

# Advancing Green Energy

Enbridge – a leader in renewable energy



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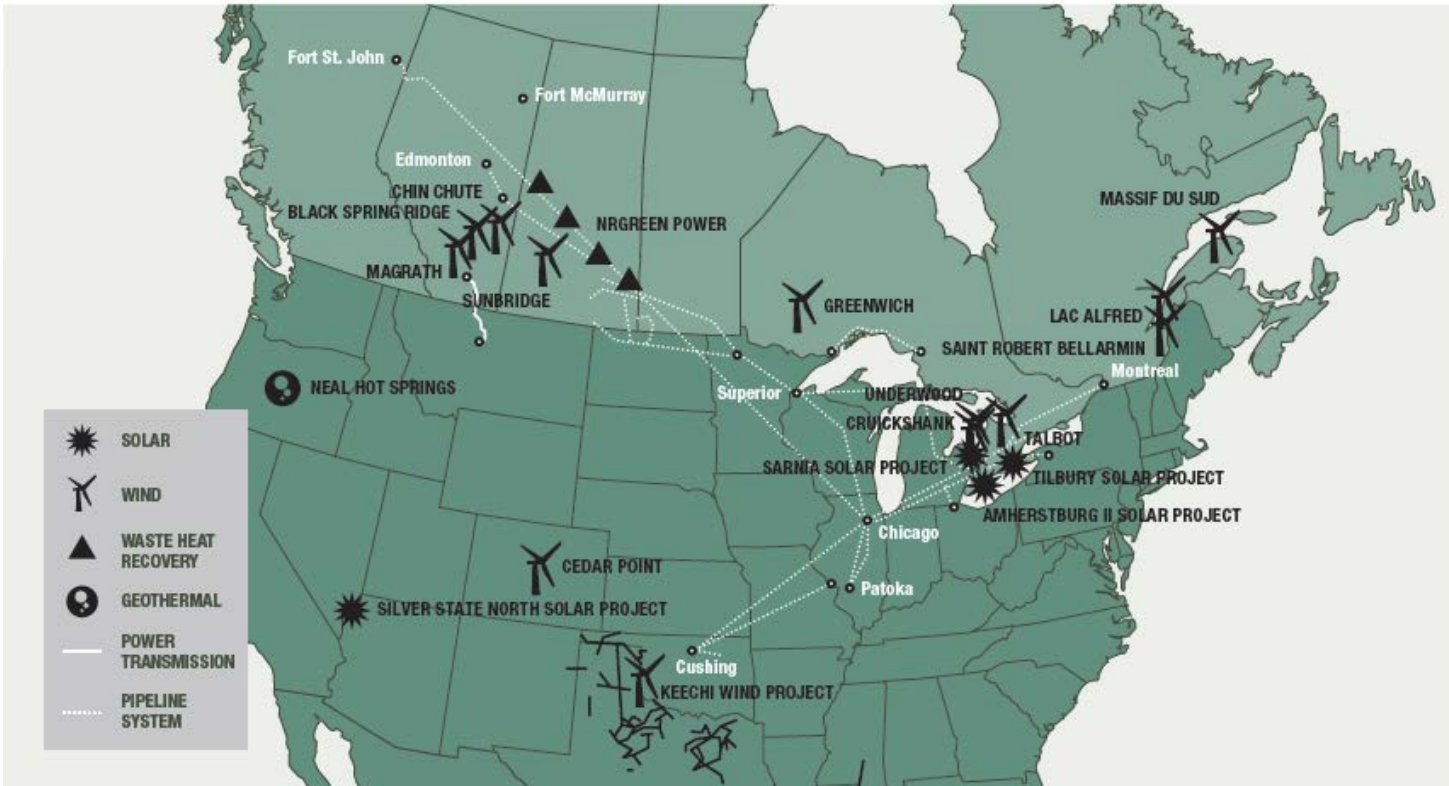


# Safety

Dig Safe - Be aware of  
underground  
infrastructure

## Enbridge – Green operations

Over the past 65 years, Enbridge has become a leader in the safe and reliable delivery of energy in North America.



## Our investments

Enbridge is one of the largest renewable energy generators in Canada.

- 14 wind farms
- 4 solar facilities
- 2 waste heat recovery projects
- A geothermal installation
- Our net capacity now sits at more than 1,600 MW and we have interests in more than 2,200 MW of gross capacity – enough to supply nearly 750,000 homes (based on gross generation).



## Renewable Ontario

Despite conservation efforts, demand for electricity is expected to increase by 15% from 2010-2030

To prepare for these changes, the province has developed a Long-Term Energy Plan (LTEP) for the period of 2010 - 2030.

By 2030, the LTEP calls for the vast majority of electricity generation in Ontario to come from:

- nuclear power (46%)
- hydro-electricity (20%)
- wind (10%)
- solar (1.5%)
- natural gas (7%), and
- for conservation measures to reduce demand by 14%.



CANSIA





In one hour, the sun sends enough solar energy to the Earth that if fully harnessed, would meet our global energy demands for **ONE FULL YEAR**

