Developing Innovative Technical Solutions At The Project Level -- Canadian Solar

September 16, 2015

CSIQ NASDAQ LISTED

CanadianSolar
Make The Difference

Company Overview

- Founded in Ontario, 2001
- Listed on NASDAQ (CSIQ) in 2006
- Over 7,000 employees globally
- Global footprint in 90 countries

Top 3 module supplier in the world

Proven project development track record and 8.5GW project pipeline

Strong bankable brand with global reach

Best product warranty backed by investment grade insurance policy

2013 Revenue
$1.65 Billion

2013 Shipment
1.89 GW

2014 Revenue
2.96 Billion

2014 Shipment
3.1 GW

Global Network for Production, Sales & Service

More than 7,000 employees in 18 countries

Global Project Experience

Experienced
project development start in 2009

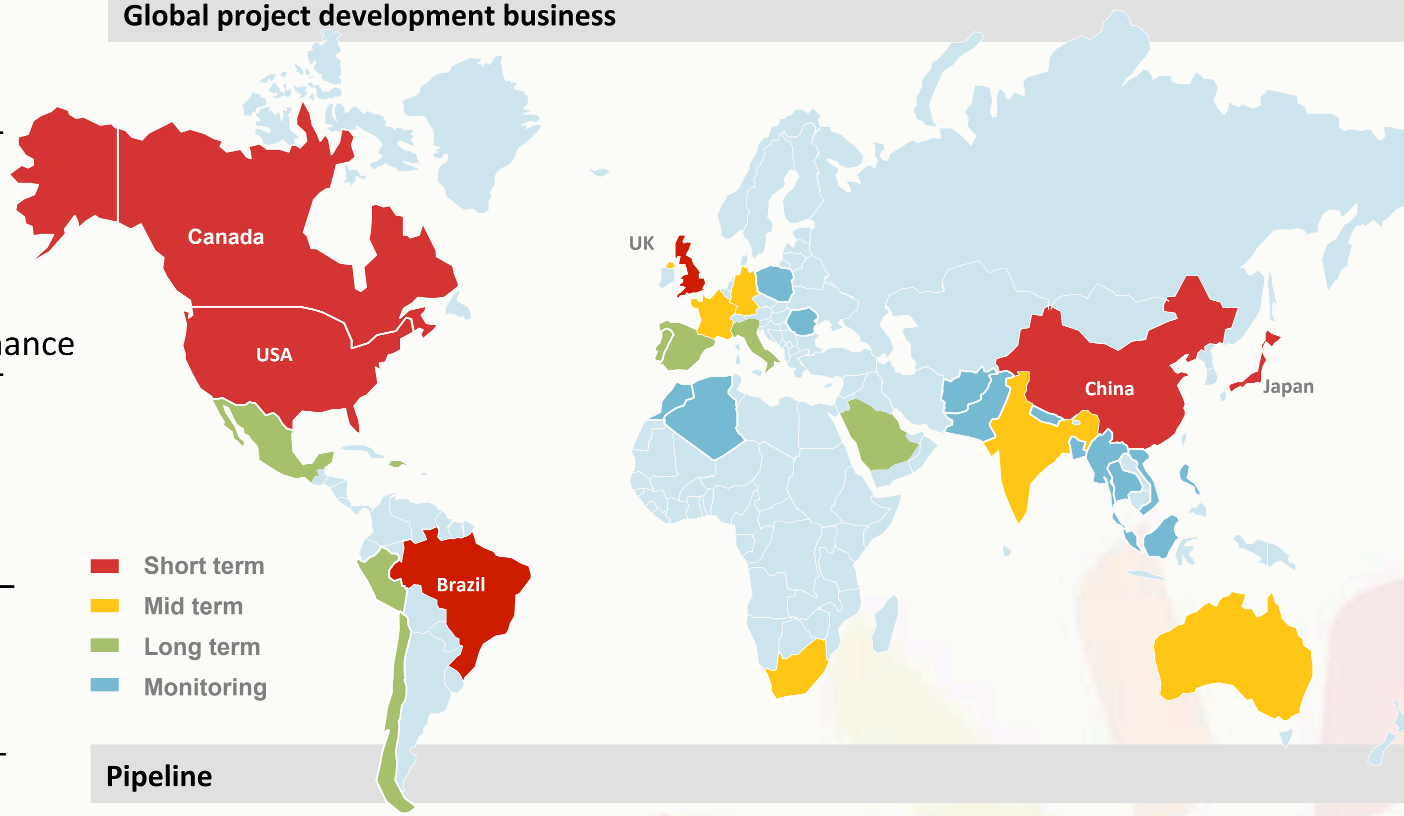
One-stop service
from design, EPC to operation and maintenance

