper recycling legislation in major foreign markets; stiff international competition from American and Scandinavian competitors, and uncertain world prices.

Pulp and paper companies had planned to spend $1.2 billion over the next three years to clean up effluents, in particular dioxins and furans. The new Federal standards announced on January 3, 1990 are estimated to cost $5 billion over the next four years, to complete the phase-in by 1994.

At one level, the industry appears well equipped to handle the science and technology associated with the tasks at hand.

The Pulp and Paper Research Institute of Canada (Paprican) was the originator of key findings on what causes dioxins and furans to form. It also determined how they could be removed or reduced below the detectable level through process modifications. Specifically, what is necessary is the reduction of chlorine bleach, and of other contaminants which act as precursors to their formation.

In October, 1989, Paprican was announced as the focus of a Network of Centres of Excellence on science and engineering for high-value papers from mechanical wood pulps.

Mechanical pulping uses fewer chemicals than kraft processes, accepts a wider range of northern trees, and is last wasteful of trees. The aim is to produce a unique new Canadian process technology.

There are at least 28 different techniques for reducing the production of dioxins in the bleaching process, ranging from improved management practices, to substitution of hydrogen peroxide for a substantial portion of the chlorine, to major process modifications.

The most radical approach is that of zero discharge or closed-loop systems. These recycle all of the water used in the production process, as well as the bleaching chemicals.

Such systems may use "supercells" which clarify water in a few minutes rather than hours, "countercurrent" systems which wash bleaching agents out of pulp with minimal water, and dry barking systems for wood entering the plant. Estimated savings from such closed-loop methods are over $233,000 annually for a 200-ton-per-day paper plant, paying for the supercell in 2.2 years.

Great Lakes Paper has installed an innovative small production plant using Canadian-designed closed-loop methods in Thunder Bay, and Millar Western is planning a $280 million closed-loop plant in Meadow Lake, Saskatchewan, using its own proprietary technology.

Despite these positive signs, ISTC officials who have spoken to pulp and paper executives recently report a sense of panic about the new Federal regulations, and an almost exclusive focus on "end-of-pipe" rather than longer-term or closed-loop approaches. Millar Western is reportedly being regarded in the industry with fear, because if their closed-loop system works well, it may become mandatory across the board.

The problem with the closed-loop approach is that it works best with new plants or major retrofits. Most of the processes and machinery and equipment to be applied to meeting the latest standards are probably already on the drawing boards, if not into implementation.

The actual selection of the longer-term options will depend, therefore, on a process of mediation between the contending parties within the industry and between the industry and regulatory bodies. It may require extra time for implementation, some front-end work on the least-cost technologies, and some underwriting of risk. It may also call for development of a system of credits for those firms that have recently invested heavily in upgraded end of pipe solutions and are not in a position to move as quickly to closed-loop systems.

4.3 Canadian S&T Capabilities:

While a substantial amount of pulp and paper machinery and equipment is imported, there are major domestic capabilities in the field as well. Both the users of the technology and specialized manufacturers and research centres are involved in technology development.

Process consultants who could help to design closed-loop systems include:

- Nystrom, Lee, Kobayashi Associates, of Vancouver;
- Acres International Limited, of Toronto;
- H.A. Symons Limited, of Vancouver;
- Reid Crowther Inc., of Calgary;
- Wardrop Engineering, of Winnipeg.

Potential suppliers of process technology include:

- ADI International Inc., of Fredericton;
- Chemvac Inc., of Montreal;
- Dresser Canada Inc., of Brantford;
- La Corporation Mabarex, of Saint Laurent;
- Lisle-Metrix Limited, of Toronto;
- Dorr Oliver (Canada) Inc., of Orillia;
- Hymac Limited, of Laval;
- Laperriere & Verreault Inc., of Trois Rivieres;
- S.W. Hooper, of Sherbrooke;
- Flakt Ross Pulp and Paper Inc., of La Salle;
- Valmet Dominion Inc., of Lachine;
- Black Clawson Kennedy Ltd., of Owen Sound;
- Devron-Hercules of North Vancouver;
- Beloit Canada Inc., of Montreal;
- Ingersoll Rand (Canada) inc., of Sherbrooke.

"Supercell" systems would probably need to be imported from West Germany in the initial instance. However, many of the items used for the Millar Western installation will be from "off the shelf".

