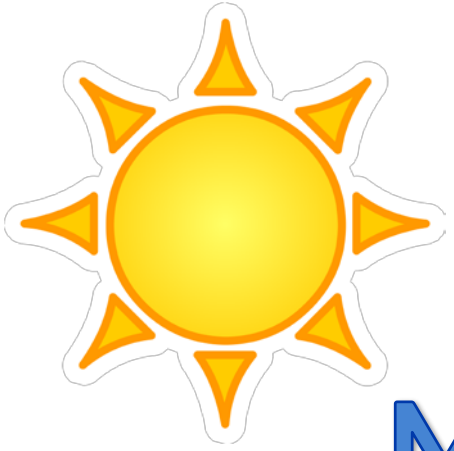


Manitoba Hydro Solar Energy Program

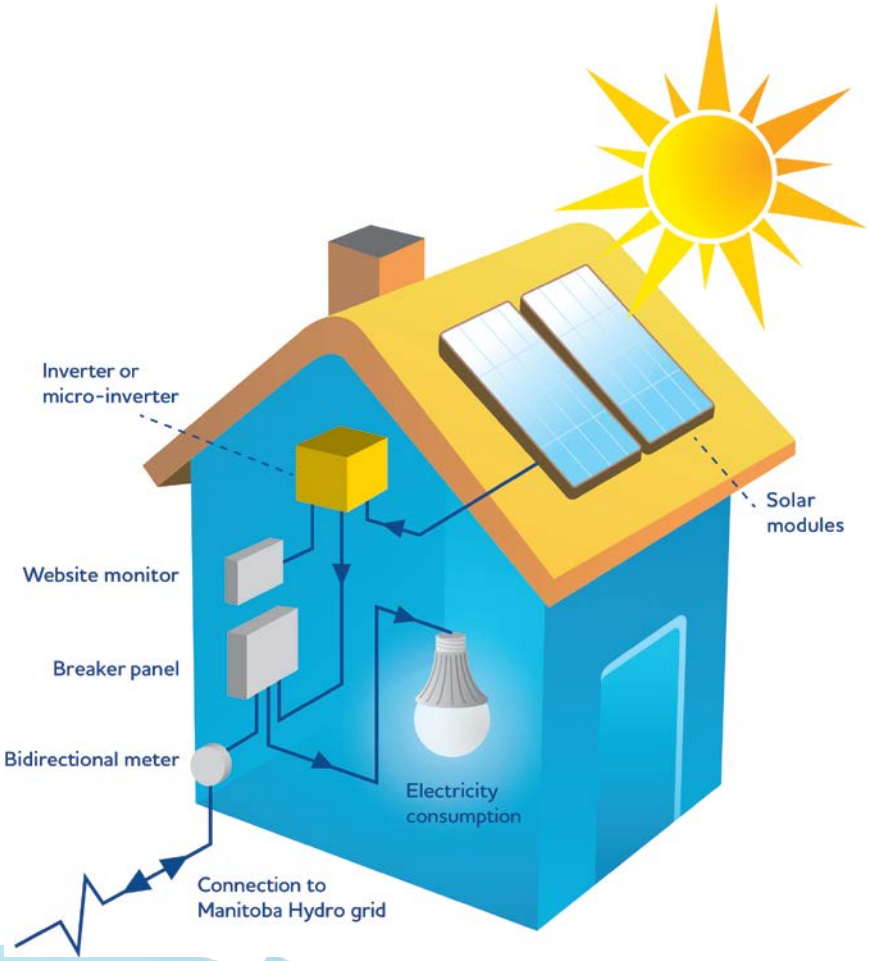
Lindsay Maitland

Power Smart

Manitoba Hydro

Solar Energy Program

Designed for Manitoba Hydro customers who would like to displace their own electricity needs with solar energy.



Manitoba Hydro

Solar PV Incentive

- Available to residential, commercial and industrial customers
- $1 per watt based on the dc rating of the system
- Minimum 1kW and maximum 200kW
- Incentive limited by the annual load displacement requirement of the site
  - Manitoba Hydro will determine the maximum incentive amount for the customer by reviewing the account history. New homes are also eligible

Manitoba Hydro

Residential Earth Power Loan

- Eligible to residential, non-seasonal customers
- Maximum financing of $30,000 for solar PV
- Loan amount is calculated at $3/watt installed
  - 5kw system would be eligible for a $15,000 loan
- Incentive will used to buy down the loan

Manitoba Hydro

Program Eligibility

- Customer must be connected to the grid
- Pre-approval is required
- Installation must be performed by a certified electrical contractor
- Equipment must be CSA approved
- Systems over 10kW may require a customer paid feasibility study
  - Any system upgrades identified through the study will be the customers responsibility