8.5 GW_{DC}
total project development pipeline

2.4 GW_{DC}
total contracted / late-stage project pipeline

> 6.1 GW_{DC}
total early-mid stage development pipeline

Global project development business



Pipeline

275 MW_{DC}
Canada [1]

114 MW_{DC}
Brazil [1]

340 MW_{DC}
China [1]

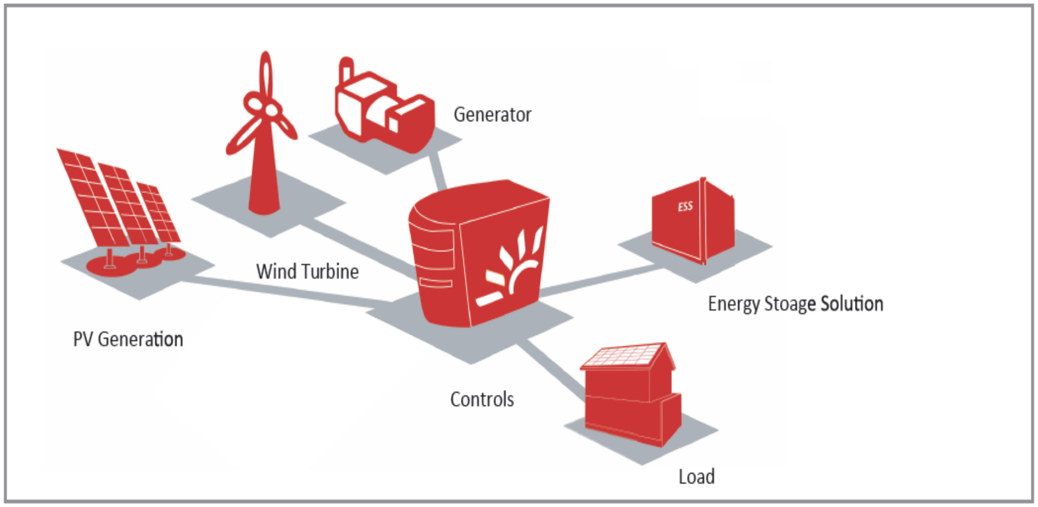
1,046 MW_{DC}
U.S. [1]

46 MW_{DC}
UK [1]

606 MW_{DC}
Japan [1]

CSI Microgrid Solutions

- **Fully Integrated Microgrid Solution** suitable remote communities, Military Bases, Campus, mining sites and other Resource Extraction Industries
- **Flexible system design** by integrating solar PV, wind, conventional generation, demand response and energy storage based on the available renewable energy resources and site specific load profiles
- **High system reliability** due to fully integrated concept and high system stability because of energy storage capabilities
- **High Renewable Energy penetration level** displacing over 50% diesel fuel annually, reducing the maintenance of the diesel gens and increase the lifespan of the equipment



- **Optimizing system sizing** based on localized natural resources, existing grid/generator and load profile, and system cost
- **Software and hardware simulation at CSI Microgrid Test Centre** for each design solution on grid stability, reliability and power quality

Microgrid Project Experience

Deer Lake

Keewaywin

North Spirit Lake

McDowell Lake

Project Case Study---Deer Lake

----How did it start?

