CANADIAN HYDROGEN SURVEY – 2004/2005

CAPACITY, PRODUCTION & SURPLUS – UPDATE

A Study Conducted for Natural Resources Canada

June 2005

Dalcor Consultants Ltd

and

Camford Information Services Inc.

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The authors wish to thank the many companies and many individuals who so generously assisted this study by providing their time and relevant hydrogen process data at numerous facilities across Canada.

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Background:

This report presents the results of a survey conducted by Dalcor Consultants Ltd and Camford Information Services Inc. in the spring of 2005 to inventory the Canadian hydrogen production capacity, actual production for the past year and the amount of hydrogen produced but not used for product feedstock or commercial sale. The consultants conducted a similar survey in early 2004. The current data presented is for production capacity as of March 2005, and the production and surplus volumes reflect 2004 annual data.

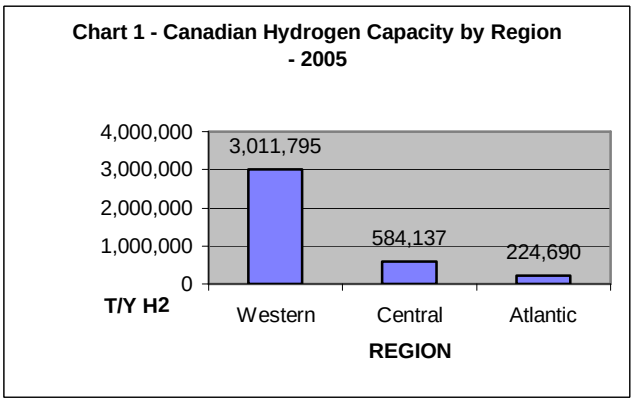
The data was collected by telephone and electronically from the vast majority of the facilities. Senior operating staff at each facility were asked to provide an average daily rate annual rate and the number of operating days or an annual production figure. There were a few exceptions to voluntary supply of data by producer companies. A few producers believed the data requested was commercially confidential and did not wish to participate in the survey. In these cases, the consultants have estimated the capacity and annual production based upon publicly available production reports and facility descriptions. This report is intended to publicly available to interested parties and does not, so far as the consultants have been advised, contain confidential information.

For purposes of this report, as for the 2003 report, Canada has been divided into three geographic regions, Western Region, Central Region and Atlantic Region.

1. Canadian Hydrogen Production

In 2004 Canada produced 3,403,000 tonnes of hydrogen, about 100 thousand tonnes more than in 2003. The comparative numbers for capacity, production and surplus hydrogen production for 2003 and 2004/2005 are displayed in Table 1 entitled "Canadian Hydrogen Capacity, Production and Surplus by Sector and Region – 2003/2004 Comparison". Percentage changes are also indicated. Detailed data sheets reflecting individual hydrogen sites surveyed are attached as Appendix A to this report.

Over the past two years the vast majority of increased hydrogen capacity, production and surplus has been in the Western Region. In that region the needs for higher quality synthetic crude oil produced by hydrogen upgrading of oilsands bitumen and the improved markets for North American ethylene have given a significant boost to Canadian hydrogen statistics.



As displayed in Table 1 and Chart 1 – *"Canadian Hydrogen Capacity by Region – 2005*, there has been an overall increase in hydrogen production capacity of about 13%. The total Canadian hydrogen capacity as of the end of April 2005 was 3.82 million tonnes per year (t/y).

CANADIAN HYDROGEN CAPACITY, PRODUCTION and SURPLUS BY SECTOR AND REGION - 2003 to 2004 COMPARISON (tonnes/year)

Rev 3 - 6/29/2005

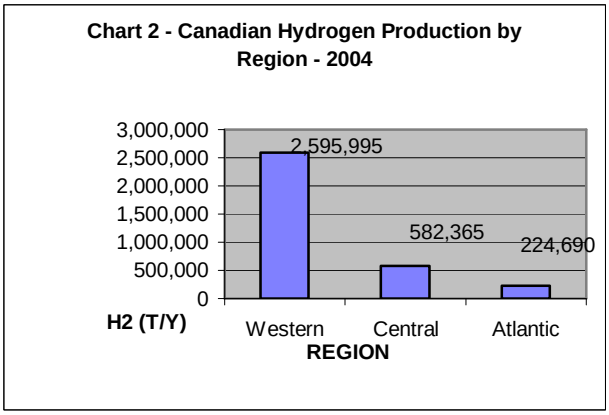
	2005 - Capacity	2003 - Capacity	Δ%	2004 - Production	2003 - Production	Δ%	2004 - Surplus	2003 - Surplus	Δ%
Western Region	(t/y)	(t/y)		(t/y)	(t/y)		(t/y)	(t/y)	
Oil Refining	163,770	198,270	0	163,300	185,355	0	0	0	n/c
2003 Correction[1]		-34,000			-22,600				
Heavy Oil Upgrading	959,000	770,000	25	789,000	770,000	2	0	0	n/c
Chemical Industry	1,302,625	912,900	23	1,105,500	912,900	4	67,900	26,100	160
2003 Correction[2]		150,000			150,000				
Chem. Ind. By-product	586,400	463,000	1	538,195	398,609	5	182,471	147,653	24
2003 Correction[3]		116,000			116,000				
Merchant Gas	0	0		0	0		0	0	n/c
Sub-total	**3,011,795**	**2,576,170**	17	**2,595,995**	**2,498,864**	3	**250,371**	**173,753**	44
Central Region									
Oil Refining	417,362	437,362	0	417,362	437,362	0	0	0	n/c
2003 Correction*		-20,000			-20,000				
Chemical Industry	74,075	74,075	0	73,591	73,591	0	0	0	n/c
Chem. Ind. By-product	72,000	72,000	0	70,712	70,712	0	22,154	22,154	n/c
Merchant Gas	20,700	16,700	0	20,700	16,700	0	0	0	n/c
2003 Correction*		4,000			4,000				
Sub-total	**584,137**	**584,137**	0	**582,365**	**582,365**	0	**22,154**	**22,154**	0.00
Atlantic Region									
Oil Refining	222,000	222,000	n/c	222,000	222,000	n/c	0	0	n/c
Chemical Industry	0	0		0	0		0	0	n/c
Chem. Ind. By-product	2,690	2,690	n/c	2,690	2,690	n/c	0	0	n/c
Merchant Gas	0	0		0	0		0	0	n/c
Sub-total	**224,690**	**224,690**	n/c	**224,690**	**224,690**	n/c	**0**	**0**	n/c
TOTALS FOR CANADA	**3,820,622**	**3,384,997**	**13**	**3,403,050**	**3,305,919**	**3**	**272,525**	**195,907**	**39**

