

# NATURAL GAS RESOURCES IN CANADA

Presented at

Climate Change 2: Canadian Technology Development

Toronto, Ontario October 3, 4 & 5, 2001

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## Abstract

Natural gas is an important component in many of the technologies aimed at reducing greenhouse gas emissions. In order to understand the role that natural gas can play, it is important to know how much may be present, where it is, when can it be accessed and at what cost. The Canadian Gas Potential Committee has completed its second report 'Natural Gas Potential in Canada – 2001' (CGPC, 2001). This comprehensive study of exploration plays in Canada addresses the two issues of 'how much may be present' and 'where is it'. The Report deals with both conventional gas and non-conventional gas.

One hundred and seven Established Conventional Exploration Plays, where discoveries of gas exist, have been assessed in all of the sedimentary basins in Canada. In addition, where sufficient information was available, twelve Conceptual Exploration Plays, where no discoveries have been made, were assessed. Sixty-five other Conceptual Plays were described and qualitatively ranked. An experienced volunteer team of exploration professionals conducted assessments of undiscovered gas potential over a four-year period. The team used technical judgment, statistical techniques and a unique peer review process to make a comprehensive assessment of undiscovered gas potential and estimates of the size of individual undiscovered gas accumulations.

The Committee assessed all gas in place in individual exploration plays. For Established Plays, estimates of Undiscovered Nominal Marketable Gas are based on the percentage of the gas in place that is marketable gas in the discovered pools in a play. Not all of the Nominal Marketable Gas will be available. Some underlies areas where exploration is not possible, such as parks, cities and other closed areas. Some will be held in gas pools that are too small to be economic and some of the pools will never be found. In some areas no production infrastructure will be available. Detailed studies of individual exploration plays and basins will be required to determine how much of the estimated Nominal Marketable Gas will actually be available.

Gas assessments were made in five assessment regions; Western Canada, Northern Canada, Eastern Canada, Central Canada, and West Coast and Interior. Each of these regions is blessed or cursed with its geological characteristics, and physical and environmental challenges that will impact the volume of gas that may be available.

Non-conventional gas resources include coalbed methane, tight gas, shale gas and gas hydrates. These present unique issues when attempting to predict how much gas may be available. The volumes of gas in place are impressively large. Technological advances will be required to extract gas from non-conventional sources at rates and costs that are attractive to investors.

Assessments of gas potential made by the Canadian Gas Potential Committee were reviewed in context with other resource estimates that are used by the National Energy Board. The vintage of analyses, treatment of exploration risk and prospect definition account for most of the differences between assessments. These have important implications concerning the volume and timing of gas supplies that may be available in Canada.

## NATURAL GAS RESOURCES IN CANADA

In the arena of “Climate Change”, natural gas is expected to play an important role for domestic and industrial users as a fuel that will produce lower greenhouse gas emissions than some alternative fuels. The importance of this role will be dictated by the availability and price of natural gas. The recently completed report ‘Natural Gas Potential in Canada – 2001’ (CGPC, 2001) issued by the Canadian Gas Potential Committee in September 2001 addresses the questions of how much gas may be present and where the gas resources are located. This paper describes how the estimates of undiscovered gas resources were made, what the results of the assessments are and what the results mean in terms of future gas supply. In brief, Western Canada is now and will continue to be the main area of gas supply in Canada; Frontier Basins will only supplement the volumes available from the Western Canada Sedimentary Basin.

The report of the Canadian Gas Potential Committee is the second in a series of ongoing reports dealing with gas resources in Canada. It presents an analysis based on year-end 1998 data that adds five additional years of information to that used in the first report that was issued in 1997 (CGPC, 1997). The Report was prepared by about fifty volunteer geologists, geophysicists, engineers and mathematicians who are dedicated to the production of high quality analyses of gas resources. It presents the most comprehensive analysis of gas resource distribution that is available in Canada. The Report deals with both Conventional and Non-Conventional Gas. For Conventional gas both the volume of discovered and undiscovered gas resources and the estimated size of the undiscovered gas pools are described. Gas assessments were made in five Assessment Regions: Western Canada Sedimentary Basin, Northern Canada, Eastern Canada, Central Canada, and West Coast and Interior.