- High dependency on diesel generation in most First Nation communities.
- Existing generation capacity could not meet the rising energy demands of their growing communities .
- 7 homes unconnected.
- Keewaytinook Okimakanak (KO) approached Canadian Solar for a solution.

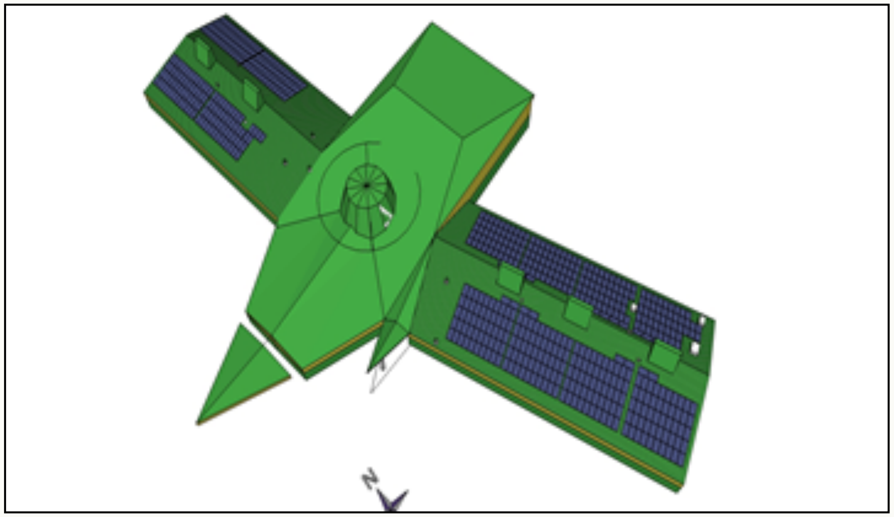
----What did we do?

- Proposed a phased-in solar capacity development plan
- **Phase I -** Install a 152kWdc/ 120kWac solar rooftop system connected to the diesel generating station.
- Gained confidence of community and utility that renewables would not have a negative impact.
- **Phase II –** We will implement a full microgrid system with 1MW solar system and energy storage.

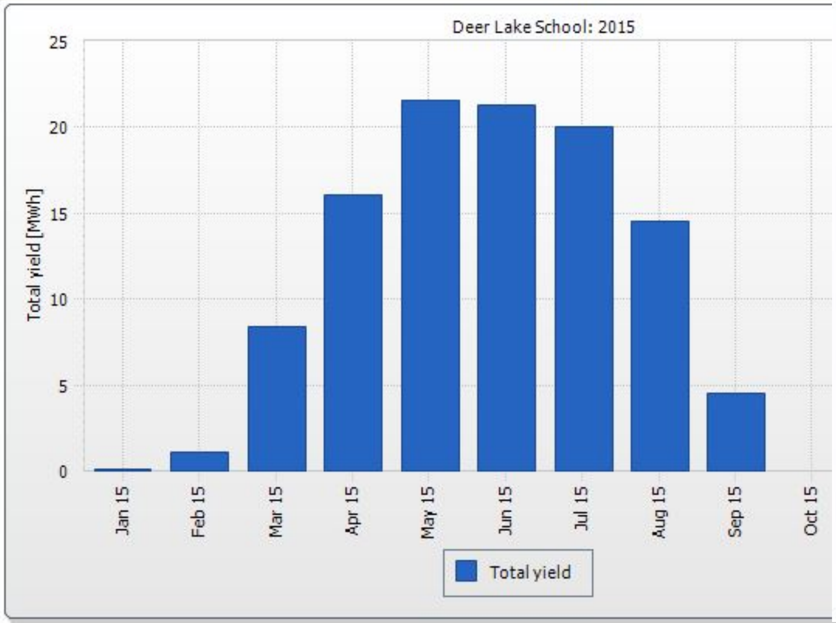
----What did we learned?

