

**Manitoba Hydro Generation Interconnection
Exploratory Study Notice
September 28, 2006**

As per the Manitoba Hydro Open Access Interconnection Tariff, the Transmission Owner has contracted TransGrid Solutions Inc. to perform an Exploratory Study to provide prospective interconnecting Generators with a rough approximation of the costs associated with the interconnection of a Facility and delivery of energy from a Facility to Manitoba load. This Exploratory Study shall be conducted in such a manner to ensure the efficient implementation of Manitoba Hydro's transmission expansion plan in the light of the System's capabilities. Following completion of the Exploratory Study the results will be posted on this MHEB OASIS site. The scope of the Exploratory Study is contained in the following outline.



Study Outline for Manitoba Hydro Exploratory Wind Studies

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Study Outline for the Manitoba Hydro Wind Exploratory Studies

Introduction:

The Exploratory Wind Studies will be looking at reliability limitations with up to 500 MW of wind, including St. Leon 100 MW wind farm, connected to the Manitoba Hydro transmission system. There is currently 100 MW of pre-existing wind power in Manitoba. Recently, an RFP was announced for an additional 300 MW. The studies will be performed at 500 MW to provide a 100 MW margin for uncertainty. The project has been divided into four phases as described in the upcoming sections. The principal objective of the project shall be to divide the province into zones and determine a MW limit and connection costs for wind generation in each of these zones.

After review and comparison of the Manitoba Hydro Generation Connection Queue and the list of Expressions of Interest (EOI) for wind generation in Manitoba, the potential wind farm locations were plotted on a map of Manitoba as shown in Appendix 1. The wind farm locations and sizes were also placed into a spreadsheet as shown in Appendix 2. Each queue position and EOI location were located on a map of Manitoba that contained the 66-500 kV transmission network. The nearest station to each location was assumed to be the interconnection point, wherever possible the location was assumed to be a 110 kV or 230 kV connection as opposed to 66 kV or lower. Typically the maximum size of wind farm that can be connected to 66 kV is approximately 50 MW and these connections will not be addressed in this study. In some cases, the nearest station is more than approximately 50 km away from the proposed wind plant collector substation. In these cases, existing 115 kV or 230 kV transmission lines would be sectionalized with a new substation.

The goal is to divide the province into zones. A preliminary estimation of the zones are listed in Table 1 below. Please see the Manitoba map in Appendix 1 and a more detailed spreadsheet in Appendix 2 for further information.

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Table 1. List of Preliminary Zones.

Preliminary Zones		Individual Bus Location
6	Minnedosa	Neepawa 230 kV Minnedosa 110 kV Raven Lake 230 kV Birtle 230 kV
5	West of Brandon	Virden 230 kV Reston 230 kV Souris 230 kV
3	Brandon	Brandon 230 kV Glenboro 230 kV Treherne 110 kV
4	Lena	Lena (G82R) 230 kV
2	St. Leon	St. Leon 230 kV Stanley 230 kV
1	Letellier	Letellier 230 kV
9	Elie	Portage 230 kV Elie 230 kV Dorsey D54C 230 kV
7	West Lk Manitoba	Ashern/A6V 230 kV Dauphin/Vermillion 230 kV
8	East Lk Manitoba	A3R/A4D (Lk Mb) 230 kV
10	East Lk Winnipeg	Grand Beach 110 kV
11	Northern Manitoba	Grand Rapids 230 kV Churchill 138 kV

The 10th and 11th zones, East Lake Winnipeg (Grand Beach) and Northern Manitoba, will not be included in the analysis. The existing transmission system would require extensive new transmission in order to relieve the significant congestion that would be caused by these interconnections.

More focus will be given to the interest expressed in the Manitoba Hydro generation connection queue as opposed to the EOI list. That being said, Table 2 below lists the interconnection points in the order that they exist in the queue, after the existing 100 MW St. Leon wind farm. Some of the buses listed above in Table 1 will not be studied as they are too far away from the connection queue locations.

