Date : 11/28/2017 10:44:36 AM
From : "Snook, Corey"
To : "Boland, Christine" , "Montague, Robyn J." , "Janes, Mark"
Subject : FW: Power Points - Wind and Electricity Concepts
Attachment : Wind PPT - November 3, 2017.pptx;Electricity Concepts PPT - November 3, 2017.ppt;ATT00001.jpg;image001.jpg;

Informative decks from NLH…

Corey Snook
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Newfoundland Labrador

From: Cowan, John
Sent: Monday, November 27, 2017 1:39 PM
To: Snook, Corey; Janes, Mark
Subject: FW: Power Points

There is some good information in this on energy. I have not really had a chance to go through it, other than a lot of it is not needed.

John

From: TManning@nalcorenergy.com [mailto:TManning@nalcorenergy.com]
Sent: Monday, November 6, 2017 10:03 AM
To: Cowan, John <JCowan@gov.nl.ca>
Cc: JeannineFitzgerald@nalcorenergy.com; DeanneFisher@nalcorenergy.com
Subject: Power Points

Hi John,

I have updated the Electricity Concepts power point to include the information you requested regarding energy use and excess energy. I have also attached a Wind power point that gives an overview of wind on our system and provides some performance data on the existing wind farms. I believe I have included everything you requested.

If you would like to see the data presented differently or would like any additional information, please let me know.

Tim

nalcor energy

Tim Manning, P.Eng
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Wind Overview

November 2017

Boundless Energy

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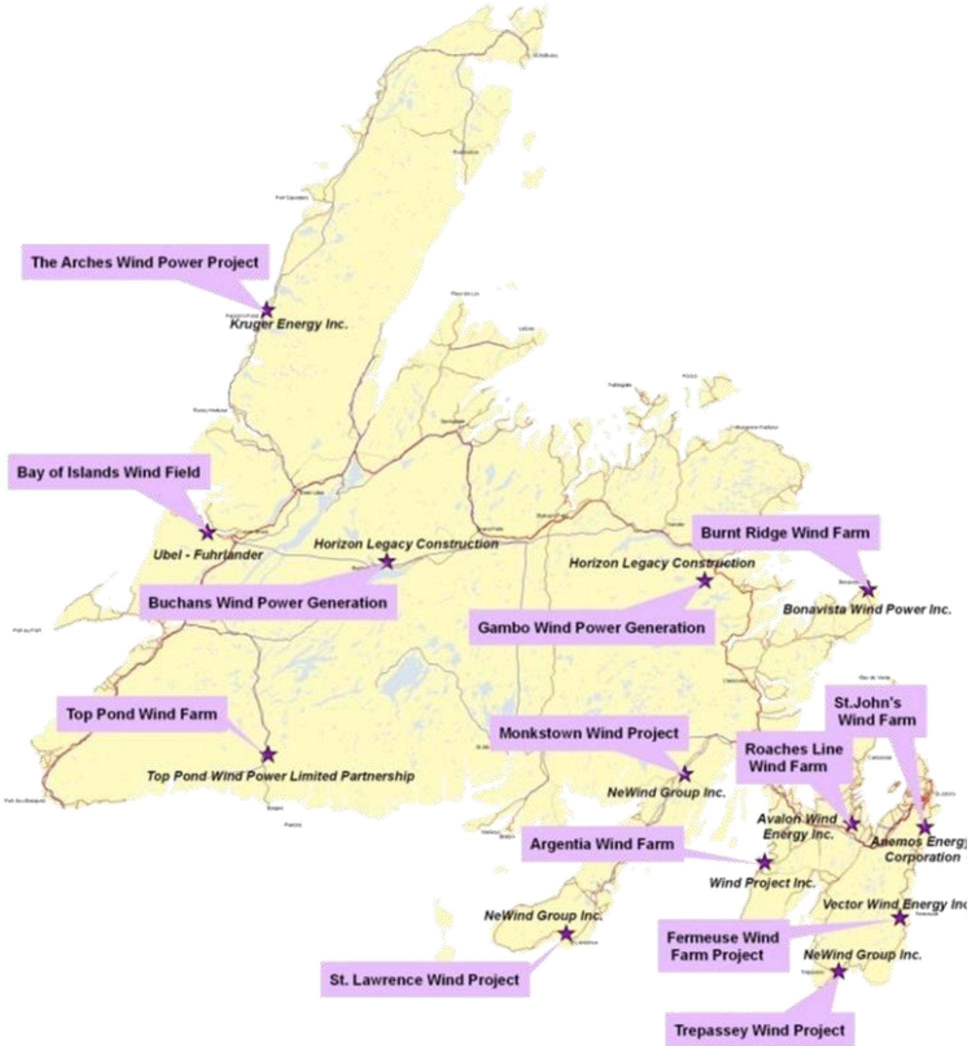
Purpose

- Provide an overview of Wind Generation in NL

History of Wind On Island

- Feasibility study completed in 2002
  - Wind potential for many 100's of MW
  - Limited amounts can be absorbed into Provincial grid
  - Estimate at time was that 80 MW of non-dispatchable capacity could be seamlessly integrated
  - Projects of 25 MW or less could easily be integrated
- RFP Issued in 2006
  - St. Lawrence was selected
  - Fermeuse project was selected in a follow up RFP
  - A number of other projects were submitted but not accepted

Location of farms submitted for RFP



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History of Wind in Labrador

- Hydro erected 4 wind monitoring towers in December 2006
  - Project was called Ossok Wind Power Project
  - Towers were located southwest of Churchill Falls near the Ossokmanuan Reservoir
  - 18 months of data was collected
  - Collected data was not overly favorable
    - Wind speeds were not great
    - Towers experienced icing issues
    - Report suggested picking another location
- Additional locations are available across Labrador
  - Remoteness of some locations will have cost challenges
- Potential exists for 1000's of MW
  - Wind pairs well with Hydro

Small Wind Development in Labrador

- Coastal Wind Monitoring Study completed in 2016
  - Wind Towers erected in the following communities:
    - Nain
    - Makkovik
    - Hopedale
    - Cartwright
    - L'Anse-au-Loup
- Study was completed by Hydro on behalf of Government
  - Wind results were promising in all communities
  - Additional work is required to determine cost of integration
  - Government has released report on its website
    - An EOI for development in isolated communities is expected to be released in the near future

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Current Wind Generation

- There are two large scale wind farms operating in NL
  - Both farms have Purchase Power Agreements (PPAs) with Hydro
  - St. Lawrence
    - In-Service Date: October, 2008
    - Size: 27 MW – Nine Vestas V90 turbines
    - Average Annual Generation: 97 GWh
    - PPA Price: $67 MWh at time of signing. Price has increased with escalation
  - Fermeuse
    - In-Service Date: April, 2009
    - Size: 27 MW – Nine Vestas V90 turbines
    - Average Annual Generation: 88 GWh
    - PPA Price: $71.5 MWh at time of signing. Price has increased with escalation

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Current Wind Generation

- There are two small scale wind farms in Ramea
  - Nalcor
    - In Service Since: 2010
    - Size: 300 KW – Three 100 KW Northwind 100 Turbines
    - Turbines have experienced numerous outages
      - Outages are a result of minor maintenance issues
      - Turbines are unregulated and not required to meet town load. This has resulted in extended periods of downtime as resources were required elsewhere
      - At the end of Q3 2017, all three turbines were repaired and are operational
    - PPA Price: Diesel offset cost. Based on formula and monthly diesel price
  - Frontier Power
    - In Service Since: 2004
      - Frontier has contractual right to first renewable generation
    - Size: 390 KW – Six 65 KW Windmatic Turbines
    - Average Annual Production: 588 MWh
    - PPA Price: Diesel offset cost. Based on formula and monthly diesel price

Wind Farm Performance

- The amount of energy produced from a wind farm is represented by its Capacity Factor (CF)
- CF is a ratio of a wind farms annual production to the maximum power it could have produced if it ran 100% of the time at its maximum capacity. CF is usually shown as a %
- As an example, a 50 MW wind farm that produces 150,000 MWh a year would have a CF of:

150,000 MWh/(50 MW x 8760 Hours) X 100 = 34.2 %

- If that same 50 MW wind farm produced 438,000 MWh a year it would have a CF of:

438,000 MWh/(50 MW x 8760 Hours) X 100 = 100%

- The amount of energy produced by a wind turbine is based on the wind speed. As the wind is not blowing all the time, it is not possible for a real world wind turbine to have a CF of 100%
- Canadian Wind Farms typically have CFs of approximately 35%

Capacity Factors of NL Wind Farms

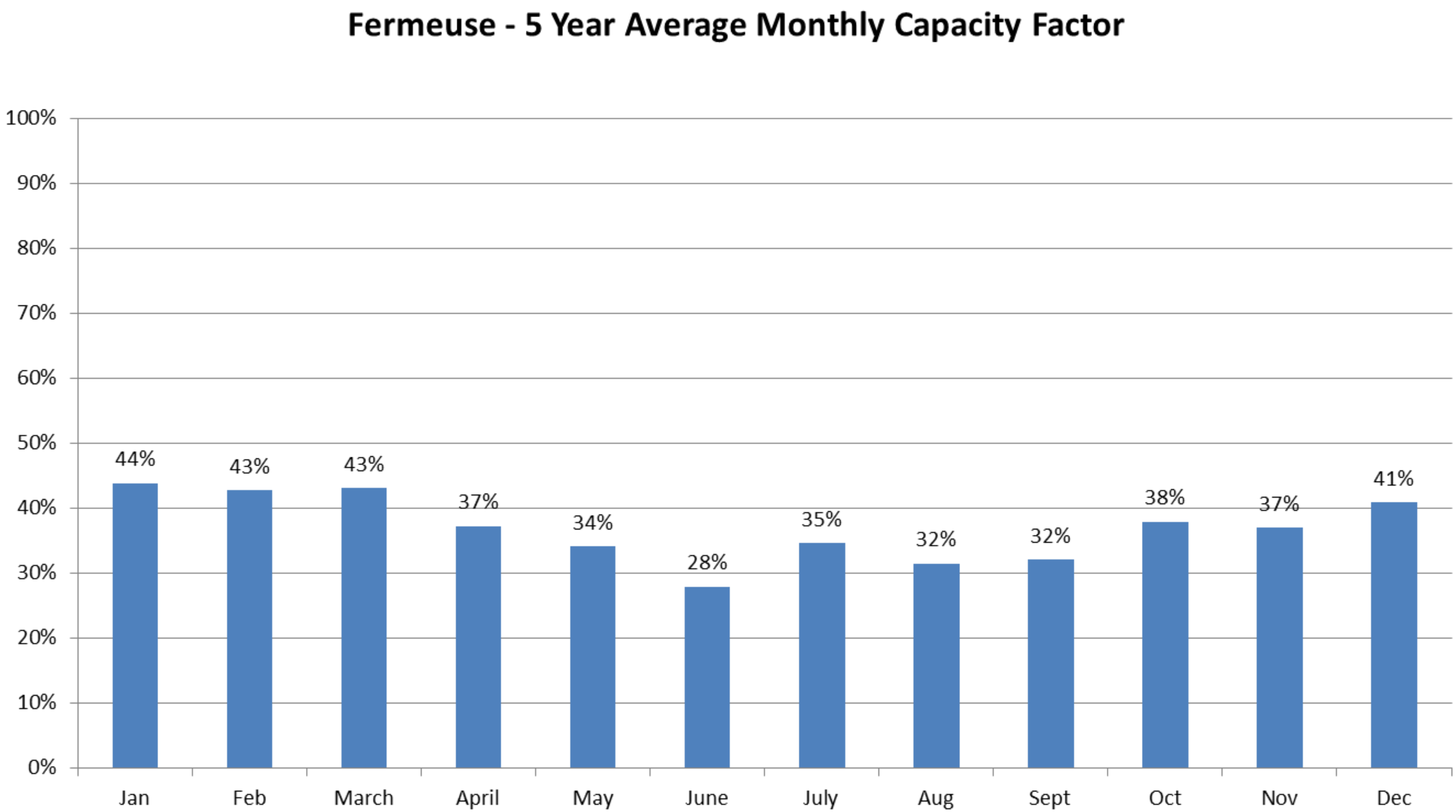
- CFs of St. Lawrence and Fermeuse are shown for each of the last five years
- CFs for these wind farms are higher than the Canadian average

Average Capacity Factors		
Year	**Fermeuse**	**St. Lawrence**
2012	38%	43%
2013	40%	40%
2014	34%	41%
2015	37%	39%
2016	37%	43%
5 Year Average	**37%**	**41%**

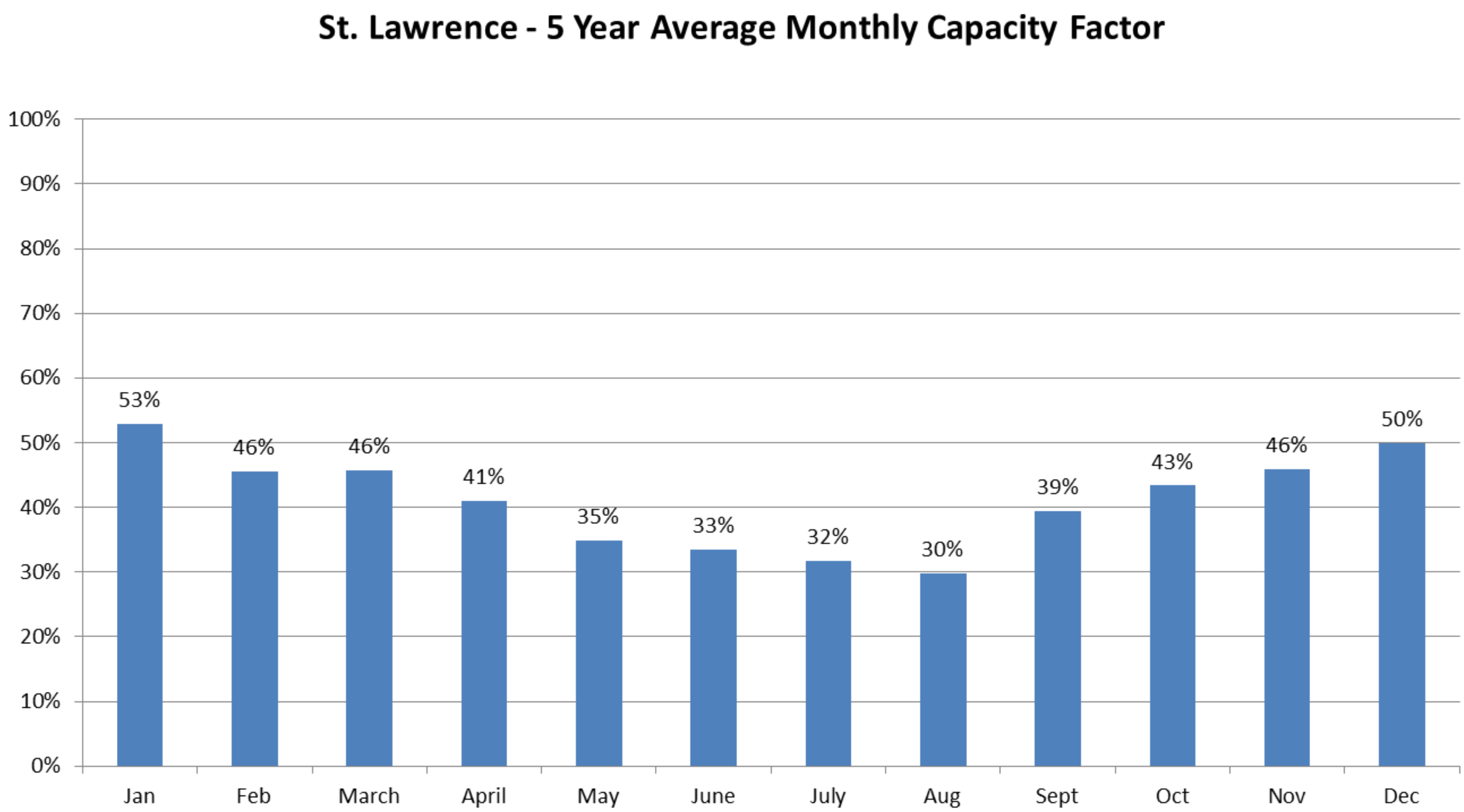
Monthly Capacity Factors

- Annual capacity factor is an important way to describe the performance of a wind farm but it is not the only way
- Monthly capacity factor can also be used to examine the performance of a wind farm
- This is important to consider in NL as we have a winter peaking system and require more energy during winter months to meet domestic load

Fermeuse Monthly Capacity Factor



St. Lawrence Monthly Capacity Factor



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Why not more wind on Island today?