Data on all 29,063 gas pools and gas fields across Canada were assembled, these included up to 42 different information items covering locations, depths, reservoir parameters and gas analyses for each pool. Information from the discovered gas pools was used as the basic input for the assessment of gas potential in 107 exploration plays that are defined as Established Plays by these gas discoveries.

The term ‘exploration play’ is commonly used in oil and gas exploration to define a geological configuration within a specified area, which combines source rock, reservoir, trap, migration, and preservation in such a way that the critical factors that control the occurrence of oil and gas are essentially similar. The exploration play is an appropriate unit for assessment as the pools in a play form a natural population that normally obeys a probability distribution (Lee, 1993).

The Committee used a combination of geological judgment and statistical methodologies to assess the volume of undiscovered gas in a play and to estimate the size of each undiscovered gas pool. Industry and government agency participation in peer reviews of



preliminary assessments contributed significantly to the assessment process, but the Committee has ultimate responsibility for the assessment presented in CGPC - 2001.

The discovered pools in a play are used as a sample to predict the total population of pools. Knowledge of the geology of a play and the exploration history in terms of seismic and drilling serve to constrain the statistical analysis. No economic cutoffs were assumed and each play area was considered to be accessible for exploration and production.

Conceptual Exploration Plays can be defined where no discoveries have been made. The geological configuration of potential traps, source rocks and other factors are described for a Conceptual Play. In such plays quantitative subjective assessments can be made where sufficient information about the geology and potential traps is available from seismic surveys and unsuccessful exploratory wells. These assessments have much more uncertainty attached to them than for Established Plays. The Committee was able to assess twelve Conceptual Plays in this manner in sedimentary basins off the East and West Coasts.

In addition, the Committee defined 65 Conceptual Plays where there was not sufficient information to make quantitative assessments. These plays were described and qualitatively ranked within the Assessment Regions. In total 184 exploration plays were recognized across Canada. Excel files holding input, output and summary information on all of the assessed plays has been compiled on a play-by-play basis and is available on CD ROM for further analysis. The complete report, including maps and charts, is also available in linked PDF format.

The assessment procedure that was followed was to assess the undiscovered gas in place in each exploration play. Gas in place is the volume of hydrocarbon and non-hydrocarbon gases in a reservoir rock in the subsurface. While this volume is important it is the volume of gas that is available for market that is of most interest. To estimate the volume of gas that might be marketable in each exploration play the percentage of gas in place that is marketable gas in the discovered pools was used to estimate the volume of marketable gas in the undiscovered gas pools in a play.

The Committee has introduced the term Undiscovered Nominal Marketable gas to describe their estimates because the gas is marketable in name only. Not all of the Nominal Marketable Gas will actually be available, because:

- no exploration is possible in parks, cities and towns or other areas where exploration is precluded or restricted, so some of the predicted gas pools will never be found,
- all undiscovered gas pools are included in the assessment, but not all of these pools will be economic to explore for or to develop,
- some pools will have too subtle a geological expression to be found, and
- not all gas pools or gas fields will have access to production and transportation infrastructure – this applies to both Western Canada and particularly to Frontier Basins.

The actual amount of marketable gas will be less than the estimated amount of Nominal Marketable Gas, but we don't know how much less. This determination will require detailed economic analyses. The Committee did not make any economic analyses, but the Report is a unique source of detailed information on every play that will permit interested users to develop estimates of gas supply under different economic scenarios. However, even without detailed economic studies, examination of the volumes and pool size distribution of Nominal Marketable Gas estimates provides a good sense of the volume of gas that might be available and where it is located.

No estimates of Nominal Marketable Gas have been made for Conceptual Plays where no discoveries have been made. In such plays there is no information on reservoir parameters or gas characteristics and of course no production history. Most important there is a very high risk on each such exploration play that the play will fail completely and nothing will be found. The principle is **“Don't count marketable resources in plays that are not established by discoveries”**.

Figure 1 shows the sedimentary basins in Canada. The gas producing areas and gas discovery areas are differentiated from areas where sedimentary rocks are present and may contain gas or oil accumulations, but where no discoveries have been made. For each of the Assessment Regions and areas within them the map shows the estimated Gas in Place, the Nominal Initial Marketable Gas and the Nominal Remaining Marketable Gas. The Nominal Remaining Marketable Gas is the volume of gas remaining after production to year-end 1998 plus the Undiscovered Nominal Marketable Gas.