Research and development needed on such problems as how to retrofit closed-loop systems in a least-cost manner could be done by the Wastewater Technology Centre, the University of British Columbia, the University of Toronto, McGill University, or Paprican.

There may also be possibilities to work with Canadian defence industries in the process of diversifying existing science and technologies to new uses in other sectors, such as the pulp and paper sector.

4.4 Action Plan:

The proposed action plan is to:

- Form strategic partnerships on R&D with industries already open to closed-loop systems, science and technology producers, and regulatory agencies;

- Consider possible financial support from the Environmental Technology Development Program or the Forest Industries R&D and Innovation Program;

- Develop a step-by-step process to remove the remaining barriers to closed-loop or zero-discharge systems in Canadian mills;

- Explore with Environment Canada reasonable milestones for phasing in new effluent regulations, contingent on commitments by industry to undertake R&D and then move to zero discharge through implementation of new systems by a date agreed upon by all stakeholders.

In support of this plan, ISTC could:

- Select a person with widespread respect in both the pulp and paper industry and government circles to convene a roundtable or symposium on "science and technology to meet ultimate standards for the pulp and paper industry"; the chairperson of a major university engineering faculty with a track record in pulp and paper would be ideal;

- Identify, with industry participation, the technological and economic barriers to closed-loop or zero-discharge systems in Canadian mills, and the ways in which these could be overcome in a cost-effective manner through R&D; Arie van Donkelaar of Nystrom, Lee, Kobayashi is a candidate for this task;

- Assemble on a confidential basis current process science and technology and end-of-pipe capital plans within the industry, presenting the results in an aggregated way;

- Consider, with Environment Canada, the mill-by-mill costs and benefits of modifying phase-in of new regulations under the Canadian Environmental Protection Act and Fisheries Act, contingent on industry committing to achieve zero discharge within an acceptable time frame;

- o Contract Paprican to identify all known existing installations of closed-loop and zero-discharge systems, to give as much performance detail as can be secured from the companies in question;

- o Consider and develop a specific project with Quebec-based stakeholders and potential Canadian partners outside Quebec in the context of the Environmental Technology Development Program;

- o Consider federal support under the Forestry Industries R&D and Innovation Program or from Phase III of the Environmental Industries Sector Initiative.

The benefits of the proposed early option for the major stakeholders are of fundamental importance. For the pulp and paper industry, fully-operational closed-loop systems in general use would mean an end to uncertainty about environmental regulations relating to effluents. It would restore public confidence in the industry, and establish the basis for exporting a leading-edge Canadian technology to other countries. Pulp produced in this manner, if accompanied by sound forest management practices, could arguably be presented to world markets as an environmentally friendly product, helping to reduce the anomalies created by recycling legislation.

From the government's perspective, there are tax revenues and Unemployment Insurance benefits saved through a healthy pulp and paper industry. As well, there is public recognition of demonstrated leadership in achieving sustainable development.

Spin-offs may be created through migration of closed-loop technologies to other environmentally-stressful industries, and opportunities to work with other industry sectors (e.g., defence industries), which are in the process of diversifying and may have developed applicable S&T.

4.5 Contacts/Sources:

Mackenzie Millar, President, Millar Western, Edmonton

Eric Hall, expert in pulp and paper technology, Environment Canada

Michele Gosselin, Chief, Socio-Economic Analysis Division, Environmental Protection Directorate, Environment Canada

Arie van Donkelaar, international expert on pulp and paper process technology, Nystrom, Lee, Kobayashi Associates, Vancouver

Bruce Jank, Director, Wastewater Technology Centre, Environment Canada

PART B: DEFENCE INDUSTRIES

4.6 Description:

The major early option to be considered for the defence industries is a government-supported action plan for R&D leading to diversification through the development of new products and services in the environmental industries sector.

These would build on the defence industries' existing strengths and start with their existing markets, e.g., pollution-control systems for naval vessels, and destruction technologies for toxic wastes. Other options in this package may also contribute. For example, Federal procurement, facilitation of science and technology transfer to the Third World and Eastern Europe and applications of defence-based S&T to the problems of other sectors under challenge (e.g., pulp and paper, chemicals).