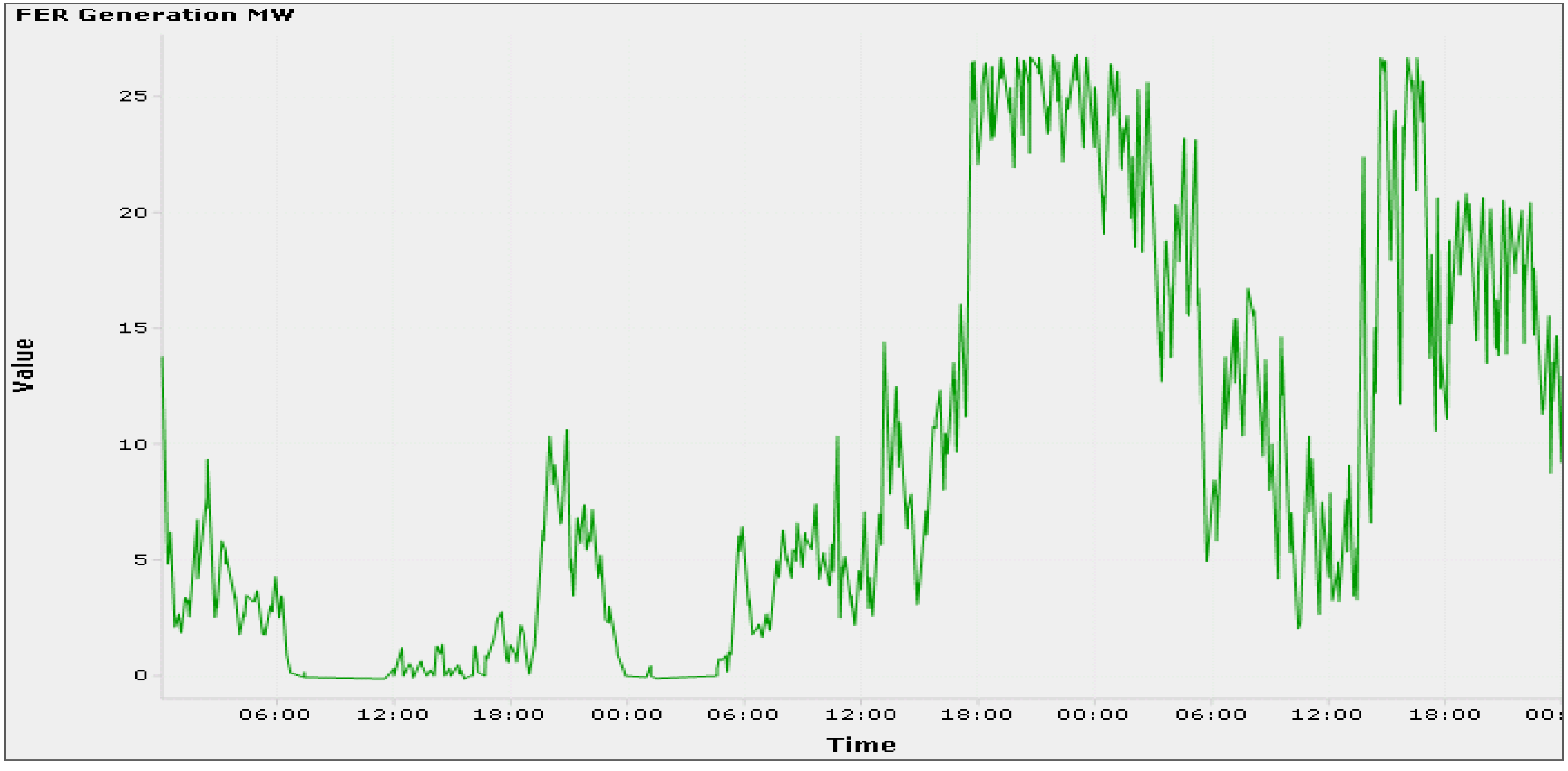
- Existing hydroelectric supply can power NL for much of the year
  - Holyrood generators used more in colder months when the load is highest
  - Costs less to generate power from existing hydro then from wind turbines
- Non-Dispatchable
  - Wind is intermittent and not always available when required
    - Wind power cannot be scheduled and varies second to second
    - Electricity generated from wind turbines is based on how fast the wind is blowing
    - On cold days the wind is not always blowing and no electricity can be generated
    - On other days when the wind is blow, there may not be enough load to serve and therefore the wind turbines are turned off.
- Cannot be relied on for capacity reasons
  - Due to their intermittent nature, wind turbines are not considered firm
  - When wind stops blowing, another source will have to start generating to maintain balance in electrical system
    - Additional reserve capacity would need to be available from another source to support wind

NL Wind Farms Combined Hours

- By looking at data from St. Lawrence and Fermeuse it is possible to get a clearer picture of wind production in NL
- Each farm has a capacity of 27 MW for a total of 54 MW of wind generation on the island

Production Summary of Fermuse and St. Lawrence Combined							
Threshold	2012	2013	2014	2015	2016	Average	% of Year
Hours with 0 MW	325	376	579	328	385	399	5%
Hours with Less that 2 MW	948	915	1226	925	961	995	11%
Hours with Less than 10 MW	2823	2706	3258	2917	2958	2932	33%
Hours Greater than 27 MW	3435	3236	2876	3014	3333	3179	36%
Hours Greater than 50 MW	266	174	288	156	277	232	3%
Hours with 54 MW	0	0	0	0	1	0.2	0.002%

Wind Generation in Fermuse



- Fermuse Generation Jan 1 to Jan 3, 2015

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Future of Wind in NL – Post Maritime Link

- Once the Maritime Link is complete, NL will be connected to the North American Grid
- Wind energy while not needed domestically could be exported from NL
  - Energy could be used domestically but will need to compete with existing energy sources
- If a business case for wind development exists, Nalcor could:
  - Develop wind project internally
  - Partner with a 3rd party
  - Sign a PPA with 3rd party
    - 3rd party producers would not have access to firm transmission and would need to pay tariff
- The capacity of the Maritime Link will potentially limit export opportunities for 3rd parties

Future of Wind in Labrador

- There exists significant potential for large wind development in Labrador for export
- Nalcor/Hydro has investigated this opportunity to a degree
  - Wind data from Ossok is available
  - Strategic direction was shifted to LCP and no additional work was completed
  - Additional work would need to be competed to fully investigate this opportunity
- Export opportunities through Quebec may provide stronger economic benefits then island wind
- Wind and hydropower work well together
  - Hydro reservoirs can act as storage for wind and hydro generators can be used as reserve capacity

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Additional Information

Wind Q & As

- ***Can wind generation be dispatched or scheduled?***
  - The ability of wind generators to operate is contingent on its availability (i.e. whether or not the wind is blowing) and therefore cannot be turned on at will. Further, the level of output of wind generators follows the wind intensity that is intermittent in nature. It therefore cannot displace the need for and availability of generating sources that can be dispatched to follow and meet the constantly changing consumer demands.

- ***What happens when the wind doesn't blow?***
  - Since electrical systems require balance between the loads demanded by its customers and the power produced through its generators, when the wind stops blowing and wind generators stop producing, other generation sources (such as hydro or thermal) must operate to meet consumer demand. In addition to the requirement to have back-up capacity available for when the wind doesn't blow, the intermittent nature of wind generation adds further variability to the system when the wind is blowing. Since other units cannot be started in time to address any shortages caused by these momentary changes in load seen by the other units on the system, it is important that when wind generation is on line, that there be sufficient additional reserve capacity on-line to address the added variability.