Manitoba Hydro

Contractor Requirements

- Power Smart participation requires a contractor complete the online Supplier Participation Agreement
  - This makes you an "approved" contractor
- No Solar PV certification required, but installation/design education is important
- Certified Journey Electrician must install all aspects of the solar PV system

Manitoba Hydro

How to take part

- Pre-approval required
- Change of Service Request
- Electrical Permit
  - Building permit within the City
- Pass Inspections
- Bi-directional Meter Installed
- Payment

http://www.hydro.mb.ca/environment/solar.shtm |

Manitoba Hydro

More Information

- Program Information: www.hydro.mb.ca/solar
- Consumption History: earthpowerinfo@hydro.mb.ca
- Electrical Codes & Standards: www.hydro.mb.ca/ecs
- City of Winnipeg Permits: http://winnipeg.ca/ppd/permits.stm

Manitoba Hydro

Program Uptake

- 5,500 plus inquiries to the program
- 520 applications received
  - 20% of customers applying for financing
- 464 applications pre-approved
- 152 installations completed
  - 145 residential
  - 7 commercial
- 14 kW (dc) average system installed
- 45 active installers

Manitoba Hydro

Solar Education
Customer & Contractor

- "Questions to Ask Your Contractor" section on our website
- CanSIA document "Going Solar: A Guide for Consumers"
- Energy Expert column addressing common questions about solar (insurance, taxes, payback calculations, etc)
- Electrical code training provided for installers

Manitoba Hydro

The Future

- Anticipating over 200 completed installations this year
- Opportunity for continued economic development in an emerging sector
- Add to the renewable energy options available to residents of Manitoba
- Efficiency Manitoba

Manitoba Hydro

The Manitoba Hydro Solar Energy Program & Distribution Considerations

Gerard Batara, P.Eng.

Manitoba Hydro

Photovoltaic Power System Global

Global Market Snapshot– **75 GW** of PV were installed in 2016. Making a worldwide capacity of **303 GW.**

Source: International Energy Agency

Share of Solar Source per Country in 2015

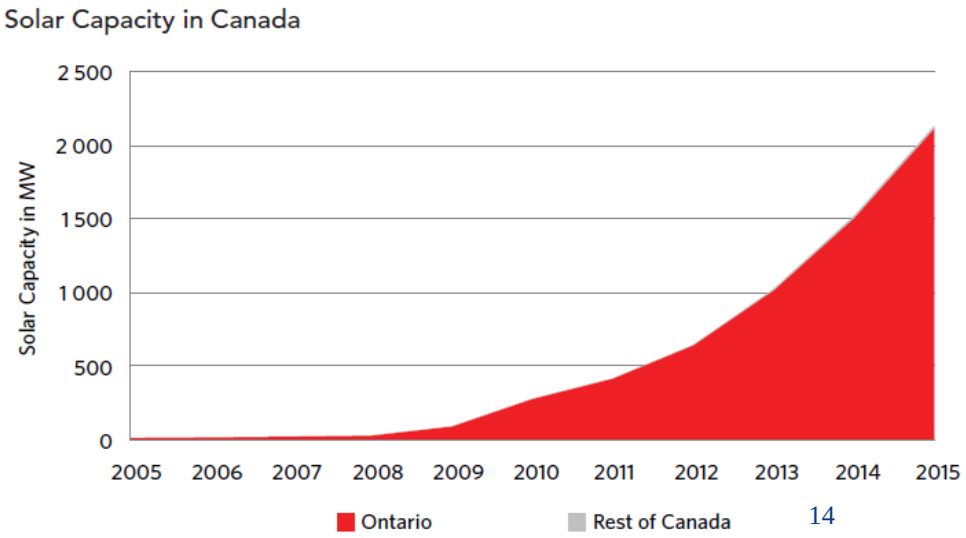
Solar	
Italy	9%
Greece	7%
Germany	6%
Spain	5%
Belgium	5%
Romania	3%
Japan	3%
Bulgaria	3%
Czech Republic	3%
Australia	2%

Share of Canada's electricity generation= 0.5%

Source: BP World Energy Statistical Review

Photovoltaic Power System Canada

* 2.14 **GW** of PV were installed in 2015. Which makes up the 1.5% of Total Canada Capacity
* In 2015, ranked 10th in the world for annual PV installations

