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PROFESSOR : **Andrew F. Lawlor**

STUDENT : **C. Duff Lowes**

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Arbor Research Corporation PSA Oxygen Generators-
Canadian Market Penetration

by

C. Duff Lowes

A research paper submitted in fulfillment of the requirements for 1.5 credits, GRADUATE INDEPENDENT RESEARCH PROJECT IB750 SECTION 016, Fall Term 1997, Adjunct Professor of Corporate Strategy & International Business Andrew F. Lawlor, Faculty Supervisor.

<u>Faculty Comments</u>

Description

Arbor Research Corporation (ARC) is a small manufacturer of Pressure Swing Absorption (PSA) Oxygen Generators. These PSA generators generate relatively small-outputs nearly-pure oxygen through absorbing the nitrogen from compressed air. Though a relatively new technology, a number of small manufacturers, as well as the major industrial gas companies have begun pushing their adoption. Currently, the most common form of oxygen production is through cryogenic distillation. Economics dictates that these huge-volume units, owned and operated by major industrial gas companies, overproduce for their area, thus driving the oxygen prices down locally. However, in areas where demand is not yet great enough to support the capital investment necessary for a cryogenic unit, there exists a potentially-strong market for PSA units.

Oxygen is required in a wide array of markets, however the most appropriate requirements for the smaller-volume and unpure output PSA oxygen generation includes most chiefly where the regular supply of cryogenic oxygen is difficult or expensive: hospitals and health-care facilities (especially in developing nations), industrial welding and flame-heating, mining ore processing, mining and oil & gas maintenance, aquaculture (fish farming), and waste & feed-water purification.

ARC currently has units installed in a wide range of markets, located primarily outside of North America. The broad cryogenic oxygen-supply coverage in the USA, and populated areas of Canada makes domestic competitiveness difficult. In an effort to expand their domestic market, partly for sales expansion, partly ease of logistics, and partly to strengthen a future IPO bid, ARC desires an expansion into Canada. Canada is deemed by ARC management a more attractive market than the USA due to Canada's less-developed industrial-gas coverage, and the potential of the remote Northern industries.

As a University of Michigan Business School MBA summer Internship assignment, ARC has commissioned a marketing report for the penetration into the Canadian market for their product.

Research Method to be Followed:

The following topics will be/ (were) investigated in an effort to formulate preliminary conclusion regarding ARC's expansion into the Canadian Market:

- Environmental Analysis
  - General summary on Canada:
    - Regional divisions
    - Political implications
    - Cultural factors
  - Canadian economic conditions
    - Market divisions by province
    - International Trade effects
    - Canadian Governmental effects
- Competitive Analysis
  - International PSA competitors
  - Canadian Industrial Gas Companies
- Company / Product Analysis
  - ARC Competitive advantage
  - Market requirements

Market Investigation
  - Canadian regional vs. segment divides
  - Mining
  - Oil & Gas
  - Medical

Industrial
Water related
- Aquaculture
- Waste water treatment
- Clean-water treatment

Information on these topics will be collected from a number of sources, including:
- On-line reference sources
- Internet searches
- Phone-contact with market users and competitors
- Travel to market areas and functions
- Industry research

Currently, ARC has a highly fragmented market coverage, without a clear strategic direction in which to operate with its present limited sales and service resources. Based on information collected on the above topics, a preliminary recommendation will be made regarding which market segments ARC is best suited to focus on considering the Canadian short and long-term market attractiveness, ARC's capabilities, synergy between market needs and ARC's technical strengths, and competition. The final document will be written for the ARC management for strategic planning purposes, and as such, be written in a technical voice that they will understand, but not necessarily any reader.

Signature of Faculty Supervisor

Adjunct Professor of Corporate Strategy & International Business

Arbor Research Corporation's Canadian Market Penetration:
Executive Summary

Segments Investigated:

Mining: Recommended

- General
  - Efficient advertising channels has worldwide implications
  - Cyclical industry subject to metal price swings, investor uncertainty
  - Mines wish to keep capital expenditures to a minimum, finite life-spans
- Mine construction:
  - Lease or rent HP sea-container units to mine construction-site users. In remote locations with high oxygen prices, sea-containers offer excellent paybacks
  - Primary mining sales target
- Mine maintenance
  - Insufficient usage to justify cylinder filling station
  - Tertiary mining sales target
- Gold ore leaching
  - Limited Canadian Sites
  - Small oxygen-leaching demand for Canadian gold-ore
  - Tertiary mining sales target
  - Need further investigation of zinc, copper leaching
- Portable mine units
  - No use in diamond mines, potential for gold
  - Need further investigation

Oil & Gas: Recommended

- Drilling site construction / maintenance
  - Same conditions as for mining, though on smaller scale
  - Sell/lease in concert with mining activities
- Offshore maintenance / Nitrogen Sea Containers
  - Proven success, conditions justify use
  - Nitrogen use decreases payback
  - Primary Oil & Gas sales target
  - Incorporate into northwest mining operations?

Aquaculture: Recommended for North American focus

- Provincial stocking hatcheries additional target, known success stories
- Growth industry, government support
- Industry at verge of technology development
- Attractive region in eastern half of Canada
- Disorganized, unsophisticated competition, distribution structure
- Efficient advertising channels

Water Treatment: Not recommended

- Ozone disinfecting feed
  - Limited use, limited growth
  - Potential for future growth if government regulation / biological conditions develop
  - Potential for regional niche in Quebec, need further investigation

Wastewater Treatment: Not recommended

- Activated sludge new construction

Ontario, Quebec, Alberta, BC largest Activated sludge users
Only ,n spec.al situations is oxygen required or spedftad

- Activated Sludge capacity upgrade from air
  - Not industry practice
  - Perceived as not economical vs. air upgrade
  - Praxair lack of success

Industrial: Limited recommendation

- General
  - Industrial concentrations located in oxygen-rich, competitive areas
  - Golden-Horseshoe most attractive region to enter
  - Difficult sales process, fragmented market out of Arbor Research Corporation's scope?
  - Remote locations offer best payback, smaller machines, harder sales
  - Potential to incorporate into northern regional sales focus
  - Potential to target US locations first, where exchange-rate and location are more manageable
- Steel cutting
  - Numerous target sites
  - Need for High purity diminishes payback
  - Potential to sell with mining / oil & gas channels
- Brazing
  - Limited market, furnace-brazing is common
  - Good justification in certain conditions due to low-purity requirements
- MIG Welding
  - Limited market, requires huge facilities
- Muffler shops
  - Good potential small-niche attack target
  - Corporate sales justifies bulk small-margin machine sales
  - Need further research

Medical: Limited recommendation

- Remote hospitals
  - Western Canada (exc. for BC) saturated with Rimer Alco systems
  - Rimer Alco customers happy
  - Potential for limited eastern site sales approach of finite number of sites
  - Excellent justification
- Portable Oxygen Generators (POGS)
  - Medical system turmoil, massive spending cuts, shift from federal to provincial control
  - Although push towards home care, provincial paid health care is decreasing, POG market is shrinking
  - Nidek units not competitive in crowded field
  - Need further provincial research
  - Potential augment to sales of Arbor Research Corporation manufactured units: total market 4000-5000 units/yr.

Segments Not Properly Investigated:

- Large Hospitals
- Nursing-Home POG use
- Swimming pool ozone
- Industrial wastewater treatment
- Pulp & Paper

- Furnaces

General Arbor Research Corporation Recommendations

Order of Segment Attractiveness:
1. Oil & Gas
2. Mining
3. Aquaculture
4. Industrial
5. Medical
6. Water Treatment
7. Wastewater treatment

Penetration Approach:
1. Remote focus: Region: western Northwest Territories / Yukon Territories / Alaska
    - Mining construction sea-container rentals/leasing
    - Oil & gas construction/exploration sea-container rentals/leasing
    - Oil & gas offshore platforms maintenance/nitrogen sea-container sales
    - Tertiary mining and/or oil & gas worldwide company (engineering firm and/or equipment rental and supply) based in Alberta
    - Tertiary remote manufacturing sales
    - Tertiary Canada-wide mine sales

2. Eastern Focus: Region: Atlantic Canada
    - Oil & gas construction/exploration sea-container rentals/leasing
    - Oil & gas offshore platforms maintenance/nitrogen sea-container sales
        - Hibernia
        - Sable Island Platforms
        - Sable Island Pipeline
        - Terra Nova exploration
        - Southern Newfoundland coast exploration

3. Aquaculture: Atlantic Canada, North American broad campaign

Additional Opportunities:
1. Immediate remote hospital sales push
2. Golden Horseshoe brazing focus
3. Corporate Muffler-shop sales
4. POG sales if self-manufactured

Table of Contents

TABLE OF CONTENTS 4

TABLE OF FIGURES 7

CANADA: DESCRIPTION 8

PROVINCES: 11

- NORTHWEST TERRITORIES (NT) 11
- YUKON TERRITORIES (YT) 11
- BRITISH COLUMBIA(BC) 12
- ALBERTA (AB) 12
- SASKATCHEWAN(SK) 12
- MANITOBA (MB) 13
- ONTARIO (ON) 13
- QUEBEC (QC) 13
- NEW BRUNSWICK (NB) 14
- NOVA SCOTIA (NS) 15
- PRINCE EDWARD ISLAND (PE) 15
- NEWFOUNDLAND (NF) 15

COMPETITIVE REVIEW 17

- MAJOR GAS COMPANIES: 17
  - *Oxygen Supply: ASU locations Map* 21
- OXYGEN GENERATOR MAKERS - GENERAL 22

MARKET SEGMENT: MINING 23

- GOLD MINING 23
  - *2. Gold Mining Glossary: Ore Types* 23
  - *3. Gold Mining Glossary: Ore Treatments* 23
  - *4. Cyanidation:* 25
  - *5. Factors affecting gold dissolution in cyanide:* 25
  - *6. Off-Site Milling:* 26
  - *7. Current Gold-Mine Applications and ARC Successes in Australia* 26
  - *8. Tailings, Cyanide treatment with Ozone* 28
- GOLD MINES TO TARGET 28
- MINE ECONOMICS: 29
- SILVER: 29
- COPPER: 29
  - *9. Copper Processing:* 30
  - *10. Copper Pyrometallurgy:* 30
  - *11. Copper Hydometallurgy:* 31
- URANIUM: 32
  - *12. Uranium Processing* 32
  - *13. Uranium Industry:* 33
  - *14. Uranium Demand:* 33
- OXYGEN IN MINE CONSTRUCTION 34
- OXYGEN IN MINE MAINTENANCE 35
- MARKETING STRATEGY 36
  - *15. Distributor Tool-kit* 36
  - *16. Advertising* 36
  - *17. Customer Contact* 38
  - *18. ARC Staff Development, Information sources* 39
  - *19. Product* 40

COMPANIES TO TARGET .... 4(
20. *Canadian Gold Mines* .... 4‹
MARKET SEGMENT : OIL & GAS **45**
INDUSTRY TRENDS **45**
OFFSHORE 45
EASTERN CANADA OFFSHORE DEVELOPMENTS 47
21. *General* 47
22. *Bids Process* 47
23. *Offshore 'Solutions Providers'* 48
24. *Hibernia* 49
25. *Terra Nova* 50
26. *Sable Island* 51
27. *Labrador Shelf* 53
28. *Western Newfoundland Coast* 54
29. *Nova Scotia* 55
30. *Well Testing* 55
LAND-BASED 55
31. *Remote Canadian Exploration & Drilling* 56
32. *Sea-Tainer Units* 56
Maintenance / Operation 58
34. *Yemen / CPI Experience:* 62
ISO9000 CERTIFICATION 65
MARKET SEGMENT: MEDICAL 65
HOME CONCENTRATORS: **67**
REMOTE HOSPITAL: 67
LONG-TERM CARE CENTERS IN CANADA 68
MARKET SEGMENT: INDUSTRIAL 69
CUSTOMER COST BENEFIT ANALYSIS **71**
COST-EFFICIENCY INSPECTION: 72
CANADIAN INDUSTRIAL CONCENTRATIONS 73
APPLICABLE SIC CODES TO TARGET 74
MARKET SEGMENT: WATER 76
AQUACULTURE (FISH FARMING): **77**
35. *British Columbia:* 77
36. *Alberta:* 79
37. *Saskatchewan:* 79
38. *Manitoba:* 79
39. *Ontario:* 80
40. *New Brunswick:* 80
41. *Nova Scotia:* 81
42. *Prince Edward Island:* 81
43. *Newfoundland:* 81
ATER TREATMENT AND WASTEWATER SYSTEMS: GENERAL 81
44. *Ontario:* 82
45. *Tri Hella Methane (THM):* 82
46. *Medical Officer of Health:* 82
47. *Cryptosporidium* 83
48. *Decision Making Process:* 83
49. *Water Treatment: Ozone Generator Feed* 83
50. *Sewage Treatment:* 84
IARY / RECOMMENDATIONS 85
IERAL **88**
.... 88

MINING 88
51. *Mine Maintenance & Construction* 88
52. *Gold Mining* 89
53. *Uranium Mining* 89
54. *Other Ores* 89
OIL & GAS 90
55. *Offshore* 90
56. *Well-testing* 90
MEDICAL: 90
57. *Home Concentrators* 90
58. *Remote Hospital:* 91
WATER: 92
59. *Ozone Generation for Water Treatment* 92
60. *Wastewater Sludge Enrichment* 92
61. *Aquaculture* 92

APPENDIX A 95

APPENDIX B 100

APPENDIX C 102

APPENDIX D 103

APPENDIX E 104

APPENDIX F 105

APPENDIX G 106

APPENDIX H 107

APPENDIX I 108

Table of Figures

Figure 1: Profitability of Supply Modes 18
Figure 2: Gas companies have diversified end-markets 19
Figure 3: Canadian Air Separation Units for merchant use locations and coverage 21
Figure 4: Oil & Gas Activity in Canada 45
Figure 5: Expected East Coast Canada drilling activity 48
Figure 6: Hibernia Consortium Partners 50
Figure 7: Terra Nova Partners 52
Figure 8: Sable Offshore Energy Project 54
Figure 9: Labrador Shelf Significant Development 54
Figure 10: Beaufort Sea Oil & Gas Exploration 58
Figure 11: Payback scenario for sea-tainer system, oxygen only 62
Figure 12: Payback scenario assuming nitrogen requirements as well 63
Figure 13: Long Term Care Center Size Distribution 69
Figure 14: Canadian Regional Cryo-Oxygen Pricing & Terms 75
Figure 15: Projected New Brunswick Fish Farm Growth 81
Figure 16: Canadian Ozone Water Treatment Locations 84
Figure 17: Canadian Wastewater Treatment Types and Distribution 86

Canada: Description

- **Population:** 27.3 million
- **Capitol:** Ottawa, Ontario
- **System of Government:** Democratic, patterned after British Parliamentary System
- **Basic Geography:** North America's Canada, at over 3.8 million square miles in land area, is one of the world's largest countries (depending on the status of Russia and its independent states), characterized by its vast sparsely populated northern regions, and cold northern climate, abundant resources and fresh-water lakes. Canada is divided into ten 'Provinces' that run roughly from west to east, and two large 'Territories' north of those.

- **Brief History:** Canada was originally discovered (not including the Vikings 600 years prior to that) by the Englishman John Cabot who landed on what is now Newfoundland ('new-found-land') in 1497. Not long thereafter, French explorers traveled down the St. Lawrence River and subsequently settled what was then known as Upper Canada (essentially Ontario) and Lower Canada (Quebec and the Atlantic Provinces). Many United Empire Loyalists (Loyal British subjects fleeing the American Revolution) settled in the Ontario region. In the 1760's, France entered into a war with the British in Europe, which fell upon the inhabitants of Canada as well, who were suffering from their own English/French fur-trapping disputes as well. In 1763, The British general Wolf defeated the French General Montcalm on the plains of Abraham, on what is now downtown Montreal. Although the British remained in control thereafter, they were vastly outnumbered by the French inhabitants, and thus very little effort was made to 'convert' the French to totally British-style culture and language. Through heavy European immigration over the years, Canada has become predominantly English speaking (60%), with sizable populations of many of the world's nations. Canada's only other major event since then was the war of 1812, in which American forces clashed with British forces on many points along the border, with the outcome being one of general stalemate. Most of the northern Basin (identified by all lands which drain into Hudson's Bay) was given to the Hudson's Bay company by the British to oversee, and deal in furs for use back in Europe trapped by the teaming-up of the Native Indians and French Trappers (known as Cour-de-bois). The Royal Canadian Mounted Police (Mounties) kept the peace in Canada's hinterlands as an armed force in remote outposts (today they serve as something similar to USA's FBI). Canada gained independence on July 1, 1876, and remained a British protectorate until 1982, whereby it converted to complete independence, with only minor ties still to the British monarchy. Canada's west was opened up dramatically with the completion of the Canadian Pacific railway in 1885. Canada fought in both world wars, and is a member of the G7 nations. Newfoundland was the last province to join Canadian federation in 1949.

Language: Canada is officially bilingual in English and French, country-wide. This means that all government services and many commercial activities must be conducted in *both* languages, including all product labeling. However, there are laws in place within Quebec that restrict the level of business-related English used-there. Although French is primarily spoken as the first language within Quebec, it is often spoken outside of Quebec in the northern or remote regions (indicative of the early settlement of French Trappers), and the Atlantic (all Provinces east of Quebec) Provinces. While many 'francophones' (French speakers) speak both English and French fluently, few 'anglophones ' (English speakers) outside of government services personnel can do the same. French-Canadian is in many ways a very different language from France's style of French.

Culture: Canadian culture could be described as very similar to American, with perhaps a more liberal outlook, a heavier emphasis on government social-programs, and a love of hockey. Depending on the area of the country, it may have a stronger British or French feel to it, but a generally more socialized European environment anywhere. There is a fair degree of resentment and animosity between the French and English-speaking populations, with the francophone citizens (40%) striving to retain their French culture and heritage, and the Anglophiles resenting the 'special treatment' that they feel will result. Other cultural divides may be roughly divided into four different regions:

1. Western Canada:
   - Vancouver, BC: Cosmopolitan
   - BC, Alberta and Saskatchewan: Characterized by a rowdier, western US-style, cowboy mystique, almost Libertarian politically
2. Central Canada: Manitoba and Ontario: Ontario is Canada's population, industrial and economic powerhouse, which can oftentimes be resented b the other regions.
3. Quebec: Strong in French Heritage and Culture.
4. Atlantic Region:
   - New Brunswick, Nova Scotia and Prince Edward Island: A little more French or Scottish than Ontario, with a simpler, quiet, fisheries-based lifestyle
   - Newfoundland: Very rural, introverted fisheries-based culture

- **Politics:** Canada has essentially a five major party system, comprising of the:

  - ***Liberals:*** The current ruling party headed by the Prime Minister Jean Cretien
    - Traditionally pro-social programs, with a mix between business and labour issues, and shaped in policy and culture by the long-serving and flamboyant former Prime-Minister Pierre Trudeau (similar to USA's Democratic Party)
  - ***Progressive Conservatives:*** ('PC's', 'Conservatives', or 'Torys')
    - Traditionally pro-business, conservative (similar to USA's Republican party)

Up until the 90's, power had traditionally been held by one of the above two parties, or in the case of a ruling-minority, wielded by a coalition with the NDP. The Bloc Quebecois and Reform Party are relatively new entrants into the political arena.

  - ***Bloc Quebecois:*** (BQ)
    - Intensely pro-French culture, which includes Quebec's separation from Canada in the party-platform as well. It was created in the 90's within Quebec out of the ashes of the 'Parti Quebecois', as a vehicle to re-start the Quebec s
    - Separation movement. Until the most recent election, the BQ was the official opposition party due to the number of seats they were able to garner in Quebec alone
  - ***New Democratic Party:*** (NDP)
    - Very pro-labour, pro-social program, liberal and socialized by US standards, usually relegated to under 20% of the vote
  - ***Reform Party:***
    - A pro-business and common-sense labour policies movement that was begun to strengthen the political influence of Canada's west (which along with the Atlantic Provinces, often feels left-out of Canada's politics due the power wielded by just Ontario and Quebec) and gaining popularity elsewhere. The reform party is often considered anti-Quebec, and unwilling to accept diversity.

The ruling party is decided by obtaining a majority of seats in the 301-seat parliament. The senate (a separate house filled with long-term appointed statesmen) must ratify all bills passed by the parliament before they can become law, and they almost always do. Government can change hands if a vote in parliament is lost, whereby an election is immediately called, or when an election is called voluntarily. Although each ruling party need not call elections for every five years, they may call one earlier than that, often hoping to have it fall within an upbeat period of public sentiment. Most recently, Canada's ruling Liberals, who held a commanding majority over the others, called an election for June 02, 1997, 1 1/2 years early.

A brief summary of the June election's results:

- **Liberals:** Leader (and remaining the Prime Minister), Jean Cretien. They won 155 seats, a 20-seat loss from the 1993 election. This gives them a slim majority, which means that they will have to be careful to keep all the members close-by so as to not lose any votes in parliament. The majority of their representation is in Ontario, which means they have lost the 'national party' status they previously liked to proclaim. The party's loss of seats could be partly attributed to discontent with Jean Cretin's brash, uncultured leadership style, and his status as the leader of the party could be in jeopardy
- **Reform Party:** Leader: Preston Manning. They won 60 seats, the second-greatest number, which bestows upon them the title of official opposition party. All of these seats were gained in the west, their traditional stronghold.
- **BlocQuebecois:** Leader: Gilles Duceppe. They won 44 seats, all in Quebec, which was a loss of 9 seats overall, and their 'official opposition' status. Un-distracted now by their official opposition duties, they vow to step-up their Quebec sovereignty campaign. However, their popular vote dropped below 40%, which could be an indicator of the province's general lack of support for separation.
- **New Democrats:** Leader: Alexa McDonogh. They won 21 seats, spread across the country, which makes them the only true 'national party' now.
- **Progressive Conservatives:** Leader: Jean Charest. They won 20 seats, a vast improvement from their previous near extinction 2-seat level. The majority of this representation was in the Atlantic region and Quebec.
- There was one independent elected: John Nunzia, a former Liberal.

In general, this means that business will be as usual, as a ruling majority can pass as many bills as they like for the next five years. However there will a considerably greater amount of regional / political conflict, with the net result of Canada continuing to be a country divided in politics and policy based upon regional sentiments. Although Canada typically has about a 75% voter-turnout rate on average, it dropped by 8% for this election, perhaps signaling voter discontent with these regional conflicts.

- **Economic Outlook**

JP Morgan believes the Canadian economy is headed into a period of above-trend GDP growth and forecasts 1997 growth of 3.4% versus 1.6% in 1996. Canada's current low dollar value represents enormous opportunities for trade with the US, however its fluctuating rate also represents risk in demand. The NAFTA pact has been fantastically successful for increasing the flow of trade between the US, Canada and Mexico. Whether the US continues to negotiate free trade deals (currently stalled in congress awaiting approval of the 'fast-track' negotiation), Canada is on track to continue to negotiate additional trade-deals with developing nations.

Each province has a similar system of government to represent its regional issues, and manage the majority of state spending within each province. The Federal government manages only the large-scale programs such as social-insurance, the military, etc., and the provincial arm of government handling such things as unemployment insurance, health-care spending, education, etc.

- *** Although excerpts from the 1994 book: 'Doing Business in Canada', by Price Waterhouse, have been included in the Arbor Research Corporation Canada market research binder, for more current and detailed information on Canada's legal, business and social affairs, a new copy can be ordered from the Toronto office, (416) 863-8178, Fax (416)365-8178.
- *** Excellent web-sites with information on Canada include:
  - Natural Resources Canada: http://www-nais.ccm.emr.ca/
  - Canadian News Service: http://cbc2.sympatico.ca/cbcnews/
  - Canadian Industry Statistics: http://strategis.ic.gc.ca

Provinces:

Northwest Territories (NT)

- **Population:** 64,402 (and an estimated 1.3 million caribou)
- **Provincial Capitol:** Yellowknife
- **Principal Industries:** Mining, oil & gas, tourism
- **Distinguishing Characteristics:** When Samuel Hearne, an explorer for the Hudson's Bay Company reached the shores of Great Slave Lake (the fifth largest freshwater lake in N.A.) in 1771, he became the first white man to have reached the lake. The city of Yellowknife established there was named after the tribe of the Indians accompanying him on the trip. Although gold was first discovered on Yellowknife bay in 1896 by miners on the way to the Klondike, it was the radium ore discovery at Great Bear Lake in 1930 that led to increases in prospecting of the entire area, and the strong mining industry that exists today. Although very remote, The Northwest Territories boasts the highest weekly earnings in Canada, due to the high mining and oil & gas wages. In addition to the current emphasis on base metals mining, the search for diamonds is intensifying. A vast portion of the north is permafrost 'tundra', a rocky marsh that remains frozen much of the year. Buildings, sewer-pipes, structures, etc. may have to be built on 'stilts' in order to isolate them from the effects of frost heave and floods. Transportation is difficult, with many remote outposts accessible only by plane, while others can only be accessed by open-water ports traverse-able 2-4 months out of the year, or by winter-time ice-roads (barges pushed by earth-movers over frozen-lakes and land portages). Year-round roads serve only the major cities, and are at best two-lane undivided highways with periods of gravel paving, subject to washouts and rock-slides. A large portion of the north's population is made up of Canada's Inuit (Eskimo) indigenous tribes, who struggle to retain some form of their traditional lifestyle.

  The Arctic north is well known for its Aurora Borealis (northern Lights), created when an electrical discharge powered by a 'generator' composed of solar wind and the earth's magnetosphere generates power as high as 1,000 billion watts. Two major climate zones divide the NWT, the Arctic, and the sub-Arctic. Temperatures in the sub-Arctic fall below 0 Degrees Celsius (32 degrees Fahrenheit) seven months of the year. In the Arctic, the average daily temperature of the warmest month of the year does not exceed 10 degrees Celsius (50 degrees Fahrenheit).

  Currently, the Northwest Territories is divided into three main districts: The MacKenzie District to the west, The Keewatin District to the east, and Franklin District to the north. On April 1, 1999, The Northwest territories will be re-divided creating two new territories, Nunavat (which means 'our land' in Inukitut) and the yet as unnamed western territory.

Yukon Territories (YT)

- **Population:** 40,000
- **Provincial Capitol:** Whitehorse
- **Principal Industries:** Mining, oil & gas

- **Distinguishing Characteristics:** Essentially similar in climate and economic activity to the Northwest Territories, the Yukon Territories' eastern border straddles the Continental divide, and lies within the Rocky Mountain range.

British Columbia(BC)

- **Population:** 3.3 million
- **Provincial Capitol:** Victoria (Pop. 285,000, on island across the strait from Vancouver)
- **Principal Industries:** Financial, manufacturing, fishing
- **Distinguishing Characteristics:** 'This westernmost province is very mountainous. The coastal area enjoys warm summers, the longest frost-free season in Canada, and mild, wet winters. Inland there are greater ranges of temperature and much less rainfall. The north has long, cold winters, short cool summers and moderate precipitation.'[1] Vancouver is a large, cosmopolitan city (pop 1.6 million) situated on a series of bays, creating a natural center for trade and commerce. It has a high (30+%) Asian and East Indian immigrant population, and as such seems a very culturally international city.

Alberta (AB)

- **Population:** 2.5 million
- **Provincial Capitol:** Edmonton (Pop 816,000)
- **Principal Industries:** Oil & gas, cattle farming, agriculture, forestry, tourism
- **Distinguishing Characteristics:** The province of Alberta covers over 600,000 square kilometers. The state motto is "Fortis et liber" ("Strong & Free"), which reflects the independent nature of many Albertans. Named after Princess Louise Alberta (Daughter of Queen Victoria and Albert), Alberta joined the Canadian federation in 1905. Its primary industries are natural resource based. Trapping opened the area up, and agriculture followed. Oil was discovered in 1914, and has been a center for growth since then. Forest related industries are growing increasingly important, as well as tourism, which draws people to its abundant outdoor activities offered. The province is bordered to the east of the flat plains of Saskatchewan, and by the Rocky Mountains and British Columbia to the west. While Edmonton is the provincial capital, the extremely clean and orderly city of Calgary (Pop 730,000) tends to be the business center where many corporations are headquartered or have their business offices located. Edmonton, and to a lesser degree Red Deer tends to be the manufacturing and oil & gas servicing hub of the province. The southern part of Alberta is a dry, treeless prairie, changing toward the north to mixed forests. Winters are cold and dry; summers are warm.'[2]

Saskatchewan(SK)

- **Population:** 990,000
- Provincial Capitol: Regina (Pop. 200,000)
- Principal Industries: Wheat, oil & gas, specialty wood products, mining
- Distinguishing Characteristics: Saskatchewan is well known for its extremely flat southern wheat-plains, however at 570,000 square kilometers, it is also has over 15% of its land area covered by freshwater lakes. Saskatchewan has a burgeoning specialty wood products industry, with a particular emphasis on oriented strand board products, and manufacturing machinery. There is an expansion of pulp-and-paper production in north-Central Saskatchewan, with large-scale harvesting of burned timber occurring as well. Additional economic activity includes the eco-tourism industry, and specialty forest products for use in

[1] Doing Business in Canada, 1994, Price Waterhouse, Pg3

[2] Doing Business in Canada, 1994, Price Waterhouse, Pg.3

natural foodstuffs and crafts. The other major urban area besides Regina is Saskatoon. Saskatchewan has long, very-cold and dry winters and warm summers.

Manitoba (MB)

- **Population:** 1.1 million
- **Provincial Capitol:** Winnipeg (Pop. 650,000)
- **Principal Industries:** Forestry, agriculture, tourism, industry
- **Distinguishing Characteristics:** 'Manitoba is the easternmost of the three prairie provinces. The north is well forested, and the south has fertile clay soil. The climate ranges from moderate in the south to extreme cold in the north. Winnipeg is the industrial center of Manitoba.'[3] Manitoba's abundance of freshwater lakes and rugged terrain make it a popular remote sports-person's destination.

Ontario (ON)

- **Population:** 10.1 million
- **Provincial Capitol:** Toronto (Pop. 4 million)
- **Principal Industries:** Manufacturing, financial services, farming, mining
- **Distinguishing Characteristics:** Geographically, Ontario is rich with freshwater lakes and rocky wilderness to the vast northern-portion and flat farmland in the south-western tip, bordered by the three Great-lakes: Huron, Erie and Ontario. The northern portion, characterized by that which is north of Toronto, Peterborough and Ottawa, is sparsely populated, and subsists mainly on vacationers ('Cottage country' to the SW's citizens), tourism and mining. Except for selected mining communities, areas north of Sudbury and Sault Ste.-Marie are practically deserted 'Canadian Shield' wilderness. The 'Golden Horseshoe' corridor is the economic and population powerhouse of Canada. It is comprised of the region that wraps around the western end of Lake Ontario including the eastern-most feeder cities of Toronto (Oshawa, Whitby, Ajax), Toronto (and northern Suburbs of Brampton, Thornhill, Markham), Mississauga, Oakville, Burlington, Hamilton, Brantford, Stony Creek, Welland, St. Catherines and Niagara Falls. This region comprises over 30% of Canada's population, 70% of Ontario's, and 75% of Ontario's total economic output. Although there are less-populated areas between some of these cities, conventional wisdom has it that eventually, this area will be one non-stop urban-area. The north has severe winters and warm but short summers, and the southern lowlands has a somewhat milder climate. Principal Ontario cities include:
    - **Toronto**
    - **Ottawa (Pop. 900,000)**
    - **Hamilton (Pop. 600,000)**
    - **Kitchener / Waterloo (Pop. 450,000)**
    - **London (Pop. 375,000)**
    - **St. Catherines (Pop. 360,000)**
    - **Windsor (Pop. 260,000)**

Quebec (QC)

- **Population:** 6.9 million
- **Provincial Capitol:** Quebec City (Pop. 625,000)
- **Principal Industries:** Manufacturing, financial services, farming, mining
- **Distinguishing Characteristics:** Quebec is similar to Ontario in that it has both an abundance of natural resources and a well-developed business and manufacturing climate, but different in

[3] I.B.I.D.

its French heritage and corresponding majority of French Speakers. Again, much like Ontario, Quebec's populace is concentrated mainly in the south, along the Saint Lawrence Seaway corridor, in cities such as Montreal, Quebec City, Hull (sister city to Ottawa) and Trois-Rivieres. Everything to the is wilderness and supports some mining activities as well. There is a substantial Native Indian and Inuit (Eskimo) population within these portions as well. Although many or most Quebecois speak English competently, they may resent an anglophone Canadian's inability to correspondingly speak French. This is where it may be an advantage in presenting oneself as an American or European, whom the Quebecois sometimes feel a greater affinity for than other Canadians. Quebec has been, and probably will forever be, embroiled in resentment over what its inhabitants feel is the English-speaking portions of Canada's population wish to diminish or wipe-out their French culture and heritage. France's Charles DeGaulle further inflamed the debate with his 1967 Montreal balcony speech in which he proclaimed 'Vive le Quebec libre (long live a free Quebec)! (as an indicator of this, the Quebec provincial automobile license plates say 'Je me souviens', which translates to: 'I remember', indicating that they remember their French heritage, and some say their defeat at the hands of the British). Quebec underwent a vote for separation in 1978, which was unsuccessful by a large margin. Following a series of unsuccessful attempts in the 1980's to get language written into Canada's constitution recognizing it as a 'distinct' society that deserves special rights and privileges, the Bloc Quebecois (BQ) led another unsuccessful vote of separation in 1995, however this time the loss was by a margin of less that 1%. The BQ vows to lead another vote sometime before the year 2000. Although technically residents of Quebec, the Native Indian and Inuit population of Quebec do not consider themselves as French, and some support the separation of the northern Portion of Quebec from Quebec if it does ever separate from Canada.

Montreal tends to be the business center of Quebec, with the headquarters of many large corporations located there. However, following Quebec's push for cultural independence, which included the enactment of bills requiring a French-only business signage and services, many Corporations (which also tend to be English-speaking: the majority of Quebec's native English-speakers live in and around Montreal) left the city for mainly Toronto. Corporations *continue* to leave due the uncertainty caused by the Separation votes.

