Distributed Energy Storage for In-Stream Tidal Power

Connecting a world class resource to a weak distribution grid.

Nova Scotia Energy Research and Development Forum, May 16 & 17 2012

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Overview

A world-class energy resource exists in the Bay of Fundy. Renewable energy developers are planning projects to install in-stream tidal turbines to generate carbon-free electricity for Nova Scotia. Many proposed projects are located in sites where there is limited access to electricity grid infrastructure. Tidal generators will feed electricity to seaside communities through local distribution grids. This research focuses on tidal energy development on the Digby Neck, a region serviced only by a weak distribution grid that is close to full capacity.

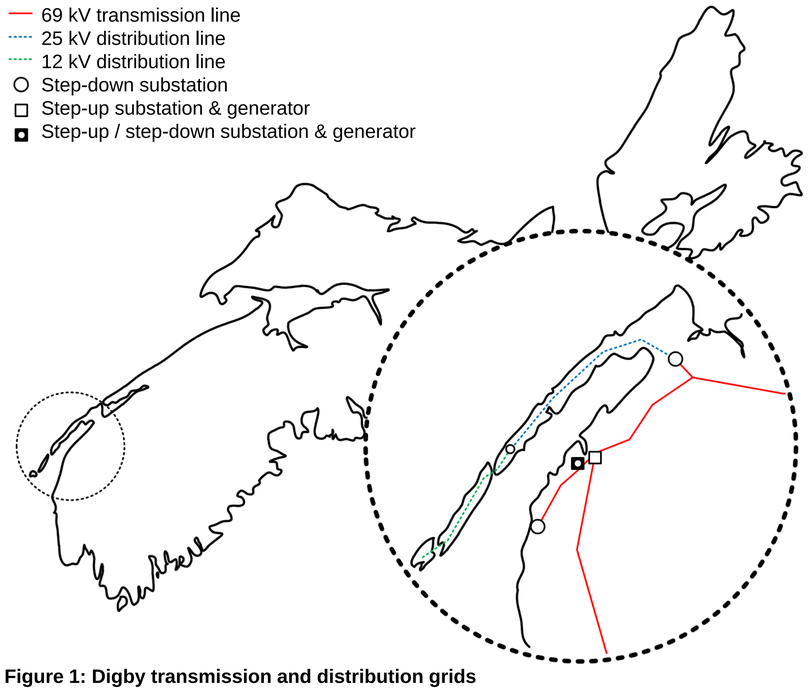

Figure 1: Digby transmission and distribution grids

The maximum amount of installed generating capacity on a distribution line is the minimum annual load on the substation that feeds it, in this case 0.9 MW. This ensures the electricity being generated is consumed locally, and doesn't feed back to the transmission grid. Since the output of tidal generators oscillates four times per tidal lunar day, the distribution capacity limit is only a concern for approximately half of the day.

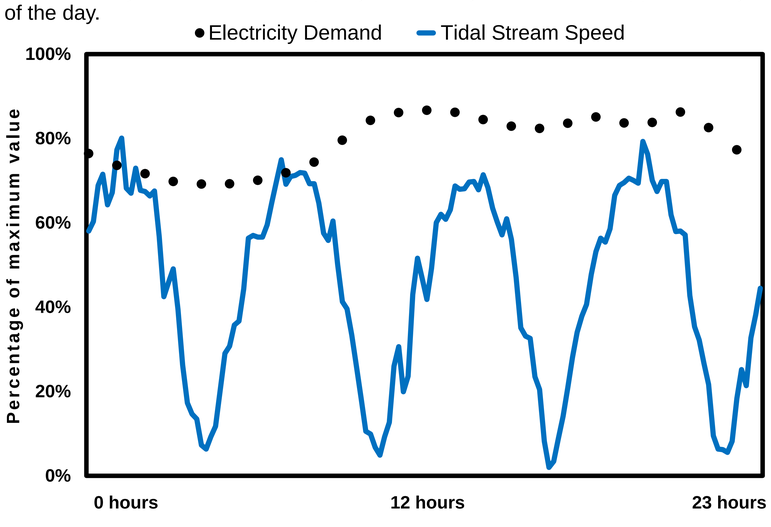

Figure 2: Daily profile of tidal stream speed (prediction based on the derivative of tide height) vs. electricity demand (observed)

Distributed Energy Storage

By decoupling the generation from the grid, energy storage allows a weak distribution line to accommodate a higher level of penetration from tidal generators, therefore maximizing the total energy capture. Without energy storage, the weak distribution grid is limited by the tidal generator's **peak** output. With energy storage, the grid is limited by the tidal generator's **average** output. The 0.9 MW capacity limit for this distribution line can be met even if the installed generating capacity is significantly higher.