Wind Q & As

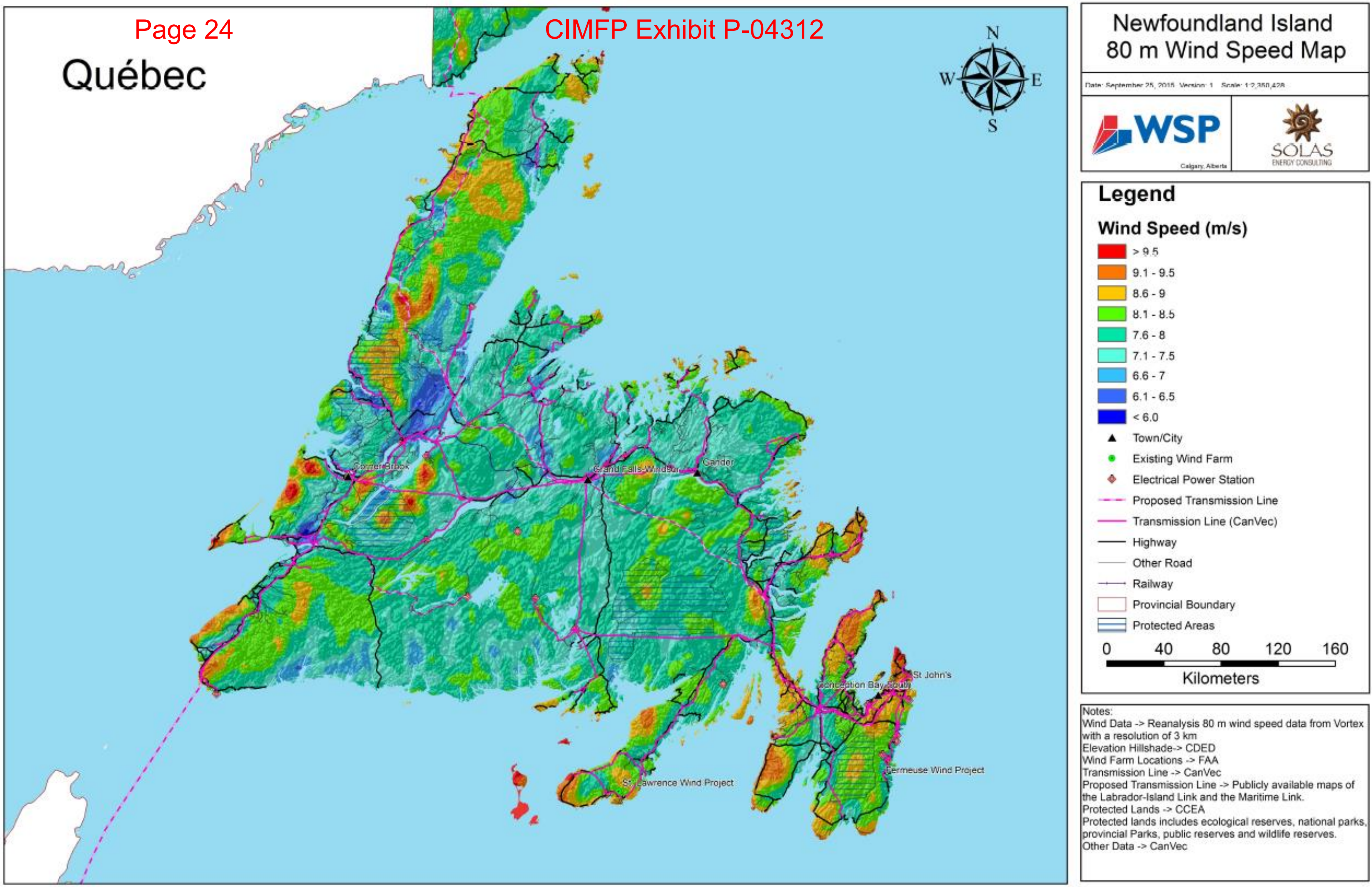
- *Why can't wind replace Holyrood?*

  - The large thermal plant at Holyrood (490 MW) has a three-fold purpose. First, Holyrood is used to meet consumer demands during periods of high consumption. Second, Holyrood supplements the energy capability of the hydro plants as inflows to the reservoirs vary and is an essential part of Hydro's supply portfolio. Third Holyrood is used to support transmission voltages and security on the eastern portion of the Island grid where the loads are high and there is little other generation. Due to the non-dispatchable and intermittent nature of wind generation, it cannot perform these functions

    Therefore, while wind offers the opportunity to displace a portion of the oil-fired energy produced at the Holyrood Thermal Generating Station, no amount of wind capacity could displace the entire facility without significant investments in other (most likely fossil-fueled) dispatchable sources.

Wind Q & As

- **What are the wind speeds in NL?**
  - Newfoundland's wind resource can be characterized as "world-class" with numerous areas experiencing average wind speeds greater than 9 m/s (32 km/h).
  - Wind speeds can be too high for generation
    - Turbines generally cut out at 25 m/s (90 km/h)
    - Ideal wind is steady, non gusting wind
  - In 2015, Business Development hired Solas Consulting to produce wind speed maps for Newfoundland and Labrador.
    - These maps were completed using Vortex Wind Data.
    - Vortex uses statistical analysis and complex modeling to arrive at wind speeds.
    - No actual wind data was collected
    - Maps were provided at 80 m and 40 m hub heights
      - 40 m hub heights are inline with smaller wind turbines used in remote communities including Ramea