Quebec has two main geographical regions: the plateau-like highlands north of the St. Lawrence River, and the Appalachian Mountains south of the St. Lawrence lowlands - a fertile agricultural area. The climate ranges from moderate in the south to extreme in the north.'[4]

Quebec's major urban centers include:

- **Montreal (Pop. 3.1 million)**
- **Quebec City (Pop. 625,000)**
- **Sherbrooke (Pop. 80,000)**
- **Three Rivers / Cap-de-la-Madeleine (Pop. 75,000)**
- **Chicoutimi (Pop. 65,000)**
- **Drummondville (Pop. 40,000)**

New Brunswick (NB)

- **Population:** 724,000
- **Provincial Capitol:** Fredricton (Pop. 50,000)
- **Principal Industries:** Agriculture, fisheries, tourism
- **Distinguishing Characteristics:** 'Nearly rectangular in shape, with an extensive seacoast, New Brunswick adjoins Quebec and the United States. The surface is mostly undulating, and the climate reflects the moderating influence of the sea. Although Fredricton is the capital city, St. John (Not to be confused with Newfoundland's St. John's) is the principal port and industrial

[4] 'Doing business in Canada', 1994, Price Waterhouse

center.' New Brunswick, (as well as all the Maritime Provinces), have moderate yet snowy winters, and warm summers.

Nova Scotia (NS)

- **Population:** 900,000
- **Provincial Capitol:** Halifax (Pop. 315,000)
- **Principal Industries:** Fisheries, oil & gas, tourism, shipbuilding
- **Distinguishing Characteristics:** 'Nova Scotia is a peninsular province almost surrounded by water; most of its mainland is in low relief. Winters are stormy on the Atlantic coast, and fog is common all year. Halifax, the capital city, is situated on one of the best landlocked harbors in the world.'[6] Continuing the tradition of Nova Scotia's economy being based on the sea, in addition to ship-building and a Navy shipyard, Nova Scotia is benefiting from the increased oil & gas exploration and drilling within the maritime region. The province is strongly influenced by its Scottish roots, and Gaelic is still spoken on Cape Breton Island.

Prince Edward Island (PE)

- **Population:** 130,000
- **Provincial Capitol:** Charlottetown (Pop. 20,000)
- **Principal Industries:** Farming (principally potatoes), tourism, fisheries
- **Distinguishing Characteristics:** Until recently, Prince Edward Island was accessible only by ferry during the months when the Northumberland Strait was unfrozen. This has helped to keep the island in its rural atmosphere, characterized by rolling-hills, farmland, harbors and sandy shores except for its one major city, Charlottetown. Beginning Spring, 1997, a causeway / bridge has been opened connecting the island to the mainland. The construction has been controversial, due to fears of environmental damage from the bridge, and a diminished way of life to the islanders. This has been tempered by the increased tourism and commercial activity that the connection will no-doubt bring. Although due to its relatively small size (as compared to Canada's vast provinces and territories), PEI is Canada's most densely populated province but it remains a very quiet, rural unblemished landscape.

Newfoundland (NF)

- **Population:** 570,000
- **Provincial Capitol:** St. John's (Pop. 100,000)
- **Principal Industries:** Fisheries
- **Distinguishing Characteristics:** Newfoundland is one province comprised of two very different parts: The somewhat developed island of Newfoundland, and the mainland and mostly wilderness portion, Labrador. These are both the province of Newfoundland yet referred to with different names. In 1497, the Englishman John Cabot landed somewhere on the Newfoundland coast (the exact location a subject of great debate) - the modern 'discovery' of Canada. In 1949, Newfoundland was the last province to join Canadian federation; before that it was a British colony. Due to this, and partly its geographical separation from the rest of the country, Newfoundland sometimes thinks of itself as a semi-autonomous country within itself. In the smaller towns and villages, speech and lifestyle are reminiscent of an earlier century. Characterized by large (20 children per family would not be uncommon), strongly religious families, the Newfoundlanders are fiercely proud and vocal society. With an economy that hinges greatly on the success, failures and seasonality of the North Atlantic and Grand

[5] Doing Business in Canada, 1994, Price Waterhouse,
[6] I.B.I.D.

Banks fishing industry, Newfoundland has spent the majority of the century in seasonal-unemployment. This has led to a regular migration of its populace to larger cities within Ontario and elsewhere within Canada looking for steady work. With the 1992 moratorium on cod-fishing due to over-fishing of the Grand Banks area, Newfoundland is desperate to develop its oil & gas, mining and aquaculture industries in an effort to preserve its economy, and become less reliant on dwindling fishing stocks. Additional excitement is being generated by recent mining discoveries of gold, diamonds, and Inco's huge Boisey's Bay / Argentia Nickel mine development. Their cultural cohesiveness requires a regional connection within the area in order to deal effectively with potential customers, in the form of a local distributor, business contact, etc. Perhaps due to their 'uniqueness', Newfoundland or Newfoundlanders are frequently used as the butt of Canada's jokes. Although they may use it frequently when referring to themselves, it would be wise to avoid using the term 'Newfie' when referring to its people. St. John's, at a population of 100,000 people, is Newfoundland's one major city, with the rest of the population scattered sparsely throughout the country's smaller towns and villages. The mainland portion of Labrador is practically deserted. In former times, its port was strategically situated to serve transatlantic ship-travel. With the advent of farther-range shipping though, it is fallen on hard times, and now trying to capitalize on serving the needs of the oil & gas exploration and repair shipping industry in the area.

Competitive Review

- Obtaining detailed, complete competitive information is a frustrating task at best. The broad scope of this marketing review did not allow time for a complete, company-by company review of both the majors gas companies and minor PSA competitors. Included within the appendix binders if an organized presentation of what competitive information has been obtained. The header sheet outlines any new company information, developments that have been discovered, and following is any pricing, product offering, advertisements, brochures etc. that has been collected. In order for this to be a useful resource to the marketing department, it will have to be constantly updated as necessary. It is the policy of the new sales / marketing management to assign the responsibility of tracking an individual company to each of the company's staff members. In order to keep a consistent format, the management (John Hyun) will provide to the staff a template in which to best deliver the information obtained.

Major Gas Companies:

General:

- Under one classification or another, L'Air Liquide, Praxair and Air Products all claim to be the largest gas distributor in North America
- The majority of oxygen is produced using cryogenic "oxygen extraction, which involves compression, cleaning, and ultimately, cooling air in a "cold box" until it liquefies at minus 168 Degrees C. During the cleaning process, a low-pressure nitrogen stream is used to scavenge unwanted moisture and carbon dioxide. The cleaned, liquefied air is separated by means of fractional distillation into liquid oxygen (LOX), liquid nitrogen (LIN) and liquid argon (LAr), in distillation columns. After distillation, the gases are warmed, compressed, and readied for use or distribution"[7]
- There is a basic trend towards consolidation within the industry. The majors, awash with cash generated through several good years, are purchasing gas distributorships and welding-supply companies, such that they will become wholly owned subsidiaries. As such, the distribution network across North America is strengthening for all the companies, and as such, local pricing competition will probably reduce somewhat. In a global context, the majors are also buying up, or signing joint-venture agreements with inefficient, or state-run gas companies or distributors in countries such as Puerto Rico, Russia, Vietnam, Italy and Argentina. Expect this global trend to continue
- Industrial gases are "a relatively high growth and stable market. The $28.5 Billion industrial gas business has diverse end-markets and historically grown at 1.5-2.0 times GDP. This growth is expected to continue on trend line.
  - We expect growth from on-site cryogenic and non-cryogenic supply systems to approach 10% based on the high level of capital investment we see in the supply mode and our expectation of increasing demand from the refining, steel, and electronics industries.
  - We expect per-unit consumption from existing industrial gases customers to continue to increase and demand from previously non-gas consuming industries to accelerate based on development of new lower-cost applications."[8]
- "Profitability is a function of both operating margins and asset turnover. The on-site mode has the highest margins but the lowest asset turnover because of its capital intensity. The cylinder

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[7] Engineering & Mining Journal, Sept, 1989, pg. 35
[8] J.P. Morgan Company Update of Praxair, May 08, 1997, Pg.1

business is just the opposite - low operating margins but high asset turnover. (Figure 1) describes the supply mode profitability.

- Non-cryo has similar margins to the on-site portfolio, but with lower capital intensity it has higher turnover and ROA. Individual non-cryo units also achieve profitability more rapidly than individual cryo on-site units
- Cryo-units are typically designed to have capacity for more than just one customer and often don't reach target operating returns until the sixth or seventh year of operation."[9]

Supply Mode	Operating margins	Asset Turnover	Pretax Return on Assets
Non-Cryo	20%	0.7x	14%
On-Site / Pipeline	20%	0.6x	12%
Cylinder / Packaged Gases	10%	1.2x	12%
Merchant / Bulk	12.5%	0.8x	10%

Figure 1: Profitability of Supply Modes

Source: J.P. Morgan

Where appropriate to use, on-site non-cryo applications look the most attractive to the gas companies, especially if they can justify the current market gas rates with the on-site sales. Due to these financial incentives, expect the growth of PSA oxygen plants to continue, in serving the majors' customers. When volumes are too high for PSA or VPSA, the trend towards on-site production, with or without additional merchant capacity, is expected to continue. BOC's core strategy is geared towards on-site service, and as such, their engineering arm is backlogged as much as 18 months with orders for PSA and small cryo plants

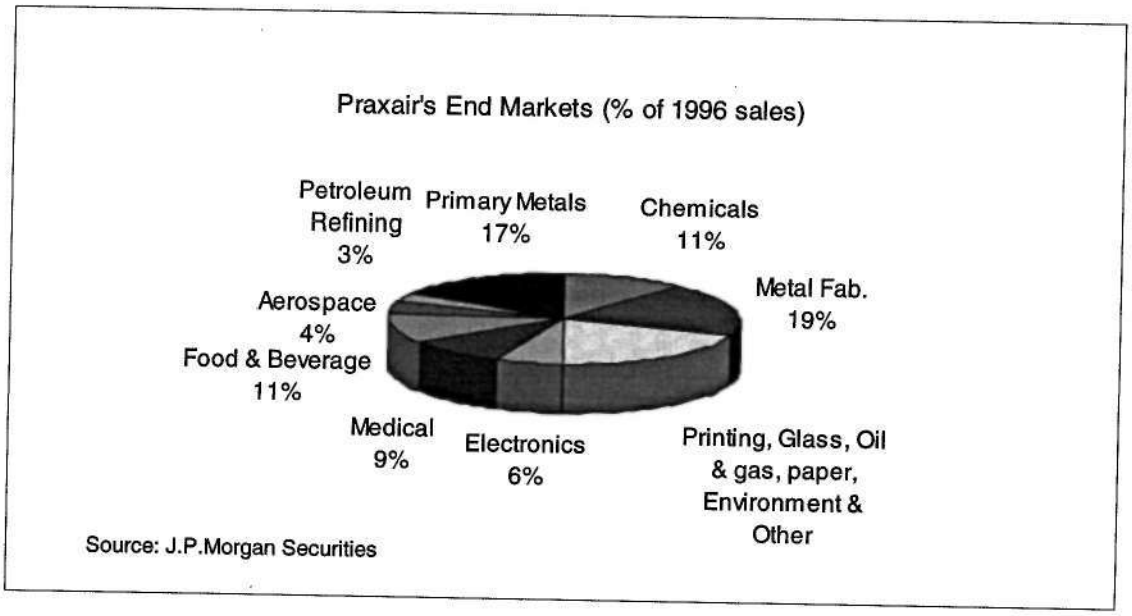
- ASU's become most profitable and justifiable when the ratio of gas demand equals the ratio of the products derived from air: 1% Argon, 21% Oxygen, 78% Nitrogen. Since some of the nitrogen is used in the process, the optimal LIN / LOX ratio is 3 to 1. Increases or decreases in the demand of one or more of these gases may affect the pricing of the remaining gases, i.e.: if the argon demand rises, total ASU production rises, and excess oxygen / nitrogen may be sold at lower prices. This is called 'Airing up for argon'. "Although argon may not continue at the torrid 8 to 10 percent annual growth rate of the last few years, all four of the majors are adding capacity."[10]
- Liquid Argon is much more profitable than LIN/LOX. As a result, LAr can be shipped nationally, whereas LIN/LOX is a regional product. LAr production is more capital intensive than LIN/LOX, adding 50% to the cost of a large liquid plant, yet accounting for 2% of overall capacity. Although about a quarter of industry-wide ASU's produce no argon at all, very few are retrofitted for argon output as the expense is prohibitive
- Increased demand for autos and appliances is positive for argon consumption as the high quality carbon steel used in these products is a major end-market for argon. A common use would be a 75% Ar / 25% CO_2 welding shielding-gas. Welding accounts for about 40% of argon consumption, and driven recently by a switch to stainless steel exhaust systems on cars (stainless steel welding commonly requires a 98% Ar / 2% O_2 mix)
- Large volume users command the lowest prices
- A major gas company's end markets are highly diversified (Figure 2), requiring a substantial distribution network, yet serving to shelter them from large-scale economic demand swings. In addition, they are well situated to take advantage of pioneering new uses and modes of

[9] J.P. Morgan Company Update of Praxair, May 08, 1997, Pg.6

[10] Chemical Marketing Reporter, Aug. 09, 1996, pg.5

delivery for their customers, assuring at least a stable customer base into the future. All the majors have R&D arms working on developing 'solutions' for customer's manufacturing and processing problems

Figure 2: Gas companies have diversified end-markets



The competitive analysis book will contain information on the following companies (and any others that develop with time):

- Air Liquide
- Praxair
- BOC Gases
- AGA
- Air Products
- Linde AG
- Airgas
- MG
- Nippon Sanso

Based on financial projections regarding the competitiveness of the large gas companies, their monopolistic advantage erodes once the oxygen must be shipped beyond a 200 mile radius away from each cryogenic Air separation Unit. Figure 3 shows the locations of all known ASU's within Canada, with 400 Mile circles drawn about them. It comes as no surprise that these areas are located primarily within the population concentration zones of Canada. Where the people are not, so the ASU's are not. However, this opens up a tremendous opportunity for PSA, as there is significant business activity beyond the reach of the ASU's, where the local price of oxygen may exceed 50 times the cost in populated areas.

1. **Oxygen Supply: ASU locations Map**

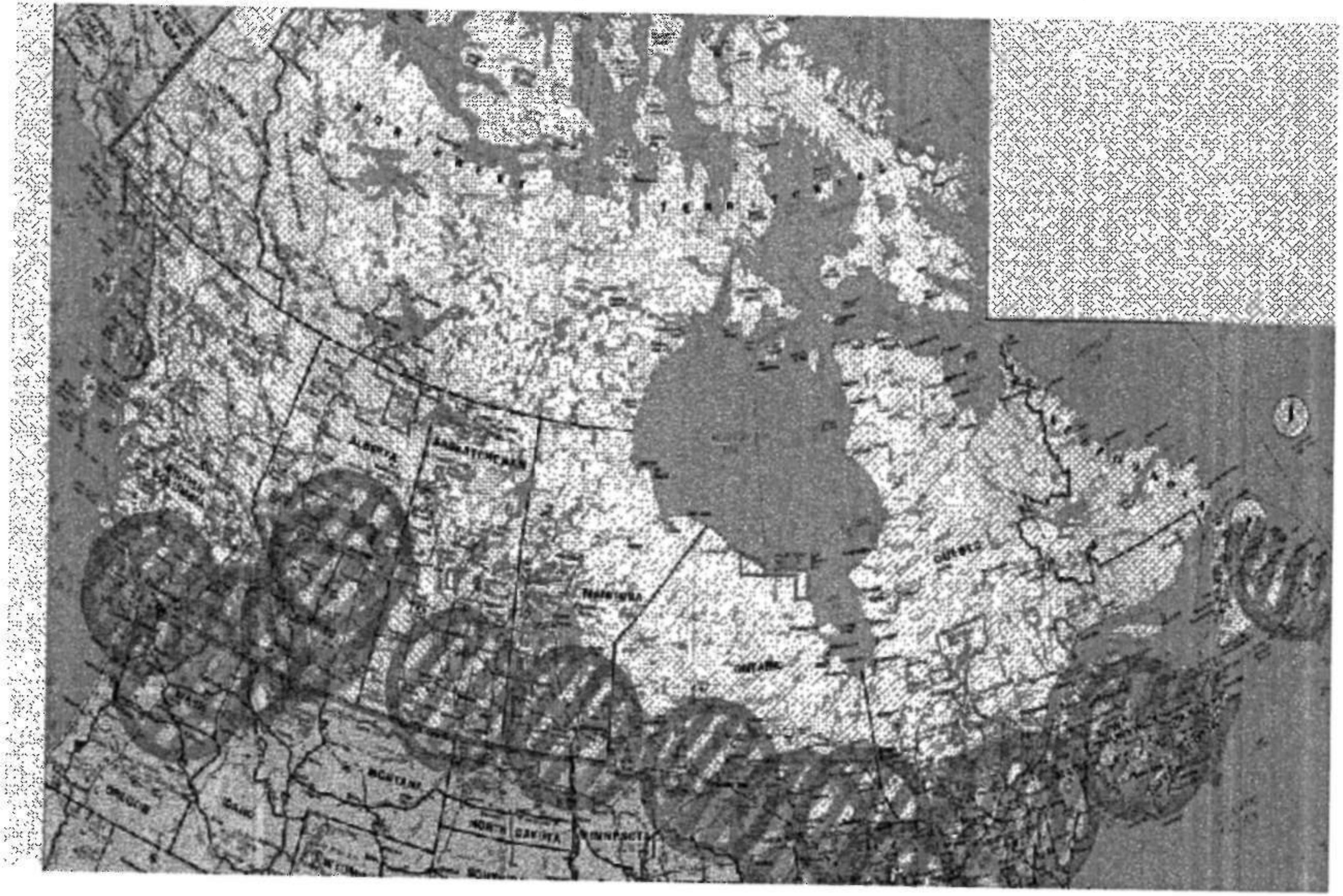


Figure 3: Canadian Air Separation Units for merchant use locations and coverage

Oxygen Generator Makers - General

PSA Companies investigated, information contained within the ARC competitive binder:

1. AirSep
2. Nitrox
3. OnSite
4. Oxitech
5. Oxytech
6. OGSI
7. SanWa
8. SeQual
9. Caire
10. Amox
11. Italfilo
12. NRI
13. BOC Gases
14. Praxair
15. Air Liquide

Market Segment: Mining

There is a robust level of mining activity, including gold mining, within Canada. However, in the interests of leveraging the maximum amount of market coverage with the fewest sales and marketing resources, it is more advantageous to treat mining as an international endeavor. In this way, worldwide mine contacts can be forged from the concentration of mining companies and mining service companies located within North America, rather than just limiting the market size to those mines located within Canada.

Gold Mining

2. Gold Mining Glossary: Ore Types

Oxide Ore: Oxide ore is mineralized rock in which some of the original minerals have been oxidized. Oxidation tends to make the ore more porous and permits a more complete permeation of cyanide solutions so that minute particles of gold in the interior of the minerals will be readily dissolved. [11]Oxide ore is relatively free of carbon and sulfides, and can be sent directly to the leaching circuit without treatment.

Refractory Ore: is gold mineralized material in which the gold is not amenable to recovery by conventional cyanide methods without treatment. 'A gold ore may also be considered refractory if soluble minerals of base metals cause the consumption of uneconomic amounts of cyanide and hinder the gold dissolution process'[12]

- Sulfide refractory ore is treated in an autoclave
- Refractory ore containing carbon is roasted

3. Gold Mining Glossary: Ore Treatments

The pre-treatment of refractory ores is most aimed at releasing gold encapsulated in sulfide particles, either physically by grinding, or chemically by oxidation of the sulfide minerals.

Active carbonaceous constituents may also render an ore refractory by actively binding with the soluble gold cyanide complex. Even after the oxidation of the sulfides, some carbon may remain un-oxidized and retain its preg-robbing characteristics. Increased oxidizing conditions, usually more severe than required for purely sulfide oxidation, may be required to overcome this problem.

- **Absorption:** Gold is absorbed (collected) out of the cyanide / gold solution onto activated carbon. The remaining cyanide solution is then recycled
- **Autoclave (Pressure oxidation):** Refractory ore without carbon is oxidized in an autoclave oven under high temperatures and pressures so as to liberate the gold from the sulfide minerals. Pressure oxidation tends to yield high subsequent gold recoveries, but at the expense of high operating costs and capital investment.
- **Bio-Oxidation:** Bio-oxidation achieves high gold recoveries, but long residence times are required at relatively low pulp densities (low volume throughput) which result in increasing capital costs for larger systems.

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[11] The Gold Institute 'The Amazing Story of Gold'
[12] Mining Magazine, April 1996, pg. 231

- Bacteria known as Thiobacillus ferroxidans and Leptospirillum ferroxidans are sprayed on piles of refractory ore . These 'bugs', eat away at the sulfur, iron and other minerals that trap the gold within the ore. Using this process, this otherwise waste-ore can be processed using conventional leaching processes.

- **Chlorination:** Historically, chlorination was the main gold-leaching agent used prior to the adoption of cyanide in the 1800's. Its main application is now for the passivation of preg-robbing carbonaceous ores prior to the cyanide leaching. The ore slurry is sparged with chlorine in closed tanks under moderate heat and retention times. Chlorination is unsuitable for the pretreatment of ores with high sulfur contents due to excessive chlorine consumption.
- Crushing:
- **Cyanidation:** A method of extracting gold or silver by dissolving it in a weak solution of sodium or potassium cyanide
- Dore' bars: Bars of impure gold (containing up to 90% gold). Dore' bars are sent to a refinery for further processing
- Gravity **concentration:**
- Grinding
    - stirred ball mills,
    - high-pressure grinding rolls
    - Semi-autogenous grinding:
    - **Ultra-Fine** Grinding: The finer the grind before oxidation, the less extreme are the conditions required for oxidation. Because less oxygen is used, and at a lower temperature, cheaper autoclaves can be used.'
- **Merrill Crowe:** Merrill Crowe is a specific process which involves filtering out particulate from a pregnant solution, and then 'cementing' gold and silver through adding zinc dust to the solution. This solution is then precipitated. Merrill Crowe is often used if the solution has a 0.5 -1 oz/ton silver content, otherwise carbon absorption is used. Oxygen is deemed detrimental to the reaction, and therefore not used.
- **Precipitation:** Gold is precipitated from the solution electrolytically or by chemical substitution.
- Refining: The crude gold is melted and chlorine is bubbled through the molten metal converting all the other metals to chlorides which are floated off. This yields 99.5% pure gold which is cast into anodes. In electrorefining, an electric current is passed through an electrolyte solution, and the anodes are gradually dissolved and deposited on the cathodes. This yields 99.99% gold, which is removed, melted and cast into bars. In the case of electrostripping, the anode does not dissolve.
- Roasting: Refractory ore containing carbon is roasted to over 1000 Deg. F, burning off the sulfides and carbon. 'Roasting has the advantage of being proven technology, but there are still environmental concerns with the process that must be addressed, usually, recoveries are not as high as those achieved through bio-oxidation, but, generally speaking, neither are the capital costs.'[14] The roasting generally occurs under the presence of pure oxygen. The high oxygen demands generally require on-site cryogenic oxygen plants, which substantially raise a mine's capital costs.

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[13] Mining Magazine, April 1996, pg. 231
[14] Mining Magazine, April 1996, pg. 231

Smelting: A direct oxygen-smelting reactor is divided into two parts: an oxidation zone and a reduction zone. This design allows two pyrometallurgical operations to be carried out simultaneously. Oxidation and purification of the metal concentrates form as the bullion is formed. Smelters are able to process high-grade ore pulp concentrates directly as mined, and produce metal bullion in the high purity range. In addition, they are able to separate out ore containing high-concentration metals, such as gold/copper. While this may be an option for some mines who have high grade ore and wish to limit their capital investment in processing equipment, they normally have long re-payment terms and excessive fees which the mines dislike. Smelters normally use large volumes of oxygen (in the 100's of tons per day), and face numerous environmental challenges due to the smelter discharges.

Stripping: The gold-loaded carbon is moved into a vessel where the gold is chemically stripped from the carbon. The carbon is then recycled.

Sulfides: Convert to sulfates when oxidized

4. Cyanidation:

Vat Leaching, Carbon In Pulp (C.I.P): Oxide ore slurry (pulp) is introduced into vats containing a cyanide solution, whereby its 'residence time' varies

Heap-Leaching: Low grade ore, or mine tailings are broken into rough chunks and placed on leach pads where a dilute cyanide solution is distributed over the surface of the heap. The solution percolated through the heap and the cyanide dissolves the gold. This solution containing dissolved gold is then collected.

Carbon In Leach (C.I.L.): A recovery process in which a slurry of gold ore, free carbon granules and cyanide are mixed together. The cyanide dissolves the gold content and the gold is absorbed on the carbon: the carbon is subsequently separated from the slurry for further gold removal.

5. Factors affecting gold dissolution in cyanide:

- The concentration of the cyanide solution
- Particle size of the ground ore (affecting the surface area of gold particles exposed to the cyanide
- Efficient mixing and suitable oxidation condition in the leach slurry
- The leach temperature and pH
- The concentration of dissolved oxygen in the leach pulp
- Presence of sulfides in the ore
- Presence of carbon in the ore
- Presence of other elements in the ore that are dissolved by cyanide, such as:
    - Copper (Cu): Copper represents a real problem because of their solubility in cyanide solutions, and their abundance relative to gold. It passes through all stages of gold recovery processes into the dore' bullion. Copper is oftentimes found as a predominant element in polymetallic ore. There are many types of copper types, each exhibiting slightly different leach characteristics. However, most will pass completely through the gold cyanidation process and poured into the dore' bar unless steps are taken to limit the copper / gold ratio before leaching.

        - The presence of copper can increase the consumption of cyanide by up to fifteen times.
    - Silver (Ag)
    - Iron (Fe)
    - Mercury (Hg)
    - Zinc (Zn)
    - Lead (Pb)
    - Tellurides
    - Arsenic and Antimony
- The addition of promoters (salts of lead or mercury) to remove sulfides from the cyanide solution to keep the surface of the gold clean

Many of the above factors can be controlled and monitored by the process operators, however the factors that are the most out of the control of the mine is the presence of sulfides, and the presence of additional elements. It is in these conditions that the addition of pure oxygen helps in the following ways:

- The cyanidation rate is increased
- The gold recovery percentage is increased
- It inhibits the dissolution of metallic sulfides, thus the cyanide usage is decreased, especially in the presence of additional elements

6. Off-Site Milling:

- Some mines produce such high grade ore (such as Eskay Creek, British Columbia), that it is more economical to ship as mined to smelters. While achieving the highest possible gold recoveries, this option also reduces capital operating costs by avoiding on-site milling.

7. Current Gold-Mine Applications and ARC Successes in Australia

Australian gold-mines might be considered an ideal market for ARC PSA oxygen generators for the following reasons:

- Australia has a well-developed gold industry, with excellent engineers
- There is considerable cryo-oxygen under-capacity country-wide, with no plans for additional capacity in-sight for the near future. Oxygen is 'rationed' to each mine as supply allows
- The gold mines in Western Australia are located in remote desert areas, with huge driving distances between each mine. This increases the merchant delivery of bulk oxygen to the mines expensive and time consuming
- The Western Australian mines have gold ores that are heavy in sulfides, that are therefore conducive to recovery gains by using direct-injection of pure oxygen in the cyanide leach cycle
- The mines, being rationed on oxygen supply, would take more oxygen, greater capacity PSA units if they could get them
- The mines are constantly experimenting, potentially finding additional uses for the oxygen in the process
- The mines are subject to rains which wipe-out the dirt roads, and can delay, or trap, oxygen delivery trucks for days. Gas delivery companies are loathe to risk getting their trucks trapped on the mine site, or in the mud by the appearance of rain during the delivery route. Although the mine can continue to operate without oxygen, losses due to diminished process efficiency without oxygen tops

AUS$4,000/hr. This makes the demand for a reliable supply of oxygen very important to the mines

- The gas companies are receptive to using PSA generators, knowledgeable as to their benefits and service, and have available budgets to fund the capital investment. The improved margins resulting from using ARC PSA units has paved the way for continued installations in the future
- The attractive margins / short paybacks realized by the gas companies by using PSA while still charging the mines bulk oxygen prices make them somewhat price insensitive to PSA installations
- The mines prefer optimized oxygen mass-flow rate over oxygen purity, provided that the purity is not too much below 90%. While this need does not 'mesh' with Arbor Research Corporation's specified PSA capabilities, this does allow for a more feasible machine. The local oxygen scarcity has made AirLiquide somewhat accepting of machines running under specified capacity, or at the bottom-end of the rated capacities
- The first entrant into the PSA market, AirSep, exhibited reliability problems, and as such has a bad name amongst the gas companies

Limiting features of the market situation:

- The mine managers do not care how they obtain their oxygen; they just want a reliable supply. This necessitates always having a bulk liquid oxygen backup to the PSA unit, which requires the system integration with the gas-company systems.
- The gas company prefers smaller tonnage units due to their portability
- If a reliable supply of bulk liquid oxygen were to be otherwise available, then they would not want PSA oxygen due to:
    - Trying to limit capital investment
    - trying to limit mine machinery service and complexity
- Currently, the PSA units are being run off of the mines power-grid, which is not a major expense to the mine. This limits the necessity for the efficiency gained with VPSA tonnage systems, which to date is Arbor Research Corporation's chief competitive advantage
- AirLiquide has stated that they will continue to do business with ARC so long as ARC does not supply its regional competitors. This limits the Australian market-size for ARC
- Both the mine, and the gas companies prefer PSA reliability over economical price. AirLiquide Australia has 'funded' Arbor Research Corporation's development of tonnage units, delays and problems due to startup difficulties. While conditions have improved, several machines are still running under specified capacity. With these conditions, it could be argued:
    A) Having gone through the development process, AirLiquide would shy away from the cost and troubles with 'breaking in' a new PSA supplier, and wants to keep its units common for economies of servicing, parts, and relationship reasons. Therefore, it can be assumed that a long-term, lucrative relationship between ARC and AirLiquide will exist
    B) Because of the troubles experienced with Arbor Research Corporation's units, and due to the ever increasing need for PSA units in Australia,

AirLiquide will look for alternative or supplementary PSA suppliers to meet its volume, delivery and reliability needs.

SeQual has recently placed a tonnage-sized oxygen unit into an Australian mine. ARC does not 'own the market', and must now respond to competitive pressures in the mining segment too. While it can be assumed that scenario A) is most likely, due to upcoming competitive pressures, and the need for the utmost in reliability, ARC will have to limit its price increases to those that can be justified with capacity or reliability increases, and strive to offer specified outputs, and long-term reliability.

8. Tailings, Cyanide treatment with Ozone

Environmental concerns are currently one of the greatest factors affecting mine design and financial feasibility today. Before any mine can be approved by local and Federal authorities, a complete environmental assessment, maintenance and reclaim plan must be performed by the prospective mine. In many cases, the most efficient or cost-effective sulfide-ore treatment method may be passed-over due to its potential environmental impact Roasting and smelters produce sulfur which leads to sulfuric acid, and ash contaminated with heavy metals, In-situ and heap-leaching threatens to leak cyanide into groundwater, Bio-oxidation uses an acid base, and pressure-oxidation threatens massive contamination due to autoclave pressure-failure, as well as the problem with disposal of sulfuric or nitric acid concentrate. With cyanidation leaching, there is the a problem with cyanide runoff and disposal to contend with, in some ways it is the 'cleanest' of the ore-processing steps. Due to the high cost of cyanide, it makes sense for most mines to recycle as much 'spent' cyanide solution as possible for leaching re-use. As well, re-used cyanide does not threaten water-tables, or need to be disposed of at high cost.

Canadian and US regulations allow a maximum of 1 PPM cyanide contamination of decant water from the mine leach-circuit contained in trailings dam. Although some international mine-sites may allow more, or have lax enforcement of regulations, the international tide is turning towards forcing mines to keep their sites environmentally safe- for Tajikstan's Zeravshan Valley gold district, the Tajikstan government requires Nelson, a Canadian mining company in joint venture with the government, to keep cyanide concentrations to 1 PPM maximum, matching the North American specifications. For this they utilize ozone detoxification. Bateman Engineering, out of Denver, specified (2) x 30o' IbVday ozone units for this purpose.

Neutralizing methods employed depend on a number of factors

Various methods exist for neutralizing waste trailings from the C.I.L. train thev include: '

- Ozone detoxification
- Oxidization with Peroxide
- Oxidation with Oxygen
- Chlorination

- While waste treatment with ozone or oxygen may not present the greatest potential market as it stands by itself, it is a complementary segment as reached through the engineering company contacts forged for mine processing implementations.

Gold Mines to target

Canadian Gold Ore:

- Presence of Sulfides
- Mine development stage

- Existence of mill over-capacity

Mine Economics:

Oftentimes, smaller gold companies, unable to mount a major gold-mining endeavor due to lack of financial resources, will endeavor to treat the trailings from existing or long-since closed international mines. Current on-site processing may involve mechanical methods only, such as flotation only, leaving piles of ore concentrate with slight recoverable gold content. Because of the low gold content, economics of treating are questionable, and may depend on many factors, such as the price of cyanide, price of gold, country taxes and cost of capital, etc. If it is deemed as economically unfeasible, then the tailings will be left to sit, waiting for future advances or changes in the operating factors. Oftentimes, the use of pure oxygen in the leach circuit, whose cost may only be a fraction of the cyanide or capital cost, can significantly increase the residence time (thereby increasing total throughput, as much ' as doubling the rate), increase gold recovery rates slightly (depending on the ore type, 1-30% increase), and decreasing cyanide usage (up to 40%). While oxygen may not have been considered due to a mine's remoteness, use of PSA could essentially put the project's economics 'over the top'. Mitigating factors include the local price of cyanide, which may account for 60%+ of operating expenses

Silver:

Silver is oftentimes found within gold ore. Using pressure oxidation ore treatment, silver is usually dropped-out as jarosite, and thus not recovered. Due to silver's low price, it is oftentimes not economical to recover silver, given the extreme margin benefits obtained from concentrating on recovering an ore's gold content. However, silver usually will pass through a leach circuit exactly as gold will, so oftentimes dore' bars are sent to a refinery with a high gold/silver content, and further refined there.

Copper:

While few strictly-copper extraction processes are amenable to PSA oxygen generation, it is important to understand copper's properties and processing in order to fully understand the gold mining process. This is because oftentimes, gold ore has within it even larger quantities of copper (and other metals such as silver, zinc, nickel, etc.), and therefore extraction processes may be designed to process and capitalize on all elements within a specific ore. Copper may be a byproduct of the gold-extraction process, and visa-versa. A primarily copper-producing mine may have at it cyanide leaching-processes as well in order to capitalize on the precious metals found within the copper-ore. Or, the entire ore may be treated as strictly gold-bearing, and the other elements, such as copper are separated from the dore' bars in the off-site refining process. Either way, there are limited application for oxygen injection within copper mining.

Copper is usually leached using sulfuric acid, and oxygen has no effect within that reaction. In order to obtain a sufficient return, copper mines may be in the 50-100 000 tons of ore processed per day range in size (as compared to gold mines, which may be 5-10,000 tons per day). Copper is a detriment to cyanidation leach in gold processing; copper is a high cyanide consumer, and the value of copper is seldom worth the value of cyanide consumed in order to leach the copper. Therefore, copper is, if at all possible, removed from the gold-slurry concentrate through flotation or gravity concentration before the leach process.