## Solar energy 101

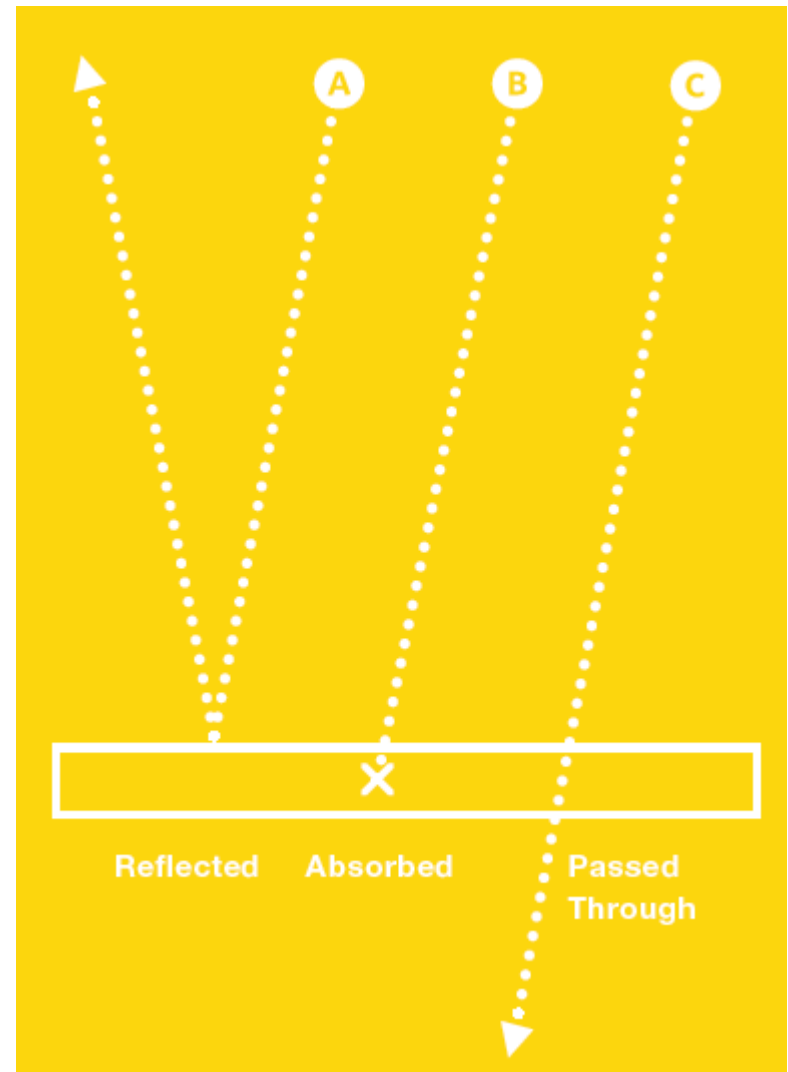
Siting a wind farm:

- Access to transmission
- Available land
- Adequate resources

Solar panels (photovoltaic cells) convert sunlight into DC electricity.

### How it Works:

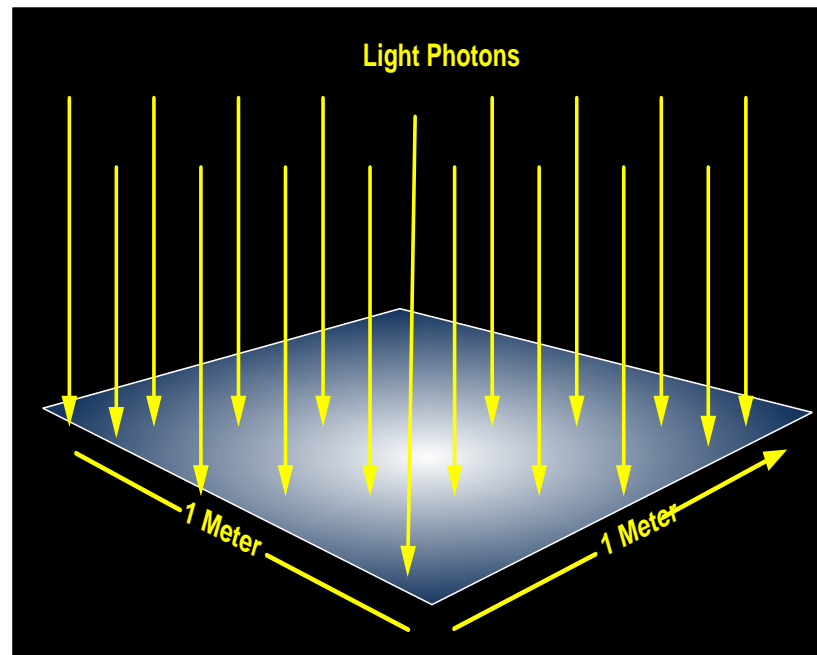
1. PV cells absorb photons (light particles)
2. The photons strike the solar cell and are reflected, absorbed or passed through.
3. If absorbed, photons interact with the semi conductor, freeing electrons which flow in one direction and exit through connecting wires as solar electricity





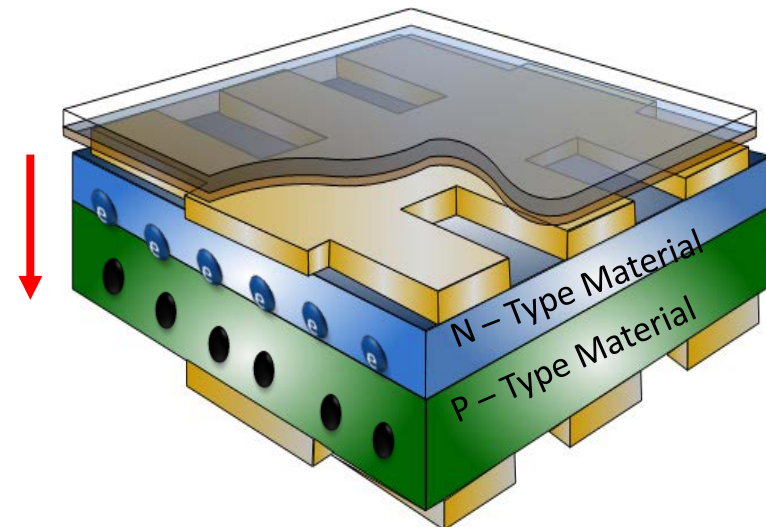
# Photovoltaic Fundamentals

- Photovoltaic modules convert sunlight into DC power.
- Photons of sunlight excite electrons inside the module which causes electric current to flow.
- Photo (*light*) voltaics (*electricity*), PV
- Light hitting the earth (**irradiance**) is measured in  $W/m^2$ . At solar noon on a typical summer day, irradiance measures **1000  $W/m^2$**  at sea level.



