Opportunities for Industrial Ecological Parks in Canada

Case Study

Sarnia-Lambton Industrial Complex

Prepared For:

Oil Gas and Energy Division
Environment Canada

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EXECUTIVE SUMMARY

The concept of industrial ecology as demonstrated at Kalundborg in Denmark, has shown that forming networks of industries and services to share resources and cascade by-products and wastes can make a valuable contribution to sustainable development. A network of this type reduces resource consumption and prevents pollution while maintaining output and jobs. The success of the network at Kalundborg has raised the question of whether similar conditions at other locations support the formation of similar industrial ecological networks? To answer this question, the Sarnia-Lambton area was chosen as a mature, heavily industrialized region and a study was undertaken to analyze the extent to which partnerships had formed and, if they had not, to identify the factors which had prevented their formation.

Study Objectives

The study of the Sarnia-Lambton area had three primary objectives:

- document successful cases of formation of partnerships and networks assembled for the purpose of resource conservation, or for reduction and recycling of process residuals, and analyze the factors that made them successful,
- identify the economic, regulatory and other barriers to forming partnerships,
- establish the principles for developing networks in other industrialized areas.

Methodology

The cooperation of the local industries was obtained through the Lambton Industrial Society (LIS), the Sarnia-Lambton Chamber of Commerce and the Sarnia-Lambton Office of Economic Development. A set of case studies of industrial partnerships was developed based on site visits and interviews with individuals directly involved in the projects. A review was also made of the Bruce Energy Centre. Despite the fact that it is not in the study area, the Centre, because of its success, is considered to be a valuable source of relevant information.

Cases Studies

Seven major case studies were analyzed; the factors that determined their success and the barriers that had to be overcome are discussed in detail:

	Purpose	Status
1.	Electric power/steam cogeneration	in operation
2.	Use of flue gas desulfurization gypsum	in operation
3.	Production of lightweight mineral aggregates	being developed
4.	Energy from municipal waste	shelved
5.	Energy from post consumer plastics	being developed
6.	Reuse of co-product sulfuric acid	being developed
7.	Cascade by-product steam (Bruce Energy Centre)	in operation

In addition to the case studies, companies provided information and opinions on factors facilitating development of partnerships.

The main environmental benefits of the seven case studies reviewed in this report are summarized below:

Case	Purpose	Environmental Benefit
Cogeneration	Improved energy efficiency	Reduction of CO_2, SO_2 and NO_x emissions
Flue gas desulfurization gypsum	Beneficial use of a byproduct	Capture of SO_2 and avoidance of landfilling
Production of lightweight aggregate	Manufacture product from fly ash and water treatment sludges	Avoidance of landfilling
Energy from municipal waste	Recover energy from waste	Avoidance of landfilling
Energy from post consumer plastics	Recover energy from plastics that cannot economically be reused or recycled	Product stewardship and avoidance of landfilling
Co-product sulfuric acid	Beneficial use of a co-product	Avoidance of deepwelling
Bruce Energy Centre	Efficient use of by-product energy	Reduction of CO_2, SO_2 and NO_x emissions

Findings

Companies in the study area have been effective in assembling partnerships to conserve resources and cascade process residuals. They devote considerable effort to identifying and developing new opportunities. The projects, developed through voluntary action on the part of the companies, have successfully reduced energy consumption and the related emissions and have found uses for materials that otherwise might have gone to landfills.

The key factors for success in developing partnerships are:

- visible economic incentive and controllable risk,
- a project champion or well defined leadership role,
- small number of participants - the larger the number of participants the more difficult it is to reach consensus,
- the necessary technology is available and proven,
- community acceptance,
- visible market for the product or service,
- available resource, including human resources,
- clear regulatory conditions.

Barriers

The barriers to development of partnerships are generally the inverse of the factors for success except that some relatively weak success factors are strong inhibitors. In particular:

- community acceptance - the Sarnia-Lambton companies and other agencies have a strong sense of their responsibilities to the community and are unwilling to proceed with projects that do not gain acceptance,

- regulations - uncertainty about the governing regulations or the length and outcome of the permitting process tends to delay or prevent a project from being initiated.

Opportunities

Opportunities exist for developing other partnerships for energy cascading or recycling of by-products in the Sarnia-Lambton area. Conditions in the area are suitable for development of an eco-park modeled on the Bruce Energy Centre with the possible addition of a district heating system if the economics prove to be viable. The advantages for development in this area include;

- a well developed industrial infrastructure,
- skilled labour force.
- available by-product energy,
- available land,
- proximity to major markets in Canada and the U.S.,
- vacuum left following downsizing,
- need to maintain critical industrial mass,
- need to maintain competitive position vis-à-vis other North American petrochemical complexes.

1. BACKGROUND

This study is the result of a joint proposal by VENTA, GLASER & ASSOCIATES (VG&A) and JAN CONSULTANTS (JAN) submitted to ENVIRONMENT CANADA. One goal of the study is to assist Environment Canada in assessing the potential for improving the sustainability of industrial operations by linking them in networks to optimize resource input and to cascade the industrial by-products and energy and materials wastes between different industries and operations in close geographical proximity. The second goal is to assess the opportunities and to indicate the strategic approach to establishing ecoindustrial communities in Canada.

There are many industrial parks, or large industrial areas in Canada, where a number of different industries are in close proximity. In many cases waste heat, effluents or solid by-products of one operation that currently are not utilized, and are emitted to the atmosphere, discharged to ponds, lakes and rivers, or contributing to the clogging of the landfill sites, could be beneficially utilized by another plant or operation. Recovered waste heat (steam, hot water) could be shared by an adjoining facility, not including only industrial operations, but perhaps also by a local municipality for residential or institutional district heating. Solid or liquid waste of one operation could constitute a valuable raw material source for another manufacturer. While such a concept of beneficial utilization of waste energy, materials and by-products within large individual industrial operations has been introduced over the last 25 years and is increasingly being practiced, the same cannot be said about multiple plants/facilities industrial parks and communities. Cascading wastes within a network of industries means that resource input and wastes generated by the network are less than that of the same industries operating in isolation.

This represents a significant step towards improved sustainability and improved competitiveness, stemming from three key points:

- pollution prevention, the focus of this concept, is often more cost-effective than traditional cleanup activities,
- waste cascading could form the basis of industry's voluntary initiatives, such as ARET or Climate Change, if the necessary cooperative regimes can be established, and
- job creation and investment opportunities can be large, if projects are identified at an early stage in industrial/municipal planning.

Development of industrial ecosystems does not depend on development of new technologies. The necessary technologies are currently available, as can be seen from the Kalundborg example mentioned below. Any barriers that exist are more likely to result from lack of awareness of opportunities, risk adverse attitudes and economic and community considerations.

The purpose of the study was to identify the opportunities for such larger ecological industrial parks in Canada, and to establish and demonstrate the conditions conducive to such an interdependency between various operations. The approach was to identify a number of potential areas having large scale industrial development. Of these, one was be be selected and a case study made of the opportunities, costs, benefits and barriers to developing an industrial ecosystem at this location.

1.1 Environmental Drivers

A primary driver of the Federal environmental policy is to make sustainable development a reality in Canada. Among the measures being taken to achieve this goal are:

The Federal Action Program on Climate Change which seeks, through voluntary action to improve the efficiency of energy use thus limiting emissions of carbon dioxide. Initiatives have been taken at the residential, community and industrial levels.

Toxic Substances Management Policy which has the dual objective of:

- virtual elimination from the environment of toxic substances that result predominantly from human activity and that are persistent and bio-accumulative,
- management of other toxic substances and substances of concern throughout their entire life cycles, to prevent or minimize their release into the environment.

Management Plan for Nitrogen Oxides and Volatile Organic Compounds, developed by the Canadian Council of Ministers of the Environment (CCME), is aimed at reducing the precursors of ground level ozone particularly in the lower Fraser Valley, the Windsor-Quebec Corridor and the Southern Atlantic region. Phase I of the plan includes:

- a national prevention program based on installation of the best available control technology economically available,
- interim emission targets for 1995 and 2000 for nitrogen oxides and volatile organic compounds,
- a program of studies aimed at gathering information to be used in setting the final emission targets.

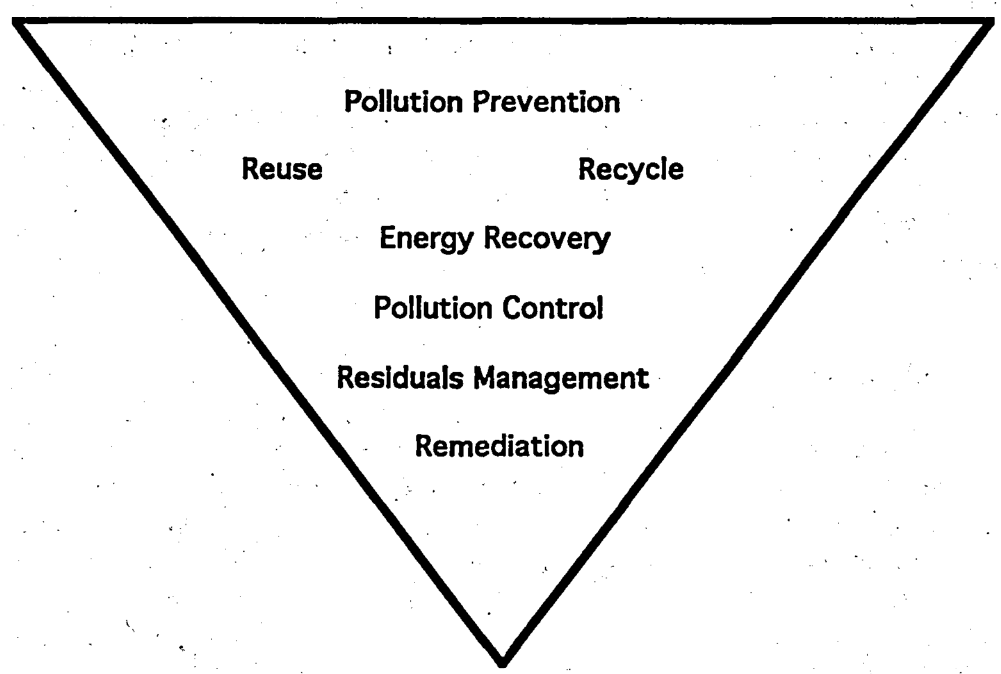
Canada-U.S. Air Quality Agreement
The international agreement was negotiated to reduce the emissions of sulfur dioxide and nitrogen oxides which result in acid deposition and acidification of sensitive lakes, streams and forests, and also cause damage to human health. The agreement contains reduction targets and timelines and sets a permanent cap on Canadian emissions of sulfur dioxide of 3,200 kilotonnes per year, starting in 2000.

The Great Lakes Program
This program has as a broad objective reduction of pollutant discharges to the Great Lakes including the virtual elimination of persistent toxic substances. The program includes:

- a substance by substance approach banning the use, manufacture and transportation of certain substances,
- a sector by sector approach dealing with specific industrial problems,
- facility by facility to tackle site specific needs,
- area by area approach where there are multiple industries and complex environmental conditions.

Federal and Provincial environmental legislation, policies and objectives are integrated into the business decisions of the companies in the Sarnia-Lambton area. The cases documented in this study indicate the continuing trend towards moving environmental protection activities into the upper levels of the environmental protection hierarchy.

THE ENVIRONMENTAL PROTECTION HIERARCHY



The cases are examples of voluntary and cost-effective efforts to reduce resource inputs and residuals from operations, while at the same time maintaining or increasing output and employment.

The formation of industrial eco-systems, or in the case of the Sarnia-Lambton companies, to form partnerships to conserve resources and reduce residuals, is a move towards pollution prevention and sustainable development. While the partnerships are formed primarily for economic reasons they make a contribution to all the environmental targets.

1.2 Concept of Industrial Ecology

Industrial ecology includes the design and maintenance of waste, energy and water exchange between facilities in order to maximize their utilization. It is an attempt to simulate the time-proven "strategies" of natural ecosystems such as wetlands or forests, that generate no waste, conserve and renew water resources, and efficiently use energy. Such natural ecosystems provide some valuable guidelines for industrial re-engineering and development.

Industries have traditionally been set up in an isolated rather than an integrated fashion. Manufacturing plants evolved like islands, taking in resources, making products, and disposing of waste as best as they could in response to regulations or economic pressures. This method of operation assumes that resources will remain abundant and that the environment can continue to tolerate disposal of wastes, both assumptions increasingly being questioned. Therefore it is appropriate to look for ways to realign the industries, to link them in networks, so that resources can be conserved and the demands made on the environment are minimized. In this respect, the industrial ecology concept fits very well into the 5Rs strategy of reducing, reusing, recycling, recovering and retaining wastes and by-products, and relevant industrial and municipal 5Rs programs.

In highly developed industrial ecosystems member industries would have developed a network of alliances ensuring cooperation on energy, water, and materials utilization. For energy, this could include sharing of high energy waste streams such as furnace waste gases, and high pressure steam, as well as low energy sources, such as post-process cooling water for space heating. Water in these industrial ecosystems would similarly cascade through the community and be matched to water quality needs. For example, waste water treated at one site might be used as cooling water at another site, rather than using potable water. Waste materials and industrial by-products of some operations such as fly ash, FGD residues, sludges, spent solvents, waste wood and paper residues, or iron and steel slags, can be identified and used as valuable raw materials by other industries.

Resource sharing partneships and industrial ecosystems can play an important role in the sustainable development and use of our energy and raw material resources, and contribute substantially to pollution prevention. They are generally initiated by the industry. To succeed, they must have a sound economic basis. At the same time, from the environmental point of view, they represent effective voluntary measures by which industry can respond to the need for effective solutions to environmental challenges.

1.3 Kalundborg Demonstration Project

While still rather unique, the feasibility of the eco-park concept has been demonstrated in Kalundborg, Denmark, where four industrial partners, a number of small businesses and the city of Kalundborg share energy, water, and waste stream materials by way of 16 separate projects. Industries are linked so that by-products and wastes flow from generators to users.

For example, the local power station generates steam as a by-product of power generation. The steam is then shared with the local refinery, manufacturing facilities, and a district heating system for the entire town. Another waste stream, treated wastewater from the oil refinery, is used by the power plant as a source of cooling water, reducing the amount drawn from the municipal supply system.

The 16 projects initiated by the Kalundborg group so far have generated about $165 million in cost savings, on an initial investment of approximately $80 million. Average pay-back period per project was 5 years.

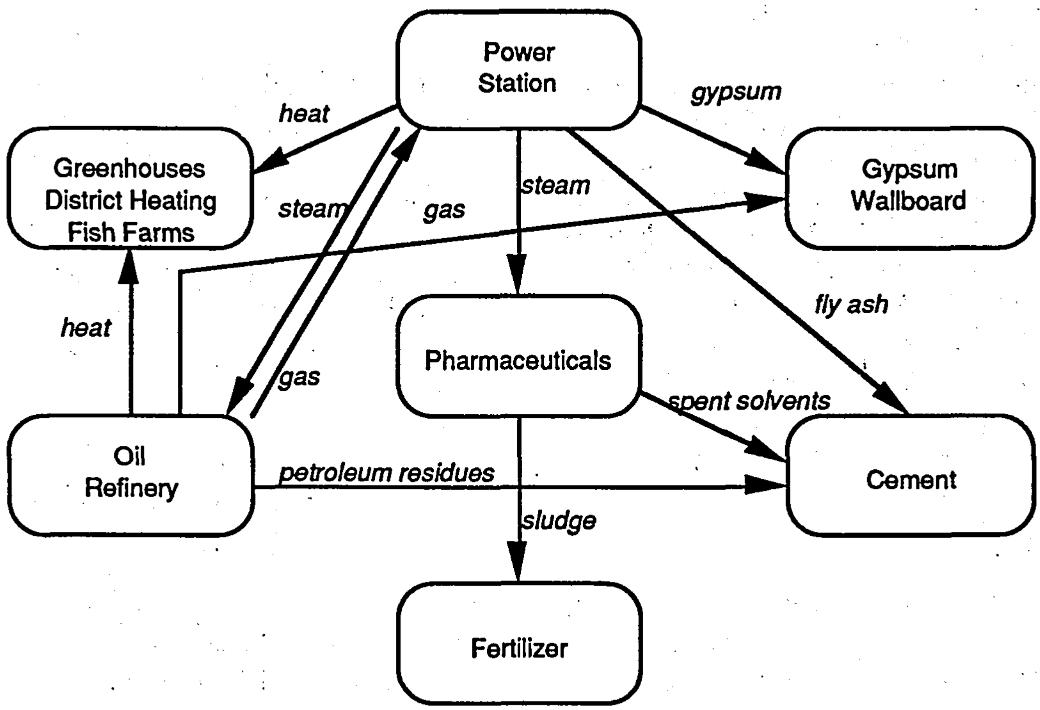


Fig. 1-1: Industrial Ecology - Kalundborg Demonstration

1.4 Beginnings of Industrial Ecology in Canada

It is not necessary to go all the way to Denmark. The January issue of "Currents", a newsletter of the Ontario Section of A&WMA, notes the Bruce Energy Centre near Kincardine that is also applying industrial ecology principles. Six different companies have been organized to take advantage of the steam capacity and waste heat available from the Ontario Hydro Bruce nuclear power station. Further plans include pipelining waste CO_2 from a fermentation plant to the local greenhouse operation to enhance growth rates for tomato production, and biomass from the fermentation plant could be used to produce livestock feed.