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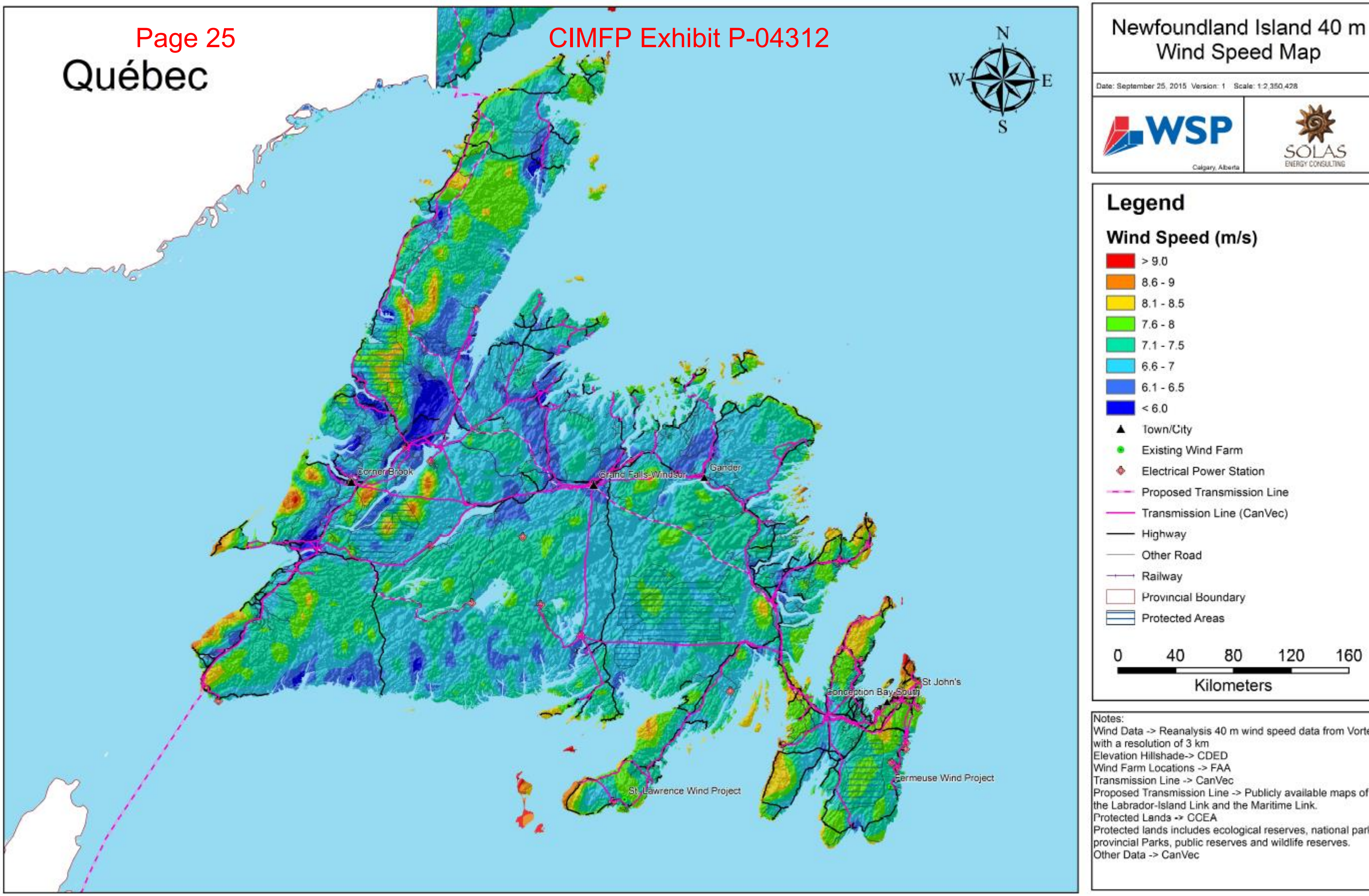
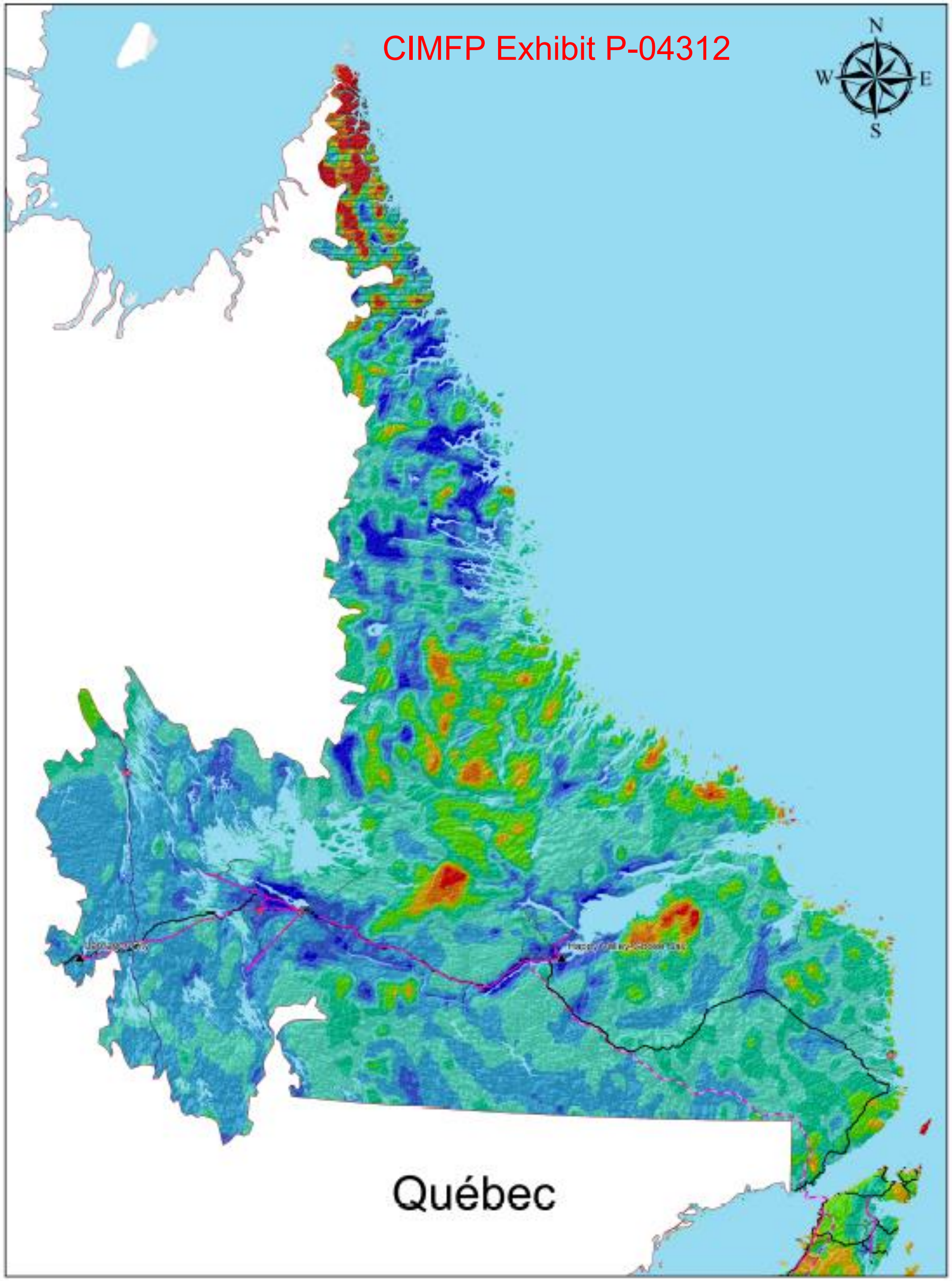

Québec
N
W
E
S
Corner Brook
Grand Falls-Windsor
Gander
St John's
Conception Bay South
St. Lawrence Wind Project
Fermeuse Wind Project
Newfoundland Island 40 m Wind Speed Map
Date: September 25, 2015 Version: 1 Scale: 1:2,350,428
WSP
Calgary, Alberta
SOLAS ENERGY CONSULTING
Legend
Wind Speed (m/s)
> 9.0
8.6 - 9
8.1 - 8.5
7.6 - 8
7.1 - 7.5
6.6 - 7
6.1 - 6.5
< 6.0
Town/City
Existing Wind Farm
Electrical Power Station
Proposed Transmission Line
Transmission Line (CanVec)
Highway
Other Road
Railway
Provincial Boundary
Protected Areas
0 40 80 120 160
Kilometers
Notes:
Wind Data -> Reanalysis 40 m wind speed data from Vortex with a resolution of 3 km
Elevation Hillshade-> CDED
Wind Farm Locations -> FAA
Transmission Line -> CanVec
Proposed Transmission Line -> Publicly available maps of the Labrador-Island Link and the Maritime Link.
Protected Lands -> CCEA
Protected lands includes ecological reserves, national parks, provincial Parks, public reserves and wildlife reserves.
Other Data -> CanVec



Labrador 80 m Wind Speed Map

Date: September 25, 2015 Version: 1 Scale: 1:3,500,000

WSP

SOLAS ENERGY CONSULTING

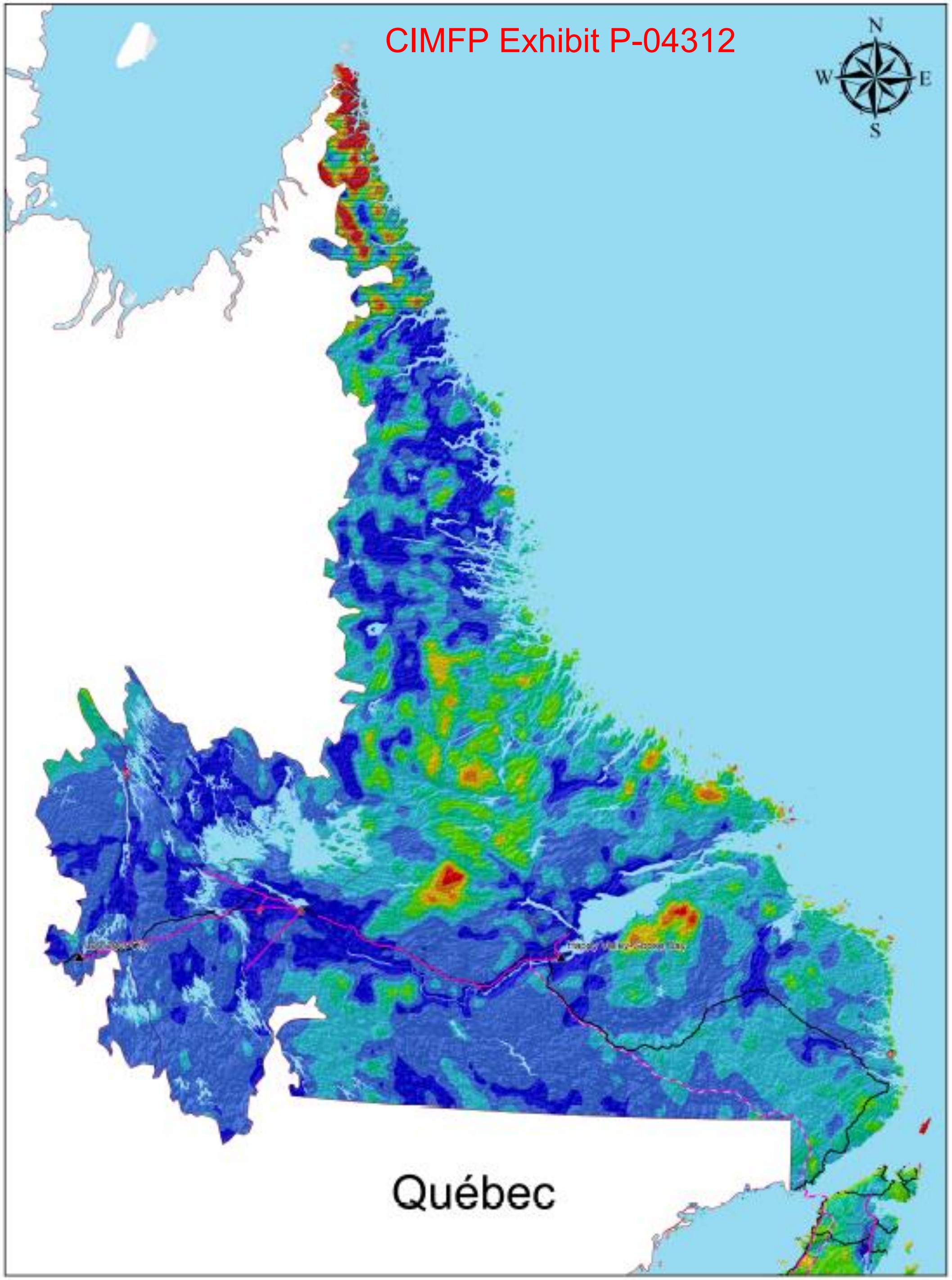
Notes:
Wind Data -> Reanalysis 80 m wind speed data from Vortex with a resolution of 3 km
Elevation Hillshade-> CDED
Wind Farm Locations -> FAA
Transmission Line -> CanVec
Proposed Transmission Line -> Publicly available maps of the Labrador-Island Link and the Maritime Link.
Protected Lands -> CCEA
Protected lands includes ecological reserves, national parks, provincial Parks, public reserves and wildlife reserves.
Other Data -> CanVec