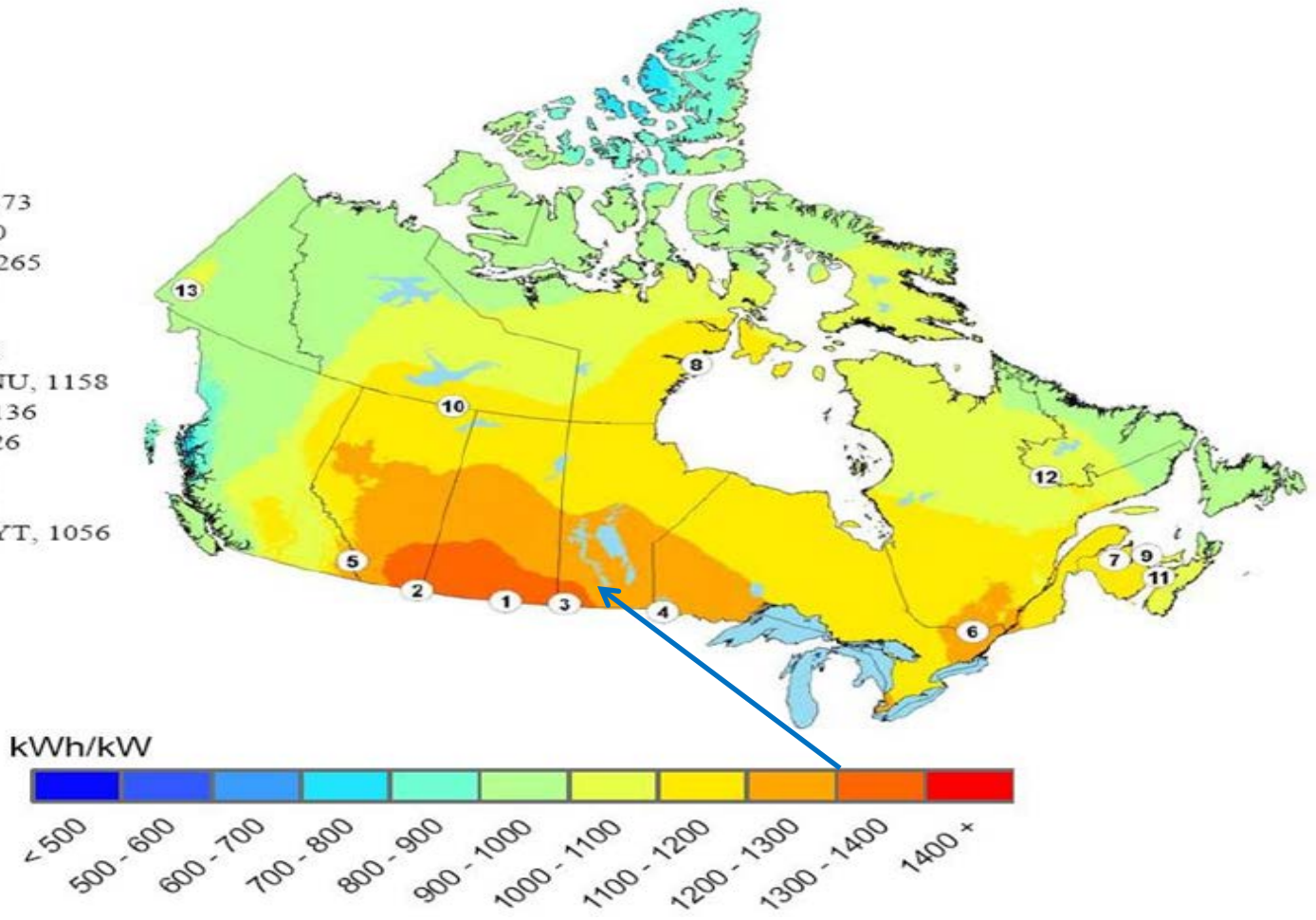


In 2015, 98% Solar Capacity are installed in Ontario

Source: Canada's Energy Future 2016

PV Potential Map

1 Regway SK, 1384
2 Wild Horse AB, 1373
3 Waskada MB, 1370
4 Rainy River ON, 1265
5 Elkford BC, 1236
6 Quyon QC, 1208
7 Chatham NB, 1168
8 Chesterfield Inlet NU, 1158
9 Miminegash PE, 1136
10 Fort Smith NT, 1126
11 Amherst NS, 1125
12 Wabush NF, 1074
13 Burwash Landing YT, 1056



Winnipeg = 1315

Source: www.nrcan.gc.ca

Sample Computation on PV Sizing

$$Capacity\ Factor\ (CF) = \frac{(Actual\ Annual\ Energy\ Production, kWh)}{(Max\ Nameplate\ Energy\ Potential, kWh)}$$