Specific areas of obvious overlap between defence/security S&T capabilities and environmental capabilities include:

- o remote sensing and imaging;
- o process-control instrumentation;
- o equipment and training programs for responding to environmental emergencies;
- o environmental monitoring;
- o selected process machinery and equipment.

The proposed departmental participants to carry out the action plan are ISTC, DSS, DND, and DOE.

4.7 Rationale for Choice:

Total savings over five years from two rounds of National Defence budget trimming will result in $3.3 less being expended. The largest portion of these cuts will be borne through reductions in defence procurement. Similarly, in the United States, the Secretary of Defense is proposing cuts of $180 billion over five years. About $7 billion annually may be reduced from procurement budgets. The bankruptcy of Leigh Instruments and difficulty of other firms are harbingers of things to come. Many defence industry stocks in Canada are trading at or near 52-week lows.

These industries represent significant clusters of high-technology capability, with highly-qualified personnel and sophisticated technology. Many are finding it hard to diversify from the technologically-demanding, high-cost, specialized nature of military procurement to competitive, domestic applications of their strengths.

A phased approach similar to that under the previous Unsolicited Proposal Program could be undertaken to promote new "environmental" R&D involving a consortium of defence-based industries; possibly focused on the problems of specified sectors under challenge (e.g., pulp and paper) and ranging eventually from the pre-competitive to the competitive stage.

This would then lead to federal support once an item has been established as viable. An example is the development of a waste disposal system for naval ships which is then marketed to the merchant marine and coastal fleets to meet new regulations under the Canadian Environmental Protection Act.

4.8 Canadian S&T Capabilities:

There are already at least three Canadian firms which are engaged in S&T both the defence and the environmental industries: NUMET Engineering Limited of Peterborough, MacDonald Dettwiler and Associates Limited, of Richmond, British Columbia, and Indal Technologies Incorporated of Mississauga, Ontario.

Some of the other firms involved in the defence industry with relevant S&T capabilities include:

- Litton Systems Canada Limited, of Toronto;
- CAE Electronics Limited, of Montreal;
- Canadian Marconi Company, of Montreal;
- Unisys Canada Inc., of Winnipeg;
- Raytheon Canada Limited, of Waterloo;
- Computing Devices Company, of Nepean;
- ITT Cannon Canada, of Toronto;
- Oerlikon Industries, of St. Jean-Richelieu;
- Bendix-Avelex Inc., of Montreal;
- Garrett Canada, of Toronto;
- Rockwell International of Canada, Ltd., of Toronto.

In relation to the specific research on alternatives for the defence industries in the environmental sector, the Canadian strengths are at the Royal Military College, the University of Waterloo, E.T. Jackson and Associates, of Ottawa, and the Canadian Centre for Arms Control and Disarmament.

4.9 Action Plan:

The proposed action plan is to:

- Build on initial consultations with DSS, DND, and DOE to fund precompetitive research proposals from consortia within the defence industries to develop new environmental science and technology using existing capabilities;

- Select from among proposals on a competitive basis to determine what, if any S&T support to provide;

- Offer, as appropriate, first purchase, stock-item procurement, R&D assistance, repayable modernization loans, etc.;

- Develop targeted strategies for entering the United States market in cooperation or in competition with defence industries there, potentially using models like the existing US-Canada Defence Development Sharing Program;

- Foster new alliances between defence industries and resource-processing industries where new applications could be made of defence-based S&T, e.g., for process controls in pulp and paper mills.

In support of this plan, ISTC could:

- Identify current involvement of the defence industries in the environmental science and technology sector and prepare a joint statement of position;

- Under the chairmanship of a person like Peter Nicholson, Senior Vice-President, Bank of Nova Scotia, who has already expressed an interest, convene a round table or symposium of industry representatives to look at the R&D required to make the transition;

- With industry support, prepare a more extensive identification of market opportunities, including an international scan of what S&T strategies are being adopted by defence industries in other countries;

- Pursuant to plans developed by industry consortia, work with DSS and DND to use procurement for environmental aspects of defence installations, operations, and equipment to support S&T for new products and services from the defence industries, both related and unrelated to existing activities;

- Consider ways to work with existing ISTC support programs such as the Phase Three Sector Initiative, the Environmental Technology Development Program, and the Forestry Technology Development Program.