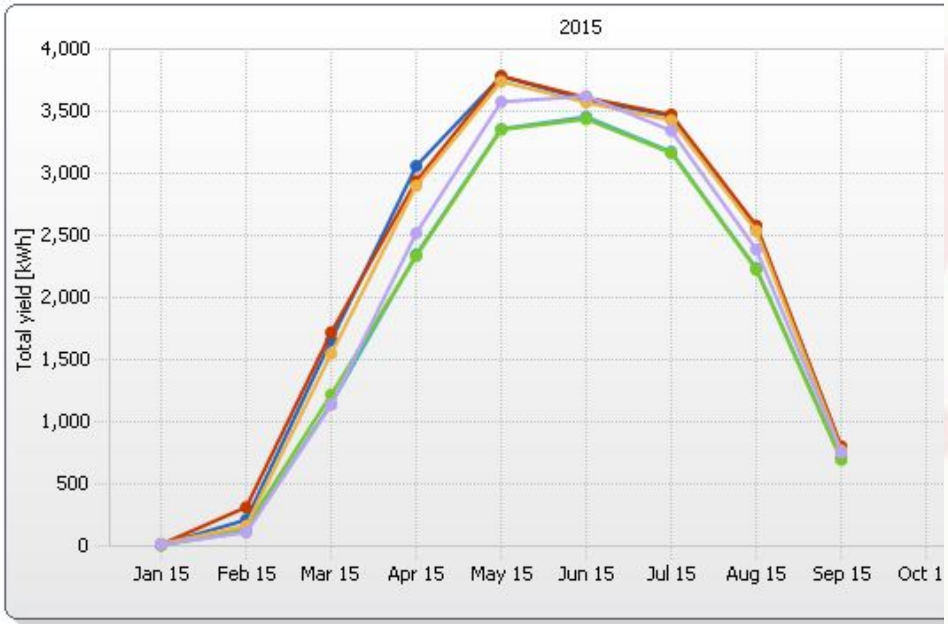
- Installation in these remote areas with extreme weather was very challenged.
- Logistics via winter roads can experience delays and unexpected complications.
- Important to triple check and cross check bills of material.
- Ability to adapt to unexpected situations.

Project Case Study---Deer Lake

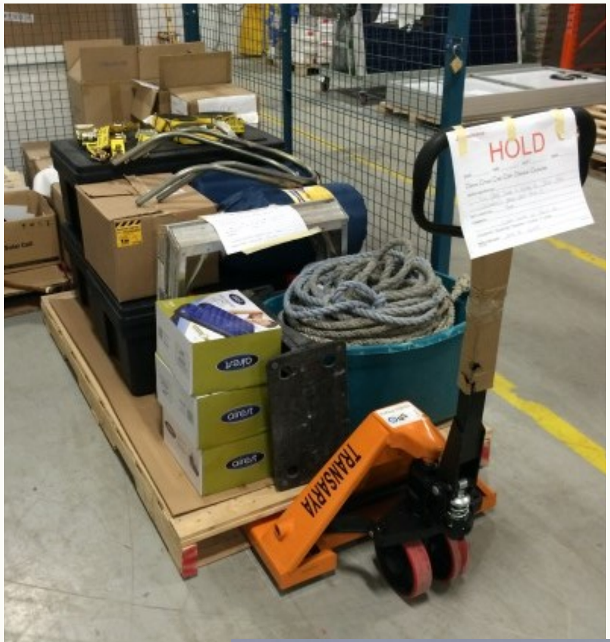


System Topology: 1000kW Diesel Generation, 500kW Hydro Turbines, 120kW Solar PV





Project Case Study---Deer Lake



← Pack Everything!

Bring your own food →

Work can be Cold!

↓

Project Case Study---Deer Lake

Expect the Unexpected!