In Table 1 areas that are more accessible for development are sub-totaled to include the Western Canada Sedimentary Basin, Ontario and Quebec and the Near Frontiers while those less accessible are sub-totaled as Remote Frontiers. For each area the table lists the Assessment Region followed by the area name. The bottom line shows the Conventional resources in all categories. This table shows the dominance of the Western Canada Sedimentary Basin in the gas resource picture in Canada. It holds 61% of the Remaining Nominal Marketable Gas. Western Canada is now and will continue to be the main area of gas supply.

Understanding the distribution of gas resources in the Western Canada Sedimentary Basin (Figures 2 a and b) is critical to understanding the volume of gas that may be forthcoming from this key area. Figure 2a illustrates the distribution of resources by pool size. Discovered and undiscovered pools are assigned to pool size classes based on the volume of gas in place. Each successive class is four times larger than the previous class. The upper limit of each of the ten size ranges is shown on the x-axis of the chart. The volume of marketable gas in each category, in trillions of cubic feet, is on the y-axis.

The data table shows the values for Remaining Gas Reserves (54 Tcf), Undiscovered Nominal Marketable Gas (88 Tcf) and Produced Gas (107 Tcf). The envelope enclosing the Remaining Reserves and Undiscovered Gas represents the amount of gas that may be available in the basin. The gas that has already been produced is shown to illustrate what was originally available. Bars depicting produced gas volumes demonstrate clearly that the larger



gas pools have been preferentially produced and are much more depleted than the pools in smaller classes. This is exactly what one would expect, as large high productivity pools were the most attractive economic targets.

Both the Remaining and Undiscovered Potential are concentrated in the smaller class sizes. The following statistics describing the distribution of undiscovered potential are instructive; remember that Canada produces about 16 billion cubic feet (Bcf) of gas per day.

Excellent high impact targets are present in the 153 undiscovered gas pools expected in the four largest size ranges in Figure 2a. These pools range in size from about 40 Bcf to 1 Tcf Undiscovered Nominal Marketable Gas (64 Bcf to 4 Tcf Gas in Place) and hold about 19% (16 Tcf) of the undiscovered potential.

About 3,200 undiscovered pools are expected in the next two smaller size ranges in Figure 2a. These pools range in size from about 2.5 to 40 Bcf Undiscovered Nominal Marketable Gas (4.0 to 64 Bcf Gas in Place) and hold 26% (21 Tcf) of the undiscovered potential.

About 64,000 undiscovered pools are expected in the next two smaller size ranges in Figure 2a. These pools range in size from about 0.15 to 2.5 Bcf Undiscovered Nominal Marketable Gas (0.25 to 4.0 Bcf Gas in Place) and are estimated to hold 43% (35Tcf) of the undiscovered potential.

11% (9 Tcf) of the undiscovered potential is estimated to be in over 135,000 micro-pools smaller than 0.15 Bcf Undiscovered Nominal Marketable Gas that lie in the two smallest class sizes.

At the average finding rate of three exploratory wells per discovery it would take about 200,000 exploratory wells, about twice as many as have been drilled to 1998, to find the 68,000 new pools larger than 0.15 Bcf. While this is an imprecise estimate it indicates the scale of drilling that may be required. An unknown number of small pools have already been discovered, but have never been booked as discoveries. Many sit behind casing in existing producing wells.

The large, high impact targets face the greatest risk of falling into areas where exploration is not possible. Detailed analyses will be required to determine how many of these pools may be accessible. The expected 64,000 pools ranging from 0.15 to 2.5 Bcf Undiscovered Nominal Marketable Gas will be challenging exploration targets in an economic sense. Pools smaller than 0.15 Bcf are unlikely to be intentional exploration targets, and are unlikely to be economic to place on production.

The stratigraphic distribution of undiscovered potential adds significant information that bears on the availability of natural gas. Figure 2b shows the distribution of marketable gas for the eight Play Groups analyzed in Western Canada. The Foothills Play Group dealt with traps involving all stratigraphic zones in the Foothills structural belt. In the remaining Play Groups, plays were organized on the basis of stratigraphic units ranging from Middle Devonian as the oldest to Upper Cretaceous as the youngest. The following statistics are relevant.

