Possibilités pour les réseaux et les partenariats en écologie industrielle dans la région de Montréal

le 15 decembre 1997

Opportunities for Industrial Ecology Networks and Partnerships in the Montreal Area

Présenté à :

ENVIRONNEMENT CANADA

- **Direction du pétrole, du gaz et de l'énergie**
  Direction générale de la prévention de la pollution atmosphérique
- **Région du Québec**
  Technologies industrielles

Prepared by:

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JAN Consultants

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ACKNOWLEDGMENTS

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The list of the individuals, whose assistance is gratefully acknowledged here, is given in the appendix of this study.

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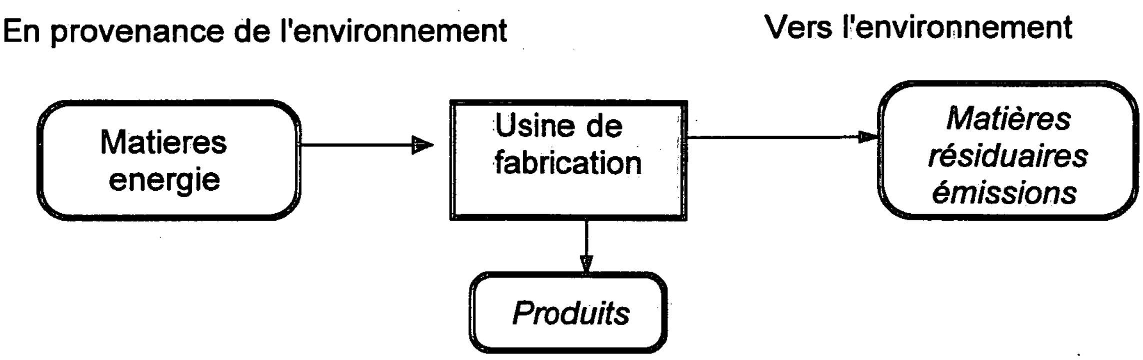
Contexte

Les industries ont toujours été isolées les unes des autres plutôt qu'intégrées. Les usines de fabrication ont évolué comme si elles étaient des îles, utilisant des ressources, produisant des biens et éliminant leurs déchets du mieux qu'elles le peuvent compte tenu des règlements ou des pressions économiques. Cette façon de procéder suppose que les ressources resteront abondantes et que l'environnement peut continuer à tolérer l'élimination des déchets, ce qui est de plus en plus douteux. Il convient donc de chercher des moyens de réaligner les industries, de les relier en réseaux, de façon à conserver les ressources et à réduire le plus possible les pressions imposées à l'environnement.

Île de fabrication type



Le terme écologie industrielle décrit les réseaux industriels dans lesquels les industries sont reliées par symbiose. Dans des écosystèmes industriels entièrement développés, les industries membres ont élaboré des réseaux afin d'optimiser l'utilisation de l'énergie, de l'eau et des matières. En ce qui a trait à l'énergie, cela comprendrait le partage les flux de déchets à grande énergie, comme les gaz d'échappement des chaudières et la vapeur haute pression, ainsi que les sources à faible énergie, comme l'eau de refroidissement post-traitement utilisée pour le chauffage des locaux. Dans ces écosystèmes industriels, l'eau serait redistribuée en cascade dans toutes les composantes de la * communauté + et répondrait aux exigences en matière de qualité de l'eau. Par exemple, l'eau résiduaire traitée dans un site pourrait servir d'eau de refroidissement dans un autre site au lieu d'utiliser de l'* eau municipale + potable. Les matières résiduaires et les sous-produits industriels de certaines opérations, comme les cendres volantes, les résidus de désulfuration des gaz d'émission, les boues, les solvants épuisés, les déchets de bois et les résidus de papier, ou le laitier de fonte et d'acier, peuvent servir de matière première à d'autres industries.

Le concept d'écologie industrielle, tel que démontré à Kalundborg au Danemark, et au Bruce Energy Centre, près de Kincardine en Ontario, a prouvé que le fait de relier des industries et des services en réseaux afin de * cascader + les sous-produits et les déchets peut contribuer considérablement au développement durable. Les réseaux économisent aux niveaux des matières premières et de l'énergie et évitent divers types de pollution de l'air, de l'eau et du sol tout en maintenant la production et en conservant les emplois.

L'écologie industrielle donne un bon coup de pouce au développement durable et elle va de paire avec les initiatives de la politique fédérale en matière d'environnement qui visent à rendre le développement durable une réalité au Canada :

- Le Plan d'action fédéral sur le changement climatique.
- La Politique de gestion des substances toxiques.
- Le Plan de gestion des oxydes d'azote et des composés organiques volatils.
- L'Accord Canada-États-Unis sur la qualité de l'air.
- Le Programme des Grands-Lacs.

Objectifs

Après le succès remporté à Kalundborg et au Bruce Energy Centre, on peut se demander si des conditions semblables rencontrées ailleurs permettraient de former des réseaux écologiques industriels. En réponse à cette question, une étude a été faite dans plusieurs secteurs industriels de la région de Montréal afin de voir jusqu'à quel point des partenariats et des réseaux s'étaient formés et, dans la négative, de cerner les facteurs qui en ont empêché la formation. Une étude semblable effectuée dans la région de Sarnia-Lambton, en Ontario, a été terminée en mars 1997.

Les principales questions posées dans cette étude sont :

- jusqu'à quel point les industries forment-elles des partenariats et des réseaux afin d'optimiser la consommation de ressources et de réduire le plus possible les résidus et les émissions?
- qu'est-ce qui pousse la formation de ces partenariats et réseaux?
- dans les cas où des partenariats potentiels n'ont pas été formés, quels ont été les obstacles?

Secteurs visés

Montréal-Est, Bécancour, Varennes, Sorel-Tracy, et l'aménagement des sites industriels urbains contaminés dans le district de Saint-Henry-Petite-Bourgogne du canal Lachine, ainsi qu'une étude de cas du réaménagement des sites industriels urbains contaminés de Trenton, au New-Jersey.

Méthodologie

Faire appel à la coopération des associations industrielles, des agences gouvernementales et autres groupes de coordination. Réunir l'information sur les cas des entreprises individuelles.

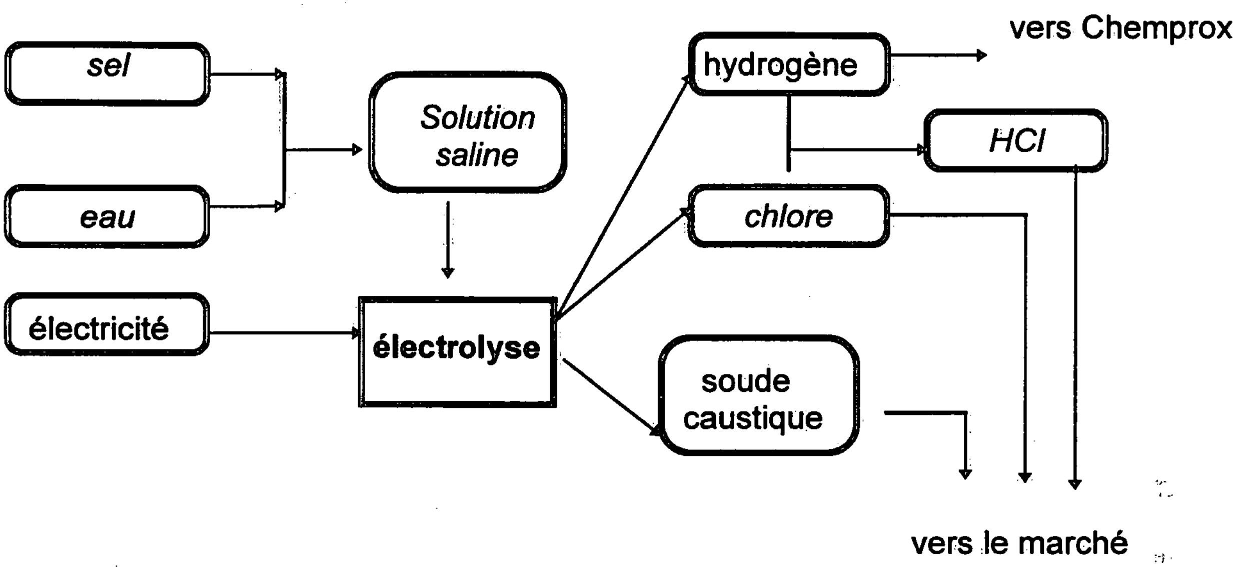
Constatations

Les industries réussissent à former des réseaux dans les parcs industriels. Ces réseaux sont de trois types :

1. **Partage des ressources**, où un produit ou co-produit d'une industrie devient une matière première ou une source d'énergie pour d'autres.

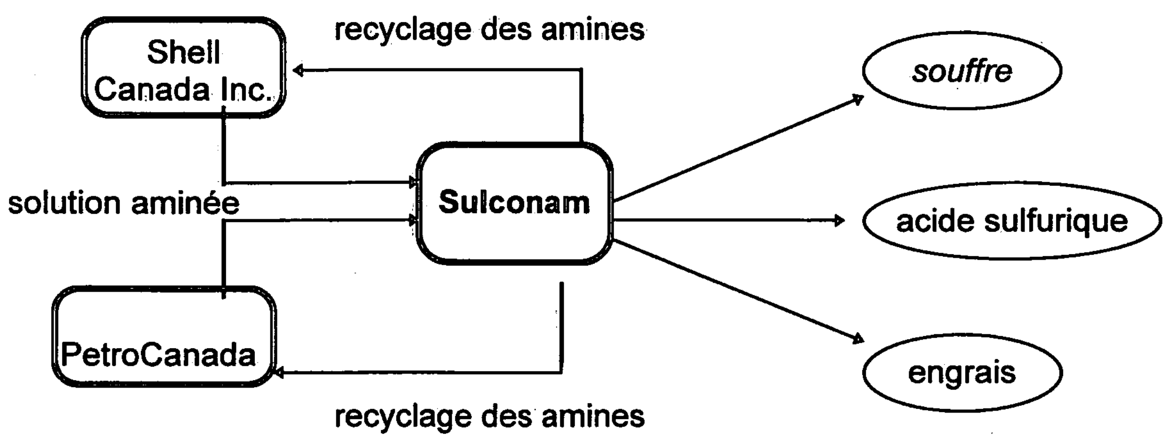
Un exemple : l'hydrogène, qui est un co-produit de la production de chlore à la ICI Canada, est fourni comme matière première à Chemprox et, dans une moindre mesure, à Hydrogenal à Bécancour.

Réseau d'ICI Canada pour l'hydrogène et autres co-produits de la production de chlore



2. **Valorisation des matières résiduaires.** Les réseaux formés dans le but de trouver des utilisations à valeur ajoutée pour les matières résiduaires en réponse aux facteurs économiques, à l'émergence de nouvelles technologies, aux règlements changeants ou aux modifications de la politique interne de l'entreprise. Ces réseaux ou liens peuvent se former avec d'autres entreprises dans un parc industriel ou avec des entreprises à l'extérieur du parc industriel; par exemple, la récupération du soufre et la production d'acide sulfurique et d'engrais par Sulconam à partir du raffinage des flux gazeux de Shell et de PetroCanada à Montréal-Est.

Sulconam se spécialise dans des produits à valeur ajoutée à partir des flux de gaz acides des raffineries



3. **Réseaux d'appui**. Tous les secteurs impliqués dans cette étude ont des réseaux qui mettent en commun les ressources nécessaires pour traiter des questions de nature non concurrentielle. Les ressources mises en commun couvrent généralement :

- les mesures d'urgence,
- la surveillance de la qualité de l'air ambiant,
- l'eau pour lutter contre les incendies,
- le traitement des eaux usées,
- les accès communs aux voies ferrées et aux routes,
- la participation communautaire.

Facteurs

L'économie est le principal facteur qui contribue à la formation de réseaux entre les entreprises. En voici un bon exemple : chercher à trouver une utilisation à valeur ajoutée des résidus lorsqu'une entreprise doit faire face à des coûts accrus pour l'enfouissement, ou lorsqu'on veut conserver la capacité des sites d'enfouissement existants afin de reporter le coût d'en ouvrir de nouveaux.

La nécessité d'établir des liens pour améliorer la compétitivité, maintenir la masse critique dans une zone industriel en déclin, ou résoudre un problème pressant catalyse les efforts en accélérant les processus de prise de décisions. Montréal-Est est un exemple d'une zone dont la base industrielle a connu un déclin et qui prend des mesures actives pour en sortir.

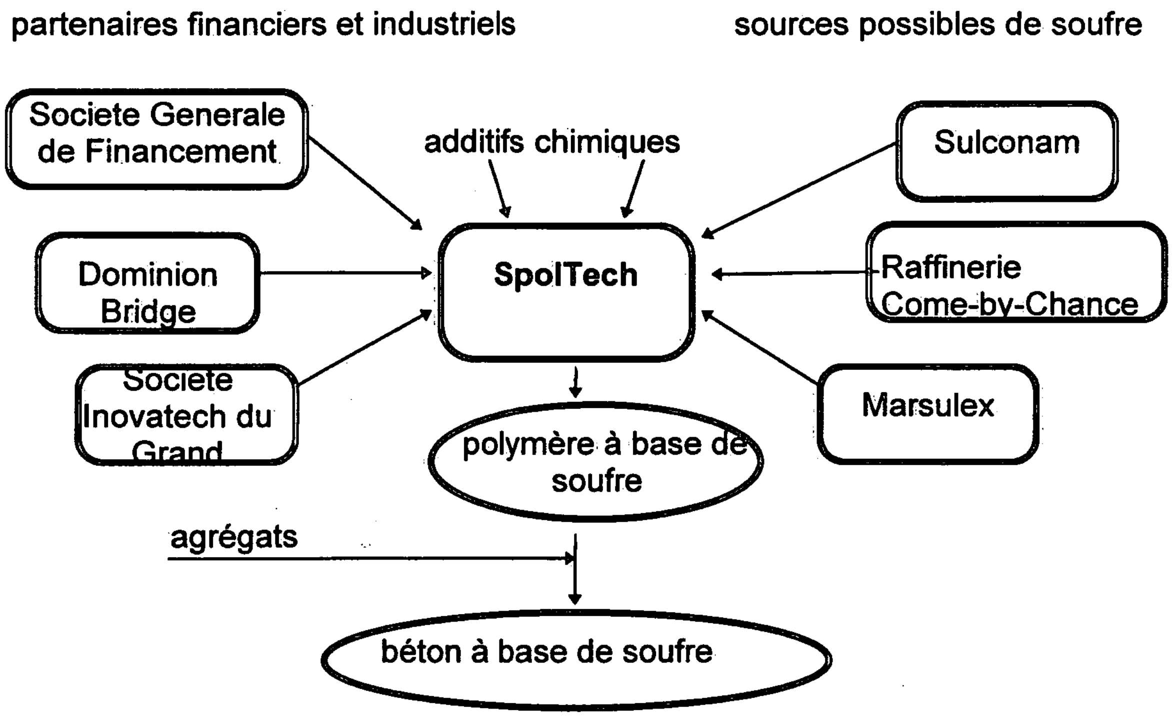
La responsabilité associée aux matières résiduaires. Les matières entreposées ou éliminées peuvent constituer une responsabilité future si les règlements changent, ou si des problèmes surgissent sur le site d'entreposage ou d'élimination.

Les politiques et la vision de l'entreprise. L'attitude de l'entreprise vis-à-vis de la prévention de la pollution et de la gérance de l'environnement se traduit par la formation de liens entre les entreprises dans le but de recycler les matières résiduaires, ou par des investissements dans le but de réduire les incidences environnementales des activités de la compagnie. Par exemple, Dow Chemical Canada à Varennes a trouvé des façons de recycler presque toutes ses matières résiduaires à l'interne, ou par le biais d'autres compagnies. En raison de sa vision d'entreprise, Dow a investi dans de l'équipement mettre son eau de procédé en circuit fermé, ce qui fait que cette compagnie ne puise plus d'eau du fleuve depuis 1990. Cette approche sera de plus en plus utilisée à mesure que les entreprises chercheront à établir des programmes environnementaux volontaires comme alternative aux règlements gouvernementaux additionnels.

Développeurs de technologies. Les entreprises qui développent de nouvelles technologies qui peuvent convertir un flux de déchets en un produit ou une matière première créent des liens entre les compagnies. Cela se traduit par la création d'emplois et une valeur ajoutée pour la collectivité.

Par exemple, SpolTech, à Montréal-Est, utilisera du soufre qui est le sous-produit d'un procédé pour faire un polymère employé dans le béton à base de soufre.

SpolTech produit du béton à base de soufre à partir de soufre récupéré



Entreprises spécialisées. Les compagnies qui se spécialisent dans le recyclage relient les producteurs d'un déchet ou d'un sous-produit aux marchés pour cette matière. Par exemple :

- Nova Pb qui récupère le plomb des vieilles piles dans l'est du Canada et le nord-est des États-Unis;
- Recyclage d'Aluminium Québec Inc. qui récupère l'aluminium des mattes de l'usine ABI de Bécancour et d'autres sources;
- Safety Kleen qui ramasse et recycle les fluides industriels d'une vaste gamme d'industries;
- Inland Technologies Inc. qui récupère l'éthylène glycol des fluides de déglaçage à l'aéroport Dorval.

Les développeurs de technologies et les entreprises spécialisées jouent un rôle majeur dans la formation de liens. Ils déterminent le besoin d'un procédé ou d'un service, et assument presque entièrement les risques associés à sa mise en oeuvre.

Facilitateurs

Associations d'industries. Ces groupes conservent activement les ressources des compagnies en réduisant les doubles emplois lorsqu'ils traitent des questions communes de nature non concurrentielle.

Groupes de développement. Les groupes de développement industriel comme CODEV, à Varennes, et les organisations semblables à Montréal-Est et à Sorel-Tracy favorisent la synergie dans leurs domaines respectifs. Cela est apparent dans les dossiers que chacun des groupes a montés dans un effort pour attirer l'usine d'éthanol proposée par Canadian Alcohols. Cette usine signifierait des investissements d'environ 100 millions de dollars et la création de 150 emplois permanents. Les liens auxquels on pourrait s'attendre avec l'implantation de la nouvelle usine d'éthanol avec les usines existantes sont semblables dans chaque cas :

- accès aux routes, au chemin de fer et à l'eau,
- eau,
- eau pour lutter contre les incendies,
- mesures disponibilité de vapeur,
- d'urgence.

Groupes de coordination. Ces groupes ont un vaste mandat et comprennent généralement les représentants des associations industrielles, des divers paliers de gouvernement ainsi que des groupes communautaires. En voici quelques exemples : SADC, une agence du gouvernement fédéral qui appuie et coordonne les activités des groupes de développement à Sorel-Tracy, et la Table de concertation pétrochimie qui traite des questions relatives au raffinage et aux produits de la pétrochimie à Montréal-Est, Varennes et Bécancour.

Organismes gouvernementaux. Les organisations gouvernementales aux niveaux fédéral, provincial et municipal jouent un rôle clé dans la stimulation du développement durable en communiquant à la fois leur vision et leur orientation, et en facilitant le développement en réduisant les risques financiers, en soutenant financièrement la construction des infrastructures ou en réduisant les tracasseries administratives et le délai nécessaires pour obtenir les autorisations requises.

Obstacles

Règlements. Les règlements qui s'appliquent à la protection de l'environnement peuvent, dans certains cas, décourager le recyclage. Il existe trois exemples de ce genre d'obstacle : Nova Pb, Eaglebrook et Recyclage d'Aluminium Québec Inc. que la classification des matières recyclables en déchets dangereux assujettit au *Règlement sur l'exportation et l'importation des déchets dangereux*. Ces règlements finissent par imposer un fardeau administratif, par réduire la souplesse d'opération et, avec l'application de droits d'utilisation, ils peuvent réduire la capacité des entreprises à importer des matières des États-Unis et influent donc sur leurs économies d'échelle.

Un autre obstacle d'ordre réglementaire cité par Chemprox est la complexité et la durée du processus d'approbation qui retardent ses projets d'expansion.

Économie. Les facteurs économiques freinent le développement de projets durables dans certaines régions. Par exemple, la demande relativement faible pour de la propriété industrielle ralentit le rédéveloppement du Canal Lachine et de Montréal-Est et, dans une certaine mesure, le développement de Sorel-Tracy. Les enjeux économiques et politiques ont également entraîné l'arrêt de deux importants projets de cogénération (Montréal-Est, Bécancour) et de plusieurs petits projets du même genre.

Il y a également le fait qu'on ne peut pas toujours justifier en termes purement économiques l'investissement de capitaux marginaux dans le but de récupérer de la chaleur résiduaire. L'utilisation de certains facteurs environnementaux approximatifs pour justifier des dépenses additionnelles en capital serait un moyen utile d'appuyer les initiatives volontaires liées aux objectifs du Canada en ce qui a trait au changement climatique et à la pollution atmosphérique. Même si on a beaucoup débattu de la valeur appropriée des émissions de CO_2, NO_x, SO_2, CH_4 et de matières particulaires à utiliser, et normalement les valeurs citées sont accompagnées de plages très vastes selon des circonstances précises et selon que l'on se sert du coût des dommages ou de celui des moyens de lutte, on tente actuellement de forger un consensus en ce qui a trait aux avantages pour la société de diverses mesures comme passer du charbon ou du pétrole au gaz. Les facteurs environnementaux et autres instruments économiques, comme les déductions pour amortissement, peuvent devenir utiles dans la promotion des investissements liés au développement durable.

Poussée technologique. Les développeurs de technologie dont les produits ou les services ne sont pas encore sur le marché font face à des difficultés qui pourraient perdurer comme, par exemple, le procédé Cansolv pour absorber le SO_2 des flux gazeux et le rendre disponible sous forme de produit.

Responsabilité. Le réaménagement des terrains industriels urbains contaminés est freiné par les préoccupations relatives à la chaîne de responsabilité qui pourrait relié les promoteurs d'un site industriel vacant aux utilisations antérieures du site, même s'il a apparemment été restauré pour répondre aux normes requises. Aux États-Unis, les règlements du gouvernement fédéral et des États ont été élaborés de façon à protéger les promoteurs et les prêteurs contre ce genre de responsabilité.

Possibilités

Les entreprises recherchent activement des moyens de réduire leur consommation d'énergie et de matières premières ainsi que leur production de matières résiduaires ou de valoriser ces dernières. Cette recherche, mue par des facteurs économiques, a porté fruits et continuera de fournir de nouvelles possibilités, dont un grand nombre ont été mentionnées par les entreprises mais ne sont pas citées dans le présent rapport pour des raisons de confidentialité.

Le tableau ci-après contient des possibilités précises signalées dans le cadre de cette étude qui pourraient tarder à être prises en considération en raison de leur nature ou du risque à long terme. Les organisations en cause pourraient participer à l'évaluation de ces possibilités, mais il faudrait pour cela l'injection de fonds de lancement.

Projet	Emplacement	Description	Avantages environnementaux
Cogénération	Montréal-Est ou Bécancour Sorel-Tracy	Étudier la possibilité d'installer une unité de cogénération de 15-20 MW	Utilisation efficace de l'énergie et prévention de la pollution
Base de données sur les matières résiduaires des procédés	Principales zones industrielles de la région de Montréal	Mettre sur pied une base de données sur les quantités de matières résiduaires, et leur composition, qui ne sont pas valorisées pour le moment	Prévention de la pollution et conservation des ressources
Chauffage urbain	Montréal-Est	Étude de la possibilité de mettre au point un système de chauffage urbain utilisant la vapeur produite par la raffinerie de PetroCanada	Utilisation efficace de l'énergie et prévention de la pollution
Séquestration du dioxyde de carbone	Bécancour	Étudier la possibilité de capture photosynthétique du sous-produit CO_2 de Norsk Hydro	Réduction des émissions de gaz à effet de serre
Possibilités d'écoparc industriel	Sorel/Tracy Contrecoeur	Évaluer les possibilités et les stratégies d'aménagement d'écoparcs industriels	Utilisation efficace de l'énergie et des matières premières et prévention de la pollution
Écoparc industriel	Montréal-Est	Étudier la possibilité d'aménager un écoparc industriel sur un terrain industriel urbain contaminé	Recyclage de terrain, utilisation efficace de l'énergie et des matières premières et prévention de la pollution

Résumé des cas étudiés

Cas	But	Avantages environnementaux
Bécancourt		
ICI Canada	Cascadage du sous-produit H_2	Remplace le H_2 des sources primaires
Norsk Hydro	Épandage des matières résiduaires en guise d'engrais	Réduit l'enfouissement
SKW	Utilisation des fumées de silice	Réduit l'enfouissement
Recyclage d'Aluminium Québec	Récupération d'aluminium à partir des mattes	Récupération de l'aluminium
Montréal-Est		
PetroCanada	Résidus du procédé utilisés comme combustible	Remplace les combustibles conventionnels dans la cimenterie
Sulconam	Récupération du soufre, utilisation des résidus comme engrais	Réduit les émissions de SO_2, utilisation à valeur ajoutée du NH_3
CCR	Fournit du cuivre et de la vapeur aux entreprises voisines	Réduit la quantité d'énergie nécessaire pour produire de la vapeur
Varennes		
KRONOS	Gypse de sous-produit utilisé pour fabriquer des cloisons sèches, récupération de CO_2	Neutralise les effluents acides, réduit la quantité d'énergie nécessaire pour produire du CO_2
Pétromont	Cascade la vapeur vers deux usines voisines	Réduit la quantité d'énergie nécessaire pour produire de la vapeur
Dow Chemical	Recyclage des déchets du procédé, système d'eau en circuit fermé	Réduit l'enfouissement, aucun effluent rejeté dans le fleuve
Sorel-Tracy		
HEBCO	Pyrolyse des vieux pneus	Récupère des produits à partir des vieux pneus
Conporec	Compostage des déchets municipaux	Produit du compost et récupère les matières récupérables des déchets
Entreprises de récupération des ressources		
Nova Pb	Récupération du plomb et du polypropylène des piles, combustibles dérivés des déchets	Recycle de plomb et le polypropylène, récupère l'énergie à partir des déchets
Eaglebrook	Production de chlorure ferrique	Récupère un produit du flux de déchets

Cas	But	Avantages environnementaux
Safety-Kleen	Récupération de fluides industriels	Recyclage et récupération d'énergie à partir des déchets
Inland Technologies	Récupération de glycol à partir des fluides de déglaçage	Recyclage et réduction des effluents
Développeurs de technologies		
Cansolv	Dépoussiérage au solvant du SO_2	Réduit les émissions de SO_2
SpolTech	Applications du soufre de sous-produit en construction	Recyclage des matériaux de construction
Réaménagement des terrains industriels urbains contaminés		
Trenton, New-Jersey	Réaménagement des aciéries Roebling	Recyclage de terrains et d'immeubles
Montréal (Québec)	Réaménagement d'une partie du canal Lachine	Recyclage de terrains et d'immeubles

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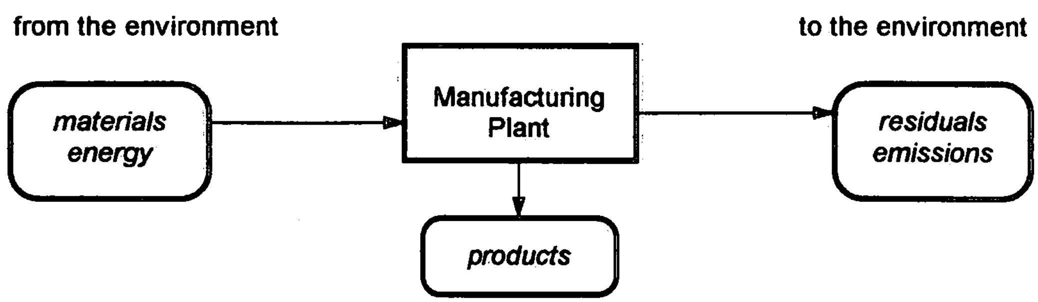
EXECUTIVE SUMMARY

Background

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 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 are 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.