# Photovoltaic Fundamentals

- Photovoltaic cells rely on substances known as **semiconductors**.
- Semiconductors are insulators in their pure form, but are able to conduct electricity when heated or combined with other materials.
- A semiconductor "doped," with certain other elements develops an excess of free electrons.
  - This is known as an **N-type** semiconductor.
- A semiconductor doped with other materials, develops an excess of "holes," or spaces that accept electrons.
  - This is known as a **P-type** semiconductor.
- Semi-conductors also act to limit current flow to one direction.



## Solar Ontario

- The efficiency of solar photovoltaics (PV) increases in colder temperatures and is particularly well-suited for Canada's climate.
- By 2018, Ontario's solar PV industry is expected to have created over 74,000 jobs
- Solar PV will result in an average of approx. 25 jobs in Ontario per installed MW
- From 2011-2018, solar is expected to add 70 cents/year to the average Ontario electricity customer's average monthly bill, compared with likely alternatives
- By 2018, the cost of adding solar to the electricity supply will amount to \$4.91 per month for the average Ontario electricity customer, or 3% of their monthly electricity bill



# Sarnia Solar





# Sarnia PV Power Plant

- The PV power plant consists of 8 generating blocks, each comprised of 10 Power Conversion Systems

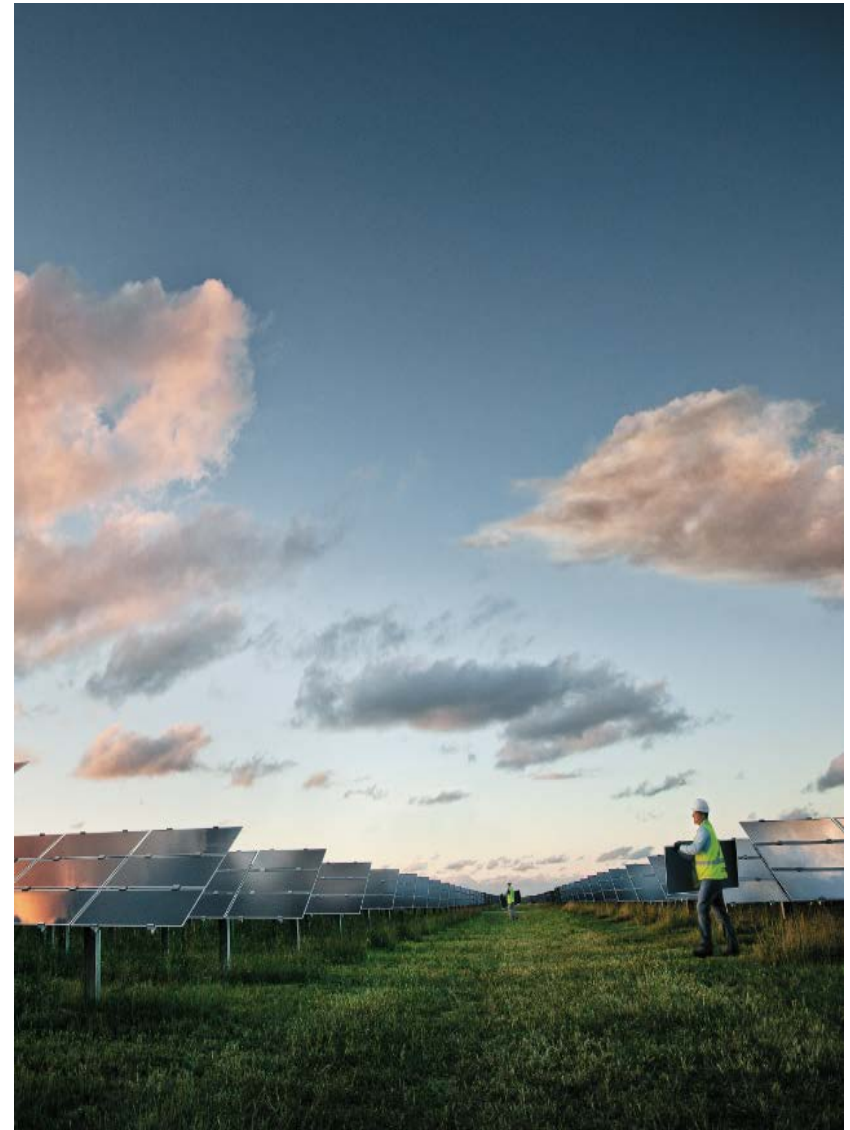


- 1150 Acre Site
- 640 approx. acres of solar
- 402 approx. Km of Cable
- 1,348,800 Modules
- 1,280 Combiner Boxes
- 160 Dc to AC Inverters
- 80 PCS Shelters
- 80 1 MVA Transformers
- 8 Blue Water 27.5 Kv Interconnection Points

## Sarnia Solar Farm

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- Was the largest operational photovoltaic facility in the world when built (2009).
- 80 MW peak capacity
- Roughly 1.3 million thin film panels, over 1,110 acres of land
- Annual yield of 120,000 MWh (corresponds to annual consumption of about 12,800 homes)
  
- 5 MW peak capacity – Tilbury Solar
- 15 MW peak capacity – Amherstburg Solar
  
- 50 MW peak capacity – Silver State North (Clark County Nevada, March 2012)