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Table 2. Nearest Connection Points for MH Wind Generation Queue.

Connection Point	Wind farm size (MW)
Elie	100
Lena	100
St. Leon	100
St. Leon	100
Lena	100
St.Laurent (East Lk Mb)	25-200
Letellier	100
St.Leon	100
Virден	10-50
St. Leon	40-200
Letellier	100-200
Lk Mb Narrows (A6V)	30-200
Letellier	100
Lk Mb Narrows (A6V)	100
St.Leon	100-300
St.Laurent (East Lk Mb)	100-200
Neepawa	20-120
Glenboro/Lena	50-100
Treherne	50-100
Virден	60-80
D54C/Elie	50-100
Portage/Elie	100-200
Portage/Elie	100-200
Neepawa	66-266
Reston	200
St. Leon	200
Deloraine 66	40-50, 150
Virден	200
Souris	200
Glenboro	200
Letellier	100

Based on Table 2, the following buses have the most interest and will be studied in further detail throughout the Exploratory Studies:

- St. Leon 230 kV - 1000 MW
- Letellier 230 kV / Rosenfeld 110 kV - 500 MW
- A3R new tap - 400 MW
- Portage 230 kV or D54C new tap - 400 MW
- Neepawa 230 or Minnedosa 110 - 400 MW
- Virден 230 kV - 330 MW
- A6V new tap - 300 MW
- Reston 230 kV - 200 MW
- Souris 230 kV - 200 MW
- Glenboro 230 kV - 200 MW
- Elie 230 kV - 200 MW
- Lena 230 kV - 200 MW
- Treherne 110 kV - 100 MW
- Stanley 230 kV - 100 MW

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Phase 1 – Determining Bottlenecks and Network Upgrades, Defining Zones and Best Connection Points

1. Objective:

The objectives of Phase 1 will be:

1. To determine what, if any, bottlenecks will occur when installing up to 500 MW of wind generation in Manitoba.
2. To determine a MW value of wind generation that can be connected to an individual bus before any bottlenecks occur.
3. To identify known fixes that have been budgeted or new Network Upgrades for obvious bottlenecks.
4. To identify the best buses and combine them into zones, possibly one bus per zone to simplify the zonal studies.
5. To determine the total area losses associated with connecting 300 MW of wind to each zone.

2. Study Procedure:

- 1) Perform PSS/E TLTG analysis on the following as per the list at the end of the Introduction section.
 - a) Individual Bus TLTG – determine maximum MW value of wind generation that can be connected before bottlenecks occur at an individual bus; identify the bottlenecks, known fixes currently in the budget, and new Network upgrades if the fix is obvious.

Power Flow Cases:

- Year 2014 summer peak maximum MH export (2175 MW) at low NDEX (350 MW)
- Year 2014 summer peak maximum MH import (700 MW) at high NDEX (1950 MW)

The power flow cases will include existing firm generation plus higher queued generation at Pine Falls (5 MW), Great Falls (4 MW), Pointe du Bois (130 MW total) and Kelsey (15 MW), as well as Wuskwatim (200 MW) and associated transmission (Birchtree-Wuskwatim, Wuskwatim-Herblet Lake, Herblet Lake-Ralls Is.).

- 2) Perform loss evaluation for each zone. Add 300 MW of wind per zone and sink to Dorsey and Grand Rapids. The same power flow cases described above will be used. Total area losses will be compared between zones.

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3. Outputs:

- 1) Maximum MW value of wind generation that can be connected to an individual location before bottlenecks occur.
- 2) Bottlenecks and necessary Network Upgrades (known fixes currently in budget as well as new fixes) that occur when up to a maximum value (for example 100-300 MW) of generation is connected to an individual bus.
- 3) Zones and associated bus(es) in each zone.
- 4) Losses associated with 300 MW of wind per zone.