Copper Element Types:

- Chalcopyrite
- Chalcocite
- Covellite
- Bornire

9. Copper Processing:

There are two main types of processes used to extract copper from ore and to produce copper metal: **pyrometallurgy**, in which the copper is separated from the other elements with which it has been chemically combined, and turned into metal heat; and **hydrometallurgy**, in which it is separated by leaching.

10. Copper Pyrometallurgy:

Sulfidic copper ores, from which most primary copper today originates are not easily leached, and so are usually smeltered

This basic technique has been used since the earliest times, and the essentials have remained relatively unchanged:

1. Crushing , then grinding to consistency of fine sand
2. Concentration by flotation, so that the copper concentration reaches as much as 40% or more in the pulp solution. Other elements may be sulfur (30%) and iron (25%); the actual contents will depend on the ore being mined
3. (Sometimes) Roasting, in which the concentrate is dried and heated before being charged into the furnace
4. Smelting, in which the concentrate is heated by oil, gas, electric, or in modern 'flash' furnaces, in which most of the heat is provided by burning of the concentrate's own sulfur content. Once heated to a molten state, the copper and the slag are drawn off separately. The copper 'matte' may consist of between 50-75% copper, together with sulfur, iron, and any precious metals.
5. From the furnace, the molten matte is transferred to a converter, which is another furnace in which air or pure oxygen is blown through the matte, oxidizing it and thereby removing the iron and sulfur. The resulting 'blister' copper is 98.5-99.5% pure. Precious metals such as gold, silver or platinum enter the blister copper, while most other impurities tend to vaporize. The oxygen requirements for a smelting process, although depending on the modernity and size of the furnace output, are considerably large enough to almost always justify an on-site cryogenic oxygen plant, and are definitely out of the workable ARC PSA / VPSA range.
6. The blister copper is re-melted and cast into flat sheets called anodes, of a shape suitable for the refinery. This re-melting process also removes residual sulfur or oxygen.
7. The anodes are further refined using electrorefining. The result is electrolytic cathode copper, assaying over 99.99% pure copper, in sheets weighing between 110 - 125 kg each, ready to be cast into wire rod, billets, or cakes.

Sulfur dioxide (SO_2) is generated by both the smelting and converting process. Due to strict environmental limits, most is recovered from the waste gases and converted into sulfuric acid in an acid plant attached to the smelter. Generally, three tons of acid is produced for every ton of anode copper. The presence of a local market for this acid can help justify the use a smelter, and if the market conditions favorable, be sold at a profit; otherwise, it must be disposed of at considerable cost.

Some gold mines who have considerable copper content in their ore, prefer to send the ore concentrate directly to an off-site smelter, and let the final gold content be produced through the smelter-refining process. Thus, the mine is able to avoid the high capital costs of gold-oxidation / leaching equipment, but they must usually wait up to three months for payment from the refinery, and at a considerable cut of the value as well.

11. Copper Hydometallurgy:

Oxide copper ores, due to the ease at which the metal elements can be liberated from the rock, are usually leached, due to the lesser capital investment and environmental concerns over those with pyrometallurgical processes. Pyrometallurgical processes are also particularly suited to low grade oxide ores which are not amenable to concentration by flotation.

The most commonly used process today is the leaching of the ore with sulfuric acid, after which the copper is extracted from the solution by electrowinning. In the past, copper was recovered from the leach liquor by precipitation involving bringing it in contact with scrap iron to produce 'cement' copper which can be flaked off the iron and then collected. Today, most leached copper is recovered by solvent extraction by selective organic reagents, which extract only the dissolved copper from the leach liquor. The material may be leached in a deep ore-body (in-situ leaching), but this is very rare. The copper ore may also be crushed to maximize recovery and then heap-leached or vat leached. The heap-leach cycle may only take days in the case of oxides, months or even years of sulfide ore is being treated. Recoveries for sulfide-ores is likely to be 50-85% and 90% for oxides.

Although less popular, there are some hydrometallurgical processes developed for treating sulfide copper ores. The main processes include:

- **Arbiter Process:** In which the ore concentrate is leached with ammonia at low pressure and 75-80 Deg. C, followed by liquid separation, solvent extraction, and electrowinning.
- **Clear Process:** In which the copper was leached in two stages: first a cupric-chloride leach at atmospheric pressure followed by leaching with ferric chloride in a pressure autoclave. Blister grade copper was produced by chloride electrowinning.
- **Escondida Ammonia Leach Process:** In which an ammonia-ammonium-sulfate solution and air leach cuprous copper from chalcocite and bornire concentrates at atmospheric pressures. Roughly half the copper is leached and the remainder is recovered by flotation. This process is superior to the arbiter process as a lime-boil circuit to regenerate the ammonia is unnecessary
- **Intec Process:** This process utilizes a leaching medium of cuptic-chloride and halogen complexes in a strong sodium-chloride solution, at atmospheric pressure and 80-85 Deg. C. The process is unique because gold is also leached and recovered on activated carbon. This process is being piloted at Chatwoods, NSW, Australia by Intec and a consortium of major companies
- **Pressure Oxidation:** The successes of pressure-oxidation processes for refractory-gold ores has sparked interest in the treatment of copper sulfide concentrates, especially chalcopyrite. Generally, total oxidation of the sulfide is achieved by autoclaving under pressure and 200-220 Deg. C with oxygen. Copper is released into a cuptic-sulfate solution, and the formation of sulfur is

avoided. Precious metals can then be recovered from the leach residue by cyanidation. Very high recovery rates can be achieved, although with autoclaving, environmental and safety issues are prominent. As with smelting, autoclaving usually consumes quantities of oxygen far above the capabilities of PSA / VPSA generating plants. There are several processes being investigated that use lesser amounts of pure oxygen, and therefore may in the future be within the Arbor Research Corporation's range.

- **Activox Process:** With the Activox pressure oxidation process, the oxidation is carried out at a much lower pressure, and at a temperature of only 100 Deg. C.

- **Bio-Oxidation:** The commercial success of bio-oxidation in treating refractory gold ores has aroused interest for copper recovery. Although primarily used with bio-heap leaching, agitated tank or vat bio-leaching is emerging for sulfidic-copper extraction. The copper would be recovered using the solvent-extraction, electrowinning operation, and the precious metals extracted from the residue by cyanidation
- **Cuprex, CANMET Processes:** These process utilizes a ferric chloride leach at 95 Deg. C and atmospheric pressure, followed by solvent extraction and electrowinning from the chloride solution to produce copper powder (Currently in pilot scale).

Uranium:

12. Uranium Processing

- Formerly, uranium mining was accomplished through underground shaft mines, however this has been proven to be extremely environmentally damaging, as well as dangerous to the underground miners, breathing in uranium dust as well as exposure to radon
- The 'newest' uranium mining method is called 'in-situ leaching', also known as 'solution injection mining'. This is the lowest-cost method because it avoids the high equipment and labor costs associated with open pit mining as well as the environmental cost of disposing radioactive tailings. Solution mining is suitable for mining shallow, low-grade uranium deposits. Although there is some concern regarding ground-water contamination, it tends to be more environmentally sound than open-pit mining methods. Solution mining was first tried in the 1960's using sulfuric acid and ammonia solutions, but this proved to be environmentally troublesome. Now all operating solution-mines use the sodium-bicarbonate / oxygen method.

  Solution mining involves drilling wells into rock formations containing uranium ore. The wells are arranged in groups of five, and a network of pipes run beneath the land's surface, connecting the wells, a central plant and pump-houses. Native groundwater, with added oxygen and sodium bicarbonate or gaseous carbon dioxide (the lixiviate) is injected into the wells to mobilize the uranium in the rock so it can be picked up and pumped to the surface. The oxygen reacts and oxidizes the uranium to the +6 valence state. The oxidized uranium then complexes with the carbon dioxide to form a soluble ion. A typical operation may pump as much as 3600 gallons of water solution per minute, with 200 PPM O2 added. At each mine site, a greater volume of solution is recovered than is injected, as the solution is diluted by groundwater.

The uranium is collected around grains of sand. The solution is then pumped from a central well and back to the plant, where the uranium is collected and concentrated in ion exchange columns. Chemicals are added to get the uranium to settle out of the solution. The remaining water is steamed or vacuumed, leaving a golden yellow powder of natural uranium called 'yellow cake'. The yellow cake is then shipped to other companies for further processing

After the extraction of the uranium, the barren fluid is re-fortified with carbon dioxide and oxygen and re-injected to extract additional uranium.

Not all ore deposits are amenable to solution mining. Those contained in porous bodies of sand saturated with groundwater are best.

- Uranium can also be produced as a by-product of phosphate mining.

13. Uranium Industry:

- Canadian uranium ore tends to be 20 to 30 times more concentrated than the average US solution-mining low-grade uranium ore. As a result, all of Canada's uranium mines utilize either an open-pit or underground mining technique with conventional ore milling methods.
- There are 7 uranium solution-mining operations in the US, mainly located in Wyoming, Texas, New Mexico, Montana, Nebraska, Utah. The US currently supplies roughly 7% of the word's uranium needs.
- Canada contributes over 30% of the world's uranium supply, and Saskatchewan over 93% of that.
- Other worldwide uranium solution-mining locations include the Czech Republic the Soviet Union, Tjikstan, Australia
- There are numerous uranium mines located worldwide that were closed over the last decade when the uranium price dipped below what was considered economical to produce at. Now, with the emergence of solution mining, and an expected increase in the worldwide price of uranium, some mining companies are re-visiting their old mine sites and reclaiming uranium from the old tailings using solution circulation and an ion exchange plant

14. Uranium Demand:

- There are currently over 300 nuclear power plants operating worldwide
- Current worldwide market demand for uranium is 140 million pounds annually After a decade-long slump in the market, excess uranium reserves will run-out by 1998. Although the market expects regulated inflows of uranium from the dismantling of US and Russian nuclear warheads, there is definitely a gap between supply and demand, and new production will have to come on line in order to satisfy demand. It is estimated that current mine production is 60-65% of worldwide demand, with known, in-ground uranium reserve-life ranges from 27-40 years depending on the price.[15] This indicates a steady future for uranium mining

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[15] Oil & Gas Journal, Sept. 04, 1995, Pg. 104

- 'Nuclear power is not expected to increase significantly in the next two decades due to limited current construction and plans for new capacity, and retirement of existing reactors'[16]
- Market: Uranium currently sells for approximately $16/lb., and is rising after years of depressed prices, seeing lows of $7 in 1993, after 1979 highs of $40/lb. Most all analysts agree that a protracted period of uranium mining growth can be expected

Oxygen in Mine Construction

The mine construction process could be summarized into the following process:

1. Exploration & testing of the area by a contracted company
2. Mine design and development by a specialty mine engineering firm such as Kilborn, located in places such as Toronto or Calgary
3. Mine module construction off site for units that can be produced into transportable-sized chunks
4. Mine construction on-site, consisting of a collection of numerous smaller contractors, each conducting their specialty. Unless in the case of a small and/or very remote mine location, rarely does a mine company get a single company to do all mine construction work. Usually it is left up to the central engineering firm to coordinate and contract the smaller firms. Many of these smaller construction firms are based out of places like Yellowknife, Whitehorse, or even Edmonton (in conjunction with oil & gas service companies).

Taken individually, these smaller construction companies would not generate enough oxygen demand to justify an oxygen generator. However, if an entity such as:

- The mine engineering firm
- The mining company itself
- A local construction company
- Mining equipment rental firm (working in conjunction with a helicopter firm for delivery)
- An ARC independent leasing division

were to operate a self-contained oxygen generator cylinder-filling unit on the mine-site, they could supply oxygen to the various contractors at reduced rates. The largest of the construction companies might acquire their own sea-container units for their own use if they see the cost benefit from it.

In addition to the cost benefits to a sea-container system, supply concerns could be solved as well. Currently, a great deal of planning and logistical coordination must be performed to ensure that a mine build-site has adequate supplies during the build-duration. Depending on the site location, supplies may need to be delivered by:

- Poor single-lane roads, open only in the summer months
- Winter roads, made by pushing barges over frozen lakes and tundra with earth-moving equipment
- Shipping, through Northern passages open 2-4 months per year
- Plane or helicopter drops

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16 Oil & Gas Journal, Sept. 04, 1995, Pg. 104

While a mine that has been operating for many years may have a good understanding of their supply needs, new construction sites do not. Having an oxygen generator on site could eliminate any delays otherwise caused by running out of oxygen. In addition, the need to overstock on a long period's cylinder needs is reduced, and thus the rental fees reduced as well.

A problem with the competing oxygen company / welding supply house emerges with the above system. These companies will still need to deliver other gases and welding supplies on-site, however they will have lost their lucrative oxygen delivery part of the business. This could open up the conditions for a local price war on the site. It may behoove the above sea-container entity to carry argon, and other gases as well.

Perhaps the most appropriate mining area to base unit distribution out of is the Northwest Territories, in and about the area surrounding Yellowknife. In addition to a number of gold mines located in that area, it serves as the central service point for remote-remote mine sites, as well as the oil & gas exploration in the area. Smaller locations in:

- Whitehorse could serve the Yukon Territories and Alaska area
- Inuvik could serve the West Arctic Oil & gas drilling area
- Arctic Bay could serve the Northern-North drilling and mining areas

- Perhaps the most suitable product for this application would be the HP3C / HP6C Sea-container, or HE3C / HE4C Sea-container. It is unlikely that any job-site would ever require greater than that capacity. With an existing price of $0.24/SCF oxygen, standard $5 per cylinder rental fee, and a discount of 10%, these units would generate in the six-to-twelve month simple payback range for the customer. However though, these paybacks are based on continuous operation, and not on periodic job-site requirements. If a contractor purchased a unit based on a known job requirement that was within the payback period, the unit could be paid-for at the end of that period, and still useful for future cash generation with other sites.
- It stands to reason that if a number of construction companies are serviced from the same central supply unit, then a common oxygen purity will have to be settled on. While some companies may be able to get away with using 95% pure oxygen for cutting purposes, others will require 99%. That would indicate that the HPC system is more appropriate for this use.

Oxygen In Mine Maintenance

- Low usage in 200-300 H-cylinders / year range does not necessarily justify generator use
- Maintenance use requires portable torches, thus cylinder filling station
- High cost of sale due to the remoteness does not justify direct selling
- Suggest use local mine-supply shop or contractor as distributor

Marketing Strategy

- Customers don't care about recovery rates, bed efficiencies, etc. What they want is a reliable flow of oxygen that meets the flow and purity specifications. If it would help in customer satisfaction, reduce development cost and time, and reduce potential service calls and sieve replacements, it might behoove to over-design machines to the point of assuring rated performance (ref. HE26 developments, time delays).
- Education and Introduction PSA to mining engineering companies, engineers through conventional leaching uses leads to additional uses off cheap oxygen found, as well as down-sizing roasting, etc. processes to fit PSA capacities where cryo applications necessitated excessive capital investment
    - example, currently heap leach rates are constrained by oxygen transfer efficiencies within the heap. If an engineer knew that an easy / relatively cheap source of oxygen could easily be available, they may try to develop a method for oxygenating the heap
- Mining engineers all seem to be 'aware' of PSA technology, yet few seem to be ready to adopt the technology due to a relative lack of education as to its effectiveness, efficiency, reliability, etc.

15. Distributor Tool-kit

A sales-staff / distributor tool-kit is currently in the initial stages of being developed by the Arbor Research Corporation marketing-staff. Within this 'tool-kit' will be an series of integrated computer spreadsheets that transform initial site, environment, cost information, etc., and develop a machine specification that best suits the customer's situational needs, a customer quote, economics and payback scenario, build-sheet, invoice, etc. automatically. Mining-related tools required will be the altitude/temperature compressor de-rate (already completed), as well as aeration devices required (needs yet to be co-developed with a full-services provider). The tool-kit will be an on-going project, needing constant updating to reflect changing prices, product offerings, customer needs, etc.

16. Advertising

There is a lack of focused, directed advertising strategy within the Arbor Research Company, possibly due to the fragmented nature of the numerous possible market segments for the generator product. Taking a page from marketing 101, there should be definite strategy followed for each advertising venture, and agreed upon and understood by the sales / marketing team. The confusion caused by trying to serve all the possible objectives below is creating a muddled marketing thrust.

Next Randol paper incorporating:
A) Summary of oxygen use, success worldwide
- Which ore types, processes, conditions amenable to oxygen use

B) Worldwide actual PSA applications, successes, obstacles overcome
C) Tie-in showing future opportunities, processes for PSA, PSA economics
D) Oxygen diffusion technology completing the application

Arbor Research Mining Copy Strategy Statement

1. Target Market: Who are we talking to?
    - Mine managers?

- Mine gas supply companies?
- Mine engineering firms?
- Global mining companies?

2. Objective: What Do we want them to do?
    - ARC Name / product awareness?
    - PSA Oxygen generator awareness?
    - Trial usage?
    - Incorporate ARC PSA units into the mine initial process design?
    - Convert from bulk Oxygen to PSA?
    - Convert from aeration to pure oxygen?
    - Begin using pure oxygen in a new processing manner?
    - Build the mine using a sea-container unit?
    - Use PSA oxygen for mine maintenance?
3. Benefit Focus: What do we promise them?
    - Reliable, uninterrupted supply?
    - Cost savings over using bulk oxygen?
    - Improved mine gold yield, throughput?
    - Decreased cyanide usage?
    - Improved margins to the gas supply company?
    - Custom made applications?
    - A competitive advantage =___________?
4. Reason Why: Why Should they believe us?
    - Australian gold-mine experience:
        - AirLiquide testimonial of savings, reliability, service, relationship, superior design, efficiency, association with strength of AirLiquide name, additional orders forthcoming?
        - Gold Mine testimonial of reliability, service, relationship, superior design, efficiency, association with strength of Gold mine name?
    - Sheer number of installations, time in market,
    - Research focus = superior, efficient design?
    - Competitive advantage
5. Tone / Attitude: How should we speak to them?
    - Seriously?
    - Tongue-in-cheek?
    - Dominant, commanding?
    - Ready and willing to please?

These factors should be determined, and then bought-off by the sales/marketing team to ensure cohesive focus. These factors will be given to the advertising people as a 'blueprint' for the desired ad. This helps specify what exactly is wanted from the advertising people, and keep them from straying from the desired effect upon following creative avenues. When formulating the copy strategy, it is best to note that conventional wisdom holds that the fewer the ideas that have to be transmitted to the desired ad viewer, the better the chances that they will 'take away' something from it. While education of the consumer is good, an ad can be confused by conflicting messages, or by information overload.

Once the advertising function has a copy proof of the ad, the sales/marketing team should review it, keeping in mind that the copy strategy has to be followed. However appealing the ad may appear, if it doesn't meet the copy strategy criteria, then it is not going to be effective in the way ARC intends. The following checklist should be asked of the group:

1. Is the copy on strategy?
    - If yes, proceed with the meeting
    - If no, send the advertising function to rework it, and have another meeting
    - If 'sort of', then discuss next steps
2. What is the headline idea (benefit summary)
3. Has the benefits been communicated (demonstrated)?
4. Has the benefit been re-enforced (redundant)?
5. What is the 'take-away'?
6. Is the ad attention getting?, is there a 'hook'?
7. Is there reader involvement (staying power, interest)?
8. Is it simple (can the idea be comprehended)?
9. Is there brand-name recognition (identity with ARC)
10. Is the message in 'sync' with the picture?

At this first copy review, it is best to resist the urge to excessively criticize the minor issues. It is best to get the 'concept' agreed upon, and then at that point the minor issues can be worked-out with a smaller group of people at a later date.

Effective Advertising venues include:

A) Randol

B) Northern Miner (Canadian focus, yet worldwide coverage)

Mining journal (out of Denver), basically a re-printing service for mining company press releases, is not recommended; the information contained within is diluted by sheer volume and frequency of the press releases, and as such the industry tends to throw it away without reading it

17. Customer Contact

Mining company headquarters may be scattered around the world, however there are concentrations of the major companies in a select few key spots. Certainly, with the industries push towards sharing risk, consolidation, and cross-pollination of equipment, development skills, and financial resources, most international mine sites will be at least co-developed by a mining or engineering company found within North America (exceptions to this might be Australia and South Africa, which have well-developed internal mining industries). The worldwide mining 'centers' are located within:

- Denver (and Colorado area)
- Vancouver (and surrounding area)
- Toronto
- Salt Lake City
- Melbourne, Australia
- Pretoria, South Africa

With Calgary and Houston being Oil & gas centers, then a Midwest 'loop' could be a convenient run for a sales associate wishing to contact mining companies, and engineering centers. Denver and Vancouver could be a productive week-long sales trip, arranging five-to-six visits in each city over five days. Certainly, with Arbor Research Corporation's initial conservation of sales resources, it makes sense to canvass the areas that provide the most mining contact 'bang-for-the-buck', as Denver and Vancouver do.

Of note, Golden Colorado (a suburb of Denver) is the home of the Colorado School of Mining. 'M' is the unofficial prime source of engineering talent within the industry, and the graduates working within the mine companies wear their 'M' class rings with pride. A) hiring an 'M' graduate could be an instant entry into the school's alumni list of contacts. B) ARC could / should endeavor to sponsor promoting the PSA usage within mining by:

- Sponsoring lectures, technical symposiums, papers, contests with students, journals etc.
- A joint venture with a professor, in which ARC could sponsor class materials or real-industry experience with students, (a valuable investment in student intern help, as an option to using MBA's)
- Donate a small oxygen generator to the school's chemistry lab, for use by the students in performing leach enhancement experiments

There is also an excellent mining school at University of Nevada, Reno, should the Colorado experience prove worthwhile.

18. **ARC Staff Development, Information sources**

It is important that the sales, and sales support staff be at least conversant regarding the mining industry. It should not be expected that all chemical processes, element types, and reagents be known, but it is possible for everyone to at least know the basic processes involved in gold and other mining operations. It is the knowledge of these steps that will help A) identify new opportunities within the industry for oxygen use, and B) assure that customer that ARC is firmly committed to serving the mining industry and solving its problems, and not just trying to sell machines to them. This report contains an honest attempt at summarizing basic mining processes. As information becomes available to update or enhance this summary, it is recommended that it be added to the report.

It is important to keep abreast of current mining technology developments. Have the staff regularly read articles relating to the mining industry. By this, I mean a wide cross section of articles, dealing with new processes, and those that may not necessarily directly affect the leach process. There seems to be a trend within ARC towards only reading articles in the gold forum and mining magazines that have the words Oxygen or PSA in the title. Many articles with titles such as "Advances in Cyanide leach technologies at the Zimbabwe mine may contain stories of successful oxygen use in cyanide leaching, or outline new methods employed for oxidation of sulfidic ores, some that involve the use of oxygen. Not only do these provide references for oxygen success, but potential sales leads as well, as many of these studies are still in the pilot-plant stages as they are written. Some suggested 'key-words' or topics to keep abreast of are:

- Treatment of sulfidic ores
- Bio-oxidation enhancements
- Cyanide / ammonia / leach advancements
- Tailings waste treatment
- Cyanide regeneration or treatment
- Modular mine processes

As the research has uncovered, there are also opportunities internationally for other types of mining, such as copper, uranium, etc. Therefore, these mining sources should be investigated as well.

In addition, articles relating to the mining industry should be regularly searched on some form of information retrieval service, such as Lexis-Nexis. If U of M interns are regularly employed, then they have free access to several of these sources. Of course The internet is a wealth of information, but the trick is knowing how to narrow the flood of that information. Some suggested excellent internet sites on mining are:

- http://www.imm.org.uk/
- http://www.igc.apc.org/mining/canada.hmtl
- http://researchmaa.com/comDanv/metal.hmtl
- http://www.northernminer.com
- Canadian Mining Industry:
  http://strategic.ic.gc.ca/sc_indps/sectors/engdoc/metl_hpg.hmtl

As part of this report's appendices, there is a binder with articles compiled and sorted regarding mining topics. While some of the articles are exceedingly dense and muddled with chemical equations and terms, the key points have been hi-lighted 'and the abstracts, introductions and conclusions usually give a good overview of the paper's aim It is recommended that this book be kept up with all applicable articles being added to it for easy, central reference for the staff.

19. **Product**

Offer a 'mining package' which delivers the maximum mass-flow of oxygen over a purity threshold, i.e. custom tailor the product to the mining company's needs.

Companies to target

A) Get Pure oxygen leach feed, ozone or oxygen cyanide treatment incorporated into an initial mine design

- Talk to the engineering companies such as:
    - Kilborn Engineering Ltd.(oil & gas as well?)
        - Kilborn is a member of the SNC-Lavalin group, which has wide-reaching mining/oil & gas/construction-industry ties
    - Fluor Daniel Wright Ltd. (oil & gas as well)
    - Bateman Engineering Inc. (Denver)
    - Dobey McKie
    - Bechtel (oil & gas as well)
    - Rescan Engineering Ltd.
    - Ledcor Industries (Reno, Vancouver, Mississauga)
- Refer to the Appendix binder for a list of primary and secondary engineering company contacts

B) Convert existing mines from using air-fed leach to oxygen-fed leach

- Talk to the mines or the mining companies themselves
- This eliminated the 'middlemen' gas companies

C) Convert existing mines already using pure-oxygen (bulk liquid) fed leaching methods over to using PSA for the following reasons;

- Mine operation consumable savings
- Reliability of supply reasons
- Need to interface with existing bulk backup supply

- Need to retain bulk for BIOX or chilled lance cooling reasons

- Talk to the existing gas supply companies, for the following reasons:
    - ready-made service arm
    - Gas companies have already embraced and realized the benefits of PSA
    - Need to choose a local gas company that needs PSA capability
    - Perform a direct-mailing to the mine managers that research has uncovered are currently using bulk oxygen, or are in need of it, or are having supply problems. Follow-up that mailing with personal contacts
    - Derive an industry-wide database of mine sites, process methods, contacts using the following sources:
        - SME directory List
        - Randol worldwide mining directory
        - Randol proprietary directory lists
        - Government regional mining information
        -

D) Supply oxygen to mines utilizing additional new uses of oxygen feed, such as pre-leaching oxidation, waste treatment, small-scale pressure oxidation

E) Supply oxygen for mine construction in remote areas or worldwide areas of high oxygen cost and/or short supply

General mining revelations:

- If you're going to sell equipment to the mining industry, whether it be to the mines directly, the mine company metallurgists, or the engineering companies, you'd better be knowledgeable about the industry, gold processing, metallurgical chemistry. Approach these people from a problems-solving applications standpoint. The last thing gold mining people want is another equipment maker trying to hawk its machines, unaware of their true needs, and trying to talk their way through the sale with 'double-talk'.
    - The mine engineers will definitely not suffer fools, the engineering companies perhaps more so
- A good book for Arbor Research Corporation's library would be: The Chemistry of Gold Extraction', 1992, Marsden & House, Ellis Horwood Publishers
- The mine development process is as follows:
    1. Exploration
    2. Samples: The mining company tests the samples to determine ore grades, probable treatment methods. In most cases, it is the ore characteristics that actually determine the final processing chosen, and not external factors such as available supplies, etc. At a cursory level, if an ore grade is high (oxide), then a mill/leach process is chosen. If an ore grade is low (refractory), then a heap-leach process is chosen.
    3. If the samples are positive, Geological Statistics are determined, which helps establish the economics of the mine, and the total mineable reserve of the property
    4. Feasibility Study: A joint effort between the mining company and the contracted engineering company. It is here where the two entities work together to create a process flow-sheet, decide the necessary capital costs, operating costs (and whether or not to use oxygen). A determination on whether or not the mine will be economically feasible at the current capital costs, gold-price is determined at this point.

5. Decision: A decision whether or not to proceed is made, financing is sought, and the final design is completed.

- The best source for mining information within Michigan will be Michigan Tech in Houghton
- South Africa, having developed the need during the apartheid area, has developed a basically self-sufficient mining technology base. Some large South African mining companies, such as Angle American, refuse to deal with American supply companies for what they feel was poor treatment during the embargo times
- Australians have largely self-developed their own gold-mining industry as well
- The US mining industry is perhaps the worst example of a target market, due to its abundant supply of bulk oxygen, excellent road system. This is only countered by its cheap and abundant electrical supply
- There is an opportunity to create a dual-product generator that produces both oxygen and nitrogen. Oxygen would be used for enhancing leach kinetics, and nitrogen used to enhance flotation kinetics. It is Newmont's opinion that the oxygen contained within air is a flotation killer, and as such using an inert gas such as nitrogen for flotation bubbling is superior. Nitrogen requirements may be in the order of 20-50 tpd of 99+% purity for a flotation circuit. Newmont is currently working on the nitrogen/flotation technology, and a paper by Gary Simmons will be published in the 97' Randol gold forum book regarding its application.
- Newmont is currently employing oxygen in several US gold operations, where they sparge oxygen into the leach circuit. This due to the ore which contains significant amounts of oxygen scavenging sulfides. Their Carlin, Nevada mine site has found that they need to add oxygen in order to maintain a 5-6 PPM oxygen dissolution rate. Carlin currently uses bulk oxygen, due to the easy supply route.
- Bio-Oxidation, it is generally believed, is so far an unproved technology with limited applications at present. There may be only 4 or 5 proven, successful BIOX applications worldwide at present. Although it has been proven successful in oxidizing refractory ores, it is seldom if ever economically viable. Its current problems include:
  - Difficulty in keeping the bacteria alive, due to not maintaining the correct pH balance, temperature, oxygen levels, toxicity concerns
  - Throughput restrictions due to tank-size limitations and relatively long retention rates
- There seems to be some debate within the industry whether or not sparging oxygen into a heap-leach, or heap BIOX process is viable.
  - On the negative side, it is argued that leach kinetics in a heap leach are less important than physical features, such as heap geometry, ore crush size, etc. Since heap retention rates may span into the years anyway, lowering these slightly with oxygen seems inefficient. Sparging oxygen into the center of a heap is difficult and costly, as well as being relatively ineffective. Super-saturating the cyanide solution with oxygen prior to dripping the leach will only see the solution equalize with the surrounding air anyway, rendering the oxygenation ineffective. Several companies have abandoned developing this process, and no large-scale mines are currently utilizing this on a commercial basis.
  - On the positive side, however, it is argued that through efficient placement of lances within the heap, oxygen can be efficiently distributed so as to improve the leach kinetics. There are several small companies working on this process, albeit admittedly the process if not yet commercially viable

- In some cases, even if refractory ore is oxidized using conventional methods such as pressure-oxidization (autoclave) or roasting, this reaction may create new oxygen scavenging sulfur species. This would require the use of oxygen in the leach circuit in spite of the pyrometallurgical pre-treatment oxidation. Both the Newmont Carlin, and Quarry, Nevada sites add oxygen into leach past the roasting process in order to decrease leach retention-time (which correspondingly increases leach throughput)
- Up until now, adding oxygen to a leach circuit in order to improve leach kinetics (such as to decrease throughput, or increase recovery-rate, etc.) has usually been a mine processing afterthought. Adding oxygen is rarely 'designed-in', due to:
    - Such reaction kinetics are difficult to predict, replicate and test in a lab-type situation,
    - It is difficult to get good design criteria
    - It simply costs more than without, and oftentimes the minimum is specified, knowing that it may be added later if needed
    - Changing ore types within a mine may require it later
    - Unless the oxygen benefit is very clear, it won't be specified, and it is generally somewhat unclear

There are currently no applications for 20 tpd or less within pressure oxidation autoclaves or roasters. Autoclaves may use up to 1200 tpd of oxygen, with even a 'small' facility using 225 tpd oxygen. Oxygen over-pressures range up to 460 psi. Canadian gold ores seldom use oxygen within the leach circuits due the basic rock source of the ores, they differ from those that may be found in, say the US, in that they hail mainly from the Canadian Shield which in most cases is not refractory, and requires just fine grinding to release the gold. This is however, a generalization though, and some select Canadian sites may still require oxygen. However, when you narrow the applicable band to only the remote areas, then the available market within Canada becomes much smaller. It is perhaps a better approach to concentrate Arbor Research Corporation's efforts on worldwide operation, fanning-out to all mine sites through the centralized approach of connections with mining companies and engineering companies The benefits of using oxygen in leach circuits is generally well known within mining company metallurgical labs, however, as stated before, it generally will not be specified in the early stages of a mine's feasibility design.
Oxygen requirement is very 'ore-specific', and cannot be assumed is necessary
Some pyrrotitic gold ores do exist in the Quebec / Yellowknife area, except that these are long-standing existing mine-sites that have readily available supplies of on-site cryogenically generated oxygen
Existing mines frequently want to increase process throughput, but without adding existing capital such as additional leach tanks. Adding oxygen into a leach circuit may decrease the necessary retention time required, thus increasing the throughput with existing tank volume. Increasing this leach kinetics by super-saturating the cyanide solution, even with moderate-to-good ore types, can decrease kinetics, decrease cyanide usage, increase gold recovery rates
Plants currently using cryogenic Air Separation Units to supply oxygen to the autoclave or roaster may still be potential oxygen targets. Usually, the pressure-oxidation step is the process bottleneck, and as such the cryo-plant output would be as fully capacitized as possible. If supply conditions were appropriate, then a PSA plant could then supply

the leach circuit. Newmonfs Santa Fe mine has a cryo plant / autoclave yet is currently considering adding oxygen to their leach circuit

- Current industry specialists in adding oxygen to leach circuits is Atomaer, though some mining companies feel that they charge too much for what is pretty basic (although patented) technology. Newmont has developed its own (admittedly inferior) technology and patented it, in order to circumvent using Atomaer's services.
- Although new gold discoveries are made every day, the world's supply of easy-to-process oxide-ore is running out. This leaves refractory ores, which, coupled with the low gold prices will require ever-more efficient mining and [processing methods to extract cost-efficiently. One could assume that the world's readily-available supply of oxide-ores will be gradually replaced with refractory ores over the next 20 years. This bodes well for oxygen use in hydrometallurgical processes, as an increase in ore sulfides will mean a corresponding increase in oxygen-scavenging ore types.
- Mr. Bohling feels that when trying to sell machines to mines using existing bulk oxygen, it is best to approach the mine superintendent / manager directly. Each mine site is semi-autonomous to corporate, and thus in the position to make day-to-day process decisions such as saving on expendable costs
- For mines currently in development, or those that will be in the future, it is best to establish contacts through a combination of the mining companies, and the engineering companies. As there are fewer engineering companies than there are mining companies, then by keeping a relationship with all the major companies, they will be the best conduit for access to each new mine project. Some of the major mining engineering companies include:
    - Kilborn Engineering Ltd.
    - Davey-Kavener
    - Bechtel
    - Fluor-Daniels
    - Ledcor
    - Rescan

As a large company, they must be able to show continuing earnings success to their shareholders, and as such they:

- Usually only take on large gold operations. Smaller projects may be sold outright or joint-ventured with smaller gold companies
- Are very conservative in their methods, slow to embrace new technologies
- Usually employ 'large mine' processing methods for their large mines, this meaning a proclivity towards autoclaves, roasting (pyrometallurgical oxidation methods) rather than heap or leach-only methods (hydrometallurgical).