Project Case Study---Fort Severn

----How did it start?

- Most remote community in Ontario.
- Highest cost of electricity generation due to transports costs of diesel fuel.
- Planned community growth.
- Prior – failed – experience with wind energy.

----What did we do?

- Proposed a phased-in solar capacity development plan
- **Phase I -** Installed a grid connected 24kWdc/20kWac solar rooftop system.
- Gained confidence of community and utility that renewables would not have a negative impact.
- **Phase II –** To implement a pilot microgrid including 300kW solar, 10kW wind and 150kW battery to study the impact on the grid with diesel as primary.
- **Phase III –** To implement a full microgrid including 600kW solar, 500kW wind and 750kW battery allowing for diesel-off operation.

----What did we learned?

- Logistics in remote locations is complicated and costly.
- Shipping BOS materials was another challenge
- Important to triple check and cross check bills of material.
- Necessity of working with the situations as they arrive and adapting to a change on the fly.

Project Case Study---Fort Severn

Wind Resource Inputs

File Edit Help

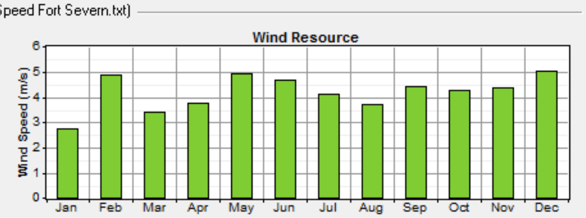
HOMER uses wind resource inputs to calculate the wind turbine power each hour of the year. Enter the average wind speed for each month. For calculations, HOMER uses scaled data: baseline data scaled up or down to the scaled annual average value. The advanced parameters allow you to control how HOMER generates the 8760 hourly values from the 12 monthly values in the table.

Hold the pointer over an element or click Help for more information.

Data source: ○ Enter monthly averages ◉ Import time series data file [Import File...]

Baseline data (from Annual Wind Speed Fort Severn.txt)

Month	Wind Speed (m/s)
January	2.721
February	4.903
March	3.412
April	3.772
May	4.938
June	4.684
July	4.112
August	3.701
September	4.399
October	4.249
November	4.352
December	5.050
Annual average:	4.184



Other parameters

Time step (minutes)	60
Altitude (m above sea level)	15.8
Anemometer height (m)	10

[Variation With Height...]

Advanced parameters

Weibull k	2.07
1-hr autocorrelation factor	0.858
Diurnal pattern strength	0.164
Hour of peak windspeed	15

Scaled annual average (m/s) 4.18 {..}

[Plot...] [Export...] [Help] [Cancel] [OK]

Solar Resource Inputs

File Edit Help

HOMER uses the solar resource inputs to calculate the PV array power for each hour of the year. Enter the latitude, and either an average daily radiation value or an average clearness index for each month. HOMER uses the latitude value to calculate the average daily radiation from the clearness index and vice-versa.

Hold the pointer over an element or click Help for more information.

Location

Latitude 56 ° 0 ' ◉ North ○ South

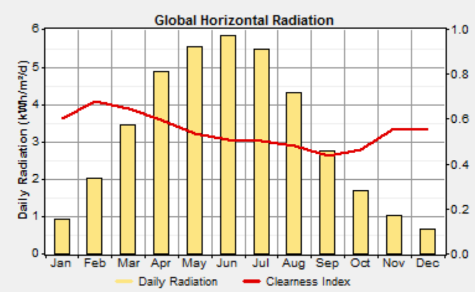
Longitude 87 ° 0 ' ○ East ◉ West

Time zone (GMT-05:00) Eastern Time (US & Canada), Colombia

Data source: ○ Enter monthly averages ◉ Import time series data file [Import File...]