Typical Manufacturing Island



The term industrial ecology has been coined to describe industrial networks in which industries are symbiotically linked. In fully evolved industrial ecosystems member industries have developed networks to optimize 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, like 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 "city water" as a resource. 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 used as raw materials by other industries.

The concept of industrial ecology as demonstrated at Kalundborg in Denmark, and at the Bruce Energy Centre near Kincardine in Ontario, has shown that linking industries and services in networks to cascade byproducts and wastes can make a valuable contribution to sustainable development. Networks conserve material and energy resources and prevent various types of air, water and land pollution while at the same time maintaining output and jobs.

Industrial ecology makes a valuable contribution to sustainable development and is consistent with Federal environmental policy initiatives aimed at making sustainable development a reality in Canada. These policies include:

- The Federal Action Plan on Climate Change.
- Toxic Substances Management Policy.
- Management Plan for Nitrogen Oxides and Volatile Organic Compounds.
- Canada-U.S. Air Quality Agreement
- Great Lakes Program.

Objectives

The success of both Kalundborg and the Bruce Energy Centre raises the question of whether similar conditions at other locations would also support formation of industrial ecological networks. In response to this question a study was made of a number of industrialized areas in the Montreal Region to identify the extent to which partnerships and networks had formed and, if they had not, to identify the factors that had inhibited them. A similar study of the Sarnia-Lambton area in Ontario was completed in March 1997.

The specific questions addressed in the study are:

- to what extent do industries form partnerships and networks to optimize resource consumption and minimize residuals and emissions?
- what are the drivers behind formation of such partnerships and networks?
- in cases where potential partnerships have not formed, what were the barriers?

Focus areas

Montreal East, Becancour, Varennes, Sorel-Tracy, and brownfield development in the St. Henri-Little Burgundy district of the Lachine Canal as well as a case study of brownfield redevelopment Trenton, NJ.

Methodology

Enlist the cooperation of industry associations, government agencies and other coordinating groups. Gather information for cases from individual companies.

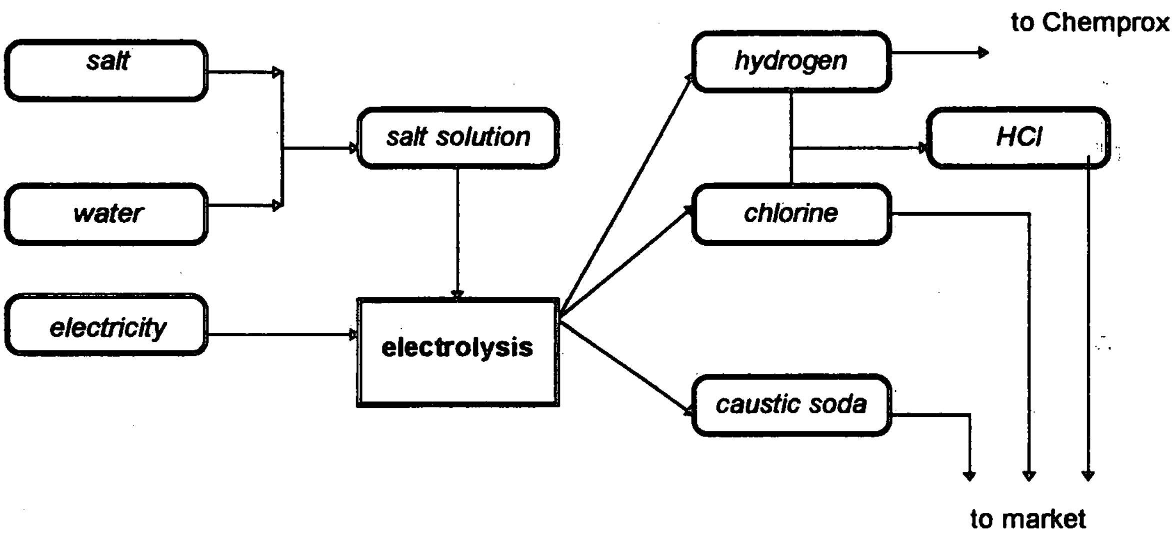
Findings

Industries are effective in forming networks within industrial parks. These networks consist of three basic types:

1. **Resource sharing,** where a product or coproduct of one industry becomes a feedstock or energy source for others.

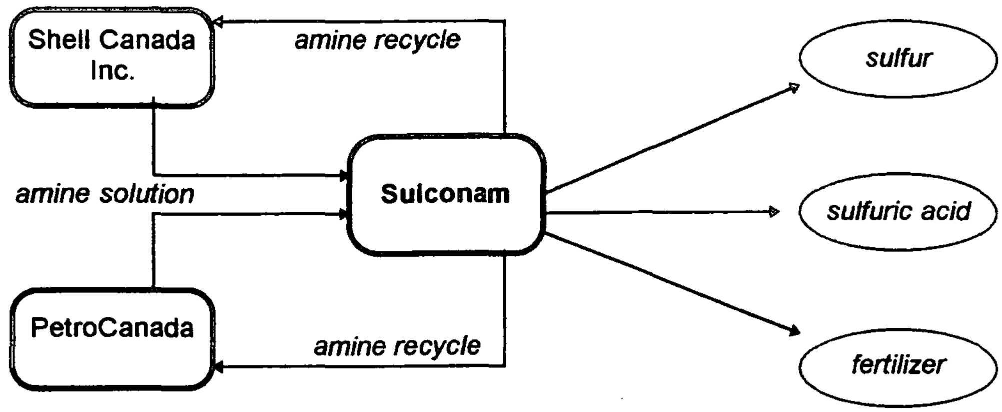
   An example is coproduct hydrogen from chlorine production by ICI Canada. The hydrogen is supplied as raw material to Chemprox and to a smaller extent to Hydrogenal at Becancour:

ICI Canada's Network for Hydrogen and Other Coproducts of Chlorine Production



2. **Beneficiation of residuals.** Networks formed for finding value added uses for residuals develop in response to economic factors, emergence of new technologies, changing regulations, or shifts in corporate policy. These networks or links may be formed with other companies in an industrial park or with companies outside the park. An example is recovery of sulfur and production of sulfuric acid and fertilizer by Sulconam from refinery gas streams from Shell and PetroCanada in Montreal East.

Sulconam Produces Value Added Products from Refinery Acid Gas Streams



3. **Support Networks.** All of the regions involved in the study have networks which pool resources to deal with issues of a non-competitive nature. The pooled resources typically cover:

- emergency response,
- ambient air quality monitoring,
- fire water,
- waste water treatment,
- common rail and road access,
- community outreach.

Drivers

Economics is the primary factor which contributes to the formation of networks among companies. A good example of this is the effort to find a value added use for residuals when an operation is faced with increasing landfill costs, or to conserve landfill capacity to defer the cost of opening a new one.

Necessity. The need to develop links either to improve competitiveness, maintain the critical mass in a declining industrial area, or to solve a pressing problem, catalyses the efforts to form linkage by accelerating decision making processes. Montreal East is an example of an area which has experienced a decline in its industrial base and is taking active steps to reverse the decline.

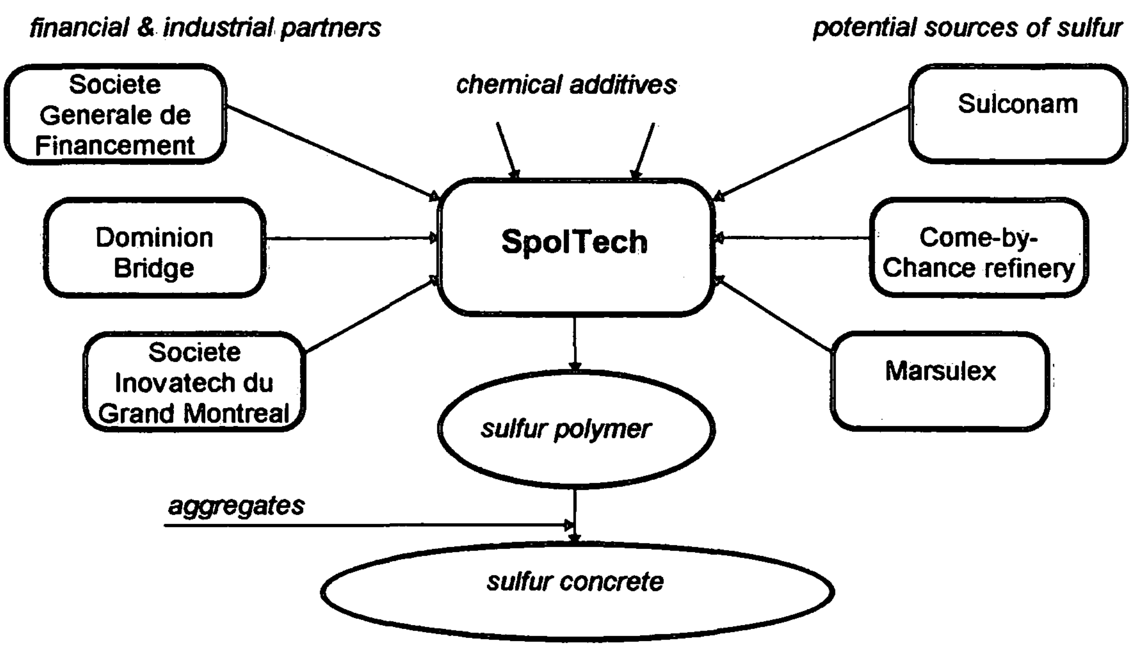
Liability associated with residuals. Stored or disposed of materials may constitute a future liability if regulations change, or if problems occur with a storage or disposal site.

Corporate policies and corporate vision. Corporate attitudes to pollution prevention and environmental stewardship result in formation of links between companies for the purpose of recycling waste materials, or result in investment to reduce the environmental effects of a company's operations. As an example, Dow Chemical Canada at Varennes has found ways to recycle virtually all its waste materials either internally or through other companies. Dow, in response to corporate vision, has invested in equipment to close-loop its process water and has been "off the river" since 1990. This approach will be increasingly relevant as companies seek to establish voluntary environmental programs as an alternative to additional government regulation.

Technology Developers. Technology development companies that can convert a waste stream into a product or feedstock create links between companies. This can result in job creation and also add value to the community.

An example is SpolTech in Montreal East which will use byproduct sulfur to make a polymer for use in sulfur concrete.

SpolTech Produces Sulfur Concrete from Recovered Sulfur



Expert Companies. Companies, which specialize in recycling, link the generators of a waste or byproduct with markets for the recycled material. Examples include:

- Nova Pb which recovers lead from used batteries in Eastern Canada and the North Eastern U.S.
- Recyclage d'Aluminium Quebec Inc. which recovers aluminum from dross from the ABI plant at Becancour and other sources.
- Safety Kleen which collects and recycles industrial fluids from a wide range of industries.
- Inland Technologies Inc. which reclaims ethylene glycol from used deicer fluid at Dorval Airport.

The technology developers and specialized companies have a key role in forming linkages. They identify the need for a process or service and assume much of the risk involved in implementation.

Facilitators

Industry associations. These groups actively conserve company resources by reducing duplication of effort in dealing with common issues of a non-competitive nature.

Development groups. Industrial development groups such as CODEV at Varennes and counterpart organizations in Montreal East and Sorel-Tracy, promote synergy in their respective areas. This is apparent in the dossiers that each has assembled in an effort to attract the ethanol plant proposed by Canadian Alcohols. This plant would mean an investment of about $100 million and create 150 permanent jobs. The links which the proposed ethanol plant could expect with the existing industries are similar in each case. They include:

- the availability of steam,
- road, rail and water access,
- water,
- firewater,
- emergency response.

Coordinating groups. Groups of this type have a broad mandate and generally include representatives from industry associations, various levels of government as well community groups. Examples are: SADC, a federal government agency which assists and coordinates the activities of development groups in Sorel-Tracy, and the Table de concertation petrochimie which deals with issues involving refining and petrochemicals in Montreal East, Varrennes and Becancour.

Government bodies. Government organizations at the federal, provincial and municipal levels have a key role in stimulating sustainable development by communicating both vision and direction, and by facilitating development through reduction of financial risk, underwriting infrastructure or by reducing the complexity and time needed to get the necessary approvals.

Barriers

Regulations. Regulations aimed at environmental protection may in some cases discourage recycling. A specific example encountered on three occasions (Nova Pb, Eaglebrook and Recyclage d'Aluminium Quebec Inc.) involves classification of recyclable materials as hazardous waste thus making them subject to the Export and Import of Hazardous Waste Regulations (EIHWR). The result of these regulations is to impose a paperwork burden, to reduce operating flexibility and, with the implementation of user fees, may reduce their ability to import materials from the U.S. and thus affect their economies of scale.

Another regulatory barrier cited by Chemprox is the complexity and length of the approval process which caused delays in carrying out a plant expansion.

Economics. Economic factors are holding back development of sustainable projects in some areas. For example the relatively weak demand for industrial property is slowing down the redevelopment of both the Lachine Canal and Montreal East, and to some extent development in Sorel-Tracy. Economic and policy issues have also resulted in two major (Montreal East and Becancour) and a number of smaller cogeneration projects being put on hold.

Another issue is that investing incremental capital to recover waste heat cannot always be justified in purely economic terms. The use of some approximate environmental externalities to justify additional capital expenditures would be a useful tool to support voluntary initiatives related to Canada's climate change and air pollution objectives. Although there has been mush debate on the appropriate value for CO_2, NO_x, SO_2, CH_4 and PM emissions that should 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 underway to reach a consensus as to the societal benefits of various actions such as switching from coal/oil to gas. Environmental externalities and other economic instruments, such as capital cost allowance, may become useful in promoting capital investment related to sustainable development.

Technology Push. Technology developers whose product or service has not yet gained commercial acceptance face a potentially long uphill struggle. An example is the Cansolv process for absorbing SO_2 from gas streams and making it available as a product.

Liability. Brownfield redevelopment suffers from concerns about the chain of liability which may link developers of a vacant industrial site to previous uses of the site, even though it has apparently been rehabilitated to the required standards. U.S. federal and state regulations have been developed to shield developers and lenders from such liabilities.

Opportunities

Companies actively search for opportunities to reduce energy and material input to their processes, and to reduce or find value added uses for residuals. This search, driven by economic factors has been successful and will continue to find new opportunities. A number of these were mentioned by the companies but because of their confidential nature, they have not been included in this report.

In the table below are specific opportunities noted during this study which, because of their long-term nature or risk, may not receive early attention. The organizations involved would cooperate in evaluation of these opportunities but an injection of seed funding is required.

Project	Location	Description	Environmental Benefits
Cogeneration	Montreal East or Becancour Sorel/Tracy	Study the feasibility of installing a 15-20 MW cogeneration unit	Efficient use of energy and pollution prevention.
Process residuals information base	Montreal Region major industrial areas	Develop an information base of quantities and composition of process residuals that are not currently beneficiated	Pollution prevention Resource conservation
District heating	Montreal East	Study the feasibility of developing a district heating system using steam from the PetroCanada refinery	Efficient use of energy and pollution prevention.
Sequestering carbon dioxide	Becancour	Study the feasibility of photosynthetic capture of byproduct CO_2 from Norsk Hydro	Reduction of greenhouse gas emissions
Industrial ecopark opportunities	Sorel/Tracy Contrecoeur	Evaluate opportunities and development strategies for industrial ecoparks	Efficient use of energy and raw materials, and pollution prevention
Industrial ecopark	Montreal East	Study the feasibility of developing an industrial ecopark on brownfield property.	Recycling land, efficient use of energy and raw materials, and pollution prevention

Summary of Cases Studied

Case	*Purpose*	*Environmental Benefits*
Becancour		
ICI Canada	Cascading byproduct H_2	Replaces H_2 from primary sources
Norsk Hydro	Fertilizer application for residual	Reduces landfilling
SKW	Construction industry use of silica fume	Reduces landfilling
Recyclage d'Aluminium Quebec	Recovery of aluminum from dross	Recovery of aluminum
Montreal East		
PetroCanada	Fuel use of process residuals	Replaces conventional fuels at cement plant
Sulconam	Sulfur recovery, fertilizer use for residuals	Reduces SO_2 emissions, value added use for NH_3
CCR	Supplies copper and steam to adjacent companies	Minimizes energy needed to produce steam
Varennes		
KRONOS	Byproduct gypsum for wallboard, recovery of CO_2	Neutralizes acid effluent, reduces energy needed to produce CO_2
Petromont	Cascades steam to two adjacent plants	Minimizes energy needed to produce steam
Dow Chemical	Recycling process wastes, closed loop water system	Reduces landfilling, no effluent to river
Sorel-Tracy		
HEBCO	Pyrolysis of scrap tires	Recovers products from scrap tires
Conporec	Composting municipal waste	Manufactures compost and recovers recyclables from waste
Resource Recovery Companies		
Nova Pb	Recovery of lead and polypropylene from batteries, waste derived fuels	Recycles lead and polypropylene, recovers energy from wastes
Eaglebrook	Production of ferric chloride	Recovers a product from a waste stream
Safety-Kleen	Recovery of industrial fluids	Recycling and energy recovery from wastes
Inland Technologies	Recovery of glycol from deicing fluid	Recycling and reduction of effluent
Technology Developers		
Cansolv	Solvent scrubbing of SO_2	Reduces SO_2 emissions
SpolTech	Construction applications for byproduct sulfur	Recyclable construction material
Brownfield Redevelopment		
Trenton, New Jersey	Redevelopment of the Roebling Steel Works	Recycling land and buildings
Montreal, Quebec	Redevelopment of a section of the Lachine Canal	Recycling land and buildings

1. OBJECTIVES

The concept of industrial ecology as demonstrated at Kalundborg in Denmark, and at the Bruce Energy Centre near Kincardine in Ontario, has shown that linking industries and services in networks to cascade byproducts and wastes can make a valuable contribution to sustainable development. Networks conserve resources and prevent pollution while at the same time maintaining output and jobs. The success of both Kalundborg and the Bruce Energy Centre raises the question of whether similar conditions at other locations would also support formation of industrial ecological networks. In response to this question a study was made of a number of industrialized areas in the Montreal Region to identify the extent to which partnerships and networks had formed and, if they had not, to identify the factors that had inhibited them.

The study analyzed successful cases. It documented delayed or failed projects and looked for potential opportunities in this mature industrialized area. It also identified the drivers and key factors for success. The study of the Montreal area applies the same study methodology to a to a more mixed industrial base. It also includes opportunities for brownfield redevelopment and the potential for using waste heat as a source of residential or commercial heating.

The specific objectives are to:

- identify and document cases where partnerships or networks for resource conservation and pollution prevention have been formed, or are proposed,
- identify the relevant drivers, costs, benefits and barriers,
- identify opportunities for other networks and partnerships and propose a strategy for implementing them.

Industrial technology 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.

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.

2. BACKGROUND

2.1 Concept of Industrial Ecology

Industrial ecology is the design and maintenance of waste, energy and water exchange between facilities in order to minimize resource input and maximize use of by-products and residuals. It attempts to simulate the "strategies" of natural ecosystems such as wetlands or forests. Individual components of the natural system generate wastes while the system as a whole does not. Such natural ecosystems provide some valuable lessons for industrial strategies.

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 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 are 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.

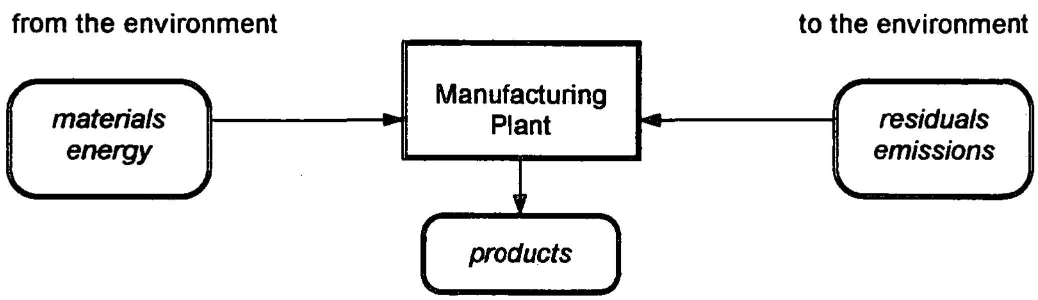


Fig. 2.1: Industrial Island

In fully evolved industrial ecosystems member industries have developed networks to optimize 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, like 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 "city water" as a resource. 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 used as 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. These concepts are more fully described in the report of the Sarnia-Lambton study (1) discused the concept of industrial ecology, thus the concept will only be described here in brief terms.

2.2 Examples of Industrial Ecosystems

The feasibility of this concept has been demonstrated in Kalundborg, Denmark and in the Bruce Energy Centre in Ontario which was visited and reviewed in connection with the Sarnia/Lambton sustainability study. In the Kalundborg case, ten industries and services share energy, water, and waste materials by way of sixteen 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 supplies district heating for a nearby 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.

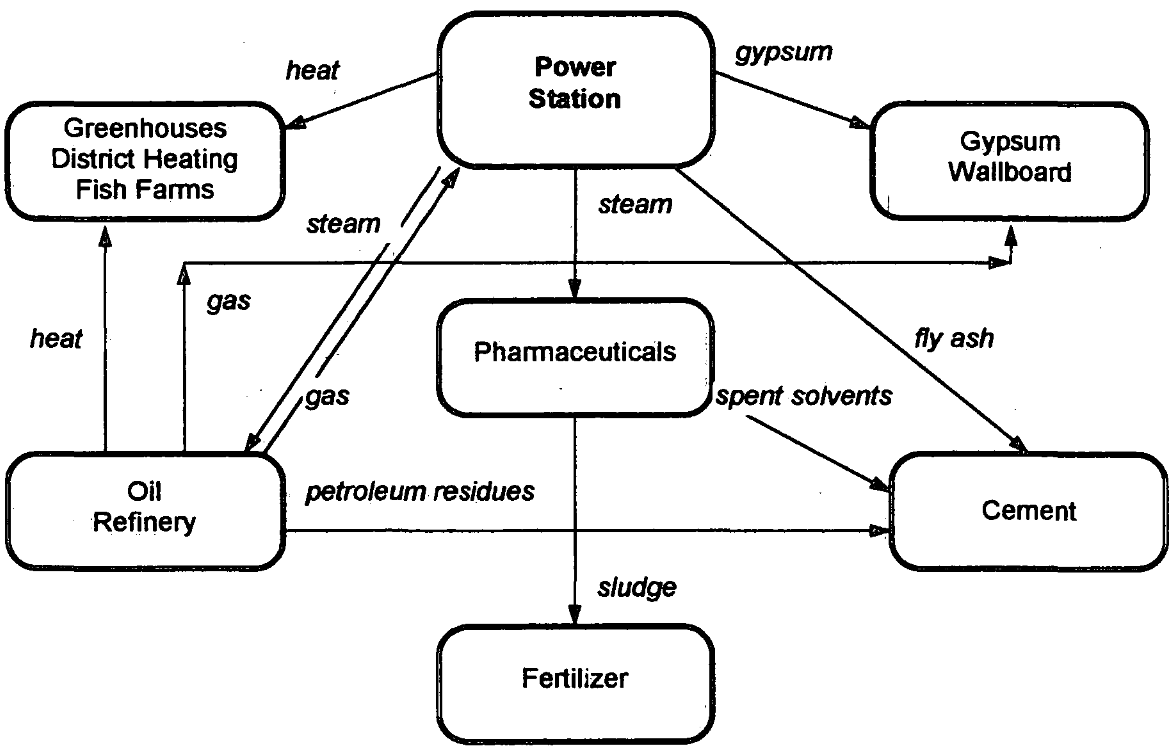


Fig. 2.2: Industrial Ecology - Kalundborg Demonstration

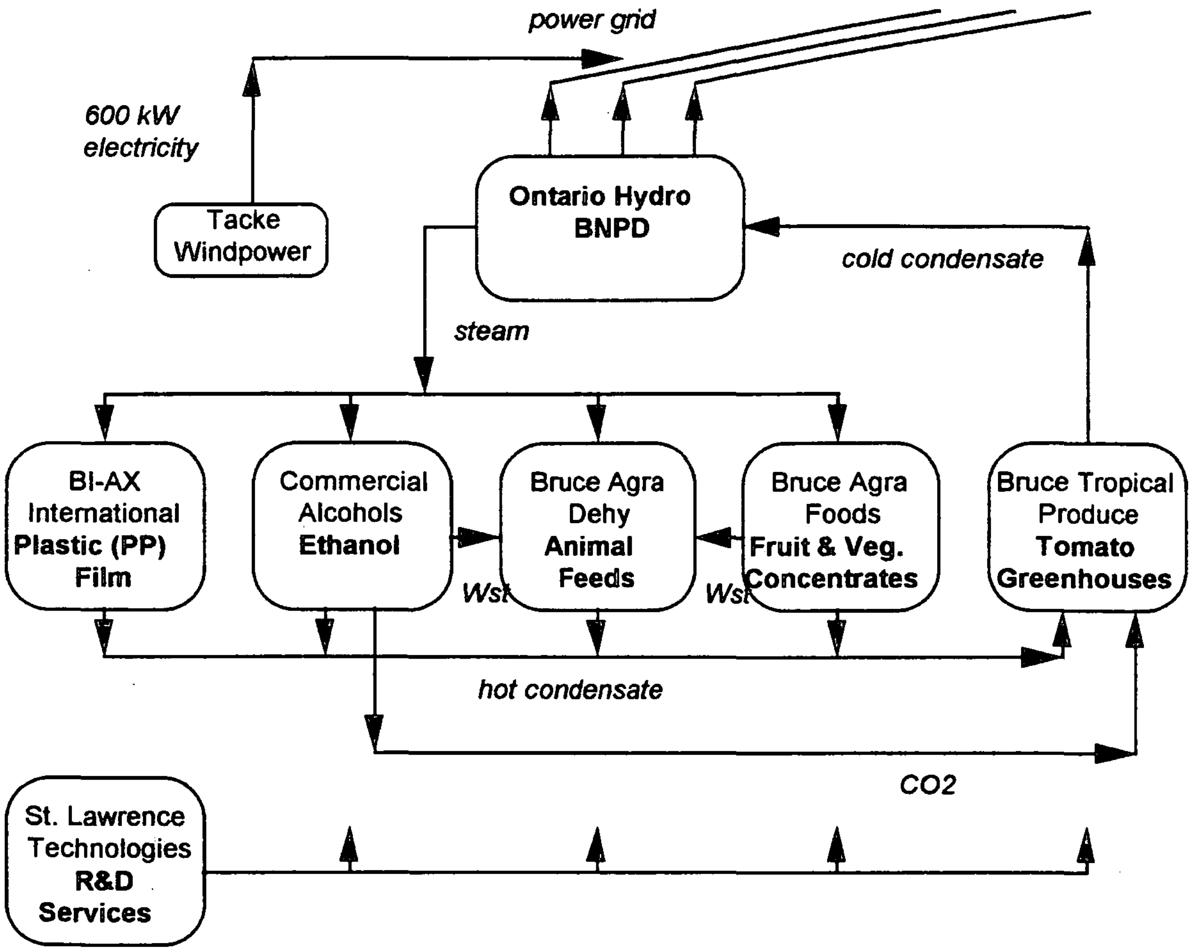


Fig. 2.3: Bruce Energy Centre, as of September 1996:

The Bruce Energy Centre near Kincardine, Ontario, was established to take advantage of excess steam available at the Bruce nuclear power station. Six different companies have been linked to take advantage of the steam available from the Ontario Hydro's Bruce Nuclear Power Development. In addition to heat cascading, plans are in place to use waste CO_2 from a fermentation plant at the local greenhouse operation to enhance growth rates for tomato production. Biomass from the fermentation plant could be used to produce livestock feed.