0 30 60 90 120
Kilometers

Legend

Wind Speed (m/s)
- > 9.5
- 9.1 - 9.5
- 8.6 - 9
- 8.1 - 8.5
- 7.6 - 8
- 7.1 - 7.5
- 6.6 - 7
- 6.1 - 6.5
- < 6.0

- Town/City
- Electrical Power Station
- Transmission Line (CanVec)
- Proposed Transmission Line
- Highway
- Other Road
- Railway
- Provincial Boundary
- Protected Areas



Labrador 40 m Wind Speed Map

Date: September 25, 2015 Version: 1 Scale: 1:3,500,000

WSP

SOLAS ENERGY CONSULTING

Notes:
Wind Data -> Reanalysis 40 m wind speed data from Vortex with a resolution of 3 km
Elevation Hillshade-> CDED
Wind Farm Locations -> FAA
Transmission Line -> CanVec
Proposed Transmission Line -> Publicly available maps of the Labrador-Island Link and the Maritime Link
Protected Lands -> CCEA
provincial Parks, public reserves and wildlife reserves.
Other Data -> CanVec

0 30 60 90 120
Kilometers

Legend

Wind Speed (m/s)
- > 9.0
- 8.6 - 9
- 8.1 - 8.5
- 7.6 - 8
- 7.1 - 7.5
- 6.6 - 7
- 6.1 - 6.5
- < 6.0

- Town/City
- Electrical Power Station
- Transmission Line (CanVec)
- Proposed Transmission Line
- Highway
- Other Road
- Railway
- Provincial Boundary
- Protected Areas

Electricity Overview

November 2017

Boundless Energy

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Agenda

- Purpose
- Electrical System in NL
- Capacity and Energy
- Transmission
- Glossary

Purpose

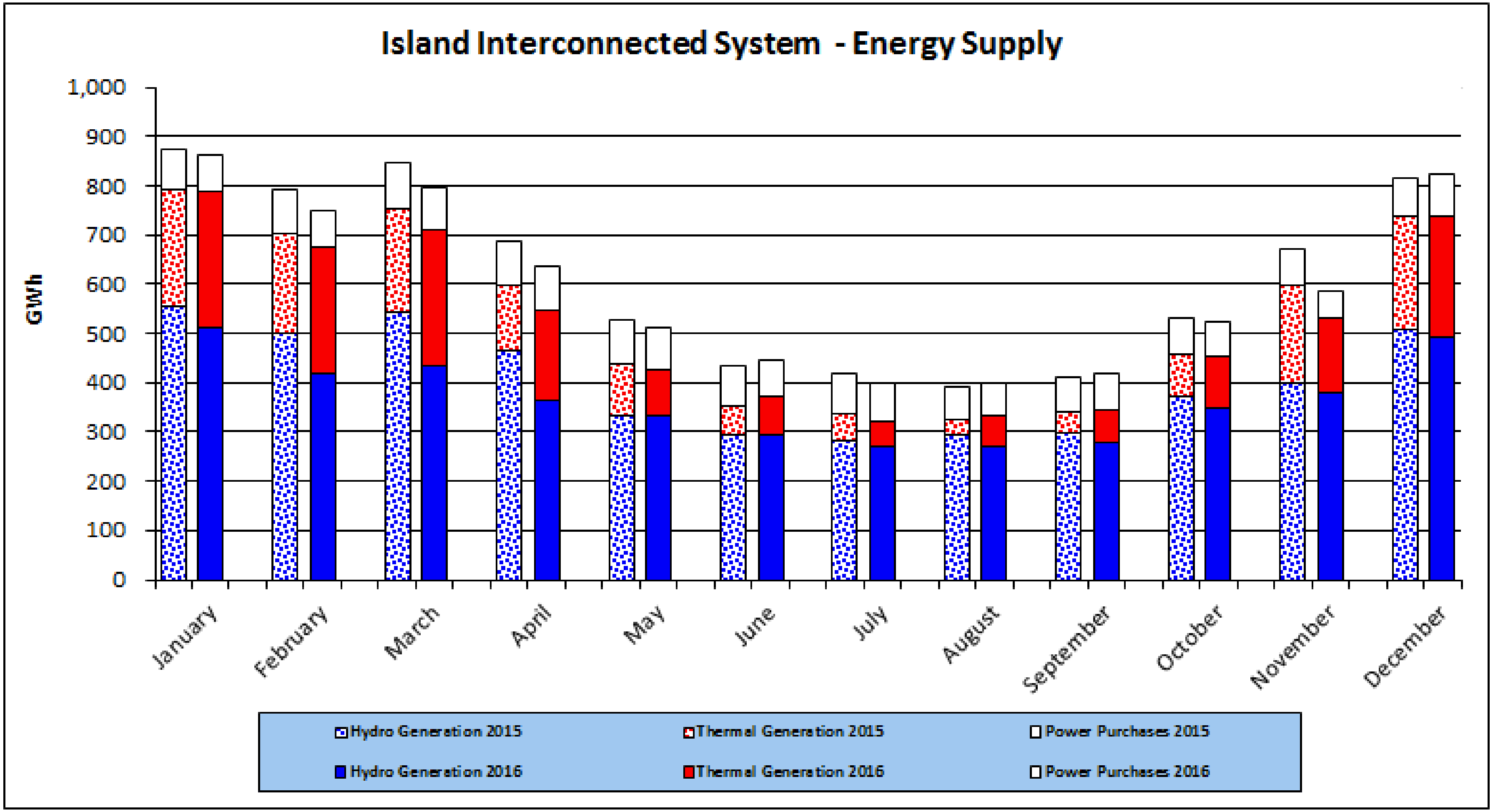
- The purpose of this presentation is to:
  - Provide a brief overview of common electricity concepts and the electrical system in NL

Electrical System in NL

NL Electrical System

- NL has a winter peaking electrical system
  - Highest or peak load on the system is in the winter
  - High usage of electric heat across the province
- In order to ensure that all industrial and residential customers in the province have access to electricity, Hydro needs to ensure that it has enough installed firm capacity to meet this peak load
  - The system is therefore sized to meet the winter peak
  - The province has enough capacity to meet its needs but there is no excess
- The load in the summer is much lower then in the winter
  - In the summer not all generators in the fleet are producing electricity as it is not required.
  - Annual maintenance is performed on units during this down time.
  - For significant portions of the year, the NL load is served by hydro generation only
- Once the province is connected to the North American Grid through the Maritime Link (ML) and the Labrador Island Link (LIL), the generators that are not being used to meet domestic demand could be used to produce energy for the export market