# Construction Process

Drive "H" Pile / Post



Install Tilt Brackets



# Construction Process

Install Tables

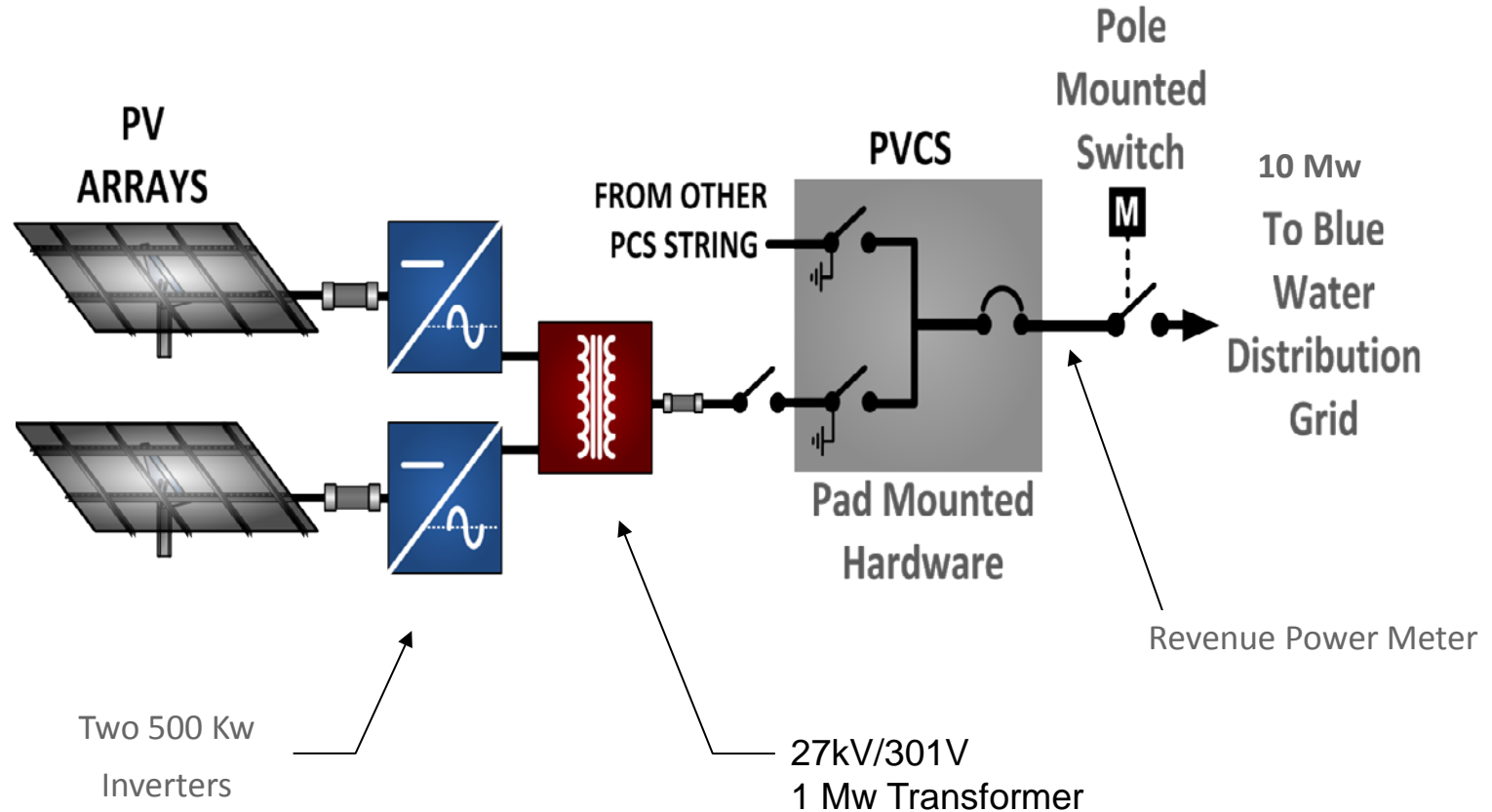


Glass Installation



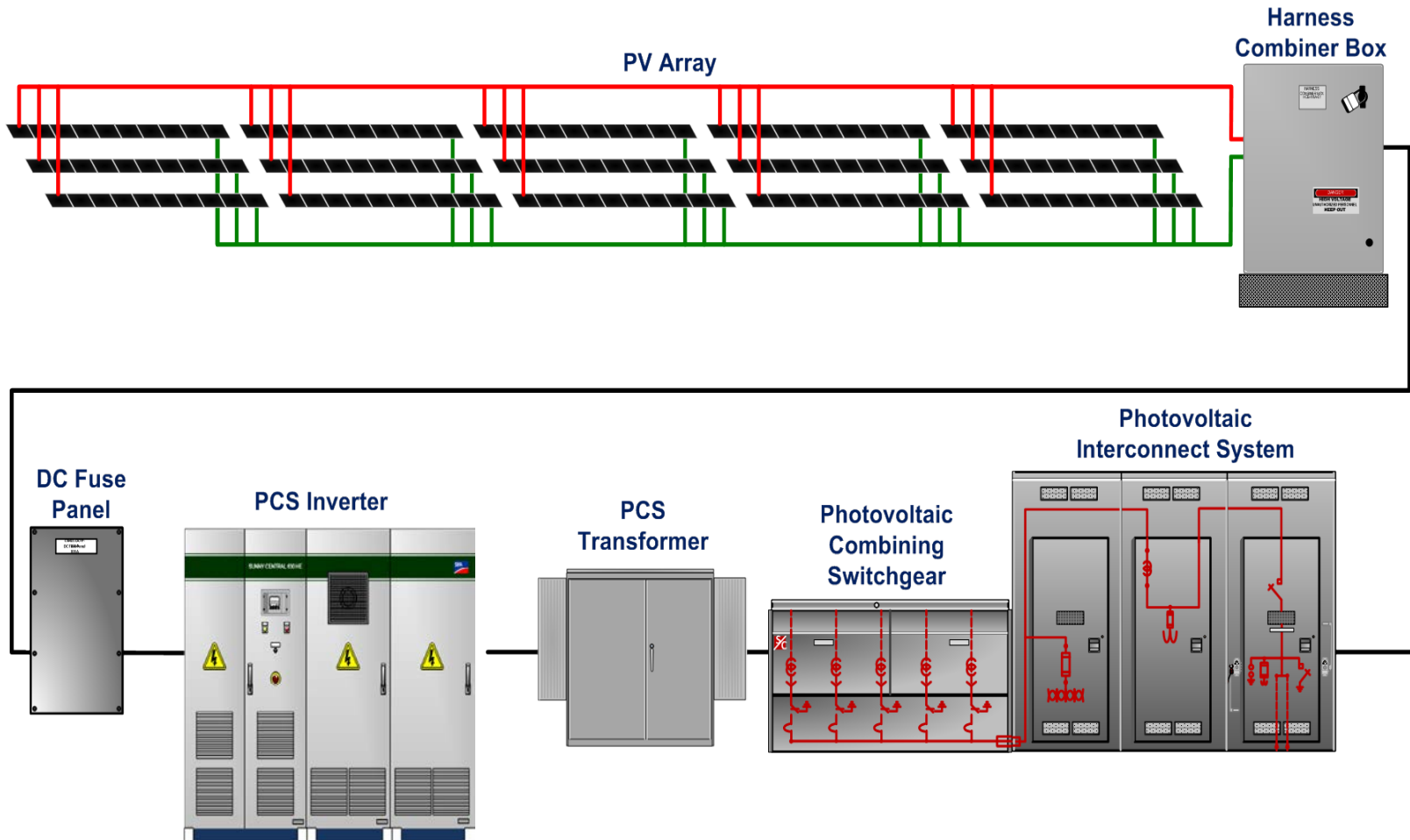
# Sarnia PV Power Plant

## One Line Diagram – Typical 1 MWac Block





# Sarnia Solar – Typical Facility Layout



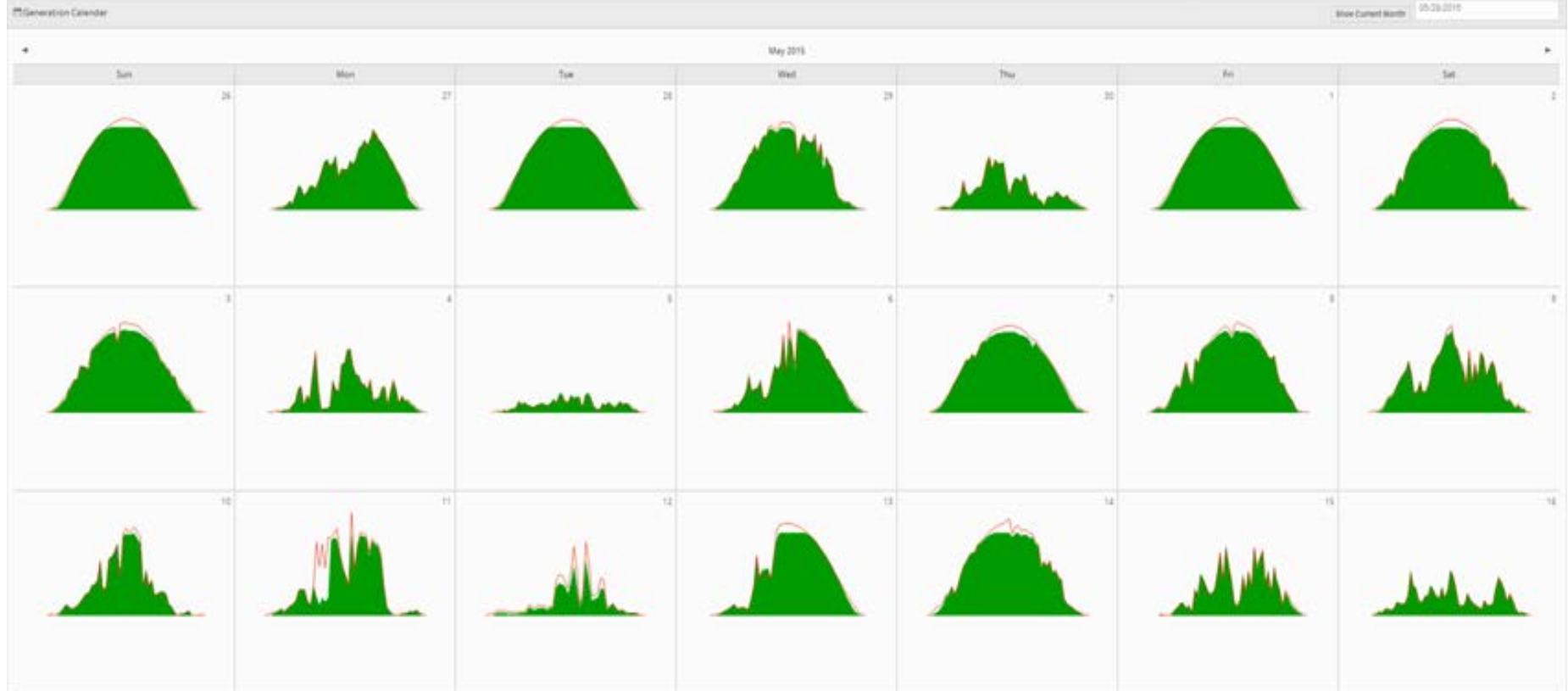
# Sarnia Solar – Operations – Heat Map



# Sarnia Solar Operations – May 2015

Dashboard - Sarnia Solar

Commissioned: 2010-08-09  
Capacity (AC): 80 MW  
Time Zone: Eastern Standard Time  
Capacity (DC): 97,628 kW  
Enbridge Inc.  
1624 Churchil Line  
Sarnia, Ontario N7T 7H3 CA  
Calendar Legend  
— SOI Irradiance  
— Power