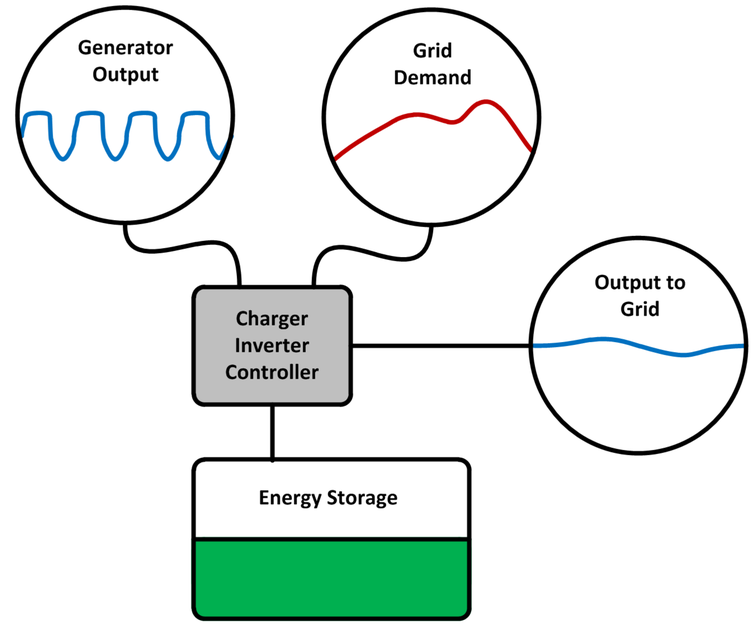

Figure 3: Distributed energy storage system

An energy storage system extends the capacity of the weak distribution grid by charging during periods of peak production, when the distribution grid capacity has been met. The energy is discharged during slack tide, when the generator is not producing.

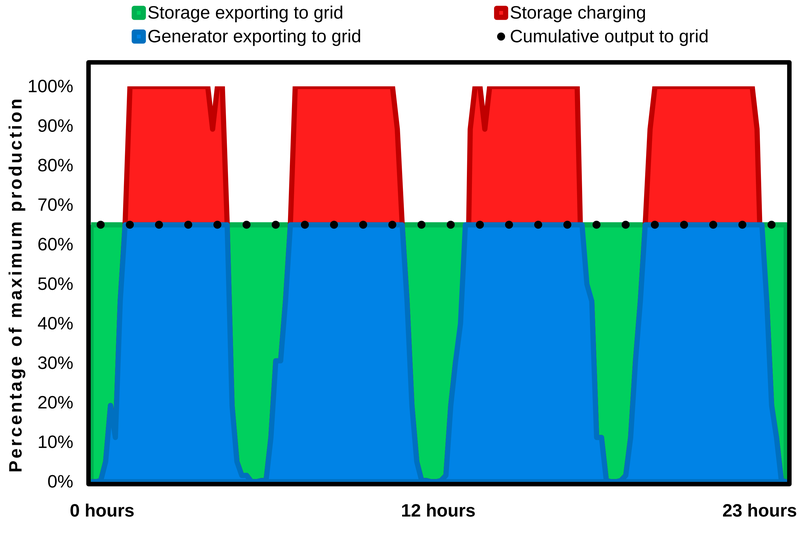

Figure 4: Charge and discharge regime for a typical generator

Current Research

The Renewable Energy Storage Laboratory is developing a model to analyse distributed energy storage suitable for placement at the interconnection point between tidal generators and weak distribution grids. The model uses real data to simulate the following:

1. **Generator**: tidal generator output is modelled based on stream velocity profiles and various tidal generator power curves.
2. **Grid**: the demand and grid export capability is modelled based on the end-use consumers in the area and NSPI feeder information.
3. **Storage**: the limitations of export capability and the output of the turbine are used to examine the necessary power and energy characteristics of the energy storage.

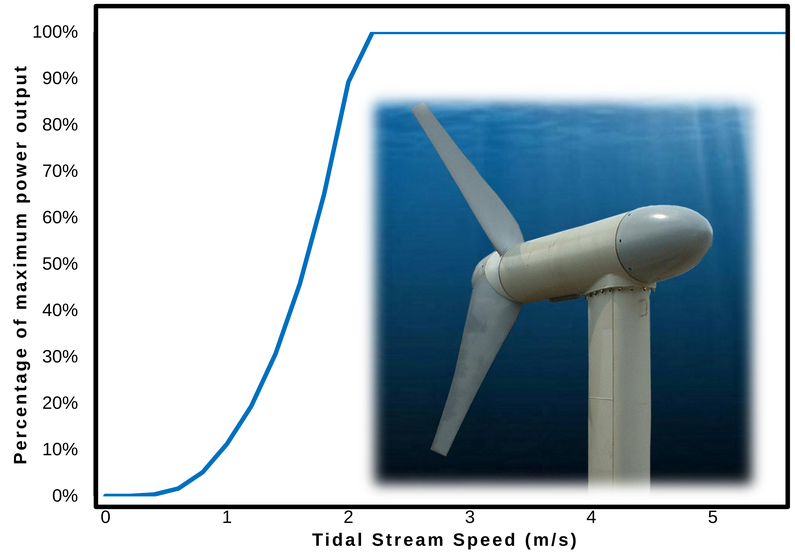

Figure 5: Representative Tidal Turbine and Power Curve (www.verdantpower.com)

The model will be used to size an energy storage system for the Digby Neck tidal generating station with respect to power, capacity, and cycle life.

Future Work

This research and the model created for it are a building block for future projects. Energy storage will be paramount in an energy system that relies on intermittent renewable energy generators. Future work includes:

- Replacing the sinusoidal output from tidal energy generators with the stochastic output from wind energy generators.
- Increasing the scope from a single distribution grid to the entire transmission grid.
- Determining the storage required for Nova Scotia to be powered completely by renewable energy.

References

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