As the Bruce Energy Centre seems to be the first practical application of industrial ecology in Canada, a site visit was made and the findings are included in this study. It is reviewed in detail in section 4.7.

There are numerous locations in Canada with concentrations of industries that appear to offer a logical choice for developing industrial ecosystem cooperation. Some of the large potential sites include:

- the Sarnia-Lambton complex,
- East Montreal,
- various locations within the Oshawa-Toronto-Hamilton "Golden Horseshoe" area,
- South Edmonton district.

There are a large number of smaller industrial parks that already exist or could be developed around major power stations, refineries and other large industrial complexes that could be transformed into industrial eco-parks. Preferably such an industrial ecosystem would include major energy users such as power generators, resource extraction and refining operations, large waste generators with recoverable materials like sewage plants (sludge, water), and manufacturing facilities generating wastes and by-products, as well as large potential users, such as cement kilns, wallboard operations, etc. At some point the inclusion of municipal solid waste (MSW) could be considered. The development of district heating using waste heat offers the potential for integration of municipal, commercial, institutional and residential partners as well.

The concept of industrial ecology offers interesting opportunities for the successful "brownfield" developments of the old, often polluted and by now under-utilized industrial cores of many Canadian cities.

The establishment of successful industrial ecosystems would not only provide Canadian industry with an advantage in the increasingly competitive world, but would also allow active promotion of such state-of-the-art ecosystem sites to potential investors. New facilities capable of taking advantage of such parks would contribute to job creation in the subject areas as well.

By developing industrial ecosystem expertise in Canada, an opportunity exists to export knowledge to other countries, for example in support of CANDU reactor sales or in connection with projects being developed and supported by the World Bank, the Asian Development Bank, and participated in by the Canadian Industrial Development Agency (CIDA).

1.5 District Energy

District energy, as a means of efficient and environmentally friendly heating, is related to the concept of industrial ecology, as excess steam or waste hot water from industrial operations can be used for district heating and cooling requirements. In district energy systems thermal energy - in the form of hot water or steam - is distributed by underground pipelines from central generation plants to individual buildings, where the energy is extracted, and return pipes bring cooled water back to the central plant. District energy provides energy efficiency, as well as environmental and economic benefits to the communities and energy customers it serves. When a readily available sources of waste hot water/steam are present, as is the case in many large industrial areas, the central plant can be eliminated, or function solely as a distribution point for the network of energy users.

In the past, the main markets for district energy included municipal (subscriber) systems that were developed in a number of major European as well as U.S. cities in areas where large concentrations of buildings provided a high density of heating and cooling demand. Large systems can consist of hundreds kilometres of piping connecting a number of energy sources and thousands of customers in office and apartment buildings, institutional and industrial facilities, and single-family homes. Hot water systems can operate in a range of up to 110 km. Even in areas without large municipal district energy systems, a central energy plant can be highly cost-effective for high-density building clusters like downtown high-rise areas or institutions such as university campuses, hospitals, office and apartment complexes, military bases, etc. Recent developments in technology are making it cost-effective to use district energy to meet the needs of communities consisting of hundreds of single-family homes combined with a few commercial and institutional buildings, as well. Such applications can be viable and desirable if there are local energy sources and if district energy offers some distinct social, environmental, and economic benefits.[22]

In Canada, space heating and cooling requirements account for a significant portion of energy use. Meeting these energy needs involves not only major expenditures by communities and building owners/occupants, but also makes a major contributions to environmental problems such as acid rain, global warming, stratospheric ozone depletion, and smog. District energy systems provide a number of benefits. They:

- contribute to energy security by facilitating use of a range of energy sources;
- contribute to more efficient use of energy sources and to energy conservation;
- concentrate energy generation at a few large, sophisticated and efficient facilities;
- promote integration of energy supply and demand;
- contribute to improving environmental quality and meeting environmental goals;
- provide building owners/occupants with a broad range of benefits.

There are no specific federal or provincial policies or incentives geared to promoting district energy use. Projects must succeed on their individual merits.

There are both opportunities and obstacles related to district energy development.

Opportunities

District energy is compatible with a number of Canadian energy needs and resources. It is compatible with national and international priorities and targets related to energy use and environmental protection. It can contribute to:

- sustainable development,
- energy efficiency and conservation,
- reduction of atmospheric emissions,
- community energy self-sufficiency and environmental quality,
- integration of overall energy needs into municipal planning, and
- retention of energy dollars and development of employment opportunities in the community.

District energy systems are well suited to meeting Canadian seasonal energy demands. Waste energy sources suitable for use in district energy systems are available in many Canadian communities, and where this is the case, they offer an almost ideal opportunity to recover the energy values otherwise often wasted. The technology is available and proven, and ongoing technical development is lowering the system costs, making district energy a viable option in more cases.

Obstacles

There remain technical, institutional, economic and perception factors that can limit district energy applications in Canada. These include current low energy costs, lack of familiarity with district energy options, high capital costs of district energy systems, and financing. With due consideration to low fossil fuel and electricity rates, district energy will not always be the energy option of choice. Current and projected over-capacity in electricity generation is not conducive to cogeneration. Energy supply choices are major decisions involving a wide range of stakeholders. Lack of familiarity or comfort with district energy can derail a specific district energy project irrespective of its technical and economic feasibility. Effective marketing of the concept and of the specific proposal is an essential part of a successful district energy project.

2. OBJECTIVES

The aim of the proposed project is to develop a case study of a heavily industrialized area. From a number of potential sites, the Sarnia-Lambton corridor was chosen for analysis of the potential for resource conservation and pollution reduction through establishment of an industrial ecosystem, to exchange and cascade waste energy, water and by-products among a contiguous group of industries. The purpose of the case study was to identify the economic costs, benefits and existing barriers.

This case study, focusing in-depth on a particular industrialized area, is intended to complement other studies currently under way that will look, on a larger but less detailed scale, for potential industrial ecosystem developments across Canada.

The proposed study is to be considered only an initial phase of a longer term, larger project. Assuming that the study will prove the feasibility of such an undertaking, it could lead in subsequent phases to:

- In-depth assessment of a wider number of similar suitable sites across Canada, and in some locations even across the international Canada / U.S. border. More detailed study of the experience, successes and failures, and the lessons learned from similar projects around the world, would be a part of this phase as well.

- The organization, set-up and start-up management of a full scale demonstration project of waste/by-product energy and resource recovery within a selected ecologically interdependent / integrated unit. A monitoring system of its development and impact on the local industrial ecosystem over a period of 5 years could be established.

3. SCOPE OF WORK / TECHNICAL APPROACH

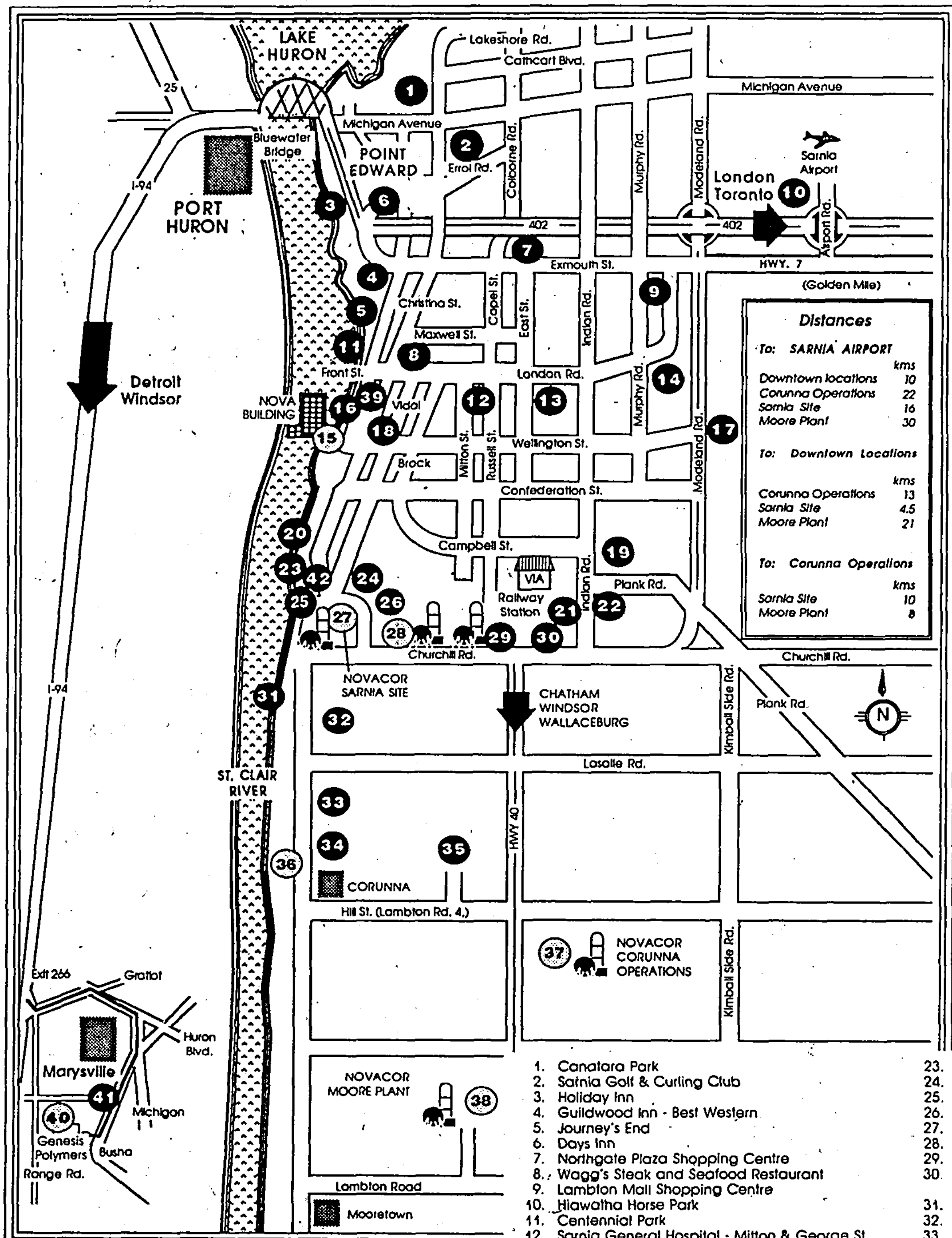
3.1 Ecosystem Site Selection

In addition to the Ontario-Hydro's Lambton coal-fired power station*, the Sarnia-Lambton area contains a concentration of chemical and petrochemical industries and related service companies such as:

Air Products Canada Ltd.
Bayer Rubber Inc.*
Dow Chemical Canada Inc.*
Ethyl Canada Inc.*
Fibrex Insulations Ltd.*
Imperial Oil Limited*
Lafarge Construction Materials
Lambton Material Mix
Montell Canada Inc.*
Shell Canada Products Ltd.*
Terra International (Canada) Inc.*
Amoco Canada Petroleum Co.
Cabot Canada Ltd.*
DuPont Canada Inc.*
Ferrera Precast Concrete Products
Globe-Vedag Corporation
L&M Fiberglass
Laidlaw Environmental Services*
Liquid Carbonic
Novacor Chemicals (Canada) Ltd.*
Sunoco Inc.*
Welland Chemical

These operations are supported by a number of smaller machine shops, sheet metal fabricators and equipment manufacturers. The area's leading, environmentally conscientious companies are members of the Lambton Industrial Society (those indicated by an asterisk), whose mission is to be recognized for excellence in promoting and fostering a healthy environment consistent with sustainable development.

Lambton county has a population of about 122,000 people, with the largest concentration in Sarnia itself (75,000 people). Sarnia's close access to all of southwest Ontario including the metropolitan Toronto area, to its sister city of Port Huron across the river in Michigan, and to the not too distant metropolitan Detroit area are additional factors that make this particular area an attractive candidate for an industrial ecosystem case study, as linkage of compatible companies within an economic transportation radius is feasible. Locations of the principal industries and operations in the Sarnia valley are shown in Fig. 1-2, and in the Appendix.



1. Canatara Park
2. Sarnia Golf & Curling Club
3. Holiday Inn
4. Guildwood Inn - Best Western
5. Journey's End
6. Days Inn
7. Northgate Plaza Shopping Centre
8. Wagg's Steak and Seafood Restaurant
9. Lambton Mall Shopping Centre
10. Hiawatha Horse Park
11. Centennial Park
12. Sarnia General Hospital - Milton & George St.
13. St. Joseph's Health en re - London Road & Russell
14. Canterbury Inn
15. NOVA Corporation of Alberta (Eastern Office)
16. Lambton Industrial Society
17. Dow Chemical Canada Inc. (Canada H.Q., R&D)
18. Sarnia Eaton Centre
19. Amoco Canada Limited
20. Esso Chemical Limited
21. Imperial Oil Limited (Tank Farm)
22. Interprovincial Pipe Line Limited
23. Imperial Oil Limited (Refinery)
24. Novacor Chemicals (Canada) Ltd. (Tech. Centre)
25. Polysar Rubber Corporation
26. Cabot Carbon of Canada Ltd.
27. Novacor Chemicals (Canada) Ltd. (Admin. Bldg.)
28. Novacor Chemicals (Canada) Ltd. (Styrene Plant)
29. Polysar Rubber Corporation (Butyl II Plant)
30. Polysar Rubber Corporation (Warehousing & Distribution Centre)
31. Dow Chemical Canada Inc. (Sarnia Division)
32. Suncor
33. Shell Canada Limited
34. Ethyl anada, Inc. -
35. DuPont Canada, Inc.
36. Novacor Chemicals (Canada) Ltd. (Pump House)
37. Novacor Chemicals (Canada) Ltd (Corunna Operations)
38. Novacor Chemicals Ltd. (Moore Plant)
39. Drawbridge Inn - Quality Inn
40. Genesis Polymers
41. (Marysville) Fractionator
42. BASF Canada Inc

Fig. 1-2: Sarnia Chemical Valley

3.2 Study Methodology

Industry cooperation in making the relevant information and data available was solicited through the Lambton Industrial Society (LIS), the Sarnia Chamber of Commerce and the Sarnia Industrial Development Office. A presentation was made to the members of the LIS and, subsequent to that presentation, meetings with the key companies were arranged.

Case studies were developed from information provided by the companies and drafts of the write-ups were given to the companies for comment prior to inclusion in the report.

3.3 Report Structure

The case studies are included in the body of the report. They are all written in a similar format covering:

- participants
- project description
- drivers/issues
- barriers.

Following the case studies a summary is made of other relevant information provided by the participating companies. This is followed by an analysis of the factors which led to successful implementation, delay or failure of the projects.

The final section of the report deals with overall conclusions, opportunities and recommendations. Supporting information is provided in Appendices

4. CASE STUDIES

This section discusses seven major case studies representing cascading or sharing of either surplus energy, steam or hot water, or industrial by-products, between different participants in the Sarnia-Lambton industrial corridor. Three of these cases (4.1, 4.2 and 4.7 represent successful, fully implemented and functioning ventures, three more (4.3, 4.5 and 4.6) are under active consideration, and one (4.4) was shelved, although it shows some potential, and under different circumstances and perhaps in a modified form, it could be reassessed. These seven case studies are only a few examples of existing or potential industrial eco-park-type cooperations and sharing of resources, demonstrating various factors enabling their success as well as barriers that had to be overcome. There exist many other opportunities.

4.1 Power/Steam Cogeneration Project

Participants

- Dow Chemical Canada Inc.
- Bayer Rubber Inc.
- Novacor Chemicals (Canada) Ltd.

Project description

Electricity is generated by gas-fired turbines at Dow and by oil-fired turbines at the Bayer plant. Steam is used internally by Bayer, Dow, and is supplied to the Novacor Chemicals Sarnia polystyrene unit. Total power generating capacity is about 150MWe: 50MWe at Bayer and 100MWe at Dow. Electricity not directly used by Bayer or Dow is sold to Ontario Hydro at a negotiated rate for transmission and is repurchased by Nova at its Sarnia, Corunna and Moore facilities. Condensate is returned from Nova to the cogeneration units at Dow and Bayer.

The cogeneration project was developed through negotiations between each of the participants and Ontario Hydro. The project is managed by an Executive Board consisting of representatives from each of the three participating companies. The project, which started in January 1995 after two years of negotiations, will be reviewed after five years of operation. The current agreement with Ontario Hydro will terminate in 15 years.