# Sarnia Solar – Operational Challenges

## – Current and Recent Site Challenges

- Animal Chewing Cables
- Site Drainage
- 23,000 Low Performing Module Changeout



## 2014 Operational Issues - Snow

- Strong southerly winds and very cold temps in January 2014
  - snow is beginning to drift in between the rows (typically the second or third row of panels).
  - Limited to only a few areas, not widespread





## Sarnia Solar Farm – community benefits

- Safe Community funding for First Responders
- In 2014 provided on-site safety training for over 200 Sarnia fire fighters
- Fall 2014 live emergency exercise with Sarnia Fire Department's training officers and two station crews participating
- Additional exercise planned for 2015 with Sarnia Fire Department
- Top site for 2014 Lambton Doors Open with over 150 visitors



# Wind Assets



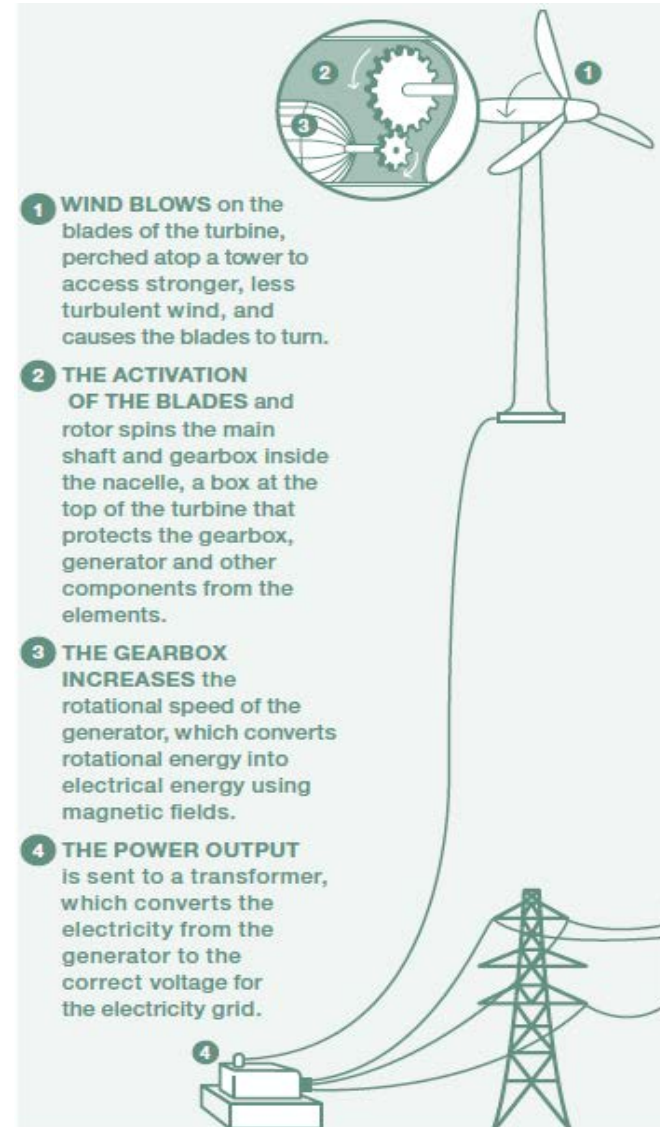
## Wind 101

### Siting a wind farm:

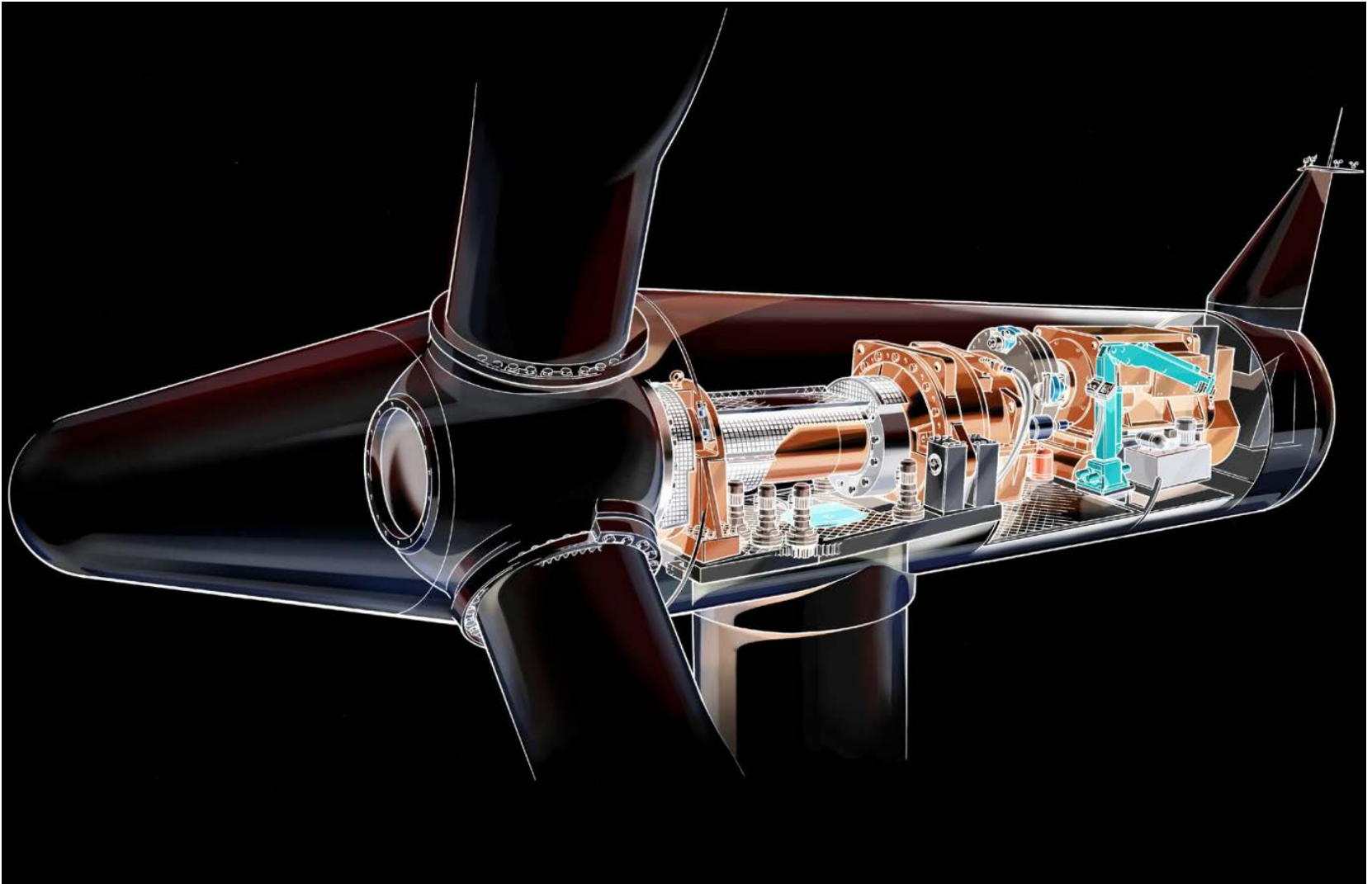
- Access to transmission
- Available land
- Adequate resources

