Technical limitations to implementing renewable generation in remote communities

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Introduction

86 of the 292 remote communities in Canada are located in the northern Canadian territories of Yukon, Northwest Territories, and Nunavut; a large number of which rely solely on fossil fuel based generation. While there is a very high interest to integrate a high penetration of renewable resources (e.g., solar photovoltaics or wind generation) into the remote power system, this possesses a number of technical issues and constraints.

The northern electric power utilities are interested in providing safe, reliable power in the most cost-effective manner. The purpose of a grid impact study is to ensure that these objectives are met from a technical perspective while integrating a high penetration of renewables.

Safe and reliable power are ensured through adequacy and security of the power system. Adequacy is the ability to supply the required power and energy without exceeding system ratings or operating limits, and with voltages and frequency within tolerances. Security is the ability to tolerate a credible event without loss of load, over-stress of equipment, or deviation from voltage and frequency tolerances. The studies performed are shown on the Old Crow system in the Yukon territory.

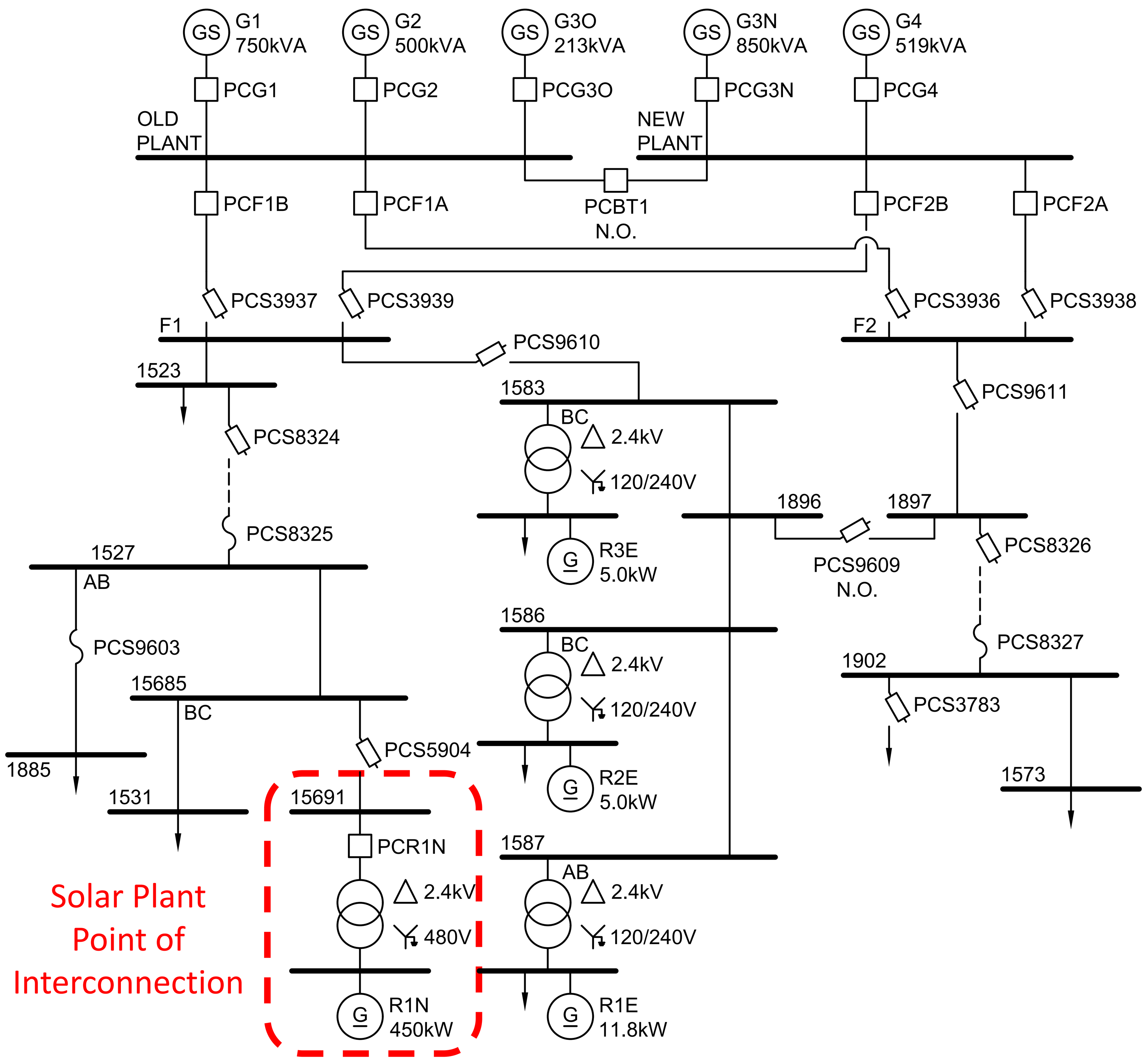

Figure 1: Single line diagram of the existing Old Crow power system.

