Technical Memorandum:

Intermittent Renewable Integration Study
Yukon Integrated System

Date: **March 21, 2025**

Prepared For: **Yukon Development Corporation**

Prepared By: **Jeremy Sneath**

ELECTRANIX

SPECIALISTS IN POWER SYSTEM STUDIES

1. Executive Summary

Background

Electranix is undertaking PSCAD simulations to confirm the impacts of existing levels of distributed energy resources (DER) and assess the impact of adding additional DER to the Yukon Integrated System (YIS), with a focus on system stability. DERs include any distributed generation (i.e.: micro-gen rooftop solar and IPP generation). High levels of renewable penetration in a small or relatively weak grid can cause significant problems, including some of the frequency control issues that have been observed in the YIS. The goal of this study is to use simulations to understand these issues and study potential mitigation options.

Please note that this study is narrowly focused on technical solutions to the issue. It does not address broader economic impacts, policy considerations, or other energy-related priorities, which are also crucial for a comprehensive understanding of the program's overall benefits and implications.

Studies

PSSE powerflow models of the YIS were updated to represent the state of the grid immediately prior to two different concerning events that occurred in 2023 and 2024, respectively. These events involved the grid frequency drifting far enough from 60 Hz that the distributed micro-gen tripped off, resulting in the frequency dropping low enough to trigger under-frequency load shedding (UFLS), resulting in power outages.

PSCAD cases were developed, beginning with importing these powerflow conditions into PSCAD and including detailed models for frequency control devices and frequency response. These details include, but are not limited to, the following: UFLS, generator protections, distributed solar ride through characteristics, and breaking resistors. A selection of event simulations was performed. These included faults, line outages, generator outages and load pickups. The results of the load pickup simulations are representative of either an actual load energization or a generation loss. The simulations were performed with two micro-gen rooftop solar protection settings:

1. With the currently installed micro-gen solar protection settings; and
2. With all micro-gen updated to the category 2 protection settings .

Results

Load Pickup

The results of load pickup simulations are very similar to reports of events that have occurred in the YIS in 2023 and 2024. A load pickup of 2 MW causes the frequency to drift outside of the existing operating range of the micro-gen solar. This results in the micro-gen solar tripping off due to under-frequency resulting in micro-gen outages. When the micro-gen solar levels are above 50% (of the currently installed 5.8 MW) this causes the frequency to drop even lower until the UFLS systems begin to trip off loads. This causes power outages for customers and is not acceptable performance following a load pickup.

All of the simulations were performed with 0, 50, 75, and 100% of currently installed micro-gen solar generation (5.8 MW). For the load pickup scenarios, when the amount of micro-gen solar is reduced to 50% (of the currently installed 5.8 MW) or less, the micro-gen solar still trips off for a 2 MW load pickup but there is no load shedding in either of the scenarios studied thus confirming that increased micro-gen solar in the current configuration exacerbates the challenge.

When the existing micro-gen solar ride-through settings are updated to category 2 (allowing the micro-gen solar to operate in a broader frequency and voltage range), the micro-gen solar does not trip on the simulated load pickups and there is therefore no load tripped. This result confirms the importance of adjusting the micro-gen solar ride through settings to category 2 as an effective mitigation for the studied load pickup scenarios. While the model suggests that adjusting micro-gen solar ride through settings significantly improves grid stability at existing micro-gen solar levels, additional grid stability challenges are likely to occur should additional distributed solar be added to the grid.

These simulations of load pickups resulting in frequency drop, micro-gen solar tripping, further frequency drop and load shedding are similar to the events of 2023 and 2024. This validates the simulation models and confirms that the micro-gen trips were the root cause of those system events.

Fault Scenarios

The results of the generator-loss/fault/clearing contingencies include varying amounts of generator tripping and UFLS tripping (power outages for loads). Some outages occur without the micro-gen solar included in the model but increasing the amount of micro-gen solar results in increased UFLS and IPP generator tripping for some of the scenarios. Upgrading all micro-gen to the category 2 ride-through settings reduces the amount of generator tripping and load outages but is not sufficient to mitigate all of the adverse effects of the micro-gen on the system performance following the generator-loss/fault/clearing scenarios studied.

Conclusions and Recommendations

- Currently installed distributed solar generation in the YIS is causing and worsening existing stability problems. Additional distributed solar generation should not be installed at this time.
- Given the frequency variability in the YIS, having devices with very sensitive frequency protection trip settings (like the existing micro-gen solar) can result in increased IPP generation tripping and load outages during relatively minor load pickup events. It is recommended that steps be taken to update all existing micro-gen solar to the category 2 ride-through settings. Changing these protection settings will not solve all of the observed issues, but it will reduce the occurrence of some of the cascading events that have occurred and been observed in the simulation results.
- It is necessary to have frequency regulating capability sufficient to cover the variability of the renewable resources but this capability needs to be fast enough to react to events before the frequency drifts far enough to cause cascading generation and load outages. This capability is missing at the current DER penetration level and needs to be addressed. A battery energy storage system (BESS) may be able to quickly respond and control the grid frequency effectively.

Next Steps

The next steps in this study are to model the existing levels of DER with the planned BESS online, and investigate the necessary system components necessary to manage existing levels of DER and increase DER penetration, including IPP and/or micro-gen.