Table 1 - Canadian Hydrogen Capacity, Production and Surplus by Sector and Region – 2003/2004 Comparison

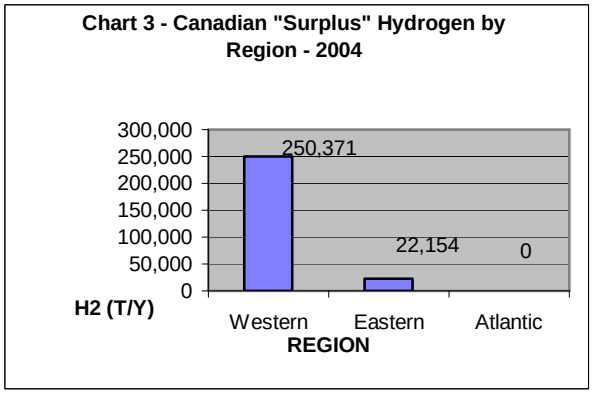
Most of this increased capacity was only on-stream late in 2004 or early 2005 therefore the associated larger capacity had little effect on the 2004 production data. Oilsands upgrading and increasingly more stringent gasoline and diesel fuel specifications have demanded new dedicated hydrogen production facilities to support oil refineries and upgrading plants, many that have been in operation for more than 20 years. Fertilizer demand also increased and accounts for about 15% of new hydrogen production.

Increased hydrogen production is most noticeable within the chemical sector where increased demand has allowed facilities that have been operating under-capacity to increase volume. Most refineries are operating at the maximum hydrogen capacity and as such cannot increase production without adding new capacity. The total increase in

Canadian hydrogen production represents only a 3% increase over 2003, an amount slightly below the anticipated 5% per annum increase. Assuming that chemical product markets remain strong there will be a significant increase in 2005 production as completed new facilities come on stream.



Surplus hydrogen, as displayed in Chart 3 has increased to 272 thousands tonnes up 39 % from 2003. This increase reflects two major sources. The first component of increase is corrected information from a single integrated chemical complex (Celanese Canada, Edmonton, AB) which added an additional 40 thousands tonnes of fuel-use hydrogen. This volume had previously been unreported in 2003.



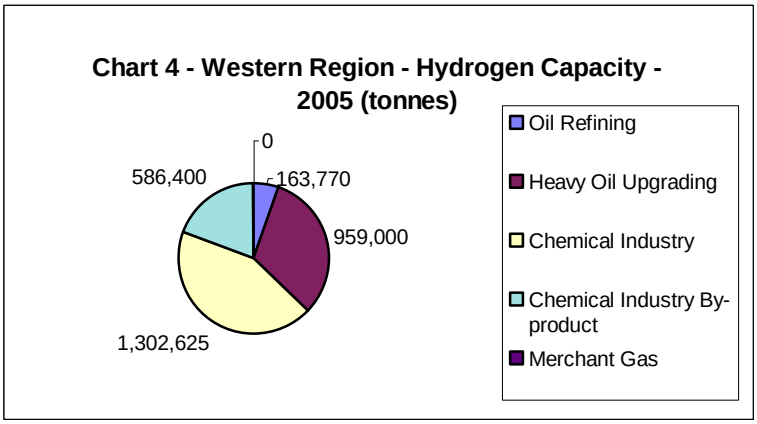
The second component of increase is the improved ethylene markets for Dow and Nova Chemicals. This year these companies added 45,000 t/y of unused by-product hydrogen from ethylene plants in Alberta and Ontario. It should be noted that under the terms of this study and the one in 2003, fuel-use of rich hydrogen streams was not considered a sufficiently high-value-use to warrant consideration as commercial use. A more detailed description of surplus hydrogen is found in Appendix B where a section of the comprehensive 2004 Canadian Hydrogen report is reproduced.