(1) G. Venta, M. Nisbet, "Opportunities for Industrial Ecological Parks in Canada - Case Study: Sarnia-Lambton Industrial Complex", Environment Canada, K2340-6-0015, March 1997.

2.3 Opportunities

There are numerous locations in Canada with concentrations of industries that offer a logical choice for developing industrial ecosystems. The fact that industrial clusters exist is in itself evidence of formation of networks. Examples are the interchange of petrochemical feedstocks in Sarnia-Lambton, the hydrogen network in Becancour and the cascading of process steam in Varennes. The current studies are focused more on linkages which formed after the complexes had been developed. These links form either to make better use of existing assets, for example the cogeneration project in Sarnia, or to find value added uses for process byproducts and residuals. Examples of the latter are the use of by-product gypsum from flue gas desulfurization or neutralization of sulfuric acid in wallboard manufacture.

Economics and company policy are the primary drivers for partnerships and networks of this type. All the companies contacted in the course of this work are active in reducing pollution by finding uses for residuals that cannot be successfully recycled into their own processes and devote considerable resources to looking for suitable uses. Not all industrial complexes appear to have the same degree of integration and opportunities exist for increasing the linkages within industrial parks by cascading energy and by-products to smaller companies thus developing more complete industrial ecosystems.

The study of the Sarnia-Lambton corridor focused on developed and developing linkages between companies and possible opportunities in a major petrochemical complex. In the Montreal area this study has focused on the same issues in Montreal East, Varennes, Becancour, Sorel/Tracy as well as brownfield redevelopment of the Lachine Canal and a successful brownfield case in Trenton, New Jersey.

There is a similarity between sustainable development projects and brownfield redevelopment. In both cases the initial investment may be greater than alternative courses of action, but there are longer term benefits. In the case of sustainable projects, these benefits are reduced resource consumption and pollution prevention. In brownfield redevelopment, the longer term benefits accrue to the surrounding community in terms of improved property values and a better quality of life. In both cases the total payback to the additional investment is hard to quantify, and in both cases at least part of the benefits are long term and to the surounding communities, while not directly providing a return to the investor.

Implementation of industrial ecosystems does not usually depend on development of new technologies. The necessary technologies are normally available. The barriers that exist, are more likely to result from:

- lack of awareness of opportunities,
- short planning horizon,
- economic considerations,

- community attitudes,
- regulations,
- lack of resources,
- entrepreneurial/risk taking issues.

The establishment and successful development of industrial ecosystems would improve the sustainability of Canadian industry and provide an advantage in the globally competitive world. It would allow active promotion of such state-of-the-art ecosystem sites to investors, provide voluntary solutions, and potentially contribute to job creation.

Industrial ecosystem expertise, developed in Canada, could offer an opportunity to export knowledge to other countries, for example to the Third World Countries "technology parks" planned, being developed and supported by the World Bank, the Asian Development Bank, and by the Canadian International Development Agency (CIDA). Another natural opportunity would be to link energy centre technology as developed at the Bruce Energy Centre to CANDU reactor sales.

3. TECHNICAL APPROACH

3.1 Focus areas

The main focus areas, as shown in Fig. 3.1, are:

- Montreal East which has, because of rationalization of the refining and petrochemical industry, lost part of its industrial base and has areas of vacant land,
- Varennes industrial park which has a degree of integration within the park and with Montreal East,
- Becancour industrial park which was to have been the site of a 135 MW combined-cycle cogeneration unit but already has a level of integration between its industries,
- Sorel-Tracy where a strong industrial ecology movement is in place,
- Lachine Canal redevelopment and successful redevelopment in Trenton, New Jersey,
- Other case studies of existing and potential networks and partnerships in the Montreal region.

3.2 Securing Industry Cooperation

For the success of the project, it is imperative to obtain the cooperation of the business leaders in the Montreal and regional industrial communities.

Societe Generale de Financement du Quebec (SGF) has been very supportive in acting as an information source and recommended the involvement of:

- Table de concertation petrochimie,
- Association industrielle de l'est de Montreal,
- Association industrielle de Varennes
- Commission d'expansion de Montreal-Est,
- Pro-Est (a Montreal East promotional organization).

A presentation made on March 18, 1997, to the "Table de concertation petrochimie" secured the cooperation of the petrochemical companies in Montreal East and Varennes and led to contacts being established with the Commission d'expansion de Montreal-Est and Pro-Est.

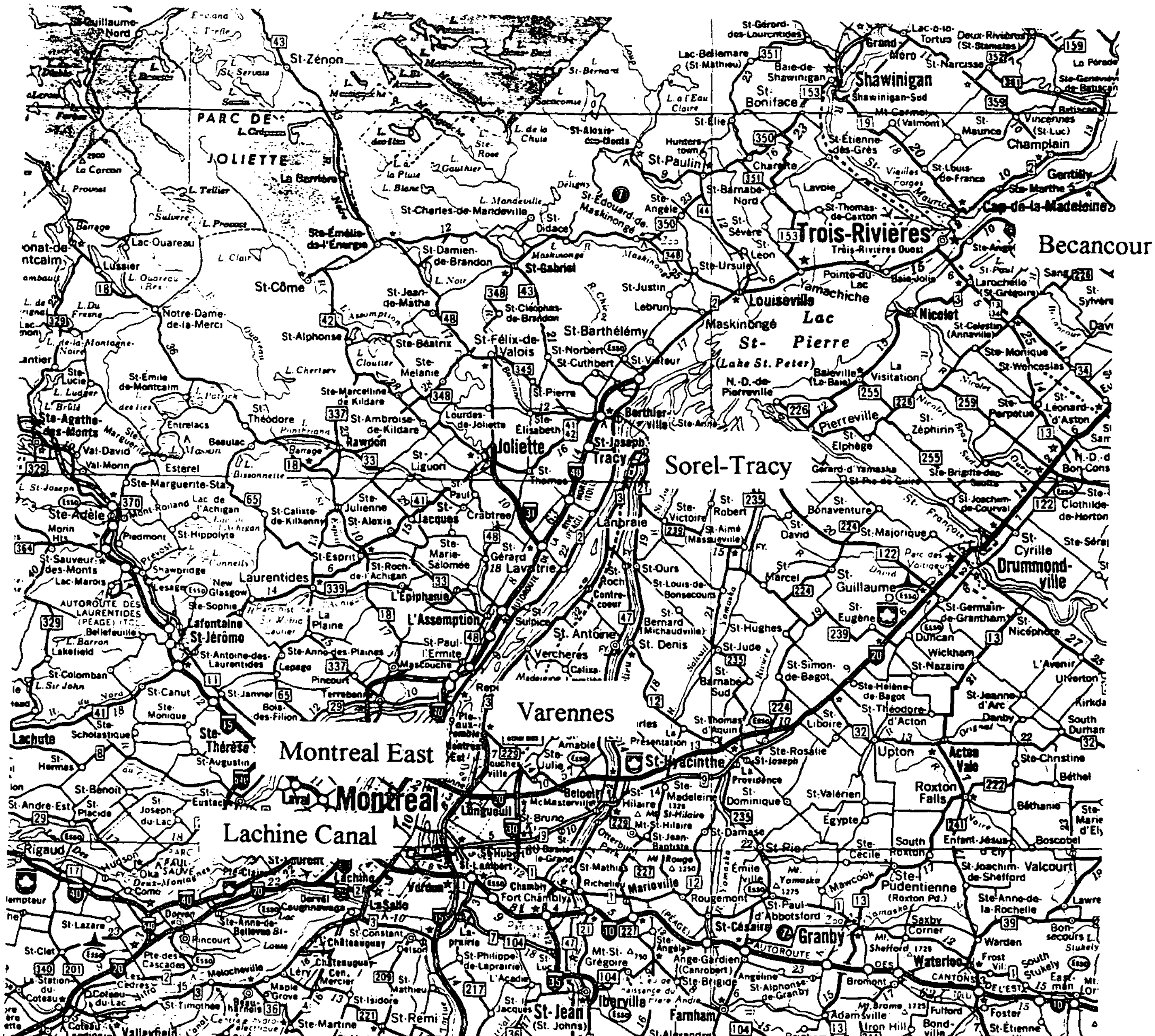


Fig. 3.1 Montreal Area / Industrial Parks Included in the Study

4. CASE STUDIES

4.1 Becancour Industrial Park

The industrial park is situated on the St. Lawrence River approximately 150 km east of Montreal. It covers 40 sq. km and currently includes 12 industries in the metal and chemical sectors. The park offers the basic advantages of:

- water transport all year,
- relatively low cost electricity,
- natural gas,
- a pool of skilled labour,
- competitive construction cost (quality bedrock),
- access to north American markets by road and rail.

Existing and Proposed Networks

There is a network linking hydrogen generators and users. In addition to hydrogen, ICI Canada provides process steam and a range of services to Chemprox but there is no integrated cascading of energy at this point.

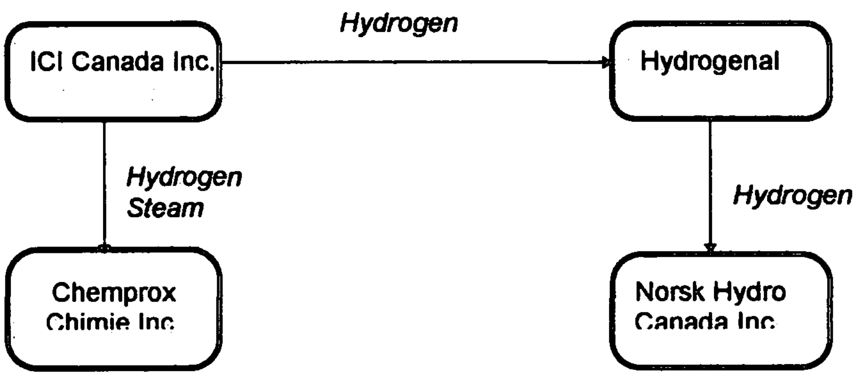
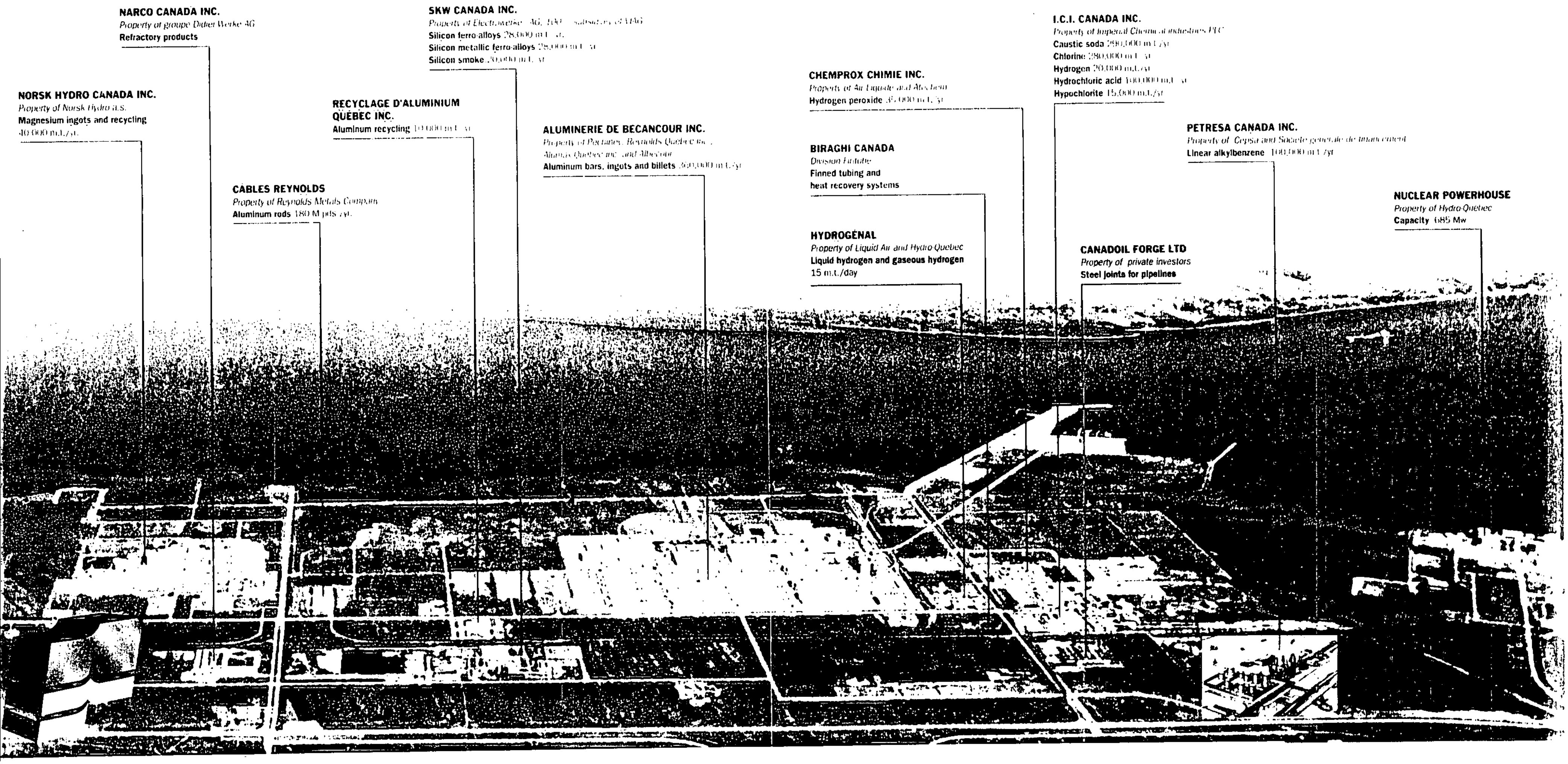


Fig. 4.1: By-Product Hydrogen Utilization

ICI generates by-product hydrogen from the electrolysis of brine. The quantity that is not used by ICI in manufacture of hydrochloric acid is sold to Chemprox for the manufacture of hydrogen peroxide. Excess hydrogen is either used as fuel by ICI or sold to Hydrogenal. Hydrogenal is a manufacturer of hydrogen by electrolysis of water or from natural gas. Its primary customer is Norsk Hydro, a magnesium producer.

Fig. 4.2 Becancour Waterfront Industrial Park



There is a partnership based on recovery of aluminum residues. Recyclage d'Aluminium Quebec Inc. separates metallic aluminum from dross from Aluminerie de Becancour Inc. (ABI) and from other aluminum plants in Quebec, Ontario and the northern U.S.

The cogeneration project proposed by TransAlta could develop another network within the park. . The primary purpose of cogeneration is to maximize the output of fuel combustion in industrial applications. When large amounts of fuel (natural gas, refinery gas or oil) are burned in industrial boilers to produce, it is often desirable to initially produce a higher grade of energy such as electricity. The waste heat from gas turbines or engine exhaust can then be used to produce steam for additional electricity, medium or low grade steam, and hot water for district heating. The TransAlta proposal would:

- generate 135 MW from non-interruptible natural gas,
- reduce boiler fuel usage,
- provide process steam to Norsk Hydro, ICI, Chemprox and Hydrogenal,
- sell the electricity to Hydro Quebec.

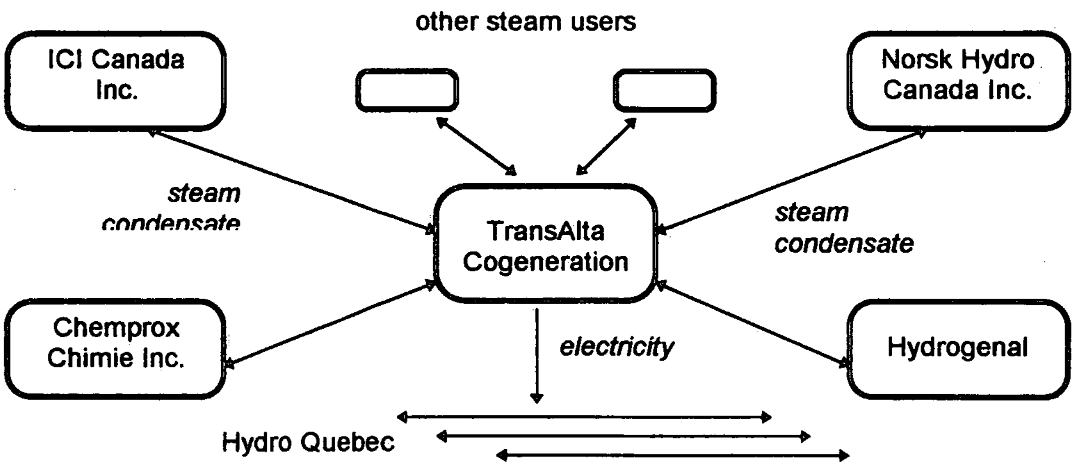


Fig. 4.3: Proposed TransAlta Cogeneration Becancour Project

The project received good socio-political support and obtained all the necessary environmental approvals. The project is currently on hold because the low price the Hydro Quebec is prepared to pay for the electricity. Hydro Quebec is willing to export the electricity through its transmission system. TransAlta does not find the terms offered by Hydro Quebec for this service to be economically viable. (It would be cheaper to export the gas and generate the electricity at the end user's site).

4.1.1 ICI Canada Inc. / Chemprox Partnership

ICI's primary raw materials are salt and water. Its products are chlorine, caustic soda and hydrochloric acid. Hydrogen is a co-product.

Annual production is:

- chlorine 270,000 tonnes
- caustic soda 300,000 tonnes
- hydrochloric acid 125,000 tonnes
- hydrogen 7,000 tonnes

The primary products are shipped by rail or truck. Hydrogen that is not used to make hydrochloric acid is pipelined to the adjacent Chemprox plant and used in production of hydrogen peroxide. Excess hydrogen is either transferred to the nearby plant of Hydrogenal, a commercial hydrogen producer, or used as fuel in ICI boilers.

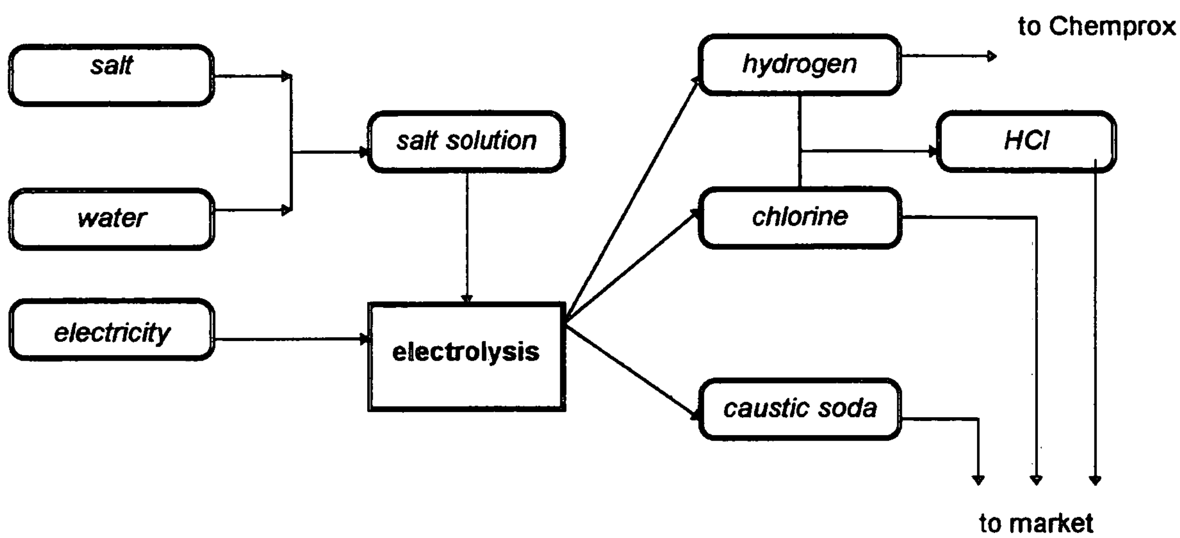


Fig. 4.4: Product Flowsheet - ICI Canada Inc. / Chemprox Partnership

ICI effectively minimizes residuals from its process by selling the sulfuric acid used to dry the chlorine when the acid is no longer usable as a drying agent. The company has developed a way of converting the sodium sulfate residue from the brine purification stage into gypsum, which should be suitable for cement manufacturing.

The partnering arrangement with Chemprox is innovative. Chemprox provides hydrogen peroxide manufacturing know-how. ICI provides manpower, including maintenance and clerical staff, hydrogen and process steam, and markets the hydrogen peroxide through its distribution infrastructure. The contract between the two companies is for 20 years and will be reviewed after 10 years.

Drivers

The main driver was the need to find a use for the approximately 22 tonnes per day of hydrogen which is generated as a co-product of the electrolysis of brine. Hydrogen is not economically transportable over long distances, thus a user in the same vicinity was needed. Having identified hydrogen peroxide as a product for which there is growing demand but not having experience in hydrogen peroxide production, ICI partnered with a company having the necessary expertise.

Barriers/Issues

The switch away from chlorine as a bleaching agent by the paper industry has been offset by increased use of chlorine in production of polyvinyl chloride.

Regulations have not been a barrier in formation of partnerships. ICI, because of the nature of its products, is already tightly regulated and is in full compliance with its own environmental policy and with provincial standards.

Conclusions

ICI has taken an innovative approach to

- forming partnerships to find economically viable uses for by-product hydrogen, and
- finding a value added application for the residual from brine purification.

Chemprox manufactures hydrogen peroxide from hydrogen supplied by ICI. The process involves reaction of the hydrogen with atmospheric oxygen in a quinone solvent. The peroxide is extracted into water and the solvent is recycled.

Capacity is currently 30,000 tonnes per year and is in the process of being doubled. The plant is located in the Becancour Industrial Park because of the supply of hydrogen.

Issues

The Chemprox plant is a recipient of by-product steam and has virtually no residuals except small quantities of solvent remaining after the recovery process.

Management expressed concern over the length and uncertainty of the permitting process which made planning and budgeting of the expansion more difficult than necessary.

4.1.2 Norsk Hydro

Norsk Hydro, a Norwegian owned company, manufactures about 40,000 tonnes per year of magnesium metal from magnesite imported from China. The process outlined in the flow diagram converts the magnesite to magnesium chloride by dissolving it in hydrochloric acid. The chloride brine is dehydrated and prilled. The prills (pellets) are melted and electrolyzed to give molten magnesium and chlorine gas. The chlorine gas is reacted with hydrogen to regenerate hydrochloric acid which is returned to the process. The metallic magnesium is cast as pure magnesium or as alloys. The by-products from the process are:

- an inorganic sludge, 7,000 - 9,000 tonnes dry weight per year,
- anode graphite 200 tonnes per year,
- carbon dioxide 73,000 tonnes per year.
- cooling water at about 40 °C from the magnesium casting operation.

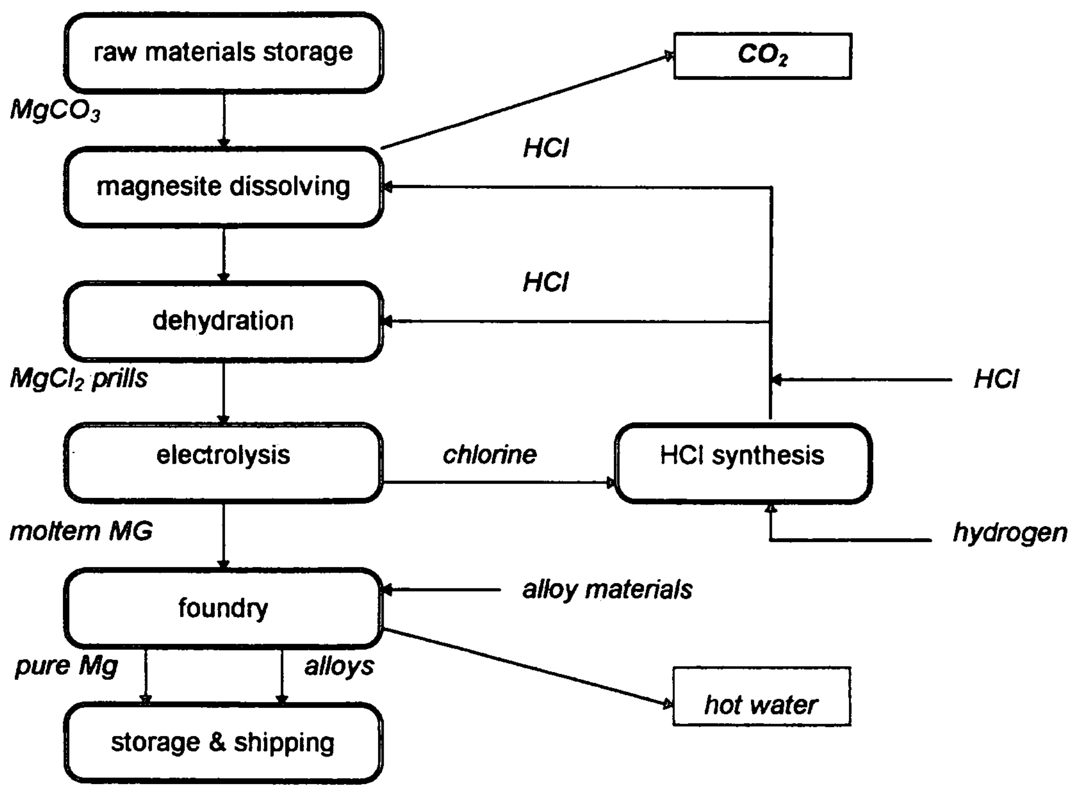


Fig. 4.5: Process Block Flow Diagram

About 70% of the graphite is recycled by Canapta, a company in Sorel, QC, where it is recycled into a range of graphite products. The remainder, which is the top of the anode, is classified as a hazardous waste because of its copper content and is landfilled. Uses for this material are being sought.

A research program in conjunction with the University of Laval is developing an agricultural application for the sludge. The magnesium content and alkaline nature of the sludge make it useful as a fertilizer and for pH control. The research is in the second year of a three year program.

The carbon dioxide emitted during reaction of the magnesite with hydrochloric acid offers a unique opportunity because of its high concentration in the gas stream compared to carbon dioxide from combustion or calcination sources. While it is possible to capture this gas for sale into the CO_2 market, doing this would only delay its eventual release. A preferred option would be to use the gas to increase photosynthesis in a green house heated by hot water from the Norsk Hydro plant or other operations in the park.

4.1.3 Aluminerie de Becancour Inc. (ABI)

Company ownership: Reynolds (50%), Pechiney (25.05%) and Alumax (24.95%).

The plant produces about 370,000 tonnes per year of aluminum from aluminum oxide received by vessel. The plant is situated in the park because of:

- favourable electricity rates,
- water transport of raw materials,
- access to U.S. markets,
- a skilled labour pool,
- bedrock which reduced construction costs

4.1.4 Recyclage d'Aluminium Quebec Inc.

Recyclage is a subsidiary of Philip Environmental. It is one of two aluminum dross recycling plants in Quebec. The other, owned by the same parent, is at Baie Comeau. The company processes about 22,000 tons per year of aluminum dross (the skimmings from the top of the molten metal), recovering about 11,000 tons of metal and storing the process residual in a company-owned monofill for future use or recycling. This process residual is classified as a special waste.