In Winnipeg CF ~ 0.15

$$Capacity, kW = \frac{(Annual\ Energy\ Consumption, kWh)}{(CF\ x\ Hours\ in\ Mean\ Year, h)}$$

Note that $(CF\ x\ Hours\ in\ Year, h) = 1315\ \frac{\frac{\text{kWh}}{\text{kW}}}{\text{yr}}$

E.g. PV capacity required to displace an annual energy consumption of 12,000 kWh,

$$Capacity = \frac{12{,}000}{0.15 \times 8765} = 9.13\ kW$$

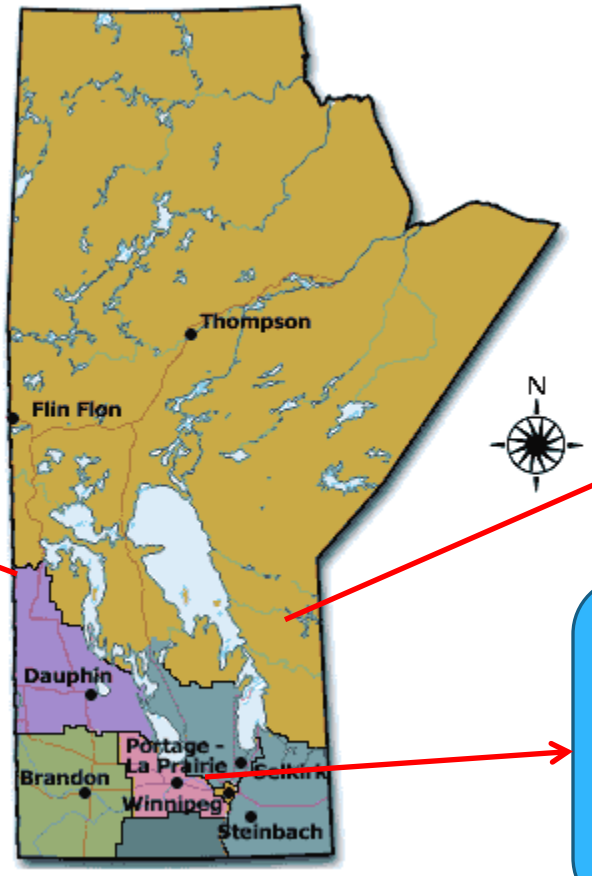
Manitoba Hydro Interconnection

Interconnection Types

- **Type 0 – Non-Parallel Operation (Break before make)**
- **Type 1 – Momentary Transition (Make before break in less than 100ms)**
- **Type 2 – Load Displacement (Sustained parallel & non-export)**
- **Type 3 – Sustained parallel with export**
- **Type 4 – Export only**

PV in Manitoba

Received and Reviewed application = 11.7 MW DC



WEST MANITOBA Received and Reviewed application:

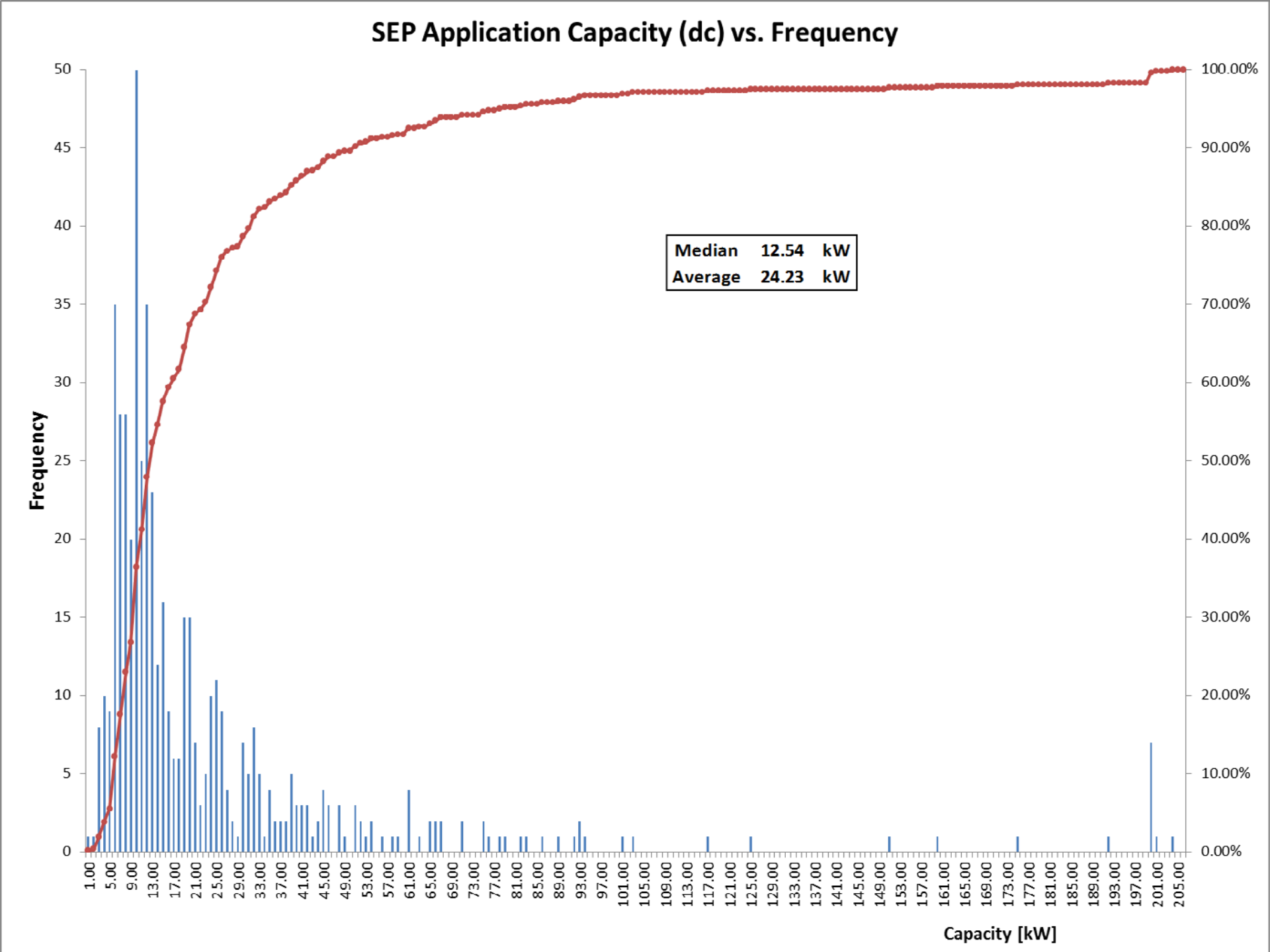
TOTAL DC POWER = 5,227 kW

EAST MANITOBA Received and Reviewed application:

TOTAL DC POWER = 4,490 kW

WINNIPEG Received and Reviewed application:

TOTAL DC POWER = 1,970 kW


SEP Application Capacity (dc) vs. Frequency
Median 12.54 kW
Average 24.23 kW
Frequency
Capacity [kW]
0
5
10
15
20
25
30
35
40
45
50
0.00%
10.00%
20.00%
30.00%
40.00%
50.00%
60.00%
70.00%
80.00%
90.00%
100.00%
1.00
5.00
9.00
13.00
17.00
21.00
25.00
29.00
33.00
37.00
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45.00
49.00
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57.00
61.00
65.00
69.00
73.00
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89.00
93.00
97.00
101.00
105.00
109.00
113.00
117.00
121.00
125.00
129.00
133.00
137.00
141.00
145.00
149.00
153.00
157.00
161.00
165.00
169.00
173.00
177.00
181.00
185.00
189.00
193.00
197.00
201.00
205.00

Solar Generation Interconnection

Major Considerations

- **Safe Operation** – shall respond appropriately during normal and abnormal system condition

- **Manageable Impacts –** must not affect the electrical design and operation of the distribution system. Thus, maintaining reliability, quality and safety with minimal impact to losses.

- **Compensates and provide grid support** - must respond harmoniously with the control and communication within the system's operating strategy.

Manitoba Hydro Interconnection

Technical Requirements

* Harmonics – The solar facility shall meet the requirements of PQS2000-02
* Flicker - The solar facility shall not cause voltage fluctuations outside of the Manitoba Hydro flicker criteria.
* Voltage Regulation & Power factor

  - The levels at PCC (Point of Common Coupling) are maintained within CSA Standard CAN3 C235.83 or Manitoba Hydro Criteria.

  - PF must be 0.90 or better.

Manitoba Hydro Interconnection

Technical Requirements

* Voltage Unbalance – The phase-to-phase voltage unbalance must not exceed 1.0% measured at no-load
* Protection system must be able to detect all types of faults as well as loss of supply (single or three phase).