### How it Works:

1. Wind blows on the turbine blades, causing them to turn.
2. Activation of blades spins shaft and gearbox inside the nacelle.
3. Gearbox increases generator speed, converting rotational energy into electrical energy.
4. Power output sent to transformer, converting electricity into correct voltage for the grid.



## Siemens 2.3 101 Turbines





# Wind Turbine Generation

1



**Wind turns rotor and spins shaft**

2



**Generator produces power at 600V AC**

3



**Travels through the turbine**

4



**Transformer at base of turbine steps up voltage from 600V AC to 44kV AC**

5

***Distribution  
Connected***

**Ties into HONI-owned  
37.5/44kV AC local  
distribution overhead  
lines**



***Transmission  
Connection***

**Ties into Enbridge-  
owned 44kV AC  
collector lines to  
substation.**

(cont'd)

6



**Transformer at  
substation steps up  
voltage from  
44kV AC to 230kV AC**

7



**Ties into 230kV AC  
HONI-owned  
transmission  
overhead lines**

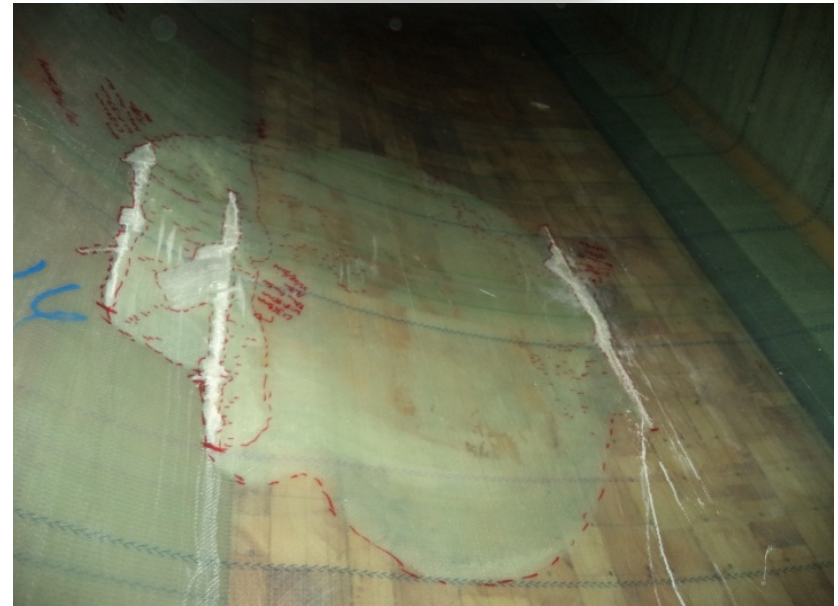
## Ontario wind farms

- Enbridge is one of the largest wind energy producers in Canada
- Underwood/Cruickshank Wind Farms (Kincardine)
  - 191 MW of peak capacity
  - 499,000 MWh of yearly wind energy production
  - Powers up to 60,000 homes per year
- 99 MW Talbot Wind Farm
- 99 MW Greenwich Wind Farm
- Saskatchewan, Alberta, Quebec, Colorado, Indiana, Texas



## Operational challenges - Blades

- Greenwich blade damage



## Operational Challenges- Blades

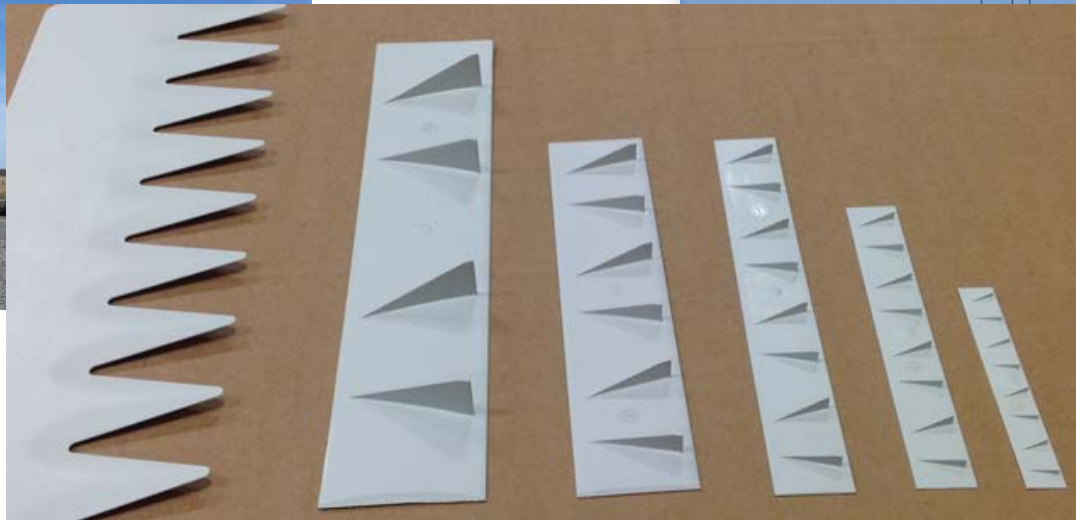
—  
Saint Robert Bellarmin  
Windfarm, QC