Although is it difficult to determine from the data comparison between 2003 and 2004, there is qualitative information that surplus hydrogen is becoming more valued. Some hydrogen producer companies are actively searching for higher-value internal use while other companies are soliciting sales for excess production. The chemical complex at Fort Saskatchewan containing Dow Chemicals, the Albion (Shell and Partners) Upgrader consumes about 65% of the surplus hydrogen produced. The Praxair hydrogen pipeline further integrates this these facilities with Celanese Canada and several other producers in the East Edmonton and Strathcona County. The Joffre, AB, ethylene plants have an integrated fertilizer facility but fertilizer plant capacity, falls short of current by-product hydrogen production. About 40% of the total 2004 Canadian surplus, or approximately 107 thousands tonnes, was produced at Joffre.

2. Canadian Hydrogen by Region

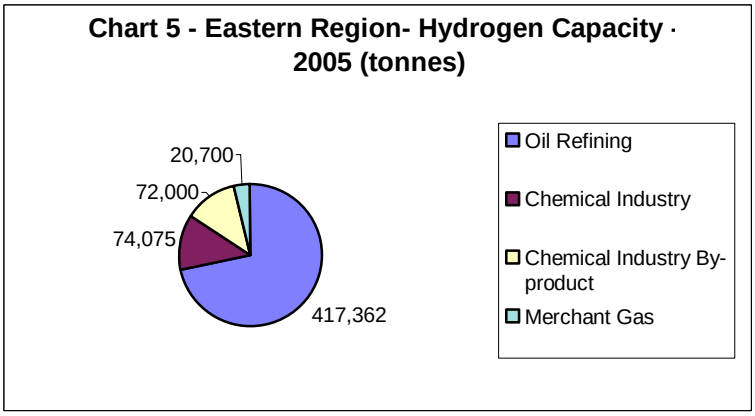
This section presents a discussion of the regional breakdown of capacity, production and surplus. Regional data is presented in Table 1 and referenced earlier in this report and in the following charts.

The Western Region, comprising British Columbia, Alberta, Saskatchewan, and Manitoba, shows a 25% increase in capacity in heavy oil upgrading applications and 21% increase for chemical applications. Chemical industry increases of 240 thousand t/y in capacity arises from new fertilizer and related chemical industry expansions, while about 190 thousand t/y of the increase is from new dedicated hydrogen plants for the production of synthetic crude oil. There were virtually no changes in capacity or production on the oil refinery, chemical by-product or merchant gas sectors. Hydrogen production increased by 3 % overall with chemical and chemical-by-product sector showing increases of 4% and 5% respectively. The other sectors in the West showed small increases in production reflecting the fact that large capacity increases came late in the year or in early 2005.

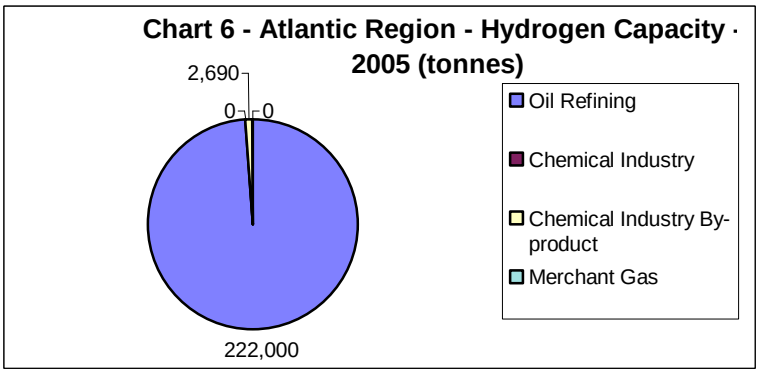


There was a 44 % increase in surplus hydrogen due to a correction this year for hydrogen used as fuel in the Celanese facility in Edmonton that had not previously been recorded and by increased ethylene production at Joffre. Total surplus hydrogen in the West is now about 250 t/y and represents about 96 % of the total Canadian surplus production.

In the Central Region, comprising Ontario and Quebec, there were no significant changes in hydrogen production since 2003. New capacity is currently under construction and will reflect changes in 2005. The surplus of 22 thousand t/y remains constant. The Central Region also has upwards of 100 thousand t/y of hydrogen produced by the coking ovens of the three major steel facilities. Attempts to recover this hydrogen have so far been unsuccessful and/or uneconomic. Consequently the corresponding hydrogen volumes have not been included in the surplus hydrogen list. This large potential remains to be tapped if the value and demand for hydrogen in Ontario increases, for example demand from PEM fuel cell vehicles.



The Atlantic Region, comprising New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland, reports no change in hydrogen capacity, production or surplus. Canada's largest oil refinery, Irving Oil, in Dartmouth, NB continues to be able to source higher quality crudes and with process improvements has not required additional hydrogen to meet newer fuel specifications. This situation is likely to change in the near future as global oil stock and quality shrinks and fuel specifications continue to tighten.



3. Canadian Hydrogen by Sector

Hydrogen industry sector totals are summarized at in Table 2 – *Canadian Hydrogen Production by Sector – 2004* set out below.