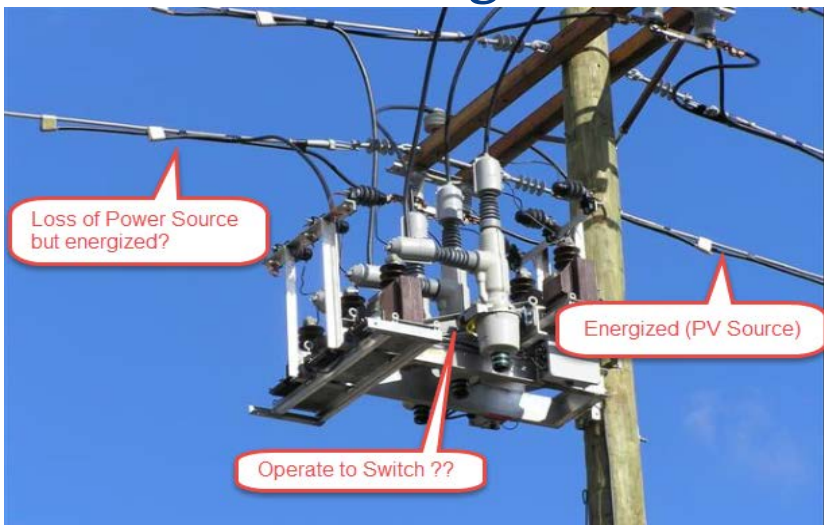
Minimum Protection requirements:

a. Over-Voltage
b. Under-Voltage
c. Over-Frequency
d. Under-Frequency
e. Overcurrent

Manitoba Hydro Interconnection

Technical Requirements

* Anti-islanding– PV must cease in supplying power once the electrical grid power is no longer present.
  - Safety of the utility worker is the utmost concern.
  - Power fed back to grid may not maintain PQ condition and can damage other customer's facility assets.
  - Failure of sectionalizer to operate due to energized line from PV generation.
  - Energized line may interfere with the protection and control during restoration of power.



DRIP - Manitoba Hydro

Distributed Resources Interconnection Process

- **Manitoba Hydro DRG 2003 –** Technical Requirements for Connecting Distributed Resources To The Manitoba Hydro system
- **CSA C22.3 No.9-08 –** Interconnection of distributed resources and electricity supply system
- **CSA C22.2 No.107.1-01 –** Interconnecting inverter-based micro-distributed resources to distribution system
- **PQS 2000-02 –** Power Quality Specification for interconnection to Manitoba Hydro's Electrical System

PV to Grid Impacts

* Source of energy - PV generation can provide local source of energy but is not intended for extra capacity
* T&D Capital cost deferral Now ? 
* Loading stress on station assets will be lessened during peaking hours