Energy system and protection studies

To determine whether adequacy can be assured, the renewable resource capacity is varied and the energy balance of the system throughout the year is analyzed. The quasi steady-state frequency, real and reactive power flows, and voltage profiles are analyzed at each dispatch and operating set point. Furthermore, nuisance tripping, non detection zones, and protection coordination studies are performed to ensure proper operation of the protection system. In the case of Old Crow, a voltage rise was observed between the diesel plant and the solar plant. The power factor of the solar plant was varied in the final design to mitigate the voltage rise to within acceptable tolerances.

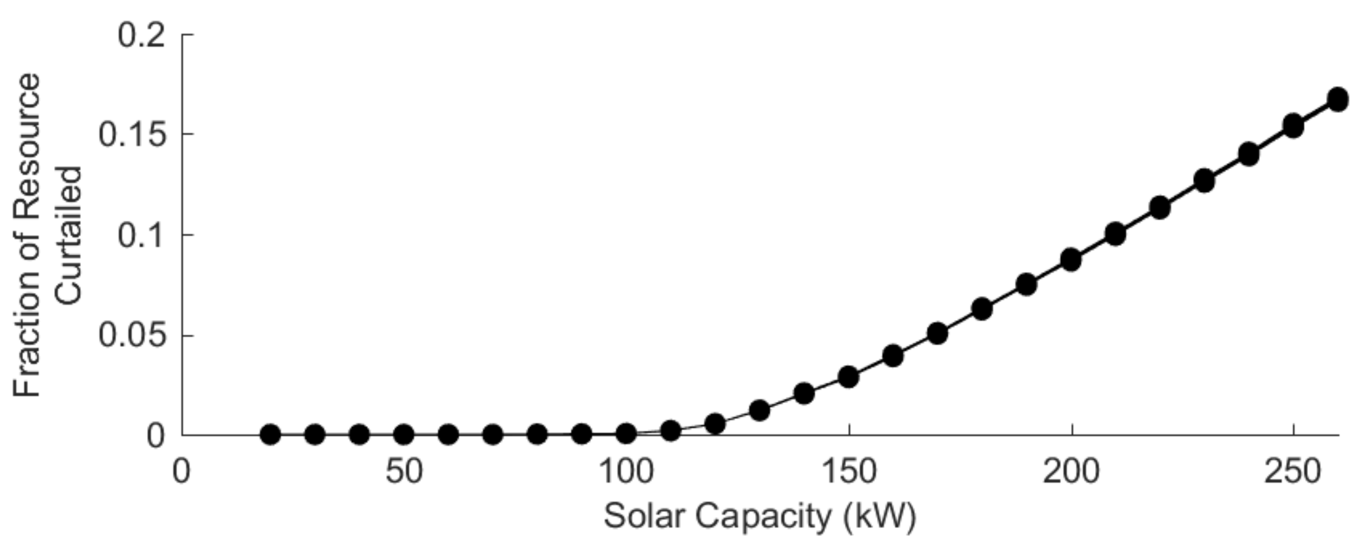

Figure 2: Fraction of total solar energy curtailed for a varying solar plant capacity operating with a unity power factor.

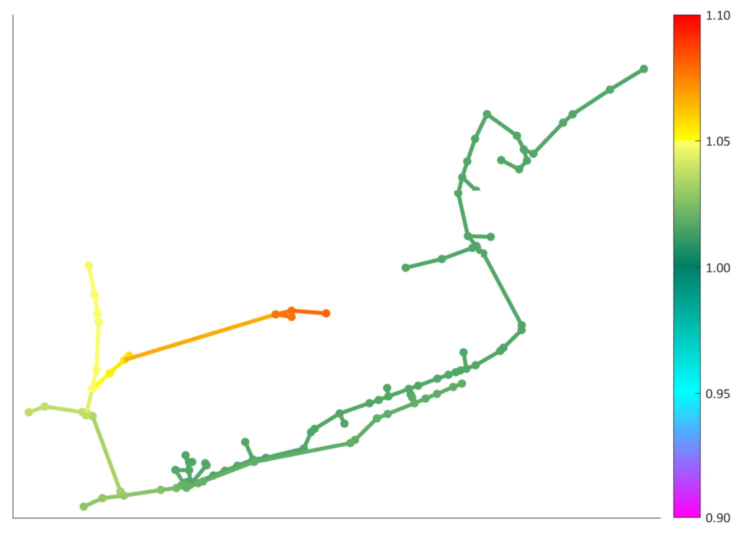

Figure 3: Heat map of voltage profile showing voltage rise on Feeder 1 where the PV is connected.