Table 2 - Canadian Hydrogen Production by Sector – 2004

Sector Totals	2005 - Capacity	2003 - Capacity	Δ%	2004 - Production	2003 - Production	Δ%	2004 - Surplus	2003 - Surplus	Δ%
Oil Refining	803,132	803,632	0	802,662	790,717	2	0	0	
Heavy Oil Upgrading	959,000	770,000	25	789,000	770,000	2	0	0	
Chemical Industry	1,376,700	1,136,975	21	1,179,091	1,136,491	4	67,900	26,100	160
Chem. Ind By-product	661,090	653,690	1	611,597	588,011	4	204,625	169,807	21
Merchant Gas	20,700	20,700	0	20,700	20,700	0	0	0	

The oil-refining sector across Canada showed a 2 % increase in hydrogen production with no change in capacity. Typically refiners use all the recoverable hydrogen produced onsite and do not have any surplus. New dedicated hydrogen plants are under construction by Air Products and Chemicals in Edmonton and Sarnia. These merchant gas company owned, steam methane reformer units, are due to begin production this year and in 2006, and will contribute about 120 thousand t/y or an additional 15 % to the refinery sector.

Hydrogen capacity for heavy oil upgrading increased by 25 % to approximately 800 thousand t/y with virtually all the capacity increase coming on-stream in late 2004 and the spring of 2005. Annual production for 2004 was only 2 % greater than in 2003. Heavy oil upgrading is expected to be the strongest long-term hydrogen production and use sector over the next 25 years. Depending upon global oil prices and North American demand, heavy oil upgrading will require from 3.5 million to a potential 6.0 million tonnes

of additional hydrogen by 2030. The increased demand will be primarily driven by new plants currently scheduled or planned for construction and from the demand for increasingly higher quality synthetic crude oil (SCO). Some industry experts suggest that hydrogen content per barrel of SCO will increase from about 1,500 standard cubic feet to 2000 standard cubic feet.

It is worth noting the Opti/Nexen gasifier being constructed at the company's oilsands project at Long Lake, Alberta. This project reflects the first breakaway from the use of natural gas and SMR as the hydrogen source for upgrading the bitumen. To quote Opti/Nexen the gasifier will use, *"asphaltene residue to produce virtually all the fuel gas and hydrogen required to fuel the commercial scale SAGD operation, a related cogeneration facility and the upgrading components"* and will be the second largest gasifier in North America. The gasifier component of the project has industry-wide attention as oilsands operators and developers are confronted with increased cost and reduced availability of natural gas.

Most chemical industry increases were in the fertilizer sector where improved prices for cereal and oil crops pushed North American demand. Capacity was increased by 21 % to meet these needs. Again the 2004 production increase was a modest 4 % pending the impact of new facilities coming on-stream. Increased surplus hydrogen by 160 % was almost entirely due to a fuel-use correction at one facility.

The Chemical By-Product sector, which includes ethylene and electrolytic-chemical facilities, increased hydrogen production by 4 % due to improved ethylene markets. There was no increase in capacity as producer companies are not confident that there are sufficient economic natural gas reserves available to justify adding capacity. Future gas pipelines from the US and Canadian Arctic fields could change this perspective.

The Merchant Gas sector did not change appreciably in 2004. However, this sector is expected to grow rapidly over the next 20 years as refinery and bitumen upgrading producers start to meet hydrogen demands by utilizing the investment capital of the major globally based merchant gas companies.

4. New Hydrogen Projects Announced

Announced new hydrogen projects in Canada amounted to about 710,000 t/y. Of this about 120,000 t/y is merchant gas production for sale to oil refineries in Edmonton and Sarnia. A total of 659-thousand t/y increase in capacity is scheduled in the Western Region, of which all but 61 thousand t/y is for bitumen upgrading. A 60 thousand t/y SMR facility will be on-stream in Sarnia, by 2006.

About 85 % of new hydrogen production related to the many announced oilsands projects. At this time only one new oil sands facility, OmniNexen's Long Lake facility, is actually under construction, with about 60,000 t/y is gasifier-based hydrogen facility. However, there are three other "green field" plants under active engineering design and site development. Of existing plants, Syncrude's new 4th line came on-stream in May 2005 and is included in this total.

Table 3 – Announced New Capacity in Canada by Region 2005

New Capacity Announced - Western Region

Supplier	Location and End-use		Cap. t/y	Type
Air Products	Edmonton, AB	Product to PetroCanada & Imperial	61,000	SMR
Suncor	Fort McMurray	SMR - Upgrading bitumen	130,000	SMR
Opti-Nexen - Long Lake	Fort McMurray	Upgrading bitumen	60,000	Gasifier
Other Oilsands Projects	Fort McMurray	Upgrading bitumen	400,000.	Not specified

New Capacity Announced - Central Region

Supplier	Location and End-use		Cap. t/y	Type
Air Products	Sarnia, ON	Product to Suncor Energy and Shell Canada refineries	69,000	SMR

New Capacity Announced – Atlantic Region

No projects announced as of April 2005

For the most part, announcements of the many new oilsands developments do not detail proposed hydrogen capacity. As the basic facility for bitumen extraction does not need hydrogen the amount of upgrading to produce synthetic crude oil (SCO) can be a delayed decision. Pipelining of bitumen from the Fort McMurray area is possible and is currently being done. The bitumen designated for pipelining is diluted with recycled petroleum diluent and pipelined to upgrading plants or in some cases to certain US oil refineries that have cokers, rendering the refineries capable of using heavy oils as feed-stock. Upgrading of bitumen near the production site offers a significantly enhanced unit price for the SCO. From a strategic point of view Alberta would like to make the highest possible value-add to the bitumen product prior to shipment outside the province. Mined bitumen, as opposed to steam assisted gravity displacement (SAGD) recovered bitumen, retains some silica content after the final separation process, consequently it is regarded as less desirable for pipelining. In the long-term, the cost of hydrogen production at bitumen recovery site is likely to remain generally competitive compared to other North American locations. Hence upgrading in Alberta should be considered a significant component of the Canadian hydrogen sector well into the future.