In Western Canada Lower Cretaceous reservoirs hold 43 Tcf (54%), over half of the Undiscovered Nominal Marketable Gas, but the largest undiscovered pools in any of the Lower Cretaceous plays are expected to hold about 20 Bcf Nominal Marketable Gas.

The prime exploration targets lie in Foothills structures and Middle and Upper Devonian carbonate reservoirs in the plains. The Foothills plays hold 14 Tcf (18%) of the remaining potential and have the largest undiscovered targets, just under 1 Tcf Nominal Marketable Gas.

Devonian Plays in the Plains hold 11 Tcf (13%) of the remaining potential in targets approaching 500 Bcf Nominal Marketable Gas.

The remaining Play Groups contain 12 Tcf (15%) of the potential.

The Play Group totals do not include the 7 Tcf of reserves appreciation that was not assigned to specific plays. Reserves Appreciation is the increase in discovered reserves over time as additional information comes available.

The distribution of undiscovered resources by province and territory in the Western Canada Sedimentary Basin essentially parallels the distribution of discovered gas resources. Alberta is expected to hold 78% of the Undiscovered Nominal Marketable gas, 16% is expected in British Columbia, 5% in Saskatchewan, and 2% in the Northwest Territories and Yukon (south of 62°).

Frontier Basins include the sedimentary basins outside of the Western Canada Sedimentary Basin and Southern Ontario and Quebec. The Near Frontier Basins are the more accessible for exploration and development. Remote Frontiers are those that are most isolated physically or by environmental moratoria. The distribution of discovered and undiscovered resources is listed in Table 1.

The most accessible Frontiers areas with Established Exploration Plays are the shelf offshore Nova Scotia, the Mackenzie Corridor and the Mackenzie Delta and shallowest part of the Beaufort Sea. As little gas production had been taken from these areas, the Nominal Initial Marketable Gas is equal to the Nominal Remaining Marketable Gas (Figure 1). Eleven trillion cubic feet of Nominal Initial Marketable gas in the plays in the Beaufort Sea have been included with the Arctic Islands assessment in the Remote Frontiers. As a result the accessible Frontier areas together hold 35 Tcf of Nominal Marketable Gas, 15% of the Canadian potential. While large highly productive fields have been found, and more are expected to be found, the total resource in these areas may not be as great as previous estimates (NEB 1999) have suggested.

The Deep Water Slope play offshore Nova Scotia is an interesting new play that has analogs in the Gulf of Mexico, offshore Brazil and offshore West Africa. The Canadian Gas Potential Committee recognized the potential of this area, but could not make an assessment because the highly competitive activity in the play precluded access to new data in the area. Industry has committed in the order of one billion dollars in work bonus bids and has acquired thousands of kilometers of 2D and 3D seismic. Drilling is expected to commence this year and will accelerate next year. These will be the first exploratory tests guided by new seismic and geological understanding of deep-water sand deposition models. If the Deep Water



Slope offshore Nova Scotia and Southwest Newfoundland is to become a major new hydrocarbon province we should expect discoveries in the early exploration wells.

More remote Frontier plays in the Beaufort Sea, Arctic Islands, Newfoundland and Labrador face severe technical and economic hurdles that will have to be crossed before any gas will be forthcoming. Offshore Newfoundland, where oil and gas are being produced at Hibernia and Terra Nova, could become a gas producing area if sufficient non-associated gas can be found to support pipeline or LNG production facilities. Most of the discovered gas resources in this area are associated with oil reservoirs. Associated gas is produced along with the oil, but it is typically reinjected to maintain reservoir pressure.

In summary, insofar as conventional gas is concerned Western Canada, and the near Frontiers hold 77%, of the Remaining Nominal Marketable Gas (Table 1). Not all of this gas will actually be marketable as a result of issues of access and economics.

In contrast to conventional gas volumes of non-conventional gas in place are impressively large. The issue is how much of the gas in place can actually be produced at economically attractive rates. The Canadian Gas Potential Committee has not included any volumes of non-conventional gas as Nominal Marketable Gas pending establishment of commercial production. Non-conventional gas includes coalbed methane, gas hydrates, tight gas and shale gas.