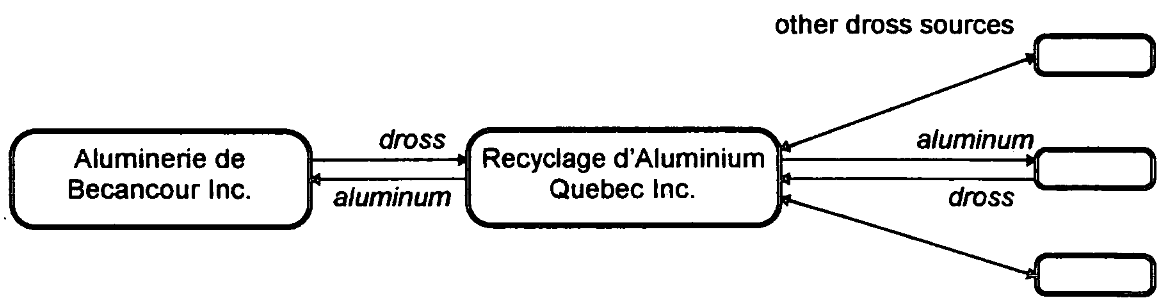


Fig. 4.6: Aluminum Dross Recycling

The major source of dross is ABI, but the company also processes material from other aluminum smelters in Quebec, Ontario and New York State. The company provides the metal recovery service on a toll basis. It isolates the material from each source, processes it in 15,000 lbs. batches and returns the metal to the generator of the dross.

The technology uses a rotary kiln which is fired by natural gas with oxygen enrichment.

Recyclage is actively seeking uses for the process residuals.

4.1.5 SKW

The company is located in the industrial park because of the relatively low cost of electricity, sources of raw material, proximity to markets and good transportation.

The plant produces silicon metal which is used in production of alloys, silicone products and electronic parts. The primary raw materials are quartz from local sources, coal and wood. The fuel source is natural gas.

By-Product

The main by-product is silica fume, a fine amorphous dust. The process material balance in one production mode is 1 tonne of product and 0.2 tonnes of silica fume from 4 tonnnes of raw material. The other production mode yields 1 tonne of product and 0.5 tonnes of silica fume from 7 tonnes of raw material.

SKW has developed a range of value added uses for its silica fume:

- addition to cement and concrete: small amounts of silica fume when added either to cement or to concrete act as a pozzolan increasing the strength of the concrete and decreasing its permeability. This latter effect lowers the susceptibility of the concrete to alkali/aggregate reactivity and also makes it less vulnerable to attack by deicing salt.
- filler for plastics in certain applications and as a substitute for asbestos,
- an ingredient in some waste stabilization mixes.

Waste heat

About 15 years ago SKW evaluated the possibility of providing this heat to a greenhouse. This opportunity was not economically attractive at that time. The waste heat is still available and the company is open to evaluating opportunities for using it.

4.2 Montreal East Industrial Complex

The Montreal East complex is a mature industrial area which has seen considerable loss of its industrial base over the last 15 years because of rationalization of the refining business, which resulted in closure of 4 of the 6 refineries in the area. The City of Montreal East, the Provincial and Federal Governments, and community groups are active in looking for ways to increase the level of industrial activity in the area. The major industries, which include the petrochemical and metal sectors, have networked their resources to a considerable degree; for example, CCR provides Alcatel and Wolverine Tube with copper and steam. Another example is Sulconam, which takes acid gas streams containing hydrogen sulfide from two refineries and produces elemental sulfur and sulfuric acid.

The common interests of the area are represented and dealt with through a number of industrial and municipal institutions, including the Association industrielle de l'est de Montreal and Ville de Montreal-Est.

Association industrielle de l'est de Montreal
The Association, headed by an executive director and operating with a small staff, consists of 9 major companies in the Montreal East area. There were 16 members before industrial restructuring.

The companies are:

- **Refining**: PetroCanada,
  Produits Shell Canada Ltee
- **Petrochemical**: Petrochemie Coastal Canada,
  Petromont,
  Sulconam
- **Metallurgical**: Metallurgie Noranda - Affinerie CCR
  Les Tuyaux Wolverine Canada Inc.
  Alcatel Cables Canada

The association's objective is to provide a forum for concerted action aimed at continuous improvement of environmental performance and the quality of life in the surrounding community.

The association, because of resource limitations. has shown considerable ability in developing partnerships to achieve its objectives. An example is the development of technical links with Environment Canada. This linkage gives the association access to testing equipment and expert know-how that enables it to carry out its air testing program. Intentions are to expand this linkage into a network including industries in Varennes and the Quebec Ministry of Environment and Wildlife.

The drivers behind the partnership with Environment Canada were:

- economic considerations,
- expansion of the association's knowledge base,
- access to greater awareness of emerging issues, for example, the importance of $PM_{2.5}$,
- openness on the part of the association members.

The barriers included:

- concern with disclosure of data,
- reconciling the interests of association members.

The possibility of developing uses for waste heat generated by the association member companies was discussed. There may be opportunities for residential, institutional and commercial/industrial heating depending on the location of the waste heat generator.

The association has demonstrated considerable entrepreneurial ability in forming partnerships and might be persuaded, if additional resources were made available, to play an active role in identifying, evaluating and possibly assisting in the development of opportunities.

Ville de Montreal-Est
The City has 20 to 23 million square feet of available industrial land, much of which has been made vacant by industrial restructuring.

The City is acutely aware of the need to maintain the competitive status of its existing industrial base and to repopulate the available land with new and complementary industries.

The current major industries are:

Petrochemicals
- Esso l'Imperiale
- Shell
- Coastal
- Ultramar
- Shell
- Sun Oil
- Olco
- Bitumar/Bituflex

Metals/minerals
- Metallurgie Noranda
- Alcatel Cables
- Tuyaux Wolverine
- Lafarge Construction materials
- Demix
- A.I.M.

The City has, since 1994, been active in promoting industrial partnerships for resource conservation and pollution prevention. Its method of promotion is to act as a catalyst and facilitator, for example, by helping to establish rights of way for pipelines and to accelerate permitting processes.

The city developed an innovative concept for an industrial ecopark to take advantage of the following factors:

- availability of industrial land
- cogeneration of electricity and steam (see case study)
- access by road and pipeline to the Port of Montreal.

In 1995 the City of Montreal East formed the Commission of economic development to promote the proposed "Parc Industrielle Portuaire" which will consist of industrial and commercial development on the land previously occupied by the Texaco Canada Inc. refinery (see map). The land has been cleaned up to the class C level at a cost of $50 million. However, the owner (Texaco) wants to be certain that the chain of liability be broken on sale of the property. A study is being undertaken to find the best way of doing this.

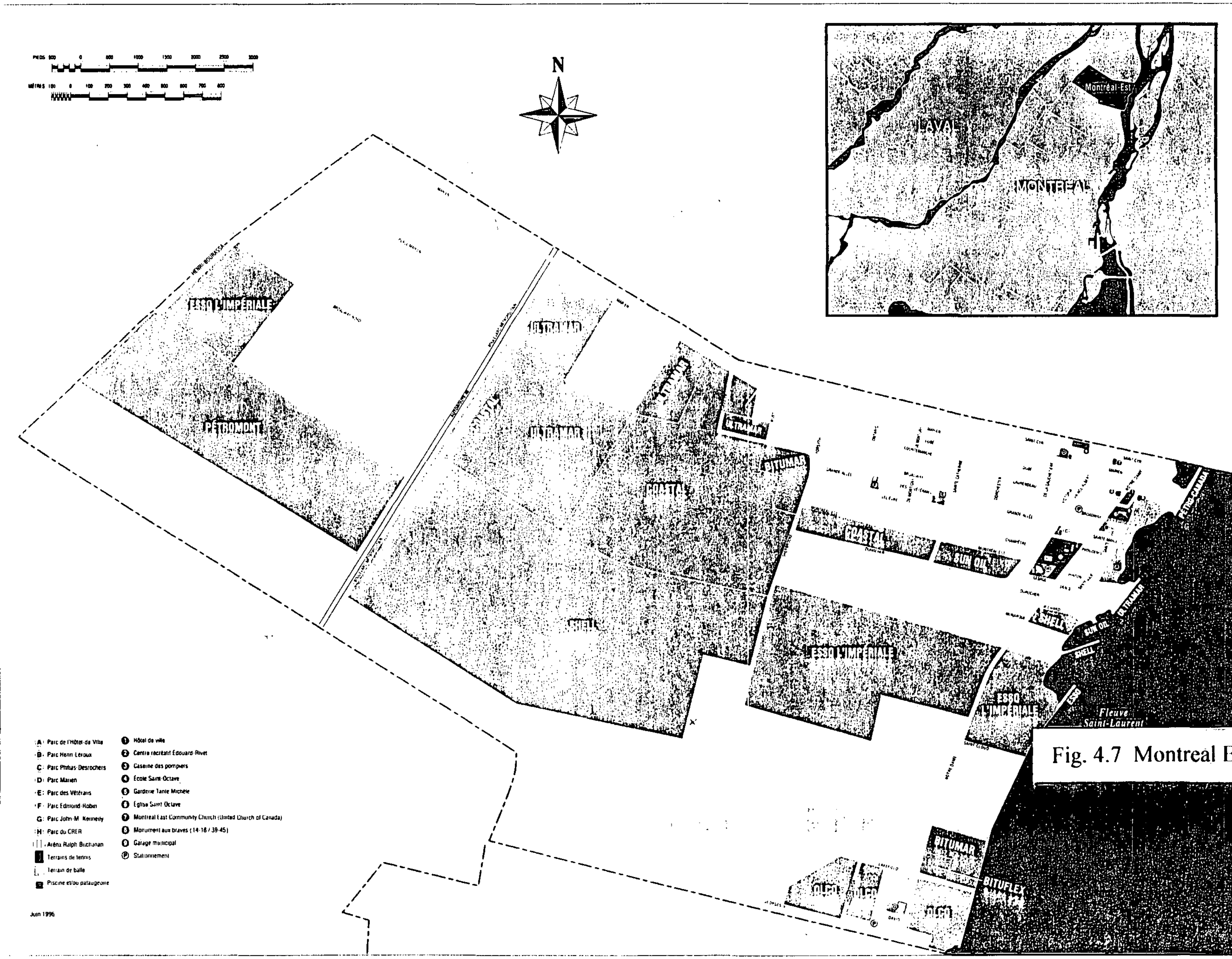
This cogeneration plant would have provided steam to existing industries and to a network of other industries in the Parc Industrielle Portuaire. The cogeneration project is currently on hold because an arrangement under which Hydro Quebec would buy the electricity has not been made.

The City of Montreal East is dealing with issues arising from the brown field nature of the land and the hesitancy of potential users. In the case of Coastal Petroleum the issue has been addressed by the city owning the land and leasing it to Coastal who owns the equipment installed on the property.

Other areas in which the city is interested are:

- production and sharing hydrogen between industrial users;
- provision of firewater from a central source particularly for smaller companies; and
- opportunities for cascading waste heat and process residuals and by-products.

Conclusion
The City has an effective organization in place for promoting industrial development. The City would probably be an active supporter of projects which contribute to its goal of environmentally sound reindustrialization of vacant land within its boundaries. The City's proposed industrial park is an excellent opportunity for assembling a cluster of complementary industries that would make a valuable contribution to sustainable development in the Montreal area..



Les édifices municipaux

Bibliothèque municipale
11370, rue Notre-Dame
Montréal-Est (Québec)
H1B 2W6 645-7431

Caserne des pompiers
11371, rue Notre-Dame
Montréal-Est (Québec)
H1B 2W5 645-7431

Centre récréatif Édouard-Rivet
11111, rue Notre-Dame
Montréal-Est (Québec)
H1B 2V7 640-2737

Garage municipal
11475, rue Victoria
Montréal-Est (Québec)
H1B 2P3 645-7431

Garderie Tante Michèle
4, avenue Laurendeau
Montréal-Est (Québec)
H1B 4Y1 645-2878

Hôtel de ville
11370, rue Notre-Dame
Montréal-Est (Québec)
H1B 2W6 645-7431

Urgences 911
(incendies ou autres)

Montréal-Est

Commission de développement économique

INDUSTRIES DE LA PÉTROCHIMIE

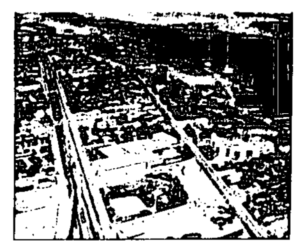


Fig. 4.7 Montreal East - Petrochemical Industry

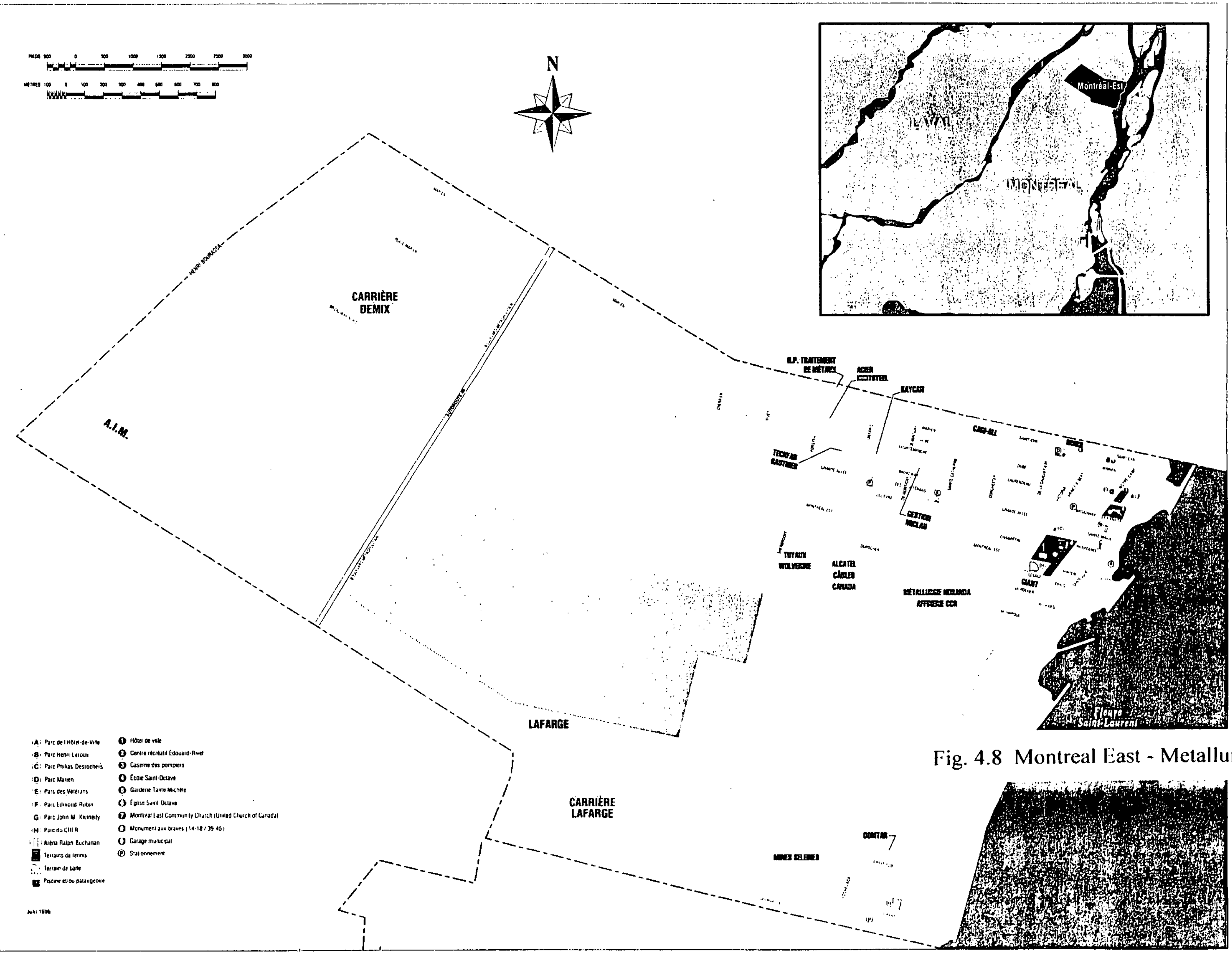


Fig. 4.8 Montreal East - Metallurgical and Minerals Industry

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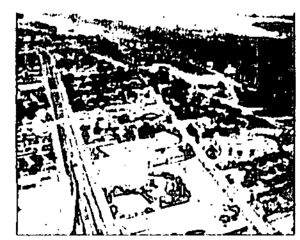
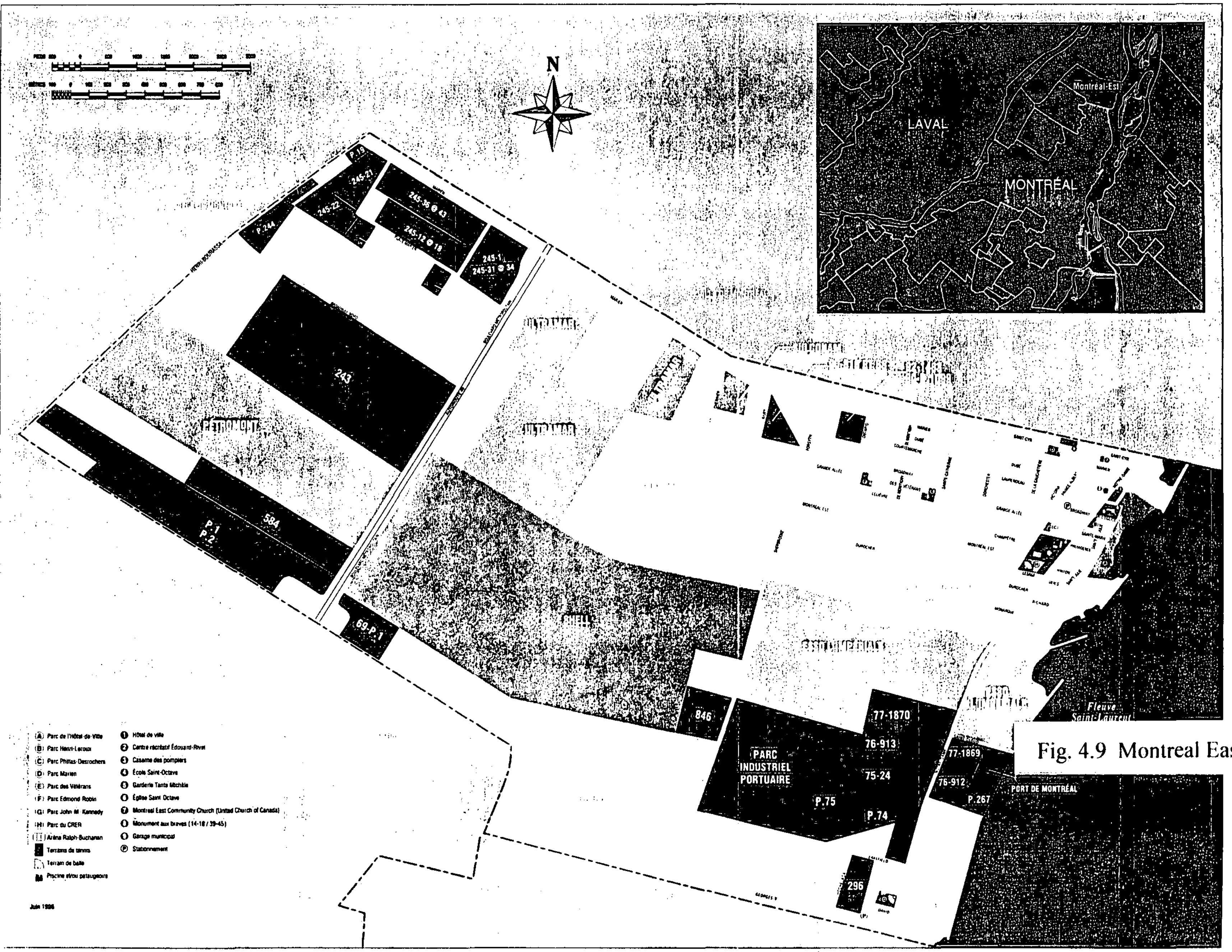
Commission de développement économique

INDUSTRIES DES MÉTAUX ET MINÉRAUX





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Commission de développement économique

TERRAINS INDUSTRIELS VACANTS

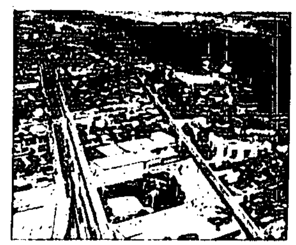


Fig. 4.9 Montreal East - Vacant Industrial Areas

4.2.1 Centre Energetique Montreal-Est (CEME) - Montreal East Energy Centre

Proponent
Societe du centre energetique Montreal-Est - Energy Company of Montreal East, an equal partnership of
- Indeck Energy Services of Montreal East, and
- Novergaz, a subsidiary of Noverco,

Potential Participants / Users

• Electricity	Hydro Quebec
• Industrial Steam	PetroCanada Shell Canada Ltd. Noranda Minerals, Inc. Alcatel Cables Canada Tuyaux Wolverine Canada Inc.

Potential Secondary Participants / Users

• Industrial Steam	Petromont Sulconam Petrochimie Coastal

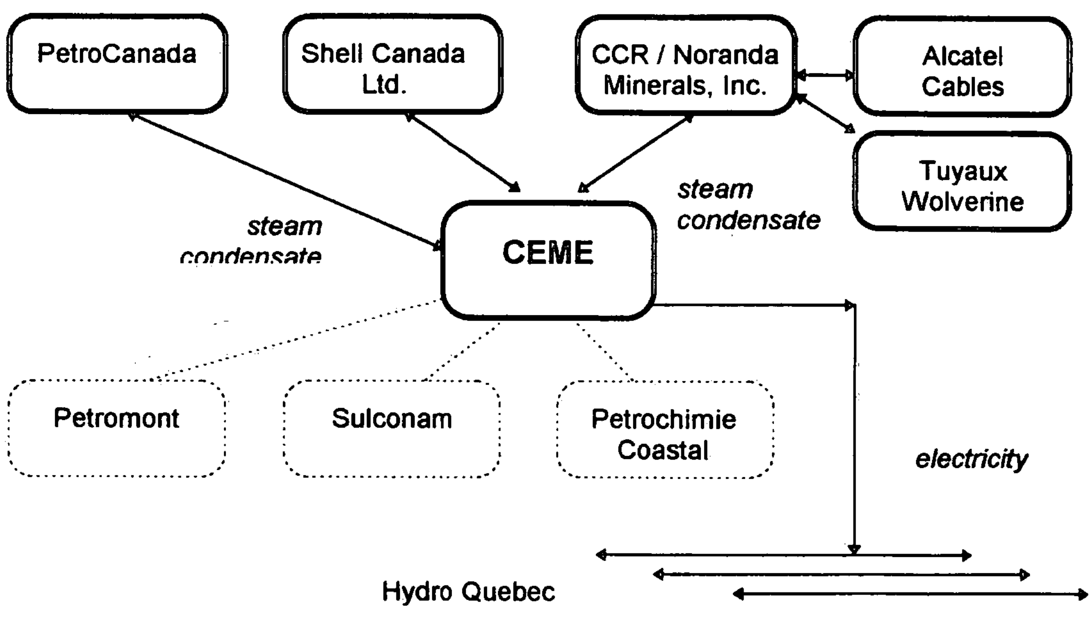


Fig. 4.10: Proposed Montreal East Energy Centre (CEME)

Project Outline / Description
A cogeneration plant situated in Montreal East, on Sherbrooke St. E. near the Shell refinery and Hydro Quebec Station (see attached plan). This natural gas-fired cogeneration plant would have a capacity to produce and supply:

- Electricity — about 216 MW
- Industrial Steam — an annual average of about 246,500 kg/h

Gaz Metropolitain will guarantee the transport and supply of the necessary natural gas to CEME. CEME would be its largest consumer, with a demand of 16 billion cubic feet of gas per year, representing almost 10 per cent of the total natural gas consumption of Quebec.

Drivers
The need to increase the critical mass of the Montreal-East industrial area which, with the closure and departure of four out of the original six major petrochemical refineries in the area, has been declining.

Technology
Cogeneration technology is well established. No new technology is needed.

Market / Distribution
At the time of project proposal and initial negotiations, there was demand for both the steam and, apparently, also power generated by the co-generation unit.

Economic Impacts
- Initial investment of more than $285 million, entirely provided by private funding.
- The direct employment of between 250 and 300 people during the 20 to 24 month construction period, to which will be added about 450 indirect employees for this timeperiod.
- The CEME cogeneration project will lead to the creation of more than 20 direct employee positions and will have a positive effect on 100 to 230 indirect employee positions. As indicated, 100 to 210 employee positions shall be maintained or created.
- At the steam customers' operations, approximately 200 employee positions will be assured by the creation of CEME.
- Savings in the order of $8 to $10 million annually in their steam costs will be realized by the steam customers with whom CEME has already signed contracts. If it arrives at an agreement with the other three potential customers, these savings can rise to $12 to $15 million dollars annually. These savings will allow the CEME participants to enhance their competitiveness within their different markets.
- When operating, CEME will buy each year goods and services of a value of approximately $75 million, of which $38 will be from Quebec ($6 million solely for the upkeep of the installations).

- The operation of CEME will reduce the electrical malfunctions suffered by the steam customers, permitting them to avoid costly interruptions to production.
- Annual savings realized by the steam customers could reach $20 million.

Avoided Emissions
Due to the closure of the main heavy oil furnaces which are presently being used by five primary steam customers of CEME for the production of their industrial steam, combined with the state-of-the-art pollution control technology proposed for the CEME cogeneration unit, substantial reduction in the following atmospheric emissions are expected:

- 60 % CO_2 emissions
- 65 % SO_2 emissions
- 50 % particle emissions
- 14 % NO_x emissions

Modern gas turbine cogeneration plants using natural gas as fuel have emissions in the order of 300 g/kWh and 0.5 kg/MWh of NO_x when total energy output is considered.

Issues and Barriers / Problems
- Negotiations with Hydro Quebec which is anxious to protect its markets;
- Approvals and authorizations from the Ministry of Natural Resources and from Hydro Quebec not received as yet.
- There are strong indications that the demand for industrial steam, as projected by some potential users at the start of the project, have changed. Because of the slow progress some of the potential participants have adopted alternate solutions, improved their efficiencies and adjusted production schedules,
- Readjusting the economics due to the changing situation in steam and power demand, as well as in the industrial base of Montreal East.

Regulations / community acceptance
- The generating station will be situated in the Montreal East industrial park, at a minimal distance of 800 metres from residences. Its exterior appearance will be visually pleasing.
- No emissions of the generating station will be visible by the inhabitants of the area. The risk of major industrial accidents is very low.

All of these points are included in the report of the public enquiry (hearing) submitted to the Ministry of the Environment by the BAPE - June 21, 1994.

Other issues
- CEME believes that this project could serve as a North American model, as this cogeneration scheme could have more steam customers than any other cogenerating station of a similar capacity and configuration.

- The creation of CEME will involve the transfer of expertise and technology presently nonexistent in the engineering, construction and service sectors in the province.
- It was felt that the project would be advantageous for Hydro Quebec, as it would have at its disposal a flexible method of energy generation, which can be realized quickly and can be easily adapted in its energy development plans in the next ten years. CEME would constitute a stabilizing element in the core of the Hydro Quebec network. The changing circumstances in the power supply and demand in the late 1990s proved this factor to be insignificant.
- The Quebec content of the investment of about $285 million would be more than 60%.
- There would be a significant Quebec content in the proposed CEME venture. Owing to its strategic alliance with Indeck, Volcano International of Saint Hyacinth, will be considered as a potential primary supplier of equipment purchases valued at $16 to $20 million.
- Indeck has likewise concluded strategic alliances with Specialites B-Pro, of Windsor, and Industries Procedair of Montreal, who together qualify as potential suppliers of equipment for CEME.