20. Canadian Gold Mines

See **Appendix A** for a complete listing of current Canadian gold mines, their locations, capacity and ore processing method employed.

See **Appendix B** for a complete inventory of current Canadian mineral mines and their locations.

Market Segment: Oil & Gas

As with mining, there is a robust level of oil & gas activity within Canada However, in the interests of leveraging the maximum amount of market coverage with the fewest sales and marketing resources, it is more advantageous to treat oil & gas as an international endeavor. In this way, worldwide contacts can be forged from the concentration of oil operators and well-service companies located within North America, rather than just limiting the market size to those mines located within Canada.

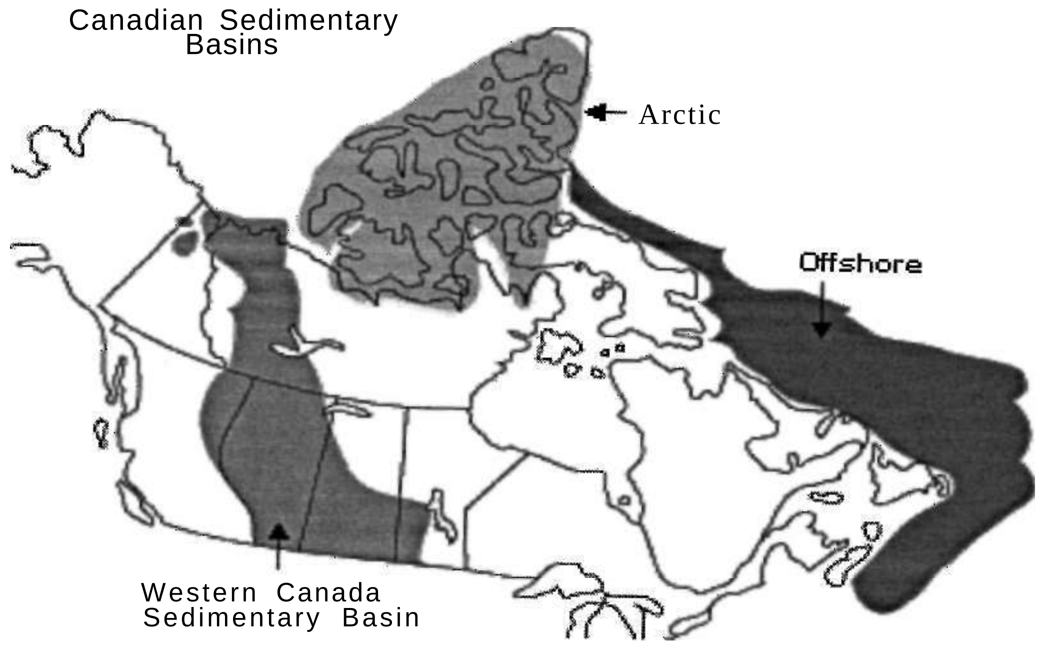


Figure 4: Oil & Gas Activity in Canada

Natural gas and crude activity in Canada today is concentrated primarily in the large Western Canada Sedimentary Basin (WCSB). This well defined basin extends from he province of British Columbia, eastward through the provinces of Alberta, Saskatchewan, and Manitoba, and includes portions of the Northwest and Yukon Territories. Covering approximately 580 thousand square miles, the WCSB reaches a depth of more than four miles near the Rocky Mountains.

Industry Trends

- PSA technology, benefits is not well known or understood within the Oil & Gas industry. traditionally, oxygen is viewed as a commodity that is and has always been supplied like any other consumable. To sell PSA to the industry will require a good deal of educational effort on the part of ARC as well. While this would normally be considered a marketing minus, there are potential benefits to ARC:
  - There is no lingering mistrust as fostered by previous ineffective systems
  - The oil & gas industry is quick to embrace new technology if it improves efficiency

- The industry is seriously embracing a steady cost-reduction track, and couching the PSA education within an aura of cost-savings will help A) get the foot in the door, B) frame a sales presentation such that oxygen generators are not just a commodity, but a serious cost-savings tool, C) give ARC a chance to display their technical prowess over the competition during this education
- Allow ARC a first-to-educate, first-mover advantage

- Oil & Gas Operating Companies (i.e. Total, Chevron, Mobil, etc.) are becoming more likely to put developments up for bid to service companies as total 'turn-key' projects. That is, a company such as Halliburton Energy Services or Brown & Root, would design, create a consortium structure, manage, contact other contractors, and in some cases, even operate a well. In this structure. The large oil & gas companies are trying to down-size, and become more efficient through outsourcing. The key service company might not control the minutia-elements of operating an oil well, such as procuring supplies, but they would contract the companies that would. Thus, reaching just a few key service companies would lead to the decision-making contacts for oxygen procurement (the 'trans-ocean' level of the process). These turnkey projects would be more likely to be employed in extremely remote or 'undeveloped' locations, in an effort to consolidate business control. For example, Halliburton's entry into this process is with the Terra Nova project (new industry to Canada's coast), and projects within China.
- Offshore wells will tend to produce greater oil volumes than those land-based, and as such the oil companies are beginning to increase their offshore activity as they try to consolidate their worldwide holdings. Although offshore rigs tend to be more capital intensive than those on land, they do carry with them advantages such as being 'insulated' from possible political upheaval of the host country, easier control over theft, and usually greater potential reserves.
- The oil & gas industry is capital-intensive averse
- Large oil & gas discovery fields are seldom developed by a single operating company. In order to share the risks, and pool the available huge capital needs for a project as large as an offshore drilling rig, many international oil companies will own a share of the program, and thus gain a corresponding share of the oil produced. The local government may gain a share as well, in order to 'kick-start' the development, provide funding guarantees, enhance local job creation, develop a service-industry, ensure the country a stable energy supply, and reap the tax revenues from the project's output. These 'development proponents' will often then appoint responsibility (or rotate responsibility amongst them) to one of local companies to manage a 'development alliance', which includes several key service companies that will have responsibility for the design outfitting and operation of the resultant drilling-rig
- There is a steady use for nitrogen of relatively high purity within the oil & gas industry. Used primarily as a foaming agent, nitrogen aids in fire fighting, foaming of cement, gas burn-off shielding gases, and pumping fluids. All offshore drilling rigs will have Nitrogen PSA generators on-board. Some land-based well-sites may have on-site nitrogen generators, some may have on-site capability, *and/or* buy liquid or gaseous nitrogen locally as well. The point is: there are opportunities, if technically possible, for the by-product of oxygen generators to be used elsewhere (this mirrors a similar trend in mining as well), thus making machine justification easier with increased savings. In addition, as Arbor Research Corporation's experience with the sea-tainer sale to Canadian Petroleum

. International has borne out, added nitrogen generators, sharing an PSA unit's air compressor to decrease total cost involved, could potentially create a niche advantage for Arc in meeting the customer's needs as best as possible. One of CPI's overseas well-sites used 400 'H' cylinders of nitrogen over a 12 month period strictly for fire-fighting purposes

Offshore

- *Safety, reliability,* and *delivery-performance* are generally placed above price and efficiency when units are being considered by the offshore oil companies. Certainly, the cost of a small PSA unit is dwarfed by the multi-million dollar equipment that is placed onto a platform, and as such the *service* aspects of a PSA sale would become very important. This being said, any PSA unit placed on a drilling platform, *absolutely, positively* must be fully long-term tested and operational (100% turn-key) before being installed. On-platform development, sieve changes, etc. would not be tolerated, and most likely give PSA an instant black-eye. This must be taken into consideration very seriously before specifications for an oil & gas-duty system are developed and published, as well as selling an as-yet unproved model. This concept cannot be stressed too seriously
- Newer, large state of the art seep-water offshore rigs, such as found in the North Sea or off the Newfoundland costs (Hibernia, the upcoming Terra Nova) usually have natural-gas powered electric generators, whereby some or all of the fuel is siphoned off of the well production. In some cases, the natural gas would otherwise have been a waste gas that is burned-off anyway. Under these conditions, electrical cost on the platforms could be almost considered as free. However, many older, smaller or shallow-water drilling-rigs still use diesel-powered generators, and thus their electricity costs would be significant to the cost-effectiveness of the PSA unit. This would have to evaluated on a case-by-case basis therefore
- All offshore rigs will have considerable on-board air compressor capacity, and in most cases, the compressor cost should not be factored into the total cost of the PSA system. If the unit is housed into a sea-tainer, the lack of a need for a compressor makes the PSA package much smaller and simpler, and potentially viable to fit into the smaller rig-standard sea containers (5'x6'x8', or 6'x6'x8')
- Many within the industry have indicated that they have a minimal need for oxygen on a drilling rig, whether for maintenance, medical or other purposes.

Eastern Canada Offshore Developments

21. General

- While the large projects such as Hibernia, Terra Nova and Sable Island are getting most of the attention in the region, there has been, and is considerable drilling activity occurring within the region, albeit somewhat closer to shore than the big projects. Due to the increased interest sparked as a result of the proven reserves within the Jeanne d'Arc Basin, oil & gas exploration is intensifying all around the Newfoundland / Nova Scotia shores.
- The east-coast of Canada individual drilling-platform projects, though magnificent in size and scope, offer only a few opportunities for topsides placements, stretched-out over many years. The real potential opportunity within this market is in supplying the local ancillary support-industry: the ship-building, topsides manufacturers and equipment

manufacturers. Additionally, a strategically-placed industry contact could open the way for supplying the more considerable North-sea and worldwide offshore drilling industry.

- While starting-off slowly, the east-coast Canada oil & gas industry will be a long-term affair, with a projected steady-stream of new developments for the area. While placing machines on drilling platform, an occurrence of only once every year or so, would not justify entering this market, the support of the general industry, as well as the potential of well-testing, might make this a worthwhile area to establish business ties within. Figure 5 outlines the expected development into the near future.

Current Projects	First-Oil	Project Life	Project Operator(s)
Hibernia	1997	19 Yrs.	Petro-Canada
Terra Nova	1999	15-18 Yrs.	Petro-Canada, Husky
Sable Island	2000	15 Yrs.	Shell, Mobil, Petro-Canada
Whiterose	2002	?	Husky
Hebron	2002 1/2	?	Mobil, Petro-Canada
Ben Nevis	2003	?	Husky, Petro-Canada
Future Projects			
Mara	2003+		Mobil, Petro-Canada
Fortune			Husky
Springdale			Esso, Husky
Trave			Husky
East Rankin			Petro-Canada
King's Cove			Petro-Canada
S.Tempest			Mobil
N. Dana			Mobil

Figure 5: Expected East Coast Canada drilling activity

- An Oilweek Magazine 'East Coast Offshore Map', located in the ARC reference binder under the oil & gas section is an excellent reference for drilling development within the eastern Canadian region

22. Bids Process

Doing business with the oil & gas business alliances that result from major-scale offshore projects, such as to be found with the Canadian projects, requires bidding for equipment placement. Each alliance delegates sections of the project, such as platform topsides, platform hull, FPSO hull, drilling services, etc., to individual companies, and then they are responsible for the coordination of the bids for their particular area. The process for the vendor company can be frustrating, time consuming, expensive, and daunting to say the least. Some large-scale bids require $millions in the bid-preparation alone. While projects such as Hibernia and Terra Nova have direct-contact bid procedures, the Sable Island Gas project *requires* that all bidding must be done through an on-line internet service. The bid and material codes are usually only available through that on-line coordinator, and their information and bids processing fee can range into the $100's of dollars.

For a start-up company with gaps in sales or product placements, the bids may reveal these inconsistencies as well. Questions such as ISO certification, past sales, placements, business alliances, servicing capabilities must be answered.

While the Hibemia and Sable Island projects are committed to being worldwide, best-value bid evaluators, the Terra Nova project claims that local content will play at least as large a role as price in evaluating the individual bids. In any event, it is important to be able to show local Newfoundland or Nova Scotia sales and service capabilities in order to be given serious consideration.

As the bids have deadlines, and are constantly popping-up for different project sections, it is necessary to keep a close-track of each individual project's bids processes. Some of the projects may offer one or two day seminars on navigating their bids process. The bids management service, as mentioned above, even though for a fee, may be of help in this arena.

After the bids process, a vendor can be placed on a 'preferred supplier' list, which gives them an advantage in securing ongoing or future projects that the project operator or alliance members are involved in.

23. **Offshore 'Solutions Providers'**

There are several companies that offer services esoterically described as '. *serving as a catalyst, bringing together a dependable local infrastructure and leading international companies to produce the best solutions for challenges in the energy sector.'* Essentially they act as sales and/or service agents, as well as 'deal-makers' between all the various' vendor organizations and the oil-project alliances departments. Each company may have a network of vendors that, when grouped-together into the organization, are able to handle the enormity of some of the oil-project jobs. One hull-maker may be able to use the large crane of another vendor, or an air compressor company may be able to also service the on-platform nitrogen generators that the solutions provider represents.

Three companies identified within this field at the 97 NOIA conference were:

- AMI Offshore Inc.
- MSL Industries
- Guptill Consulting Service

The largest, and seemingly most professional provider of the three was AMI Offshore. It is their policy to approach each particular company alliance differently, producing either a joint-venture, sales alliance, distributorship, loose alliance etc. where it best fit. In any event, AMI is reputed to have excellent industry connections, with not just the oil companies involved in eastern Canada, but in the North Sea platforms, with worldwide oil operators, oil & gas service providers (such as Halliburton), and even *mining* companies. Their specialty seems to be providing services to remote or hard-to-reach operators (such as offshore or remote mines), and are presently involved Newfoundland's Boisey Bay Nickel mining project as well. A company such as AMI would be able to offer ARC instant oil & gas industry knowledge and connections, sales support, 24 hour worldwide servicing capabilitv all for a price or cut that would need to be negotiated.

The Newfoundland government's *Department of Industry, Trade & Technology* offers a free 'business alliance' service as well, whereby they would try to connect ARC with an appropriate area distributor.

24. Hibernia

The Hibernia platform plays a defining role in the emergence of the oil & gas industry off of the east Coast of Canada. Already eighteen years in the development stages, the project has been started and stopped and delayed repeatedly due to questions over oil prices, funding, environmental concerns, and technical ability. Eventually, it was a strong push by the Newfoundland government, hoping to develop a new alternate local industry to fishing, that cleared the way for the project to proceed in 1990 with funding and regulatory approvals. The projects operating concern, Hibernia Management and Development Company (HMDC), is a consortium of partners consisting of (Figure 6: Hibernia Consortium Partners):

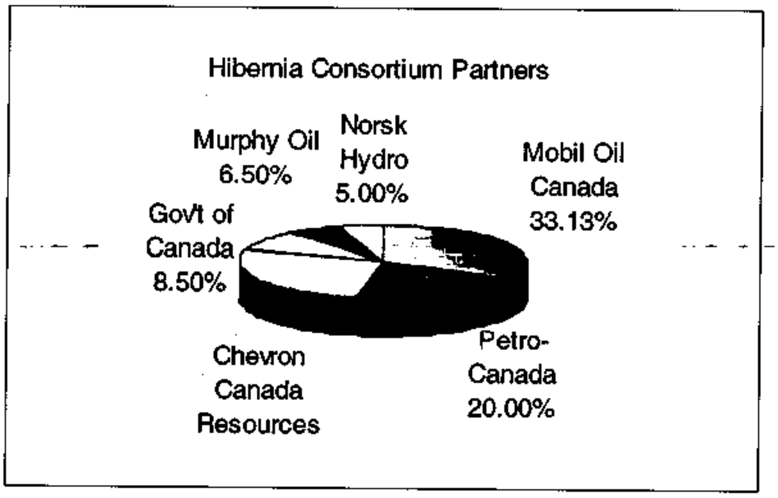


Figure 6: Hibernia Consortium Partners

HMDC (was)is responsible for the construction, management and operation of the Hibernia project.

The Hibernia field is situated offshore 315 Km east-southeast of St. John's, Newfoundland, at an average ocean depth of 80 metres. Recoverable petroleum reserves are estimate to be in excess of 615 million barrels, and located in two main reserves: The Avalon sandstones (2,400 M depth) and Hibernia sandstones (3,700 M depth). The overall expenditures of the project are estimated to be $CDN5.8 Billion, and operating expenses over the 19 year life of the project at $7.5 Billion.

The chief technical difficulty surrounding the Hibernia project was that it was to be located directly within what is known as 'iceberg alley'. The design chosen was a fixed columnar base of concrete which would store oil production within, yet be able to survive a direct collision with an iceberg on its outer jagged ring of concrete abutments. The base, once 'grouted' to conform to the ocean-floor, and filled with steel-shot, will be of fixed location for the life of the project. Platform support services will include tug-boats with the ability to 'lasso' iceberg upstream of the platform, and tow them sufficiently off-course so as to prevent a collision.

The Hibernia program involved the base being constructed at a specially-constructed shipbuilding site at Bull Arm, Trinity Bay, Newfoundland. The topsides were contracted into several modules with international shipbuilding companies, towed on-site, and then joined together before being joined with the base. The resulting support companies that developed to serve the Hibernia project has heavy support from the

Newfoundland government, and form a basis with which to support the ensuing further oil & gas development in the area.

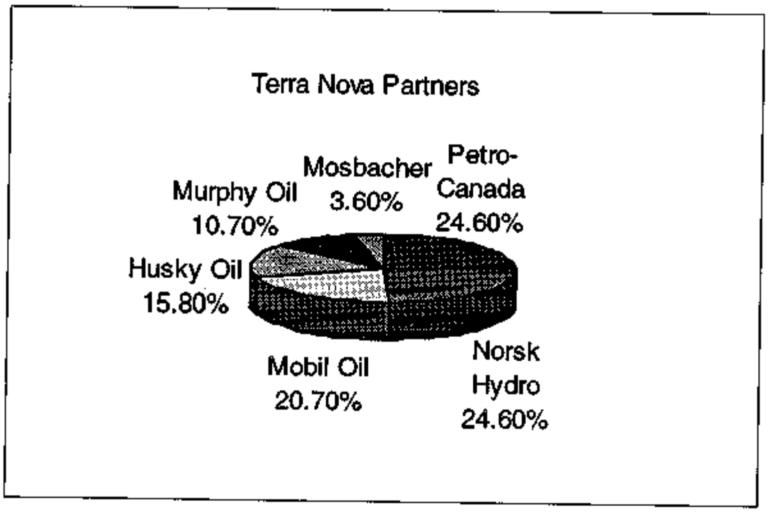
The Hibernia project, once finally approved, was brought-in on-schedule (a point of great pride to those who were previously predicted to fail by industry experts, being the largest single construction project in North America), and the alliance members consider their efforts and organization to be of world-leading offshore technology. The oil companies involved, as well as others following the Hibernia progress closely, consider Hibernia to be a showcase of leading-edge offshore technology and management systems, and hope to implement the most successful developments onto all subsequent projects.

The Hibernia drilling platform was towed into place in the spring of 1997, and expects to produce first-oil by the end of 1997. While the Hibernia project has to date been fully outfitted already, the consortium members of HMDC are still developing their preferred suppliers list, and representatives of the procurement division at the 97' NOIA conference indicated that they would still be open to machinery technology that could yield incremental improvements in operating costs and safety. A copy of the HMDC preferred suppliers application form is included in the ARC Appendix binder in the Oil & Gas section.

25. Terra Nova

The Terra Nova field is located 350 Km SW of the Hibernia field in the Jeanne d'Arc Basin region of the Grand Banks (off the east shore of St. John's Newfoundland). It is comprised of three fault-regions: the Graben, East Flank and Far East. Five delineation wells have been drilled so far, and they indicate an estimated field reserve of one billion barrels of oil, of which 300-400 million barrels is recoverable. The field is estimated to have a life of 15 to 18 years. Terra Nova is expected (at earliest) to begin first production in the end of 1999.

Petro-Canada is the 'operator' in the field. It shares the pre-development with its partners:



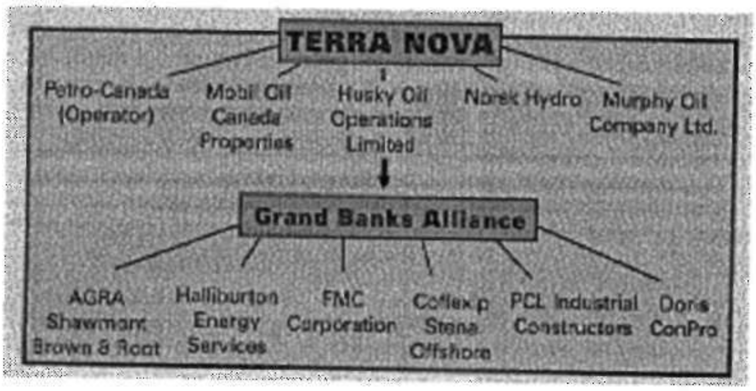


Figure 7: Terra Nova Partners

Project management will be accomplished through the Grand Banks Alliance (GBA). Petro-Canada has selected the alliance to execute engineering, procurement, construction, installation, commissioning, and possibly pre-development drilling activities up to the first production of first oil. The GBA members consist of

- SBR Offshore
- Doris Conpro
- PCL Industrial Constructors
- Coflexip Stena
- Halliburton Canada
- FMC Canada

The project partners and GBA member companies will establish a single alliance known as the Terra Nova Alliance. Each company in the alliance will participate on a risk and reward basis, with targets established to meet the functional, quality, safety, environmental, cost and schedule requirements. Therefore, like as with Hibernia, is in each partner's interests to achieve overall project efficiency through cost-reduction ideas (possibly with PSA oxygen), regardless of whether other suppliers may lose share (as with possibly gas companies supplying oxygen).

Halliburton Canada has the responsibility for securing topsides outfitting on the FPSO and drilling platform. Although Halliburton representatives at the 97' NOIA conference indicated that there would be no need for on-site oxygen on the FPSO, there still exists an opportunity of placement onto the drilling platform.

Unlike as with Hibernia, the Terra Nova alliance has indicate that there will definitely be a bias placed on accepting bids by companies with some presence or impact on the local Newfoundland / Nova Scotia economy. Therefore, while not a *necessity,* an alliance with a local Newfoundland company (such as AMI) is of great benefit in bid acceptance. There is a copy of Terra Nova *Procurement Contacts List, Equipment Requirements List, and Vendor Questionnaire* in the ARC appendix binder under the Oil & gas section. The questionnaire is somewhat detailed, and requires historical data on previous unit placements, and financial information. While 'oxygen generator' is not included in the equipment code list, it could be referenced as 'other', and a Halliburton procurement specialist would contact ARC for further product detail, and assign a specific code to oxygen generators. Please note that similar topsides equipment such as separators, air compressors and nitrogen generators come up for bids the 3rd Qtr, 1997.

Forty-four sub-sea wells are planned to deplete the Terra-Nova field. These will be drilled in clusters with a conventional drilling unit. Located in 'glory holes' (holes in the sea-floor where the well-head is placed to protect it from the scouring effect from icebergs), the well-heads will flow oil through flexible hoses and risers to the Steel Floating Production Storage and Off-loading (FPSO) vessel. The FPSO will be able to handle 150,000 barrels of oil per day, inject sea-water, and store up to 6 days worth of production, should heavy seas or icebergs threaten regular off-loading. This is a oil-tanker outfitted to act as a junction between the oil-lines and shuttle-tankers. It is permanently moored unless an iceberg threatens it, where it would unhook the lines and move to safety until the iceberg passes. The production contract for the Terra Nova FPSO has already been awarded to Bailey Sea (NFLD) Ltd. The individual wells will be drilled by a floating drilling-rig, although permanently moored in place. Thus the Terra Nova alliance has elected to use a mobile system of FPSO and floating platform drilling rig, which is less capital intensive, as well as technically difficult, than the Hibernia fixed-platform system.

26. Sable Island

The Sable Offshore Energy Project development plan includes six offshore natural gas fields in the vacinity of Sable Island (about 200 Km off the southeast Coast of Nova Scotia):

- Thebaud
- Venture
- North Triumph
- South Venture
- Glenelg
- Alma

It extends onshore to gas processing facilities in the Country Harbour Area and to liquids processing facilities in the Point Tupper area (see Figure 8: Sable Offshore Energy Project). The project will require the construction the construction of an onshore gas plant and liquids processing facility and a total of six offshore platforms. The six fields are anticipated to deliver a sales gas volume of 11.3 million M3/day to markets in Canada and the eastern United States.

The project involves the phased development of three Mobil-operated fields in the direct vicinity of Sable Island (Venture, South Venture and Thebaud) and three Shell operated fields to the south of Sable Island (North Triumph, Glenelg and Alma). Once the project passes the certification hurdle in November 1997, it can be expected to go on-line sometime in 1999-2000. Total capital expenditures are expected to top CDN$4 Billion.

The bids program is operated on online exclusively, and can be reached by accessing any of the three web-sites:

•http://www.bids@nf.sympatico.ca
•http://www.bids@istar.ca
•http://www.nbnet.nb.ca
•Toll-free information line: (800)397-0393

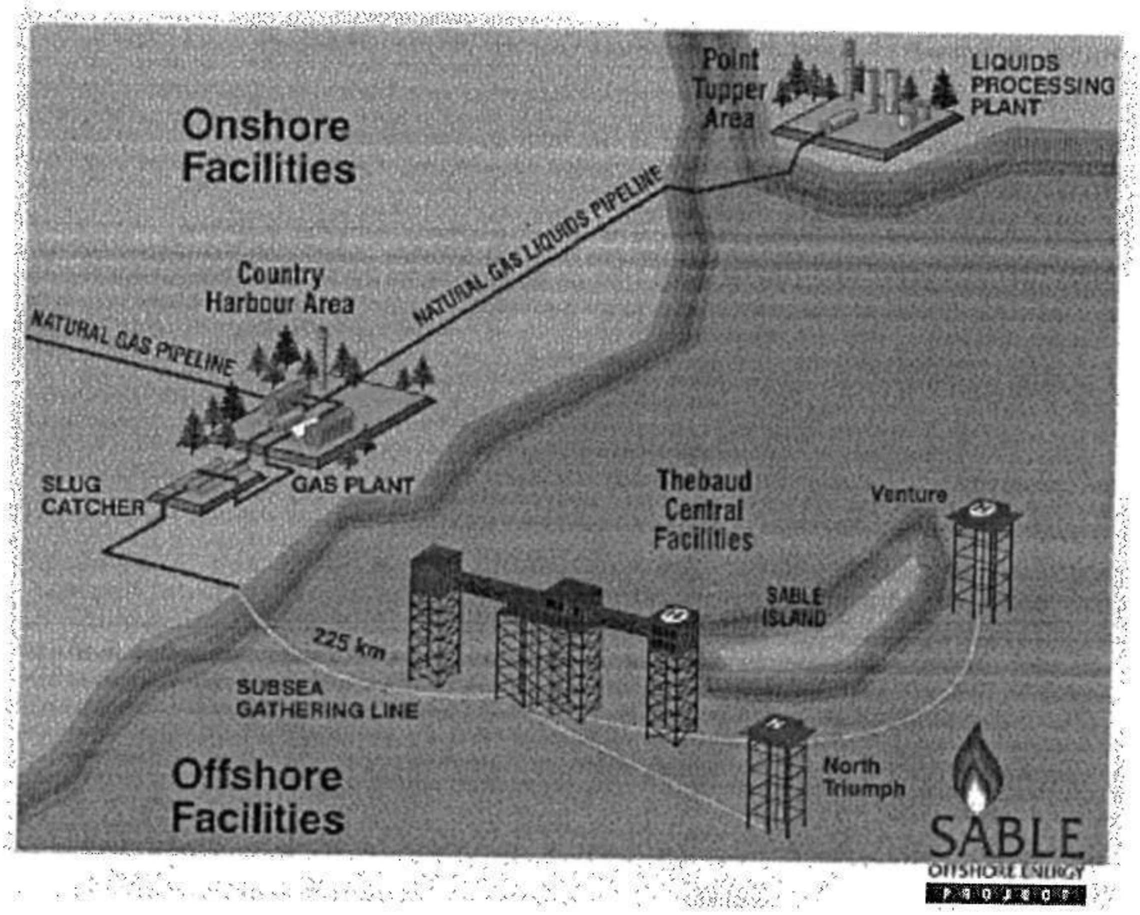


Figure 8: Sable Offshore Energy Project

27. Labrador Shelf

Smaller-scale oil-field exploration is being undertaken off the east-coast of the Labrador shoreline. The current discoveries are (Figure 9: Labrador Shelf Significant Development):

Figure 9: Labrador Shelf Significant Development

Significant Oil-Field Discovery	Oil Company Interest
Snorri	Petro-Canada
Hopedale	Husky
N. Bjarni	Petro-Canada
Bjarni	Petro-Canada
Gudrid	Petro-Canada

Although this field is currently not producing any oil or natural gas, there is significant interest in further development of the area, with large-operator support.

28. Western Newfoundland Coast

To date, the only significant discovery has been parcel 1021 owned by Hunt Overseas Operating Co. This region is characterized by small, local exploration companies and operators, performing exploratory drilling with modified mining equipment and makeshift offshore rigs.

Although currently not a 'hot-spot' of drilling activity, there seems to be a great deal of optimism within the industry for this area, characterized by the recent involvement of some major companies such as Mobil and Hunt.

The southern portion of this exploration area is currently reachable by a major highway, although several-hundred miles from the 'island's' only ASU located in St. John's. There is only a minor highway reaching the northwest coast of Newfoundland. The remoteness of these areas, as well as the eventual offshore activity makes this area a potential market as well for portable oxygen generator systems.

29. Nova Scotia

Other than Hibernia, the only well currently producing on Canada's East coast is the Cohasset operated by PanCanadian Petroleum.

30. Weil Testing

A potentially attractive market for oxygen production exists within the offshore practice of 'Drill-Stem' testing. Currently, oil wells of all types (offshore rigs or land-based) need to be tested for flow and pressure characteristics. The testing is done to enable verifying the reserve size, as required by many government for revenue monitoring purposes, or for internal company planning and justification purposes. The testing is performed in two stages: first during the exploration phase, but before full-scale production It is then performed again approximately six months to a year after first-oil production in order to confirm the initial results. The test may involve flowing the oil at maximum capacity for anywhere from six hours to six days, depending on local conditions and requirements Although against regulations in Canada, well-test burn-off is widely practiced elsewhere

During the pre-production well test, the infrastructure is usually not in place yet to capture the product that flows during the test, therefore the flowing oil or gas is burned-off instead. The oil or gas is usually released from a nozzle that is suspended from a boom extending as far away from the drilling-rig as possible. Some less developed countries dependent on oil & gas revenues and/or with lax environmental rules or enforcement may allow merely burning the oil straight, releasing the by-products of incomplete combustion into the atmosphere. However more developed countries require efficient burning therefore compressed-air is currently added to the oil-stream to gain greater efficiencies. It can be expected that, with time, the developing countries will move towards more environmentally enforcement as well. Although the burning of natural gas is less of an environmental concern than with oil, the two are usually contained within each oil-field, and thus must be taken together.

Presently, the oil companies are able to realize almost 99% burning efficiency usinq compressed air. A typical well-test flowing 7000 barrels of oil/day may require 1500 SCFM of compressed-air, requiring five or six large portable air-compressors feeding the stream These compressors are large (each the size of an 8' x 8' x 16' sea container), and must be stacked on top of each other (especially in the case of an offshore exploration drilling-rig where deck-space is at a premium). Since there is considerable capital investment in these compressors, as well as the cost of upkeep, they are moved from well-test-site to site in order to fully capacitize them. This requires the further logistical troubles and expense of moving and hooking-up the compressors at each test.

Currently, well-sites are limited due to reasons of size and logistics, to roughly 2000 SCFM air at 12,000 barrels per day at 99% efficiency. Any increase in the efficiency, flow-rate or decrease in air-flow required would correspondingly decrease the time and cost associated with the well-stem testing. (1500 SCFM would contain roughly the oxygen output of a 20 tpd PSA system)

During the post-production testing phase, depending on the collection-infrastructure involved, the test-oil may be bumed-off, but more likely though will be collected into a pipeline or tankers. The burn-off is also more likely to be employed for offshore units, as many land-based projects have existing pipelines to tap into.

The opportunity for oxygen exists in either maintaining or improving the burning efficiency, while reducing the air-compressor capacity required. There is no known current development into using oxygen for this purpose within the oil & gas industry. Therefore, the opportunity exists for ARC to carve out a niche in this area through effective oil-company relationships, and technical co-development towards this purpose.

An Industry source estimates that if an advantage to using oxygen is proved, then there is a market potential in the $100's of millions / year (400+ units/year @ $500k each). An easily portable unit(s) costing within the $250,000-$500,000 range could become an industry standard for well testing. It is common for the oil & gas industry to adopt new technology quickly once it has been proven in a few areas, in order to remain competitive. There is virtually an unlimited horizon to the market size, in that every well ever drilled worldwide must be tested, and most installations drill multiple wells during their lifetime, each needing testing. There is no foreseeable future to the curtailment of oil & gas exploration.

The technology for this must first be *developed,* therefore sales could not be expected to materialize for several years from the start of development. A logical first step would be to attract some industry champion(s) for the technology. *Mark Wilson, Senior Technical Specialist, Halliburton Energy Services, Calgary,* would be a good start. Although he is excited regarding the technology prospect, he does suggest contacting the 'Corporate office, well-testing technology' people in the Halliburton, Houston office. Halliburton is a world-leading oil & gas field services / engineering company, and co-developing the technology with them, or a company like them, could open up markets in the projects that they will have contracts for, or ARC/Halliburton could co-market the technology to other companies as well. As these units would be portable, and used on a number of exploration / well projects, then they could be most effectively marketed through an oil companies central services department, rather then having to visit each well-site.

A potentially valuable marketing angle to the oil & gas operators for the use of oxygen in burn-off would be following government regulations concerning well pollutant emissions, and posturing oxygen-enrichment technology as a necessity, as well as a cost-efficiency tool.

Land-based

31. Remote Canadian Exploration & Drilling

Currently, there is very little drilling activity on frontier lands within Canada. In the north, most wells are drilled in the winter time. In order to continue to hold an exploration license, a well must be drilled in the first four years. Therefore studying exploration licenses is usually a good indication of where the near-future drilling will occur.