Widespread coal deposits in the Western Canada Sedimentary Basin, the Interior Basins in British Columbia and in the Maritimes are being investigated in pilot projects directed toward determining if methane can be produced at commercially attractive rates. Studies to date suggest that the permeability of coals in Canada is low. Some challenges for new technology include:

- locating areas with sufficient permeability to enable acceptable producing rates,
- enhancing existing permeability to achieve a satisfactory producing rate per well, and
- mitigation of the overall environmental impacts of developing coalbed methane production such as disposition of produced water and drilling many thousands of wells.

Natural gas hydrates are an ice-like solid formed by the inclusion of low molecular weight hydrocarbons in the crystal lattice of water under a specific temperature and pressure regime. Gas hydrates are widely distributed in Canada (Majorowicz and Osadetz, 2001). The distribution is known from exploration wells and seismic in the Mackenzie Delta and Beaufort Sea, onshore and offshore in the Arctic Islands and off the East Coast. Hydrates are inferred to be present off the West Coast based only on seismic information.

Richards Island in the Mackenzie Delta is the site of an ongoing research program where a test of the producibility of gas from a known hydrate zone in the Mallik area is planned in the winter of 2002. On Richards Island gas hydrates occur in highly porous Tertiary sands and gravels. Research into the technology required to produce natural gas from hydrates will be critical before commercial production can be obtained. A related project offshore Japan is underway to test subsea production from hydrates. As the hydrates on Richards Island occur in conjunction with deeper conventional gas pools the opportunity may exist to increment



production of gas from hydrates with the production from conventional reservoirs once a pipeline to the Mackenzie Delta has been built.

Production of gas from tight gas reservoirs and from shale is taking place now, but this is not distinguished from production from conventional reservoirs and it is difficult to measure the contribution from the non-conventional components. In some cases contributions of gas from coals may also be commingled with conventional production.

The following conclusions may be drawn regarding future gas supplies in Canada:

Western Canada will continue to be the main gas supply area in Canada, but this area is mature and future supplies will increasingly be drawn from smaller, short-lived pools that will require intensive exploratory drilling, the more accessible Frontier areas are already providing incremental gas supply on the East Coast and this will increase as additional projects proceed, Frontier developments will require major investments in pipeline and production infrastructure.

Non-Conventional gas sources may be important if pilot studies prove successful for non-conventional gas, technology to improve per well productivity and address related environmental issues would be required.

remote Frontier areas face severe economic and technical hurdles; little exploration is in progress and the lead-time to even conduct exploration is large to say nothing of commercial production,

future gas supplies from all plays in Canada will require large capital expenditures and extensive drilling programs to access the predicted gas resources, and

Future gas supplies will not be the low cost type that has been enjoyed up till now.

The repetition of assessments on a five-year cycle is an objective of the Committee; this permits examination of what has transpired since the previous assessment as a check on the assessment process and logic. The Canadian Gas Potential Committee 2001 assessment for Conventional Gas is 31 Tcf lower than the assessment made by the Committee in 1997. The difference is due to a number of positive and negative changes caused by new information, assessment of new plays, and the involvement of new volunteers with different experience. The net result is a decrease in Initial Nominal Marketable Gas Endowment of about 8%, which is well within the margin of error for assessment work. The net difference in the Western Canada Basin is -14 TCF, in the Near Frontiers -17 Tcf and no net difference in the Remote Frontier assessments. In CGPC – 2001 no estimates of marketable gas have been included for non-conventional gas resources.

No estimates of Undiscovered Nominal Marketable Gas were made for plays where no discoveries have been made or for Non-Conventional Gas. As a result the CGPC – 2001 Report results of 342 Tcf of Nominal Initial Marketable Gas (Table 1) is 320 Tcf lower than the Case 2 estimate included in the National Energy Supply Demand to 2025 Report (NEB, 1999 Table 5.1). The NEB Case 2 used the Conventional Gas assessment for the Western Canada Sedimentary from CGPC – 1997. However, in that case the NEB included



Unconventional Gas and estimates outside of the Western Canada Sedimentary Basin that were based on out of date Geological Survey of Canada Reports. Significant parts of those estimates lie in remote Frontier Basins or in areas where subsequent exploration has had negative results or both.