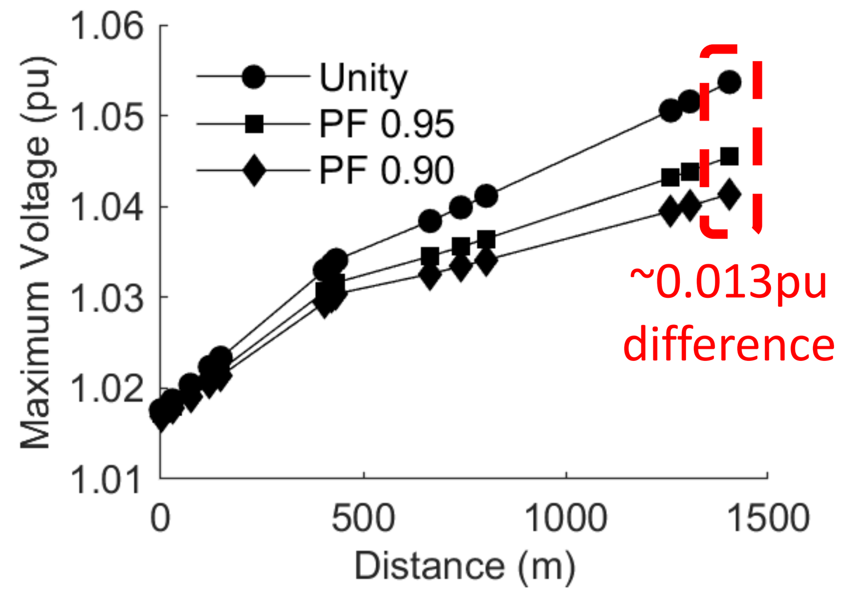

Figure 4: Maximum voltage from the diesel plant to the solar plant for varying solar plant power factor.

Large-disturbance stability studies

To determine whether security can be assured, a large contingency is simulated on the system. For the interconnection of a large renewable resource, this worst-case concern is what happens if the resource either trips off unexpectedly or loses power rapidly (e.g., due intermittency of the resource). To assess this, Monte Carlo simulations are performed and the fraction of non-behavioural measurements for voltage and frequency are analyzed. Non-behaviour is defined as the exceedance of a threshold for a defined length of time.