Conclusions

The cogeneration unit is potentially an important cornerstone for redevelopment of vacant land in Montreal East and important also for maintaining the competitive position of the area.

According to its proponents, the project is still on the books, although at this stage, due to the lack of commitment of Hydro Quebec to the electrical power generated by the CEME, it is inactive and there is much uncertainty about its eventual approval and implementation.

This report recommends that an evaluation be made of installation of a smaller, 15 to 20 MW unit.

4.2.2 Shell Canada Ltd.

Cogeneration

Shell was one of the initial supporters of the cogeneration project as a customer for process steam. As the project was delayed significantly, Shell, in the interim has reduced its requirements for steam. Should the project still go ahead, Shell would still be interested in purchasing steam, but at quantities which would be considerably different than originally envisaged.

For industrial partnerships to succeed the timeline must be defined and be acceptable to all the players.

Shell is open to considering partnerships with the caveat that such partnerships must not put the Company's core business at risk or have the potential for upsetting refinery production.

Shell can offer:

- land zoned for heavy industry,
- water treatment capacity,
- steam,
- mutual aid in case of emergencies,
- rail sidings and load out facilities,
- raw water.

Residuals available:

waste heat: low grade, 1500 gals per min. at 25 C,
spent catalysts as cement raw material,
caustic (recycled by U.S. processor).

4.2.3 PetroCanada

CANMET Hydrocracker Pitch

The original development objective for the CANMET Hydrocracker was to upgrade oil sand bitumen. The application of the unit has expanded to include processing of a wide range of refinery residues. The 5,000 barrels per day demonstration unit at the PetroCanada Montreal refinery started operation in 1985, and having met the demonstration objectives, was shut down in 1989. An increase in the light/heavy crude differential coupled with the need to curb high sulfur bunker production provided the incentive to restart the plant as a refinery unit in 1992.

The CANMET hydrocracking process produces a residual pitch. Finding a value added end use for this material is important in the overall economics of the hydrocracker. Since the physical properties of the pitch make it unsuitable in conventional asphalt or pitch applications, PetroCanada evaluated opportunities for selling it as a fuel. The most appropriate fuel use is in cement manufacturing because:

- it is a large scale energy user,
- burning zone conditions ensure complete combustion,
- sulfur in the fuel is effectively trapped in the cement kiln,
- the iron sulfate in the pitch is beneficially used in the cement process.

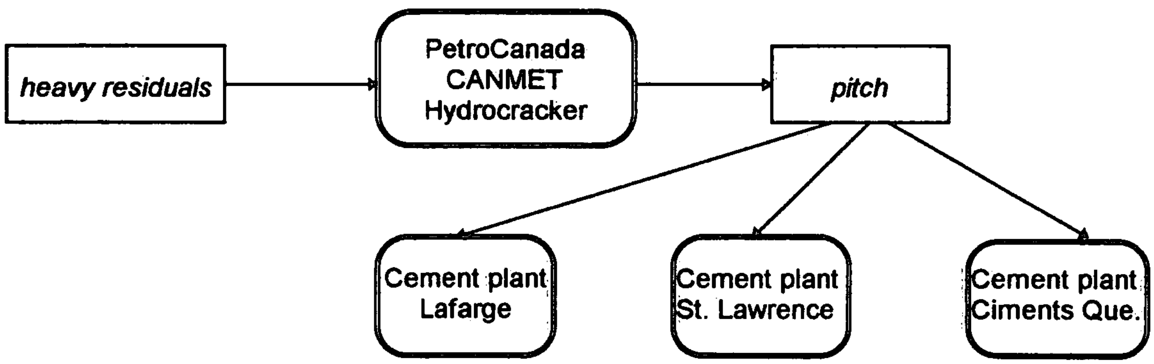


Fig. 4.11: PetroCanada CANMET Hydrocracker Project

PetroCanada initially installed a pitch storage and handling system at the Lafarge Canada plant at St. Constant which is located about 15 km south of Montreal. The installation has a heated storage capacity of 600 barrels which is roughly enough for one day. The pitch is delivered in liquid form on a daily basis at a temperature of 150 - 180°C. This temperature is necessary to keep the pitch at a suitable viscosity. PetroCanada also assisted in development of a suitable burner.

The project has been in successful operation since 1991. About 375,000 barrels per year (60 million litres) are used as fuel and the network has been expanded to include the St. Lawrence cement plant at Jolliette, Quebec, and the Ciments Quebec plant near Quebec City.

Other Residuals
Catalysts

- alumina catalysts are used in cement manufacture,
- other metallic catalysts are recycled,
- polymerization catalysts containing phosphate are being evaluated (in conjunction with CRIQ) as possible fertilizers.

Waste heat
The refinery could sell steam if an economically viable application were found. A possible opportunity would be to supply the industrial area adjacent to the refinery on the east side with process steam and space heating. This opportunity should be evaluated.

The refinery generates about 35,000 gals. per minute of hot water at about 49°C.

Other potential synergy
SpolTec (see section 4.5.1) has technology for using a sulfur polymer as an asphalt extender. There is a possibility that this technology could be used to upgrade the physical properties of the CANMET pitch.

Conclusion
PetroCanada is alert to the need to add value to residuals and by-products rather than disposing of them, and has been effective in doing so. The company, in addition to investing in pollution prevention measures such as improved combustion, shows considerable entrepreneurial ability and a willingness to evaluate opportunities.

4.2.4 Sulconam

Description

Sulconam is a privately owned company which takes the hydrogen sulfide by-product from the Shell and PetroCanada refineries to produce elemental sulfur and sulfuric acid. The plant has the capacity to produce 160 tonnes per day of sulfur. Current production is about 35,000 tonnes per year.

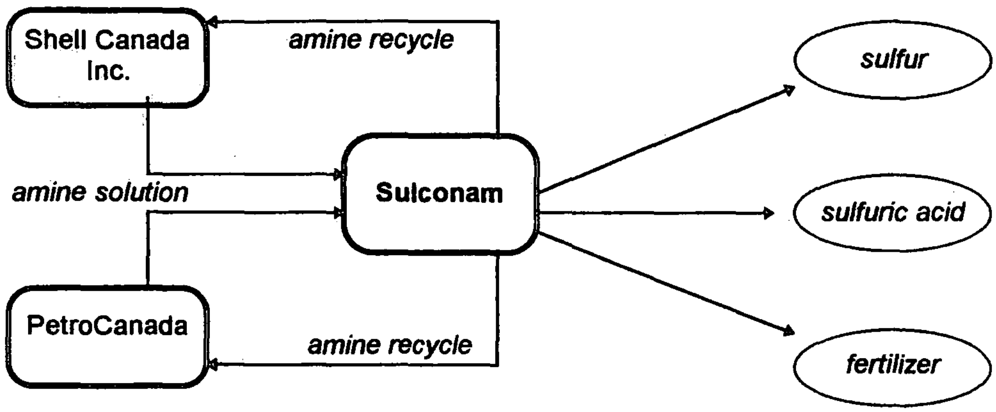


Fig. 4.12: Sulconam's Use of By-Product Hydrogen Sulfide

In summary, H_2S is absorbed in an amine solution which is pipelined from the refineries to the Sulconam plant. The H_2S and other dissolved gases such as NH_3, CO_2 and some hydrocarbons are separated from the amine which is recycled to the refineries for absorption of H_2S.

The H_2S is converted to elemental sulfur in a three reactor Claus unit which recovers 95% of the sulfur in the H_2S stream. The gas from the Claus reactor goes to a tail gas unit where it is burned to give SO_2. The SO_2 is oxidized to SO_3 and subsequently reacted with water to give 73-77% sulfuric acid.

Gases from a sour water stripper consisting of H_2S, NH_3 and water are also treated in the incinerator of the tail gas unit. NH_3 is oxidized to nitrogen.

Total sulfur recovery is 99.5%. The sulfur is shipped as a liquid mainly to customers in Quebec. The sulfuric acid is shipped by railcar primarily to Hamilton, Ontario for steel pickling.

The plant uses the equivalent of about 75,000 barrels of oil per year mostly to generate steam. Sulconam would have been a user of steam from the proposed cogeneration project. There are two opportunities for Sulconam:

Opportunity #1

Sulconam is developing a use for the NH_3 from the sour water stripper. The NH_3 will be reacted with sulfuric acid to give ammonium sulfate. The sulfate crystallizing from a saturated solution will be centrifuged to about 5% water, dried and granulated. The product will be sold to a fertilizer company.

Drivers: The NH_3 affects the operation of the Claus and tail gas units and also produces some NO_x which has been considered as a possible contributor to a "firecracker" smell noticed in the general area.

Ammonium sulfate used in Quebec as fertilizer for forage crops is currently imported. The proposed Sulconam production of 10,000 to 15,000 tonnes would replace part of the imports. Ammonium sulfate currently sells for about $120/tonne. Demand is expected to grow.

Barriers: The physical form of the ammonium sulfate was a barrier that has been largely overcome. Development work was needed to ensure that the physical form of the material would not cause it to stratify when blended with other fertilizers. The ammonium sulfate must be produced in a form that has the same physical form and density as other components of fertilizes blends.

Opportunity #2

Sulconam will also provide liquid sulfur to an adjacent company which proposes to use it initially in sulfur concrete and later as an asphalt extender. (see SpolTech case 4.5.1).

4.2.5 Montreal East Metallurgical Complex

Participants

- CCR Division of Noranda Minerals Inc.
- Alcatel Cable
- Tuyaux Wolverine Canada Inc.

Potential Future Participants

- Cansolv Canada Inc.
- Centre Energetique Montreal-Est (CEME)

Project Outline / Description

Three companies of the Montreal East metallurgical complex share industrial steam and raw materials flow. CCR is a major electrolytic copper refinery; Alcatel Cable operates a copper-wire rod mill and Wolverine produces copper tubing. CCR refines 99% pure copper from Noranda copper smelters in Horne and Gaspe. It supplies 99.99% refined copper to secondary copper producers, including adjacent Alcatel and Wolverine operations. CCR treats reject copper from these two industries as well as a bleed stream from Alcatel.

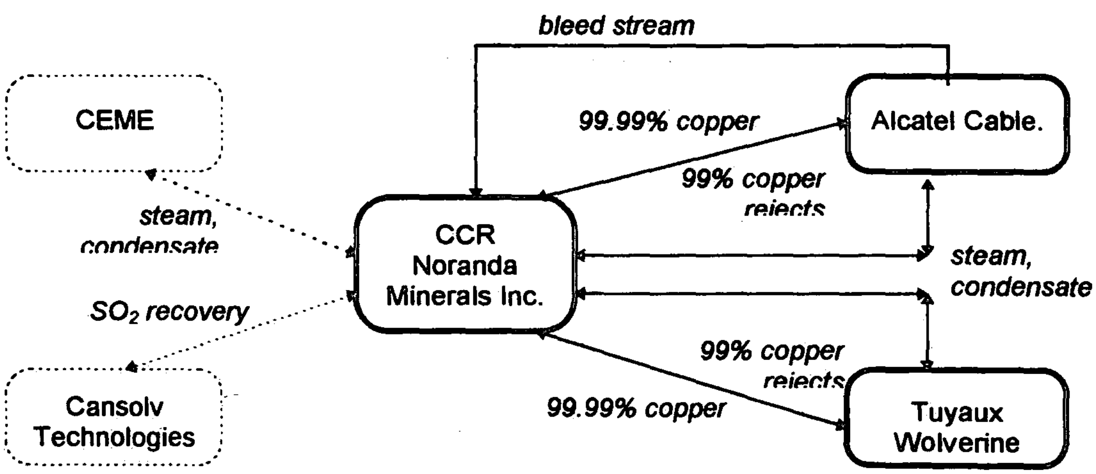


Fig. 4.13: Sharing of Resources within the Montreal East Metallurgical Complex

This sharing of resources has historical basis; both Alcatel and Wolverine were, at one time, a part of the Noranda organization. Today, economic and environmental drivers keep the "partnership" going. Further integration and cooperative efforts under consideration include participation in the CEME cogeneration project as well as the possibility to recover SO_2 using the CANSOLV[R] System for the precipitation of selenium from selenious acid. The CCR refinery is a major consumer of industrial steam. For every tonne of copper, a half of a tonne of steam is needed. At this time, this steam is generated in CCR gas-fired boilers. Excess steam is used by Alcatel and Wolverine. The CCR electrolytic process consumes about 110-million kWh annually.

Drivers

- **Economics**. The value of noble metals drives virtually 100% recycling of all wastes internally generated in the process, as well as some from outside sources. High purity (>99.99%) of the finished metals limits the type of copper rejects that can be directly recycled. Contaminated or lower purity copper has to be shipped back to the smelters.

- **Energy**. As a large industrial and electricity user, the Montreal East metallurgy complex is a potential participant in the CEME cogeneration project.

Technology

The Montreal East metallurgy complex is a fully integrated world-class copper and precious metals electrolytic refinery complemented by copper wire, cable and tubing production. CCR has the capacity to refine 360,000 tonnes of copper and produces about 30-million ounces of silver, 1.2-million ounces of gold, smaller quantities of precious platinum and palladium, as well as by-products, such as tellurium and selenium.

The relevant technologies are well established.

CCR

99% pure copper anodes come to the CCR refinery mainly from the Noranda Horne and Gaspe smelters. While these smelters account for the bulk of the CCR copper supply, CCR also processes a range of copper scrap, impure blister copper and precious metal slimes.

Through a process of electrolysis, the copper is stripped from an anode and plates onto thin pure copper sheets, so-called starting sheets, which are loaded as cathodes into the cells. There are 1800 such cells in the 600' x 600' electrolytic tankhouse filled with a solution of copper sulfate and sulfuric acid. When the starting sheets reach approximately 125 kg, they are removed and replaced by new ones. After an additional 10 days, the cathodes are removed once again, the anodes are replaced and a new cycle begins. The whole cycle takes about 21 days. For each 300 kg anode, two 125 kg cathodes are produced.

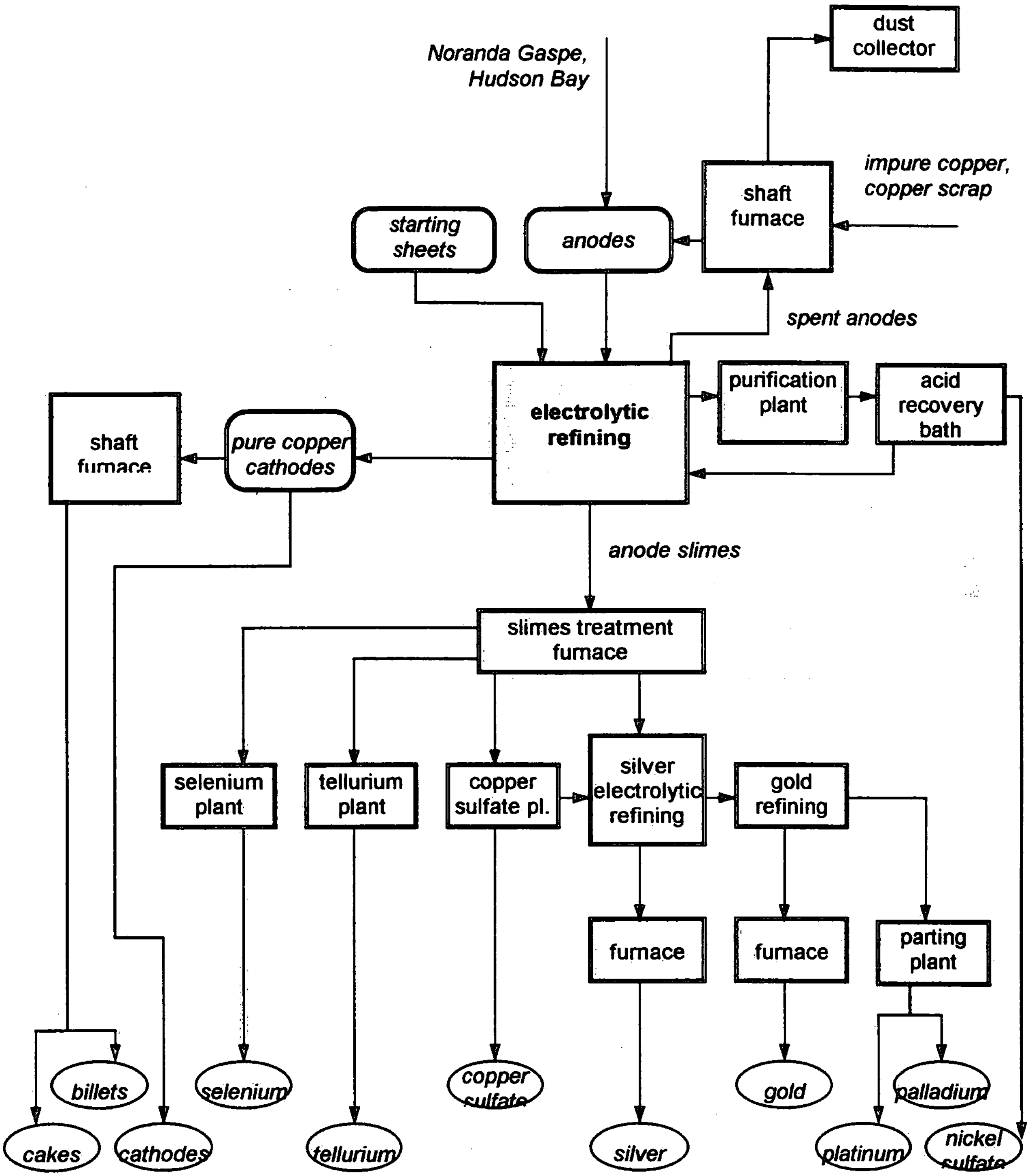


Fig. 4.14: CCRNoranda Minerals Process Flowchart

Throughout the process, impurities such as gold, silver, selenium and tellurium drop from the anodes to the bottom of the cells in the form of anode slimes. Other impurities, such as antimony, bismuth and nickel accumulate in part in the solution and are removed in the purification and acid recovery plants. The purified electrolyte is returned to the tank house; the nickel sulfate is sold.

The anode slimes are first treated to remove the residual copper and tellurium which are subsequently refined in separate plants. These slimes are loaded into a furnace known as a Top-Blown Rotary Converter (TBRC). Once the selenium has been removed, the remaining metal, known as Dore metal, is cast in the form of anodes. These Dore anodes are refined by electrolysis to obtain pure silver. The anode slime resulting from this treatment undergoes a hydro-metallurgical process to yield pure gold. The silver and gold obtained this way are cast into ingots. Finally, a platinum palladium sponge is precipitated from the solutions.

Alcatel Cable

Alcatel Cable, formerly a part of Noranda Minerals known as Canada Wire & Cable, has been a part of the French Alcatel organization since 1991. About 160,000 to 170,000 tonnes/year of copper cable, 8 mm and 10 mm in diameter, are produced in Alcatel's foundry, caster and continuous 13 steps rolling mill. Currently it operates 6-1/2 days/week, close to its capacity. Direct natural gas-firing is used to remelt and draw copper cable. Natural gas consumption is approximately 8-million m3/year. About 75% to 80% of the 99.99% pure copper supply comes mainly from copper refineries including CCR, the remaining 20% to 25% is the same high purity copper obtained as cathode from other suppliers.

The melting temperature of copper is 1083°C. Alcatel keeps the foundry temperature at around 1125°C. There is some 210 °C waste heat available, that is not utilized at this time. Sulfuric acid baths are used for copper cable cleaning. Sulfuric acid is recirculated, with some make-up, forming essentially a closed loop. Steam is bought from CCR, and the condensate is reused in the cleaning baths. The volume of cooling water at a temperature differential of about 2°C is too low for economical heat recovery.

Issues and Barriers

Companies of the Montreal East metallurgical complex are all potential participants of the CEME cogeneration project. CCR is a potential customer for the CANSOLV^R process. The issues and barriers associated with these two ventures are discussed in detail under appropriate case histories.

The potential barrier to the use of Cansolv SO_2 in selenium precipitation is the critical need for its absolute purity. No organic impurities can be tolerated.

Regulations / community acceptance.

CCR operates a state-of-the-art multi-million dollar effluent treatment facility. There is no effluent discharge to the St. Lawrence river. Clean effluent is discharged to the municipal collector. The total suspended solids (TSS) content meets their Montreal Urban Community (MUC) permit requirements.

Factors contributing to success

- The close cooperation and interdependency of the three companies of the Montreal East metallurgy complex have both historical as well as economic and environmental reasons.
- Their experience in respect to sharing of resources could also play a role in their positive attitude towards the CEME cogeneration project.
-

Conclusions

The companies in the metals complex have a positive attitude toward capitalizing on new opportunities. CCR Noranda Metallurgy, Alcatel Cable and Wolverine Tubes already operate in close industrial partnership, sharing energy and materials resources. The two opportunities that exist include a broader partnership with other players in the Montreal East industrial community, namely the proposed CEME cogeneration project and CANSOLV^{R} system to recover and use SO_2.

4.2.6 Lafarge Canada Inc.

Description
Lafarge operates a cement terminal on what used to be part of a large cement plant in Montreal East. Some of the land and buildings are available for use by other industries.

- area 2,000,000 sq. ft.
- previous use: cement manufacturing,
- environmental status: there are no known environmental issues. Land that is not currently used has been cleaned to Class C standards and partly landscaped,
- buildings:
-

Number	Area
4	100' x 200'
1	250' x 160'
1	392' x 100'
1	85' x 50'

The site has rail and good road access. There is access to silos at the Port of Montreal. The silos are currently equipped for loading vessels but could be modified for vessel unloading. Lafarge currently leases some space for storage on an opportunity basis but would prefer a medium to longer term arrangement. It considers the best use for the site would be for bulk storage.

The Company's criteria for selecting possible uses, if the property is being leased, are:

- environmentally sound,
- not offensive to the neighbouring community,
- not in competition with Lafarge.

Lafarge would also consider sale of the property under conditions which satisfy these criteria.

Conclusion
The large area with its well maintained buildings and access to rail, road and water transport makes this a good site for development.

4.3 Varennes

Similarly as in Montreal East, area interests are represented in a number of industrial and municipal associations and development organizations

L'Association Industrielle de Varennes has, as members, the major companies in the area:

- Albright & Wilson, Amerique,
- AET-technologies d'extrusion appliquees,
- Air Liquide Canada Inc.
- Dow Chemical Canada Inc.
- L'environment Eaglebrook Quebec Inc.
- KRONOS Canada Inc.
- Montell Canada Inc.
- Petromont Inc.
- Praxair Canada Inc.

There is a number of synergies and existing resource sharing between various companies in the park. Some of them are shown in Fig. 4.15.

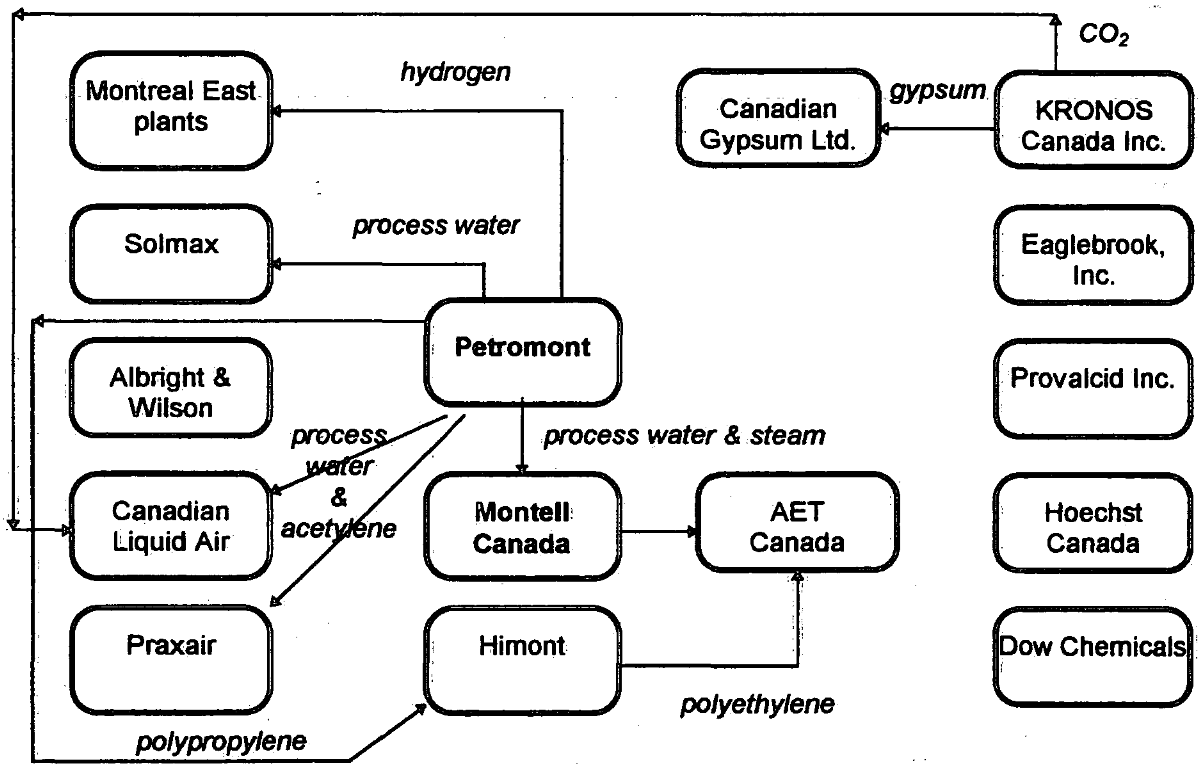


Fig. 4.15: Varennes Industrial Park

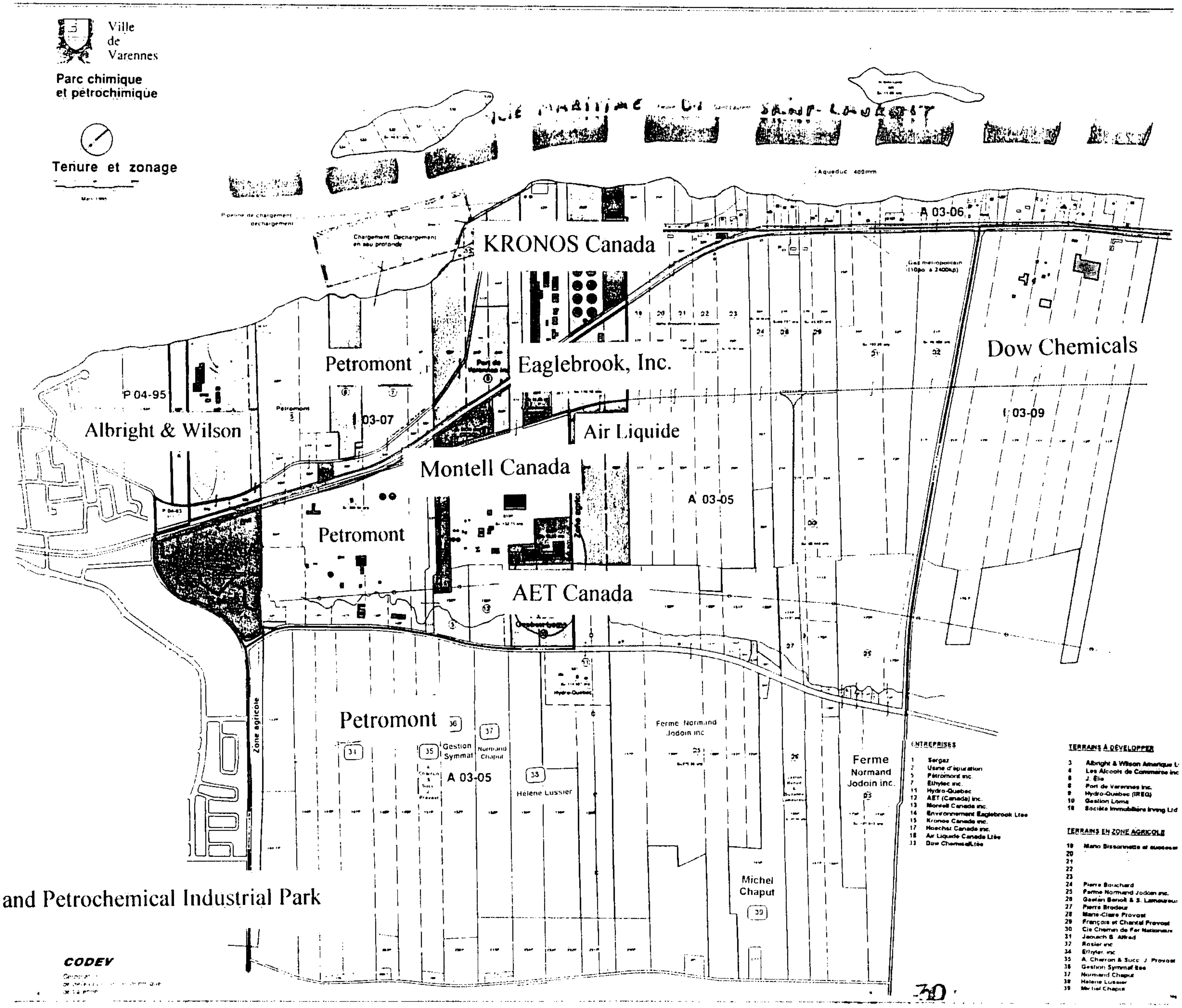


Fig. 4.16 Varennes Chemical and Petrochemical Industrial Park

The association conducts ambient air monitoring on behalf of its members. It conducts an ongoing community outreach program by disseminating information to the surrounding community and acting as a focal point for complaints or other public concerns. The association arranges site visits to member plants for interested members of the community.