For a current complete listing of proposed oilsands projects, please refer to the following web address: www.alberta-canada.com/oandg/files/pdf/oilsands_spring2005.pdf

APPENDIX A

CANADIAN HYDROGEN INVENTORY

CAPACITY, PRODUCTION & SURPLUS

2004/2005

Prepared by

Dalcor Consultants Ltd

And

Camford Information Services Inc

Rev 2: June 19/05

Western Region

Oil Refinery (H_2 tonnes/year)

Company	*Plant Location*	Capacity	*Principal Product*	*Production*	*Sold*	*Surplus*	*Remarks*
Chevron	Burnaby, BC	10,000	petroleum products	10,000		0	3,000 current surplus (fuel) destined for gasoline and diesel treatment over next 3 years
Consumers Co-op Refinery	Regina, SK	61,000	petroleum products	60,600	Overstated 2003 - 95,000t/y	0	Internal debottlenecking will provide sufficient H2 to meet diesel specs.
Husky	Prince George, BC	1,200	petroleum products	1,200		0	By-product H2 from naphtha reformer, new SMR unit on stream March 2006 1200 t/y
Imperial Oil	Edmonton, AB	16,570	petroleum products	16,500		0	Avg. daily volume 16.5 t/y H2 processed, increasing by 2006. Will purchase approx 14,000 t/y from APCI
Petro-Canada	Edmonton, AB	32,000	petroleum products	32,000		0	NB: New 71 million scf/d H2 plant by Air Products. On-stream Apr 2006, 48,000 t/y PetroCan, 14,000 t/y IOL
Shell Canada	Scotford, AB	43,000	petroleum products	43,000		0	Additional required for 2006 diesel hydrotreater
Total		**164 K**		**164 K**		**0**	

Heavy Oil Upgrading (H_2 tonnes/year)

Company	*Plant Location*	*Capacity*	*Principal Product*	*Production*	*Sold to Others*	*Surplus*	*Remarks*
Husky Energy	Lloyd-minster, SK	75,000	synthetic crude oil	75,000		0	
Albian - Upgrader	Scotford, AB	225,000	synthetic crude oil	225,000		0	Does not include 100 t/y from Dow
NewGrade Energy	Regina, SK	39,000	synthetic crude oil	39,000			Upgrader is integral part of Consumers' Coop Refinery
Suncor	Fort McMurray, AB	130,000	synthetic crude oil	130,000		0	Announced increase in hydrogen production to 260,000 t/y by 2012
Syncrude	Fort McMurray, AB	490,000	synthetic crude oil	320,000		0	Hydrogen plant #4 at 173,000 t/y on stream in April 2005
Total		**959 K**		**789 K**		**0**	

Chemical Process Use (H_2 tonnes/year)

Company	*Plant Location*	*Capacity*	*Principal Product*	*Production*	*Sold to Others*	*Surplus*	*Remarks*
Agrium	Carsland, AB	104,000	ammonia, urea	100,500		0	
Agrium	Fort Saskatchewan, AB	86,500	ammonia, urea	86,500		0	
Agrium	Joffre	0		0		0	Purchases H2 at 100,000 t/y from NovaChem
Agrium	Redwater, AB	160,125	ammonia, ammonium nitrate, urea	129,400	Understated in 2003 - 92,000t/y	0	Unit #1 - 52,000 t/y capacity. Unit #2 - 108,125 t/y
Alberta Envirofuels	Edmonton, AB	35,000	iso-octane	35,000		0	Current surplus ~ nil, up-grade of PSA will gen-erate 2,500 - 5,600 t/y
Canadian Fertilizers	Medicine Hat, AB	190,000	ammonia, urea	189,000		0	Membrane hydrogen recovery unit installed
Celanese	Edmonton, AB	216,300	cellulose acetate, formalde-hyde, & methanol	216,300	Understated in 2003 at 134,000t/y	60,500	Surplus used as fuel. 130,000 t/y for methanol and 26,000 t/y to Shell Albion ugrader via Praxair pipeline.
Degussa	Gibbons, AB	3,000	hydrogen peroxide	2,800		0	1,800 Nm3/hr from Praxair pipelining, 3,600 Ncm/hr from own SMR
FMC	Prince George, BC	3,000	hydrogen peroxide	0		3,400	H2 purchased from Chemtrade, sodium chlorate plant - 2 km pipeline
Methanex	Kitimat, BC	170,000	methanol	170,000		0	
Methanex	Medicine Hat, AB	150,000	methanol	0		0	Facility moth-balled - up to 150,000 t/y could be available
Saskferco	Belle Plaine, SK	86,000	ammonia, urea	86,000		0	
Simplot	Brandon, MB	83,700	ammonia, ammonium nitrate, urea	75,000		4,000	Could produce up10,000 t/y if demand increases.
Sherrit Gordon	Fort Saskatchewan	15,000	ammonia, ammonium nitrate, urea	15,000.0		0	Also on Praxair pipeline
Total		**1.3 M**		**1.1 M**		**66 K**	

Chemical Process By-Product (H_2 tonnes/year)