The only land-based remote production currently underway is Norman Wells (Imperial Oil) Northwest Territories

- Kotaneelee / Pointed Mountain (AMOCO) Northwest Territories, near BC border

The best Canadian contacts for tracking Remote Canadian land-based drilling activity are:

- Alberta Energy and Utilities Board, Mr. K.G. Sharp
  640 5th Ave S.W.
  Calgary, Alberta
  T2P 3G4
  Phone: (403)297-8311
  Fax: (403)297-6917

- Doug McKenzie, Manager Energy technology and well licensing
  1810 Blanchard Street
  Victoria, B.C.
  V8V1X4
  Phone (604)952-0321
  Internet: http://www.ei.gov.bc.ca

There is an excellent Canadian Ministry of Indian Affairs & Northern Development website describing in detail (with maps) all sites either currently under exploration, or areas up for exploration bids in Northern Canada. Rather than merely restate it here, it can be accessed at: http://www.inac.gc.ca/oil/north/north.html.

In summary though, the areas of great interest are:

- **Norman Wells,** Northwest Territories and surrounding area (map at http://www.inac.gc.ca/oil/bulletin/graphics/map3_4a.gif)
- **Great Bear Basin Parcels,** Northwest Territories (map at http://www.inac.gc.ca/oil/bulletin/graphics/map3_4b.gif)
- **Central Mackenzie Valley,** Northwest Territories (map at http://www.inac.gc.ca/oil/bulletin/graphics/map3_4c.gif)
- **Beaufort Sea,** Yukon / Northwest Territories / Alaska, onshore and offshore, (map at http://www.inac.gc.ca/oil/bulletin/graphics/map4_1b.gif, and Figure 10)

All of these areas except some at Norman Wells are functionally unreachable by highway, and subject to serious weather-related supply disruptions no matter what mode of transportation is used.

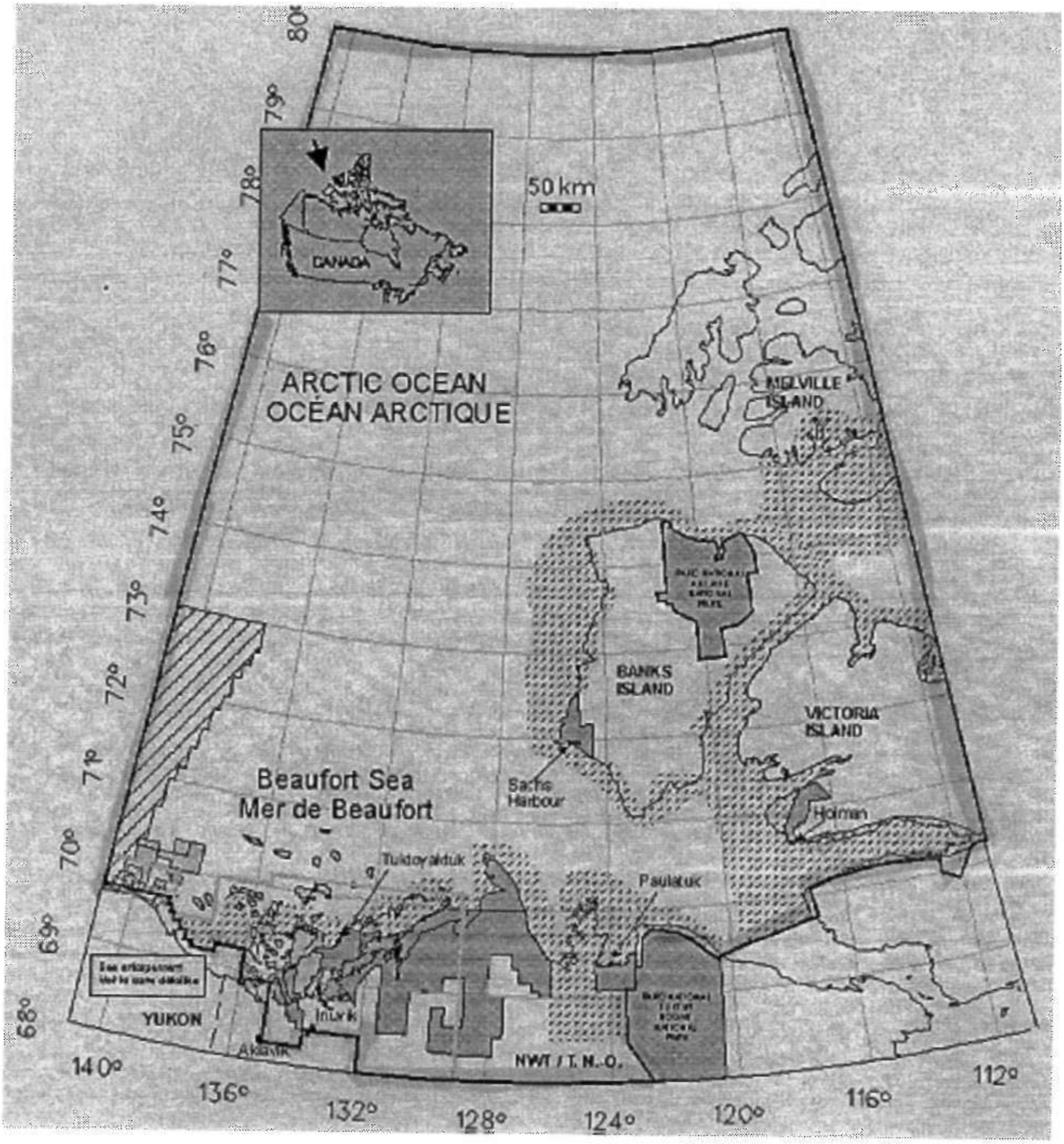


Figure 10: Beaufort Sea Oil & Gas Exploration

32. Sea-Tainer Units

Containing a PSA unit within a sea-tainer may have several advantages to both ARC and the customer, such as:

- Allowing a turn-key package that controls variables such as improper setup, damage during shipping and installation, improper protection from the elements etc.

- Allowing a sensible shipping solution, where everything is already firmly secured, and self-contained
- Negating the need for creating space within possibly already cramped maintenance buildings

However, the chief benefit that is usually touted: the ability to move at the end of the project, does not necessarily apply for land-based, international well-sites, for maintenance use. This is because usually, when a company drills in a foreign country, they have some sort of minority-control or joint-development agreement with the host country's government. Therefore, any of the operating equipment used within the site must *stay* within the host country. Therefore, if it remains cost-effective, a PSA installation could be installed within a well-complex's buildings or a shed.

Any piece of equipment used in the well-site's initial construction, however, imported for that purpose, could leave the country at the end of the job. Therefore, for a well-construction contractor, a sea-tainer concept would still be a viable idea.

- An industry source feels that perhaps the most promising 'remote' potential market within North America well-construction would be on the North slope of Alaska/Yukon/Northwest Territories, where a tremendous amount of drilling activity, in extremely difficult supply conditions, is being undertaken.
- The Norman Wells area (Northwest Territories, West of great Bear Lake) is an active drilling region which can only be supplied by ice-barge during a few months of the year
- Much like as with gold-mining, as the most of the 'easy' oil-fieids are already developed, oil exploration is beginning to move towards developing in 'difficult' areas, such as on mountainous terrain, or remote regions of the world, which are currently inaccessible by boat or on roads.
- Except for the Norman Wells region, new construction within Canada will be minimal, however worldwide, industry sources estimate perhaps 100 new 'remote' land-based' sites will be developed.
- EPC construction vendors would be able to take a portable sea-tainer generator with them from construction site-to-site
- Oftentimes in order to obtain qualification from the host country for developing a field, an oil operator must build road, bridge, port, pipeline infrastructure, waste & water treatment facilities, refining / processing plants, employee barracks, etc. These activities, in addition to the actual well-site and related structures, represent considerable steel-cutting potential in most likely remote or underdeveloped locations.
- The construction phase is oftentimes carried-out by a number of contractors known as 'Engineering Process Companies' (EPC's). Since most oil companies are attempting to down-size their development staffs, much of the design, construction, establishing of supply lines work involved in building oil-fields are managed or contracted-out by EPC's. They get the jobs through a bidding process administered by the oil companies. If such is the case, an oil company does not care what type / process by which supplies and specifically oxygen, is obtained. The EPC, however, may not care either, as it would be most likely their construction vendors that perform the actual cutting / welding operations on-site, and they would be responsible for their own consumables. There are therefore three potential processes by which PSA could be adopted into the construction process:
    1. ARC approach the known construction contracting companies, the names of which are possibly obtained through the EPC's

    Halliburton has suggested contacting their 'Integrated Solutions' (I.S.) group in Houston to investigate the best possible arrangement with them.

2. ARC approach the major EPC's, and suggest they supply themselves, or by arrangement with ARC, have 'some-company' supply oxygen to a construction site for all the vendors to employ. 'Some company' could be:
    - An ARC / distributor joint venture within the well-field region
    - An ARC division, poised to deliver and operate units worldwide, as controlled from their home location
    - A third-party contractor or company that will likely be on-site for the life of the construction-phase, and wants to limit their oxygen costs, as well as supplement their construction-work income with oxygen-sales
    - A third-party company, situated either within the well-site region, or near ARC, that wants to have a loose arrangement with ARC whereby they will purchase units and operate the supply business wholly separate from ARC
3. ARC ally with the EPC's in some way in which that the EPC's convince/require their construction contractors to utilize whenever economically attractive PSA oxygen, as a condition of winning a bid, and as an step towards cost-containment, a portion of at least, will be reduced from their current bid-price

While this sort of 'getting into the vendors shorts' approach is quite prevalent in the automotive industry, and catching on in other arenas in which companies wield considerable power over their vendors, it is not a 'happy', 'friendly' way to do business. Such an approach in a staunchly independent, conservative industry as oil & gas may completely backfire and have companies resenting having PSA 'pushed' on them. It might possibly be mentioned to an EPC, however should not be taken as the first approach

In any of these approaches, ARC could either sell-outright its machines, provide them on a lease, lease-to-own, or an annuity-stream, gas-sale basis. The oil & gas companies are trying to push the capitalization responsibility onto its vendors, and inevitable they will try to do the same to their own. In a capitalization-averse industry such as oil & gas, the latter-two attempts are recommended (though the outright purchase option should ' always be available).

- Some of the most prevalent EPC's include:
    - Brown & Root
    - McDermott (UK)
    - Mustang Engineering (Houston)
    - Quantel (Calgary)
    - Fluor Daniel
    - Colt Engineering
    - Halliburton Energy Services
    - Baker Hughes

  (Note that some of these Fluor Daniel and B&W also service the mining field)
- There is no 'central-bids registry' in which the worldwide oil-field development scene can be easily tracked. Contacts will have to be kept with each individual EPC, as well as constant reading of trade publications, internet surfing, etc., in order to know of upcoming well-construction / outfitting bids
- Oil companies are generally less 'forward' with information regarding present and future well-sites than with mining. This is partly due to the fact that they rarely need to solicit investor funding like the mines do. Therefore detailed, accurate information on the

worldwide oil & gas fields will be somewhat difficult to obtain. Some suggested information sources:

- Oil-field service companies
- Engineering
- Government regional information sources: (Keep in mind that local governments would prefer that the local businesses get the oxygen supply contracts, rather than an outside manufacturer.)
  - Production accounting of wells
  - Railroad commissions
  - Regulatory boards
  - Energy Utilities Boards (Canada, by Province)
- Trade publications
- Internet sites:
  - Canadian Oil & Gas Industry: http://strategis.ic.gc.ca/cgi-bin/dec/wwwfetch?/sgml/
  - Oil & Gas Journal: http://pennwell.com/ogj.html
  - Sable Island Development: http://www.soep.com
  - Oil & Gas in Canada's North: http://www.inac.gc.ca/oil/north/north.html
  - Alberta Oil & Gas: http://www.worldweb.com/
  - Discovery Place Oil & Gas on-line resource centre: http://www.discoveryplace.com/
- Direct oil-company contacts
- Internal contacts, banging on doors, etc.

- Industry sources have estimated the current world-wide ongoing well-field development market to be:
  - 25-30 major ($Billion+) projects
  - 55-60 minor ($0.5 - $1 billion) projects

- Assuming a $100,000-$150,000 price tag for a sea-tainer system, a 20% penetration of the total market over the next three year period, and 90 total projects over this period then short-term revenues from such a segment might equal $600k - $900k/year on average. An all-out direct-to-EPC sales effort might take one 1/2 sales-person (sales and market research), whose costs may be $30k/yr. total compensation + $9k benefits, etc. + 15 trips x ($3k each avg.) = $84,000 Thus the salesperson generates sales of, at best, 10.7 x expenses
- However, if one assumed a cross-over effect of 5 additional maintenance sales / year generated as a result of contacts within the EPC's, then this salesperson now generates $1.65m/year sales or 19.6 x expenses

33. Maintenance / Operation

ARBOR RESEARCH CORPORATION: OxyPure Generators — **Cylinder Filling Sea-Containers**

Days/year: 340 | Hours/day: 24 | SCF/cyl: 244

	'Value'	Cyl/day	Cyl/month	Cyl/year	SCF/Hour	SCF/Day	SCF/Month	SCF/Year	Nm3/Hour	Nm3/Day	Nm3/Month	Nm3/Year
Cyl/day	5.0		141.67	1700.00	50.83	1220.000	34.567	414.800	1.336	32.07	908.76	10905.09
Cyl/month	1.0	0.035		12.00	0.36	8.612	244	2.928	0.009	0.23	6.41	76.98
Cyl/year	200.0	0.588	16.67		5.98	143.529	4.067	48.800	0.157	3.77	106.91	1282.95
SCF/Hour	1.0	0.098	2.79	33.44		24.000	680	8.160	0.026	0.63	17.88	214.53
SCF/Day	1.0	0.004	0.12	1.39	0.04		28	340	0.001	0.03	0.74	8.94
SCF/Month	1.0	0.000	0.00	0.05	0.00	0.035		12	0.000	0.00	0.03	0.32
SCF/Year	1.0	0.000	0.00	0.00	0.00	0.003	0.08		0.000	0.00	0.00	0.03
Nm3/Hour	1.0	3.741	106.01	1272.07	38.04	912.695	25.865	310.384		24.00	680.00	8160.00
Nm3/Day	1.0	0.156	4.42	53.00	1.58	38.037	1.078	12.933	0.042		28.33	340.00
Nm3/Month	1.0	0.006	0.16	1.87	0.06	1.342	38	456	0.001	0.04		12.00
Nm3/Year	20000.0	9.170	259.82	3117.81	93.23	2237.467	63.395	760.746	2.451	58.82	1666.67	

Price discount (%):	10%
$1US exch rate:	0.72
Current O2 cost/Nm3:	$9.130
Operating days/year:	340
Operating hours/day:	24
Actual Annual O2 Req's (Nm3):	1,282
Capital Interest Rate (%):	8%
Capital Amort Span (yrs):	10
Annual O2 Cyl Rental Fee ($):	$5,000
Annual O2 Service Fee ($):	$0
Electricity cost ($/KWH):	$0.150

Cyl use Multiplier:	2	(rentals=12, in-house use=2)
StartUp cost (%):	4%	
Shipping & Taxes (%):	10%	
Cyl fill/handle annual labour ($):	$30,000	
Current Nitrogen Cost/Nm3:	$3.740	
Nitrogen Output Spec. (Nm3/hr):	1.8	
Nitrogen Capacity Factor	90%	
Actual Annual N2 Req's (Nm3):	0	
Annual N2 Cyl Rental Fee ($):	$0	
Annual N2 Service Fee ($):	$0	
Nitrogen Option Cost ($):	$0	
Nitrogen Generator Cost ($):	$0	
Nitrogen unit spare parts (%):	0%	
Nitrogen unit yearly maint labour ($):	$0	

SCF/cyl 244

	'Value'	$/SCF	$/Nm3	$/Cylinder	$/Liq.Gal	$/Liq.Liter
$/SCF	$0.240		$9.13	$58.56	$27.62	$7.30
$/Nm3	$1.000	$0.026		$8.41	$3.03	$0.80
$/Cylinder	$12.000	$0.049	$1.87		$5.66	$1.50
$/Liquid Gal	$1.000	$0.009	$0.33	$2.12		$0.26
$/Liquid Liter	$1.000	$0.033	$1.25	$8.03	$3.79	

Unit Weight:	15000	16000	17000	18000	20000	15000	15500	16000	16500	18000	20000	22
Price $US:	$43,800	$78,800	$91,825	$138,400	$161,300	$32,200	$50,150	$53,750	$58,300	$69,125	$111,275	$122,
	HP2C	HP6C	HP9C	HP14C	HP20C	HE3C	HE4C	HE6C	HE7C	HE14C	HE20C	HE2
	75	175	240	350	500	100	150	200	250	500	750	100
Days/Year Operating	340	340	340	340	340	340	340	340	340	340	340	34
Hours/Day Operating	24	24	24	24	24	24	24	24	24	24	24	24
Unit Output (Nm3/hr)	1.97	4.60	6.31	9.20	13.14	2.63	3.94	5.26	6.57	13.14	19.72	26.2
Duty Cycle	98%	98%	98%	98%	98%	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%	98.0
Oxygen Production (Nm3/month)	1,314	3,066	4,204	6,131	8,759	1,752	2,628	3,504	4,380	8,759	13,139	17,5
Yearly Oxygen Mch Capacity (SCF)	599,717	1,399,340	1,919,095	2,798,680	3,998,114	3,277	4,916	6,554	8,193	16,386	24,579	32,7
Yearly Oxygen Mch Capacity (Nm3)	15,767	36,789	50,453	73,577	105,110	21,022	31,533	42,044	52,555	105,110	157,666	210,2
Yearly Oxygen Capacity (244 SCF H'Cylinders)	2,458	5,735	7,865	11,470	16,386	3,277	4,916	6,554	8,193	16,386	24,579	32,7
Actual Hours running per year for O2	664	284	207	142	100	498	332	249	199	100	66	50
Capacity factor (from Hrs Left max per year)	8%	3%	2%	2%	1%	6%	4%	3%	2%	1%	1%	1%
Nitrogen Production (Nm3/month)	1,200											
Yearly Nitrogen Mch Capacity (SCF)	547,518											
Yearly Nitrogen Mch Capacity (Nm3)	14,394											
Yearly Nitrogen Capacity (244 SCF H'Cylinders)	2,244											
Actual Hours running per year for N2	0											
Capacity factor (from 8670 hrs max per year)	0%											
Hours/year left for oxygen Production	8,670											
Power Costs												
Electric $/KWH ($CDN)	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
KWH/Nm3 (either O2 or N2 machine)	4.57	4.22	3.07	3.73	2.61	3.43	2.37	3.69	2.95	2.61	2.12	1.59
Avg. Electric Cost/Nm3 Oxygen ($CDN)	$0.6862	$0.6326	$0.4612	$0.5592	$0.3914	$0.5147	$0.3549	$0.5535	$0.4428	$0.3915	$0.3179	$0.238
Annual Electric Cost - Arbor System ($CDN)	$455	$180	$96	$80	$39	$256	$118	$138	$88	$39	$21	$12
Maintenance & Other Costs												
Spare Parts/Year	$821	$1,478	$1,722	$2,595	$3,024	$604	$940	$1,008	$1,093	$1,296	$2,086	$2,296
Maintenance Labor/Year	$500	$500	$500	$500	$500	$501	$502	$503	$504	$505	$506	$507
Cylinder filling/handling labour/year	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000
Tot Annual Maint. & Other Costs - Arbor System	$31,321	$31,978	$32,222	$33,095	$33,524	$31,105	$31,442	$31,511	$31,597	$31,801	$32,592	$32,803
Annual Equip Amort.												
Arbor Unit Price ($CDN, includes discount)	$54,750	$98,500	$114,781	$173,000	$201,625	$40,250	$62,688	$67,188	$72,875	$86,406	$139,094	$153,06
Sea Container Option	$33,750	$37,500	$41,250	$43,750	$41,250	$33,750	$33,750	$37,500	$37,500	$41,250	$41,250	$41,250
Compressor	$9,014	$12,528	$16,729	$28,111	$28,111	$9,014	$9,014	$12,528	$16,729	$28,111	$28,111	$28,111
Nitrogen Unit Option	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Nitrogen Generator Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

Figure 11: Payback scenario for sea-tainer system, oxygen only

ARBOR RESEARCH CORPORATION : OxyPure Generators								Cylinder Filling Sea-Containers			
Days/year:	340	Hours/day: 24		SCF/cyl: 244							
	'Value'	Cyl/day	Cyl/month	Cyl/year	SCF/Hour	SCF/Day	SCF/Month	SCF/Year	Nm3/Hour	Nm3/Day	Nm3/Month	Nm3/Year
Cyl/day	5.0		141.67	1700.00	50.83	1220.000	34,567	414,800	1.336	32.07	908.78	10905.09
Cyl/month	1.0	0.035		12.00	0.36	8.612	244	2,928	0.009	0.23	6.41	76.98
Cyl/year	200.0	0.588	16.67		5.99	143.529	4,067	48,800	0.157	3.77	106.91	1282.95
SCF/Hour	1.0	0.098	2.79	33.44		24.000	680	8,160	0.026	0.63	17.88	214.53
SCF/Day	1.0	0.004	0.12	1.39	0.04		28	340	0.001	0.03	0.74	8.94
SCF/Month	1.0	0.000	0.00	0.05	0.00	0.035		12	0.000	0.00	0.03	0.32
SCF/Year	1.0	0.000	0.00	0.00	0.00	0.003	0.08		0.000	0.00	0.00	0.03
Nm3/Hour	1.0	3.741	106.01	1272.07	38.04	912.895	25,865	310,394		24.00	680.00	8160.00
Nm3/Day	1.0	0.156	4.42	53.00	1.58	38.037	1,078	12,933	0.042		28.33	340.00
Nm3/Month	1.0	0.006	0.16	1.87	0.06	1.342	38	456	0.001	0.04		12.00
Nm3/Year	20000.0	8.170	259.82	3117.81	93.23	2237.487	63,395	760,746	2.451	58.82	1666.67	

Price discount (%):	10%	Cyl use Multiplier:	2	(rentals=12, in-house use=2)
$1US exch rate:	0.72	Start-Up cost (%):	4%	
Current O2 cost/Nm3:	$9.130	Shipping & Taxes (%):	10%	
Operating days/year:	340	Cyl fill/handle annual labour ($):	$30,000	
Operating hours/day:	24			
Actual Annual O2 Req's (Nm3):	1,282			
Capital Interest Rate (%):	8%	Current Nitrogen Cost/Nm3:	$3.740	
Capital Amort Span (yrs):	10	Nitrogen Output Spec. (Nm3/hr):	1.8	
Annual O2 Cyl Rental Fee ($):	$5,000	Nitrogen Capacity Factor	90%	
Annual O2 Service Fee ($):	$0	Actual Annual N2 Req's (Nm3):	1000	
Electricity cost ($/KWH):	$0.150	Annual N2 Cyl Rental Fee ($):	$500	
		Annual N2 Service Fee ($):	$1,000	
		Nitrogen Option Cost ($):	$20,000	
		Nitrogen Generator Cost ($):	$12,000	
		Nitrogen unit spare parts (%):	3%	
		Nitrogen unit yearly maint labour ($):	$1,000	

SCF/cyl: 244

	'Value'	$/SCF	$/Nm3	$/Cylinder	$/Liq.Gal	$/Liq.Liter
$/SCF	$0.240		$9.13	$58.56	$27.62	$7.30
$/Nm3	$1.000	$0.026		$6.41	$3.03	$0.80
$/Cylinder	$12.000	$0.049	$1.87		$5.66	$1.50
$/Liquid Gal	$1.000	$0.009	$0.33	$2.12		$0.26
$/Liquid Liter	$1.000	$0.033	$1.25	$8.03	$3.79	

Unit Weights	15000	16000	17000	18000	20000	15000	15500	16000	16500	18000	20000	22000
Price $US:	$43,800	$78,800	$91,825	$138,400	$161,300	$32,200	$50,150	$53,750	$58,300	$69,125	$111,275	$122,450
-	HP2C	HP6C	HP9C	HP14C	HP20C	HE3C	HE4C	HE6C	HE7C	HE14C	HE20C	HE26C
	75	175	240	350	500	100	150	200	250	500	750	1000
Days/Year Operating	340	340	340	340	340	340	340	340	340	340	340	340
Hours/Day Operating	24	24	24	24	24	24	24	24	24	24	24	24
Unit Output (Nm3/hr)	1.97	4.60	6.31	9.20	13.14	2.63	3.94	5.26	6.57	13.14	19.72	26.29
Duty Cycle	98%	98%	98%	98%	98%	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%
Oxygen Production (Nm3/month)	1,314	3,066	4,204	6,131	8,759	1,752	2,628	3,504	4,380	8,759	13,139	17,518
Yearly Oxygen Mch Capacity (SCF)	599,717	1,399,340	1,919,095	2,798,680	3,998,114	3,277	4,916	6,554	8,193	16,386	24,579	32,771
Yearly Oxygen Mch Capacity (Nm3)	15,767	36,789	50,453	73,577	105,110	21,022	31,533	42,044	52,555	105,110	157,666	210,221
Yearly Oxygen Capacity (244 SCF H'Cylinders)	2,458	5,735	7,865	11,470	16,386	3,277	4,916	6,554	8,193	16,386	24,579	32,771
Actual Hours running per year for O2	664	284	207	142	100	498	332	249	199	100	66	50
Capacity factor (from Hrs Left/max per year)	8%	4%	3%	2%	1%	6%	4%	3%	2%	1%	1%	1%
Nitrogen Production (Nm3/month)	1,200											
Yearly Nitrogen Mch Capacity (SCF)	547,518											
Yearly Nitrogen Mch Capacity (Nm3)	14,394											
Yearly Nitrogen Capacity (244 SCF H'Cylinders)	2,244											
Actual Hours running per year for N2	630											
Capacity factor (from 8670 hrs max per year)	7%											
Hours/year left for oxygen Production	8,040											
Power Costs												
Electric $/KWH ($CDN)	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
KWH/Nm3 (either O2 or N2 machine)	4.57	4.22	3.07	3.73	2.61	3.43	2.37	3.69	2.95	2.61	2.12	1.59
Avg. Electric Cost/Nm3 Oxygen ($CDN)	$0.6862	$0.6326	$0.4612	$0.5592	$0.3914	$0.5147	$0.3549	$0.5535	$0.4428	$0.3915	$0.3179	$0.2384
Annual Electric Cost - Arbor System ($CDN)	$888	$578	$386	$432	$286	$580	$341	$486	$367	$286	$221	$162
Maintenance & Other Costs												
Spare Parts/Year	$1,121	$1,478	$1,722	$2,595	$3,024	$604	$940	$1,008	$1,093	$1,296	$2,086	$2,296
Maintenance Labor/Year	$1,500	$500	$500	$500	$500	$501	$502	$503	$504	$505	$506	$507
Cylinder filling/handling labour/year	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000
Tot Annual Maint. & Other Costs - Arbor System	$32,621	$31,978	$32,222	$33,095	$33,524	$31,105	$31,442	$31,511	$31,597	$31,801	$32,592	$32,803
Annual Equip Amort.												
Arbor Unit Price ($CDN, includes discount)	$54,750	$98,500	$114,781	$173,000	$201,625	$40,250	$62,688	$67,188	$72,875	$86,406	$139,094	$153,063
Sea Container Option	$33,750	$37,500	$41,250	$43,750	$41,250	$33,750	$33,750	$37,500	$37,500	$41,250	$41,250	$41,250
Compressor	$9,014	$12,528	$16,729	$28,111	$28,111	$9,014	$9,014	$12,528	$16,729	$28,111	$28,111	$28,111
Nitrogen Unit Option	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Nitrogen Generator Cost	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000

Figure 12: Payback scenario assuming nitrogen requirements as well

- While international construction contractors may import their construction consumables into the well-site's country, the host country prefers that the well source its operational consumables from local vendors. In many less-developed, international locations, oxygen is, as well as being expensive, oftentimes of very poor quality and/or short-supply. Tanks may be poorly maintained, the gas contained within of low purity, or the tank may be merely insufficiently filled. The time and effort to monitor the gas quality represents a real incentive for a well procurement manager to source a reliable oxygen source (the same would go for other gases, notably nitrogen). In this way, remote-remote markets may also be supplemented with 'less-developed' markets.
- (Obviously), a well-site within North America currently served by a reliable, cheap oxygen source would not be a good potential market for PSA. Thus, ARC should target areas of not only short supply/high prices, but poor quality as well.
- The most appropriate decision makers for adopting PSA oxygen for drilling well-site operational / maintenance purposes would be the site maintenance managers. However, as the trend towards EPC turnkey control increases, these companies could be approached centrally to adopt PSA at the appropriate sites within their umbrella of control
- Where turn-key EPC's are not employed for a well project, an EPC for well operation only , such as Halliburton or Schlumberger may be used. These 'service' companies perform intangible well services for the oil company, and would most likely be responsible for consumables procurement decisions.
- 95% purity is sufficient
- A land-based well site may go through two different oxygen usage patterns. During the first 2-3 years, building activity and well development will be higher. Once the site is fully prepared and drilling begins, usage will steady.
- A well-site does not stop at just one well drilled. After each hole is drilled to the proper depth, and the hole has been prepared, the well-head must be tapped into the pipeline, which involves cutting and welding of the pipe. This 'field expansion' operation is the main potential usage of oxygen on the site. Maintenance and medical uses are minimal as compared to this. A typical drilling cycle may consist of:
    - 11 days drilling
    - 4-5 days pick-up rig, move to new location, set-up at new location
    - 11 days drilling
    - 4-5 days pick-up……..etc.

A new well-head must be connected after each drilling cycle. Therefore there will be a steady demand for oxygen over the life of an oil-field, and that would usually last at least 5 years (certainly beyond the payback range for an onsite PSA machine). The trend in the industry is moving towards using nearly portable drill-rigs, which will decrease the moving/setup time, and thus increase the number of wells that can be drilled in a given period of time. This would increase the oxygen usage rate, yet decrease the total well-field life; this would bode well for ARC, given that PSA units used for maintenance/operational purposes would not be moved from site to site.

- The Yemen example well-site used 1700 oxygen cylinders (of unknown fill or purity) over a twelve-month post-development period, in which 20 new wells were drilled and general maintenance performed. Even if it was assumed that those cylinders were of 90% fill/purity quality, that is still 373,000 SCF/year, or the highly under-capacitized output of a HP2C or HE3C. While a complete ARC manufacturing cost analysis on any given unit is impossible at this point, it is generally accepted that:

- The smaller the unit, the smaller the margin by percentage of sales
- The margin, gained through the value-added portion of assembling the unit's components, can be increased as the *options* are added to the unit. Thus an HP cylinder-filling option is better than an HE without, a sea-tainer is better than without, an added nitrogen generator is better than without, etc. All these additions, of course, raise the payback time to the customer

- Assuming a $100,000-$150,000 price tag for a sea-tainer system, a 10% penetration of the total market over the next three year period, and 400 total sites, then short-term revenues from such a segment might equal $1.3m - $2m/year on average. An all-out direct-to-well-site sales effort might take one sales-person (sales and market research), whose costs may be $60,000/yr. total compensation + $18,000 benefits, etc. + 24 trips x ($4000 each avg.) = $161,000. Thus the salesman generates sales of, at best, 12.4 x expenses. While this is not great, it would provide a much-needed steady cash flow to a start-up company

34. Yemen / CPI Experience:

AT present, the ARC sea-tainer cylinder-filling system is in Yemen, awaiting installation & startup. As there is a five year maximum that Foreigners can stay within Yemen, there will be a turnover of well-process personnel over the next year. Yemen is used as something of a training-ground within the company. If the installation goes well, and production smooth, then these personnel can be expected to bring the 'PSA success' concept with them to their new international well-site assignments (CPI is active in Libya, Nigeria, Vietnam, Indonesia, Columbia, etc.). In this way, and as well managers talk to their other internationally-based friends, the benefits of PSA can be expected to spread by word-of-mouth. Obviously, it is vital that this first PSA installation be given high priority such that it go smoothly. In addition, getting quality videotape and/or pictures of the installation, the surrounding environment, and perhaps testimonials from site-personnel would be a good basis for a 'reference-account' video-tape that could open the door for 'remote-remote' installations in any industry, oil & gas & mining included.

ISO9000 Certification

Having ISO quality certification is becoming more of a necessity in any business, yet even more so within the international-intensive oil & gas industry. Several industry sources have indicated that although it is not an 'official' requirement on most projects for suppliers to have ISO certification, it is a huge asset on a bid submission to do so. Thus, ARC would still be a viable bid contender without having ISO, as long as the other PSA manufacturers did not either.

Eventually, they feel that some large alliances will require the certification from all suppliers, though this scenario would be many years off.

Some offshore alliance 'brokers', such as AMI, do have the ISO certification, and allying with them would allow at least an appearance of being under the ISO umbrella.

Some large alliance projects, such as the Hibernia project, are viewed as best-in-class undertakings, and as such quality certification is viewed as especially important.

However, the procurement departments that in order to be continuously improving, then new technologies, and as such start-up companies, will need to be embraced. Thus 'new', 'revolutionary' and advantageous technologies, will be accepted without ISO backing, so long as the promise of eventual attainment is there.