The association plays an active role in pooling resources such as emergency response and in finding other ways to increase the competitiveness and sustainability of the industrial complex.

Corporation de Developpment Economic de Varennes (CODEV) was established in 1994 with the mission of:

- promoting industrial, agricultural, commercial, tourist and residential development in Varennes,
- creating a climate suitable for economic development,
- supporting local businesses,
- being responsive to local needs,
- facilitating the establishment and maintenance of business enterprises,
- developing synergies between industries and other stakeholders,
- offering a single window approach to potential developers,
- maintaining an awareness of opportunities for new development projects suitable for Varennes.

The organization plays a valuable role in attracting new business to the area by being aware of the types of synergies and advantages available in the industrial community. These include:

- steam,
- industrially zoned land,
- water,
- sewage treatment
- fire water,
- rail lines and road access,
- emergency response,
- skilled labour force,
- community outreach through the Varennes Industrial Association,
- purchasing power.

An example of the work of CODEV is the current effort to attract an ethanol plant to Varennes. This plant would produce 150,000,000 litres per year, create 100 direct jobs and 450 indirect jobs with a capital investment of $150 million.

Conclusion

CODEV, because it consists of representatives of all stakeholder groups in the area, is well positioned to identify and encourage opportunities for sustainable development.

Specific cases of industrial partnerships and cascading of resources in the Varennes area are discussed below.

4.3.1 KRONOS Canada, Inc.

Participants
- KRONOS Canada
- Canadian Gypsum
- Air Liquide

Description
KRONOS produces titanium dioxide pigment, used in paints production, from rutile ore or from slags. The company uses two processes:

> **Chloride** which extracts the titanium from ore or slag as $TiCl_4$ using chlorine as a reagent. Production by this process is 52,000 tonnes per year.
>
> **Sulfate** which extracts the titanium from slag as a sulfate using sulfuric acid. Production by this process is 19,000 tonnes per year.

In the sulfate process, the acid remaining after the titanium salts have been precipitated and washed, is neutralized with limestone to give synthetic gypsum. The purity, crystal size and moisture content of the gypsum are controlled so that it can be used as a raw material in the production of wallboard in the Montreal plant of Canadian Gypsum. Finding a value added use for the acid neutralization residual, gypsum, has made a major contribution to pollution prevention.

The other byproduct of the neutralization process is CO_2. KRONOS and Air Liquide have developed a partnership which will capture the CO_2, scrub and dry it at the KRONOS site, and pipeline for compression and shipment at the adjacent Air Liquide site.

Approximate material balance of the sulfate process:

	Tonnes per year.
TiO_2	19,000
Gypsum	65,000
CO_2	17,000

The drivers for recovery of synthetic gypsum were the need to neutralize the waste acid and to recover the neutralization product as a marketable product. The driver behind the CO_2 recovery project is a corporate commitment to reduce, where economically possible, greenhouse gas emissions.

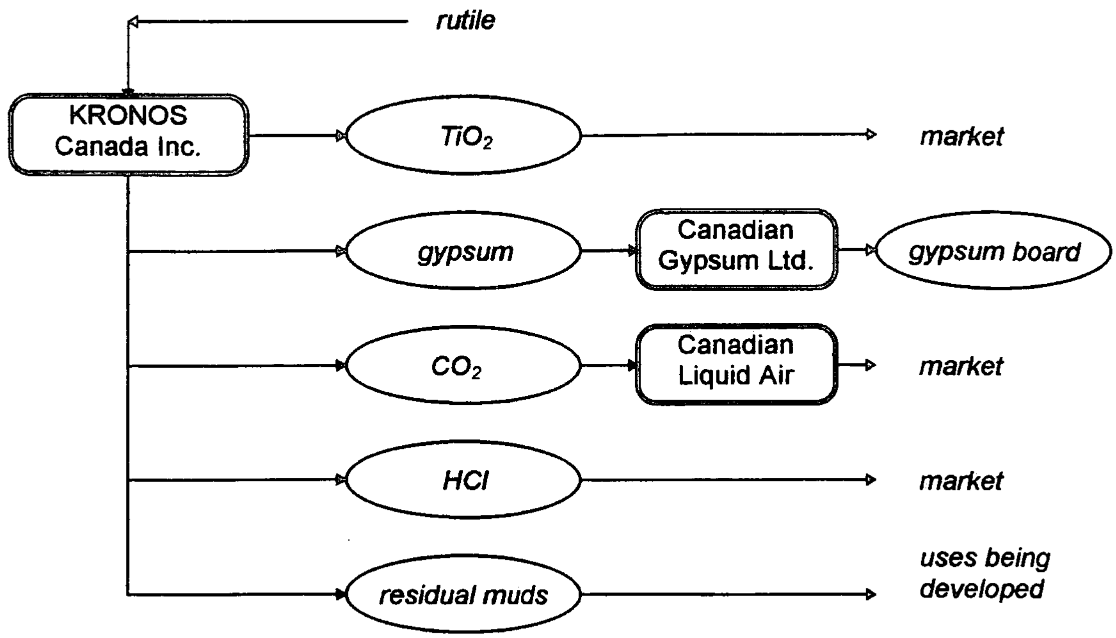


Fig. 4.17: Utilization of Titanium Dioxide (TiO_2) Production By-Products

The chloride process recycles the chlorine produced when the $TiCl_4$ is oxidized to TiO_2. Some HCl is present in the gas stream from the separation and purification step. This HCl is sold as commercial grade hydrochloric acid or is neutralized if the demand for acid is less than the quantity generated.

Factors for success:

- small number of participants,
- no new technology required,
- established markets,
- corporate commitment,
- proximity of participants,

Barriers

- scale of capital investment.

The future

Both the sulfate and chloride processes have a neutral, non-hazardous sludge residual which is currently landfilled. KRONOS is actively looking for value added uses for these materials.

Conclusions

KRONOS has been successful in finding value added uses for its primary residuals and is pursuing opportunities for recycling its other residuals.

4.3.2 Eaglebrook, Inc.

Participants

- Eaglebrook, Inc.
- Generators of steel pickle liquor
- Water treatment organizations

Description

Eaglebrook collects byproduct pickle liquor from steel plants in Canada and the U.S. and converts it into ferric chloride for use in water treatment as a flocculant.

The Company's overall balance of material sources and markets (this includes other production facilities as well as Varennes) is as follows:

	Sources of pickle liquor	Markets for ferric chloride
Quebec	2%	18%
Ontario	17%	8%
U.S.	81%	74%

In Varennes, more than half of the plant's ferric chloride capacity serves to supply the Montreal Urban Community's water treatment plant.

Eaglebrook's process involves direct chlorination of ferrous to ferric chloride in an exothermic reaction. The process includes the option of dissolving iron with ferric chloride and chlorine if additional iron is needed. This reaction is also exothermic. Heat exchangers remove excess heat prior to storage and shipping of the product.

Factors for success:

- technical know-how,
- ability to guarantee service to the pickle liquor generators,
- ability to match pickle supply with demand for ferric chloride while maintaining minimal on site storage of raw material or product,
- lean, innovative organization.

Barriers

The proposed user fees associated with the Exports and Imports of Hazardous Waste Regulations (EIWHR) threaten to increase the cost of serving U.S. customers and may make it uneconomical to recycle material from the U.S. at Varennes. The primary objection that Eaglebrook has to these proposed fees is that the spent pickle liquor should not be classified as a waste since it is a raw material for recycling, not a material destined for disposal. While the intention of the regulations is to protect the environment, their unreasonable application, and the proposed user fees, will only serve to discourage recycling.

The future
Eaglebrook is extending its technology to apply it to other iron bearing byproducts and process residuals and hopes to be in a position, by the end of 1997, to recycle other materials in the Varennes complex.

4.3.3 Dow Chemical Canada

Description
Dow's facility at Varennes has three product lines; styrofoam insulation, ziploc bags and latex for coating applications. The facility has taken specific steps to minimize its impact on the environment:

- 68% of all residuals are recycled. Most of this is onsite but some is done by off-site services. The remaining 32% consists of cafeteria wastes, fibrepak drums, wood and non-recyclable packaging,
- water use is closed looped and the facility has been off-the-river since 1990,
- a cooling tower for cooling water so that this water no longer goes to a cooling pond; the effluent from a biological treatment unit for sanitary water goes to a pond on the plant property (this pond also serves as a source of firewater),
- a styrene contaminated water stream was closed looped back into the process in 1984; when the concentration of contaminants reaches too high a level the organics are separated as "recycle oil" which is sent to an approved incinerator,
- the boiler has been equipped with three burners to burn natural gas, recycle oil and process vent gas which otherwise would be vented to the atmosphere,
- oversize latex particles, those not passing a 425 mesh screen, were until recently sent to landfill. Dow has arranged to have the material emulsified in a solvent and used as a fuel in the U.S. Regulations in Quebec do not permit its use in Quebec. The quantity of the latex residue is about 50 tons per year,
- waste plastic material from the Ziploc operation which cannot be recycled as food grade is recycled off-site,
- the facility evaluates the use of CO_2 as the blowing agent for styrofoam by 2003.

Drivers
The primary driver for much of the sustainability related action at Varennes is Dow's corporate policy. The Varennes site is responsible for developing its own vision of how the policy objectives could best be achieved and for making this vision a reality.

Conclusion
Dow at Varennes has taken positive and creative steps to reduce the environmental effects of its operation.

4.3.4 Applied Extrusion Technologies (Canada) Inc. (AET)

Description

AET at Varennes extrudes polypropylene packaging material. It has three bubble process lines which produce polypropylene for containers and one tender process line which processes polypropylene for wrapping applications such as cigarette packs. AET recycles its polypropylene process wastes back into the extrusion processes.

The Company receives process steam which is cascaded from Petromont to Montell and AET. Montell also supplies water. The Company shares road access and rail with Montell. AET shares emergency response capability and emergency training with the local industries.

The Varennes Industrial Association, of which AET is a member, is the primary vehicle for community outreach. The Community addresses its concerns to the Association and gets responses from it. The Association monitors air quality with data from a number of sampling points in the area installed by the Association.

Conclusion

AET has a positive attitude towards formation of partnerships to make its operations more competitive and sustainable and is open to evaluating opportunities which lead in this direction.

4.4 Sorel - Tracy

Due to time constraints, the region was not studied to the same degree as the others. This section gives a brief overview of some of the special aspects of the area.

Sorel-Tracy is a centre of heavy industry on the St. Lawrence Seaway, about 80 km east of Montreal. It has experienced a decline in its industrial base and is interested in attracting new capital investment to maintain its critical mass and increase jobs.

Development Organizations

In Sorel-Tracy there is a high level of interest and integration among the groups seeking to promote industrial, commercial and tourist development. The vision shared by industry, labour and the community is to develop the area along sustainable lines and to enhance the quality of life in the region.

The Societe d'aide au developpement de la collectivite du Bas-Richelieu (SADC) acts as an umbrella group stimulating and coordinating the activities of other organizations. The mission of SADC is to "stimulate the community's participation in taking charge of its future."

To further this goal the SADC:

- organizes activities that promote concerted action,
- offers financial and technical services to small businesses and independent workers,
- undertakes strategic planning,
- supports local initiatives,
- encourages local committees,
- promotes local identity,
- stimulates dynamic involvement of the population.

Other key organizations include the Corporation de developpement economique, Asociation des grandes entreprise (AGIR), the Table de concertation en environnement du Bas-Richelieu and the Sorel-Tracy campus of the Universite du Quebec which provides technical and other forms of support.

The degree of integration available among the industries in the area is clear from the region's bid developed by the Corporation de developpement economique, to attract the Canadian Alcohols proposed ethanol plant.

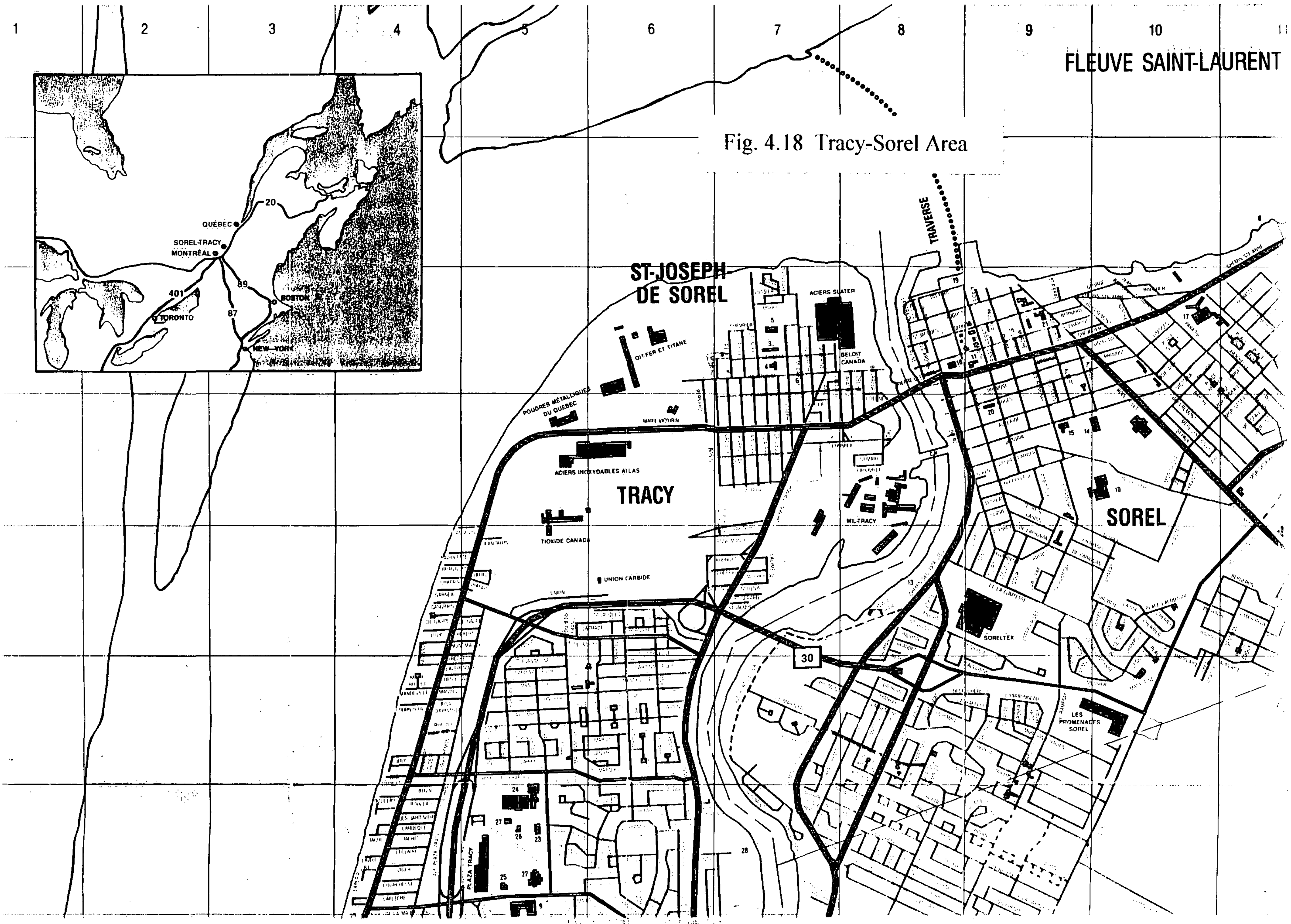


Fig. 4.18 Tracy-Sorel Area

Sorel-Tracy can offer:

- process steam (from Canadian Tioxide),
- water,
- firewater,
- road, rail and water access,
- emergency response,
- waste water treatment.

The region has been successful in attracting technology developers for example:

HEBCO operates a pilot plant aimed at optimizing pyrolysis of scrap tires, plastics and possibly shredder fluff from recycling automobiles.

The company has developed a modular unit capable of pyrolyzing 700 tires (7 tonnes) per batch with a cycle time of about six hours. The products include oil, carbon black and steel from bead and tread wire. Markets exist for the oil and steel, and efforts are being made to find the highest value application for the carbon black.

Conporec has developed a 42,000 tonne per year demonstration plant which composts the putrescible fraction of household waste and separates other materials for recycling. Of the collected waste, approximately 30% currently goes to landfill. This fraction is expected to drop to 10% in the future.

Mass balance of collected waste [%]

	Present	Future
Landfill	30	10
Recycling	15	35
Composting	55	55
Total Recovery	70	90

Heavy industry in the area has made gains in pollution prevention, for example, the $40 million investment by QIT-fer et Titane Inc. in waste water treatment which recovers fine, suspended mineral particles. The company is currently landfills this material but is actively looking for a value added end use.

4.5 Resource Recovery Companies

These companies provide, or are in a position to provide, services to industries not only in the Montreal area but also in some cases process materials drawn from generators within an economical transportation radius.

4.5.1 SpolTech: Use of Recovered Sulfur in Sulfur Polymer-Based Construction Materials

Proponent

- SpolTech

Other Financial and Industrial Partners

- Societe Generale de Financement
- Dominion Bridge
- Societe Inovatech du Grand Montreal

Potential sources of sulfur

- Sulconam
- Come-by-Chance refinery, NF
- Marsulex

Potential Users

- Construction and civil engineering industry
- Stabilization and encapsulation of toxic wastes

Project Outline / Description

Founded in 1996 following three years of intensive development, SpolTech proposes to manufacture and market sulfur polymer-based construction materials, systems and application technologies, based on the use of sulfur recovered by-product from a range of desulfurization processes. SpolTech will supply the sulfur polymer from its own or licensed facilities located near the major construction markets. The construction start-up of the first plant was initiated this spring, with plant start-up scheduled for August.

The sulfur polymer, in the molten state, can be mixed with aggregates, replacing and competing with cement as concrete binder. No water is added. Among the characteristics of sulfur concrete are:

- outstanding mechanical strength;
- impermeability;
- resistance to acids and salts;
- resistance to freeze / thaw;

- electrical and thermal insulating properties;
- fast setting characteristics, rapid strength development and ability to be in service within 24 hours;
- recyclability.

SpolTech considers the main potential clients for sulfur polymer concrete to be local, provincial and federal governments, as well as airport and port authorities, electrical utilities, railways, mining, chemical and heavy industries. SpolTech has to integrate its efforts with a number of government authorities and existing construction channels to ensure rapid and smooth market penetration. A number of specific demonstration projects are planned for 1997.

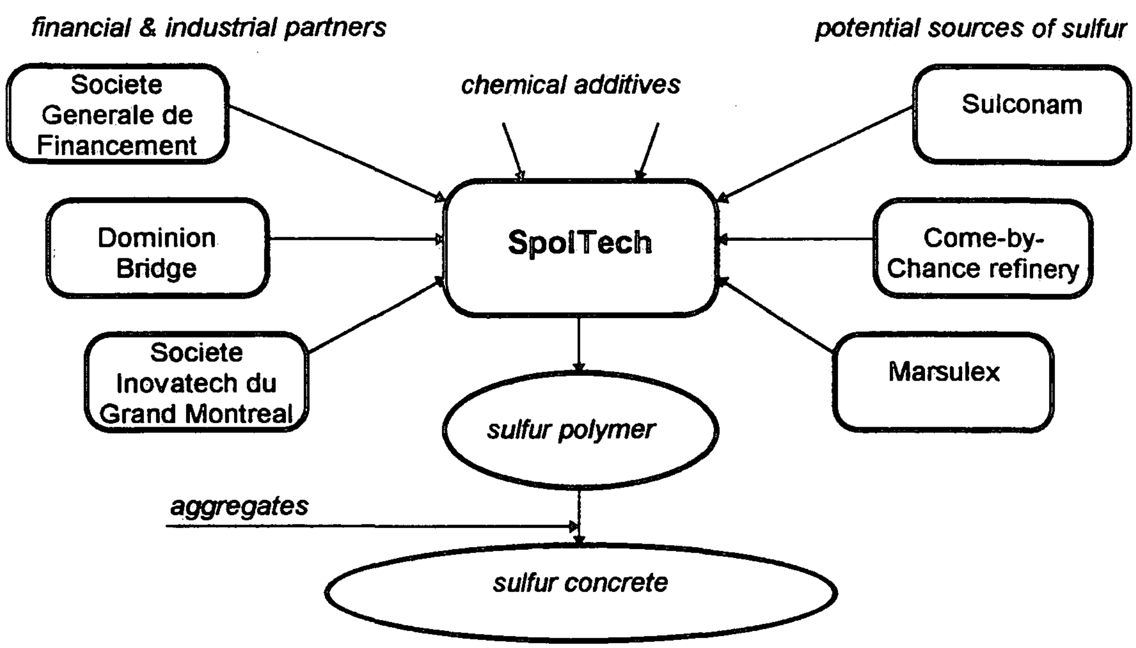


Fig. 4.19: Use of Recovered Sulfur in Sulfur Polymer-Based Construction Materials

Drivers

- Failure of traditional construction materials to perform over long periods of time in certain applications;
- Increasing displacement of sulfur from its traditional markets by flue gas desulfurization products.
- Regulations: The Canadian and U.S. Clean Air Acts mandating significant reductions in SO_2 emissions.
- Requirement to reduce the life cycle costs of construction work.

Technology

Sulfur polymer concrete technology is not new. There are over 20 years of experience with sulfur concrete, although due to a number of factors, it has not yet been generally promoted and accepted in the market place. One of the possible reasons is that for the early proponents of sulfur concrete technology, petrochemical concerns such as Chevron, Shell or Gulf Oil, sulfur concrete technology was not a part of their core business. Also there have been some technical challenges to be satisfactorily resolved, such as the sulfur odour. A major economic challenge to wider utilization of sulfur polymer concrete, however, appears to have been the wide fluctuations in the availability and price (anywhere from $10-$20/tonne to $200/tonne range) of secondary sulfur.

SpolTech technology uses sulfur (95%) mixed with chemical agents (5%). SpolTech's technology is based on know-how originating in Eastern Europe.

Market

At the outset, SpolTech intends to concentrate on markets where the special properties of sulfur polymer concrete offer significant advantages over conventional materials, such as construction and civil engineering projects requiring chemical (acid, salt) and corrosion resistance, as well as high mechanical strength and fast setting time. This could include construction and repair of infrastructures such as roads, airport runways, sidewalks, parking lots, bridges, etc. Waste encapsulation and stabilization, as well as production of specific precast concrete products, such as pipes, railway ties, prefabricated walls and highway dividers, will also be considered. Sulfur polymer is not intended to replace portland cement, but to compete with it in niche applications where its specific characteristics and long term performance provide a distinct advantage over the traditional concrete.

SpolTech is commited to ensuring product and application quality as well as stable and competitive pricing through close relationships with its supply and distribution channels and the end users.

Economics

The cost of sulfur polymer concrete will be higher than the cost of conventional portland cement-based concrete. However, in those applications where the performance and long term durability prevail, it is believed that the life cycle costs will be on par or better. SpolTech market share is expected to be in the range of 2.5% of all concrete applications.

Issues and Barriers / Problems

- Acceptance of sulfur concrete; despite its 20 year old history, sulfur concrete still remains and is considered to be a relatively new material by the traditionally very conservative construction and civil engineering communities;
- Insufficient database regarding long term performance and durability of the sulfur polymer concrete;

- Lack of standards, code and regulatory bodies' approvals for sulfur polymer concrete;
- Fluctuations of sulfur supply and costs; successful negotiations for a supply of sulfur within guaranteed price range.
- Possible higher initial sulfur concrete placement costs;
- Contractors' unfamiliarity and lack of training in use and applications of sulfur polymer concrete;

Factors contributing to success:

- SpolTech is approaching some of the barriers by forming of strategic alliances with various governmental bodies and financial and industrial partners.
- A number of important demonstration jobs have been arranged and are waiting for the material to be produced in order to be executed.
- Failure of traditional construction materials to perform over time in certain applications, resulting in willingness of users to consider new materials, their durability and life cycle costs;
- SpolTech's technological data base, through diligent and thorough R&D effort both at the product and application levels, is under development. (R&D and product assessment is being conducted at certified laboratories and research centres).
- SpolTech is 100% dedicated to sulfur concrete technology and market applications, sulfur polymer being its core business.
- SpolTech intends to market sulfur polymer concrete only through trained and licensed contractors to assure application quality control. The target niche is those areas where traditional portland cement-based concrete does not provide sufficient performance and long term durability.

Conclusions

SpolTech is developing a useful value added application for sulfur. Sulfur concrete and subsequently other sulfur polymer derived materials such as extended asphalt should have lower life cycle costs than competing materials.

SpolTech's commitment and entrepreneurial drive should give the product a firm footing in the market.

As an example of future potential, there is a possibility that the sulfur polymer might be able to upgrade the pitch from the PetroCanada CANMET Hydrocracker so that the pitch can be used in construction applications.

4.5.2 CANSOLV[R] Gas Stream Desulfurization & Sulfur Dioxide (SO_2) Recovery

Proponent

- Cansolv Technologies Inc.

Potential Participants

- Refineries, ore smelters, fossil fuel power stations and other industries emitting SO_2 in their gas streams. Initial target: Montreal East industrial complex, pulp and paper industry, with other potential application elsewhere in Canada and the U.S.A.
- SO_2 users, primary target being the fertilizer and pulp & paper industries.