Company	*Plant Location*	*Capacity*	*Principal Product*	*Production*	*Sold to Others*	*Surplus*	*Remarks*
Cancarb	Medicine Hat, AB	26,000	Carbon Black	20,000		0	All used for process fuel with heat recovery to boiler for 30 MW steam turbine power to city grid
Chemtrade Pulp Chemicals	Prince George, BC	4,000	sodium chlorate	3,400	3,4000 t/y sold to FMC for hydrogen peroxide production	0	
Dow Chemical	Ft Saskatchewan, AB	130,000	electrolytic and process chemicals	124,000	N.B.: Understated in 2003 at 14,000	8,000	Some captive for hydrochloric acid production
ERCO	Bruderheim, AB	4,000	sodium chlorate	3,600		3,600	By-product H2, about 75% for internal fuel use; remainder vented
ERCO	Grand Prairie, AB	4,700	sodium chlorate	4,700		5,000	By-product H2 from sodium chlorate manufacture
ERCO	Hargrave, MB	2,000	sodium chlorate	2,000		2,000	By-product H2 from sodium chlorate manufacture - vented to air. Fuel use contemplated
ERCO	Vancouver, BC	5,500	sodium chlorate	5,500		5,500	By-product H2 - vented to air
ERCO	Saskatoon, SK	5,000	sodium chlorate, chlorine, caustic soda	4,200	Sell 250 t/y to surfactant mfg plant	2,000	Surplus currently vented,
Nexen	Brandon, MB	15,000	sodium chlorate	14,000		6,300	By-product H2 from sodium chlorate manufacture, 8,000 t/y used as fuel.
Nexen	Bruderheim, AB	4,500	sodium chlorate	4,100		1,802	By-product H2 from sodium chlorate manufacture, 1,860 t/y used as fuel, 407 t/y vent gas control, remainder vented
Nexen	Nanaimo, BC	1,500	sodium chlorate	1,500		1,269	vented to air,

Nexen	Vancouver, BC	4,200	chlorine, caustic soda	4,195	1,200 t/y for re-refining of oil	0	Most is fuel, 3,000 t/y., some internally for hydrochloric acid
Dow LHC-1	Ft Saskatchewan, AB	140,000	ethylene	140,000	100,000 t/y sold to Shell	40,000	
Nova Chemicals - E-1,2,&3	Joffre, AB	240,000	ethylene	207,000	100,00 t/y sold to Agrium, 0.2 t/y sold to Air Liquide	107,000	Facility below capacity. Facilities E-1 and E-2 are Nova and E-3 is jointly owned with Dow
Total		**586 K**		**538 K**		**182 K**	

Hydrogen Pipe Lines (H_2 tonnes/year)

Company	*Plant Location*	*Capacity*	*Principal Product*	*Production*	*Sold to Others*	*Surplus*	*Remarks*
Praxair	Strathcona, AB	80,000	hydrogen	18,000	H2 from Celanese meth-anol plant to Dow, Shell, Degussa		28,000 t/y additional capacity exists from Celanese if PSA is expanded. 30 km. 8 inch pipeline @ 800 psig.
Total		**80 K**		**18 K**		**0**	

Rev 2: June 19/05

Central Region

Oil Refinery (H_2 tonnes/year)

Company	Plant Location	Capacity	Principal Product	Production	Sold to Others	Surplus	Remarks
Imperial Oil	Sarnia, ON	39,000	petroleum products	39,000		0	SMR'S 2 and catalytic reformer. Has sufficient H2 capacity for future demand.
Imperial Oil	Nanticoke, ON	54,362	petroleum products	54,362		0	One catalytic reformer
Petro-Canada	Mississauga, ON	9,000	petroleum products	9,000		0	Facility in the process of being closed
Petro-Canada	Montreal East, PQ	125,000	petroleum products	125,000		0	Capacity was increased in 2003.
Shell Canada	Corunna, ON	17,000	petroleum products	17,000		0	Depending on feed H2 capacity is about 15mstc/day from CR3 reformer
Shell Canada	Montreal East, PQ	45,000	petroleum products	45,000		0	Depending on feed, capacity is 30-35mstc/day. Trying to increase daily feed by 15%. Additional H2 is purchased from Coastal and Petromont.
Sunoco	Sarnia, ON	48,000	petroleum products	48,000	Excess crude H2 is sold to Praxair Canada (2 million SCFper day)	0	H2 capacity also treats some of Shell diesel fuel production
Ultramar/Valero	Levis. PQ	80,000	petroleum products	80,000	N.B. Overstated 2003 at 80,000 t/y	0	H2 estimate by Dalcor. Facility is 2nd largest refinery in Canada.
Total		**417 K**		**417K**		**0**	

Chemical Process Use (H_2 tonnes/year)

Company	Plant Location	Capacity	Principal Product	Production	Sold to Others	Surplus	Remarks
ADM	Windsor, ON	1,075	Hydro-genated veg. oil	591		0	SMR unit on stream in 1996, production as needed, operating 50-60% of capacity

Kemira Chemicals	Maitland, ON	3,000	hydrogen peroxide	3,000		0	
Terra Intern-ational	Courtright, ON	70,000	ammonia, urea	70,000	H2 production for ammonia, & urea	0	small excess H2 is flared, operating rated output
Total		**74 K**		**73 K**		**0**	

Chemical Process By-Product (H_2 tonnes/year)