Market Segment: Medical

The Canadian medical system is currently undergoing some profound changes. Hospital down-sizings and consolidations are becoming the norm, however different Provinces are at different stages. The end result will be a greater push of patient services into home-based, quasi-private care that is loosely administered by the provincial Health Ministries. While this development may be favorable for the home concentrator market, it does diminish the chance for larger hospitals willing to make large capital investments

Home Concentrators:

- Total Canadian market size may equal 35,000 units turning-over every 5-8 years, or 4,400-5000 units per year. While home-use may increase, the government's willingness to pay will drop, thus affecting a corresponding drop in demand as well.
- Procedures for the placement of home concentrators differ from province-to-province:
  - **Ontario:** The placement of home concentrators has over the years moved from being the hospital's responsibility, to the Community Care Access Center (CCAC, a quasi-governmental brokerage house for home-care services and equipment), now directly to the Respiratory Therapy or oxygen supply houses. It is the physician's responsibility to test and determine whether a patient requires a home concentrator. Once that is determined, if the patient meets the Health Ministry oximetry test criteria, they can have respiratory services provided for by OH IP (Ontario Health Insurance Plan: Seniors Drug Eligibility Card.) free of charge. If the patient does not meet the test criteria, yet is deemed as palliative care, then they will also get the concentrator free for a three-month limit. If the patient is still living after three months, then payment will be re-evaluated. Anyone may enlist the services of an RT and acquire a home concentrator at their own cost (or private health insurance's cost), yet to use oxygen, which is deemed a drug, they must get a physician's prescription. It is the physician's responsibility to prescribe and refer home concentrator usage to a RT or oxygen supply house of their choice.
  The Ontario home concentrator vendor market is very competitive, with the following features:
  - Over 10 competitors in the market
  - Prices to the RT houses (actual sale, not list) range from CDN$1300-1400. Prices are negotiated, and less in other Provinces
  - Warranties range up to 7 years, with options for extended warranties, or variable warranties for certain components (e.g.: sieve lifetime, 3 years compressor). The larger RT service companies may stock parts and concentrator spares, and perform the easier maintenance themselves with their own maintenance departments
  - Purity ranging up to 96%
  - Flow rates of 5 l/min. standard, as high as 6 l/min.
  - Serious Competitors:
    - AirSep
    - CAIRE (Div. of Minnesota Valley Engineering, Burnsville, Minnesota)
    - Healthdyne
    - Puritan Bennet
    - Nidek is known-of, but they are not a serious competitor

- RT Companies evaluate concentrators on the following competitive traits:
    1. Price
    2. Warranty, durability, maintainability and simplicity
    3. Size / Weight (smaller is better)
    4. Capacity
- Machines have been known to last as long as 12 years with proper maintenance. Some companies write-off the machine financially at the end of the warranty period
- RT companies can be approached simply by calling purchasing managers or sending product information
- Other potential segment: nursing homes, estimated need for (1) concentrator for every (20) beds available. This market could possibly be best served not by POGS, but by on-site generators or sea-container portable generating cylinder-filling stations that service regional centers one day per week, or perhaps all of one health-carte companies' locations within a given region.
- Total market size for concentrators is currently 13,000 units, changing-over every roughly 5-8 years. This is down from 17,500 units in 1980
- As the government health-care cuts continue, and the oximetry test thresholds get more stringent, the government-paid market size is expected to shrink steadily, and thus the total market size will as well. It is believed that if faced with the prospect of having to pay for out-of-pocket, many people will do without instead. In addition, the allotted usage time is shrinking as well; the current average machine patient usage period is 6-8 months (usually commencing upon death)

Remote Hospital:

- Territory control has recently changed from Federal to provincial control
- Purchasing decisions are made within local boundaries, largely free of provincial control
- Decision-making unit starts in the purchasing or procurement departments, then must be passed before the hospital board.
- The centrally located hospital serves many smaller 'nursing stations' or clinics in more remote regions, sometimes covering vast areas
- The hospital typically supplies this areas oxygen needs to: nursing stations, clinics, ambulance services, medivacs, and source home concentrators for these locations as well
    - Fill 'D', 'M' or 'E' cylinders from larger cylinders
    - Some hospitals are allowed to sell the oxygen, some are not.
- Rimer Alco has upgraded smaller systems with larger cylinder filling stations to allow for a hospital to supply to the surrounding community
- Manitoba, Saskatchewan, Alberta and Yukon Territories currently blanketed with Vital Air / Rimer Alco systems
- Opportunities still exist in British Columbia, Ontario, Quebec and Newfoundland's Labrador, but there is some awareness of oxygen generators, and Rimer Alco and AirSep are answering quote requests
- Decision criteria:
    - Based on initial capital investment, variable pay-back periods
    - Assurance of reliable supply: northern supply routes subject to:
        - Poor work ethic
        - Inclimate weather
        - Infrequent supply rotations

- Seasonal availability: 2-4 months/year if by sea, 4-months/year if by winter-road
    - Having to overstock on cylinders, suffer inflated rental costs
- See the remote Canadian hospital location maps (by Province or Territory) in the appendix binder, and how they relate to local ASU locations.
- Due to the quick-pace of Canadian hospital down-sizings, consolidations, and budget cuts, hospital location and size information will quickly become outdated. If the remote hospital segment is to be pursued within Canada, it is recommended that an updated copy of the '*Canadian Hospital Directory*', Canadian Hospital Association be purchased. The price is approximately US$125.00, and can ordered by calling (613)238-8005

Long-Term Care Centers in Canada

Long-term care centers in Canada can be both accredited and not, and found in a number of venues such as hospitals, nursing & rehabilitation homes and residential centers. Both publicly-run, and private centers are available.

Oxygen could be implemented into long-term care centers through two likely scenarios: portable oxygen generator sales or leasing, or through cylinder filling stations (portable, serving a region's care-centers' needs, or permanent on-site).

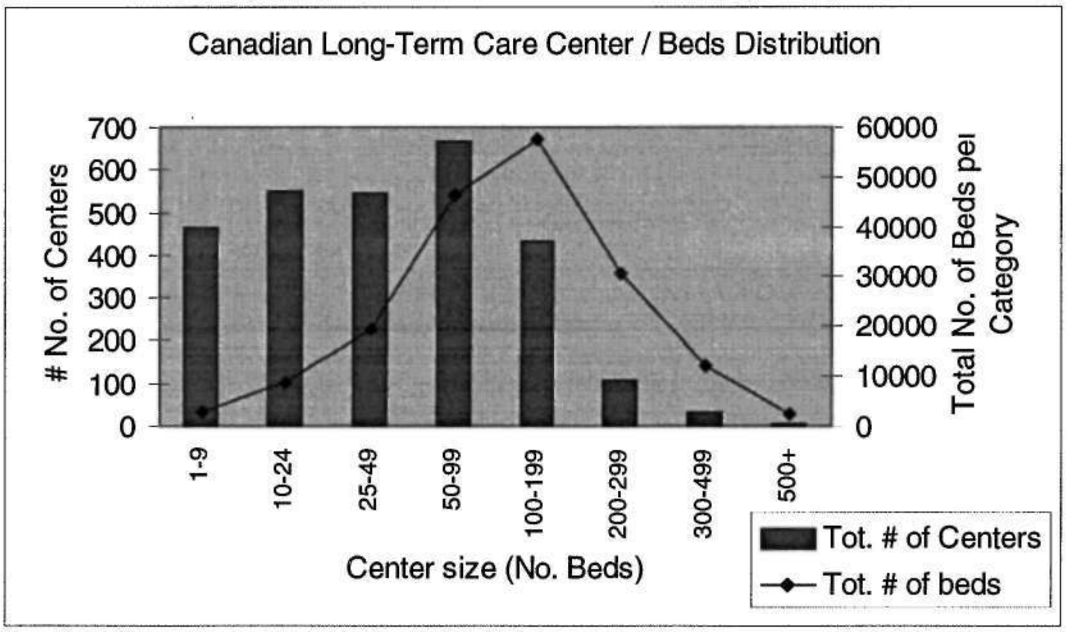


Figure 13: Long Term Care Center Size Distribution

There are approximately 3000 long-term care centers in Canada with 205,000 beds, indicating a potential patient-base needing oxygen of 10,250 persons.
If ARC were to yield a 10% share of this market, that would involve 1025 patients, or 300 centers. However, by analyzing the statistics, the centers are extremely fragmented in location, and the larger centers (those best served by the on-site placements) are usually

located within the well-populated urban centers that are correspondingly well-served by cryogenic oxygen (as well as having a strong respiratory-therapist network already in place). Previously, research uncovered an extremely tough competitive market in the POG segment for home health care, and thus not necessarily an attractive segment. Although long-term care centers do centralize these placements somewhat, again, the placements per center only become attractive in those that are larger, and already well served with oxygen.

This development leads to a focus on those centers that yield the most beds with the fewest (and thus correspondingly less fragmented) necessary center visits. By analyzing Figure 13, it can be seen that the 100-199 beds, 200-299 beds, and 300-399 beds categories correspondingly yield fewer centers. Targeting just the 200-399 beds centers would allow ARC to reach over 4000 patients, with visiting just 150 centers. At these size-levels, they are also less likely to be located directly within the large, urban areas.

The long-term care segment potentially yields, with a dedicated sales resource, 40 POG placements/year, or several on-site machine placements. Nevertheless, A category such as this does not stand alone, and should be considered as supplementary to any remote hospital ventures.

Market Segment: Industrial

- The level of oxygen delivery service in the industrially concentrated areas is efficient and reliable, and therefore the driving force towards an oxygen generator would have to be cost reduction.
- The primary driving force for making unnecessary capital investment in the industry is long-term cost reduction. The author's experience in industry is every large manufacturing location is driven towards cost reduction for two basic reasons:
  - Variable cost reduction improves the bottom line
  - Corporate office requires/demands that corporate-set cost reduction targets (under a variety of programs named CIP, CRT etc.) be met, and oftentimes tied to managerial bonuses. To this degree, even the appearance of cost reduction, whether actually realized or not, is very important such that the savings progress can be charted and displayed at the quarterly management reviews. This is a big game played between the plant engineers, purchasing managers, plant managers and corporate management, with budgeted capital outlays oftentimes spent on non-performing cost reduction projects so that it stays in next year's budget, and the CIP (Cost Improvement Program suggestion) can be added to the chart. This environment is favorable to a product such as Arbor Research Corporation's oxygen generator, (regardless of the fact that it *is* cost efficient), because definite cost figures, such as cost per sourced SCF 02 vs. cost to generate 02, can be quoted, and savings calculated based on that. This may be done without taking into account issues such as added labour, added burden, electricity costs, compressor capacity losses, cost of capital, etc. By doing this, the plant engineer can make the CIP look even better. Cost saving suggestions which gauge less quantifiable concepts such as reduced injuries, etc. (even though they may be very real and significant) are harder to write-up and get approved.

  Although basically a financially flawed method of gauging savings performance, simple payback is most often used to initially gauge a project's worthiness. Any project with a capital investment under 1-2% of the yearly capital expenditure budget, and a payback under one-year usually gets an easy approval. Under two or three years may need further review, but if the principle looks sound, and the company secure financially, it may get approved.
- Customized machine sales to professional industrial locations are not necessarily easy. There are very specific purchasing and technical specifications that need to be met, and engineers will invariably want to modify any 'standard' machines. In addition, once installed, these same engineers will want further revisions, and will not rest until it runs perfectly in *their own* opinion. Many visits and meetings will be required. Inevitably, there will be discussions as to how much extra work the machine vendor will need to perform gratis in order to satisfy the engineer. If friction results, a vendor can very quickly get a bad reputation because plant engineers have a well established information network.
- If there is a need for servicing, especially if the plant operation depends on the oxygen supply, servicing will need to be effective and *immediate*
- Plant engineers are traditionally *very, very* conservative. Many will not risk shutting down a plant's operations just to save on operating expenses. Keep in mind that these are the people who will have to actually make it work, regardless of how much the financial or purchasing departments may like an idea. In some applications, it may be best to

approach a plant with redundant, parallel, or incremental systems, rather than a one-time complete system.

- Many multi-location, multi-national industrial companies have 'Best-Methods' programs, whereby if one plant location discovers a way to reduce it costs, it is shared with the other plant managers at quarterly reviews. If management likes the concept, and the technology is transferable across the company, it may be budgeted for every applicable location. Therefore, good service, and satisfactory results in one location can lead to greater future sales within an organization.

Customer Cost Benefit Analysis

A customer cost-benefit analysis for the product range that Arbor Research Corporation offers was conducted, and under the following categories:

- **Appendix C:** HP System (99% oxygen purity) replacing bulk liquid
- **Appendix D:** HP System (99% oxygen purity) replacing cylinders
- **Appendix E:** HP System (99% oxygen purity) replacing cylinders (requiring a cylinder filling station)
- **Appendix F:** HE System (93+/- 2% oxygen purity) replacing bulk liquid
- **Appendix G:** HE System (93+/- 2% oxygen purity) replacing cylinders (requiring a cylinder filling station)
- **Appendix H:** HP System self-contained in a sea shipping container
- **Appendix I:** HE System self-contained in a sea shipping container

For each category, the following calculations were performed for each Arbor Research Corporation model:

- A simple payback calculation was performed (not taking into account the capital costs)
- A more complex payback was performed, taking into account the cost of capital and customary amortization periods for various industries. It is assumed that manufacturing locations will amortize over ten years, and mines or oil rigs over three-five years

- Please note that these calculation spreadsheets are for comparison purposes only (between particular model offerings), and may not accurately reflect actual operating costs depending on the actual operating environment parameters such as oxygen requirements, cost, electricity cost, etc. A different, detailed, spreadsheet has been developed for the express purpose of developing customer-specific paybacks and unit sizing

The categories were sorted in terms of best paybacks, based on under one-year, or under two-year payback periods, and the following conclusions were reached:

1. (Most obvious): The greater the prevailing oxygen price, the better the generating payback. In Canada, this means generally that the more remote the location, the higher the oxygen price, and the less the oxygen supply competition, and therefore the better the payback
2. (Also very obvious): The larger the customer's oxygen needs (and correspondingly larger capacity machine required), the shorter the payback

3. In all cases, HE systems replacing bulk systems (assuming the customer has compressor capacity) had the best paybacks, at any current oxygen price (with simple paybacks ranging from 6 to 24 months)
4. Next, HE Sea-Container systems, due to the high cost of oxygen in remote locations, were attractive (with paybacks ranging from 4 to 14 months). Although the larger units were included in the cost comparisons, it is unlikely that any customer would ever need greater than the 24-hour/day output of an HE/HE 2 or 3
5. Next, HP sea-Container Systems, again, due to the high cost of remote oxygen, (with simple paybacks ranging from 8 to 26 months)
6. Next, HE cylinder filling stations replacing cylinders, (with simple paybacks ranging from 32 to 12 months)
7. Next, piped HP systems replacing cylinders, (with simple paybacks ranging from 34 to 16 months)
8. HP cylinder filling stations, for non-remote industrial applications, replacing either bulk liquid or cylinders, were not economically feasible
9. The simple payback and complicated payback sorting mirrored each other, with the simple paybacks being shorter
10. HE3 capacity and below machines never attained under a one year payback
11. The payback is very dependent on the cylinder rental fee or service fee that a company is currently paying to the oxygen supply company. Generally, the smaller users have less bargaining power and subsequently pay greater oxygen prices and rental fees. However, some areas of Canada are so competitive that even the minor users pay little or no fees beyond the raw oxygen cost. This, in addition to the absolute variability of contract conditions from customer-to-customer, requires that before actual cost efficiency can be determined, customer paybacks must be evaluated on a case-by-case basis with all applicable variables taken into account
12. The exchange rate between the US and Canadian dollar, as well as the 'discount factor from list price' affect the cost effectiveness greatly. Of course, the weaker the Canadian dollar against the US dollar, the less attractive the systems look

Cost-efficiency inspection:

1. The companies requiring larger the machines should be targeted, because:
    - They look more attractive to the customer
    - They have better profit margins
    - They are better able to cover the higher costs-of-sale
    - Larger companies should already have plant compressors
2. Companies that don't require 99% purity oxygen are more feasible sales targets
3. Any company requiring enough 99% oxygen such that it is in the feasible payback range would have most likely have already converted to bulk liquid oxygen supply, thus making the payback greater than with cylinder use
4. In addition to a plant's bulk needs, many plants have maintenance departments or small work-benches that require the periodic use of portable oxygen cylinders for oxyacetylene cutting or brazing. The HE or HP cylinder filling stations that could supply both a plant's bulk and cylinder oxygen needs only become cost effective at very high usage (never for the HP, HE7 and above. This would suggest that:
    - Companies requiring high purity oxygen in cylinders are not appropriate

- Companies that require oxygen in bulk low-purity amounts, as well as in cylinders for only occasional oxyacetylene cutting, where the cutting quality is not paramount, are only appropriate in HE7 capacities and above.

5. Very large facilities that perform mainly MIG-welding will tend to use oxygen (2% oxygen of an oxy / argon shielding gas mix), where the relative purity is unimportant, however they would have to be an unbelievably large facility to require greater than an HE3 system.

Based on the above conclusions, the best industrial target companies are:

1. Large brazing or soldering manufacturers with requirements greater than an HE3
2. Any remote facility where the oxygen price is $0.10/SCF or greater:
   - If requiring a cylinder filing station: HP6C or HE3C or greater
   - If only requiring bulk delivery: HP2 or HE1 or greater[17]

   With remote manufacturing facilities, two basic trends may emerge: they will tend to be smaller companies, and the costs of sale to these remote locations will be higher. It is unlikely that anything greater than an HE3/HP2 could be sold to an individual company. Thus to compensate for the high sale cost / low machine margin combination, the machines should be sold at a lower discount. This is made possible by the higher oxygen prices still generating acceptable paybacks. Currently, the remote locations such as Yellowknife, NWT will tend to have only one or few oxygen suppliers.
3. Any steel-cutting company where cutting-quality is relatively unimportant, such as scrap-steel, structural-steel, facilities with only hand-torch cutting, and not automatic CNC cutting machines, muffler shops
4. Any steel-cutting company, such as ship-building (who also service oil & gas platform pontoon, etc. construction) where the total steel-cutting is so large that a generator can be justified.
5. Any location with supply difficulties where a sea-container system is appropriate whether HP or HE

Canadian Industrial Concentrations

Industry within Canada tends to be concentrated within the following basic areas:

- Vancouver
- Calgary / Edmonton
- Regina
- Winnipeg
- Windsor to Toronto / Golden Horseshoe
- Montreal to Quebec City
- Halifax / St. John / Moncton

[17] Depending on the choice of distribution/service method, these smaller machines may be uneconomical to sell in remote locations. The threshold to be determined pending distribution determination. However in remote locations, almost any size industrial user of more than the equivalent of 5 cylinders per day will realize savings benefits

Canadian Oxygen Pricing Terms Cross-section

**As of 6/97'	Cylinder Gaseous cost/SCF	Cylinder Liquid cost/SCF	Liquid bulk cost / SCF	Cylinder rental rate / month	Service fee	Common contract length	Electricity $/kW
Vancouver	$0.13	$0.04	$0.01	$5	no	1 - 3 - 5	$0.12
Calgary	.04	$0.03	$0.01	$1	no	5	$0.14
Edmonton	.04	$0.03	$0.01	$1	no	1-3	$0.14
Regina	.045	$0.025	$0.01	$1-$3	$300/mo. tot.	1 - 2	$0.12
Winnipeg	.05	$0.03	$0.01	$1-$3	365/mo. - bulk	5	$0.14
S-W Ontario	$0.05	$0.03	$0.005-0.01	6.7 - liquid	incl.	1	$0.13
Golden Horseshoe	$0.05	$0.025	$0.01	$0	no	1	$0.12
Montreal-QC	$0.05	$0.025	$0.01	$0 - $5	no	1 - 3 - 5	$0.12 - $0
St. John - Halifax - Moncton	$.05 - $.07	$0.02-$0.03	$0.015	$5	no	1 - 3 - 5	$0.08-$0

Figure 14: Canadian Regional Cryo-Oxygen Pricing & Terms

All these locations lie directly within a 200 mile radius around one or several cryogenic Air-Separation Unit intended wholly or partly for merchant use. Due to this fact, the oxygen prices within these industrial regions are very competitive. By inspection of the available data on regional oxygen prices, it would seem that southwestern Ontario / Golden Horseshoe offers the most promise for oxygen generators: the cylinder gas is the most expensive amongst the industrialized regions, and the contracts almost universally pegged at one year. The one year contracts are reflective of a variety of oxygen-supply / welding-supply houses within the area offering greater buyer bargaining power. This competitive situation makes it easier for a business to convert to generators, as the risk of alienating the only gas supplier in the region is diminished.

As with in most North American regions, the gas supply companies are also usually the welding / brazing supply houses to the industries. This raises the risk of a company receiving reduced service, increased suppliers cost should they cancel their oxygen orders from the same location. Again though, there are many choices for welding supplies, including exclusive package deals direct from any particular torch manufacturer.

A detailed accounting of the most applicable industries within these groups will have to be performed upon focusing on the industrial segments. Certainly though, if one assumed that roughly 40-50% of these companies were suitable for an oxygen generating product (based on preliminary surveys), and then there were at least as many additional smaller companies and those not included within these SIC codes, then there would be a sizable base of potential targets.

Applicable SIC Codes to target

Applicable SIC codes for the largest 20,000 companies within Canada:

Steel Cutting

SIC Code	Description	Number
SIC 1541	Industrial Building & Warehouses	185
SIC 1542	Nonresidential Construction	290
SIC 1622	Bridge, Tunnel and Elevated Highway	50
SIC 1629	Heavy Construction	85
SIC 3441	Fabricated Structural Metal	37
SIC 3443	Fabricated Plate Work (Boiler)	55
SIC 3446	Architectural Metalwork	20
SIC 3448	Prefabricated Metal Buildings	23
SIC 3499	Fabricated Metal Products	47
SIC 3523	Farm machinery and Equipment	40
SIC 3531	Construction Machinery	32
SIC 3533	Oil & Gas Field Machinery	40
SIC 5082	Construction and Mining Machinery	80
SIC 7539	Automotive Repair Shops (Muffler)	4 major
	Total	984

- Although great in numbers, the steel-cutting industry, because of its need for high-purity oxygen, is not as an appropriate target as for brazing, which has fewer potential targets. Note that none of these companies have fallen within the area as considered remote. The remote companies, however, because of their relative captive concentrations (concentrated amongst the larger communities), should be easy to identify.

Brazing / Soldering

SIC Code	Description	Number
SIC 3432	Plumbing fixture fittings and trim	11
SIC 3433	Heating equipment, except electric	21
SIC 3585	Refrigeration and heating equipment	3
SIC 3911	Jewelry Precious metal	21
SIC 3914	Silverware, Plated Ware	12
	Total	68

A great number of brazing companies use electric-furnace brazing (or some similar variation), where it is advantageous to have no oxygen within the process. This will diminish the available market considerably. Although these companies are considered the largest 20,000 in Canada, it should be noted that the majority tend to be within the 60-100 employee range. Preliminary surveys indicate that where the process is applicable, this 50-100 employee company size is near the threshold of oxygen usage for attractive paybacks, and machines above HE3 capacity. Approximately 32% of the companies are in the over one-hundred employees size-range.

Market Segment: Water

Aquaculture (Fish Farming):

The Aquaculture industry within Canada could be characterized by the following traits:

- Stronger In British Columbia and the east Coast than in the Central Provinces
- Entering a competitive phase in the product life cycle
- Fragmented structure, with few large-scale producers who are technically advanced, and many smaller, less sophisticated farms
- Uneducated as to the benefits and economics of technical innovation, and suffering from clearly defined sources of information and technical expertise
- Served by a disorganized and undefined distribution network
- Entering a shakedown period whereby the smaller producers will have to expand and increase technical innovation in order to compete effectively with the larger producers (such as ShurGain[18]) moving in
- Industry growth rates are in the 10-15% range, and expected to grow steadilv throuqh the year 2000
- Strongly encouraged by the Canadian federal Government.
- There are two major classes of hatcheries:
    - Provincial (government-run) hatcheries are for mainly re-stocking programs. For fish produced for the purpose of stocking lakes and streams, it is commonly believed that raising fingerlings under low density conditions increases the fishes' chances of survival in the wilds. Thus, the high-density benefits of using oxygen are not necessarily desired.
    - Private hatcheries for either commercial consumption fingerling production, or for private-pond re-stocking
- Currently, Canadian aquaculture is a $300 million industry, projected to grow to $680 million by the year 2000. This represents roughly 17% of the commercial fisheries sector of the economy. With the increased over-fishing and moratoriums on fishing on both the east and west coasts, Canada is looking to Aquaculture as a means of sustaining the important Canadian fishing Industry. It should be noted, however, that although the 'talk' of government support is high, very little useful help has been so far noticed.
- The Canadian Aquaculture Supplies and Services industry is currently at $270 million, and projected to increase to $560 million by the year 2000
- Experiencing friction from environmental activists mostly in BC, but may eventually spread to other Provinces as well

- Oxygen use in Fish production is:
    - Estimated to be roughly 15-20% penetration
    - Not as universally adopted due the abundance of trout and salmon production (cold-water fish)
    - In spite of the Canada's abundance of freshwater lakes ands streams, it appears that the major fish farming operations are located within relative population concentration areas, and thus utilize pumped well water to a certain degree. This

ShurGain is a worldwide food producer, primarily a grain distributor, who is looking to vertically integrate its operations from feed-to-fish production, among other segments opens up the need for re-circulation systems to control costs, and oxygenation of the potentially oxygen-poor underground water.

- Oxygen Generator Use is:
  - Economical in all areas, regardless of local price, due to their continuos operation and compatibility with low-purity oxygen
  - Suffering from lack of education as to its benefits
  - Largely dominated by AirSep and OnSite products
  - Regardless of the type of fish produced (cold water vs. warm), or system used (closed vs. pass-through), hatcheries still have a need for oxygen production due to the fact that they will always need to control the water conditions and fluctuations closely for the less durable fingerlings. Ozone generators are used to purify hatchery water (another source Of the need for oxygen generators), and oxygen generators can be used for the largely indoor hatchery applications.

In all cases there is a use for oxygen in the transport from the hatcheries to the farms, however this is an impractical application for generators for the following reasons:

- The air feed requirements are unable to be met with the power output of the trucks
- The short seasonal use of these trucks prohibits any large capital investments

There is some development into transport oxygen generators, although they are currently not completely developed. It is hoped that the increased consumer desire for fresh seafood, coupled with the consistency of aquaculture production and increased use of live fish tanks in restaurants and grocery stores will develop the transport industry such to the point that the trucks can be utilized year-round.

- Due to the relative lack of education and expertise within the aquaculture industry, and due to the need for a farmer to marry an oxygen generator with supplemental equipment such as diffusers, compressors, ozone generators, etc., the existence of consultants and full-service distributors is important to driving adoption of these higher-technology farming techniques. Aquatic Eco-Systems, Inc., the undisputed leader in aquaculture supply and distribution, also offers education classes and constancy services, As well, their rather complete catalogue offers short educational tips within each product section. This catalogue offers mainly AirSep products within its catalogue. Another major east Coast distributor, Valox, out of Fredericton, NB, carries OnSite generators, as well as being the Canadian distributor for Aquatic Eco-Systems' products.

  The proper distribution of oxygen generators to the aquaculture must have as well a service element attached to it, that offers 24-hour, fast response service. If problems arise with these systems, the lives of fish are at stake, and farmers will not accept slow turnaround. The Vaiox distributor praises OnSite's 24-hour service response time.

  - One novel method that Valox uses to overcome user mistrust and lack of education: they place a machine in a portion of the farm's operation, keeping any oxygen backup system intact. The machine is not sold to the user; instead the oxygen produced is sold to the user at a price somewhere between the delivered rate and the actual cost of operation. These payments are attributed towards the purchase, something similar to a rent-to-own situation. This way, the distributor sells places and eventually sells a machine, makes a profit on the oxygen sold, and the farmer gets to see the benefits of cheaper oxygen production at no risk to themselves.

35. British Columbia:

The British Columbia Aquaculture industry is currently under great pressure from the environmentalist movement, due to pollution and political concerns. A coalition of the Native Indigenous Tribes, environmentalists, and ocean fishermen have mounted considerable governmental support against the industry. There has been a moratorium on any new hatchery sites being added to the province, so it is possible that the existing producers may want to expand their existing facilities with higher yield systems, or add non-polluting re-circulation systems. The trend of the BC industry is for the fish farms to becoming more vertically integrated, which out of the (18) existing farms, may spell some additional systems being created.

- Currently, there are (4) or (5) oxygen generator being used by the hatcheries. They were all distributed by Point Four Systems, of Vancouver, and are AirSep 160 / 450's. AirSep was originally chosen due to their aggressive advertising, and Point Four approached them to be their east coast distributor. It was the Point-Four Rep's opinion that due to the environmental regulation, the Oxygen generating market in BC is currently stagnant to shrinking.
- Current economics make oxygen generators very cost efficient as compared to delivered oxygen.
- 98% of British Columbia's Aquaculture Industry is devoted to Ocean farmed Salmon
- The other 2% is devoted to fragmented, small trout farms for sport fishing purposes
- There are a total of (7) hatcheries within the province to support the (mainly) salmon industry:
- (3) are Commercial ventures
- (4) are provincial Fisheries and Oceans Facilities used for stocking lakes and streams

All hatcheries utilize free-flowing, aerated ponds. Ozone generators are used to purify some of the hatchery feed water, but all are atmospheric air-fed.

36. Alberta:

The Alberta aquaculture industry is small, with the following characteristics:

- Roughly (12) small indoor commercial ventures use groundwater feed and produce mostly trout for stocking small farm ponds and streams
- These locations are spread widely across the province
- There are (4) provincial ministry hatcheries located in Briarmore, Calgary, Cold Lake, Caroline (Rocky Mountain House) that produce 4 million trout fingerlings per year for use in stocking lakes and streams for sport-fishing purposes
- These all use aeration towers, with high freshwater flows
- Due to the cost of year-round heating and electricity, the water (groundwater at 4 degrees Celsius) is kept relatively cold
- Nobody is currently using oxygen, or oxygen generators

37. Saskatchewan:

Saskatchewan's commercial aquaculture industry centers mainly on providing fingerlings for use in stocking small ponds with rainbow trout for roughly 2500 individual locations. Most of these are homeowners or farmers that stock their ponds as a hobby. Since these ponds will freeze-over during the wintertime, and usually result in a winter-kill due to oxygen depletion under the ice. Some farmers will rig up a home made aeration device, usually powered by a windmill, with varying results.

- The province has (5) indoor commercial fish hatcheries, all geared towards producing trout for pond stocking. They utilize well-water aerated systems, averaging 10-15 tanks each. They are relegated in location to the lower-half of the province. Due to competitive situations, these hatcheries have no plans to expand.
- There is one large provincial hatchery, producing 700,000 trout fingerlings, and 50 million walleye eggs per year. It uses a single-pass well-water system.
- In addition, there are (5) Fingerling brokers, who pre-sell fingerlings to their clientele, and source them from lower-cost large-hatchery American sources. These brokers require oxygen to oxygenate the bags of water the fingerlings are delivered to their locations in, usually squirted into the bag from a cylinder. Most of these brokers are temporary endeavors, sometimes operating only a few weeks out of the year. Thus, capital investment is not an option for them. The presence of these brokers makes business very competitive for the local hatcheries.
- There are two culture-cage operations in lakes

38. Manitoba:

Manitoba has a large commercial fishing industry from it fresh-water lakes that rivals that of the great-lakes, and therefore provincial support of the aquaculture is somewhat diminished.

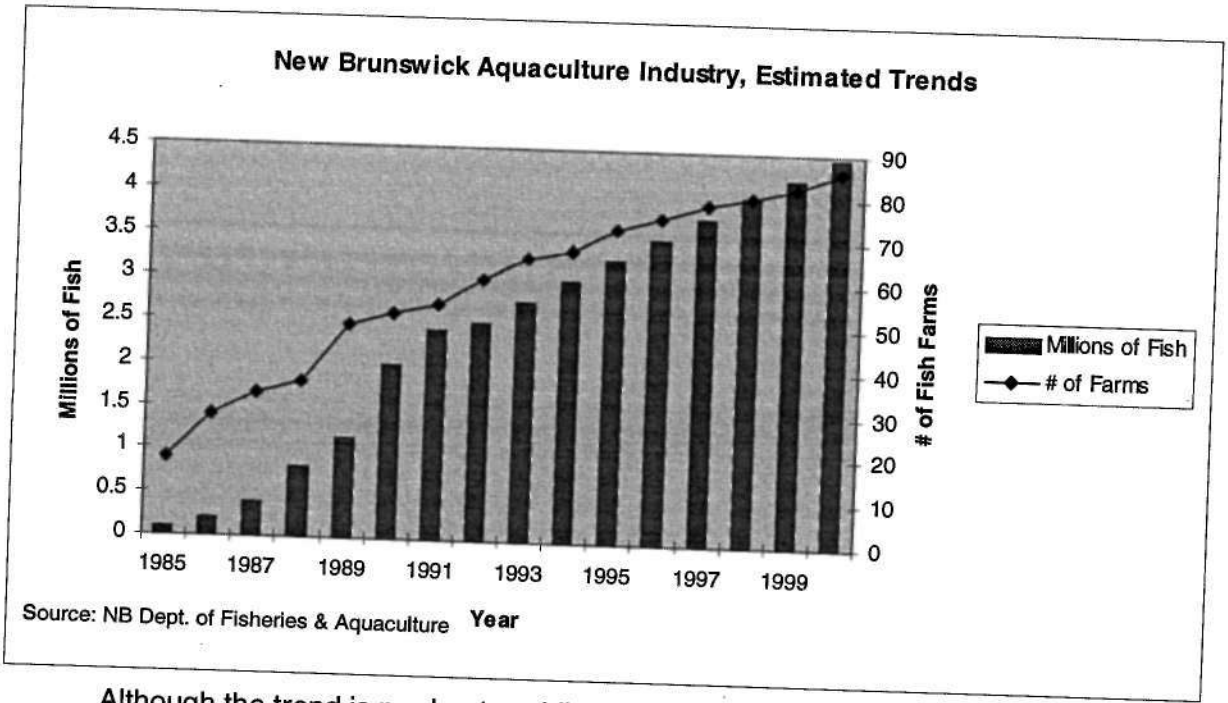
- There are (2) provincial hatcheries
- there are (2) private hatcheries, producing rainbow trout for mostly hobby farmers. What commercial food production is done, used to be in rainbow trout, but due to the low price demanded for trout ($1-2/lb), some arctic char has been produced as well.

39. Ontario:

Although the majority are located in relatively rural locations, all are certainty within easy driving-range of regular oxygen supply and as such not considered a first-strike segment location.

40. New Brunswick:

Figure 15: Projected New Brunswick Fish Farm Growth



Although the trend is moderate, while the fish volumes increase, the total number of fish-farms is expected to decline, indicating that farms are growing larger, more productive and thus more professionally operated. As the level of technical proficiency increases throughout the industry, pure oxygen will be increasingly adopted in order to boost fish-yields.

41. Nova Scotia:

In opposition to conventional theory held by the western hatchery operators, the Nova Scotia hatcheries use oxygen generators to optimize hatchery yields, believing that it does not affect the survival rate of the fish in the wilds.

42. Prince Edward Island:

Prince Edward Island's Aquaculture industry is small, and concentrated mainly in shellfish, or open-sea operations.

43. Newfoundland:

Previously, Newfoundland's economy used to rely mainly on either north Atlantic cod fishing and processing, or unemployment insurance. Now that there has been a moratorium placed on cod fishing within the Grand Banks, The government is looking towards Aquaculture, mining or Oil & Gas as replacements for that lost industry. For this reason, Newfoundland is perhaps one of the fastest growing aquaculture regions of Canada. Its characteristics include:

- (2350) metric Tonnes of fin-fish produced in 1996, which corresponds to roughly \$10 million farm gate value, or 10% of the eastern region's production.

Water Treatment and Wastewater Systems: General

Within Canada, water utilities are generally municipally based and managed. The Federal and provincial governments have oversight capacities, however the operational decision-making is made at a facility level based on municipal conditions and needs. Some provincial areas may have within it a collection of large and small utilities that are owned and operated by Crown Corporations (Quasi-private organizations that are privately managed, yet federally funded and profitable). Although in Canada, Crown Corporations are typically very inefficient (Canada's horrendous postal system is an example), there are Federal mandates to provide efficient and cost-effective services to the populations served by these utilities. A good example of these crown corporations is the Ontario Clean Water Agency, a $580 million dollar corporation which operates:

- 208 water and wastewater treatment facilities owned by the province
- 221 municipally owned facilities
- Assists 84 municipalities in building or expanding their facilities

In total, this corporation covers 18% of the province's water treatment and 29% of the wastewater treatment. They have centralized engineering services which consult to the units they operate, including a department that handles efficiency upgrades.