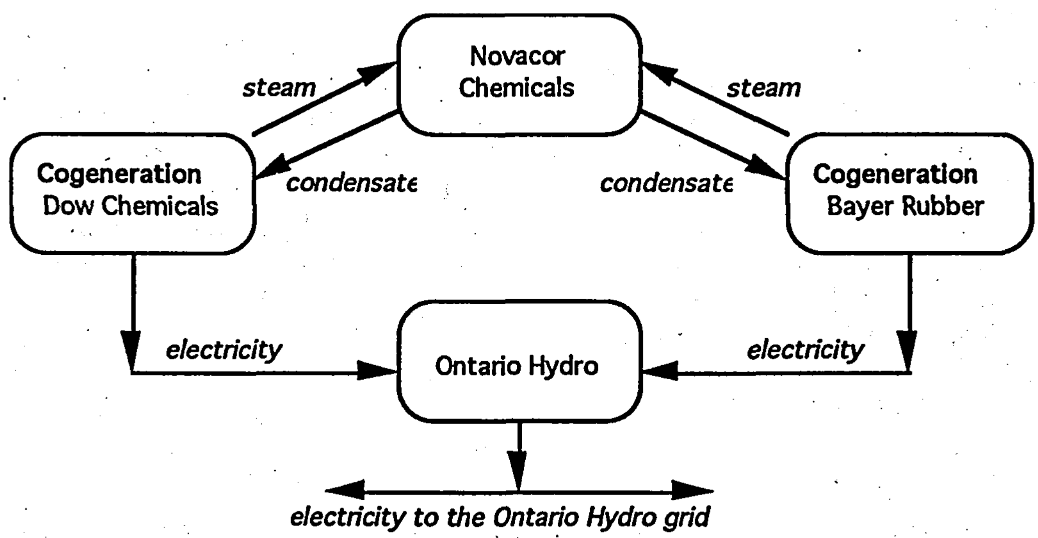


Fig. 4-1: Power/Steam Cogeneration Project

Drivers

- **Dow** had shut down its chlorine unit resulting in excess generating capacity. Dow wanted a way to make better use of excess capacity and reduce fixed costs.

- **Bayer** downsized production and had spare generating capacity. It also wished to achieve better utilization of its equipment and to reduce fixed costs.

- Nova needed an economical source of steam to make its polystyrene unit more efficient in a very competitive market. An additional driver for Nova was the fact that rising Ontario Hydro power rates were threatening the polystyrene unit's competitiveness. Nova could have installed a package gas turbine to generate its own power and steam at a marginally higher cost. Their decision to seek a pooled solution was based on a conscious effort to prevent downsizing of other operations in the Sarnia-Lambton complex and to maintain the critical industrial mass in the area to avoid further decreases in competitiveness vis-à-vis the Gulf coast.

Technology

Well established; no new technology was needed.

Markets

There was demand for the steam and power generated by the units.

Economics

The infrastructure was mainly in place, with the exception of the steam line to the Nova plant. Total capital investment including existing assets was in the range of $55 million. Annual operating costs are about $100 million including fuel. Of this total, $20 million is fixed cost.

Emissions avoided

Cogeneration and utilization of steam could potentially raise the efficiency of the system from about 38% to 85%. In other words, if approximately 9.5 GJ of thermal energy is required to generate 1 MWh, then the cogeneration system will capture 85% of this or 8.05 GJ compared to 3.6 GJ per MWh if the steam is not used. From the difference of 4.45 GJ/MWh due to the cogenerated steam, the avoided emissions that would be generated if steam for the three cogeneration project partners were produced separately, can be estimated. In our estimates of the avoided emissions we assumed that 1/3 of the fuel used in the system was oil and 2/3 was gas. The total avoided emissions are about 926 tonnes of CO_2, about 4.5 tonnes of SO_2, and about 1.5 tonnes of NO_x per day.

Barriers / problems

- Reconciling the risk profiles of the three participants;
- Negotiating a rate with Ontario Hydro, who was anxious to protect its markets;
- Division of capital investment among participants;
- Division of benefits;
- Readjusting the economics when one possible participant, Suncor, dropped out, having negotiated a supply arrangement with Hydro.

Factors contributing to success

- Low risk;
- Partners all large companies known to each other;
- Support from the provincial government and local MP;

- Capital investment relatively small, affecting mainly one participant;
- All participants having something to gain;
- Return on investment spelled out in advance through rate negotiations and fixed demand for steam. No threat to steam supply. No backup steam supply installed; participants feel business risk is acceptable;
- No regulatory issues;
- A background of steeply rising power costs;
- Existing, proven technology;
- Demand for power and steam guaranteed.

The future

Deregulation economics are strong enough to allow, in fact, further expansion.

Major new plant is being built to take advantage of low cost available generating capacity resulting from the cogeneration venture, including a large rechargeable battery production facility (Bayer) in which some 2000 tonnes per year of high performance spherical nickel hydroxide will be produced starting in 1997, thus doubling the total worldwide capacity. Bayer's decision to locate this leading edge technology operation in Sarnia was based on the availability of the low cost cogeneration power.

Steam demand is not increasing as rapidly as power demand, meaning that there will be excess low pressure steam available. A new customer is needed. There is preference for one large customer.

4.2 Flue Gas Desulfurization Gypsum

Participants

- Ontario Hydro
- Westroc Industries Ltd.

Project outline / description

After considering various flue gas desulfurization (FGD) options to remove 90% of sulfur dioxide emissions from its Lambton TGS, Ontario Hydro installed wet limestone FGD scrubbers with in-situ forced oxidation on two of its 4 x 510MW pulverized coal-fired utility boilers. The installation was designed to produce commercial quality by-product gypsum. FGD gypsum can replace natural mined or quarried gypsum in most of its usual applications, including production of gypsum wallboard, which accounts for 75–80% of total gypsum consumption.

FGD gypsum from the Lambton TGS was offered to all wallboard producers in the area. A contract was negotiated with Westroc Industries to provide 175,000 to 200,000 tonnes of FGD gypsum annually for their Mississauga, ON flagship plant. During 1995 this plant switched completely from natural gypsum to FGD by-product gypsum, thus becoming the first Canadian gypsum wallboard plant operating on 100% by-product/waste gypsum.

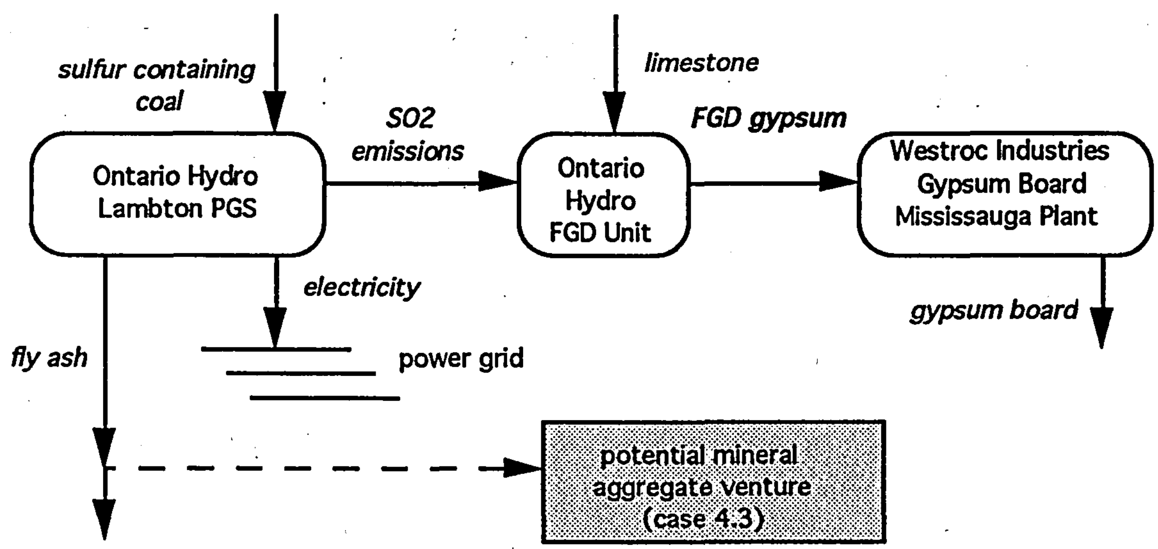


Fig. 4-2: Flue Gas Desulphurization Gypsum

Drivers

- As a result of international agreements on acid rain, Canada committed, in 1984, to reduce acid gas emissions by 50% by 1994. The required reductions passed on to major industrial sectors led to legislating Ontario Hydro to reduce its annual acid gas emissions, defined as the sum of SO_2 and NO_x emissions, to 215 ktonnes (maximum limit on SO_2 emissions 175 ktonnes.) by 1994.

- Environmental approvals mandated the selection of an FGD technology capable of producing a marketable commodity, commercial grade gypsum, as opposed to waste that would have to be landfilled or stockpiled.

- Westroc's source of natural gypsum from its Drumbo, ON mine for its 220,000 tonnes/year operations in Mississauga was of low quality and of limited supply.

Technology

Wet lime/limestone FGD processes with in-situ oxidation are well proven, operating on 235 coal-fired units with a total capacity of 70,923 MWe around the globe (12/1992), representing 42% of worldwide FGD installations.

Use of FGD by-product gypsum in wallboard manufacturing is well established and proven in many operations in Germany and Japan, and gradually gaining acceptance in the US as well.

FGD wet limestone technology developed by Gottfried Bischoff GmbH of Germany was selected by Ontario Hydro. A turnkey contract was awarded in October 1990 to Joy MK Projects Company, the North American licensee of the Bischoff FGD technology, with a projected scrubbers start-up by summer 1994.

Markets

Three potential markets for utilizing the FGD gypsum - wallboard, cement production and agricultural applications - were pursued. The wallboard industry in the market radius of the Lambton TGS with its capacity of 2.84 Mtonnes/year was a logical target.

Economics

Natural gypsum is a low cost commodity, available at as low a cost as $6 to $10/tonne FOB mine or quarry. Shipping costs had to be minimized to economically market FGD gypsum against mined gypsum, confining the potential market to the Great Lakes basin, while at the same time allowing its transportation to potential users close to major population centres, some distance away from the Sarnia-Lambton industrial complex. It is assumed that the landed cost of FGD gypsum at Westroc's Mississauga plant is $12–$15/tonne.

Emissions avoided

In Ontario Hydro FGD Program Environmental Assessment [20], it is estimated that non-controlled SO_2 stack emissions from a typical 500 MW unit burning 170 tonnes of coal/hour (2.5 % sulfur content) are 8.3 tonnes/hour. At the Lambton TGS, where two of the 510 MW units were equipped with a wet limestone FGD unit operating at 90% efficiency, this results in about 15.2 tonnes/hour of SO_2 emissions avoided.

According to a dispersion model, estimated maximum half-hour SO_2 ground level concentrations (GLC) are 250 $\mu g/m^3$ for the current set-up of the Lambton TGS (two units operating with wet scrubbers and burning 2.5% sulfur content coal and two non-scrubbed units using premium

1.97% sulfur content coal). This compares with 408 μg/m³ maximum 1/2-hour GLC with no scrubbers and premium coal only.

Due to replacement of natural gypsum with FGD gypsum, some additional emissions are avoided as no energy is expended on gypsum extraction. Based on 0.0455 GJ/tonne of gypsum extraction energy [21] and approximately 200,000 tonnes of gypsum a year generated by Lambton TGS, this represents annual avoidance of about 685 tonnes of CO_2, 1.4 tonnes of SO_2, and 7.15 tonnes of NO_x.

Barriers / problems

- vertical integration of the gypsum industry, including control of sources and sufficient supply of natural gypsum;
- reluctance of the gypsum industry to use by-product gypsum;
- lack of experience of Canadian gypsum industry with using FGD gypsum;
- real and perceived problems with handling and calcining of FGD gypsum;
- tight physical and chemical characteristics specifications for commercial grade gypsum;
- economics - competing with low cost commodity (natural gypsum);
- substantial higher cost for the capital investment and operation of forced air FGD system producing gypsum as opposed to inhibited air FGD system producing waste sludge.

Regulations / community acceptance

Ontario Hydro was mandated to select FGD process capable of producing commercial grade gypsum at the Lambton TGS.

Factors contributing to success

- Regulatory action requiring Ontario Hydro to reduce its SO_2 emissions, and to use gypsum producing FGD technology in the process.
- Cooperation between Ontario Hydro and Westroc in making the process work, joint effort to resolve the problems and to share in the successes. Understanding by both participants of each other's needs and willingness to work together.
- Experience of Westroc's sister companies overseas with utilization of FGD gypsum.

The future

Success of 100% conversion of Westroc's Mississauga wallboard operations to by-product gypsum in 1995 has led to the use of FGD gypsum in both CGC's 300,000 tonnes/yr and Westroc's 300,000 tonnes/yr plants in Montreal. Both plants are to operate 100% on by-product/waste gypsum by the end of 1996.

Use of FGD gypsum by wallboard producers not only provides an environmentally sound alternative to landfilling or stacking of FGD process residues, but through reduced volume of natural gypsum reduces the ecological impact of its mining or quarrying as well.

4.3 Lightweight Mineral Aggregates

Potential participants

- Bayer Rubber Inc. + up to ten other wastewater sludge generating industrial operations in the Sarnia/Lambton/Port Huron area
- Sarnia municipal wastewater treatment facility
- Ontario Hydro
- Lafarge Canada Inc.

Project outline

Setting up an operation producing lightweight sintered, mineral aggregates from by-products and wastes is being considered. The technical and economical feasibility of such a venture are being assessed by the potential participants. The intention of the project is to use a rotary kiln to sinter a pelletized mixture of fly ash and wastewater treatment sludges to give a marketable lightweight aggregate. The product would be marketed through the distribution network of a construction materials company.

The sludges are available from municipal sources in the Sarnia-Lambton area and from industrial wastewater treatment facilities in Sarnia-Lambton and in Port Huron, Michigan. Fly ash could come from the Ontario Hydro Lambton TGS or from the Detroit Edison station south of Port Huron. As currently envisaged, the project would collect the sludges from a number of generators and process them with fly ash at a site which minimizes transportation costs, where environmental approvals or permits are possible and community acceptance is positive.

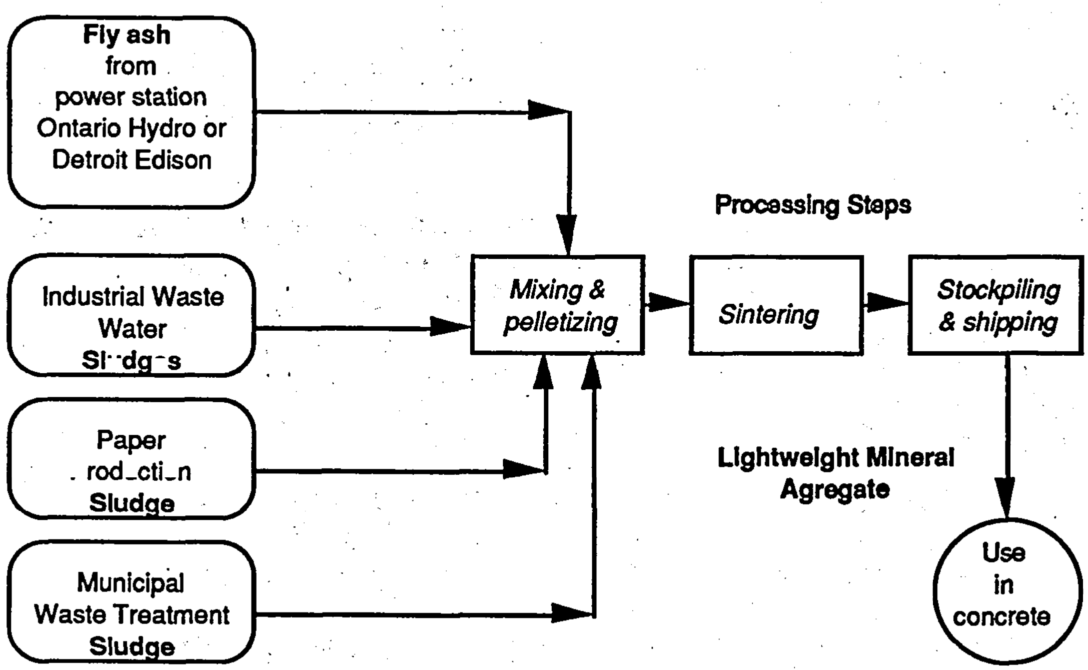


Fig. 4-3: Lightweight Mineral Aggregates

Drivers

General

- Industrial wastewater treatment sludges are currently either landfarmed or landfilled. Municipal sludges are used in agriculture. Fly ash is either sold for use by industry or stockpiled.
- The general motivation for the project is to find an alternative to the existing methods of use or disposal of sludges and to find an additional application for the fly ash that is currently stockpiled or that is being generated in excess of current uses.