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Phase 2 – Look at Whole Manitoba Picture: All Zones and Combinations of Zones

1. Objective:

The objectives of Phase 2 will be to look at all zones and combinations of zones to determine:

1. Where the first bottleneck occurs and which zone(s) triggered the bottleneck.
2. Favored zones and combinations of zones to minimize bottlenecks and Network Upgrades, taking into account zone popularity as shown by the generator connection queue.
3. Several practical, least-cost arrangements of 500 MW total wind generation in Manitoba, along with associated Network upgrades.

2. Study Procedure:

- 1) Perform PSS/E TLTG analysis on the following:
 - a) Combinations of Zonal TLTG – re-run TLTG analysis on combinations of zones for several arrangements of a total of 500 MW, finding mitigations for bottlenecks. Zone combinations could be in groups such as:

5 zones x 100 MW
4 zones x 125 MW
3 zones x 167 MW
2 zones x 250 MW

Power Flow Cases:

- a. Year 2014 summer peak maximum MH export (2175 MW) at low NDEX (350 MW)
- b. Year 2014 summer peak maximum MH import (700 MW) at high NDEX (1950 MW)

The power flow cases will include existing firm generation plus higher queued generation at Pine Falls (5 MW), Great Falls (4 MW), Pointe du Bois (130 MW total) and Kelsey (15 MW), as well as Wuskwatim (200 MW) and associated transmission (Birchtree-Wuskwatim, Wuskwatim-Herblet Lake, Herblet Lake-Ralls Is.).

3. Outputs:

- 1) List of bottlenecks and Network Upgrades for each combination.
- 2) List of preferred combinations of zones based on minimum bottlenecks and favored connection queue sites.

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Phase 3 – Determining Zonal Connection Costs

1. Objective:

The objectives of Phase 3 will be:

- 1) To determine generic connection costs per zone based on what reasonably makes sense from the results of Phases 1 and 2, based on:
 - a) Maximum reasonable value of wind generation per zone
 - b) Network upgrades for that zone
 - c) Actual direct connection costs, such as new breakers, new stations, and transmission lines to the connection points

2. Study Procedure:

- 1) Calculate cost estimates for each zone based ranges of MW values, including costs such as:
 - a) New high voltage breakers
 - b) New high voltage stations
 - c) New high voltage transmission lines to Interconnection point

There could be several cost estimates per zone depending on the how the zonal generation is shared between individual buses in that zone. For example, if all generation in a zone is connected to a single bus this would result in a different cost estimate than if the generation were split between three buses because the direct connect costs would be higher for the three bus scenario.

- 2) Calculate Network Upgrade cost estimates for each zone.

3. Outputs:

- 1) Direct connection costs per zone.
- 2) Network upgrade costs per zone.
- 3) List of least-cost combinations of zones to supply 500 MW of total wind generation.

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Phase 4 – Transient Stability Analysis: DFIG versus Induction Generator

1. Objective:

The objectives of Phase 4 will be:

1. To compare the dynamic performance of the induction generator versus the doubly-fed induction generator
2. To determine whether or not dynamic reactive power support, such as an SVC, would be required

2. Study Procedure:

- 1) For the least-cost options as determined from Phase 3, perform transient stability analysis on the year 2014 maximum export power flow case to test for:
 - a. Transient undervoltage violations / voltage collapse (summer peak) – apply local three-phase line faults and stuck breaker single-line-to-ground faults
 - b. Transient overvoltage ride-through (summer off-peak) - apply 'nbz' fault – loss of D602F followed by dc reduction
- 2) If dynamic VAR support is required, re-run worst cases with an SVC to determine approximate rating necessary to meet interconnection criteria. Incorporate a cost estimate for any required dynamic VAR support to the applicable zone(s).

3. Outputs:

- 1) For each of the least-cost options, a summary of transient stability results and dynamic performance of the two wind generator types, including the need for and approximate rating and cost estimate of an SVC.