Any discussion of the use of gas for the purpose of diminishing Greenhouse Gas emissions should view the position of Canada in a North American and World sense. Table 2 incorporates the latest information published by the Potential Gas Committee in the United States (Potential Gas Agency, 2001).

Table 2 North American Recoverable Resources - Tcf				
	U.S. <sup>3</sup>	Canada <sup>2</sup>	Mexico	North America
		CGPC - 2001		
Traditional Proved	156	54	33	243
Traditional Future <sup>1</sup>	539	179	27	745
Total Traditional	695	233	60	988
CBM <sup>4</sup> Proved	11	-	-	11
CBM Future	71	-	-	71
Total CBM	82	-	-	82
Total Recoverable	777	233	60	1070
	73%	22%	6%	
<sup>1</sup> Includes Frontier discovered and undiscovered gas resources in Canada as well as Western Canada undiscovered potential.				
<sup>2</sup> Canadian undiscovered estimates are Nominal Marketable gas.				
<sup>3</sup> U.S. from PGC 2000 not including Speculative Resources				
<sup>4</sup> CBM is Coalbed methane				

The PGC Speculative category has not been included in order to make the comparison on the most consistent basis. The 233 Tcf estimate for Canada includes all of the Nominal Marketable Gas including the Remote Frontiers, not all of that gas will be available.

In a worldwide sense the traditional proved reserves of gas in North America make up about 5% of the proven gas in the world at year-end 2000. North America produces about 31% of the gas in the world from these reserves (BP, 2001).

Reduction of Greenhouse Gas emissions from Canada through the accelerated use of natural gas as a fuel must face the issue that the gas supply may be less than has been anticipated. Careful analysis of the supply and the economic and environmental trade offs will be required.