Benefits arising from a successfully-managed diversification from defence production to environmental protection have world-wide significance. They represent the achievement of a model for the future now being advocated by the leaders of both the United States and the Soviet Union, and will have major ripple effects in Eastern Europe and parts of the Third World. Even more limited case studies applying to given products will be valuable as a demonstration of Canadian leadership.

For the industries in question and some of the communities in which they are located, survival may be at stake. For the government, there are corporate tax revenues, and savings of Unemployment Insurance and welfare expenditures, as well as major public support for a clear shift in priorities.

For ISTC, there is valuable learning about the role of S&T in defence industry diversification, which can be applied to other sectors under challenge (e.g., Pulp and Paper, Chemicals, etc.) and aspects of the Department's programs.

4.10 Contacts/Sources:

- Jim Finan, expert in socio-economic aspects of defence, Department of National Defence and Royal Military College
- John Lamb, Executive Director, Canadian Centre for Arms Control and Disarmament
- Ernest Regehr, Professor, and specialist in defence industries analysis, University of Waterloo
- Peter Nicholson, Senior Vice-President, Bank of Nova Scotia; member, NABST; member, Board of Directors, Canadian Centre for Arms Control and Disarmament
- Barney Danson, The Winchester Group, former Minister of National Defence
- E.T. Jackson, President, Jackson Associates, consultants

5. EARLY OPTION: SCIENCE AND TECHNOLOGY TO HELP GET THE FEDERAL HOUSE IN ORDER

5.1 Description:

The second option will assist in "getting the Federal house in order" by "kick-starting" the CFC recycling industry across Canada. Science and technology that is needed for major Federal users will be procured in a strategic manner. Such services and equipment have general application across Canada and around the world.

The proposed partners to carry out the action plan in pursuit of the option are ISTC, DSS, DOE, and DND as major user.

5.2 Rationale for Choice:

The Federal government uses CFCs in approximately 30,000 different locations across the country, and has 1100 pounds stored in one location at Cold Lake, Alberta alone. Overall, the government probably uses at least 70 metric tonnes across Canada. Under a plan for "getting the Federal house in order", the government is planning to show leadership by capturing and reusing all CFCs in its possession by 1992.

Furthermore, major international parties, including Canada, will be undertaking a process shortly to negotiate a fund ($250M or more) to promote the development and implementation of new S&T and clean processes to protect the ozone layer, with CFCs as a critical target.

The major federal user departments and agencies are National Defence and Transport Canada. The Federal government uses CFCs in shipboard refrigeration units, at military bases, and in Federal vehicles. There are over 25,000 refrigerators in DND housing alone.

From the best available expert reviews of technology, it will take some time to develop, test, and put in place acceptable alternatives to chlorofluorocarbons in use around the world as coolants in refrigeration, air conditioning, and heat pump equipment.

Even when these alternatives have been developed, it will take time to replace the millions of refrigerators, commercial freezers, air-conditioned automobiles, and other equipment which uses them.

The development of replacement chemicals is well underway, and Dupont Canada has a major plant under construction in Maitland, Ontario to be the world's first supplier of HCFC-123. However, none of the current replacement substances is fully acceptable from an environmental perspective. They are called "bridging" substances.

The creation of a recycling industry makes sense not only because it will capture CFCs now being allowed to escape into the atmosphere, but also because it can later recycle the bridging chemicals.

There is nothing to prevent Canadian scientists from searching for alternatives to CFCs, but this appears to be a high stakes game, with a few major international players, including ICI, Dupont, Allied, and one German firm.

CFC recycling involves:

- o condensing units which remove the CFC gas as a vapour and can be applied in the case of the most common product, CFC-12, used in automotive air conditioning, household refrigerators, etc.;
- o liquid recovery pumping for CFC-11 and other liquid forms of CFC;
- o adsorption techniques for mixtures of CFCs and air.

Under proper recycling practices, it is estimated that 92% to 99% of used refrigerants can be recycled, and may cost about the same as new refrigerant.

Beyond the 30,000 Federal units, there are 9,421,000 domestic refrigeration units with CFCs in use in Canada, 5,524,000 home freezers, and perhaps 1.9 million air-conditioned automobiles. **This is a ubiquitous technology.**

Worldwide, there are nearly 250 kilotonnes of CFCs in use as refrigerants, over 100 kilotonnes of which is in use for automotive air conditioning.