Study Outline for the Manitoba Hydro Wind Exploratory Studies

Deliverables:

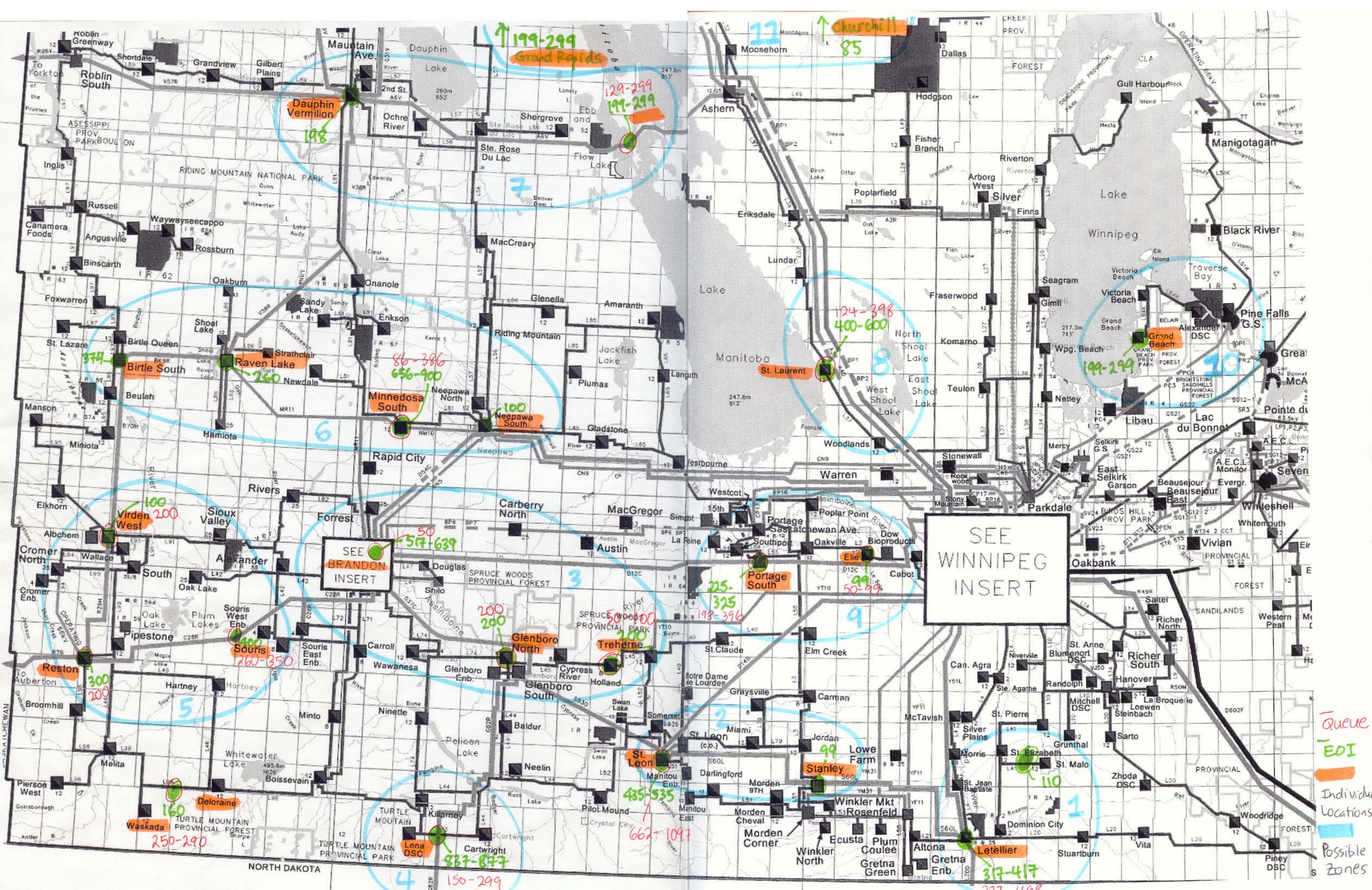
Each phase of the project shall deliver a report describing the objectives, study procedures, study results and conclusions.