Baseline data (from New Text Document.txt)

Month	Clearness Index	Daily Radiation (kWh/m2/d)
January	0.603	0.944
February	0.679	2.025
March	0.645	3.445
April	0.598	4.859
May	0.533	5.542
June	0.509	5.824
July	0.500	5.459
August	0.480	4.298
September	0.436	2.735
October	0.466	1.707
November	0.557	1.043
December	0.552	0.655
Average:	0.530	3.217



[Data Source...] [Plot...] [Export...]

Scaled annual average (kWh/m²/d) 3.22 {..}

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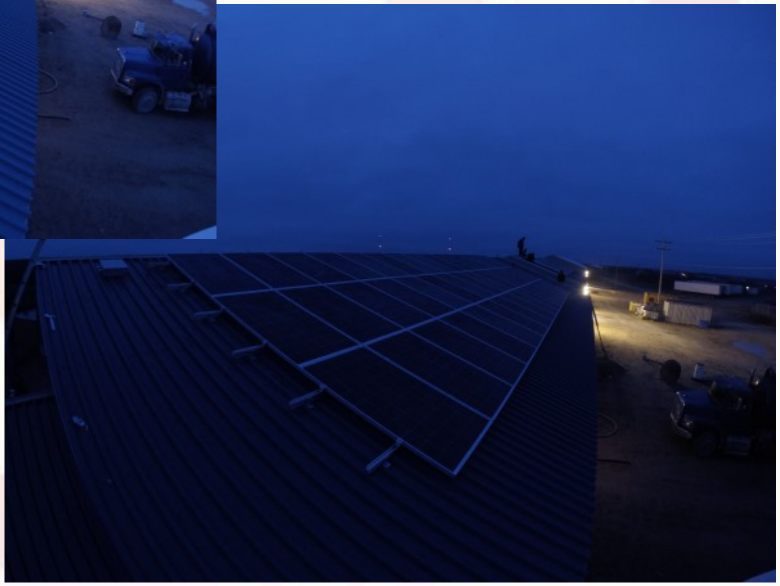
Project Case Study---Fort Severn

Sometimes you work against time…



…cause the next day it snowed!

Project Case Study---Fort Severn

Sometimes you work in the dark!

Project Case Study---Microgrid Testing Center

----How did it start?

- Ontario is building one of the most advanced electricity grids in the world.
- The Smart Grid Fund has been supporting innovative projects to develop a modern and intelligent electricity system since 2011.
- Canadian Solar submitted an application and was awarded funding for the microgrid testing center.

----What did we do?

- The Testing Centre will focus on micro-grid solution testing, and system solution design and smart grid assessment services.
- The Test Centre will allow us to simulate proposed smart microgrids with their unique characteristics under near real life conditions verifying steady state and dynamic performance including stability, reliability, power quality and safety of the microgrid system in both islanded and grid connected modes.
- The results of this testing will provide confidence to utilities and investors to support smart grid technology and systems implementation and to facilitate field testing.

----What will we learn?

- Not everyone supplier in the market has real project experience in microgrid control systems.
- Sound knowledge and better understanding about each part of the testing process.
- The complexity of the Testing Centre highlights the potential complexity of real world Microgrid applications.

Project Case Study---Microgrid Test Center

- Microgrid Control System
- PV system
- Wind Turbine
- Flywheel
- Battery Storage System
- Load Banks
- Diesel Gensets
- Grid Simulator
- PV Solar Simulator
- Wind Simulator
- Forecasting

System Change Framework

Technical 👍

- Worldwide project development, system analysis and design.
- CSI works to understand the needs of all partners in a project – communities, utilities, suppliers, etc.
- Need to consider future demands along with the current needs.

Socio-Economic and Capacity Building

- Helping communities understand renewables in remote microgrids can be of benefit.
- Providing temporary employment to community members during construction.
- Training local community members to monitor and maintain systems.

Policy 👎

- The CSI team works in line with the established government funding and utility policies.
- Government funding policies slow the progress of projects because the funding takes too long.
- Utilities are new hybrid renewable systems and slow to process applications.

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