5.3 Canadian S&T Capabilities:

There are at least two large-scale CFC recycling firms in Canada, Anachemia and Varnacolor, both located in the Toronto region. These have links with the large chemical companies, such as Dupont, which take back the CFCs and certify them for reuse.

In addition, there is a Toronto company called Refrigerant Reclaim, which has a mobile CFC recovery unit - the Rejuvenator. Refrigerant Reclaim is currently negotiating to manufacture it under licence, in Montreal, and is looking into new S&T to enhance the unit from a Canadian perspective. It has 116 distributors for the unit across Canada.

A Mr. Ken Gill of Kingston has developed a Canadian recycling technology. As well, there are manufacturing firms in Atlantic Canada (Enspeco) and in St. Catharines, Ontario (Probar Industries).

Union Carbide Canada is working on a method of reclaiming gaseous CFCs, called a "molecular sieve" which is expected to be ready in about 6 months.

The Ontario Ministry of the Environment is field testing a mobile CFC recovery system for use with old refrigerators and freezers. In all, there are about 15 - 20 different types of recycling equipment in Canada now.

Large-scale manufacturing of equipment developed in Canada could be undertaken by such refrigeration firms as Keep Rite, since the technologies involved are similar.

Apart from the R&D on the molecular sieve, what is needed are standards for both the recycling equipment and for the recovered chemical. Refrigeration manufacturers are tending to specify virgin CFCs, owing to concerns about impurities. Otherwise, their warranties are void.

5.4 Action Plan:

The proposed action plan is to:

- Call, through the DSS electronic bulletin process, for expressions of interest in a specific DND CFC clean-up problem or site;
- Building on initial consultations with DSS, DND, and DOE, offer Federal funding for precompetitive R&D to consortia which will assist in defining performance standards, simplify designs and technologies of available machines, and convert offshore solutions into Canadian technologies;
- Establish a set of science-based equipment and services specifications based on the results of the R&D;
- Make a first purchase by the Federal government of the Canadian technology which emerges.

The recapture and recycling technology chosen would need to be compatible with bridging and replacement chemicals for CFCs.

A more detailed sequence of events on recycling technology could be:

- Identify the current state of the science and technology required for the CFC recycling industry in Canada, concentrating on refrigerants, chillers, and automotive air conditioners;
- Based on qualifying plans from industry proponents, support any remaining R&D or demonstration that is needed through regular programs, such as IRAP, with potential cost-sharing from Phase III of the Sector Initiative;
- Establish equipment and services standards based on R&D and testing;
- Conduct and adjudicate the competition for the purchase of equipment and/or services;
- Purchase and put into operation the new equipment/services.

In implementing the action plan, DND would act as the prime user in identifying and describing their needs. DSS would issue a request for proposals via their electronic bulletin, as noted above, and then manage the process of vetting them. ISTC would vet the business plans.

ISTC and DOE would vet the technology development plans, and DND would ensure appropriateness to their needs. The demonstration of the technologies could be cost shared among departments. Once demonstrated to DND's satisfaction, DSS would manage the first purchase.

The benefits of such a step-by-step approach to CFC recycling are clear: DND is able to move more rapidly and cheaply on its clean-up program, Canada and DOE achieve targets for CFC management more quickly, ISTC is able to develop a major Canadian industrial strength, and DSS is able to test a "green procurement" policy in a very tangible way.

On a broader plane, the private sector will benefit from substantial numbers of jobs in both manufacturing and service sectors, based on products or services with a large market; the public at large will benefit from reduced CFC impacts on the ozone layer. In some cases, procurement of CFC-recycling science and technology may also contribute to defence industry diversification.

5.5 Contacts/Sources:

- Ted Newall, President, Dupont Canada, Mississauga
- George Wentlandt, President, Anachemia Limited, Mississauga, Ontario
- Ben Brasz, President, Refrigerant Reclaim Limited, Weston, Ontario
- Victor Buxton, international expert on CFC replacements, Chief, Chemicals Control Division, Conservation and Protection, Environment Canada
- Fred Chen, international expert on CFC recycling, Industrial Programs Branch, Conservation and Protection, Environment Canada
- Sharon Suter, Ontario government expert in CFCs, Waste Management Policy, Waste Management Branch, Ontario Ministry of the Environment

6. EARLY OPTION: SCIENCE AND TECHNOLOGY LEADING TO INDUSTRIAL OPPORTUNITIES IN THE THIRD WORLD AND EASTERN EUROPE

6.1 What It Is:

The third early option responds to the need for coordinating mechanisms for firms which have environmental science and technologies and services to offer, either the Third World or to Eastern Europe.