Estimated Schedule:

- 1) The Phase 1 deliverables will be provided within three (3) weeks of project kick-off.
- 2) The Phase 2 deliverables will be provided within two (2) weeks of Phase 1 being completed.
- 3) The Phase 3 deliverables will be provided within three (3) weeks of Phase 2 being completed.
- 4) The Phase 4 deliverables will be provided within three (3) weeks of Phase 3 being completed.
- 5) A draft report of the entire study will be provided one (1) week after completion of Phase 4, the goal being by the first week of January 2007.
- 6) A final report will be provided two (2) weeks after receiving comments on the draft report.

Appendix 1.

Wind Generation: Map of Manitoba



Dauphin
Vermilion
198

199-299
Grand Rapids

129-299
199-299

11
Moosehorn

Churchill
85

374
Birtle South

260
Raven Lake

86-386
656-900
Minnedosa South

100
Neepawa South

124-398
400-600

St. Laurent

199-299
Grand Beach

20

100
200
Viridian West

SEE
BRANDON
INSERT
50
57-639

200
200
Glenboro North

50
200
Treharne

225-325

198-396
50-99
Eli

SEE
WINNIPEG
INSERT

400
260-350
Souris

300
200
Reston

200
200
Glenboro South

50
200
St. Leon

99
Stanley

99
Lowe Farm

110
St. Elizabeth

160
250-290
Waskada

160
Deloraine

837-877
Lena DSC

837-877
Cartwright

435-535
Pilot Mound

662-1097
Morden

99
Stanley

377-417
Letellier

- Queue
- EOI
- Individual Locations
- Possible Zones

Appendix 2.

Comparison of Wind Generation Expressions of Interest and Manitoba Generation Queue.

Preliminary Zones	Individual Location	Preliminary Zones (MW)				Zone Rank	Bus Rank	
		EOI	Queue	EOI	Queue			
		Totals	Totals	Buses	Buses			
2	St. Leon	St.Leon 230 kV Stanley 230 kV	634	1097	535 99	1097	1	1
5	West of Brandon	Virden 230 kV Reston 230 kV Souris 230 kV	788	750	100 300 388	200 200 350	2	8 8 5
4	Lena	Lena (G82R tap) 230 kV Waskada/Deloraine (66kV)	1037	589	877 160	299 290	3	6 7
9	Elie	Portage 230 kV Elie 230 kV Dorsey D54C 230 kV tap	424	575	325 99	396 99 80	4	3 9 10
1	Letellier	Letellier 230 kV Arnaud/St.Malo (66 kV)	527	498	417 110	498	5	2
8	East Lk Manitoba	A3R tap (Lk Mb) 230 kV	600	398	600	398	6	
6	Minnedosa	Neepawa 110 kV, 230 kV Minnedosa 110 kV Raven Lake 230 kV Birtle 230 kV	1943	386	100 900 260 674	386	7	4
3	Brandon	Brandon 230 kV Glenboro 230 kV Treherne 110 kV	1039	350	639 200 200	50 200 100	8	11 8 9
7	West Lk Manitoba	Ashern/A6V 230 kV tap Dauphin/Vermillion 230 kV	497	299	299 198	299	9	6
10	East Lk Winnipeg	Grand Beach 110 kV	299	0	299			
11	Northern Manitoba	Grand Rapids 230 kV Churchill 138 kV	384	0	299 85			
		Totals			8163	4942		

Note: In the EOI list, there were several site locations that very either very vague or not descriptive enough. These site locations are not included in the above lists.

Legend:

Because more attention will be given to the queue list, these buses will not be studied in the Exploratory Studies.