Company	*Plant Location*	*Capacity*	*Principal Product*	*Production*	*Sold to Others*	*Surplus*	*Remarks*
Coastal Petrochemicals	Montreal East, PQ	9,000	xylenes	9,000		0	
Eka Chemicals	Magog, PQ	6,000	sodium chlorate	5,100	Sold to BOC for liquid H2 production - 5.9 million SCF/day	900	By-product H2, burned as fuel or vented
Eka Chemicals	Valleyfield, PQ	6,000	sodium chlorate	6,000		6,000	By-product H2, burned as fuel or vented
ERCO	Buckingham, PQ	7,000	sodium chlorate	7,000		7,000	By-product H2, burned as fuel or vented
ERCO	Thunder Bay, ON	3,000	sodium chlorate	3,000		3,000	By-product H2, burned as fuel by adjacent pulp & paper plant or vented
Nexen Chemicals	Amherstburg, ON	3,000	sodium chlorate	3,060		2,754	By-product H2, 306 t/y internal requirements for vent control; excess vented
Nexen Chemicals	Beauharnois, PQ	3,000	sodium chlorate	2,552		2,500	By-product H2, burned as fuel 1,250 t/y, remainder vented
Nova Chemicals	Corunna, ON	15,000	ethylene	15,000		0	Ethylene by-product, H2 is consumed internally for reforming or fuel use
Nova Chemicals	Sarnia, ON	7,000	styrene	7,000	to Air Products (11,500 SCF/d)	0	Styrene by-product, H2 for captive purposes
PCI Chemicals	Becancour, PQ	8,000	caustic soda, chlorine	8,000	H2 is pipelined for H2O2 or liquefied.	0	H2 pipelined to Kemira for H2O2 and to Air Liquide for liquefication

Petromont	Varennes, PQ	5,000	ethylene	5,000	H2 is sold to a nearby refinery for use in refinery operation	0	Ethylene by-product
Algoma, Dofasco, Stelco	Ontario	0	Coke oven off-gas	0		0	High purity H2 c/w carbon dust. Estimated ~100,000 t/y. Not successfully recovered
Total		**72 K**		**70 K**		**22K**	

Merchant Gas Production (H_2 tonnes/year)

Company	*Plant Location*	*Capacity*	*Principal Product*	*Production*	*Sold to Others*	*Surplus*	*Remarks*
Air Liquide	Hamilton, ON	2,200	hydrogen	2,200	80% sold to steel mills, rest sold to merchant market	0	also has 500 SCF/day compressor
Air Products	Sarnia, ON	11,000	hydrogen	11,000	Liquefied H2 sold by tank truck to customers		Receives H2 as a by-product from Nova Chemicals ethylene manufacture.
HydrogenAL	Becancour, PQ	3,500	hydrogen	3,500	Liquefied H2 sold by tank truck to customers	0	H2 from PCI Canada's (7 metric t/d) HydrogenAL's has 3,500 t/y steam reformer
Praxair	Sarnia, ON	4,000	hydrogen	4,000	purified by PSA unit, some compress-ed for bulk liquid transport, rest is shipped by pipeline to	0	Receives H2 as a by-product from Nova Chemicals ethylene manufacture

					customers		
Total		**20 K**		**20 K**		**0**	

Hydrogen Pipe Lines (H_2 tonnes/year)

Company	*Plant Location*	*Capacity*	*Principal Product*	*Production*	*Sold to Others*	*Surplus*	*Remarks*
PCI Chemicals	Becancour, PQ	8,000	hydrogen	8,000	H2 is pipelined to Arkema's H2O2 plant and to HydrogenAl.	8,000	
Petromont Pipeline	Varennes, PQ	10,000	hydrogen	8,000	Production from a dedicated SMR unit	0	H2 is piped across St. Lawrence, serves facilities of several companies. Est. 10 kms total.
Total		**18 K**		**16 K**		**8 K**	

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Oil Refinery (H_2 tonnes/year)

Company	*Plant Location*	*Capacity*	*Principal Product*	*Production*	*Sold to Others*	*Surplus*	*Remarks*
Imperial Oil	Dartmouth, NS	12,000	petroleum products	12,000		0	Estimated by Dalcor, H2 by-product from refinery reformer
Irving Oil	St John, NB	100,000	petroleum products	100,000		0	Estimated by Dalcor. Facility is largest refinery in Canada
North Atlantic Refining	Come By Chance, NFLD	110,000	petroleum products	110,000		0	H2 from plateformer as off-gas and from steam reformer unit
Total		**222 K**		**222 K**		**0**	

Chemical Process Production (H_2 tonnes/year)

Company	*Plant Location*	*Capacity*	*Principal Product*	*Production*	*Sold to Others*	*Surplus*	*Remarks*
PCI Chemicals	Dalhousie, NB	2,000	caustic soda, chlorine, sodium chlorate	2,000		0	By-product H2, captive use for HCl
St Anne Chemical	Nackawic, NB	690	caustic soda, chlorine, sodium chlorate	690		0	By-product H2, captive use for HCl, currently shut-down December 2004
Total		**2.7 K**		**2.7 K**		**0**	

APPENDIX B

SECTION 2.3 – CANADIAN HYDROGEN SURPLUS – 2003

A reprint from "Canadian Hydrogen – Current Status & Future Prospects", first published August 2004

Prepared by

Dalcor Consultants Ltd

Intuit Strategies Inc

And

Camford Information Services Inc

Quote: ***2.3 Canadian Hydrogen Surplus – 2003***

The term surplus has been given to that volume of hydrogen production that could be purified as industrial, commercial or in the future consumer hydrogen. It is presently either used for furnace fuel or vented to the atmosphere. As mentioned earlier in this section the current Canadian surplus is about 200 thousand tonnes per year. (Consultants note: this amount has increased to 272 tonnes in 2004).