44. Ontario:

Ontario, the most populated province in Canada, has roughly 500 water treatment facilities. At present, however, out of the 500, there are only 4 systems using ozone purification. Of these four systems, none use oxygen feed. This low level can be partly attributed to three major factors:

1. Ozone purification, and oxygen generators are a relatively new concept, and usually only adopted with new facilities. Many facilities take several years to be designed and approved for construction, and thus were designed before these technologies were common.
2. Cost containment is always a factor, especially with the cash-strapped Ontario government. Ozone purification is relatively expensive as compared to using chlorination, and few municipalities would specify or retrofit to ozone without a non-cost related reason.
3. Education regarding ozone generation is minimal, and due to its complicated nature (as compared to chlorination), less likely to be adopted by smaller, less sophisticated municipalities.

45. Tri Hella Methane (THM):

THM is a by-product of the reaction between organic material and chlorine. It is considered a carcinogen. THM tends to be a problem for surface drinking-water systems in the north with high algae or organic growth levels in their water sources. The Ontario Government has recently lowered their allowable levels of THM for safe drinking water from 350 PPT to 100 PPT (The US is currently at 50 PPT in some places). Upon this change, the Ontario government commissioned a task-force (within the Ministry of the Environment) to determine the best methods for water treatment facilities to meet this new THM level. Approximately 20 facilities were deemed as not meeting this new level, and of them, the majority were able to solve the problem with refining their chlorination doses, or switching to chloramination (chlorine / ammonia mix). There were two new small northern facilities that adopted ozone for this, as well as for taste reasons.

It is a possibility that the allowable THM levels will be lowered to 50 PPT, however that is at this point just speculation, and likely out far in the future considering the recent change down to 100 PPT. Ozone purification is one other method of solving the THM problem.

46. Medical Officer of Health:

The Ontario Medical Officer of Health is responsible for the safety of drinking water regulations. The Ministry of the Environment is responsible for inspecting facilities to ensure that they meet those regulations. Although this abatement section does have the capacity to order a facility to convert their process in order to meet THM and other regulations, they will rarely do so. They are not considered a heavy-handed department, and will take into consideration available funding, future proposed upgrades, etc., before issuing orders. It is most likely that facilities will only need or want to make an upgrade to ozone when they will otherwise be making capacity upgrades, or building new facilities.

47. Cryptosporidium

Cryptosporidium is the new issue within water quality, made more visible with some recent deaths in Milwaukee due to it being present in the water. These water-borne micro-organisms are difficult to detect and monitor, and as such there are no current safe level guidelines. Cryptosporidium is potentially fatal to those with weakened immune systems, such as the elderly, and those with AIDS. Chlorine is ineffective against it, and research is currently being conducted on effective methods of treating this organism. If ozone was found to be effective in treating cryptosporidium, combined with the THM problem, ozone disinfecting could become the next big thing in water treatment. Some already claim ozone as effective, but there is no definitive proof as yet.

Even without clear safe level guidelines, an order from the medical officer of health to boil drinking water would be a huge public-relations disaster for facilities, and thus possibly spur conversion. The Ontario Ministry of Health has sent letters out to all water treatment facilities warning them that cryptosporidium could be a potential problem.

48. Decision Making Process:

New or existing facilities will most likely hire outside engineering firms to design and specify their water treatment systems. While provincial regulations must be met, and plant engineers might have some directional say as to the type of systems, the engineering firms have the most leverage in determining system methods.
Some large engineering firms within Ontario:

- CGNF (subsidiary of US CH2M Gordon Story Ltd.), Ken Mains, (416)499-9000
- Proctor & Redfern, Mike Guntry (416)445-3600
- RAL Engineering, Bob McGraw, (905)853-0626

A prime distributor for Ozone systems is Hankin Atlas, Ron Laroche, and he indicates that the ozone feed system specification depends on a number of factors, including:

- Local conditions of oxygen price, supply
- Plant capitalization levels
- Plant design date
- Efficiency required

Hankin Atlas currently uses AirSep oxygen generators

49. Water Treatment: Ozone Generator Feed

A copy of the *National Inventory of Municipal Waterworks and Wastewater Systems in Canada in 1986* has been obtained, and within it is a listing of every facility within Canada arranged by province and alphabetically, and containing information regarding treatment methods, population covered, and capacity. In addition, each province has a provincial summary of the population segments covered, and treatment methods employed. This document was updated every ten years, however due to federal budget cuts, there are no immediate plans to update this document. While some of the information may be dated, it does offer invaluable insight into provincial treatment trends, existing sites, and potential conversion targets.

Canada mainly uses Chlorine to treat its drinking water, except for 20 sites that use ozone, located in British Columbia, Manitoba, Ontario, and mainly Quebec. Figure 16: Canadian Ozone Water Treatment Locations details those ozone locations.

Province	City / Municipality	Average flow (M^3/day)	Design flow (M^3/day)	% Capacity
British Columbia	Port Alice Village	n/a	n/a	n/a
Alberta	Loon Lake Hamlet	60	92	65%
Saskatchewan		n/a	n/a	n/a
Manitoba	Portage La Prairie	6818	22729	30%
	Whitemouth Village	n/a	n/a	n/a
Ontario	Barrie	n/a	n/a	n/a
	Mannheim	n/a	n/a	n/a
Quebec	Buckingham	6136	19092	32%
	Drummondville	31821	54551	58%
	Ile-Perrot	3635	6818	53%
	Lac-Etchemin	2044	4090	50%
	L'Assomption	6818	9091	75%
	L'Epiphanie	1862	5454	34%
	Oka	680	2272	30%
	Pierrefonds	43186	79554	54%
	Quebec City	181839	182748	100%
	Repentigny	8227	53641	15%
	Saint-Denis	8181	22729	36%
	Saint-Eustache	9091	13637	67%
	Sherbrooke	55414	68189	81%
	Terrebonne	17728	18183	97%

Figure 16: Canadian Ozone Water Treatment Locations

In addition to the National Inventory, the American Waterworks Association compiles a 1995 *Canadian Water Industry Data Base*, giving utility profiles of 300 Canadian Water Treatment systems serving 10,000 or more people. The most useful details gleaned from this report for oxygen generator purposes is:

- Of the Surface water systems (which tend to be the larger systems):

- 9% were either in the procurement phase, or already in expansion (on average, the much smaller of the surface water systems)
- 10% indicated plant expansions may take place within 5 years (on average, the largest groundwater systems)
- 18% currently use ozone

- Of the Groundwater systems (which tend to be smaller systems):
  - 31% were either in the procurement phase, or already in expansion (on average, the larger of the groundwater systems)
  - 35% indicated plant expansions may take place within 5 years (on average, the smaller of the groundwater systems)
  - 3.5% currently use ozone

- General:
  - Annual electricity costs averaged 13% of total Overhead expenditures
  - Chemical costs averaged $0.01 per 1000 liters treated
  - 22% of utilities had conducted research into ozone use
  - Since 1990, all utilities have averaged a 14% per year decrease in capital outlays. However, this decreasing trend is decreasing (meaning although spending is down, it has been increasing lately). The average utility spent CDN $3.2 million in capital expenditures per year.

50. Sewage Treatment:

Figure 17: Canadian Wastewater Treatment Types and Distribution offers a summary of the Inventory, and it is summarized as follows:

- Activated Sludge treatment systems are most common in Ontario, Quebec, British Columbia and Alberta, with a total of 233 systems across these four Provinces, 258 overall
- Extended Aeration is common in all of the above Provinces, and it dominates the eastern Provinces as well.
- Lagoons are the most common method overall, with facultative or anaerobic being the most common treatment processes.
- No systems use ozone disinfectant, instead using some form of chlorination
- Canada's population is relatively well served with sewage treatment, averaging 83%
- Most facilities serve less than 30,000 people, and only 6 systems serve between 500,000 - 1,000,000 people.

Figure 17: Canadian Wastewater Treatment Types and Distribution

Province	No. of Facilities <1000 pop. served	No. of Facilities 1,000-30,000 pop. served	No. of Facilities 30,000-500,000 pop. served	No. of Facilities 500,000-I million pop. served	% Population Served with sewers	Secondary						Tertiary / Lagoon			Disinfectant	
						Conventional Activated Sludge	High Rate Activated Sludge	Extended Aeration	Rotation Biological Contractor	Contact Stabilization	Oxidation ditch	Anaerobic lagoon	Aerated lagoon	Facultative lagoon	Chlorine	Ozone
Northwest Territories	40	11	0	0	83%	0	0	0	0	0	0	0	0	16	0	0
Yukon Territories	11	4	0	0	78%	0	0	1	0	0	0	7	5	3	0	0
British Columbia	33	100	19	0	68%	16	6	16	3	0	7	11	38	19	50	0
Alberta	338	109	7	2	80%	4	2	9	11	1	2	193	25	317	6	0
Saskatchewan	147	61	9	0	91%	2	1	0	1	0	1	8	13	168	4	0
Manitoba	237	41	1	1	94%	0	3	11	3	1	1	0	10	141	15	0
Ontario	65	335	46	2	80%	96	8	95	0	24	12	4	23	128	175	0
Quebec	700	760	29	1	86%	82	19	34	0	6	1	15	129	15	120	0
New Brunswick	21	64	6	0	91%	4	1	5	2	2	9	0	24	64	39	0
Nova Scotia	46	63	4	0	81%	2	2	35	2	3	23	0	18	5	78	0
PEI	13	11	0	0	99%	0	0	2	0	2	0	0	2	14	4	0
Newfoundland	232	90	1	0	66%	1	3	21	2	6	1	3	0	0	22	0

The best potential targets for conversion in the existing systems would be those 35 High rate activated sludge systems in BC, Alberta, Ontario and Quebec. It is likely that for capacity increase, a utility would convert a conventional Activated sludge system to high rate before they retrofit to oxygen enrichment.
Although lagoons can be injected with bottled oxygen under peak-load conditions, it is generally not done.
It is the opinion of a wastewater engineering consultant with CGNF (Canada's Largest), and the Ministry of Environment and Energy's Wastewater Specialist that the 'Canadian' market for oxygen use on wastewater treatment is 'terrible', for the following reasons:

- It is only appropriate under special circumstances, such as:
  - Pulp & Paper mills who have on-site oxygen generating capacity from their pulping operations
  - Areas where Facility site footprint is constrained, therefore capacity / square foot is best attained using oxygen. An example is Barrie, Ontario, whose site was so boggy and required such extensive footings, that space was minimized
  - Special deals with oxygen companies are negotiated, where ASU-plants are located on-site. An example is Winnipeg whereby the city leased land to Air Products to build an ASU located next to the waste-water treatment facility, and Air Products had the option of building and operating it at whatever capacity they deemed necessary for their capacity needs. In this way, the city was able to reduce their capital investment by having Air Products bear some of the investment
- Over the last ten years, total oxygen usage for wastewater has decreased
- For plants needing to increase capacity, it is most likely to attain peak-loads, or periodic large loads such as a factory release. In these situations, it is more economical to use bottled oxygen on this intermittent basis
- Increasing capacity using oxygen is at beat a five-year stop-gap method, and can also be accomplished using the addition of polymers or clarifiers to the sludge. A facility is less likely to make a large capital investment for what is deemed a stop-gap solution
- Approximately 30-40 plants have applied for capacity increases over the past several years, and in all cases, they have met this increased capacity by increasing the air transfer efficiency through means such as adding more blowers, changing from coarse to fine bubble aeration, etc.
- Air transfer technology using among others, ceramic disk membranes has improved transfer efficiencies enough over the last several years that (except in the special circumstances), air injection is much more economical than oxygen use
- Very large facilities, which, because of their technological maturity and inter-city space constraints, are the more likely users of oxygen injection. They are also, however, because of their size, able to acquire either very large VPSA or ASU plants for greater efficiency
- Praxair has already made full presentations to ministry and municipal officials regarding switching pure-oxygen use and the use of their PSA or ASU oxygen generating plants. So far, they have had no luck.

Summary / Recommendations

General

ARC is operating within an extremely competitive environment: facing two main fronts of competition both from the major gas companies vying to supply bulk oxygen, as well as an ever-expanding number of PSA makers trying to each carve out their market niche.

Competitive Advantage:

- Price
    - At present, ARC's cost structure is such that without greatly increased volume of orders, or a evolutionary breakthrough in technology, they will never be a cost-leader within the industry. At present, ARC machines are priced at a price premium, substantiated by a service, quality positioning.
- Reliability
    - To date, most or all of ARC's installed machine base has not proven itself to be particularly reliable, on two different fronts:
        - General breakdowns or loss of performance
        - Inability to initially meet specified performance targets in purity or output
        - With ARC's only major installed machine base, in Australia, performance and reliability has been so poor, that without a huge shortage of oxygen and reliable PSA suppliers in the area, the customer would/should have dumped ARC long ago.
- Technical superiority
    - The only claimed differentiating factor attributable to the ARC PSA design is its efficiency. To date, that has never been proved, and casual observation of operating machines in the Australian market indicate that they are not meeting electrical efficiency specifications (the abundant electrical supply I that market make this a minor problem). ARC is currently using the same basic PSA design used by all in the industry, and past patents are for technology that has since been discarded.
- Service
    - ARC's service department is at best, skeletal, with only a few key ARC employees able to competently service machines in the field. Until this department's ability to field worldwide requirements improves, customers are left waiting with machine breakdowns, or face exorbitant premium charges
    - ARC's history of interaction with the customer is, to put it delicately, is atrocious. Customers are blamed for all machine faults, denied needed service, hassled,

Mining

51. Mine Maintenance & Construction

There would not be a sufficient market potential here to justify the expense and resources required to adequately enter into this segment, were it not for the fact that this entry could be easily facilitated through a synergous alliance with engineering companies, who have access to other mining markets as well. The drop in gold prices would dampen this market, however other mine types are flourishing, and use on copper, zinc, diamond, etc. would be possible

52. Gold Mining

Pursuing this segment **is** recommended, but with the following conditions:

- The recent drastic drop in the price of gold has put a damper on worldwide gold mining activity. The mining industry is very cyclical, and when the operating mining-cost/ounce drops below the price of gold, many or most mines simply shut-down and wait fore the price to rise again; the gold will still be there in the future. This is not, however all bad though, as there are still two additional avenues to explore:
  - Existing, newer mines still carrying high carrying charges, with mining costs/ounce near the threshold of gold price. The use of oxygen in the processing could drop the cost below the economical operating range again. Mine managers will be more willing to adopt the use of oxygen to gain all efficiencies; usually they are less apt to adopt newer technologies when the price of gold is high, and processing is running along smoothly
  - The benefits of PSA oxygen will have to be stressed heavily then along the lines of increased throughput and cost savings, rather than efficiency claims
  - New mines that have received funding and will proceed to be built, however they will need all operating efficiencies possible. The use of PSA oxygen will then be possible for both cyanidation feed, and in the initial remote construction
  - Since the decision chain is accessed at the same point for all three choices, mining can still be pursued through the central access pots at the mining headquarters and gas company contacts

53. Uranium Mining

In a long-term viewpoint, uranium mining should be pursued. Since uranium in-situ mining requires larger outputs of oxygen, this falls well into a general strategy push towards larger, higher-margin machines.

- Canada is not an attractive market, due to its concentration of relatively high purity uranium, and use of strip-mining
- The international market, and newer US mines are most attractive. As part of the gold marketing push, the uranium mining companies can be accessed in the same cities.
- Greater market research needs to be performed before attacking this segment

54. Other Ores

There is constant development being performed by the major mining companies to bring processing efficiencies into the gold, copper etc., industry. This includes the elimination of large-scale smelter and autoclave units, for both capital intensity and environmental reason. The introduction of on-site, low-pressure and temperature oxygen processing into the process is well matched for PSA. Through regular contacts with the engineering consultants, and development departments of the mining companies, these developments should be closely followed.

Oil & Gas

55. Offshore

Unfortunately, late-summer information developed the impression that there is limited need for PSA units on existing wells. The only potential implementation would be through the initial specification of the units into the designs of the platforms. Frankly, ARC has neither the resources, or service & quality mentality to survive the rigorous bidding process required for this segment. The only hope is that is PSA begins to get adopted through other oil & gas uses, then it will be adopted into the platforms as well

Land-Based

There is tremendous potential here, especially if adopted through synergous alliances with engineering companies with ties into both the international oil & gas and mining markets. Each new land-based well construction has need for a PSA sea-tainer system, for both construction and future maintenance needs. Whether or not the nitrogen option is deemed attractive is open to interpretation. Its economics are tentative, however due to quality reasons, it may be attractive in remote international locations. Arc currently has an installed unit within this segment coming online, and should take all pains to ensure that its implementation goes smoothly.

56. Well-testing

There is immense potential here, however the amount of effort required in a joint development program between ARC and a oil company would probably be beyond their capabilities at present. Along-with entry into this market for maintenance purposes, inquiries to engineering outfitters and major oil companies should be made

Medical:

57. Home Concentrators

Pursuing this segment is **not** currently recommended for the following reasons:

- Heavy current competition has led to price competition below a level that makes it unfeasible to sell the re-badged Nidek units.
- Warranties range up to seven years, and even lifetime on sieve-beds. While the validity of these claims can be debated, the customers value this as purchasing criteria. As no warranty currently exists on the Nidek units, matching competitive units' warranties could result in a net loss on the sale of the Nidek units if future claims arise within the warranty period.

- While the home-care market is expanding due to Hospital downsizing and consolidation, there is a corresponding amount of government cuts in paid home-care eligibility. Overall, the market is declining.

- **Recommendation:**
  - With a total market size of 4000-5000 units per year, Canada's concentrator market might only be attractive if Arbor Research Corporation begins manufacturing its own POGS, and can therefore control cost and warranty variables. Therefore, with a 10-15% share of the market gained, Canada might be a useful *supplement* to Arbor Research Corporation's concentrator sales. The decision to self-produce POGS will of course, have to based on other factors as well, beyond the scope of this Canada study

58. Remote Hospital:

This segment is **not** recommended for long-term focus due to the following reasons:

- The market size is limited.
- A substantial portion of the total country's market size has already either been approached-by, or sold by Rimer Alco / Vital Air.
- The remote locations, and the nature of the segment specialization would incur high selling costs

- **Recommendations:**
  - There is a finite number of remote hospital locations (perhaps 6-12), located primarily in British Columbia and Ontario and eastward that has not been sold by Rimer Alco yet. From a preliminary survey, it appears that these hospitals are currently aware of the technology, and interested in sourcing a system. Kuujjuaq Medical Center in northern Quebec is currently sourcing bids on competing systems. As Arbor Research Corporation has the necessary CSA approval to sell medical packages in Canada, its biggest obstacles at present are its lack of name recognition and sales presence.
    - Determine the location of each remote-area hospital in the remaining Provinces
    - Bases on some preliminary calls, determine their applicable variables, such as demand, prevailing oxygen cost, electricity rate etc.
    - Put together 6-12 detailed information packages with specific cost savings for their facility. Outline unequivocally the benefits of the Arbor Research Corporation system over Rimer Alco's, including operating conditions. Electrical savings over the Rimer Alco system should be quoted in *yearly* savings
    - If possible, reference medical success in other locations, and McGill if appropriate
    - Follow-up with sales calls and if promising, coordinated visits.
    - As this would be a 'temporary' segment, and not all remote locations will be successful, service / distributors would have to be determined on a case-by-case basis
    - This should all be done ASAP!, before the opportunity is lost.

Water:

59. Ozone Generation for Water Treatment

Pursuing the ozone generation market for water treatment facilities is **not** recommended for the following reasons:

- Capital Investment funds are in short supply
- Ozone Purification is not currently well understood or adopted
- Ozone generation is not cost effective as compared to the industry standard- Chlorination
- There are no existing Canadian health regulations that would force the adoption of ozone purification

- **Recommendations:**
  - Keep abreast of developments on Cryptosporidium, and whether or not ozone treats it
  - Keep current on the provincial health standards for allowable THM levels
  - Establish and maintain a relationship with the major water treatment engineering forms that serve the Canadian Market, which may lead to any available water treatment or wastewater applications
  - Consider regional penetration of the Quebec market only through other distribution connections

60. Wastewater Sludge Enrichment

Pursuing the wastewater treatment market is **not** recommended for the following reasons-

- Industry decision makers are of the opinion that except in special circumstances oxygen is not cost efficient vs. air. True or not, the industry perception is as such
- Praxair has already tried to sell the market and so far been unsuccessful
- The market is limited, both in new and upgraded facilities. New facilities rarefy occur, and the industry trend has been to expand aeration techniques, rather than adding oxygen for expansion of capacity

- **Recommendations:**
  - Keep in touch with the industry for upcoming facility plans under special circumstances through membership and representative networks through membership in the Equipment Suppliers Association branch of the National Water and Environment Federation. If desired, this show occurs everv vear usually in the US.
  - Try to leverage any associations maintained for the ozone market with industry engineering consultants, who most likely handle or know of the wastewater developments as well

61. Aquaculture

Pursuit of the aquaculture market segment **is** recommended for the following reasons-

- It is a growth industry, widely recognized to expand steadily at least throuqh the year 2000

- The vastness of Canada is not really an issue, as the most attractive region is eastern Canada, which can be reasonably covered with few distribution/service points
- As larger food producers enter the market, and existing producers become more professional and vertically integrated in order to stay competitive, the need for oxygen generators will grow at a faster pace than the general industry
- For what its worth, within the eastern region, it has strong government support
- It is at an attractive stage of the industry/product life-cycle: Past its infancy and gaining momentum. Current adoption of oxygen is in the 15-20% range. Following the agricultural industry-life cycle, farms will have to get larger and more efficient in order to compete. Although there is general awareness of the use of oxygen, it needs to be further reinforced through education. In a somewhat crowded competitive market, education of these benefits and savings can be used to distinguish Arbor Research Corporation's products from the others
- There are a captive, finite number of trade distribution and advertising channels. Although most of the major channels are currently committed to competitor's products, as the industry grows, and smaller service/distribution channels expand, there will be room to accept the Arbor Research Corporation line
- With proper distributors, the eastern Market could be reasonably managed through the Arbor Research Corporation offices with a single sales-resource.
- There is an opportunity to package the product through joint agreements with compatible companies' products, such as diffusers, blowers, etc.
- Current competitive presence is not aggressive or noticeably professional or properly positioned. There seems to be a lack of 'organized' aggressiveness in this industry, with the competition treating it as a tertiary market for their products.
- Advertising through trade journals can be expected to reach a high percentage of the market, and yet rates are reasonable
- Aquaculture advertising tends to be more North American in scope rather than just Canada or US. therefore awareness gained in Canada will benefit the US market, and visa-versa.
- Arbor Research Corporation has a cooperative Canadian success story for which to reference
- There is an opportunity for inventive terms of sale in order to boost adoption
- Requirements are for HE systems, which are much more cost effective. Due to the continuously-running usage, and relatively rural locations of the farms, the prevailing oxygen prices are not necessarily a factor in justifying the systems. Under almost all conditions, the generators are cost-effective
- The most immediate need for the systems are hatcheries. As farms consolidate and vertically-integrated, the growth-pond applications will be introduced to existing technology as well, easing adoption
- Fish farms are not currently saddled with the supply/distribution issues that may arise with other industrial customers, such as common welding/gas suppliers, long-term contracts, etc.
- Although currently, the machine capacity required is small, it can be expected to increase as farms consolidate and grow. In addition, through education, the benefits of central systems can be advertised. The lower-end Arbor Research

Corporation machines that may be most suitable for farms (HE3+), are the tried-and-true designs.

- If Arbor Research Corporation decides to mass-produce POGS, the aquaculture industry offers an attractive market to sell some of them in, especially if the CADET is refined.

- **Preliminary Recommendations:**
  - Alliances must be forged with area aquaculture distributors, and aquaculture consultants
  - If possible, the outfitting of the food-processing giants should be targeted
  - Arbor Research Corporation must get into an aquaculture catalogue ASAP (i.e. : 'Aquaculture Supply', Florida farms Inc.)
  - A professional approach to devising printed material advertising copy should be followed, and used to create awareness
  - It is possible, that in the pursuit of alternative market segments within Canada, Arbor Research Corporation's Aquaculture 'department' can be managed from a North American focus.

Appendix A

Northwest Territories

No.	Mine Name	Location	Company	Mill Started	Ore mill Capacity (t/day)	Process
1	Mirimar Con Mine	Yellowknife	Con Exploration Ltd.	1938	1400	Cyanidation
2	Lupin Mine	Contwoyto Lake	Echo Bay Mines Ltd.	1982	2300	Cyanidation
3	Giant	Yellowknife	Royal Oak Mines Inc.	1948	1200	Flotation, roasting, cyanidation
4	Colomac	Yellowknife	Royal Oak Mines Inc.	1990	10,000	C.I.P.
5	Ptarmigan / Tom	Yellowknife	Treminco Resources	1989	200	Gravity, Flotation

Yukon Territories

No.	Mine Name	Location	Company	Mill Started	Ore mill Capacity (t/day)	Process
1	Mount Namsen	Mount Namsen area, W of Carmacks	B.Y.G. Natural Resources Inc.	1968	270	Gravity, flotation, C.I.L.
2						

British Columbia

No.	Mine Name	Location	Company	Mill Started	Ore mill Capacity (t/day)	Process
1	Nickel Plate Mine	Hedley	Homestake Canada Inc.	1987	3267	Cyanidation / Merrill Crowe
2	Eskay Creek Mine	Eskay Creek	Homestake Canada Inc.	1994	250	Crushing only, smeltered in Japan & Quebec
3	Stewart	Stewart	Westmin Resources Ltd.	1989	2200	Cyanidation, C.I.L.
4	Snip Mine	Stewart, "Fly-in, Fly-out'	Cominco, Ltd.	1922	450	n/a
5	Cassiar	Cassiar	Cusac Industries Ltd.	1980	300	Gravity, flotation
6	Myra Falls	Strathcona Provincial Park, Vancouver Is.	Westmin Resources Ltd.	1966	4000	Flotation
7	Golden Bear	Atlin Mining District	North American Metals, Corp.	1990	360	Grind, Roast, leach, refine, heap-leaching
8	Princeton	Princeton	Similco Mines Ltd.	1972	26000	Flotation, copper concentrate containing gold is shipped to Japan
9						

Saskatchewan

No.	Mine Name	Location	Company	Mill Started	Ore mill Capacity (t/day)	Process
1	Jolu Gold Mine	140 km N of La Ronge	Golden Rule Resources	1988	500	Gravity, Cyanidation, C.I.P.
2	Contact Lake	Contact Lake, La Ronge Provincial Park	Cameco Corp.	1995	700	C.I.L, C.I.P.
3	Seabee	125 km NE of La Ronge	Claude Resources Inc.	1991	400	Cyanidation, C.I.P.
4	Komis Mine	La Ronge Gold Belt	Waddy Lake Resources Inc.	1996	n/a	n/a
5	Potential mine	Box / Athona Properties	Greater Lenora Resources	1997+	100,000 oz annual gold	Gravity, Flotation
6	Potential mine	Historic Anglo-Rouyn, Lac La Ronge Provincial Park	Kristo Gold Inc.		26,000 ox gold, 93,000 oz silver, 2400 t copper tot.	Reprocessed acid tailings
7	Potential mine	Amisk/Laurel Lake, Flin Flon area	Claude resources Inc. / Cameco / Husky Oil		140,000 oz gold tot.	n/a
8						

Manitoba

No.	Mine Name	Location	Company	Mill Started	Ore mill Capacity (t/day)	Process
1	Puffy Lake	Sherridon	Pioneer Metals Corp.	1987	900	Flotation, Cyanidation
2	BT Deposit	Lynn Lake	Granduc Mining Corp.	1986	1200	Crushing, grinding, Cyanidation, C.I.P, stripping, electrowinning, melting
3						

Ontario

No.	Mine Name	Location	Company	Mill Started	Ore mill Capacity (t/day)	Process
1	Campbell	Balmertown	Placer Dome (CLA) Ltd.	1949	1455	Crushing, grinding, jigging, tabling, flotation, pressure oxidation, Cyanidation, C.I.P. precipitation
2	Detour Lake	Timmins	Placer Dome (CLA) Ltd.	1983	2916	Crushing, grinding, leaching, C.I.P, stripping, electrowinning
3	Dome	South Porcupine, Tisdale Twp.	Placer Dome (CLA) Ltd.	1912	9800	Crushing, grinding, leaching, C.I.P, stripping, electrowinning
4	Golden Patricia	70 km SW of Pickle Lake	Barrick Gold Corp.	1988	460	Gravity, Merrill Crowe Circuit
5	Holt McDermott	Harker/Holloway Twp.	Barrick Gold Corp.	1988	1360	Cyanidation, C.I.L.
6	Hoyle Pond	Hoyle Pond	Kinross Gold Corp.	1985	500	Some processed at Bell Creek, Gravity, cyanidation, Merrill Crowe
7	Bell Creek	Timmins	Kinross Gold Corp.	1987	400	Gravity, Cyanidation, Merrill Crowe
8	Macassa	Teck Twp.	Kinross Gold Corp.	1933	500	Cyanidation, C.I.P
9	Lakeshore Trailings	Teck Twp.	Kinross Gold Corp.			
10	David Bell	Hemlo	Teck Corp. / Homestake Canada inc.	1985	1400	C.I.P.
11	Williams	Marathon	Teck Corp. / Homestake Canada inc.	n/a	12,783 Kg gold / year	n/a
12	Eagle River	Wawa	River Gold Mines Inc.	1995	250	n/a
13	Golden Giant	Hemlo	Battle Mountain Canada Ltd.	1985	3000	C.I.P, cyanidation
14	Kerr	Virginiatown	A.J. Perron Gold Corp.	1938	2000	Cyanidation, gravity / flotation
15	Red Lake	Balmer Twp.	Goldcorp Inc.	1948	1000	Cyanidation, flotation
16	Hoyle Pit	Timmins, Tisdale Twp.	Royal Oak Mines Ltd.	n/a	3,529 Kg gold / year	
17	Pamour No. 1	Whitney Twp.	Royal Oak Mines Ltd.	1936	3400	Flotation, cyanidation, heap leaching
18	Nighthawk Lake	Cody Twp.	Royal Oak Mines Ltd.	1996		Milling at the Pamour Mill
19	Cheminis	Cheminis	Northfield Minerals Inc. / Towerland Properties Inc./	1991	1500	Flotation, cyanidation, C.I.L.