The proposed participants are ISTC, CIDA,IDRC, External Affairs, the International Centre for Sustainable Development and evolving PROs (e.g., BC Institute for Sustainable Development). The participants, and industry partners would develop a network for focused brokering and diffusion of Canadian-based environmental S&T. As a way of testing the concept, ISTC could consider the possibility of establishing small Western (British Columbia) and Eastern (Ontario) private sector-based offices to launch the approach, promote the formation of strategic consortia, and facilitate the diffusion of environmental S&T.

6.2 Rationale for Choice:

CIDA and IDRC both have small units dealing with relevant subjects spread around their organizations. External Affairs missions in Eastern Europe have many other concerns beside environmental industries, and are short-staffed in relation to the much higher volume of interchange since late 1989.

Early Canadian efforts to assess the need for industrial pollution control science technology can be put into a context of cooperation agreements on environmental science and technology, as they are in relation to the Soviet Union. To the extent feasible, the Canadian approach to Eastern Europe should be that we will help these countries to move directly into clean technologies as they modernize their industrial machinery and equipment.

Environmental considerations have been a significant factor in Canadian aid to developing countries, but focused on rural areas. Overriding priorities arise out of the relationship between the environment and military security matters.

These include linkages between post-war reconstruction in Central America, Namibia, and elsewhere with low-pollution technologies; preparation now to respond in a major way to the environmental disaster created by war in the Sudan and Ethiopia; and Canada's lead role in supporting assistance to developing countries by the industrialized nations to adopt clean S&T.

6.3 Canadian S&T Capabilities:

Canada has major strengths in the field of environment and development:

- Alconsult International Ltd., of Calgary;
- CSSA Environmental Consultants Ltd., of Montreal;

- Lavalin International, of Montreal;
- Wardrop Engineering, of Winnipeg;
- Marshall, Macklin, Monaghan Limited of Don Mills;
- North/South Consultants, of Winnipeg;

and others.

6.4 Action Plan:

The proposed action plan is to:

- Develop outlines of environmental S&T strategies appropriate to the needs of the recipient countries, based on current stakeholder consensus;
- Provide Federal seed funding, on a cost-shared basis with the private sector, to establish two project offices to test the strategies;
- Convene round tables of stakeholders, including receiving countries, suppliers of environmental science and technologies, financial institutions, and independent experts from universities to devise strategic plans to guide the work of the project offices.

Canadians suffer from a world-wide reputation for having products and services of excellent quality which are then poorly marketed. The proposed strategic plan and test project offices will assist in marketing the S&T front end of major export streams. That is, once Canadian science and technology have developed a market niche, full-scale production, either based in Canada or under licence, can follow.

For immigrants from the Third World and Eastern Europe now seeking to reestablish business links with their homelands, the offices will likely prove of particular value in helping to identify relevant contacts in a rapidly changing governmental scene there. That is, while immigrants may be familiar with many aspects of their native country, they may be out-of-date with both government structures and environmental laws and conditions.

This early option may also complement defence industry diversification and diffusion of new S&T developed by resource sectors under challenge (e.g., pulp and paper, chemicals).

6.5 Contacts/Sources:

- Jim MacNeill, Institute for Research on Public Policy
- John Cox, Institute for Research on Public Policy
- Barbara Lamb, Resource Systems Management International, consultants

- Dal Brodhead, Jackson Associates, consultants
- David Brooks, International Development Research Centre
- Robert Platts, President, Scanada Consultants

7. EARLY OPTION: INTERPRETING AND PRESENTING THE FINDINGS OF ENVIRONMENTAL SCIENCE

7.1 What It Is:

Commentators and people consulted in the writing of this report call for increased dialogue among those in universities and research centres who carry out environmental science, those in industry who attempt to grapple with the findings in operational terms, and those who translate the results of science into public awareness (media, science writers) of these issues.