Specific

- The interest by Bayer in having a dry, on-site landfill. At present sludges from bio-treatment are dewatered to about 35% moisture. This material is landfilled but is difficult to compact. Finding a use for the sludge would decrease disposal costs and extend the life of the landfill.
- Municipal sludges are being used by local farmers. In periods of wet weather, land application is delayed and sludges accumulate. A reliable year-round outlet for this waste would be an advantage for the municipalities.
- The Lambton TGS sells some of its fly ash for use as a raw mix component in cement manufacture or as a waste stabilizer at the Laidlaw landfill site in Sarnia. Excess ash is stockpiled on plant property. The capacity of this stockpile area is limited and finding additional uses for the fly ash would extend the use of the site and delay the need to get approval for a new site.

Technology

The proponents of the project are evaluating the Minergy sintering process to produce about 100,000 tonnes per year of lightweight aggregate from 90,000 tonnes of fly ash and 30,000 tonnes of sludge.

The installation would be similar to the commercial plant owned and operated by the Wisconsin Electric Power Company at the Oak Creek Power Plant near Milwaukee. The plant processes 85,000 tons of fly ash and 60,000 wet tons of wastewater sludges to produce 95,000 tons of lightweight aggregate per year. Potential steam production is 40,000 lbs per hour. The operation is in compliance with all Wisconsin and US federal emissions regulations.

Economics

- The estimated capital investment in a sintering plant with a capacity 100,000 tonnes per year of aggregate is $21 million.
- Revenues are generated from the sale of the lightweight aggregate plus the avoided costs of disposal of sludges or stockpiling fly ash. Costs include transportation of the sludges to the processing site, operating costs of the sintering plant and product distribution costs.

- **Sales revenue:** the target market is the Detroit area which is expected to be able to absorb 100,000 tonnes of lightweight aggregate per year at a price of $20 - $40 per tonne. This sets the annual sales revenue at $2 - $4 million.
- **Avoided costs:** the majority of the industrial generators of wastewater treatment sludges have landfarming space on plant property. Thus disposal costs are relatively low. The municipal sludge generators also have a low cost disposal option by making the materials available to local farmers. Similarly the fly ash at the Lambton plant is stockpiled on plant property. The cost of stockpiling is low and will remain so until the existing site is full and a new one has to be approved.
- **Operating costs:** these costs are not yet available.

Regulations / community acceptance

Getting a certificate of approval in Ontario or an operating permit in Michigan should not be a major obstacle for the following reasons:

- the feed materials are non-hazardous;
- the process fuel is natural gas;
- temperature and residence time in the kiln is sufficient to destroy organics in the sludges;
- the process has undergone emission tests to demonstrate compliance with its Wisconsin operating permit.

Community acceptance has not been tested because a site for the plant has not been selected. The proponents of the project recognize that any process which brings in waste material from other areas risks public opposition; additionally, municipal wastewater treatment sludges can have an unpleasant odour.

Entrepreneur / risk taker

At present, Bayer is acting as the project leader, but does not see itself as the operator of the sintering plant. Ontario Hydro has an interest in having the project succeed but does not want the leadership role. The other generators of sludges who do not have high disposal costs would be willing to support the project provided it offers a better alternative than their current disposal methods.

Strengths and weaknesses

Strengths

Technology:	The technology is proven; no development work is needed.
Participants:	All are willing to support feasibility work
Material inputs:	Adequate quantities, consistent quality
Product quality:	Meets ASTM standards
Market:	Established
Distribution:	Existing network
Regulatory Compliance:	Has been established in Wisconsin

Weaknesses

Cost of entry:	Relatively large capital investment
Economics:	May not be able to generate an adequate return on capital
Community acceptance:	Not tested
Risk taker/Entrepreneur:	No participant apparently willing to operate the plant

Conclusions

Potentially a very good project from the point of view of beneficial use of by-products. It has been proved to be technically and environmentally sound. To advance towards implementation, the economics need to be established more clearly, in particular the options for reducing the initial investment.

Once economics have been established, the issues of project leadership and community acceptance can be addressed.

4.4 Energy from Waste - Sarnia Chamber of Commerce 1989 Study

Proponent

- Sarnia/Lambton Chamber of Commerce

Potential participants

- industry in the Sarnia/Lambton industrial complex
- municipal solid waste facilities in the Lambton, Essex and Kent counties, and Greater Toronto Area (GTA)
- Ontario Hydro

Project outline / description

The Sarnia/Lambton Chamber of Commerce conceived the siting of a large scale Energy from Waste (EFW) facility in the area. The concept was an energy project with environmental benefits. The EFW facility would produce electrical and/or thermal energy and at the same time reduce the volume of municipal solid waste (MSW) that must be disposed of in landfills. As landfills are themselves a major air/water pollution source (VOCs, methane, etc.), avoiding landfilling the MSW would have an additional environmental benefit.

The fuels that were considered for use were non-toxic industrial by-products from industries in the Sarnia area and MSW delivered from municipalities within Ontario. A $150,000 study was commissioned from Gore & Storey.

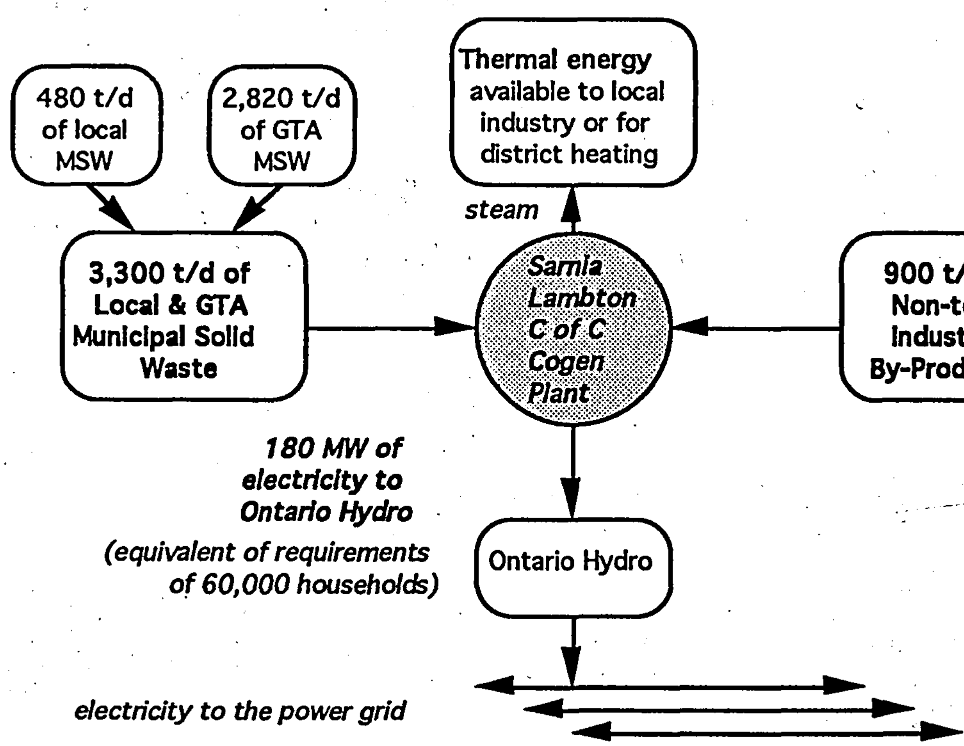


Fig. 4-4: Energy from Waste - Sarnia Chamber of Commerce 1989 Study

Drivers

- A method of effectively and efficiently disposing of non-toxic industrial by-products from industries in the area.
- A means to safely and efficiently reduce the quantities of non-recyclable MSW that must be disposed of in landfills, while recovering a renewable resource in the form of electrical and thermal energy.
- A new industry providing 130 permanent jobs during the operating life of the facility, estimated to be in excess of 25 years.
- Potential to attract other industries to the industrial area where the facility would be sited, by means of offering steam at low cost.
- By becoming a non-utility generator (NUG), supporting Ontario Hydro in providing part of the 3300 MW of electricity planned from NUGs in Ontario Hydro's demand/supply plan of December 1989.
- Supply and service opportunities within Lambton county, expansion of local tax revenue base (in excess of $5-million annually), employment during approximately 3 years of construction (about 2000 jobs).

Technology

Modern EFW technology is well established. Such facilities are equipped with heat recovery systems, efficient particulate and emissions controls, automatic combustion controls, and CEM. These facilities are designed to meet the stringent air emission regulations in Ontario and Canada. CEM systems monitor emissions and ensure compliance. The facilities are constructed to contain odours, prevent dusting and noise emissions.

The equipment suitable for this project was waterfall mass burn for MSW and a fluidized bed boiler for industrial residual hydrocarbons (RHC). Multi stage turbines driving synchronous electrical generators are proven technology for generating electrical power from EFW facilities. The turbines are fed superheated medium or high pressure steam which is exhausted at sub-atmospheric pressures and condensed. The electricity is generated at 13.8 kV and transformed to 230 kV for distribution into the OH electrical grid.

Fuels and energy markets for the EFW

Two types of fuels considered for the project were:

- non-toxic industrial by-products from the industries in the Sarnia area, and
- MSW delivered from municipalities within Ontario.

Combustion of 3,300 tonnes/day MSW is considered the practical size for the MSW part of the EFW. The MSW quantities available from the three adjoining counties (Lambton, Kent, Essex), after the MOE's targeted 3Rs diversion of 50% is achieved, total about 480 tonnes/day. The additional required quantities of 2820 tonnes/day of MSW could be provided from the GTA.

900 tonnes per day of residual hydrocarbons (RHC) and some rubber wastes were the available quantities of identified non-toxic industrial by-products.

From the combustion of 3,300 tonnes/day of MSW and 900 tonnes/day of RHC, 180 MW of electricity would be available for sale to Ontario Hydro. This represents the electrical requirements of over 60,000 households. Discussions with OH indicated its willingness to purchase the electricity produced by the EFW facility.

A survey of industries within the Sarnia area indicated no interest, at that time, for companies to purchase electricity or steam directly from the EFW facility. However, the potential to attract steam customers at a future time as industrial developments are constructed near the EFW facility appeared to be reasonable.

Economics

The estimated construction cost of the EFW facility, in 1990$, was $612.5 million. The operating and maintenance costs were approximately $85 million.

Economic analysis showed that the weighted average cost of capital, which was also the project's required rate of return, was 9.4%. For the most likely operating scenario, the simple payback period was 8 years; the internal rate of return was 16.4% and the discounted payback period was 12 years. Sensitivity analysis indicated that the MSW tipping fees had the most impact economically.

Barriers/problems

- 1989/1990 was the wrong timing for an initiation of any EFW project; political climate did not support any ventures related, or considered to be related, to incineration;
- lack of support by regulatory and political bodies;
- transport, handling and processing of MSW, and the public concerns and community's resistance to such schemes - NIMBY syndrome;
- environmentalists' resistance to any EFW schemes, as opposed to 3Rs;
- withdrawal of financial backing in the face of public and environmentalists' resistance;
- withdrawal of interest by potential industrial participants due to potential negative implications, following the public hearings;
- lack of commitment by Ontario Hydro.

Regulations / community acceptance

It was felt that the EFW facility meets all legal and environmental requirements. However, it was expected that the approval process would be lengthy due to an adverse political climate. The extent of the community resistance to MSW "in their backyards" was badly underestimated.

Factors contributing to failure

- The proponent of the EFW scheme and its potential participants were not prepared for the degree of resistance by the local community and the external lobby.
- The image of the MSW as a potential health problem.
- The sheer size of the project, and the fact that the majority of the fuel used would come from MSW, from outside of the community, as opposed to RHC.
- The lack of awareness of landfills as air/water pollution source.

The future

Although shelved, the Sarnia CofC EFW project is not completely dead. The changing outlook on the EFW facilities as alternatives to landfilling, the changing political and regulatory climate could lead to a resurrection of the project, albeit modified to reflect the current situation.

Although this EFW project failed, indirectly it paved the way for other, smaller, less ambitious EFW projects in the Sarnia area, such as use of dry coke as a source of energy by Imperial Oil.

Pyrolysis of plastics and other combustible wastes, currently considered by Nova, using proven technology to give a clean gas which would be used as fuel at its plant could provide an indication of feasibility of EFW today. *(This project is reviewed in more detail separately.)*

Use of waste low pressure steam and/or waste hot water in industrial "energy parks" is, probably, at least in the short term, a more readily acceptable alternative to large scale energy from waste projects.

4.5 Energy from Post Consumer Plastic Resources

Proponents and primary participant

- NOVA Chemicals (Canada) Inc.

Secondary participants

- Generators and collectors of plastic wastes

Project description

Development of a unit to gasify post-consumer plastic resources (PCPR) by starved oxygen pyrolysis. This is an established technology used, for example, to recover fuel from scrapped tires. The gasification products would be used as fuel by NOVA Chemicals. The unit would be located in Sarnia and would draw PCPR by truck or rail from the surrounding area and possibly from Toronto and Detroit.

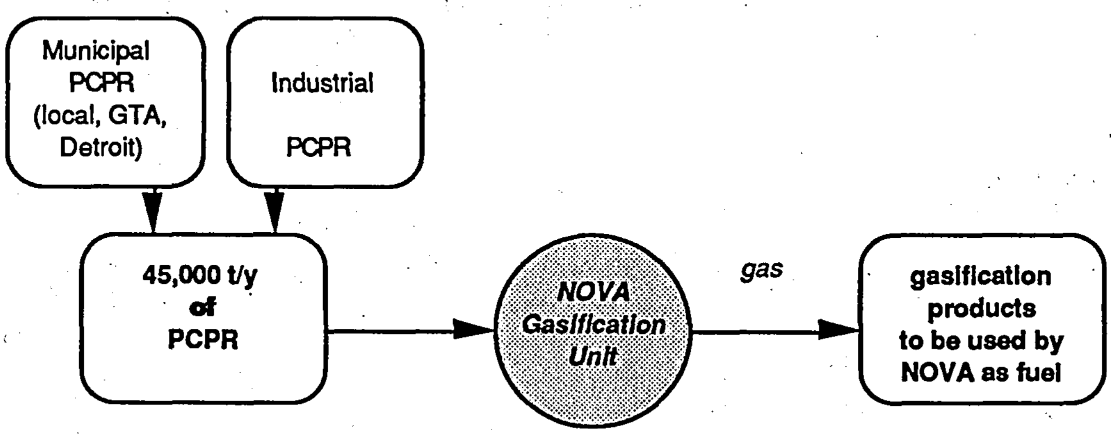


Fig. 4-5: Energy from Waste - Novacor Chemicals

Drivers

As part of its commitment to product stewardship, NOVA Chemicals is considering sustainable options for recovering value from PCPR which are in excess of what the recycling markets can absorb. This project would complement current municipal programs for mechanical recycling as part of a 5 R's initiative to manage PCPR.

5R initiative

Economics

The target quantity for the unit is about 50,000 tonnes per year of feedstock. The estimated capital investment is $10 - $20 million. Tipping fees are currently estimated to be $50 - $70 per tonne. Assuming that 50,000 tonnes per year with a tipping fee of $60 were processed, revenue from tipping fees would be $3,000,000 leaving the remainder of the return to be from the energy value of the gas. Tipping fees would decrease once the capital investment is paid off.

To assure the economics the quantity of material processed would have to be about 45,000 tonnes. There are large post consumer streams in addition to plastics which could be processed, such as:

- auto shredder fluff which is a persistent disposal problem,
- waste paper which cannot be absorbed by recyclers, and
- rubber waste.

However, the return on investment would continue to be sensitive to tipping fees.

Issues and barriers

- Public acceptance is uncertain due to an unknown perception to pyroprocessing PCPR;
- Attitude of municipal governments is uncertain;
- Technology is fully developed;
- Regulations should not be an issue because the process has been shown to operate in compliance with relevant standards;
- Economics are not a strong driver at this point but the process appears to be sustainable in the long term with the operating costs covered by the value of the energy.

Next steps

The development stages for the project are to evaluate the supply and potential revenues from suitable feedstocks. A market survey would be conducted working with the relevant municipalities to determine their willingness to participate in a committed way. A subsequent action would be to conduct an environmental life cycle inventory of gasifying PCPR and other energy resource wastes. Steps have been taken to inform the industrial community about the opportunity and to get the support at the same time. If the results of the development process are positive, a community outreach program would be implemented.

Conclusions

This is potentially a very interesting project because it offers a good way of demonstrating the viability of waste-to-energy projects starting with a small scale operation which, because it uses non-hazardous materials, should be acceptable to the community. Support from Environment Canada to promote understanding of Energy from Waste projects and how they fit in a 5 R's program would increase the probability of success for this project.

4.6 Co-Product Sulfuric Acid Project

Proponent and primary participant

- Ethyl Canada Inc.

Secondary participants

- Sarnia area-based liquid fertilizer producer
- Michigan-based dry fertilizer producer

alternately

- Greater Toronto Area-based paper manufacturer

Project description

Ethyl manufactures a range of fuel and oil additives, including a diesel ignition improver in the Sarnia operation. The process generates a by-product stream of about 9,000 tonnes per year of 45% or 75% sulfuric acid. A small portion of the acid is sold to a liquid fertilizer manufacturer near Sarnia. The majority is deepwelled.