Quebec

No.	Mine Name	Location	Company	Mill Started	Ore mill Capacity (t/day)	Process
1	Beaufort Gold Project	Pascalis Twp.	Aurizon Mines Ltd.	1986	n/a	Cyanidation
2	Geo. H. Dumont Mine	Bourlamaque Twp.	Aur Resources Inc.	1981	n/a	Mine closed, custom milling performed, Flotation, cyanidation
3	East Malarctic Mill	Fourniere Twp, Malarctic	Barrick Gold Corp.	1938	3000	Gravity, flotation, cyanidation
4	Bousquat Complex, #1 & 2	Bousquat Twp.	Barrick Gold Corp.	1979	not app.	Processing off-site at East Malarctic mill, Gravity, flotation, cyanidation
5	Doyon Mine	Bousquat Twp.	Barrick Gold Corp.	1981	3500	Cyanidation, C.I.P.
6	Desmaraisville	Lesuere Twp.	Espalau Mining Corp.	1982	500	Cyanidation
7	Sillidor Mine	Rouyn-Noranda	Hemlo Gold Mines Inc.		n/a	Processed at Falconbridge Ltd's Kidd Creek smelter and at Cambior Inc's Yvan Vezina mill
8	Chimo Mine	Chimo	Cambior Inc.	1994	1500	Flotation and gravity concentration
9	Yvan Vezina Mill		Cambior Inc.	1984	1300	Cyanidation, C.I.P. - mill treats Sillidor, Mouska, Chimo mine concentrates
10	Mouska Mine	Cadillac, Bousquet Twp.	Cambior Inc.	1990	800	Shrinkage Stope
11	Sleeping Giant Mine	80 km N of Amos	Cambior / Aurizon		900	Cyanidation
12	Malartic / Fourniere	Malartic & Fourniere Twp.	Camflo Mill Inc.	1969	1300	Cyanidation
13	Donalda Mine	Rouyn-Noranda	Minorca Resources Inc.	1994	n/a	n/a
14	Copper Rand Mine	McKenzie Twp, Chibougamau	MSV Resources Inc.	1959	3000	Flotation, C.I.P.
15	Portage mine	Roy Twp.	MSV Resources Inc.	1959	n/a	Milled at Copper Rand
16	Eastmain	Eastmain	MSV Resources Inc.	1993	n/a	Milled at Copper Rand
17	Norbec-Manitou	Val-d'Or	ITEC-Mineral Inc.	1980	900	Cyanidation
18	Dubuisson	Dubuisson	Kiena Gold Mines Ltd.	1984	1500	Crushing, semi-autogenous grinding, cyanidation, C.I.P. filtration
19	Main Mine	Obalski Twp.	Meston Resources, Inc.	1955	2400	Ore millet at Joe Mann Mine in La Dauversiere, Chibougamau, Flotation cyanidation and gravity concentration
20	Francoeur Mine	Beauchastel Twp.	Richmont Mines Inc.		750	Milled off site
21	Val-d'Or Mine	Val-d'Or	Norebec-Manitou Inc.	1993	600	Flotation, cyanidation
22	Val-d'Or Mine	Val-d'Or, Bourlamaque Twp.	Placer Dome Canada Ltd.	1937	1500	Cyanidation
23	Astoria Mine	Rouyn-Noranda, Rouyn Twp.	Yorbleau Resources Inc.	1993	not app.	Ore processed at Kerr mill in Virginiatown, Ontario

New Brunswick
Nova Scotia
Prince Edward Island
Newfoundland

No.	Mine Name	Location	Company	Mill Started	Ore mill Capacity (t/day)	Process
1	Hope Brook Mine	Couteau Bay	Royal Oak Mines, Inc.	1987	3000	Cyanidation

Appendix B

Province	Mine	Company	Gold	Silver	Copper	Nickel	Zinc	Lead	Platinum	Molybdenum	[illegible]	Uranium	Palladium
Yukon Terr.	Faro Mine	Anvil Range Mining Corp.		x			x	x					
	Mount Namsen	B.Y.G. Natural Resources Inc.	x	x			x	x					
	Rose Creek	Curragh Inc.					x	x					
Northwest Terr.	Polaris Mine	Cominco Inc.					x	x					
	Mirimar Con Mine	Con Exploration Ltd.	x										
	Lupin Mine	Echo Bay Mines Ltd.	x										
	Nanisivik	Nanisivik Mines Ltd.					x	x					
	Giant Mine	Royal Oak Mines Inc.	x										
	Colomac Mine	Royal Oak Mines Inc.	x										
	Ptarmigan Mine	Treminco Resources	x										
British Columbia	Goldstream Mine	Bethlehem Resources Corp.		x	x		x						
	Island Copper Mine	BHP Minerals Canada Ltd.			x					x			
	Sullivan Mine	Cominco Ltd.					x	x					
	Snip Mine	Cominco Ltd.	x										
	Cassiar mine	Cusac Industries Ltd.	x	x									
	McKleese Lake	Gibraltar Mines Ltd.			x					x			
	Highland valley	Highland Valley Copper			x					x			
	Nickel Plate Mine	Homestake Canada Inc.	x	x									
	Eskay Creek mine	Homestake Canada Inc.	x	x									
	Golden Bear Mine	North American Metals Corp.	x	x									
	Endako Mine	Placer Dome Canada Ltd.								x			
	Princeton	Similco Mines Ltd.	x	x	x								
	Stewart	Tenajon Resources Corp.	x	x									
	Silvana Mine	Treminco Resources Ltd.		x			x	x					
	Myra Falls	Westmin Resources Ltd.	x		x		x						
	Stewart	Westmin Resources Ltd.	x	x									
Manitoba	BT Deposit	Granduc Mining Corp.	x										
	Trout Lake Mine	Hudson Bay Mining & Smelting Co. Ltd.			x		x						
	Westarm Mine	Hudson Bay Mining & Smelting Co. Ltd.			x		x						
	Callinan Mine	Hudson Bay Mining & Smelting Co. Ltd.			x		x						
	Ruttan Mine	Hudson Bay Mining & Smelting Co. Ltd.			x		x						
	Birchtree Mine	Inco Ltd.			x	x							
	Thompson Mine	Inco Ltd.			x	x							
	Pufly Lake Mine	Pioneer Metals Corp.	x										
	San Antonio Mine	Rea Gold Corp.	x										
Saskatchewan	Key Lake Mine	Cameco Corp.										x	
	Rabbit Lake Mine	Cameco Corp.										x	
	Contact Lake Mine	Cameco Corp.	x										
	Seabee Mine	Claude Resources Inc.	x										
	Jolu Gold Mine	Golden Rule Resources	x										
Ontario	Lang's	Agnico-eagle mines Ltd.		x									
	Kerr Mine	AJ Perron Gold Corp	x										
	George W. MacLeod Mine	Algoma steel Inc.									x		
	Holt-Mcdermott Mine	Barrick Gold Corp.	x										
	Lake Shore Division	Barrick Gold Corp.	x										
	Macassa Mine		x	x									
	Kidd Creek Mine	Falconbridge Ltd.			x		x						
	Lockerby mine	Falconbridge Ltd.			x	x							
	Strathcona Mine	Falconbridge Ltd.			x	x							
	Onaping/Craig Mine	Falconbridge Ltd.			x	x							
	Fraser Mine	Falconbridge Ltd.			x	x							
	Thayer Lindsley Mine	Falconbridge Ltd.			x	x							
	Red Lake Mine	Goldcorp Inc.	x										
	Golden Giant Mine	Hemlo Gold Mines Inc.	x										
	Clarabelle / Copper Cliff Mill	Inco Ltd.	x	x	x	x			x				x
	Coleman Mine	Inco Ltd.			x	x							
	Copper Cliff North Mine	Inco Ltd.			x	x							
	Copper Cliff South Mine	Inco Ltd.			x	x							
	Crean hill Mine	Inco Ltd.			x	x							
	Creighton Mine	Inco Ltd.			x	x							
	Frood-Stobie Mine	Inco Ltd.			x	x							

Province	Mine	Company	Gold	Silver	Copper	Nickel	Zinc	Lead	Platinum	Molybdenum	[illegible]	Uranium	Palladium
Ontario (Cont'd)	Garson Mine	Inco Ltd.			x	x							
	Levak Mine	Inco Ltd.			x	x							
	Little Stoble Mine	Inco Ltd.			x	x							
	McCready West Mine	Inco Ltd.			x	x							
	Shebandowan Mine	Inco Ltd.			x	x							
	Winston Lake Mine	Inmet Mining Corp.			x		x						
	Hoyle Pond Mine	Kinross Gold Corp	x										
	Bell Creek Mine	Kinross Gold Corp	x										
	Lac-des-Iles Mine	Lac des Iles Mines Ltd.	x		x	x							x
	Geco Mine	Noranda Mining and Exploration Inc.			x		x	x					
	Cheminis Mine	Northfield Minerals Inc.	x										
	Campbell Mine	Placer Dome Canada Ltd.	x										
	Detour Lake Mine	Placer Dome Canada Ltd.	x										
	Dome Mine	Placer Dome Canada Ltd.	x										
	Malarctic/Barrick mine	Republic Goldfields Inc.	x										
	Stanleigh Mine	Rio Algom Ltd.										x	
	Pamour No. 1 mine	Royal Oak Mines Inc.	x										
	Timmins Surface mine	Royal Oak Mines Inc.	x		x								
	Stock Twp. Mine	St.Andrew Goldfields Ltd.	x										
	Hislop Twp. Mine	St.Andrew Goldfields Ltd.	x										
	David Bell Mine	Teck-Corona Operating Corp.	x										
	Haley Mine	Teck-Corona Operating Corp.											
	Westmeath Mine	Timminco Ltd.											
Quebec	La Ronde Mine	Agnico-Eagle Mines Ltd.	x		x								
	Bouchard-Hebert Mine	Audrey Resources			x		x						
	Beaufor Gold Project	Aurizon Mines	x										
	East Malarctic Mill	Barrick Gold Corp.	x		x								
	Bousquat Complex #1 & 2 Mine	Barrick Gold Corp.	x	x	x								
	Doyon Mine	Barrick Gold Corp.	x	x									
	Les mines Selbaie	Billton Metals Canada Inc.			x		x						
	Chimo Mine	Cambior Inc.	x										
	Yvan Vezina Mill	Cambior Inc.	x	x									
	Mouska Mine	Cambior Inc.	x										
	Sleeping Giant Mine	Cambior Inc.	x										
	Malartic & Fourniere	Camflo Mill Inc.	x										
	Sillidor Mine	Hemlo Gold Mines Inc.	x										
	Cooke Mine	Inmet Mining Corp.	x		x								
	Norbec-manitou	ITEC-Mineral	x	x					x				
	Dubuisson Mine	Kiena Gold Mines Ltd.	x										
	Donalda Mine	Minorca Resources Inc.	x										
	Copper Rand Mine	MSV Resources	x	x	x								
	Portage Mine	MSV Resources	x	x	x								
	Eastmain Mine	MSV Resources	x										
	E-Zone Orebody Mine	Noranda Minerals			x								
	Orebody from Mount Copper	Noranda Minerals			x								
	Isle Dieu Mine	Noranda Minerals			x		x						
	Norita Mine	Noranda Minerals			x		x						
	Val-d'Or Mine	Norebec-Manitou inc.	x	x									
	Bourlamaque Twp.	Placer Dome Canada Ltd.	x										
	Lac Tio / Tracy Mine / Mill	QIT-Fer et Titane Inc.									x		
	Mount Wright Mine	Quebec Cartier Mining Co.									x		
	Port Cartier Mine	Quebec Cartier Mining Co.									x		
	Francoeur Mine	Richmont Mines Inc.	x										
	Casa Berardi Mines	TVX Gold Inc.	x										
	Joubi Mine	Western Quebec Mines Inc.	x										
	Astoria Mine	Yorbeau Resources Inc.	x										
New Brunswick	No.12 Bathurst	Brunswick Mining & Smelting Corp. Ltd.		x	x		x	x					
	Noprthumberland Co.	Brunswick Mining & Smelting Corp. Ltd.			x		x	x					
Newfoundland	Scully Mine	Cliffs Mining Co.									x		
	Labrador City	Iron ore Company of Canada									x		
	Hope Brook Mine	Royal Oak Mines inc.	x		x								
	Voisey's Bay Deposit	Inco Ltd.				x							

Appendix C

Industrial Facility: 99% O2							
Currently using bulk liquid							
Price discount:	10%						
US / CDN exch rate:	0.72						
Current O2 cost/SCF:	$0.01	$0.38	NM3				
Operating days/year:	365						
Operating hours/day:	24						
Electricity cost:	$0.13	**Price $US:**	**$20,175**	**$38,225**	**$48,825**	**$61,500**	**$84,400**
			HP2	**HP6**	**HP9**	**HP14**	**HP20**
			75	175	240	350	500
Days/Year Operating			365	365	365	365	365
Hours/Day Operating			**24**	**24**	**24**	**24**	**24**
Unit Output (Nm3/hr)			**1.97**	**4.60**	**6.31**	**9.20**	**13.14**
Duty Cycle			98.00%	98.00%	98.00%	98.00%	98.00%
Oxygen Production (Nm3/month)			**1,410**	**3,291**	**4,514**	**6,582**	**9,403**
H 'Cylinders per year			**2,639**	**6,157**	**8,443**	**12,313**	**17,591**
Power Costs							
Electric $/KWH ($CDN)			**0.13**	**0.13**	**0.13**	**0.13**	**0.13**
KWH/Nm3 O2			1.97	1.97	1.97	1.97	1.97
Avg. Electric Cost/Nm3 Oxygen ($CDN)			**$0.2561**	**$0.2561**	**$0.2561**	**$0.2561**	**$0.2561**
Annual Electric Cost - Arbor System ($CDN)			**$4,335**	**$10,114**	**$13,871**	**$20,229**	**$28,898**
Maintenance & Other Costs							
Spare Parts/Year			$200	$200	$200	$200	$200
Maintenance Labor/Year			$200	$200	$200	$200	$200
Tot Annual Maint. & Other Costs - Arbor Sys			**$400**	**$400**	**$400**	**$400**	**$400**
Annual Equip Amort.							
Arbor Unit Price ($CDN, includes discount)			$25,219	$47,781	$61,031	$76,875	$105,500
Est. Freight, Taxes & Installation (20%)			$5,044	$9,556	$12,206	$15,375	$21,100
Installation & Start-up			$4,000	$4,000	$4,000	$4,000	$4,000
Building/Leasehold Improvement Costs			$10,000	$10,000	$10,000	$10,000	$10,000
Total Customer Cost			$44,263	$71,338	$87,238	$106,250	$140,600
Annual Capital Costs (10 Years at 8%)			**$6,596**	**$10,631**	**$13,001**	**$15,834**	**$20,954**
Total Costs							
Operating Costs (per year)			**$4,735**	**$10,514**	**$14,271**	**$20,629**	**$29,298**
Total Cost (per year)			**$11,331**	**$21,146**	**$27,272**	**$36,463**	**$50,252**
Cost Per Unit Oxygen ($/m3)			**$1.524**	**$1.906**	**$2.027**	**$2.210**	**$2.291**
Cost Per Unit Oxygen ($/SCF)			**$0.040**	**$0.050**	**$0.053**	**$0.058**	**$0.060**
Present Oxygen Costs							
Present Annual Oxygen Cost			**$6,438**	**$15,022**	**$20,602**	**$30,045**	**$42,921**
Present Annual rental/service costs			**$0**	**$0**	**$0**	**$0**	**$0**
Total annual cost			**$6,438**	**$15,022**	**$20,602**	**$30,045**	**$42,921**
Annual Savings with Arbor System			**($4,893)**	**($6,123)**	**($6,670)**	**($6,418)**	**($7,331)**
SIMPLE PAYBACK (Months)			**-120.2**	**-160.4**	**-182.6**	**-237.2**	**-278.1**
PAYBACK (incl. capital costs) (Months)			**-136.3**	**-181.2**	**-206.0**	**-266.8**	**-312.4**

Appendix D

Industrial Facility: 99% O2							
Currently using cylinders ----> convert to piped							
Price discount:	10%						
US / CDN exch rate:	0.72						
Current O2 cost/SCF:	$0.05	$1.90	NM3				
Operating days/year:	365						
Operating hours/day:	24						
Electricity cost:	$0.13	**Price $US:**	**$20,175**	**$38,225**	**$48,825**	**$61,500**	**$84,400**
			HP2	**HP6**	**HP9**	**HP14**	**HP20**
			75	**175**	**240**	**350**	**500**
Days/Year Operating			365	365	365	365	365
Hours/Day Operating			**24**	**24**	**24**	**24**	**24**
Unit Output (Nm3/hr)			**1.97**	**4.60**	**6.31**	**9.20**	**13.14**
Duty Cycle			98.00%	98.00%	98.00%	98.00%	98.00%
Oxygen Production (Nm3/month)			**1,410**	**3,291**	**4,514**	**6,582**	**9,403**
H 'Cylinders per year			**2,639**	**6,157**	**8,443**	**12,313**	**17,591**
Power Costs							
Electric $/KWH ($CDN)			0.13	0.13	0.13	0.13	0.13
KWH/Nm3 O2			1.97	1.97	1.97	1.97	1.97
Avg. Electric Cost/Nm3 Oxygen ($CDN)			**$0.2561**	**$0.2561**	**$0.2561**	**$0.2561**	**$0.2561**
Annual Electric Cost - Arbor System ($CDN)			**$4,335**	**$10,114**	**$13,871**	**$20,229**	**$28,898**
Maintenance & Other Costs							
Spare Parts/Year			$200	$200	$200	$200	$200
Maintenance Labor/Year			$200	$200	$200	$200	$200
Tot Annual Maint. & Other Costs - Arbor System			**$400**	**$400**	**$400**	**$400**	**$400**
Annual Equip. Amort.							
Arbor Unit Price ($CDN, includes discount)			$25,219	$47,781	$61,031	$76,875	$105,500
Est. Freight, Taxes & Installation (20%)			$5,044	$9,556	$12,206	$15,375	$21,100
Conversion to piped			$7,566	$14,334	$18,309	$23,063	$31,650
Installation & Start-up			$4,000	$4,000	$4,000	$4,000	$4,000
Building/Leasehold Improvement Costs			$10,000	$10,000	$10,000	$10,000	$10,000
Total Customer Cost			$51,828	$85,672	$105,547	$129,313	$172,250
Annual Capital Costs (10 Years at 8%)			**$7,724**	**$12,768**	**$15,730**	**$19,271**	**$25,670**
Total Costs							
Operating Costs (per year)			**$4,735**	**$10,514**	**$14,271**	**$20,629**	**$29,298**
Total Cost (per year)			**$12,459**	**$23,282**	**$30,001**	**$39,900**	**$54,968**
Cost Per Unit Oxygen ($/m3)			**$1.386**	**$1.731**	**$1.842**	**$2.020**	**$2.095**
Cost Per Unit Oxygen ($/SCF)			**$0.036**	**$0.046**	**$0.048**	**$0.053**	**$0.055**
Present Oxygen Costs							
Present Annual Oxygen Cost			**$32,191**	**$75,112**	**$103,010**	**$150,223**	**$214,605**
Present Annual rental/service costs			**$13,193**	**$30,783**	**$42,217**	**$61,567**	**$87,953**
Total annual cost			**$45,384**	**$105,895**	**$145,228**	**$211,790**	**$302,557**
Annual Savings with Arbor System			**$32,925**	**$82,613**	**$115,227**	**$171,890**	**$247,589**
SIMPLE PAYBACK (Months)			**20.6**	**14.0**	**12.5**	**10.5**	**9.8**
PAYBACK (incl. capital costs) (Months)			**23.4**	**15.8**	**14.1**	**11.8**	**11.0**

Appendix E

Industrial Facility: 99% O2							
Currently Using Cylinders							
Cylinder Filling Station							
Price discount:	10%						
US / CDN exch rate:	0.72						
Current O2 cost/SCF:	$0.05	$1.90	NM3				
Operating days/year:	365						
Operating hours/day:	24						
Electricity cost:	$0.13	**Price $US:**	**$43,800**	**$78,800**	**$91,825**	**$138,400**	**$161,300**
			HP2C	**HP6C**	**HP9C**	**HP14C**	**HP20C**
			75	**175**	**240**	**350**	**500**
Days/Year Operating			365	365	365	365	365
Hours/Day Operating			**24**	**24**	**24**	**24**	**24**
Unit Output (Nm3/hr)			**1.97**	**4.60**	**6.31**	**9.20**	**13.14**
Duty Cycle			98.00%	98.00%	98.00%	98.00%	98.00%
Oxygen Production (Nm3/month)			**1,410**	**3,291**	**4,514**	**6,582**	**9,403**
H 'Cylinders per year			**2,639**	**6,157**	**8,443**	**12,313**	**17,591**
Power Costs							
Electric $/KWH ($CDN)			**0.13**	**0.13**	**0.13**	**0.13**	**0.13**
KWH/Nm3 O2			1.97	1.97	1.97	1.97	1.97
Avg. Electric Cost/Nm3 Oxygen ($CDN)			**$0.2561**	**$0.2561**	**$0.2561**	**$0.2561**	**$0.2561**
Annual Electric Cost - Arbor System ($CDN)			**$4,335**	**$10,114**	**$13,871**	**$20,229**	**$28,898**
Maintenance & Other Costs							
Spare Parts/Year			$200	$200	$200	$200	$200
Maintenance Labor/Year			$200	$200	$200	$200	$200
Tot Annual Maint. & Other Costs - Arbor System			**$400**	**$400**	**$400**	**$400**	**$400**
Annual Equip Amort.							
Arbor Unit Price ($CDN, includes discount)			$54,750	$98,500	$114,781	$173,000	$201,625
Est. Freight, Taxes & Installation (20%)			$10,950	$19,700	$22,956	$34,600	$40,325
200 H 'cylinders cost			$19,000	$19,000	$19,000	$19,000	$19,000
Installation & Start-up			$4,000	$4,000	$4,000	$4,000	$4,000
Building/Leasehold Improvement Costs			$10,000	$10,000	$10,000	$10,000	$10,000
Total Customer Cost			$98,700	$151,200	$170,738	$240,600	$274,950
Annual Capital Costs (10 Years at 8%)			**$14,709**	**$22,533**	**$25,445**	**$35,856**	**$40,976**
Total Costs							
Operating Costs (per year)			**$4,735**	**$10,514**	**$14,271**	**$20,629**	**$29,298**
Total Cost (per year)			**$19,444**	**$33,048**	**$39,716**	**$56,485**	**$70,274**
Cost Per Unit Oxygen ($/m3)			**$0.888**	**$1.219**	**$1.392**	**$1.427**	**$1.638**
Cost Per Unit Oxygen ($/SCF)			**$0.023**	**$0.032**	**$0.037**	**$0.038**	**$0.043**
Present Oxygen Costs							
Present Annual Oxygen Cost			**$32,191**	**$75,112**	**$103,010**	**$150,223**	**$214,605**
Present Annual rental/service costs			**$13,193**	**$30,783**	**$42,217**	**$61,567**	**$87,953**
Total annual cost			**$45,384**	**$105,895**	**$145,228**	**$211,790**	**$302,557**
Annual Savings with Arbor System			**$25,940**	**$72,847**	**$105,512**	**$155,305**	**$232,284**
SIMPLE PAYBACK (Months)			**47.9**	**26.6**	**21.0**	**20.2**	**15.7**
PAYBACK (incl. capital costs) (Months)			**54.7**	**30.4**	**23.9**	**23.0**	**17.8**

Appendix F

Industrial Facility: 95% O2											
Currently Using Bulk Liquid											
Price discount:	10%										
US / CDN exch rate:	0.72										
Current O 2 cost/SCF:	$0.01	$0.38	NM 2								
Operating days/year:	365										
Operating hours/day:	24										
Electricity cost:	$0.13	Price $US:	$4,300	$5,625	$6,575	$10,150	$13,750	$15,300	$26,125	$34,375	$43,550
			HE1	HE2	HE3	HE4	HE6	HE7	HE14	HE20	HE26
			30	50	100	150	200	250	500	750	1000
Days/Year Operating			365	365	365	365	365	365	365	365	365
Hours/Day Operating			24	24	24	24	24	24	24	24	24
Unit Output (Nm 3/hr)			0.79	1.31	2.63	3.94	5.26	6.57	13.14	19.72	26.29
Duty Cycle			98.00%	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%
Oxygen Production (Nm 3/month)			564	940	1,881	2,821	3,761	4,702	9,403	14,105	18,807
H 'Cylinders per year			1,055	1,759	3,518	5,277	7,036	8,795	17,591	26,386	35,181
Power Costs											
Electric $/KWH ($CDN)			0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
KWH/Nm 3 O 2			1.97	1.44	1.70	1.39	1.39	1.20	1.23	1.05	1.02
Avg. Electric Cost/Nm 3 Oxygen ($CDN)			$0.2561	$0.1872	$0.2211	$0.1807	$0.1794	$0.1560	$0.1598	$0.1365	$0.1326
Annual Electric Cost - Arbor System ($CDN)			$1,734	$2,112	$4,989	$6,117	$8,097	$8,801	$18,036	$23,104	$29,925
Maintenance & Other Costs											
Spare Parts/Year			$200	$200	$200	$200	$400	$400	$400	$400	$400
Maintenance Labor/Year			$200	$200	$200	$200	$300	$300	$300	$300	$300
Tot Annual Maint. & Other Costs - Arbor System			$400	$400	$400	$400	$700	$700	$700	$700	$700
Annual Equip Amort.											
Arbor Unit Price ($CDN, incl discount)			$5,375	$7,031	$10,719	$12,688	$17,188	$19,125	$32,656	$42,969	$56,938
Est. Freight, Taxes & Installation (+20%)			$1,075	$1,406	$2,144	$2,538	$3,438	$3,825	$6,531	$8,594	$11,388
Total Customer Cost			$6,450	$8,438	$12,863	$15,225	$20,625	$22,950	$39,188	$51,563	$68,325
Annual Capital Costs (10 Years at 8%)			$961	$1,257	$1,917	$2,269	$3,074	$3,420	$5,840	$7,684	$10,182
Total Costs											
Operating Costs (per year)			$2,134	$2,512	$5,389	$6,517	$8,797	$9,501	$18,736	$23,804	$30,625
Total Cost (per year)			$3,095	$3,770	$7,306	$8,786	$11,871	$12,922	$24,576	$31,488	$40,807
Cost Per Unit Oxygen ($/m 3)			$2.232	$3.054	$3.152	$3.932	$3.960	$4.458	$4.585	$5.405	$5.643
Cost Per Unit Oxygen ($/SCF)			$0.059	$0.080	$0.083	$0.102	$0.102	$0.117	$0.123	$0.144	$0.148
Present Oxygen Costs											
Present Annual Oxygen Cost			$2,575	$4,292	$8,584	$12,876	$17,168	$21,460	$42,921	$64,381	$85,842
Present Annual rental/service costs			$7,916	$13,193	$26,386	$39,579	$52,772	$65,965	$131,929	$197,894	$263,858
Total annual cost			$10,491	$17,485	$34,970	$52,455	$69,940	$87,425	$174,850	$262,275	$349,700
Annual Savings with Arbor System			$7,396	$13,715	$27,664	$43,669	$58,069	$74,503	$150,274	$230,787	$308,893
SIMPLE PAYBACK (Months)			13.9	9.6	7.9	6.0	6.1	5.2	4.6	3.9	3.8
PAYBACK (incl capital costs)(Months)			15.5	10.7	8.7	6.6	6.7	5.8	5.1	4.3	4.2

Appendix G

Industrial Facility: 95% O2											
Currently Using Bulk Liquid											
Price discount:	10%										
US / CDN exch rate:	0.72										
Current O2 cost/SCF:	$0.01	$0.38	NM 2								
Operating days/year:	365										
Operating hours/day:	24										
Electricity cost:	$0.13	Price ($US):	$4,300	$5,635	$8,575	$10,150	$13,750	$15,300	$26,125	$34,375	$45,650
			HE1	HE2	HE3	HE4	HE6	HE7	HE14	HE20	HE26
			30	50	100	150	200	250	500	750	1000
Days/Year Operating			365	365	365	365	365	365	365	365	365
Hours/Day Operating			24	24	24	24	24	24	24	24	24
Unit Output (Nm3/hr)			0.79	1.31	2.63	3.94	5.26	6.57	13.14	19.72	26.29
Duty Cycle			98.00%	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%
Oxygen Production (Nm3/month)			564	940	1,881	2,821	3,761	4,702	9,403	14,105	18,807
# Cylinders per year			1,055	1,759	3,510	5,277	7,034	8,795	17,591	26,386	35,181
Power Costs											
Electric $/KWH ($CDN)			0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
KWH/Nm3 O2			1.97	1.44	1.70	1.39	1.38	1.20	1.23	1.05	1.02
Avg. Electric Cost/Nm3 Oxygen ($CDN)			$0.2561	$0.1872	$0.2211	$0.1807	$0.1794	$0.1560	$0.1598	$0.1365	$0.1326
Annual Electric Cost - Arbor System ($CDN)			$1,734	$2,112	$4,989	$6,117	$8,097	$8,801	$18,036	$23,104	$29,925
Maintenance & Other Costs											
Spare Parts/Year			$200	$200	$200	$200	$400	$400	$400	$400	$400
Maintenance Labor/Year			$200	$200	$200	$200	$300	$300	$300	$300	$300
Tot Annual Maint. & Other Costs - Arbor System			$400	$400	$400	$400	$700	$700	$700	$700	$700
Annual Equip Amort.											
Arbor Unit Price ($CDN, incl. discount)			$5,375	$7,031	$10,719	$12,688	$17,188	$19,125	$32,656	$42,969	$56,938
Est. Freight, Taxes & Installation (+20%)			$1,075	$1,406	$2,144	$2,538	$3,438	$3,825	$6,531	$8,594	$11,388
Total Customer Cost			$6,450	$8,438	$12,863	$15,225	$20,625	$22,950	$39,188	$51,563	$68,325
Annual Capital Costs (10 Years at 8%)			$961	$1,257	$1,917	$2,269	$3,074	$3,420	$5,840	$7,684	$10,182
Total Costs											
Operating Costs (per year)			$2,134	$2,512	$5,389	$6,517	$8,797	$9,501	$18,736	$23,804	$30,625
Total Cost (per year)			$3,095	$3,770	$7,306	$8,786	$11,871	$12,922	$24,576	$31,488	$40,807
Cost Per Unit Oxygen ($/m3)			$2.232	$2.054	$3.152	$2.932	$3.000	$4.455	$4.605	$5.405	$5.643
Cost Per Unit Oxygen ($/SCF)			$0.059	$0.080	$0.083	$0.103	$0.102	$0.117	$0.123	$0.144	$0.148
Present Oxygen Costs											
Present Annual Oxygen Cost			$2,575	$4,292	$8,584	$12,876	$17,168	$21,460	$42,921	$64,381	$85,842
Present Annual rental/service costs			$7,916	$13,193	$26,386	$39,579	$52,772	$65,965	$131,929	$197,894	$263,858
Total annual cost			$10,491	$17,485	$34,970	$52,455	$69,940	$87,425	$174,850	$262,275	$349,700
Annual Savings with Arbor System			$7,396	$13,715	$27,664	$43,669	$58,069	$74,503	$150,274	$230,787	$309,893
SIMPLE PAYBACK (Months)			13.9	9.6	7.9	6.0	6.1	5.2	4.6	3.9	3.8
PAYBACK (incl. capital costs)(Months)			15.5	10.7	8.7	6.6	6.7	5.8	5.1	4.3	4.2

Appendix H

Cylinder Filling station: Sea Container						
99% purity required						
Price discount:	10%					
US / CDN exch rate:	0.72					
Current O2 cost/SCF:	$0.240	$9.129	NM 3			
Operating days/year:	365					
Operating hours/day:	24	Unit weight#	15000	16000	17000	18000
Electricity cost:	$0.15	Price $US:	$43,800	$78,800	$91,825	$138,400
			HP2C	HP6C	HP9C	HP14C
			75	150	350	500
Days/Year Operating			365	365	365	365
Hours/Day Operating			24	24	24	24
Unit Output (Nm 3/hr)			1.97	3.94	9.20	13.14
Duty Cycle			98.00%	98.00%	98.00%	98.00%
Oxygen Production (Nm 3/month)			1,410	2,821	6,582	9,403
cylinders per year			2,639	5,277	12,313	17,591
Power Costs						
Electric $/KWH ($CDN)			0.15	0.15	0.15	0.15
KWH/Nm3 O2			4.57	4.92	2.11	2.61
Avg. Electric Cost/Nm3 Oxygen ($CDN)			$0.6862	$0.7380	$0.3163	$0.3915
Annual Electric Cost - Arbor System ($CDN)			$11,615	$24,982	$24,982	$44,182
Maintenance & Other Costs						
Spare Parts/Year			$200	$200	$200	$200
Maintenance Labor/Year			$200	$200	$200	$200
1/4 man to operate filling station			$15,000	$15,000	$15,000	$15,000
Cylinder Inspection			$500	$500	$500	$500
Tot Annual Maint. & Other Costs - Arbor System			$15,900	$15,900	$15,900	$15,900
Annual Equip. Amort.						
Arbor Unit Price ($CDN)			$54,750	$98,500	$114,781	$173,000
Est. Freight, Taxes & Installation			$8,270	$12,832	$14,646	$20,655
200 H' cylinders cost			$19,000	$19,000	$19,000	$19,000
Sea-Container option			$33,750	$37,500	$41,250	$43,750
Compressor			$9,014	$12,528	$16,729	$28,111
Total Customer Cost			$115,770	$167,832	$189,678	$256,405
Annual Capital Costs (3 Years at 8%)			$44,923	$65,124	$73,601	$99,494
Total Costs						
Operating Costs (per year)			$27,515	$40,882	$40,882	$60,082
Total Cost (per year)			$72,438	$106,006	$114,483	$159,575
Cost Per Unit Oxygen ($/m3)			$4.194	$3.069	$1.420	$1.386
Cost Per Unit Oxygen ($/SCF)			$0.110	$0.081	$0.037	$0.036
Present Oxygen Costs						
Present Annual Oxygen Cost			$154,515	$309,031	$721,072	$1,030,102
Present Annual rental/service costs			$13,193	$26,386	$61,567	$87,953
Total annual cost			$167,708	$335,416	$782,638	$1,118,055
Annual Savings with Arbor System			$95,270	$229,410	$669,155	$958,480
SIMPLE PAYBACK (Months)			18.0	10.9	4.1	4.0
PAYBACK (incl. capital costs) (Months)			23.7	14.3	5.5	5.2

Appendix I

Cylinder Filling station: Sea Container									
95% purity required									
Price discount:	10%								
US / CDN exch rate:	0.72								
Current O2 cost/SCF:	$0.240	$9.129	NM 3						
Operating days/year:	365								
Operating hours/day:	24	Unit weight#	15000	15500	16000	16500	17000	17500	18000
Electricity cost:	$0.15	Price $US:	$32,200	$50,150	$53,750	$58,300	$69,125	$111,275	$122,450
			HE3C	HE4C	HE6C	HE7C	HE14C	HE20C	HE26C
			100	150	200	250	500	750	1000
Days/Year Operating			365	365	365	365	365	365	365
Hours/Day Operating			24	26	24	24	24	24	24
Unit Output (Nm 3/hr)			2.63	3.96	5.26	6.57	13.14	19.72	26.29
Duty Cycle			98.00%	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%
Oxygen Production (Nm 3/month)			1,881	2,821	3,761	4,702	9,403	14,105	18,807
Cylinders per year			3,518	5,277	7,036	8,795	17,591	26,386	35,181
Power Costs									
Electric $/KWH ($CDN)			0.15	0.15	0.15	0.15	0.15	0.15	0.15
KWH/Nm 3 O2			3.43	2.37	3.69	2.95	2.61	2.12	1.59
Avg. Electric Cost/Nm 3 Oxygen ($CDN)			$0.5147	$0.3549	$0.5535	$0.4428	$0.3915	$0.3179	$0.2304
Annual Electric Cost - Arbor System ($CDN)			$11,615	$12,014	$24,982	$24,982	$44,182	$53,801	$53,801
Maintenance & Other Costs									
Spare Parts/Year			$200	$200	$200	$200	$200	$200	$200
Maintenance Labor/Year			$200	$200	$200	$200	$200	$200	$200
1/4 man to operate filling station			$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000
Cylinder Inspection			$500	$500	$500	$500	$500	$500	$500
Tot Annual Maint. & Other Costs - Arbor System			$15,900	$15,900	$15,900	$15,900	$15,900	$15,900	$15,900
Annual Equip Amort.									
Arbor Unit Price ($CDN)			$40,250	$62,688	$67,188	$72,875	$86,406	$139,094	$153,063
Est. Freight, Taxes & Installation			$6,820	$8,132	$8,582	$9,151	$10,504	$15,773	$17,170
monthly/2 H 'cylinders cost			$13,926	$20,889	$27,852	$34,815	$69,629	$104,444	$139,258
Sea-Container option ($cdn)			$33,750	$36,250	$37,500	$40,000	$41,250	$42,500	$43,750
Compressor			$9,014	$9,014	$12,528	$12,528	$16,729	$28,111	$28,111
Total Customer Cost			$94,746	$127,959	$141,122	$156,841	$207,790	$301,811	$353,241
Annual Capital Costs (3 Years at 8%)			$36,765	$49,652	$54,760	$60,859	$80,629	$117,113	$137,069
Total Costs									
Operating Costs (per year)			$27,515	$27,914	$40,882	$40,882	$60,082	$69,701	$69,701
Total Cost (per year)			$64,280	$77,567	$95,642	$101,741	$140,711	$186,814	$206,770
Cost Per Unit Oxygen ($/m 3)			$2.791	$2.246	$2.077	$1.767	$1.222	$1.082	$0.898
Cost Per Unit Oxygen ($/SCF)			$0.073	$0.059	$0.055	$0.046	$0.032	$0.028	$0.024
Present Oxygen Costs									
Present Annual Oxygen Cost			$206,020	$309,031	$412,041	$515,051	$1,030,102	$1,545,153	$2,060,204
Present Annual rental/service costs			$17,591	$26,386	$35,181	$43,976	$87,953	$131,929	$175,905
Total annual cost			$223,611	$335,416	$447,222	$559,027	$1,118,055	$1,677,082	$2,236,110
Annual Savings with Arbor System			$159,331	$257,850	$351,580	$457,286	$977,344	$1,490,269	$2,029,340
SIMPLE PAYBACK (Months)			9.2	7.3	6.2	5.2	3.3	3.0	2.5
PAYBACK (incl. capital costs) (Months)			12.0	9.6	8.1	6.8	4.3	3.9	3.3