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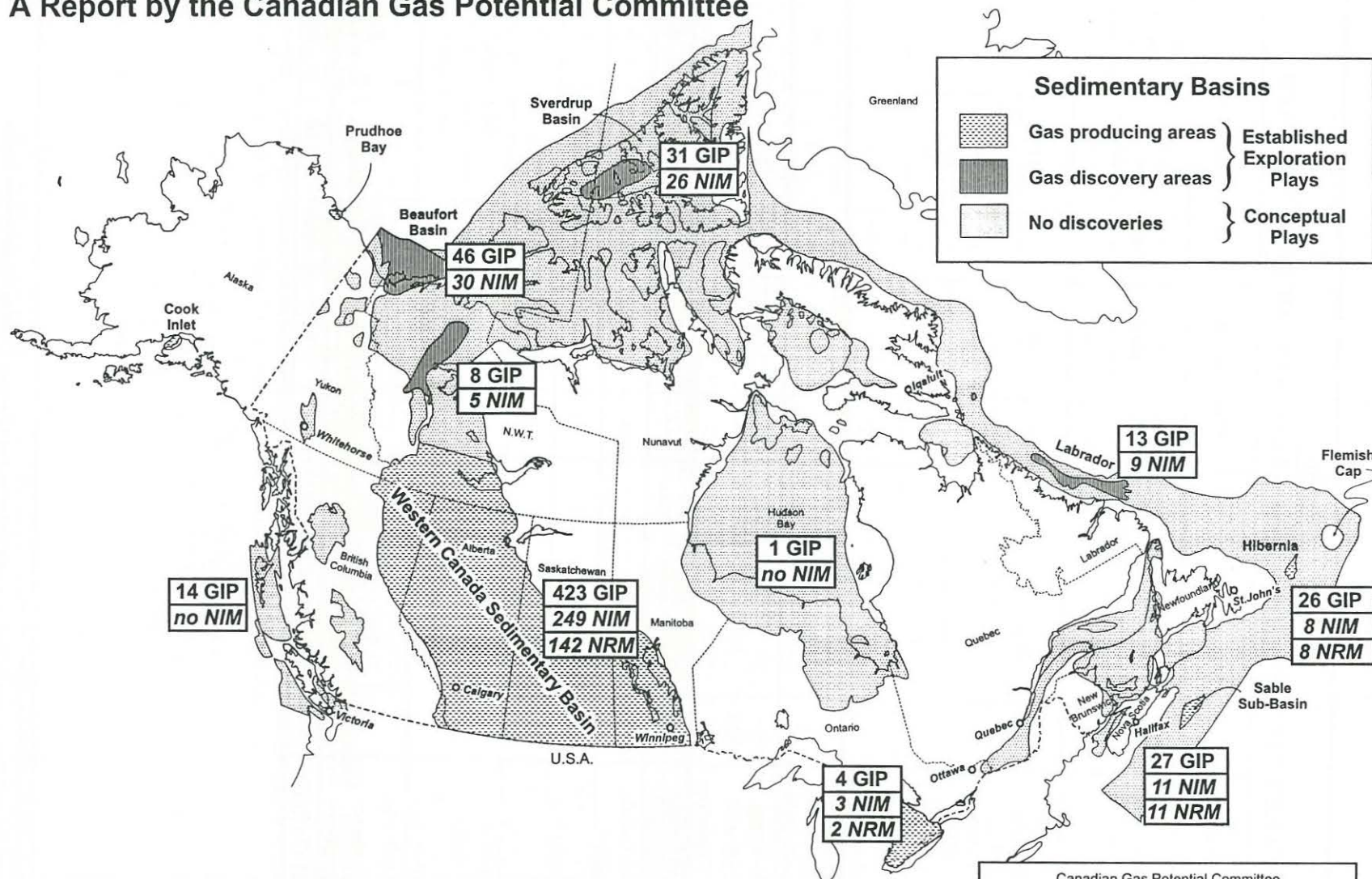
<b>Table 1</b> <b>DISTRIBUTION OF CONVENTIONAL GAS RESOURCES IN CANADA</b>								
Volumes in trillions of cubic feet	Discovered			Undiscovered		Endowment		
Assessment Region and Area	Initial Gas in Place	Initial Marketable Gas	Remaining Marketable Gas	Initial Gas in Place	Nominal Initial Marketable Gas	Initial Gas in Place	Nominal Initial Marketable Gas	Nominal Remaining Marketable Gas
Western Canada Sedimentary Basin <sup>1</sup>	277	161	54	146	88	423	249	142
Central Canada Ontario and Que.	2	1	0.4	2	1.4	4	3	2
Eastern Canada Nova Scotia	10	6	6	16	5	27	11	11
Northern Canada Mackenzie Corridor	1	1	1	7	5	8	5	5
Northern Canada Mackenzie Delta	13	8	8	16	11	29	19	19
<b>Sub-Total WCSB and Near Frontiers</b>	<b>303</b>	<b>178</b>	<b>70</b>	<b>187</b>	<b>109</b>	<b>490</b>	<b>287</b>	<b>179</b>
Eastern Canada Newfoundland	9	4	4	17	4	26	8	8
Eastern Canada Labrador	7	5	5	6	4	13	9	9
Northern Canada Beaufort Sea	1	0.4	0.4	16	10	17	11	11
Northern Canada Arctic Islands	20	16	16	11	9	31	26	26
West Coast Offshore <sup>2</sup>	No Discoveries			14	Not Estimated	14	Not estimated	
Central Canada Hudson Bay	No Discoveries			1	Not Estimated	1	Not estimated	
<b>Sub-Total Remote Frontiers</b>	<b>37</b>	<b>26</b>	<b>26</b>	<b>65</b>	<b>29</b>	<b>102</b>	<b>54</b>	<b>54</b>
<b>Total Canada</b>	<b>340</b>	<b>204</b>	<b>96</b>	<b>252</b>	<b>138</b>	<b>592</b>	<b>342</b>	<b>233</b>

1 Undiscovered Resources includes appreciation in the Western Canada Sedimentary Basin.

2 Access restricted by environmental moratoria.

# NATURAL GAS POTENTIAL IN CANADA - 2001

A Report by the Canadian Gas Potential Committee



## Canadian Conventional Gas Endowment in Tcf (Year-End 1998)

592	Gas in Place (GIP)
342	Nominal Initial Marketable (NIM)
233	Nominal Remaining Marketable (NRM)