The company is working to develop a new market use for the by-product in Michigan. This would also be a fertilizer application, but its seasonality pattern (October to June) would offset the seasonality of the Ontario liquid fertilizer operation (June to October) thus providing a year-round use for the acid. Between these two applications, all 9,000 tonnes of co-product acid would be beneficially utilized. To access the US market the by-product would be shipped as 70-75% acid. In this state it is not as corrosive as 45% acid.

Shipping more 45% acid would need an investment in new corrosion resistant piping and storage.

Drivers

Ethyl wants to develop a beneficial use for the sulfuric acid which is currently going to deepwell. Finding a means of avoiding the costs of deepwell disposal would be a significant step towards securing the competitiveness of the Sarnia operation vis-à-vis the US Ethyl operation in Orangeburg, SC.

Economics

The economics are sound. The value of sales to the prospective US market and the reduced costs would provide a good return on the investment needed to supply this market.

Technology

The technology is proven, no development work is necessary.

Market and distribution

There are two potential users of the by-product; distribution would not be an issue.

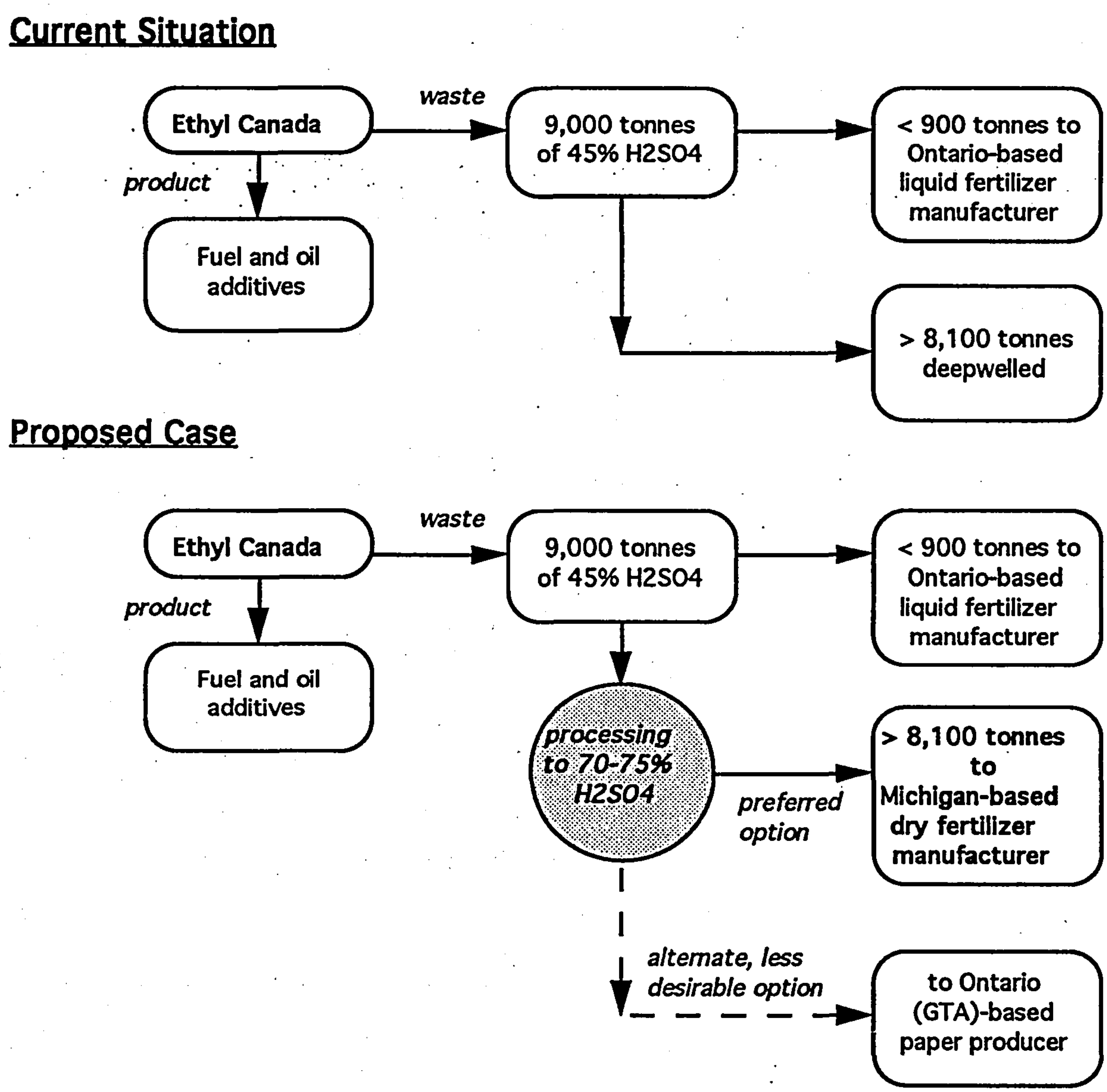


Fig. 4-6: Co-product Sulfuric Acid Project

Barriers

- **Regulations**: the primary stumbling block is the reluctance of the Michigan Department of Environmental Quality (DEQ) to allow a co-product to be used in an agricultural application. It is not a transportation issue since the acid can be shipped into the US for disposal.

- It is the trans-boundary land use of the co-product acid that is a barrier. The co-product can be used within Ontario without objection. However, there is not sufficient demand for co-product acid for fertilizer production in Ontario to absorb the quantity generated by Ethyl.

- Ethyl would not consider becoming a fertilizer manufacturer. Such a venture is too far removed from its core business. Joint venture manufacturing of fertilizer in the Sarnia area could be a possibility. This would have the benefits of local (on site) co-product utilization and job creation.

Next steps

- If a positive ruling cannot be obtained from the Michigan DEQ, the company will continue to look for alternative uses. An opportunity currently being considered is to ship the acid as an "anti-pitch agent" to a paper manufacturer near Toronto. This would burden the project with considerably greater transportation costs. The economics of this alternative are considerably less advantageous than the fertilizer option. The company's sister plant in the US is currently supplying the same by-product to a paper company in North Carolina.

- If no additional markets are developed, the material will continue to be disposed of in deepwells.

4.7 The Bruce Energy Centre

The Bruce Energy Centre is not located in the Sarnia-Lambton corridor, but is about 130 miles to the north. It was visited and included in the study because it is perhaps the first successful and highly visible Canadian industrial eco-park, and because it could serve as a model for future industrial sustainable development in the Sarnia-Lambton area. Its accomplishments to-date, as well as some future options are described in some detail, as this pioneering facility is an example of what can be done, perhaps even on a larger scale, elsewhere.

Proponent

- Integrated Energy Development Corp.

Participants

- Bruce Agra Foods Inc.
- Bruce Agra Dehy Inc.
- Bruce Tropical Produce Inc.
- St. Lawrence Technologies Inc.
- BI-AX International Inc.
- Commercial Alcohols Inc.
- Tacke Windpower Inc.

Steam supplier

- Ontario Hydro - Bruce Nuclear Power Development

Project outline / description

Ontario Hydro BNPD's eight steam generators provide 80 million lbs. of steam per hour, primarily used to generate some 6GW of electricity, representing 25% of the total Ontario consumption. There is also considerable volume of excess steam available for secondary use (Fig. 4-7). Integrated Energy Development Corp. conceived the potential of the industrial ecosystem based on high-volume availability of by-product steam from the BNPD.

The Bruce Energy Centre, as North America's first energy intensive industrial eco-park for profit, was initiated some 12 years ago. Its founder, single-mindedly working to develop the eco-park, organized a group of six companies to take advantage of the steam capacity and waste heat from the BNPD. This steam is a potential ideal source of heat energy for a broad range of industrial and agricultural processes such as dehydration, concentration, distillation, evaporation, hydrolysis, curing as well as space heating. Furthermore, thoughtful positioning and coordination allows the participants in the park to recycle and recover by-products of one industry as raw material inputs to another.

A missing part of the equation, that could potentially make the Bruce Energy Centre (BEC) more successful, would be access to lower rate, off-peak electricity from the BNPD.

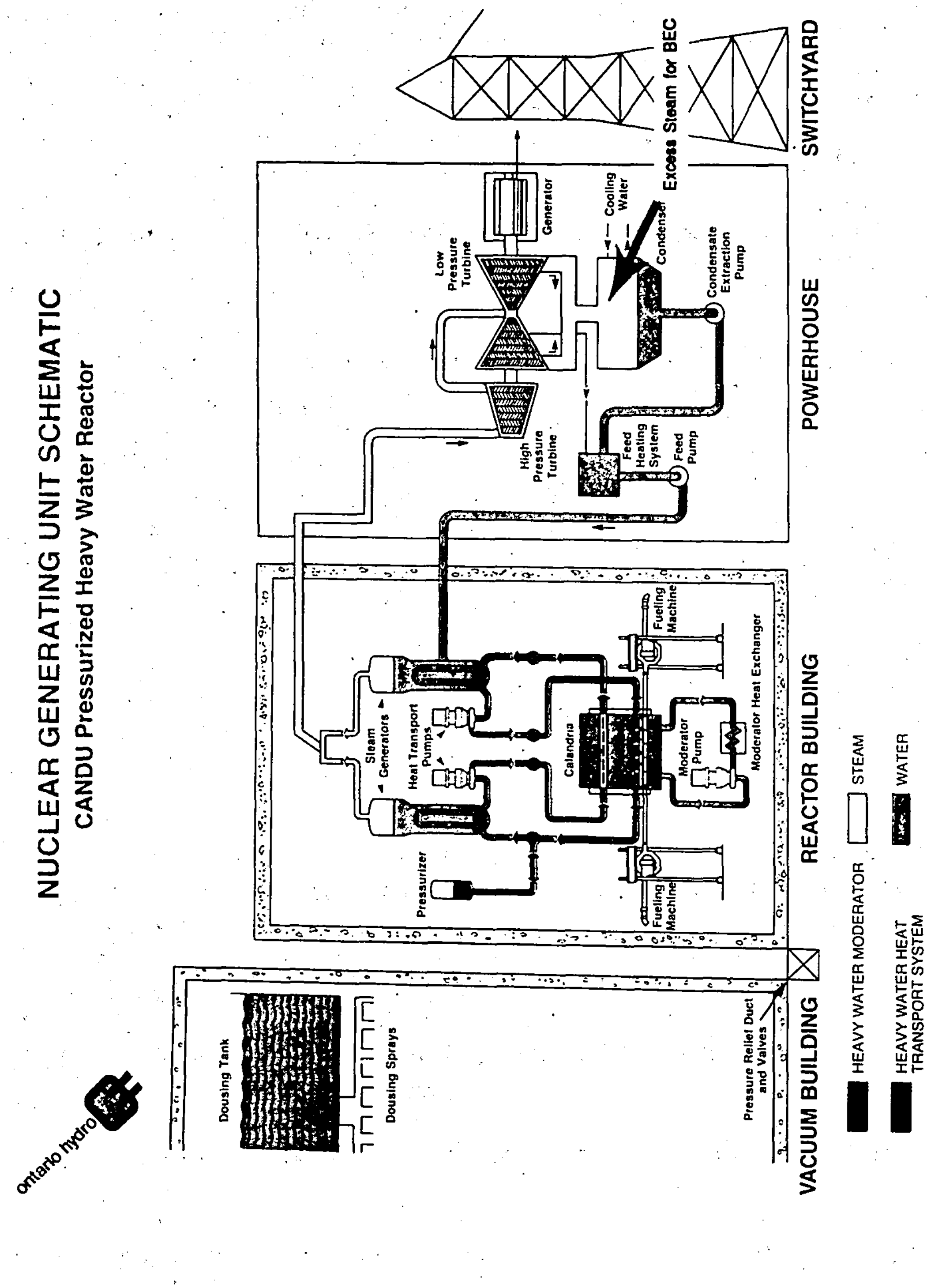


Fig. 4-7: Ontario Hydro BNPD and its relationship, as a source of steam, to BEC

Operations currently involved in the BEC include:

- **Bruce Tropical Produce,** which grows 2.3 million pounds of tomatoes each year in a an 8-acre hydroponic greenhouse, the equivalent production of a 100-acre field. Bruce Tropical has a spring and fall crop of 75,000 plants. The greenhouses depend on steam for heat. Hot water coils heat the greenhouses and then the cooled water returns in a closed loop to the BNPD. They also have the capability to grow a winter crop under 2.5 MW grow lights, although the lack of agreement with Ontario Hydro regarding access to low cost off-peak power, at this time, does not allow it. A state-of-the-art rooftop weather station monitors the greenhouse conditions and automatically controls fertilizer and feed composition. Biological pest control and bumblebee pollination are also used. The company has been a part of the BEC since 1988 and has 30 employees.

- **Bruce Agra Foods,** a division of Apotex Inc., is a food processing facility designed to process raw vegetables, fruits and fruit juices into concentrates, sauces and purees. Their evaporators, using steam energy from the BNPD, can concentrate 84,000 gallons of raw products per day, to give about 10,000 gallons of finished products, depending on the level of concentration required. Bruce Agra Foods' residues are not wasted, but in keeping with the eco-park's philosophy of integrated development, dried in the dehydration plant (Bruce Agra Dehy Inc.) and used for animal feed, or utilized as a feedstock for ethanol by the alcohol plant (Commercial Alcohols Inc.). or alternately composted on local agricultural land.

- **Bruce Agra Dehy** dehydrates locally grown crops to produce nutrient-rich feeds for horses and livestock. The facility produces 90,000 tonnes of feed cubes per annum, using steam to run its dehydrators. It processes alfalfa, corn, oats and recovered apple pomace from Bruce Agra Foods. Residual corn mash from the Commercial Alcohols plant has also been used by Bruce Agra Dehy.

- **Commercial Alcohols** is the largest manufacturer and distributor of alcohol in Canada. It began its operations in 1989 and currently annual production is 23 million litres of industrial and fuel alcohol from 58,000 tonnes of locally grown corn. The corn is broken down to starch, then sugars, then fermented to produce ethanol, which is subsequently purified by distillation. Steam is used in ethanol processing and distillation. Waste CO_2 from the fermentation plant can be used by Bruce Tropical Produce to enhance growth rates for the tomato production. In addition to conventional ethanol applications such as in food and beverage preparation, and consumer products, Commercial Alcohol, in 1992, began supplying alcohol for ethanol-blended gasoline. (Apart from conserving irreplaceable natural resources, alcohol-powered motor vehicles, as current research into alternative fuels shows, exhibit lower NO_x, HC, CO and PM_{10} emissions than their gasoline- or diesel-powered equivalents.)

- **BI-AX International** was the first company at the BEC. It is the only all-Canadian company that supplies a special polypropylene (PP) film to domestic and international markets. It improves the quality of conventional PP plastic film, making it stronger and more stable. The plastic is heated in ovens "fired" by steam, then rolled and biaxially stretched, producing a strong product that does not stretch and lies flat. The Bi-Ax products are used in laminates for books, in photo albums, a variety of tapes and in food production. It has a staff of 35 people and operates on a 24 hours/day, 7 days/week basis with a product capacity of 1000 lbs/hour.

- **St. Lawrence Technologies** is a R&D facility that has developed some of the equipment and processes used in the BEC to convert renewable resources to a wide range of products, like fuel ethanol, brewing adjuncts, fibre ingredients, and adhesives. They play an important role in the Centre, by providing technical support to other companies there.

- **Tacke Windpower Inc.**, the newest addition to the BEC, at this time, is a giant 600 kW wind turbine (50 metre tower with 43 metre blade assembly diameter). It is the largest grid-connected wind power generator in Canada, and reflects the BEC's philosophy of energy intensive industries deriving their power from environmentally clean sources.