Annual Energy Use in Newfoundland



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NLH Generation Sources

- Hydroelectric
  - There are hydroelectric generating stations located across Newfoundland and Labrador
  - This is the province’s main source of electricity
- Thermal
  - Holyrood Thermal Generating Station
  - Holyrood Combustion Turbine
  - Hardwoods, Stephenville, HV-GB Gas Turbines
- Diesel
  - 25 Diesel Plants
- Wind
  - 3 Wind Farms (Hydro has PPAs with these wind producers)
- Additional power is also purchased from Newfoundland Power and CBPPL

Balance on the Grid

- An electrical grid must be in balance. The supply of electricity must equal the load at all times
- If there is an imbalance, then the Grid will react to ensure that balance is restored
- The load on the Grid fluctuates constantly based on customer demand
- To ensure balance, the electrical Grid signals dispatchable generators across the province to increase or decrease generation to meet the new load
  - In normal operations, this happens instantaneously and customers are not impacted by these changes
- If a generator experiences a problem and shuts down unexpectedly, the Grid reacts by shedding load (dropping customers) so that the system regains balance
  - The instantaneous shedding of load results in an unplanned outage to customers
  - This is called under frequency load shedding and is explained here
- A outage can also occur if the load gets too high and goes beyond the capacity of the electrical system

Meeting Capacity Requirements

- To ensure that the load never gets as high as the firm capacity of the system, NL Hydro's System Planning Group forecasts what the load will be both in the short term and long term.
- Long term predictions of future load growth are used to help ensure that there is enough installed capacity to meet customer demand. If the load is expected to increase, additional firm capacity may have to be built.
  - Capacity takes time to build/install. Approximately 2 years for a Combustion Turbine and 5 years for Hydro Plants. Approval is also required by the PUB
- The installed capacity on the island is based on the maximum load that is expected on the Grid plus a safety factor
  - Simply put, the safety factor is an additional amount of capacity that is kept in reserve. The amount of reserve is determined by System Planning and is based on reliability standards and best industry practices
- Generation sources like Wind Turbines and Solar Panels are non-firm generation sources and cannot be relied on to supply power when required and therefore can not be considered firm capacity

Capacity and Energy

Capacity and Energy

- It is often said that NL is long on energy but short on capacity. What does this actually mean?
  - As discussed previously, the NL interconnected system is designed to meet the peak load. This peak load only happens a few hours a year
    - If the load on the system was expected to increase through normal load growth or through the addition of a large industrial customer, NL Hydro would have to build or secure a new source of firm capacity to meet the new peak load
    - NL Hydro operates the system with only the amount of firm capacity that is necessary to meet peak load.
      - Any additional firm capacity beyond what is required to meet peak load would not be economically prudent as the costs of adding capacity would be paid for by ratepayers
    - Therefore during the peak winter periods, the interconnected system is "short" on capacity as there is no excess beyond what is needed to serve customers
  - During the remainder of the year, the installed capacity of all the generators on the island is larger then what is required to meet the needs of the province
    - These generators are capable of producing additional energy that is not required to meet domestic load. In fact, the generators are capable of producing significant quantities of energy that can be exported to external markets
    - This is why the province is "long" on energy

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Capacity & Energy Analogy

- It can be helpful to explain capacity and energy by looking at the case of a Restaurant
  - Capacity - The total number of seats in a restaurant is the Capacity.
    - As an example, a restaurant that can seat 100 people will have a Capacity of 100 people
    - If 50 people are currently seating in the restaurant than it will be operating at half its capacity
    - If 101 people wanted to sit in the restaurant at the same time it would be over capacity and one person would have to wait in line.
    - Unlike restaurants, the electricity system does not have lines. The system must be sized to accommodate all customers at the same time and must be built large enough to serve everyone

Capacity & Energy Analogy

- Energy - The specific number of meals that can be served in an hour, a week, or a year would be equal to Energy
  - Looking at our 100 seat restaurant, the number of meals that will be consumed in a day, week or year will depend on the demand by customers
    - If the restaurant is busy and all tables are full (Full Capacity) than the restaurant will produce 100 meals an hour but no more due to the lack of additional seats
    - If the restaurant is open 24 hours a day and all tables are full for every hour of the day the restaurant will produce 2400 meals a day (24 x 100)
    - If the restaurant is open 24 hours a days, 365 days a year and every table is full every hour of the day, the restaurant will produce 876,000 meals a year (8760 hours in a year x 100)
  - In this example the capacity of the restaurant is 100 people and the annual energy produced is 876,000 meals
  - This is equivalent to a 100 MW generator producing 876,000 MWh of energy over the course of a year

Capacity & Energy Analogy

- Determining the optimal restaurant size
  - A restaurant is designed to seat an optimal number of people
    - They want to have enough tables to serve all the customers that they expect to walk through their doors
    - If the restaurant is too big, the owners will have to pay additional costs
      - They will be paying rent on a building that is oversized, they will have to pay extra wait staff to serve the tables even if they are not being used, etc.
    - If the restaurant is too small, they will have a long line and will be turning customers away
    - When designing the restaurant capacity, the owners must decide how many customers they are comfortable turning away
    - Most restaurants are not full every hour of every day and an optimal number of seats must be determined to ensure customers are satisfied and that the restaurant is operating in the most economical way

Capacity & Energy Analogy

- Valentines day and Mother's Day are very popular days for people to eat out at restaurants. On these days most restaurants are usually at full capacity at all hours.
  - On these days, if the restaurant had 10 or 20 more seats, they would have no problem filling these seats
  - On these days the restaurant is capacity constrained
  - During almost all other times of the year, the restaurant is not at full capacity and it would not be cost effective to build seating for 10 or 20 more people for two days of the year
  - A smart restaurant owner will design the size of their restaurant to make sure that it is full most of the time but that is not oversized
- Like Valentines Day and Mother's Day in restaurants, the electrical system has peak days. These are the coldest days in the winter
  - Unlike restaurants, the electrical system can not make people wait in line. The system needs to be designed to meet everyone's demands. This means that the system must have the capacity to meet the expected load
  - As building extra capacity is expensive and is paid for by ratepayers, it is important to build enough to serve the needs of the province but no more

Capacity & Energy Analogy

- To Summarize:
  - The NL electrical system is designed to serve the peak load
    - That means that there is enough installed capacity or MWs to serve all customers on the coldest day of the year but not a significant amount of excess
    - During the rest of the year, the installed capacity is larger then required to meet the load and the province can produce significantly more energy than it requires
    - Newfoundland can be said to be long on energy and short on capacity
    - Post Muskrat Falls, the excess capacity can also be used to produce energy for export
  - If a new industrial customer came forward with a requirement for firm power during the peak periods, new capacity would have to be built to serve this load

Capacity & Energy Analogy

- Looking at our restaurant example, this would be equivalent to a new office building that is planning to open next to the restaurant.
  - If the new building is built, it would bring new customers to the restaurant.
  - It may make economic sense for the restaurant to expand the number of seats to meet the new customers demand
  - Before the restaurant spends money to expand its capacity, it will need to:
    - Determine if there are any other things it can do to generate more revenue from its existing infrastructure
    - Gain assurances that the new building is going to be built and that new customers will need to be served regularly

