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Nova Scotia POWER
An Emera Company

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Distributed Generation Limitations on Rural Distribution Networks

Background

Distributed Generation (DG) is Electricity generated from a variety of technologies which are connected directly to a distribution network, close to the intended customer. These technologies are commonly solar-cells, wind turbines, and hydroelectricity plants.

Problem Definition

Nova Scotia Power has observed power quality issues on some rural distribution networks which have DG technologies connected to them.

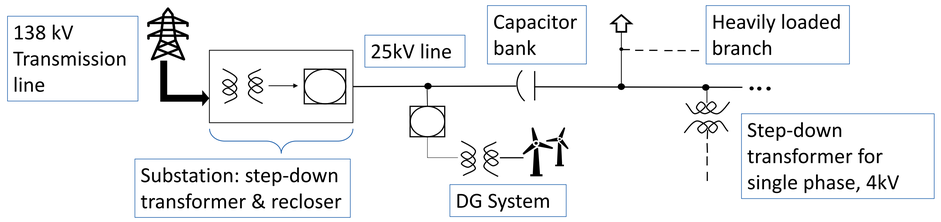
These power quality issues are below the threshold which causes customer problems, but they have been interfering with generators.

Project Scope:

- Model 22km 25kV Rural Distribution Network using Power Systems Simulation Software.
- Vary model parameters to determine the set of find the limitations for DG capacity in the network.
- Develop a system for defining a general set of limitations for DG capacity on any rural Distribution network.
- System recommendations must comply with NS Power Distribution Engineering Practices (DEP).

Modelling the Network

- It is important to create a model that is accurate to the real-world system. Using data gathered by NSP, the distribution network was simplified to a one-line diagram. This allows the group to model the network using a power systems software. The diagram below shows a generalization of the details which will be included in the model.

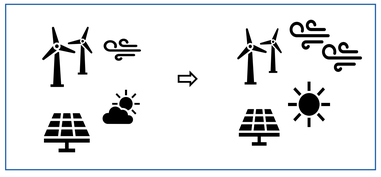


- Impedance is crucial to an accurate model; it is determined by:
  - Wire size/length
  - Transformer impedances
  - Transmission line connection into the substation.
- The model will be verified by confirming its output matches recorded NSP data such as fault levels and nominal voltage.

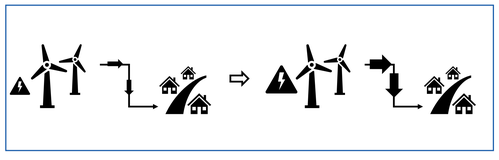
Model Analysis

- Once the model has been verified, it will be analyzed by varying specific parameters.

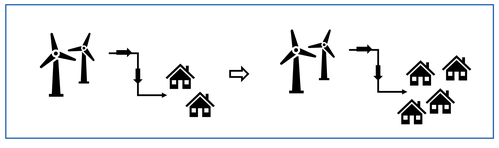
- Vary output of Connected DG's:
  - This will represent changes in wind speed or solar irradiance.
  - Capture short term power quality to create a voltage profile and transient analysis.
  - Observe fluctuations, flicker, and harmonic distortion as a result.



- Increase Capacity of DG's:
  - By increasing the maximum output (kW).
  - Reanalyze power quality and find a point where no more DG is recommended.



- Vary system fault current levels:
  - Higher fault levels represent more loading on the feeder. Increase DG Capacity at different fault levels.
  - Plot the limitations as fault levels and capacity are increased.



Impacts of Distributed Generation

DG has three primary impacts on Power Quality:

- Voltage Fluctuation
- Voltage Flicker
- Harmonic Distortion

The short-term impacts of these three phenomena three impacts will be studied using transient analysis.

Future Work

The following items will be completed by the end of the Fall 2022 semester.

1. Complete Model of Distribution Network
2. Verify Model using NS Power data
3. Complete DG Parameter Analysis
4. Develop Voltage Profiles for Distribution Network
5. Research solutions to increase DG capacity
6. Develop straightforward chart which displays general DG limitations for a range of distribution network characteristics.

References

"IEEE Draft Standard for Measurement and Limits of Voltage Fluctuations and Associated Light Flicker on AC Power Systems," in IEEE P1453/D5.1, February 2022 , vol., no., pp.1-84, 23 Feb. 2022

"IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems," in IEEE Std 519-2014 (Revision of IEEE Std 519-1992) , vol., no., pp.1-29, 11 June 2014, doi: 10.1109/IEEESTD.2014.6826459.

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