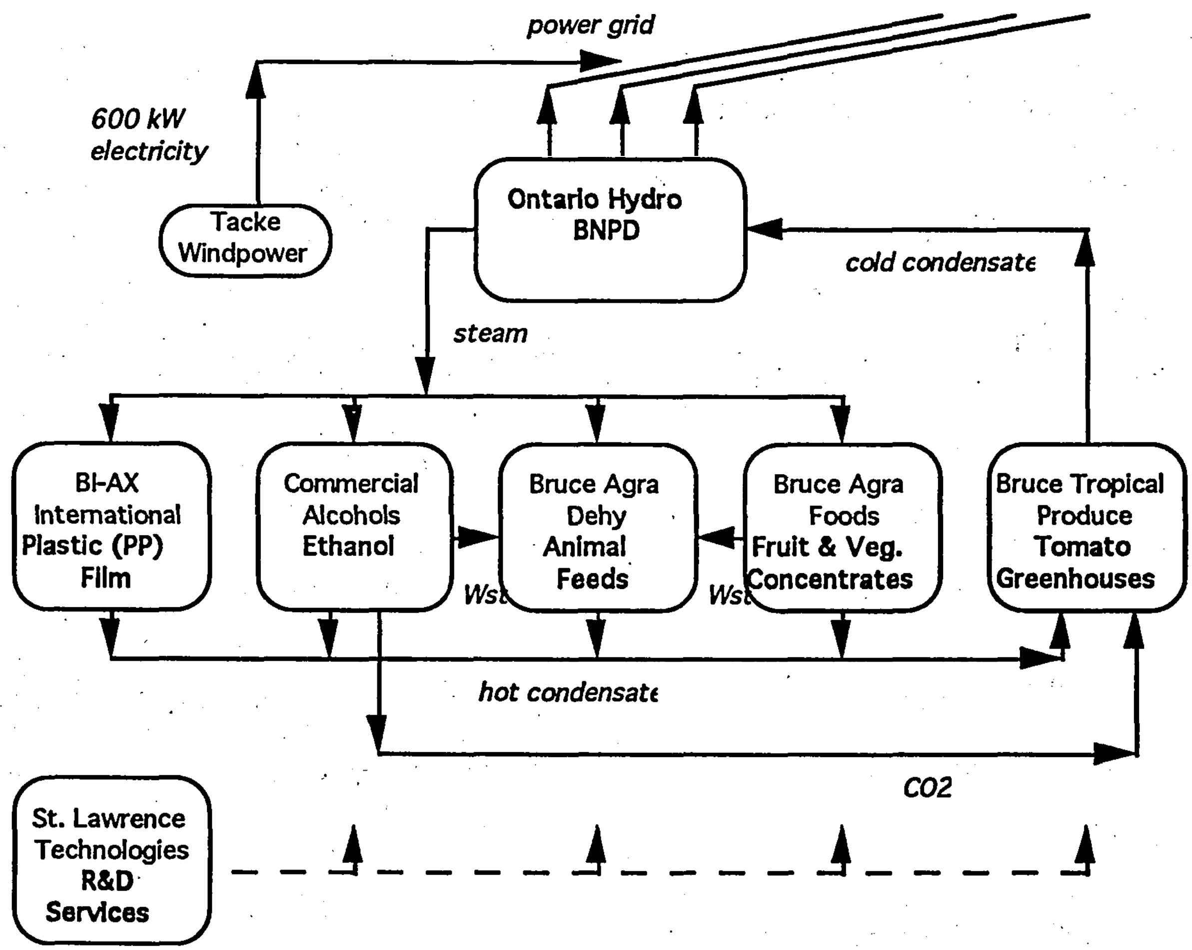


Fig. 4-8: Bruce Energy Centre, as of September 1996

Drivers

- Availability of excess steam from Ontario Hydro - Bruce Nuclear Power Development (BNPD).

- Strong personal commitment to sustainable development, enthusiasm backed by political support.
- Availability of a skilled workforce following completion of construction of the BNPD.

Technology

Use of excess or by-product steam as a source of heat energy in a broad range of industrial processes is well proven. What is novel here, as far as Canada is concerned, is the development of an industrial park containing a cluster of smaller industries based there solely because of the excess of this source of steam/heat, and coordinated in such a manner that their own wastes and by-products can be further cascaded and used between them.

Emissions avoided

The six companies of the BEC are drawing, on average, about 60,000 lbs of steam per hour, an equivalent of some 38,000 litres of oil per day, or almost 14-million litres of oil per year. This cascading and beneficial use of the excess steam from BNPD represents an annual avoidance of about 43,000 tonnes of CO_2, 487 tonnes of SO_2 and 93 tonnes of NO_x, as well as 1.7 tonnes of VOCs, 0.5 tonnes of CH_4 and 8.4 tonnes of CO of atmospheric emissions that would be generated if, for example, heavy fuel oil would be used by BCE for their steam generation.

Economics

All of the participants in the BEC are private industry commercial entities. Clean energy from BNPD combined with local renewable resources reduces their costs of doing business.

Markets and distribution

Although it would appear that the BEC is already in a relatively remote location from the major centres of population in southern Ontario, it is still only 120 miles northwest of metropolitan Toronto. Furthermore, it is within one day's trucking distance to more than 50% of North America's population.

Bruce Tropical Produce greenhouse-grown tomatoes delivered to the southern Ontario market can compete quality- and price-wise with imported ones from California or Florida. Other types of products, such as those of BI-AX International are intended mainly for the international markets.

Issues and barriers

- communication of a shared vision between the enterpreneur and support by regulatory and political bodies;
- development of long term vision, commitment and incentives by the provincial and federal bodies, and Ontario Hydro, to fully develop the BEC's potential;
- lack of commitment by Ontario Hydro with respect to off-peak power supply;
- an ideal location with respect to the source of steam (BNPD), but relatively remote with respect to integration to other industries and markets.

Regulations / community acceptance

The BEC (Phase I) has environmental assessment on 360 hectares (900 acres). At present, there is a plan of subdivision for 240 hectares (600 acres) with the remainder available for future development. Community fully accepted the BEC, and is justifiably proud of this unique, world-class eco-park in their backyard. Companies located in the BEC also provided some much needed jobs for the local economy.

Conclusions

The BEC is a truly world-class eco-park in its concept and implementation. It clearly demonstrates the role of a champion or entrepreneur in bringing this industrial eco-park concept to fruition.

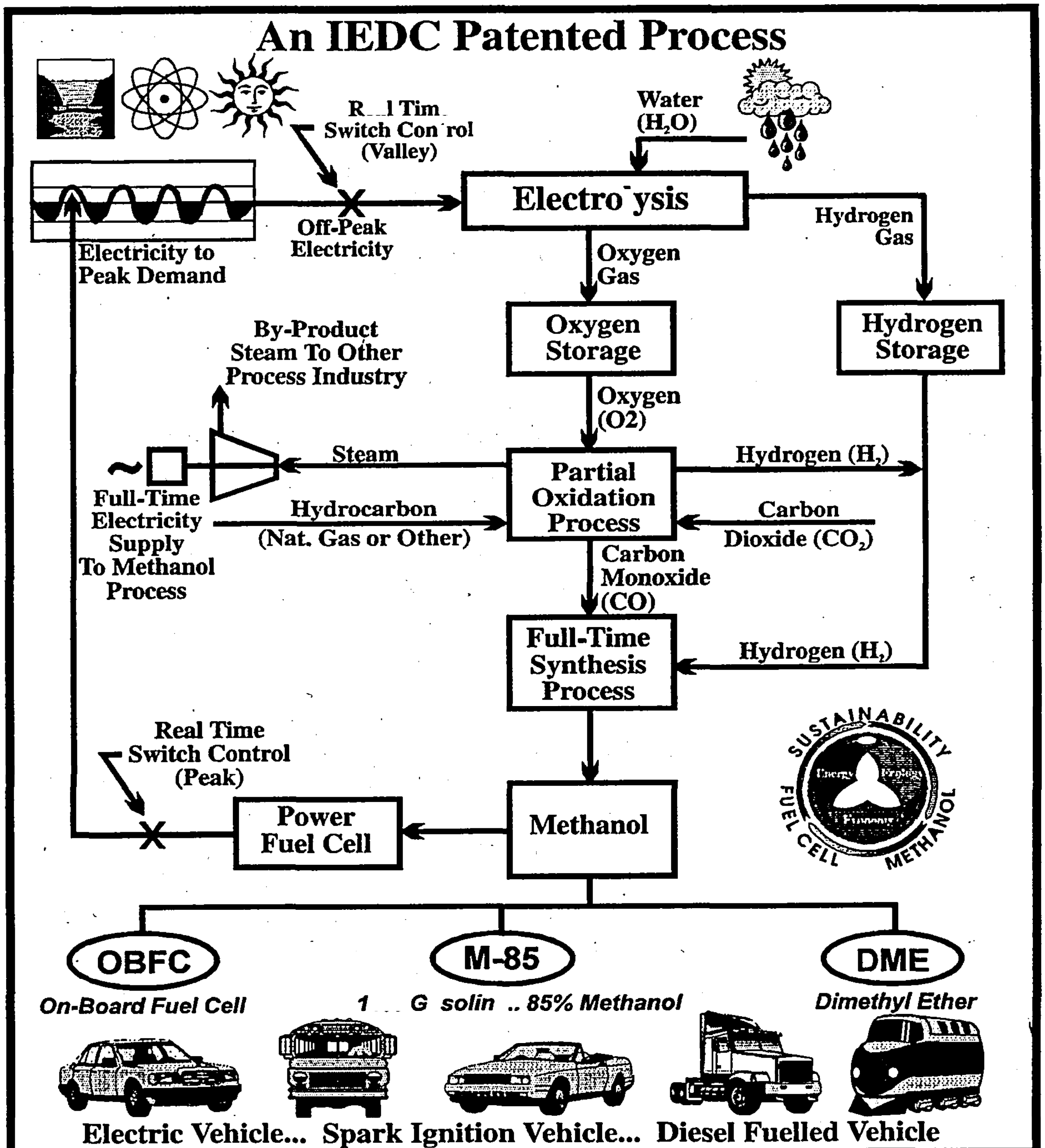
What has been achieved here can be duplicated at other locations centred around large power stations, and possibly other large industrial operations, such as those in the Sarnia-Lambton corridor.

The future

Sam MacGregor, the driving force behind the Integrated Energy Development Corp. (IEDC), is brimming with ideas and enthusiasm for further expansion of the BEC. IEDC has patented an environmentally friendly process to synthesize methanol as sustainable fuel, based on the use of off-peak power generating capacity. It is visualized that this excess off-peak power could be used to dissociate water to produce hydrogen and oxygen. Water-based H_2 and O_2 would be used together with a hydrocarbons source, such as natural gas, to react with CO_2 from the BEC fermentation and distillation processes to generate CO and a second stream of H_2 for the synthesis of methanol.

This synthetic methanol using hydrogen and oxygen produced by water electrolysis as a tool for optimizing power generation and recycling CO_2 offers a potentially major source of fuel for both light-duty and heavy-duty vehicles, with considerably lower emissions than currently used gasoline and diesel fuels. (The synthetic methanol could be further used as a feedstock for production of dimethyl ether (DME), one of the cleanest available fuels under consideration at this time.) A joint Ontario Hydro and IEDC study conducted by Ford, Bacon & Davis, confirmed the technical and economic feasibility of methanol synthesis premised on IEDC's proprietary process. Fig. 4-9 offers a schematic of the IEDC synthetic methanol process, and Fig. 4-10 shows an integration of such a process into the overall BEC Master Plan.

In a paper presented by Sam MacGregor at the 1996 Kalundborg Workshop, it is estimated that by using 2,740 MW for water electrolysis to generate H_2 and O_2, (and this number is considered quite reasonable from the operational equilibrium point of view, considering that Ontario's peak electricity power demand is some 18,000 MW with a base demand of some 11,000 MW), some 17.5 billion litres per year of methanol could be synthesized. It is claimed that this volume represents about 43% of Ontario's current gasoline and diesel fuels consumption.



Integrated Energy Development Corp.

Fig. 4-9: Schematic of IEDC's synthetic methanol process

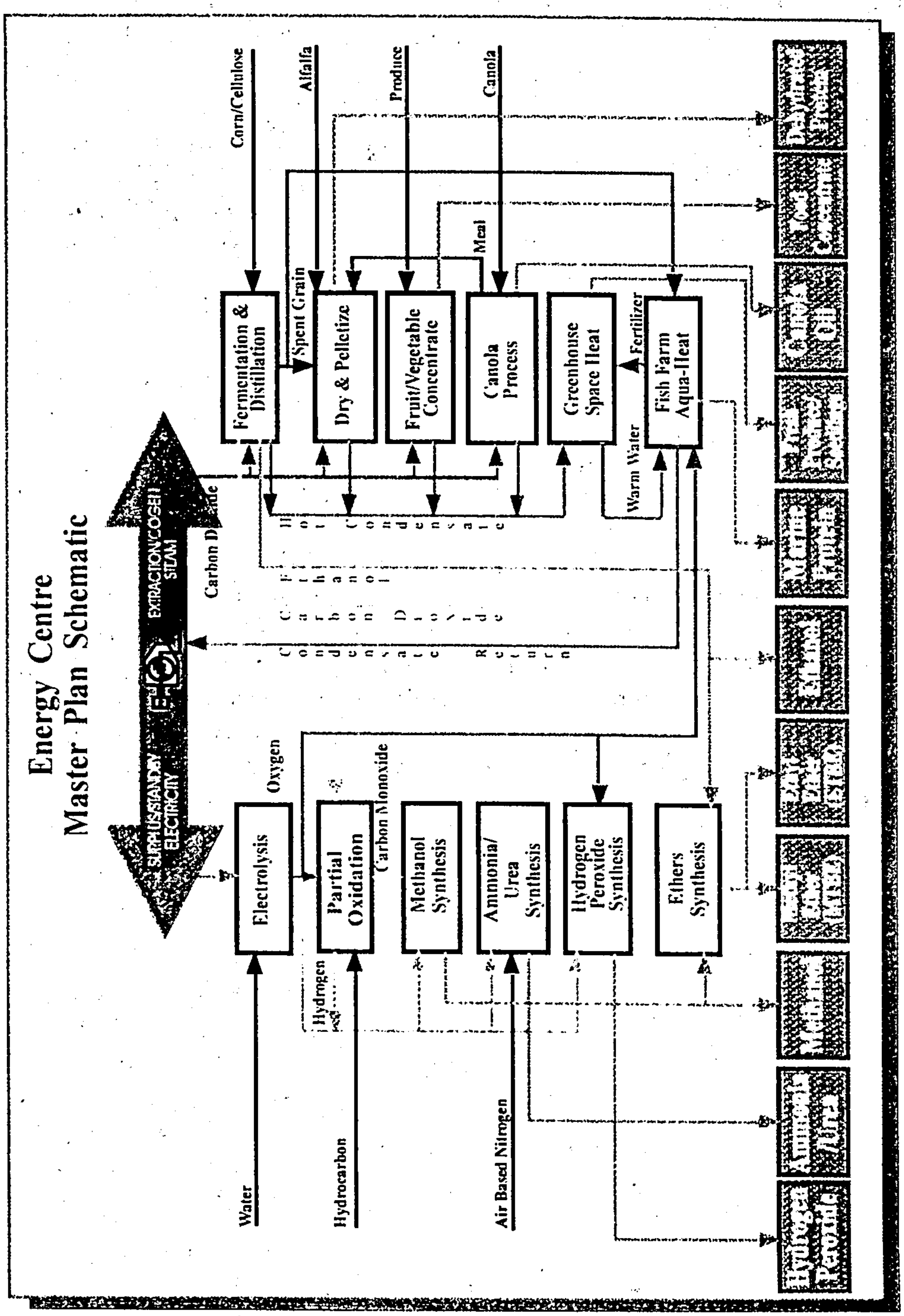


Fig. 4-10: Bruce Energy Centre Master Plan

IEDC is now proceeding with a working prototype of its synthetic methanol process in a 200 kW mode. It is projected that this prototype will synthesize 400 US gallons of methanol a day, and it will be integrated with the BEC 8-acre greenhouse operation (Bruce Tropical Produce Inc.) which currently serves as an end-of-the-line condensor for the steam/condensate system serving the Centre. The CO_2 supply to the methanol process will be derived from an existing 13,000 US gallon/day alcohol fermentation plant (Commercial Alcohols Inc.) at the BEC site that now exhaust some 50MT/day of CO_2 to the atmosphere. As well, the CO_2 will be used in photosynthesis by the 80,000 tomato plants growing in the greenhouse. The 200 kW, representing about 10% of IEDC's greenhouse lighting load, will be employed in an interruptible mode to provide the H_2 and O_2 from demineralized water for the process.

Once the prototype has been commissioned and operated for an appropriate period of time, and enough experience is gained, IEDC is planning to proceed with a 2.0 MW version.

5. OTHER CONTACTS

A number of other Sarnia-Lambton companies and organizations were approached and visited, and the subject of waste and by-product resource sharing was discussed with them as well. Some of these companies, such as Imperial Oil, already have an active program of reuse of their co-products. With others, various opportunites that are either currently under consideration, or could be considered and developed in future, were identified. However, as the information available to us at this point is not as complete as in the seven case studies reviewed in Section 4, less definite conclusions could be drawn from these with respect to the factors affecting their success or barrirers that have to be overcome.

5.1 Fibrex Insulations Inc.

Fibrex is a producer of mineral wool insulation products. Mineral wool, also called rockwool, is an insulation product similar to fibreglass. Its main constituent is basalt rock. Blast furnace slag, a by-product of iron production, can replace some of the basalt in the melt. Coke is used as a fuel. Neither of these raw materials is available locally; all have to be transported in. The higher melting point of mineral wool, (1200°) when compared to fibreglass (850–1000°), is its strong point, which caused it to be used extensively as a pipe insulation for hundreds of kilometers of pipelines in the Sarnia-Lambton chemical valley.

Until recently, this operation was a part of the Partek organization. Within the last year, however, it has been spun off by Partek and sold to the US-based Fibrex. Fibrex closed its Aurora, IL, plant in favour of the Sarnia operation. Having limited resources devoted more to day-to-day operations affects the ability to undertake technical, energy or environmental improvements. Partek did not pass on to Fibrex the pipe insulation business; a staple of its operation in Sarnia. Fibrex produces industrial board (flat) insulation, and developing other market applications, such as, for example, hydrophonic growing medium.