Those who could become involved include ISTC, DOE, the Canadian Science Writers Association, the Canadian Chamber of Commerce, the Business Council on National Issues, and other similar organizations.

7.2 Rationale for Choice

Environmental scientists in universities and research centres continue to improve their capacity to monitor and measure changes in the natural environmental, using the methods of toxicology, epidemiology, and ecology. Their findings frequently result in new appreciations of environmental risk, as in the case of global warming, ozone depletion, and the discovery of dioxins and furans in effluents.

Such findings frequently to lead to major investments and adjustment by industry, including the closure of plants and the disruption of community economies. There are risks associated with both the effects of environmental deterioration on life and health, and the impact on jobs and industries of new investment requirements.

The findings of science often must, of necessity, identify large areas of uncertainty. Canadian work on the psychology of decision-making in conditions of uncertainty shows that the **way in which risk factors are presented** can be extremely important in subsequent human assessments and behavior. In addition, there is such a large volume of environmental data that the decision process can become unmanageable.

It is vital to search for common ground on the matter of how much environmental risk is "unacceptable" and how to present risks in ways that non-scientists can understand and act on. Research results may be conveyed in the media in terms that are beyond the comprehension of lay persons, e.g., not in the context of day-to-day risks such as smoking or driving a vehicle. By the time a context is provided, the agenda for action may have been set, regardless of the direct and opportunity costs involved.

Moreover, there can be no effective movement on the whole range of environmental science and technologies if those charged with corporate decision-making and operational responsibility do not have appropriate information bases upon which to take decisions. These are needed chiefly because of dangers that those taking tough industrial/environmental decisions will be "swamped" by the scientific and technical information available, or will not be able to find what they require. As in the case of medical care and other rapidly advancing fields, information management has become a major organizational and technological problem.

7.3 Canadian Capabilities:

Canada has important strengths in risk assessment, environmental monitoring and measurement, Geographic Information Systems, and information and communications technology. Firms involved include:

- Beak Consultants Limited, of Brampton;
- Canpolar Inc., of Toronto;
- INTERA Technologies Limited, of Calgary;
- Terra Surveys Limited, of Ottawa;
- Concord Scientific Corporation, of Toronto;
- Hatch Associates Limited, of Toronto;
- MacDonald Dettwiler and Associates Ltd., of Richmond British Columbia
- TYDAC Technologies Inc., of Ottawa;
- Jacques, Whitford Group Limited, of Halifax;
- Geovision Corporation, of Ottawa.

7.4 Action Plan:

The proposed action plan is to:

- Build on contacts with the Canadian Science Writers Association, the Canadian Chamber of Commerce, and DOE to develop a new approach for more effective communication of environmental risks and scientific results;
- Initiate regional symposia for science writers, researchers, and industry representatives on environmental monitoring, measurement and risk assessment, targeted to particular issues and industrial sectors;
- Following the symposia, support development of management information tools to improve the identification and assessment of environmental risks.

In more specific terms, ISTC and DOE could:

- Contract with a university or Learned Society to convene symposia for science writers, researchers, and industry representatives on environmental monitoring, measurement and risk assessment; Claude Forget or Pierre-Marc Johnson could possibly chair such a symposium;
- Work with DSS to support development and procurement of expert, decision-support and management information systems for use by line managers in the Federal government in assessing environmental risks;

- Support a Canadian display to promote science and technology for risk assessment at trade fairs and conferences.

The proposed regional symposia will contribute to altering basic institutional positions and pressures associated with the perception of environmental risk. Major and lasting benefits will have been achieved if science writers include explanations of comparative risks and industry consequences in every report they prepare.

Science and technology for dealing with risks must include the management sciences as well as the "hard" sciences. Canada has a world-recognized strength in the psychology of risk perception. From this broader perspective, decision-support systems can recognize the human factors in assessing environmental options as well as retrieving and presenting information and data in a more manageable way.

7.5 Contacts/Sources:

- Michael Simmons, Vice-President, TYDAC Technologies
- Nola Seymoar, Director General, Special Projects, Environment Canada
- Brian Emmett, Director General, Corporate Policy, Environment Canada
- Dr. Fred Roots, Science Advisor Emeritus, Environment Canada