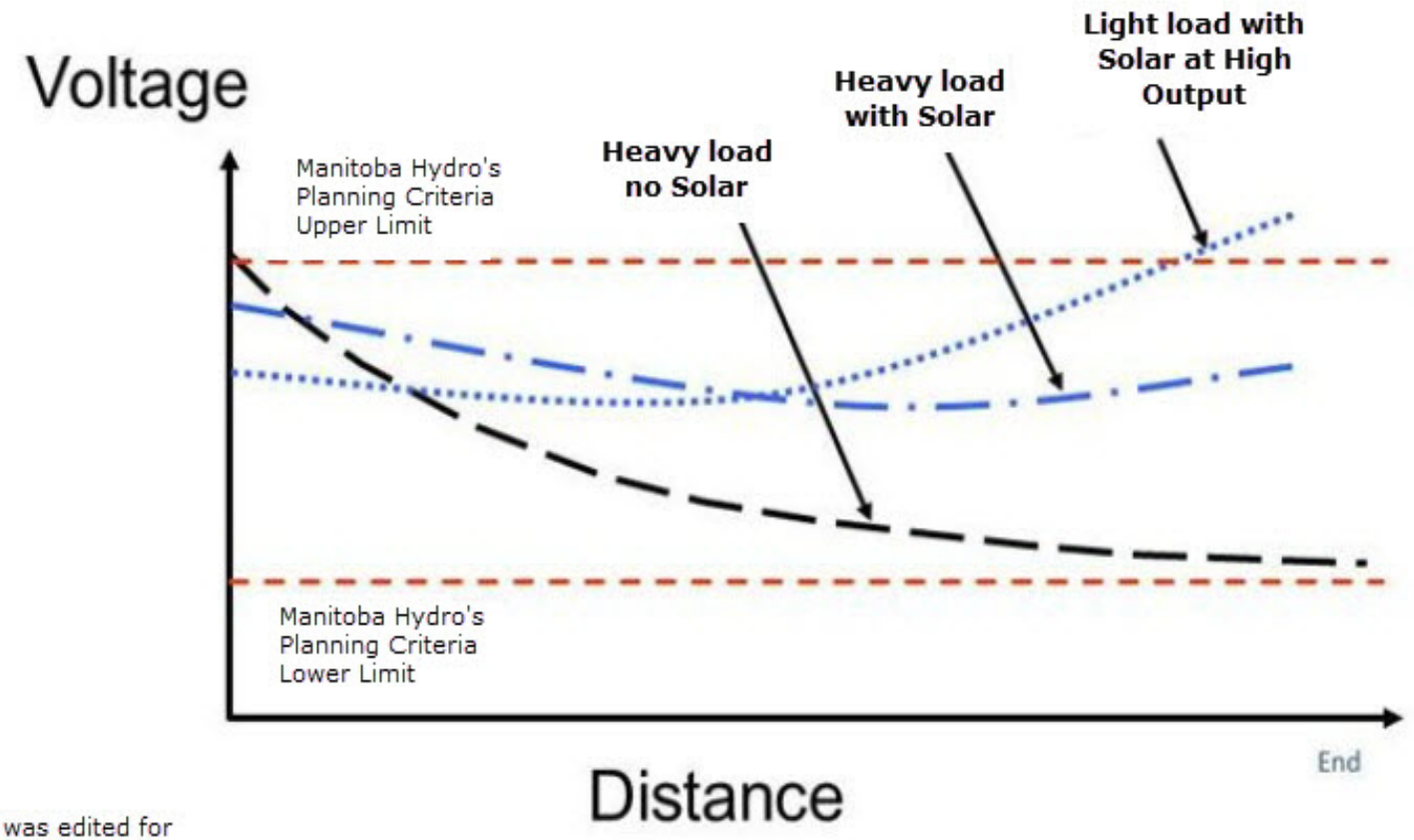
PV to Grid Impacts

* Control & Communication – electrical system will react as originally designed on a conventional power flow. However, PV source are mostly installed at the point of energy consumption

Conventional Power Flow

Point of energy consumption

PV to Grid Impacts



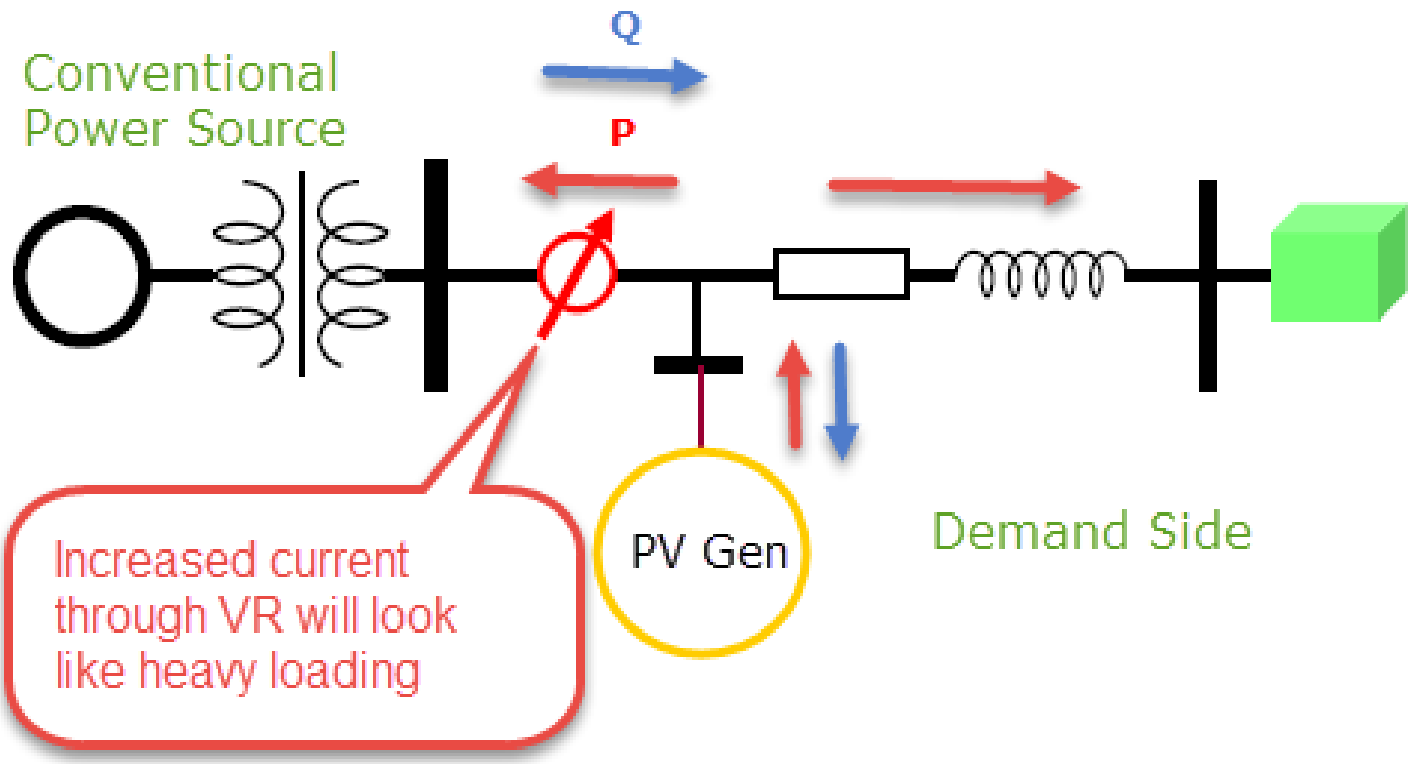
Picture was edited for presentation purposes only
Ref: EPRI