Two areas were identified that potentially offer some benefits as far as the sharing and cascading of wastes and by-products are concerned:

1) use of waste heat internally generated by the cupola, and
2) increased use of by-product blast furnace slag as replacement of natural basalt.

1) The furnace cupola operates at 1800°C. A water jacket is used to partially cool the cupola; some of this heat is used for preheating, and in principle there is a capacity to produce steam. Most of this heat, however, is wasted. At the same time, the plant's premises and warehouse are unheated. The waste heat generated in the mineral wool manufacturing process could be used for space heating. This is of interest to Fibrex, although the company president is quick to point out that with their current manpower, physical and financial resources, this is something beyond their capability. The use of waste heat for the facility space heating could possibly be an opportunity for a joint Environment Canada / Fibrex demonstration project.

2) There are some opportunities to utilize by-products and wastes of other industrial processes as raw materials inputs in mineral wool production. Fibrex is currently exploring other sources of coke, hoping to realize some savings. Unfortunately, the locally available petroleum coke from Imperial Oil, due to its high sulfur content, cannot be used on the wool production.

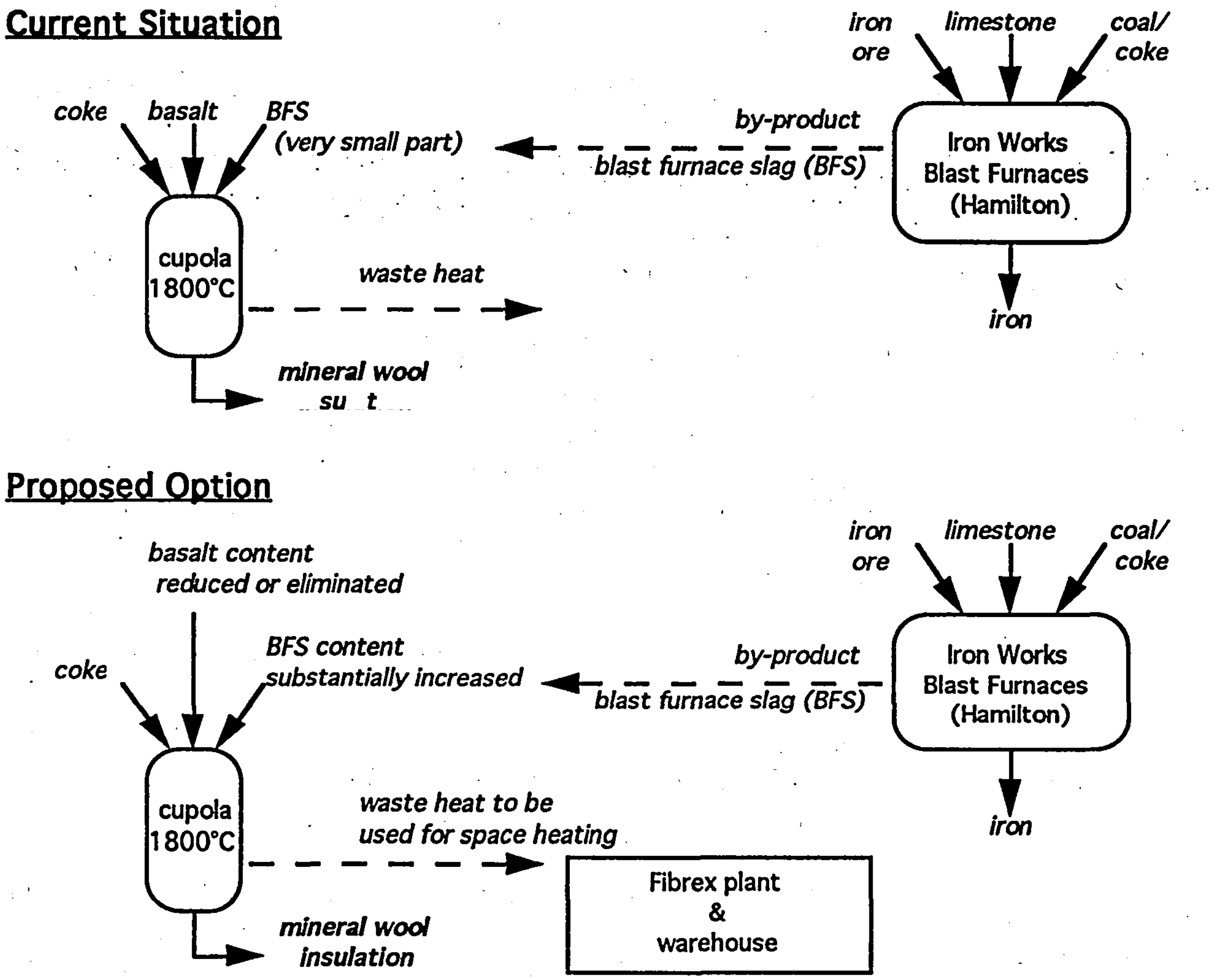


Fig. 4-11: Fibrex Insulations Inc. Opportunities

Greater use of blast furnace slag (BFS), a by-product of iron making from not too distant Hamilton, ON, to replace a portion of basalt as the basic raw material, appears to be an attractive option. There are a number of mineral wool plants that operate on 100% BFS basis, especially here, in North America. At this point, Fibrex is using a relatively low percentage of BFS in its raw materials mix. The proportion of BFS to basalt rock could potentially be increased, however, Fibrex is facing a number of barriers:

- small organization, and resulting lack of resources (people, money);
- increased BFS/basalt ratio can lead to technical / manufacturing problems such as changes in rheology of the melt, increased amount of shot (non-fiberized material) and product variability;
- organizational - changing market & business orientation;
- no access to R&D;

This is an example of a small organization which because of resource limitations is in a survival mode. At the recent "Environment & Energy Conference of Ontario", the position of small and medium size companies, such as Fibrex, regarding any investment towards improved energy efficiencies and/or environment were put in perspective:

- Small business has one major challenge; its survival. Unless energy- or environmental-oriented investment supports the survival of the company, such an investment will not be made.
- Smaller companies lack the awareness of energy efficiency, environmental challenges, climate change and similar issues.
- Small businesses lack resources, specific know-how, staff and financial means enabling them to tackle environmental and energy efficiency-related projects.

5.2 Dupont Canada

DuPont Canada is involved in sharing emergency resources with neighbour companies. This is motivated by the benefits from economies of scale. The Company is open to the concept of cascading wastes and byproducts under the following conditions:

- economics would be the driver,
- the activity must not have an adverse impact on DuPont's competitive position,
- the activity should not incur a liability for Dupont,
- if a partnership resulted in the installation of an operation close to DuPont, it would have to be built and operated to the Company's standards,
- the partner or partners would have to be culturally compatible with DuPont.

The plant is leanly staffed, leaving limited resources to develop this type of network. The plant does not have the resources to interface with numerous small companies. This would result in too high a level of "distraction" and diversion of staff time. If a network were to be developed involving a number of small organizations, DuPont would prefer dealing with one individual representing the small companies

5.3 Imperial Oil

Imperial Oil is producing a number of secondary products stream, industrial by-products and wastes at its site in Sarnia. These include:

- **Petroleum coke,** that is not really a waste issue. Imperial Oil has a CO boiler that burns coke production in the generation of steam for their internal use. Excess coke that is not burned by Imperial is sold as a solid fuel to other industrial users, most often to cement kiln operators. Petroleum coke was never disposed of, it is considered by Imperial Oil to be another material of their process and a commodity for sale.

By-products / Waste Streams

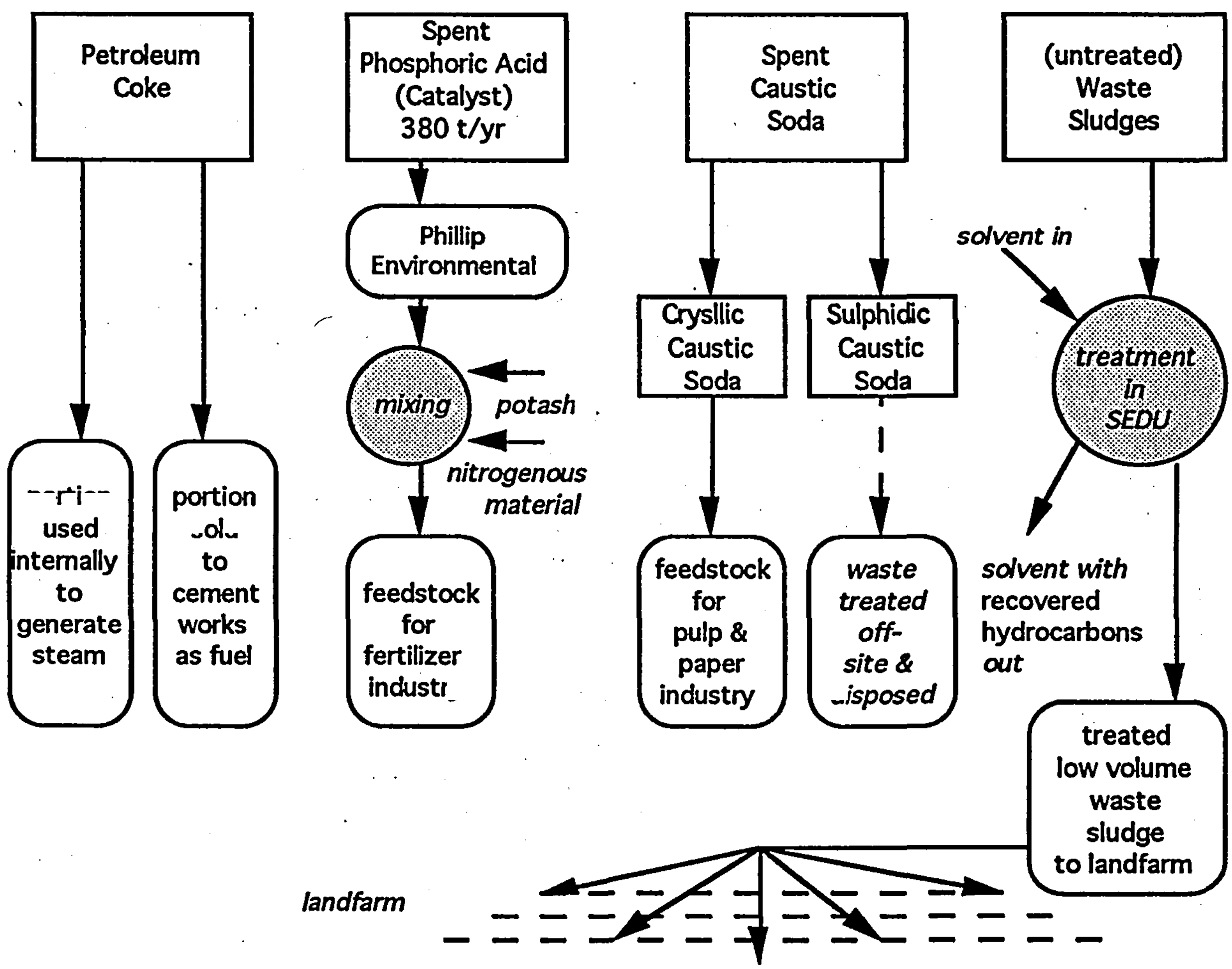


Fig. 4-12: Imperial Oil By-Products Handling & Re-Use

- **Spent phosphoric acid,** that is no longer landfilled. Until 1990 the spent catalyst went to a New England fertilizer company for the production of fertilizer. When that operation was sold, the potential liabilities increased to unacceptable levels and Imperial returned to landfilling the material as a hazardous waste. Since 1995, however, they route the spent catalyst to Phillip Environmental in Ontario. They mix the catalyst with potash and nitrogenous material for the production of fertilizer. This product is not considered a hazardous waste in Ontario due to the fact that it is a raw material feed for the fertilizer industry. Phillip is a fully licensed facility to conduct the blending process. Approximately 380 tons of spent catalyst are generated by Imperial a year, and cascaded through Phillip to the fertilizer producers.

- Another by-product stream generated at the Imperial site is **spent caustic soda.** Presently the majority of their crysllic caustic is sent to the pulp and paper industry as a feed for their processes. The sulphidic caustic soda is disposed of in a waste treatment plant off site. Efforts are continuing in Imperial and Exxon corporate research facilities in both Canada and the US to discover recycle or reuse options for both types of caustics.

- **Waste sludges** are treated by Imperial Oil in their SEDU (solvent extraction & dissolving unit). Solvent is used to treat waste sludges prior to landfarming. The process reduces the volume of sludge generated, allows for recovery of hydrocarbon components in the sludges, and renders it landfarmable on Imperial's own landfarm thus eliminating the need for offsite fixation and landfilling. This is particularly useful in the case of sludges that contain higher concentrations of heavy molecule hydrocarbons that would otherwise not be an appropriate waste stream for their landfarm. Imperial's SEDU is an internal process that does not involve any other party, or waste sludges from any other generator.

6. REVIEW OF KEY ISSUES

6.1 Drivers

The primary driver behind the development of any industrial partnerships between various companies, be it for environmental or energy purposes, is economics. Secondary drivers are corporate policies such as Responsible Care, and corporate culture, both of which can affect the choice of a course of action and encourage development of partnerships.

6.2 Factors for success

Project Champion or Entrepreneur

It is essential that one or more individuals have a strong commitment to the project, particularly if it is outside the envelope of normal company business or if it has an element of risk. The role of the champion is to:

- communicate the vision of the project to potential participants,
- get commitment from the participants,
- secure the necessary resources to implement the project,
- support negotiations for sharing the costs and benefits,
- help resolve problems.

Large organizations seldom foster enterpreneurship; the lean companies of the 1990s often do not have the resources, inclination or corporate culture to deal with small users of their energy and materials by-products. In many cases, therefore, it can be easier if the project's champion is from outside the company; a third party person or entity.

Limited number of participants

The difficulty in implementing a project increases with the number of participants. There may be different goals which will have to be reconciled. There will probably be different attitudes to risk, and the sharing of costs and benefits will be more complex. Difficulty increases if the companies involved are in different business sectors, and increases even more if some of the potential participants are small. Analysis of the case studies suggests that if a number of small companies are to be included in a network involving one or more large companies, it is preferable that the small companies be represented by one voice.

Economic incentive and risk control

A clear economic benefit must be visible to all the participants. The benefit must be sufficient to cover not only the capital but also the investment in time and effort. The project must not expose the participants to unacceptable risk, either financial or environmental. The level of risk must, therefore, be definable and within the risk profiles of each of the participants. The application of environmental externalities for decision making purposes may aid in investment planning.

Technology

Projects which are outside core business have a much greater chance of success if they use developed technology, and thus do not involve the added uncertainty of a development program.

Community acceptance

The companies included in the study are strongly aware of their corporate citizenship and role in the community. They take care to demonstrate responsible stewardship for their products and waste streams. They are unlikely to engage in projects which do not receive community acceptance despite outreach programs. Projects requiring shipping of large volumes of outside wastes, especially MSW, to the processing sites within the community, are especially vulnerable and their negative image very difficult to overcome.

Markets and Transport

If a project, developed to cascade materials and energy, results in a new product or service, there should be an identified market for it. Creating a market adds another level of cost and uncertainty.

Marketable by-products are not necessarily utilized in close proximity of their generation. Under the right economic and regulatory conditions they can be transported over distances of several hundred kilometres.

Regulations

In most of the cases which were studied, regulations did not play a major role, however, if the permitting process is likely to be protracted or the outcome uncertain, projects are unlikely to be undertaken.

6.3 Barriers

The barriers to implementing projects are basically the inverse of the factors for success. Factors which act as weak drivers for a project may, if they act in a negative fashion, constitute very strong barriers. A generic barrier is the reluctance of companies to become actively involved in activities which are outside their core business. Individuals within a company are unlikely to develop and promote opportunities which lie outside the organization's sphere of business experience. This barrier can be overcome if a credible entrepreneur from outside the company is willing to devote resources to developing a project, "selling" it to the company and finding ways to make the perceived risk acceptable. Effective "marketing" of the concept of industrial ecology and of a specific proposal is an essential part of a successful industrial eco-system project.

The main technical, institutional and economic barriers, real or perceived, can be divided into two categories:

Factors which will prevent implementation

- weak economics,
- community acceptance / resistance,
- unacceptable risk or a high level of uncertainty.

Factors which will delay and possibly defeat a project

- lack of a champion,
- multiple participants,
- need to develop a market,
- development of technology,
- regulations.

Economics

The return on investment must be sufficient to motivate all the participants in a project. For example, in developing a partnership to cascade waste heat between a large company and several small ones, the value of the waste heat may be significant to the small partners. But the revenues accruing to the large company for providing the heat may be too small to attract corporate resources.