Transmission

Transmission

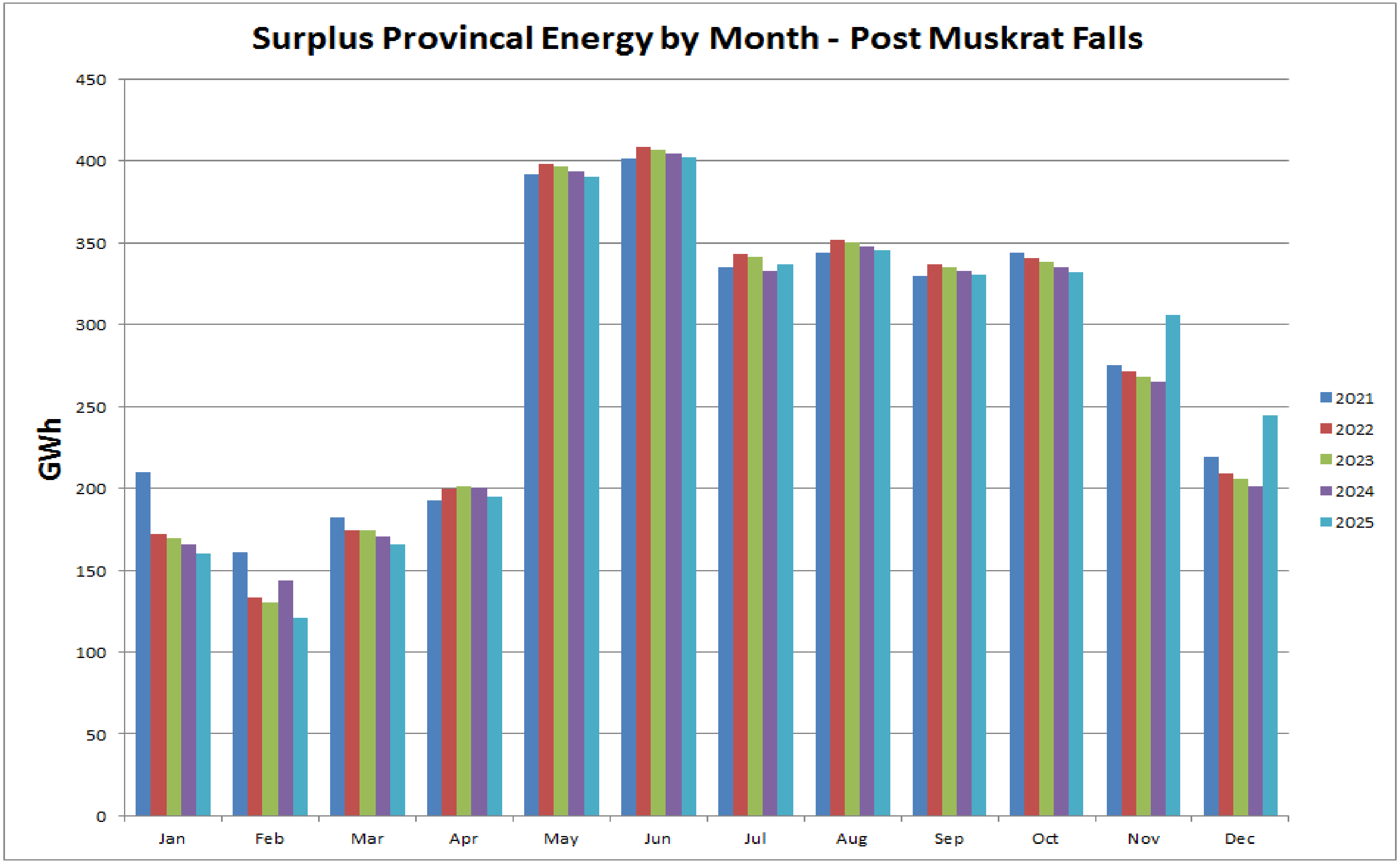
- The Maritime Link (ML) and the Labrador Island Link (LIL) are being completed as part of the Lower Churchill Project
  - The ML has a capacity of 500 MW and the LIL has a capacity of 900 MW
- For the first time ever, the island of Newfoundland will be connected to the North American electrical Grid
- Excess energy from NL will now be able to be sold to external markets in Canada and the United States.
  - Alternatively, it will be possible to import energy if required
- The amount of energy that can be sold will depend on the excess energy in the province that is available for sale and the space available on the transmission links
- The LIL will be used mostly to bring energy from Muskrat Falls to NL
- The ML will be used to export energy to NS and beyond
  - A portion of the capacity of the line will be dedicated to existing commitments to Emera and NSPI
  - The remainder of the line will be used to export electricity to external markers or import electricity if required

Transmission Rights

- There are two types of transmission rights:
  - Firm - The guaranteed right to delivery electricity across a transmission line during a period of time
    - This could be 24 hours a day, 365 days a year or it could only be during peak hours
    - Firm transmission is contracted and the generator of electricity is able to schedule its energy deliveries
  - Non-firm - Allows for the flow of energy when there is space on the line.
    - Holders of firm transmission rights have the first right to use the line.
    - Holders of non-firm transmission rights are allowed to flow if firm energy is not being delivered
    - Ability to flow will fluctuate and it is not possible to guarantee delivery during any specific hour of the day
- Nalcor has the firm transmission rights for both the ML and the LIL
  - Nalcor will look to use these firm rights to export/import as much electricity as economically and technically possible
  - There will be times when Nalcor will not be flowing electricity across the links and non-firm transmission rights will be available for purchase.

Excess Energy

Excess Energy Available For Export



nalcor energy

Glossary

Glossary

- Capacity - Is related to power and is the maximum power output of a generator, i.e. it is the highest amount of electricity that a generating unit is capable of producing at any moment
  - As an example , a 100 MW generator can produce electricity at any power level between 0 to 100 MW. The maximum it can produce is 100 MW and thus has a capacity of 100 MW
  - When we talk about the capacity of the Newfoundland electrical system, we mean the maximum power output of all the generators added together
  - Firm capacity is the total power available from dispatchable generation sources on the island
  - Another term related to capacity is Capacity Factor (CF). The CF is the average energy generated divided by the rated peak energy
    - A 100 MW generator operating at 100 MW for half the hours in a year would have a CF of 50%

Glossary

- Energy - Is the amount of electricity a generator actually produces over a specific period of time
  - For example, a generator with 100 megawatt (MW) capacity that operates at that power level consistently for one hour will produce 100 megawatt hours (MWh) of electricity
  - If the generator operates at only half its capacity for one hour, it will produce 50 MWh of electricity
  - Many generators do not operate at their full capacity all the time and the generators output will vary based on conditions at the power plant and load on the Grid
  - As energy numbers can be quite large, there are sometimes expressed in GWh (1 GWh = 1000 MWh) or TWh (1 TWh = 1000 GWh)

Glossary

- Generation Types
  - Dispatchable - Generating plants that can adjust their power output up or down based on changes in the load or based on a command from a system operator are said to be dispatchable generation
    - These generators can be counted on to supply the exact amount of power required when it is required. This type of generation can be considered firm capacity
    - Hydro Plants, Diesel Plants and the Holyrood Thermal Generating Station are all examples of dispatchable generators. These plants all have a way to store the fuel (water, diesel, etc.) required to spin their turbines
  - Non-Dispatchable – Generation that cannot be controlled by a system operator or respond to changes in the load is non-dispatchable
    - Intermittent sources of power like wind turbines and solar panels are examples of non-dispatchable generation. These generation types are considered non-firm and do not have a capacity value
    - Wind turbines and solar panels can not be counted on to provide power at all times due to the constantly changing weather conditions
    - There amount of power produced from a wind turbine fluctuates from second to second based on constantly changing wind speeds
    - Non-dispatchable generators due not have a means to store their fuel source (air, sun, etc.) for use at later date

Glossary

- Generator - A device that turns the rotation of a magnetic core into electricity
  - A turbine is connected to a generator and is used to rotate the core
  - Generators can be large or small and the size is measured in Watts, Kilowatts or Megawatts. 1 megawatt = 1 million watts
- Grid - The Grid is an interconnected network of equipment used to deliver electricity from producers to consumers
  - It consists of generating stations, high voltage transmission lines that carries electricity over long distances, distribution lines that connect individual customers, etc.
  - The Grid allows generating stations to be connected to customers across the province and also allows the generators to instantaneously respond to changes in the load
- Load - The demand for electricity at any moment in time
  - The Provincial load is measured in MW or GW.
  - The load on the Grid fluctuates every second of every day
  - The supply of electricity must equal the load at all times
  - Generators connected to the Grid ramp their production up or down to maintain balance

Glossary

- Power - Is the amount of electricity produced by a generator at a given moment in time. A generator can have a range of power outputs up to its maximum rating (capacity of unit). Power is measured usually measured in kilowatts, megawatts or gigawatts
- Turbine - A mechanical device used to turn a generator.
  - Turbines are essential large fans that are turned (rotated) by using air, water, or steam.
  - Holyrood uses steam turbines, hydro plants use water turbines and wind turbines use air.