The use of hydrogen as a furnace fuel does have the environmental advantage; in most cases it of replaces natural gas with a carbon-free fuel. Substitution of the hydrogen used as fuel in any specific facility will result in the increasing the user facility's carbon output and could in some cases possibly put the facility out side its permitted limit. With that caveat only, higher economic use could be made of the surplus hydrogen in virtually every case, if there is an appropriate end-user.

At this time, all the surplus hydrogen in Canada is either a by-product from the ethylene extraction process or from the chlor-alkali electrolyser process. The potential of hydrogen recovery from coking operations was unsuccessfully attempted by Dofasco and was abandoned after several year because of the extremely complex particulate clean-up necessary and the wide variability of the off-gas content due to coal variation and process demand. The hydrogen by-product gas are characterized at follows:

Typical gas compositions for the major hydrogen by-product sources

Ethylene typical ethane cracker off-gas

Hydrogen 85 - 90%
Methane 10 to 15%
Ethylene - ppm trace
Ethane - ppm trace
Carbon Monoxide - <1 %
Typical exhaust pressure - ~80 psia

Chlor-Alkali typical off-gas (composition as percent dry-weight)

Hydrogen 99%
Inert gases - <1 %
CO - ppm trace
CO2 - ppm trace
SO2 - ppm trace
N2 or perhaps NH3 - ppm trace
O2 - ppm trace but can be up to 5%

Cl or HCL - ppm trace or perhaps up to 1%
Typical exhaust pressure – atmospheric
Note: Moisture content of the by-product gas is up to 29.9% wet-weight

<u>Typical coking off-gas</u> (composition as a percent dry weight)
Hydrogen 55%
Methane 25%
Nitrogen 10%
CO/CO_2 9%
Other hydrocarbons 2%
Note: Moisture content is about 50% wet-weight, and a range of contaminants such as tar vapour, ammonia, hydrogen sulfide, naphtha's.

Existing separation and purification technology can readily clean up the fist two by-product streams to high purity or with cryogenic cooling to very high purity suitable for electronic chip manufacture. Clean up of coke oven off-gas has not been successfully done. The chlor-alkali by product hydrogen typically requires only drying and minor purification. Although it is has the advantage of being relatively pure, the need to compress the chlor-alkali by-product hydrogen from atmospheric to a working pressure is a significant cost factor especially as most user processes require compression to at least 10 atmospheres.

Given the above description, it is important to note that all "surplus" hydrogen is not the same. The actual value of the hydrogen to an end-user will depend upon some of all of the following factors.

- *The gas pressure is low or at ambient levels. Compression, especially from atmospheric level is costly,*
- *The gas mixture may contain contaminants that are averse to existing purification technologies, some refinery purge gases contain large quantities of sulphur. Coking off-gas is the extreme version of the contaminant issue.*
- *Transportation costs from source to end-user are excessive.*
- *Reliability of supply from the source facility may not meet the demands for the same degree of "up-time" as that of the prospective end-user,*
- *The output volume from the source may vary considerably over daily or seasonal intervals and be inconsistent with the requirements of the prospective end-user.*

It may appear that there is substantial waste occurring in the limited use of the excess hydrogen, yet there are various factors that come into play to determine if hydrogen

available at a specific location is a more cost-effective feed stock than production dedicated or on-purpose hydrogen. Unquestionably the increasing value of hydrogen will begin the process of more complete utilization. The numerous, semi-urban, locations of many chlor-alkali plants could offer an economically attractive source for limited quantities of hydrogen, especially during the early stages of FCV availability. The advantage of these sources is that, with the exception of the Maritimes, chlor-alkali plants are conveniently scattered across Canada, near most major urban areas.

Significant amounts of hydrogen are lost through process inefficiencies in collecting and purifying syngas. The "surplus" amounts presented in this report do not include the hydrogen lost in exhaust gas from purifiers; typically this will be in the order of 10 to a maximum of 15%. Nor does it include lean hydrogen off-gases from such refinery processes as fluid catalytic crackers that may generate off-gas with 10 to 20% hydrogen content. Other process off-gases may have as much as a 40% hydrogen content. The hydrogen wastes streams are typically added to the "furnace fuel line" of a refinery or chemical process plant and mixed with other vented gases to form a portion of the plant heating needs.

Dalcor estimates that this lost hydrogen across the entire hydrogen production sector in Canada amounts to between 350 and 400 thousand t/y. Of this about 50% will be in stream containing less than 30% hydrogen. The remainder, or 175 to 200 thousand t/y is of sufficient concentration that current technology and increasing hydrogen value will combine to make recovery of the feasible. . Hydrogen rich streams that were not considered to be cost-effective to recover in the past will likely become new hydrogen sources, especially for refineries that are faced with continually increasing demands for hydrogen. Work in the field of separations in general and more specifically in adsorbents will push PSA purifiers and alternate technologies to improve separation efficiency. Improved catalysts, adsorbents and process engineering have the opportunity to find some big wins.

Process improvements continue to address the level of waste hydrogen in the petrochemical sector. Improved separation technology is again one of the better opportunities for potential economic CO_2 reduction.

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