The industry's effort to effectively invest incremental capital to recover waste heat or other by-product resources cannot always be justified in purely economic terms. The use of some approximate environmental externalities to justify additional capital expenditures would be a useful planning tool to support voluntary industry initiatives related to Canada's climate change and air pollution objectives. Although there has been much debate on the appropriate value for CO_2, NO_x, SO_2, CH_4 and PM emissions to be used, and normally quoted values have very large ranges depending on specific circumstances and whether damage costing or control costing is used, efforts are under way to reach a consensus as to the societal benefits of various actions, such as switching from coal/oil to high efficiency gas. Environmental externalities and other economic instruments such as capital costs allowance, may become useful in promoting sustainable development and related additional capital expenditures.

Community acceptance / resistance.

The companies in the Sarnia-Lambton area are profoundly aware of their corporate citizenship and role in the community. They take care to demonstrate responsible stewardship for their products and manage their waste streams in a manner that complies with or exceeds regulatory requirements. They maintain outreach programs to communicate their plans and progress to the surrounding community. If a new project does not receive community acceptance despite an outreach program, it is very unlikely that the project would proceed.

Risk

If a project is outside a company's core business or involves partners with whom the company is not familiar, the risk may be perceived as unacceptable.

Lack of a project champion

Companies have limited manpower. This can mean that people are not available to lead projects even though the companies would benefit if the project went ahead. This situation can result in the participants being willing followers, none of whom can commit sufficient time to act as a leader.

Leadership is even more critical in developing larger networks which may fail to get off the ground because the gain to any one company is not great, even though the benefit to the group as a whole is significant.

Regulations

Regulations can act as a major impediment. Corporate resources are limited. If the outcome of the approval process is uncertain or if the process is likely to be protracted, resources will probably be reallocated to a project with a more immediate chance of success.

7. OPPORTUNITIES

Based on the findings of the study, the type of the networks which are most likely to be in place, or proposed, are those involving a small number of large companies. These networks can be based on cogeneration and cascading of by-product steam, or may simply be sharing backup steam generating capacity or emergency response capability. They are formed because of clear mutual benefit and the relative ease of establishing relationships between large companies.

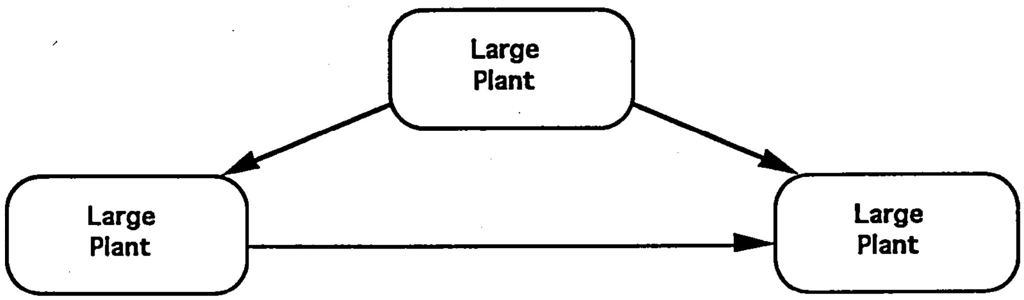


Fig. 7-1: Typical Existing Networks in the Sarnia-Lambton Industrial Complex.

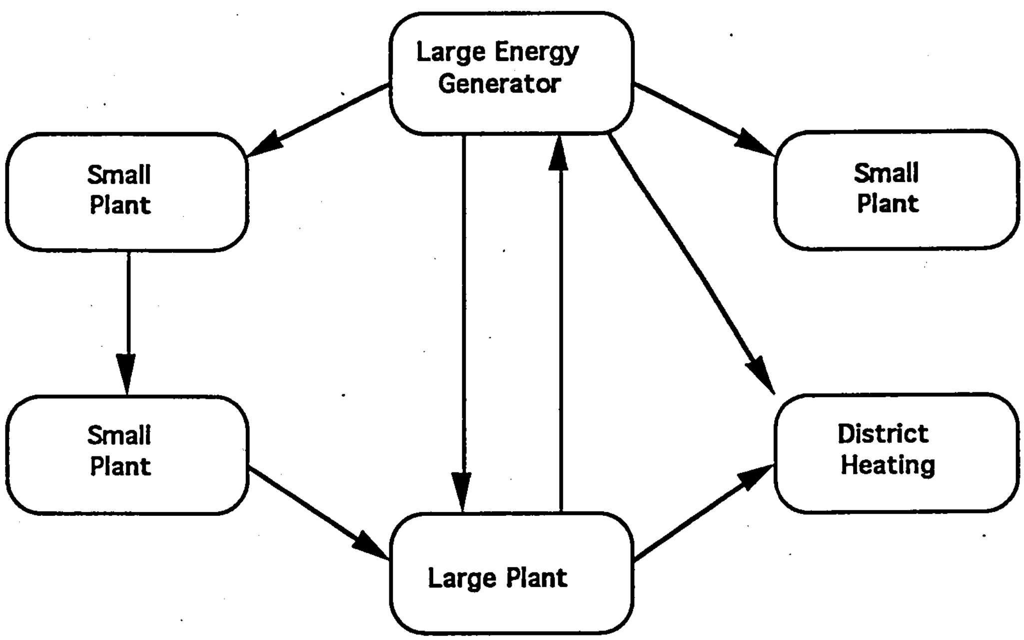


Fig. 7-2: Diagram of an Extended Network

The best starting point for an extended network and a major opportunity in the Sarnia-Lambton area for the creation of an eco-park would be one modeled on the Bruce Energy Centre using one or possibly two major companies as anchors supplying energy to smaller companies. Low pressure steam as well as hot water (condensate) are available from most of the major petrochemical and chemical operations, and they present a definite opportunity for small and medium size users in energy parks. (At one large chemical plant 150,000 gals per minute of 38°C water go to cooling towers.) Energy networks are practical as they use developed technology, costs and revenues can be accurately estimated, and community attitudes are likely to be favourable. Once the network is in place, it can be extended to include other types of by-products.

The wide availability of excess hot water or steam as an opportunity for district heating, while apparently not considered in the past, should not be overlooked and should be reviewed within the overall framework of the industrial eco-system. While in the past, generally, district heating was used mainly in areas of high population concentrations, changes in technology are making it cost-effective to meet the needs of residential communities consisting of single-family homes and a few commercial and institutional buildings. Such applications can be viable and desirable if there are local energy sources and if the district energy offers some distinct social, environmental, and economic benefits.[22]

The development of a wide network for sharing of waste resources, and the establishment of industrial eco-parks that would include not only cascading of waste steam and industrial by-products between various companies of the Sarnia/Lambton industrial corridor, but that could provide the waste heat to the municipality for district heating as well, would go a long way towards the area's sustainable development and pollution prevention. Such a voluntary action approach and the cooperation of the industry/community (that, nevertheless, still must be based on sound economic ground) would also fit rather well into the Responsible Care® Initiative of the chemical industry.

Community leadership of the Sarnia-Lambton area, concerned about continuing job losses and economic decline of the area, is today actively searching for new ideas, opportunities and new ways of supporting the economical renewal within the area. Environmental and recycling industry sectors have been identified to be among those offering opportunities. The Council for Economic Renewal has been striving to establish strong community leadership for economic renewal and a dynamic competitive economic area, to diversify the economic base and to develop an enterpreneurial community. Conditions supporting business development of industrial eco-park(s) within the Sarnia-Lambton area are favourable.

In our preliminary discussions with the Office of Economic Development, a strong interest in our study and potential impact of development of industrial ecological parks on economic renewal and diversification of the community industrial base was shown. We believe that there are definite opportunities for such parks in the Sarnia-Lambton area. There already are five or six areas there in various stages of development, designated as industrial parks. While these parks, today, as other conventional industrial parks, have just road access, electricity, gas and water available, we see an opportunity for the Office of Economic Development jointly with private interests, and perhaps with governmental support, to bring excess high/low pressure steam, hot water, or even off-peak electrical power to one or two of their industrial parks, to establish Sarnia-Lambton's first industrial eco-parks.

8. CONCLUSIONS AND RECOMMENDATIONS

The major companies in the Sarnia / Lambton corridor have been effective in forming partnerships and networks to optimize resources. Examples are cogeneration of electrical power and process steam, and pooling of back-up steam supplies and emergency response capability. Networks typically consist of large companies involved in similar or complementary businesses and consist of a small number of participants. Sharing and cascading of wastes and by-products have had an immediate beneficial impact on the environment, as demonstrated for the seven cases studied in the Sarnia / Lambton industrial complex:

Case	Purpose	Environmental Benefit
Cogeneration	Improved energy efficiency	Reduction of CO_2, SO_2 and NO_x emissions
Flue gas desulfurization gypsum	Beneficial use of a byproduct	Capture of SO_2 and avoidance of landfilling
Production of lightweight aggregate	Manufacture product from fly ash and water treatment sludges	Avoidance of landfilling
Energy from municipal waste	Recover energy from waste	Avoidance of landfilling
Energy from post consumer plastics	Recover energy from plastics that cannot economically be reused or recycled	Product stewardship and avoidance of landfilling
Co-product sulfuric acid	Beneficial use of a co-product	Avoidance of deepwelling
Bruce Energy Centre	Efficient use of by-product energy	Reduction of CO_2, SO_2 and NO_x emissions

Opportunities exist for further sharing and cascading of excess and waste steam and heat to secondary industries, provided economics support such steps. It is not only the availability of these resources, but also the favourable circumstances within the community encouraging the economic renewal of the area, that are supportive of development of industrial ecological parks on the Kalundborg or Bruce Energy Centre models.

There are a number of factors that make the Sarnia-Lambton valley an area particularly well suited for the development and successful operation of a major eco-park, including:

- in-place industrial infrastructure,
- skilled labour force,
- abundant sources of excess / by-product energy,
- available space,
- proximity to major markets in Canada and the U.S.,
- vacuum left following downsizing / departure of major industrial operations,
- need to maintain critical industrial mass in the corridor,
- need to maintain the competitive position within the North American framework of similar petrochemical/chemical areas.

Major companies in the area would, in principle, support such ventures and would be willing to cascade their waste hot water or excess steam for beneficial use by others. However, we strongly believe that for the success of such ventures there is a need to establish and develop such industrial eco-parks on an independent basis, out of the physical boundaries of these companies, and their involvement in operational management and legal responsibility. They have to be organized and managed on a sound economic basis by an independent private entrepreneur, within the framework of a supportive regulatory and political climate.

Recommendations

1) We recommend a follow-up study to define concrete opportunities for the establishment of a Bruce Energy Centre-type of industrial energy park in the Sarnia-Lambton area, to identify and quantify available waste streams, to identify anchor companies, to work with them, the Office of Economic Development and the Council for Economic Renewàl to establish the economics and the necessary incentives.

2) Further, we recommend to verify the findings and applicability of the Sarnia-Lambton initial study in other areas and jurisdictions, especially in older, larger areas, that following departure of obsolete industries, are striving for brownfields redevelopment (Montreal East, Hamilton, sections of downtown Toronto, South Edmonton), re-establishment of their economic base and integration of such eco-parks into the cities' civic structures such as district heating.

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APPENDIX 1

Contact List

CONTACT LIST

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Fibrex Insulations Inc.	Geoffrey Moore President	(519) 336-7770
Imperial Oil Limited	Pat Foley Land & Waste Management Systems	(519) 339-4814
	Peter Forristal Environmental Group Leader	(519) 339-2191
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Notes: * by phone only
** no participation, due to conflicting schedule, or no interest

Organizations	Contact	Phone number
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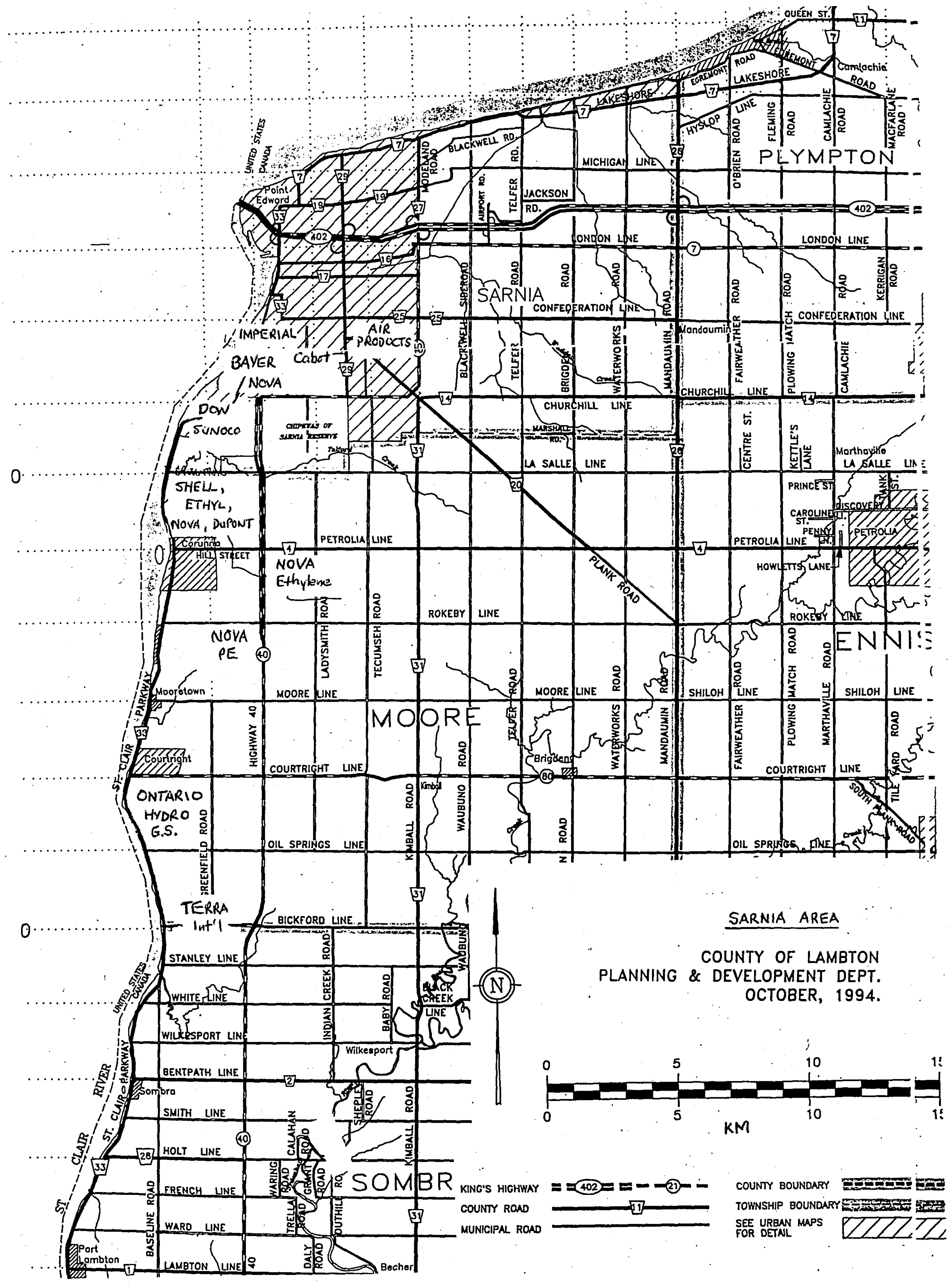
Office of Economic Development	Mike Ireland Development Manager George Mallay General Manager	(519) 332-1820

APPENDIX 2

Lambton County Map


SARNIA AREA
COUNTY OF LAMBTON
PLANNING & DEVELOPMENT DEPT.
OCTOBER, 1994.
KM
KING'S HIGHWAY
COUNTY ROAD
MUNICIPAL ROAD
COUNTY BOUNDARY
TOWNSHIP BOUNDARY
SEE URBAN MAPS FOR DETAIL
PLYMPTON
SARNIA
MOORE
SOMBR
ENNIS
IMPERIAL
AIR PRODUCTS
BAYER
Cabot
NOVA
DOW
SUNOCO
SHELL, ETHYL, NOVA, DuPONT
NOVA Ethylene
NOVA PE
ONTARIO HYDRO G.S.
TERRA Int'l
Point Edward
Camlachie
Mandaumin
Marthaville
Corunna
Mooretown
Courtright
Brigden
Kimball
Wilkesport
Sombra
Port Lambton
Becher
PETROLIA
QUEEN ST.
LAKESHORE
EGREMONT ROAD
HYSLOP LINE
BLACKWELL RD.
MICHIGAN LINE
JACKSON RD.
LONDON LINE
CONFEDERATION LINE
CHURCHILL LINE
LA SALLE LINE
PETROLIA LINE
PLANK ROAD
ROKEBY LINE
MOORE LINE
SHILOH LINE
COURTRIGHT LINE
OIL SPRINGS LINE
BICKFORD LINE
STANLEY LINE
WHITE LINE
WILKESPORT LINE
BENTPATH LINE
SMITH LINE
HOLT LINE
FRENCH LINE
WARD LINE
LAMBTON LINE
ST. CLAIR PARKWAY
ST. CLAIR RIVER
UNITED STATES
CANADA
HIGHWAY 40
CHIPPEWAS OF SARNIA RESERVE