Project Outline / Description

CANSOLV[R] System is a new, high efficiency process for the removal of SO_2 from gas streams. SO_2 is produced as a by-product that can be further processed to sulfuric acid or elemental sulfur. CANSOLV[R] System represents a new source for these sulfur products. From the environmental point of view, the CANSOLV[R] System is a preferable alternative to the accepted SO_2 control technologies, such as wet limestone desulfurization, that produce large amounts of not always usable by-products, and that often have to be landfilled. The CANSOLV[R] System is a regenerative process that uses a unique absorbent that has a high capacity for, and reacts quickly with SO_2. It is claimed that this process requires less space, is more efficient and more cost effective than the existing desulfurization limestone-based technologies.

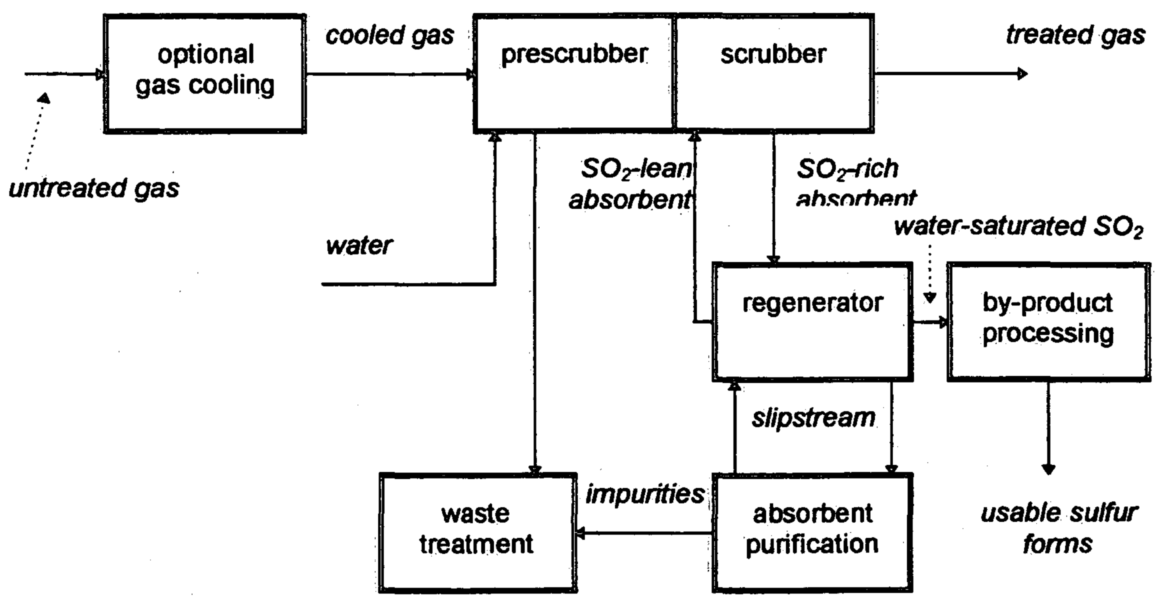


Fig. 4.20: CANSOLV[R] Process Flow Chart

It is expected that the recovered SO_2 will be easily absorbed by the extensive North American market for sulfur products, the dominant uses being the manufacture of fertilizer and soft wood pulping.

Drivers

- Regulations. The Canadian and U.S. Clean Air Acts mandating significant reductions in SO_2 emissions.
- The fact that the most commonly used desulfurization technology, the wet limestone inhibited oxidation process, generates large volumes of calcium sulfite waste that has to be landfilled, effectively only exchanging an air pollution issue for a solid waste problem.
- Even when forced air oxidation technology generating calcium sulfate (gypsum) is used, the North American markets may not be able or willing to absorb all these new sources of FGD gypsum, with the result that some of the gypsum will still have to be landfilled.
- Economics. According to the company, the capital investment associated with the CANSOLV^R System and its operating costs are lower than for the wet limestone FGD processes.

Technology

The CANSOLV^R technology was originally developed by Union Carbide, which invested $30-million over the years 1988 to 1993 resulting in a patent (U.S. Patent 5,019,361). Due to a corporate decision to concentrate efforts in other areas, this technology was acquired from Union Carbide by some of its original researchers/ developers incorporated now under the name Cansolv Technologies Inc.

SO_2 is removed from the gas streams by their contact with a water solution of specific, proprietary amine absorbing medium at temperatures less than 60° C. The spent absorbent is regenerated by removing captured SO_2. The CANSOLV^R technology is one of the very few regenerable desulfurization processes available, the most widely used one, at this time, being the Wellman-Lord process that uses sodium sulfite solution as the sorbent. However, this process is no longer offered by the licensor. The main advantage of regenerable systems is that they produce raw chemical feedstock rather than a residue by-product.

Some of the specific benefits of the CANSOLV^R technology, as opposed to conventional wet limestone technologies, include:

- no equipment erosion due to abrasion, as with slurry processes;
- small absorber size made possible due to the extremely rapid mass transfer and high capacity of the amine absorbent for SO_2;
- homogeneous solution simplifies design and operation;
- no scaling of the absorber and gas ducts;
- no solids handling and disposal problems.

The CANSOLV^R System was tested at a $10-million 2 MWe pilot plant scale facility located at the Suncor Oil Sands Group operations at Fort McMurray, Alberta, during a 9-month period from February to November, 1991. The pilot plant was designed to treat 6000 Nm^3/hr of flue gas emanating from the Suncor utilities boilers, which burn 7% sulfur petroleum coke as fuel. Nevertheless, the fact that, at this time, the SO_2 system is not a proven commercial technology, is the main challenge that it faces.

Environmental implications

The CANSOLV^R technology has the capability to remove SO_2 down to a few ppm. There are virtually no residues - just small amounts of trapped particulates and some other chemical species resulting from impurities in the gas stream.

Market

The SO_2 recovered by the CANSOLV^R process can be liquefied and sold as liquid SO_2. Alternatively, the SO_2 gas can be further processed into sulfuric acid or elemental sulfur. The choice of by-product will be determined by the particular conditions associated with the site of the desulfurization plant installation.

End uses of SO_2 include pulp & paper, metals, dyestuffs and food processing. Canada produces about 150,000 tons/year at two smelters and exports about 50,000 tons a year to the U.S.A. Various sources give the total U.S. consumption at about 250,000 to 400,000 tons, including the imports from Canada, about 200,000 tons of which is produced by the burning of sulfur. Due to the relatively small SO_2 market size, it would not be possible to absorb the quantities of SO_2 that could be produced if several utilities decided on liquid SO_2 as the preferred by-product. It is estimated that just eight 300 MWe CANSOLV^R plants would be able to supply the total U.S. SO_2 demand. Furthermore, sulfite pulping, due to environmental factors and rather low yield, is falling out of favour in comparison with other pulping processes.

As far as the sulfuric acid is concerned, its total U.S. demand is about 42 million tons/year, the major end user being the fertilizer industry (69%), with industrial uses such as ore and metal processing, chemical manufacturing, petroleum refining, and water treatment accounting for the rest. Today, 80% of H_2SO_4 is produced by burning of sulfur, with the remaining 20% produced mainly by the removal of SO_2 from smelter gases. A typical 300 MWe plant capable of producing 55,000 tons represents only 0.1% of the total U.S. acid demand. Since the sulfuric acid market is so large, it is expected that this would be the option chosen by most of the CANSOLV^R technology users, and that the sulfuric acid produced by the CANSOLV^R System would most likely displace Frasch sulfur which is largely used to produce acid for phosphate fertilizer manufacture.

Economics

Capital investment for a basic small CANSOLV^R System capable of treating a gas stream from a 5 MWe to 10 MWe unit or its equivalent is about $3.5 million. Additional research and development, tailoring of the system for the specific process and its optimization could add another $1 million.

Union Carbide commissioned a study to compare the economics of several commercial processes to the CANSOLV^{R} System for a site specific case. Four lime/limestone processes and the Wellman-Lord regenerable process were selected for comparison on a power plant consisting of 2 x x150 MWe units burning medium sulfur level coal. According to the results of the study, the capital costs of typical wet limestone FGD processes were about one and a half times higher than those of the CANSOLV^{R} System, while their operating costs were about two and a half times higher. Both the capital and operating costs of the Wellman-Lord regenerable process were more than twice as high as those of the CANSOLV^{R} System. Only the lime spray dryer process was lower as far as the capital is concerned (about 60% of the CANSOLV^{R} System). Its operating costs, however, were about two and a half times higher.

Issues and Barriers / Problems

- The major barrier facing the CANSOLV^{R} System is the fact that it is not a proven commercial process.
- For an oil refinery or a power plant a less than 100% process reliability of technology can represent a loss of hundreds of thousands of dollars, and as such it will not be considered without a demonstrated, long term performance track record in similar full scale industrial application. They will use only time proven technology, even if it is less efficient and more expensive. According to the IEA Coal Research, as of the end of 1992 worldwide, out of almost 170,000 MWe of FGD fitted coal-fired units, only 4.5% used regenerable processes, mainly the Wellman-Lord installed at several German and U.S. power stations. In contrast, almost 81% of the units used wet, mainly lime/limestone scrubbers.
- There is a reluctance to be first with the new technology. Without proven, successful commercial applications, Cansolv Technologies cannot sell its technology. And, of course, nobody wants to provide the demonstration site, as the process is still unproved in full scale industrial use. Cansolv Technologies Inc. needs a successful commercial application.
- The fact that Union Carbide, a major chemical company, decided not to pursue this technology and its investment in it, is a further negative factor in Cansolv Technologies' efforts to have it implemented.
- No major problems are expected with respect to the egulations and community acceptance. Regulations, in this case, are drivers, not barriers.

Conclusion

The CANSOLV^{R} process is a technically proven and effective technology for removing SO_2 from gas streams. Adoption by industrial users depends on the installation of one or more full scale commercial units so that the operational reliability of the process can be demonstrated.

4.5.3 NOVA Pb - Lead Recycling from Scrap Car Batteries

Participants

- NOVA Pb
- Used battery and other scrap lead generators.

Description

NOVA Pb is a secondary lead smelter located on a fifty acre site in an industrial park in Ville Ste-Catherine, a south shore suburb of Montreal. NOVA Pb is Canada's largest integrated lead recycling facility with a production capacity of more than 50,000 tons of lead per year. NOVA Pb lead products are London Metal Exchange approved and are sold internationally. NOVA Pb refines more than forty different specifications of lead alloys each with its own elemental composition.

The Company's lead output rose from 15,600 metric tons in 1985 to 46,900 metric tons in 1995 and is projected to reach 80,000 in 2000. Of the total, 18,000 to 20,000 metric tons is from batteries recovered within the Province of Quebec. The remainder of the scrap is from sources within an economical transportation radius including the United States.

NOVA Pb's recycling process.

Incoming batteries are processed as soon as they are received. They are crushed and put through a classification which system segregates the different battery components. Acids are neutralized. Battery paste, plastic separators and ebonite, which act as a source of energy and as reducing agents, are remixed with the lead-bearing materials prior to treatment in rotary kiln. The kiln, fired with natural gas and waste oil, reduces lead salts to metallic lead bullion. The lead bullion and by-product slag are each removed separately. The slag is stored in an on-site monofill for future reprocessing.

Lead-bearing materials from other, non-battery sources, can also be processed.

Other byproducts, used as reagents or energy sources in the kiln, include breeze coke, scrap iron borings and packaging material such as drums and pallets received at the site.

The kiln is equipped with an after burner to ensure complete combustion of organics in the exhaust gas leaving the kiln. A conditioning tower scrubs acid gases from the gas stream before it enters a baghouse for control of particulates.

The molten bullion from the kiln is transferred to one of three 60 metric ton holding kettles. The kettles are sampled and assayed to determine their optimal use. For example, bullion containing a high level of antimony will be refined to antimonial-lead alloys while low antimony material will be refined to soft or corroding grade lead. Molten metal is transferred to one of a series of 8 refining kettles each of 100 metric ton capacity. The content of each kettle is assayed and the final product is cast into 27 kg ingots or 1000 kg blocks.

Polypropylene is isolated from the other plastic battery parts and is sold separately. About 95% of batteries in Canada are recycled.

The company plans to close-loop all its water and achieve zero discharge by the end of 1997.

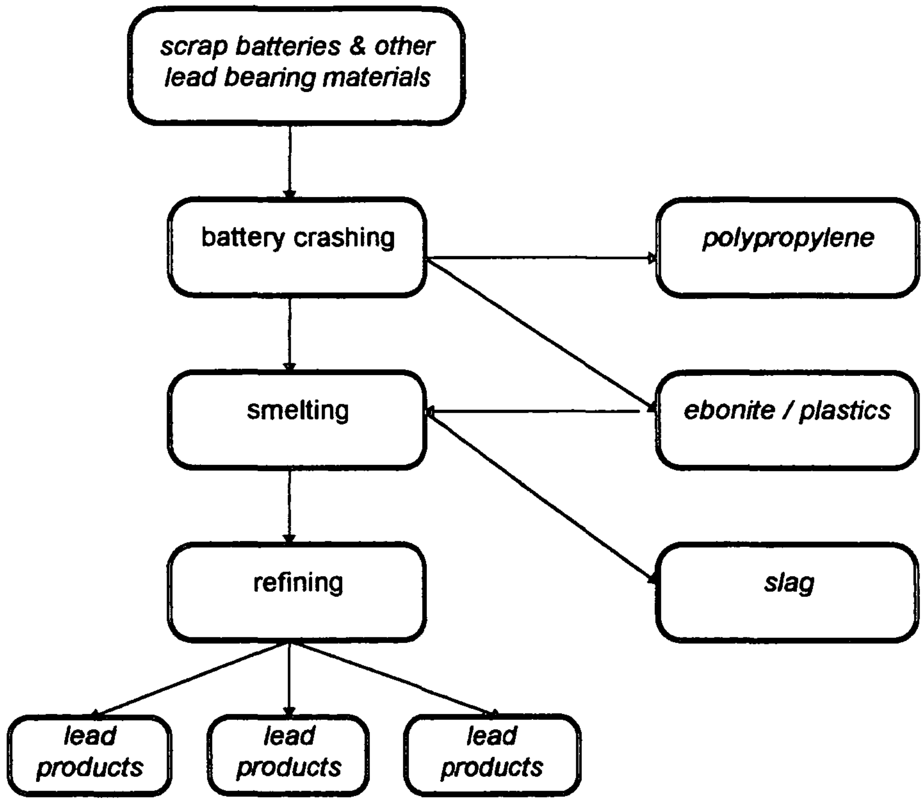


Fig. 4.21: Material Flow from Recycled Batteries

Drivers

The economics are based on the revenue generated from resale of lead less the cost of acquiring the scrap, plant operating costs and transportation. Lead prices have not risen in the past eight years, fluctuating between US$0.22 and $0.37 per pound between 1990 and 1997. During this period, the company, in response to its own environmental policy and government regulations, has made considerable capital investments. These and other factors have motivated NOVA Pb to adopt an innovative approach to finding ways to reduce operating costs in a tightly regulated business. For example;

- installing a shredder to process pallets and other packaging as sources of energy,
- evaluating the use of used oil filters as a source of iron,
- isolating polypropylene as a saleable product,
- replacing natural gas with used oil,
- using ebonite scrap as an energy source.

Barriers

The major barrier at this point stems from the federal regulations which treat used batteries as a hazardous waste destined for disposal rather than a used product to be recycled. These regulations, while aimed at ensuring appropriate handling and transportation of used batteries, tend to act as an disincentive to recycling by:

- decreasing the flexibility of operations,
- introducing unnecessary delays,
- adding a considerable level of cost without providing additional environmental protection.

Specific examples are:

1. Excess paperwork resulting from the need to provide notifications for each shipment as if it were from a new source despite the fact that it may be one of many shipments from the same company.

   A cost effective *solution* would be to develop a procedure which establishes a blanket notification for all shipments of the same material between a foreign exporter and recycler.

2. The notification process introduces delays of 30-45 days. This delay may cause a generator of waste batteries to seek other disposal routes.

   Solution: look for ways to accelerate the process when it involves generators and recyclers.

3. The manifest system has failed to adjust to the fact that deregulation of the U.S. trucking industry has changed the structure of the truck transportation business.

   Solution: review the system and find ways to adapt it to the changes which have occurred in the trucking industry.

4. Labeling of individual batteries and pallets within a shipment adds a cost of about $20,000 per year with no apparent benefit.

Solution: when a truck contains only one type of material and is going to a single destination, truck placarding should be sufficient.

In addition to these specific issues, the cost recovery proposals associated with the EIHW regulations will add a considerable cost burden to NOVA Pb. Rather than set user fees based on the current operation of the EIHW system, it would be more appropriate to look for ways to make the system more cost effective and then, if necessary, introduce user fees.

Recyclable materials like batteries that have been purchased by the importer are not likely to be disposed of in an inappropriate way, therefore do not need to be controlled in the same manner as hazardous wastes. If this is recognized then the impact of cost recovery on recyclers could be considerably moderated.

Conclusion

NOVA Pb makes a valuable contribution to sustainable development by not only recovering lead but also by using other waste streams as reagents and sources of energy in its recycling process.

The Company's investment in an after burner and gas conditioning tower puts it in a position to use a wide range of materials as energy sources in an environmentally safe manner.

Environmental regulations tend to act as a disincentive for battery recycling in Canada. NOVA Pb is open to discussions with regulatory agencies to find ways to reduce the inflexibility and cost of regulations while at the same time meeting the objectives of the regulations.

4.5.4 Safety-Kleen Canada - Industrial Fluid Recycling

Participants
- Safety-Kleen Canada Inc.
- Small quantity generators of hazardous and contaminated fluid wastes.

Project description
Safety-Kleen provides services to companies involved in:

- automotive maintenance and repair,
- manufacturing
- commercial printers
- imaging: photo-processors, quick print chains, health and other industrial imaging,
- paint refinishing: auto body shops, original equipment manufacturers,
- dry cleaners.

The company offers a closed loop service providing customers with:

- a range of industrial cleaning fluids,
- equipment to minimize their use and capture contaminated materials,
- a collection service to remove spent fluids,
- an assurance that spent fluids will be recycled, used for energy recovery or, if necessary, disposed of by incineration.

Safety-Kleen is the developer of the "sink on a drum" technology which minimizes the use of solvents and vapour emissions in parts cleaning applications.

In the Montreal area, the company collects used oil from automotive service centres. The collected material is transferred to its rerefining operation in Breslau, Ontario where it is rerefined into a range of products including rerefined lubricating oils and asphalt extenders. Spent solvents are collected and blended at a transfer site at St. Constant to give an industrial fuel which is shipped to cement plants in the U.S. No cement plants in Quebec are currently permitted to use this fuel despite the fact that the technology has been demonstrated to be environmentally sound.

Safety Kleen handles about 50% of the used oil generated in the Montreal area. The remainder is used as fuel in pulp and paper mills, greenhouses, cement kilns in the U.S. and other industrial applications.

Drivers

- regulations requiring environmentally appropriate management of waste fluids,
- revenues from sale of recycled fluids,
- economic benefit of using wastes as cement kiln fuel as opposed to incineration,
- economic benefit of acting as supplier and recycler,
- economies arising from large scale network for delivery of solvent products and collection of wastes,
- the service requirements of small scale generators.

Barriers/Issues

- competition from fuel uses for waste oil,
- low cost of entry into the used oil collection business,
- hazardous waste regulations that impede recycling or raise costs; for example glycol must be carried in separate loads,
- difficulty of getting approval to use spent solvents as cement kiln fuel.

4.5.5 Glycol Recycling

Participants

- Inland Technologies Inc.
- Dorval Airport

Project description

The purpose of the project is to recover and recycle airplane deicing fluid at Dorval.

Inland has developed a proprietary process, based on vapour recompression technology to remove water, from the ethylene glycol in recovered deicing fluids. The water content of the spent fluids varies from 70 - 99% depending on weather conditions. Recovered deicing fluids with less than 5% ethylene glycol are isolated in a holding tank, tested to make sure that they comply with the appropriate standards and are discharged to sewer.

Recovered liquids with above 5% ethylene glycol content are treated to bring the glycol level to 40-60%. The intention is to sell the recovered product into the general glycol market. The optimal situation would be to have the recovered material reused to deice airplanes. The barrier to this course of action is that aviation standards are rigid, requiring extensive physical and chemical testing of each batch of material, in order to use it on aircraft prior to take-off.

The annual quantity of deicing fluid used at Dorval is 5-6 million litres.

Drivers

The primary drivers for recovering the glycol are environmental and economic. Spent deicing fluid must be removed from the spray pads and managed in an environmentally safe way. The airlines pay to have it collected and disposed of. In the absence of recycling, all the fluid would be disposed of and be subject to sewer charges. Inland generates revenue from fees charged to the airlines and sales of recovered glycol, less whatever sewer charges are incurred by disposal of unrecyclable material.

The cost of entry in the glycol recycling business is relatively low: less than $1 million for a commercial unit.

Future

The Inland process provides a technically and economically sound means of recovering a product from a waste stream and will gradually be extended to more airports in Canada and the U.S. where the quantities of spent deicing fluid are sufficient.

4.6 Brownfield Redevelopment

Abandoning industrial properties represents poor use of potentially valuable assets. Additionally, these vacant properties can lead to deterioration of the adjacent areas in a gradual downward spiral. Governments at the municipal, provincial or state and federal levels in both Canada and the U.S. are taking steps to stimulate the redevelopment of deindustrialized land. Recycling abandoned industrial property can made a valuable contribution to sustainable development.

Although there are emerging cases of brownfield redevelopment in Canada, the concept and implementation is more advanced in the U.S. For this reason, in addition to studying the Lachine Canal redevelopment, two successful cases in Trenton, NJ, are also discussed.

While there are many site-specific issues, a published U.S. study "Lessons from the Field" groups the factors for successful brownfield redevelopment under five headings:

(a) **Players and institutional capacity**

- presence of an active local government or redevelopment authority
- consolidation of project management under one roof,
- strong public private partnerships,
- dynamic project leadership,
- coordination between levels of government.

(b) **Community involvement**

- strong community participation,
- capitalizing on the community's vision,
- job creation and training.

(c) **Regulatory and legal issues**

- voluntary cleanup programs and liability relief,
- clarity and consistency of regulations

(d) **Costs and financing**

- suitable location and market conditions,
- interest of major developers,
- availability of public sector financing,
- attracting private sector financing,

(e) **Risk management and cleanup**

- risk management instead of risk elimination,
- cleanup standards tailored to end use,
- use of innovative remedial technologies

The lessons have been applied in the three following case studies:

4.6.1 Case #1 - The Roebling Complex, Trenton, NJ

Key participants

- Berman Development Company (developer)
- Trenton Roebling Community Development Corporation (community action group)
- City of Trenton
- State of New Jersey
  - Governor's Office
  - Economic Development Authority
  - Housing and Mortgage Finance Agency
  - Casino Reinvestment Development Authority

Description

The complex covers about 50 acres and consists of:

- The vacant land and 27 buildings which belonged to the John A. Roebling's Sons Company which manufactured wire rope and cables and designed and erected cables for suspension bridges. The site was occupied by the company from the early 1850's to the 1950's.
- The vacant land and 15 buildings which were the machine shops and foundry belonging to the American Steel and wire company that operated from 1850 to 1987. See map and related diagrams

The buildings are of solid construction and show no signs of exterior vandalism. The surrounding areas to the north, east and south are relatively modest two story homes which previously were occupied by the workers in the two factories. The majority of these homes are still occupied.

The city of Trenton's redevelopment strategy is to convert the site to "people" uses rather than to reindustrialize it. Approximately one third of the site has been rehabilitated and is used for:

- residences: senior citizens housing that is currently being built by conversion of the former Clinton St. Wire Mill,
- retail space in the former South Rope Shop,
- office space in the former Physical Testing House, the Research and Development Lab, and the Roebling Plant office buildings,
- a technology museum " The Invention Factory" being developed in what used to be the Machine Shop.

Proposed development includes; apartments, a performing arts complex, a YMCA, a 10,000 seat arena, additional parking.

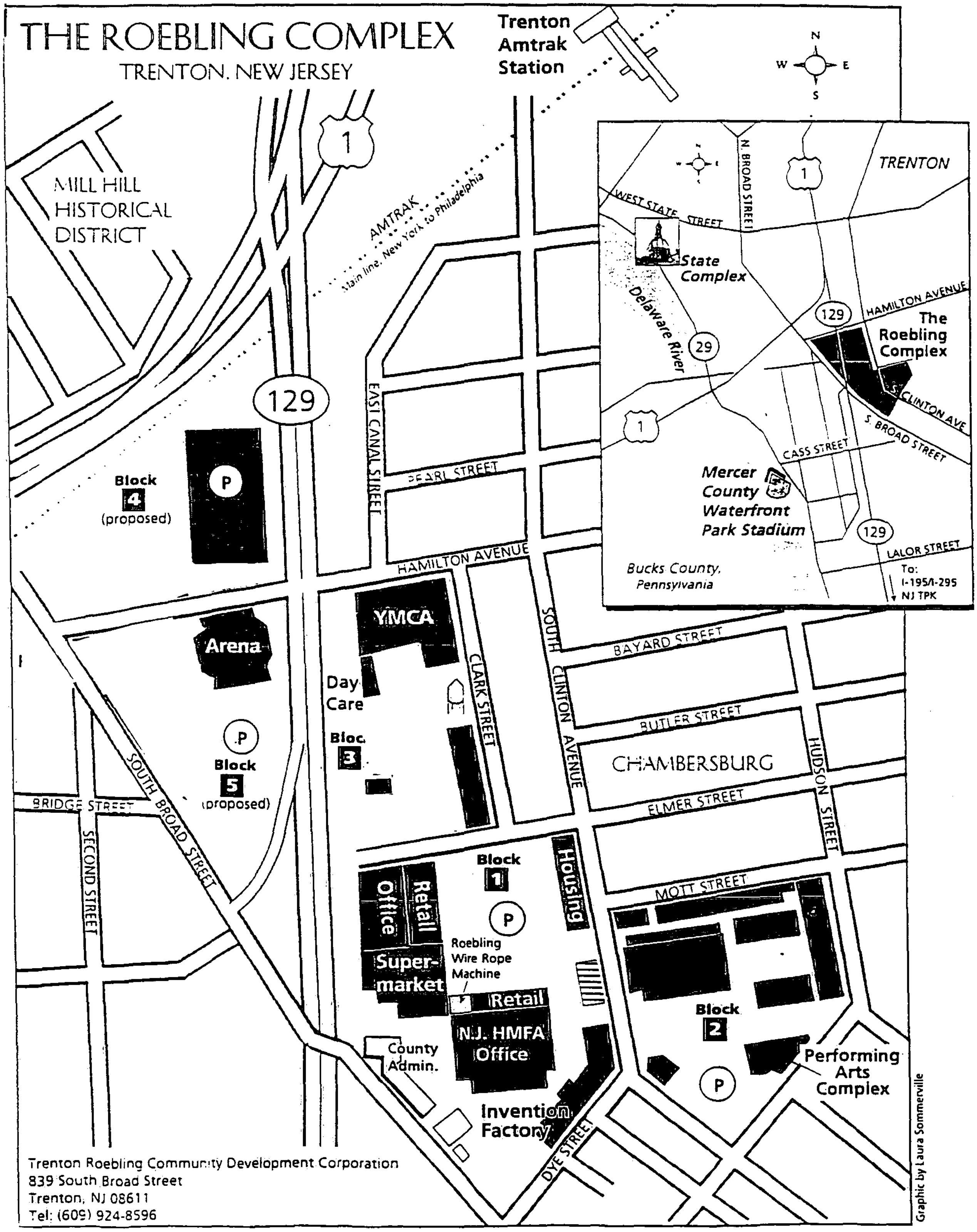


Fig. 4.22 Brownfield Redevelopment - The Roebling Complex, Trenton, NJ

Drivers

The primary driver was the need to reverse a downward drift in a high profile historical area.