Voltage Regulation

PV to Grid Impacts

* Voltage regulation issues during reverse power
  - Conventional VR will attempt to regulate the source side of the line using a non-fixed and weak reference coming from solar generator
  - Fighting its own setting may result to loss of coordination with Regulator's LTC
  - Need to upgrade the control system to prevent regulator "runaway"

PV to Grid Impacts



PV to Grid Impacts

Stiffness Factor can be an indicator of flicker and voltage sensitivity for weak feeders.

SF = I_{SC} / I_{DSG}

I_{SC} : System fault current

I_{DG}: Full Load rated output current
(PV Generation)

PV to Grid Impacts

Stiffness Factor (SF)	Recommendation
SF >250	**Insignificant:** Absolutely no concern that flicker or voltage change will be an issue for any type of DSG source
100 < SF≤ 250	**Nearly Insignificant:** Very little concern unless DSG is started/stopped frequently or has unusual fluctuations
50 < SF≤ 100	**Minor Concern:** Moderate concern for fluctuating sources such as wind and PV. Will need to assess rates of fluctuations and start/stop cycles but still probably not an issue in most cases
25 < SF≤ 50	**Significant Concern:** Any DSG source connecting with an SF in this range will need serious analysis of planned start/stop cycles and output fluctuations and may need some mitigation equipment
15 < SF≤ 25	**Very Significant Concern:** DSG in this range can cause serious voltage flicker and fluctuations – especially if PV or wind. Mitigation equipment and/or system changes probably are needed
SF ≤ 15	**Extreme Concern:** Voltage changes may be so severe – especially if PV or wind - that project is not viable without extreme application of mitigation devices or feeder upgrades

Ref: EPRI (Electric Power Research Institute)

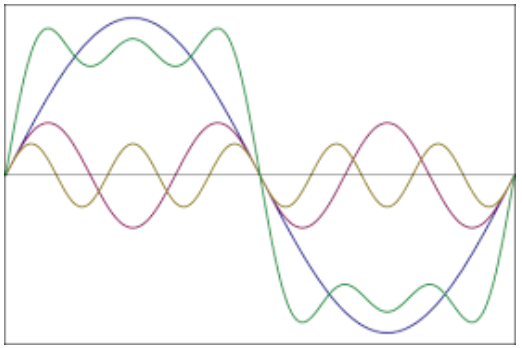
PV to Grid Impacts

* PV inverter add harmonic distortion to PCC current due to electronic based switching.

MB Hydro recommends transformer upgrade based on PV Power Output:

- Pole mount 1-phase & 3-phase at 120%

- Pad mount 1-phase at 120%
  & 3-phase at 110%



Pre-approval and the SLD Requirements

* Name of PV owner / Address of PV installation
* Installer with addresses and contact information
* Actual PV array configuration– using the proper electrical symbols

Required Details:

- **PV Module** model, ratings ac/dc power, voltage, current
- **Inverter** model, ratings ac/dc power, voltage, current
- External utility, lockable disconnect and other details required by the code

Pre-approval and the SLD

- Service panel & meter with ratings
- Total PV Output Capacity (AC / DC)
- PV cells must have CSA/cUL/cETL Stamp
- Inverters must be:
  - CSA C22.2 no. 107.1-01 certified
    (Required by MB Hydro Inspectors)

SUMMARY

* Unintentional islanding may compromise safety of maintenance works along the line
* Power supplied from PV may not maintain PQ condition to supply other customer's loads
* PV service voltage may go outside of applicable limits
* Harmonic distortion to PV current due to power electronic based switching devices
* Upgrade of voltage regulator control capable of reverse power

Thank You
For Listening