Blade bearing failure





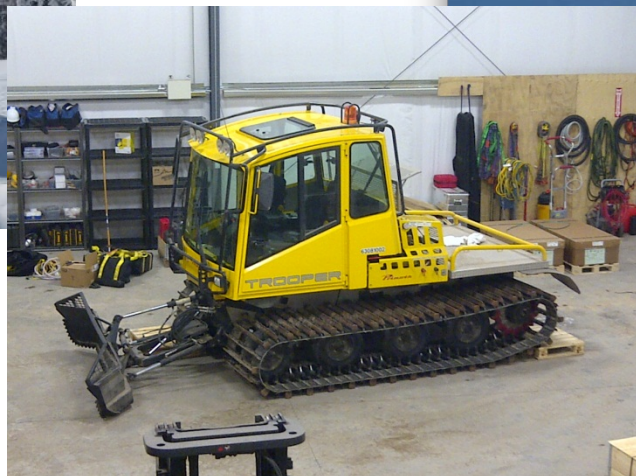
## Operational challenges – Blade Improvements





## Operational challenges – Winter Weather & Icing

- Icing and ice throw on wind turbines
- Quebec winter access – SnowCats

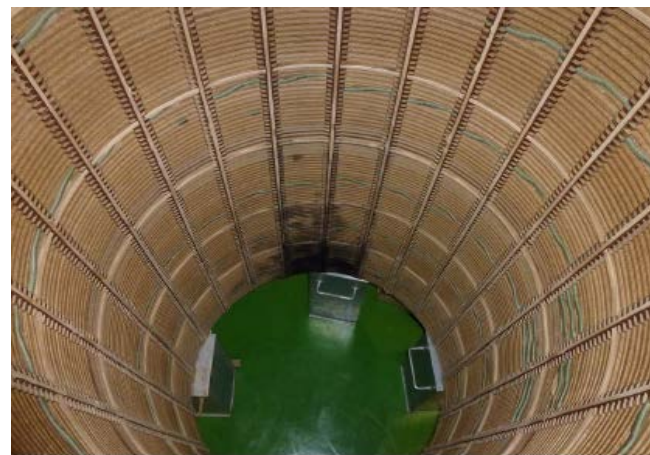


# Operational Challenges - Transformer Issues



## Greenwich Wind Farm

- T2 transformer tripped offline on March 2
  - oil testing confirmed high acetylene level, suggesting internal arcing
- Transformer sent back to Korea for repairs
- Returned to service August 29, 2014



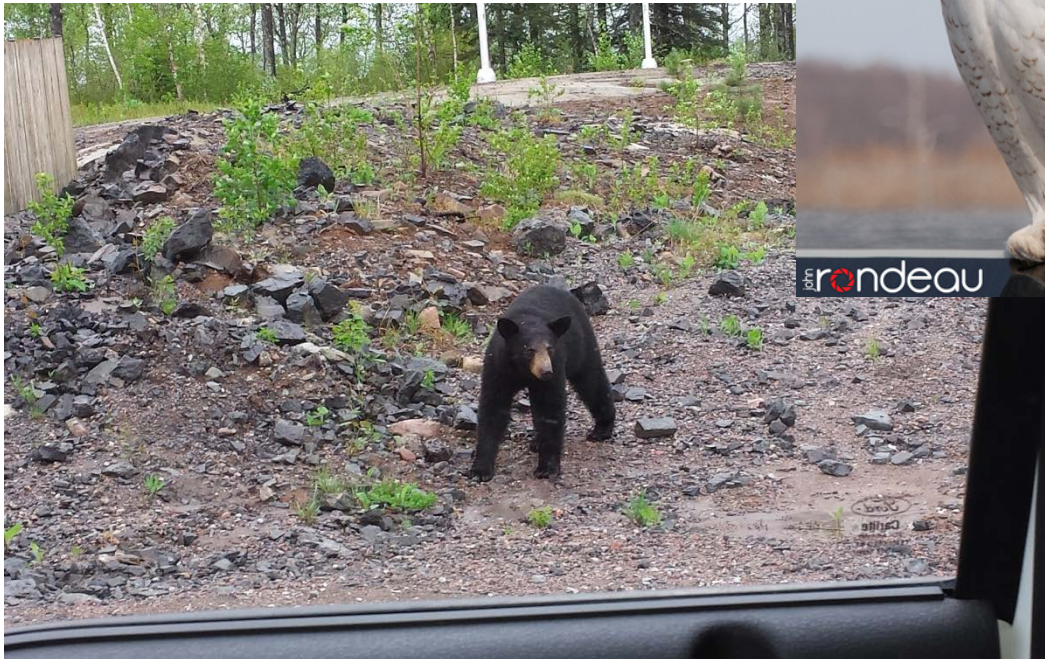


## Operational challenges - Wildlife

- Greenwich – Bears
- Sarnia – Cable Chew



rondeau



## Common question

Why are the turbines not turning?

- Not enough wind
- Service
- Balance of Plant service / outage
- Dispatched from Independent Electricity System Operator





## Emerging technologies

We're also investing in a wide range of alternative energy projects/ technologies :

- geothermal energy,
- stronger, more efficient renewables and,
- integrated storage technologies, which help balance the grid by addressing the intermittent nature of wind and solar
- Waddell Falls – Run of River Hydro



**Q & A**