Factors for success

- entrepreneurial drive by the City of Trenton,
- formation of effective partnerships,
- central location,
- well-preserved adjacent neighbourhoods,
- active community organizations,
- availability of funds,
- an active developer,
- shared vision on the part of the City of Trenton and the developer,
- job creation.

Barriers

- environmental: this was not a major issue. The contamination consisted primarily of asbestos, some underground tanks, lead and other metals. The 12.5 acre section of the site that has been redeveloped cost $1,052,000 to clean up to the Department Environmental Protection standards.
- economics were relatively weak but were helped by financing with soft loans,
- change of state Governors Florio to Whitman. There was concern that Governor Whitman might not continue the support that Governor Florio had extended.
- reluctance of the staff of the Housing Mortgage Financial Agency (HMFA) to move from a suburban location to the Roebling complex.

4.6.2 Case #2 - Circle F factory, Trenton, NJ

Participants

- City of Trenton
- Lutheran Social Ministries of New Jersey (developer and general partner)
- Circle F Civic Association (community group)
- Fleet Bank
- American Properties Corp.

Description

The site, which covers one city block, was the original location of the Trenton Watch Company starting in 1870's. Operations switched to the manufacture of electrical components under the name Circle F factory. In the 1970's the property changed ownership several times ending up in the hands of American Properties Corporation. The factory operator at that time was the Liberty Lighting Company. In 1990 Liberty Lighting went bankrupt and the factory closed. In 1991 the City of Trenton designated the Circle F neighbourhood as a Neighbourhood Preservation Area and embarked on a community rebuilding program.

Roughly half the site was occupied by long, narrow, multi-story buildings constructed between 1880 and 1930. The other half contained a single, large, concrete structure built in the 1950s. The former were not suitable for industrial use but could be renovated for housing. The latter was not suitable for housing but could be used for industrial purposes.

The APC retained ownership of the concrete building and the City of Trenton acquired the others. The City selected Lutheran Social Ministries (LSM) to develop a seniors' housing project. LSM, with financing from Fleet bank, undertook the work which should be completed in 1997. The city actively sought industries whose operations would fit into a residential area and selected Merlin Industries, which manufactures canvas pool covers. Operations started with 14 workers and have grown to 90.

Drivers
The primary drivers were the need to prevent deterioration of a downtown neighbourhood and job creation.

Factors for success:
- entrepreneurial drive by the City of Trenton,
- clear development strategy,
- active community organization,
- development of productive partnerships,
- access to financing,
- availability of funds,
- an active developer.

Barriers/hurdles
- developing an economically viable package,
- environmental cleanup issues,
- finding an industry that would not generate noise or other environmental problems in a commercial/residential area.

Environmental issues
The site was cleaned up by APC prior to its sale. The work was done to an agreed plan and a Letter of Completion was issued by the State of New Jersey Department of Environmental protection. However, a later inspection by the City and LSM found that extensive removal of lead paint, and, to a lesser extent, removal of PCBs and asbestos, remained to be done. The additional cost of $450,000 could not be recovered from the previous owner because of the Letter of Completion.

Regulatory and legal issues / Statutory background
Brownfield redevelopment in New Jersey: Legislative Context

The U.S. EPA has delegated responsibility in this area to the State of New Jersey. The State laws have sought to facilitate brownfield redevelopment by limiting, or at least clearly delineating the boundaries of the liability of the seller, buyer/developer and investor/lender.

Primary State Remediation Statutes:
- Hazardous Discharge Site Remediation Act (NJSA 58:70B)
- Industrial Site Recovery Act (NJSA 12-1K-6)
- Spill Compensation and Control Act (NJSA 58:10-23.11)
- Solid Waste Management Act (NJSA 132:1E)
- Underground Storage of Hazardous Substances Act (NJSA 58:10A-22)
- Water Pollution Control Act (NJAC 7:26E)

Relevant regulations.
The regulations support the statutes by defining the cleanup process, setting the standards to be achieved and listing the technologies which have been approved. Once the appropriate actions have been taken, the state will issue a notice of No Further Action, meaning that the purchaser need undertake no further remedial action.

- Primary State Remediation regulations/Criteria
- Ground Water Quality Standards (NJAC 7:9-6)
- Industrial Site Recovery Act regulations (NJAC 7:26B)
- Oversight of the Remediation of Contaminated Sites (NJAC 7:26C)
- Soil Cleanup Criteria (2/94)
- Surface Water Quality Standards (NJAC 7:9B)
- Technical Requirements for Site Remediation (NJAC 7:26E)

Conclusions
Redevelopment activity in Trenton is progressing well because of:
- drive, vision, focus and entrepreneurial skill demonstrated by the City,
- effective partnering by the City with developers and community groups,
- supportive state legislation,
- well defined regulatory standards and procedures,
- access to funds through grants and less-than-market-rate loans,
- taking action before neighbourhoods deteriorate too far,

4.6.3 Case #3 - St. Henri-Little Burgundy Section of Lachine Canal, Montreal QC.

Participants

- Societe de Developpment Industrielle de Montreal (SODIM)
- Industrial developers

Description

Redevelopment of unused industrial property in the area of the south bank of the Lachine Canal between the Charlevoix bridge and the Wellington Street bridge.

In 1988-89, the City of Montreal acquired a number of parcels of unused land between St. Patrick St. and the canal and also some property on the south side of St. Patrick St. including the Northern Electric building. (map attached).

The City, acting through the Societe de developpment de Montreal (SODIM), undertakes the responsibility of providing land meeting the provincial B to C standards suitable for commercial and light industrial use. Previous land use suggests that there should not be major contamination in this area. Soil contamination is primarily metals. There is negligible hydrocarbon contamination. Clean-up is based on sampling and risk assessment and has resulted in removal and landfilling of material excavated during construction and sealing off undisturbed areas for use as parking lots with asphalt or concrete. Of the total land available, more than half has been redeveloped.

SODIM's charter allows it to sell land outright to developers or to build and lease property to an industrial user. Agmont, for example, leases from SODIM.

Market forces combined with the zoning requirement for light industry are shaping the development. It not is being done in an integrated way, meaning that the developers are nor sharing resources.

Background

The Lachine Canal was constructed between 1821 and 1825 as a means of by-passing the Lachine rapids. The canal was enlarged in two stages, the first in 1843 -1848 and the second 1873 -1875. Up to about 1840, the canal was used primarily for transportation. After 1840, in order to increase revenues, lots were sold along the canal with access to hydraulic power. This move initiated several waves of industrial development. The first, from 1845 to 1876, involved such industries as sawmills, leather and some small foundries. In fact, during this period 50% of the lots in the St. Gabriel area (the area currently being redeveloped) were involved in the wood industry. Between 1876 and 1896, the industrial focus shifted to milling and primary textiles, again using hydraulic power as an energy source.

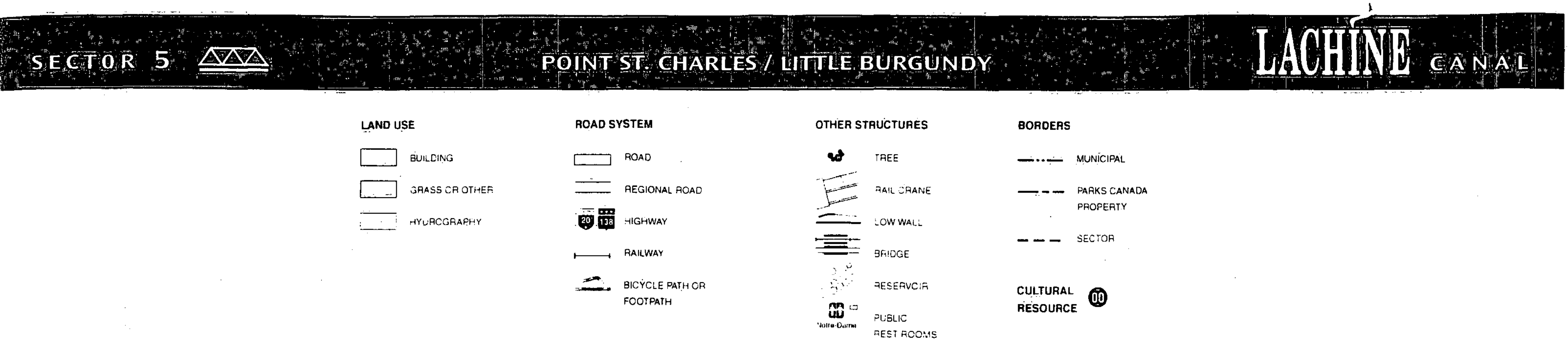
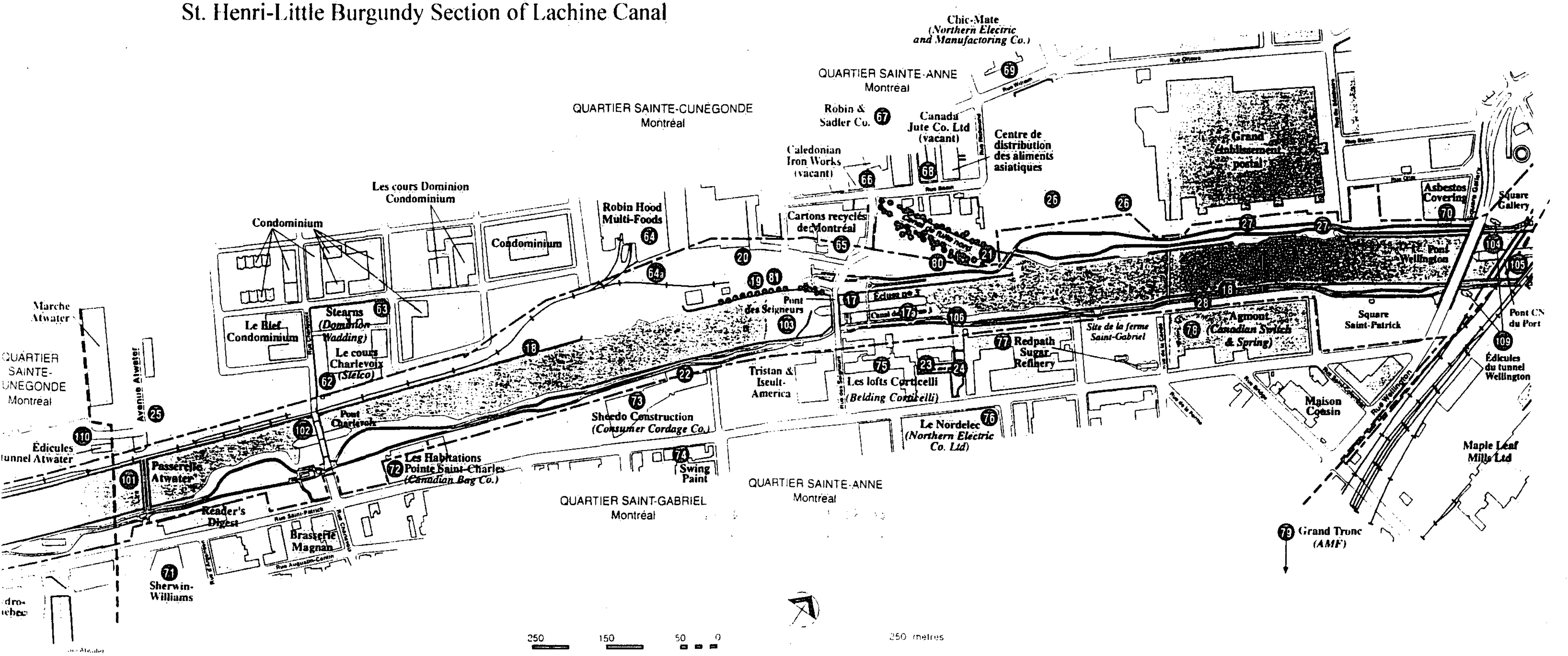


Fig. 4.23 Brownfield Redevelopment
St. Henri-Little Burgundy Section of Lachine Canal



After 1896, the industrial properties were acquired by larger companies which used the canal for logistical purposes as well as a source of hydraulic power. The majority of these companies were in operation until the canal was made obsolete by the St. Lawrence Seaway in 1959.

The locations of these companies with shutdown year are shown in the accompanying map. Going east from the Charlevoix bridge these are:

- Canadian Bag Company in operation since 1907 making bags using fibres from an associated adjacent company Consumers Cordage. The company ceased operations in the 1970s. The building was renovated and is currently used for residential purposes. (Les Habitations Point St. Charles)

- Consumers Cordage and the related company

- John Converse Co. in operation since 1850 producing primary textiles ceased operation in the 1970s. New warehouses have been constructed on these properties by S.A.I.M and Tapis Art-Deco.

- Philips Electrical, founded in 1905, manufactured electrical cable. Operations ceased in the 1970s. The building was destroyed by fire in 1988. SODIM built offices and a distribution warehouse in 1995 for lease to Tristan & Iseult, a clothing retailer.

- Belding Corticelli a silk yarn and fabric manufacturer started operations in 1876 and closed in 1982. The building has been converted for residential use.

- Redpath Refinery office building was occupied by SODIM as its head office until 1995. It was sold in 1996 for use as an office.

- Ferme St. Gabriel. This property was apparently never used industrially. It is currently being developed to expand Agmont's operations.

- Canadian Switch and Spring Company operated a foundry manufacturing railcar equipment starting in 1897. Operations were discontinued in 1975. In 1994 the building was renovated for Agmont America as a textile processing plant.

- The Northern Electric building was constructed in 1913. The building was acquired by SODIM and is currently being leased to multiple tenants.

Drivers
The primary driver is the city of Montreal's wish to ensure appropriate use of land close to the city centre. Redevelopment of this area will have a spin-off benefit of preventing a decline of the adjacent mixed-use neighbourhood (see map).

Economics
The developers acquire or lease the land at full market value. The city offers no incentives; however, incentives for industrial development may be available from the federal or provincial governments.

The building standards for the area mandate a four wall building (frame and cladding is not sufficient). This may tend to increase initial cost but adds to the life of the project.

Factors for success:
- proximity to the city centre,
- easy access to highways,
- accessible by public transport,
- security risk comparable to other industrial areas,
- financing has been readily available; no financing has been denied because of environmental risk,
- accessible by public transport,

Barriers
The only barrier being faced at present is the relatively weak demand for industrial land.

5. CONCLUSIONS

In general, the findings in the heavy industrial sectors in the Montreal area indicate that networks form to include small numbers of large companies because of clear mutual benefit, and the relative ease of establishing relationships between large companies.

The linkages observed between companies in industrial parks appear to consist of three basic types:

Resource sharing networks, where a product or major by-product from one source becomes a primary feed stream for others. Examples of this are:

- cascading hydrogen at Becancour from ICI to Chemprox and, and to lesser extent, to Norsk Hydro,
- cascading steam at Varennes from Montell to Petromont and AET,
- refined copper at Montreal East moving from CCR to Alcatel Cables and Wolverine Tube,
- the proposed cogeneration projects at Becancour and Montreal East.

Networks to beneficiate process residuals. Networks of this type tend to form at a later stage in evolution of an industrial complex than the resource networks. They are typically the result of a shift in economics that make it more expensive to dispose of residuals, or because of changes in regulations. Another motivating factor is corporate policy which may set rigorous standards for managing a facility's wastes.

Examples of this type of network include:

- neutralization of residual sulfuric acid with limestone by KRONOS at Varennes to give calcium sulfate which is used by Canadian Gypsum to manufacture wallboard,
- proposed capture, purification and sale by Air Liquide of the CO_2 released at KRONOS in neutralization of sulfuric acid,
- use in construction applications of the tailings generated at the QIT plant in Sorel,
- development of ammonium sulfate for sale into the fertilizer market by Sulconam at Montreal East to add value to the ammonia present in the H_2S streams which Sulconam treats for Shell and PetroCanada.

Support Networks. All of the regions involved in the study have networks which pool resources to deal with issues of a non-competitive nature. The pooled resources typically cover:

- emergency response,
- ambient air quality monitoring,
- fire water,
- waste water treatment,
- common rail and road access,
- community outreach.

This type of network tends to be maintained by an industry association.

Drivers

Economics is the primary factor which contributes to the formation of networks among companies. A good example of this is the effort to find a value added use for residuals when an operation is faced with increasing landfill costs, or the need to conserve landfill capacity to avoid the cost of opening a new one.

- *Necessity*

The need to develop links either to improve competitiveness, maintain the critical mass in a declining industrial area, or to solve a pressing problem, catalyses the efforts to form linkage by accelerating decision making processes. Montreal East is an example of an area which has experienced a decline in its industrial base and is taking active steps to reverse the decline.

- *Liability associated with residuals*

In parallel to the drive to reduce disposal costs by finding value added end uses for residuals is the awareness that stored or disposed materials may constitute a future liability if regulations change or if problems occur with the storage or disposal site.

- *Corporate policies and corporate vision*

Corporate attitudes to pollution prevention and environmental stewardship result in formation of links between companies for the purpose of recycling waste materials, or result in investment to reduce the environmental affects on a company's operations. As an example, Dow Chemical Canada at Varennes has found ways to recycle virtually all its waste materials either internally or through other companies. Dow, in response to corporate vision, has invested in equipment to close-looped its water and has been "off the river" since 1990. This approach will be increasingly relevant as companies seek to establish voluntary environmental programs as an alternative to additional government regulation.

- *Technology Developers*

Technology development companies create links between companies. They do this by developing a technology that can convert a waste stream into a product. Examples are Eaglebrook at Varennes which converts spent pickle liquor into ferric chloride for sale in water treatment, or SpolTech in Montreal East which will use by-product sulfur to make a polymer for use in sulfur concrete.

Another form of linkage resulting from technology development is by development of a process that makes the by-product of one company usable by another. An example is Cansolv Technologies Inc. which has a process for capturing SO_2 in a solvent. The SO_2 can then be made available to potential users and the solvent recycled.

- *Expert Companies*

Companies, which specialize in recycling, link the generators of a waste or by-product with markets for the recycled material. Examples include:

- NOVA Pb which recovers lead from used batteries in Eastern Canada and the North Eastern U.S.
- Recyclage d'Aluminium Quebec Inc. which recovers aluminum from dross from the ABI plant at Becancour and other sources.
- Safety Kleen which collects and recycles industrial fluids from a wide range of industries.
- Inland Technologies Inc. which reclaims ethylene glycol from used deicer fluid at Dorval Airport.

The technology developers and specialized companies have an entrepreneurial role in forming linkages. They identify the need for a process or service and assume much of the risk involved in implementation.

- ***Facilitators***

Industry associations.

These groups actively conserve company resources by reducing duplication of effort in dealing with issues such as:

- ambient air quality monitoring at Montreal east and Varennes,
- community outreach Varennes,
- emergency response,
- common problems of a non-competitive nature.

Development groups

Industrial development groups such as CODEV at Varennes and counterpart organizations in Montreal East and Sorel, promote synergy in their respective areas. This is apparent in the dossiers that each has assembled in an effort to attract the ethanol plant proposed by Canadian Alcohols. This plant would mean an investment of about $100 million and 150 permanent jobs.

The links with the existing industries which the proposed ethanol could expect are similar in each case. They include:

- the availability of steam,
- road, rail and water access,

- water,
- firewater,
- emergency response.

Coordinating groups.
Groups of this type have a broad mandate and generally include representatives from industry associations, various levels of government as well community groups. Examples are: SADC, a federal government agency which assists and coordinates the activities of development groups in Sorel-Tracy, and the Table de concertation petrochimie which deals with issues involving refining and petrochemicals in Montreal East, Varrennes and Becancour.

Government bodies
Government organizations at the federal, provincial and municipal level have a key role in stimulating sustainable development by communicating both vision and direction, and by facilitating development through reduction of financial risk, underwriting infrastructure or by reducing the complexity and time needed to get the necessary approvals.

Good examples of the role of government are the part played by the City of Montreal in the redevelopment of the Lachine Canal and the City of Trenton, NJ in its redevelopment of the Roebling Steel works. In both cases the cities acquired vacant property, assured that the property was rehabilitated to the appropriate environmental standards and found private sector investors to redevelop the sites.

Barriers
- *Regulations*

Regulations aimed at environmental protection may in some cases discourage recycling. The specific example encountered on three occasions (NOVA Pb, Eaglebrook and Recyclage d'Aluminium Quebec Inc.) involve classification of recyclable materials as hazardous waste, thus making them subject to the Export and Import of Hazardous Waste Regulations (EIHWR). The result of these regulations is to impose a paperwork burden, to reduce operating flexibility and, with the implementation of user fees, possibly reduce their ability to import materials from the U.S. and thus affecting their economies of scale.

Another regulatory barrier cited by Chemprox is the complexity and length of the approval process which caused major delays in carrying out a plant expansion.

- *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 to the large company for providing the heat may be too small to attract interest or resources.

Another issue is that investing incremental capital to recover waste heat cannot always be justified in purely economic terms. The use of some approximate environmental externalities to justify additional capital expenditures would be a useful tool to support voluntary initiatives related to Canada's climate change and air pollution objectives. Although there has been mush debate on the appropriate value for CO_2, NO_x, SO_2, CH_4 and PM emissions that should 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 underway to reach a consensus as to the societal benefits of various actions such as switching from coal/oil to gas. Environmental externalities and other economic instruments, such as capital cost allowance, may become useful in promoting capital investment related to sustainable development.

Economic factors are holding back development of sustainable projects in some areas. For example, the relatively weak demand for industrial property is slowing down the redevelopment of the Lachine Canal and Montreal East, and to some extent development in Sorel-Tracy.

Economic and policy issues have also resulted in two major (Montreal East and Becancour) and a number of smaller cogeneration projects being put on hold.

Technology developers whose product or service has not yet gained commercial acceptance, despite the fact that it has been demonstrated to work, face a potentially long uphill struggle. An example is the Cansolv process for absorbing SO_2 from gas streams and making it available as a product.

- *Liability*

Brownfield redevelopment suffers from concerns about the chain of liability which may link developers of a vacant industrial site to previous uses of the site, even though it has apparently been rehabilitated to the required standards. U.S. federal and state regulations have been developed to shield developers and lenders from such liabilities.

6. Opportunities

Companies actively search for opportunities to reduce energy and material input to their processes, and to reduce or find value added uses for residuals. This search, driven by economic factors has been successful and will continue to find new opportunities. A number of these were mentioned by the companies but because of their confidential nature, they have not been included in the report.

In the table below are specific opportunities noted during this study which, because of their long-term nature or risk, may not receive early attention. The organizations involved would cooperate in evaluation of these opportunities but an injection of seed funding is required.

Project	**Location**	**Description**	**Environmental Benefits**
Cogeneration	Montreal East, Becancour or Sorel/Tracy	Study the feasibility of installing a 15-20 MW cogeneration unit	Efficient use of energy and pollution prevention.
Process residuals information base	Montreal Region major industrial areas	Develop an information base of quantities and composition of process residuals that are not currently beneficiated	Pollution prevention Resource conservation
District heating	Montreal East	Study the feasibility of developing a district heating system using steam from the PetroCanada refinery	Efficient use of energy and pollution prevention.
Sequestering carbon dioxide	Becancour	Study the feasibility of photosynthetic capture of byproduct CO_2 from Norsk Hydro	Reduction of greenhouse gas emissions
Industrial ecopark opportunities	Sorel/Tracy Contrecoeur	Evaluate opportunities and development strategies for industrial ecoparks	Efficient use of energy and raw materials, and pollution prevention
Industrial ecopark	Montreal East	Study the feasibility of developing an industrial ecopark on brownfield property.	Recycling land, efficient use of energy and raw materials, and pollution prevention

Cogeneration

Conduct a preliminary feasibility study of installation of a 15-20 MW cogeneration unit at Montreal East or another selected location.

The cogeneration units which were previously proposed for Montreal East and Becancour were large scale: in the order of 200 MW. The capital investment was large and the economics were weakened by the price that could be obtained for the electricity.

A smaller unit may prove feasible because of:

- reduced risk due to a lower capital investment,
- changes taking place in electricity markets,
- smaller quantities of steam to be marketed.

The purpose of this study is to demonstrate effective use of energy when used to generate electricity while at the same time providing steam and hot water. The environmental benefit is a net reduction of combustion gas emissions.

Process residuals information base

Develop an information base of the quantities and composition of air emissions, process residuals, and waste heat that are currently not being beneficiated. The information base should include all the major industrial complexes in the Montreal region.

The purpose of this information is to identify opportunities for cascading wastes as raw materials and energy sources. The result will be better use of resources and pollution prevention.

District Heating

Study the feasibility of district heating of a mixed industrial/commercial/residential area to the east of the PetroCanada refinery.

The PetroCanada refinery has steam generating capacity which could be made available to provide heating to an area east of its operations if technical and economic feasibility were established.

PetroCanada would contribute time and data to such a study.

The benefits would include efficient use of energy and a net reduction of combustion gases.

Sequestering carbon dioxide

Study the feasibility of photosynthetic capture of byproduct CO_2 from Norsk Hydro with a large scale greenhouse operation or other photosynthetic system to make use of available:

- by-product CO_2,
- waste heat,
- hot water.

Conversion of magnesite to magnesium chloride results in the release of about 1.8 tonnes of CO_2 per tonne of magnesium. The capacity of the Norsk Hydro plant is approximately 40,000 tonnes per year of magnesium with emissions in the order of 70,000 tonnes.

Assuming that CO_2 requirements for a greenhouse with a target level of 1000 ppm CO_2 are about 0.4 lbs per square foot of growing area per hour, and assuming three air changes per hour, the daily requirement of a 1000 square foot growing area would be approximately 4.4 tonnes of CO_2. The rate of uptake of the would be a function of the mode of operation and greenhouse crop. The daily emissions of CO_2 from magnesite production are about 200 tonnes.

Norsk Hydro, which generates these three by-products, will support this study by contributing time and data.

This of the study could be applied to other locations where CO_2 is generated. The environmental benefits would be sequestering a greenhouse gas and beneficial use of waste heat.

Industrial Ecopark Opportunity 1.

Evaluate opportunities and development strategies for industrial ecoparks in Sorel/Tracy and Contrecoeur.

The gradual decline of heavy industry in Sorel/Tracy areas has given rise to a matrix of groups who are concerned with various aspects of redevelopment. These groups share the vision of revitalization by attracting capital investment and creating jobs. They also share the vision that redevelopment should be along environmentally sound (sustainable) lines.

A study of this area would be valuable to:

- identify opportunities for industrial ecoparks,
- document the roles and objectives of the support groups,
- develop strategies for achieving these objectives.

The study area should be extended to identify opportunities for industrial ecoparks in the neighbouring industrial complex in Contrecoeur.

Environmental benefits include efficient use of energy and raw materials, and pollution prevention.

Industrial Ecopark Opportunity 2.

Study the feasibility of developing an industrial ecopark on brownfield property in Montreal East

The municipality of Montreal East has developed the concept of a sustainable industrial park/port complex. The objective of this proposed complex is to redevelop a vacant industrial site of approximately 10 million square feet and thus reverse the decline of the industrial base and create jobs in the area. This is an excellent opportunity to design an industrial park along sustainable lines.

The scope and focus of this study should be developed by consultation with the:

- municipal government,
- provincial government,
- federal government,
- local industry associations,
- community groups,
- potential investors.

The environmental benefits include recycling land, efficient use of energy and raw materials, and pollution prevention.

Appendix - Contact List

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