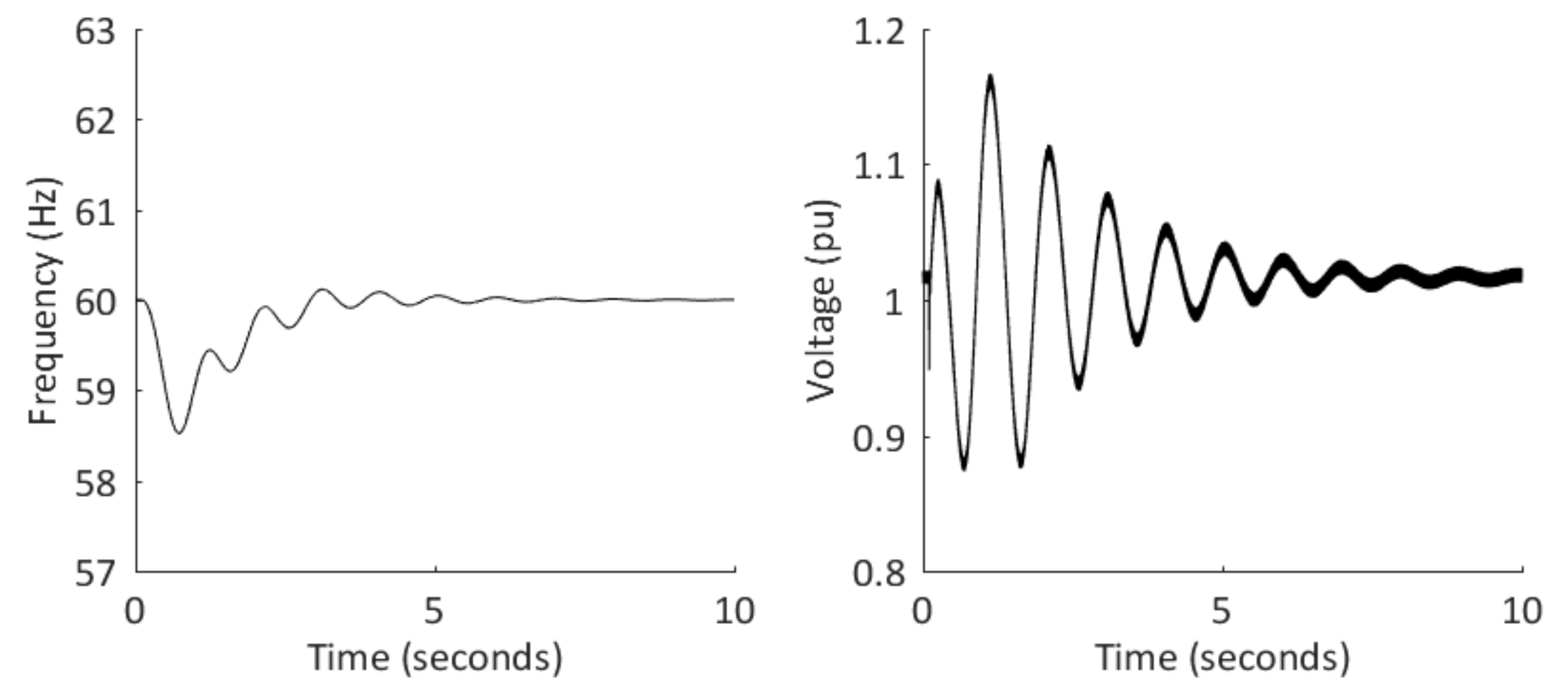

Figure 5: Frequency and Generator 4 voltage after instantaneous loss of 263kW of Solar PV.

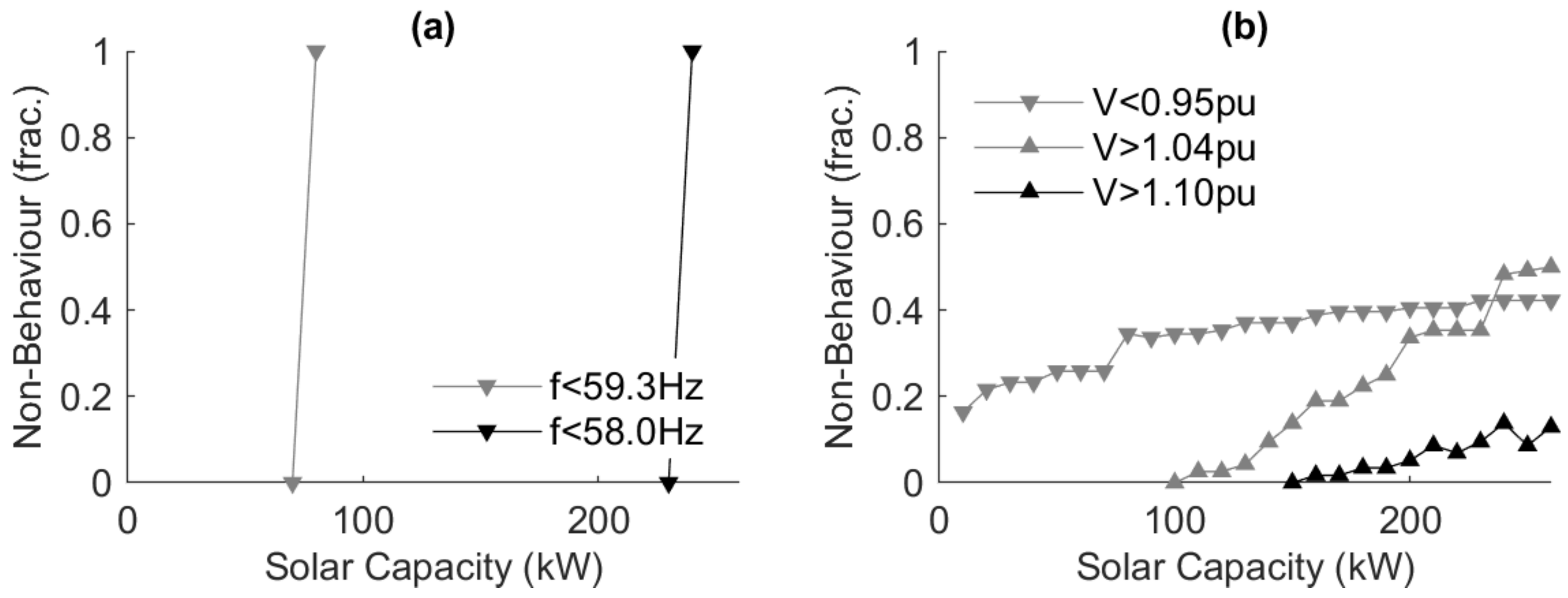

Figure 6: Fraction of non-behavioural (a) frequency and (b) voltage measurements after instantaneous loss of the solar plant for varying solar plant capacity.

Discussion

Traditionally, utilities have limited the penetration level to 20% installed capacity as compared to the peak load. This blanket statement is being challenged by the research team at the Yukon Research Centre where grid impact studies are being automated to be sufficiently generic to apply to other systems, while being sufficiently specific to have results pertinent to each community. Studies are currently underway for Inuvik (Northwest Territories), Cape Dorset (Nunavut), and Arviat (Nunavut).

Acknowledgements

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