Integrating DERs to the Yukon Grid: Challenges of Grid Inertia

Summary

On December 15, 2023, the Yukon Government (YG), in collaboration with the ATCO Electric Yukon (AEY) and Yukon Energy Corporation (YEC), paused the Yukon Microgeneration (MG) Program. This decision was made in response to technical constraints on the Yukon power grid, and to allow for a technical review of how additional Distributed Energy Resources (DERs) could be integrated safely.

Yukon Energy Corporation (YEC) has since published the executive summary of this technical review here: ***https://yukonenergy.ca/energy-in-yukon/micro-generation/***.

Following the program pause, the Utilities have received several inquiries about connecting DERs outside the MG program – specifically, the proposed systems would not export energy to the grid. However, due to the unresolved technical constraints identified in Phase 1 of the review, **no new DERs can be connected at this time without explicit utility approval, regardless of whether they export energy or participate in the MG program.**

Adding further DERs under current conditions risks compromising the stability and reliability of the Yukon's electrical grid.

Introduction: Building a Resilient Energy Future

Over the last 25 years, more than 90% of the electricity supplied on the main Yukon grid, on average, has been renewable, coming primarily from YEC's three hydro facilities in Whitehorse, Mayo, and Aishihik.

In recent years, the Yukon has also made significant progress in advancing DERs, both off-grid and on-grid. Notably, YG's microgeneration program achieved its 2030 target for installed solar capacity seven years ahead of schedule. Additionally, under YG's Independent Power Production policy and Standing Offer Program, 5.35MW of solar power and 4MW of wind power have been connected to the Yukon's main grid through power purchase agreements with seven independent power producers.

Indigenous-owned, high-penetration renewable projects have also been successfully integrated into remote microgrids in Old Crow, Beaver Creek, and Kluane - with a similar initiative underway in Watson Lake. Supported by battery storage and microgrid controllers, these systems can operate with diesel generators turned off, demonstrating the potential for clean, community-led energy solutions in remote microgrids.

Today, demand for electricity is growing – driven by population growth, home electric heating, and broader electrification. During winter peaks, homes and businesses (excluding mines) use about 80% of YEC's available generation capacity. This underscores the need to prioritize firm, reliable winter power.

To meet long-term electricity goals, utilities are following a phased approach. Over the next five years, the focus is on building a reliable and robust grid. This includes:

- upgrading existing transmission and distribution infrastructure,
- constructing new power centres to deliver firm winter power,
- activating the grid-scale battery in Whitehorse, and
- renewing licences and permits for existing facilities.

Together, these projects will allow the utilities to meet peak winter demand and help stabilize the renewable resources already on the system.

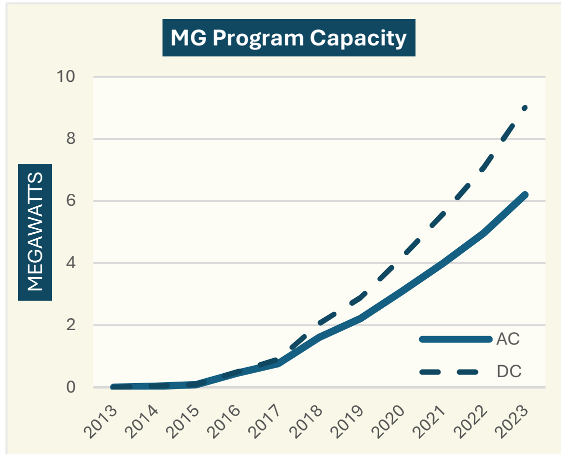
In parallel, the utilities are modernizing the grid to enhance flexibility. Research into emerging technologies – tailored to Yukoners' evolving needs – will help balance electricity supply and demand and ensure reliability even when intermittent renewable resources fluctuate. Automating existing systems will also play a key role, enabling faster fault detection, isolation, and service restoration.

Throughout this process, the utilities will continue engaging First Nations to advance energy initiatives that address grid's immediate priorities – such as improving reliability and supporting local energy planning. These collaborations are already shaping current and upcoming projects and are central to building a resilient and sustainable energy future.

Finally, the utilities will continue working closely with YG to bridge the gap between technical challenges and evolving policies through coordinated planning, technical reviews, and pilot projects that reflect Yukoners' needs while helping build the grid for the future.

Much of this work is already underway. Projects like the Whitehorse Power Centres are boosting winter capacity, and studies are exploring how to safely integrate more renewables. These efforts will strengthen the grid's ability to support higher DER volumes, manage intermittency, and continue delivering safe, dependable service across the Yukon.

History



Since 2013, the Yukon has experienced a significant increase in the adoption of DERs, primarily in the form of solar photovoltaic (PV) systems. As of March 2025, there are over $6MW_{AC}$ ($9MW_{DC}$) of MG program solar PV connected to the Yukon Integrated System (YIS). (See chart.)

In addition to MG program installations, projects developed under the Yukon's Independent Power Producer (IPP) program, along with legacy DER generation, bring the total connected DER capacity on the YIS to nearly $17MW_{AC}$. Proportionally, DER capacity can make up a significant amount of total grid supply, which varies between 30 and 50 MW on an average summer day.

Technical Challenges of DER Integration

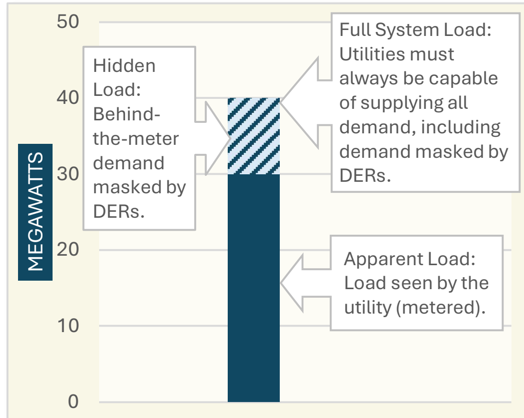
Grid Inertia and Short-Circuit Strength

The growing integration of DERs is creating new challenges for grid stability. As DER capacity increases, it reduces both **grid inertia** and **short-circuit strength**, pushing the system beyond critical operational thresholds.

In traditional power systems, inertia is provided by large spinning generation units. These machines store kinetic energy in their rotating mass, which helps the grid respond smoothly and predictably to sudden changes in load or disturbances. Generally, the larger the generator, the more inertia it contributes.

In contrast, inverter-based DERs – like wind and solar PV – are connected through power electronics and do not have the same physical spinning mass. As a result, they contribute little or no inertia, making it harder to maintain frequency stability and manage power quality. This shift complicates grid operations and increases the risk of instability during disturbances.

Intermittency and Apparent Load



As DER penetration increases, the Utilities observe a reduction in **apparent load** – the portion of electricity they must supply directly. For example, if total system demand is 40MW and 10MW is being met by DERs, the Utilities only see 30MW of apparent load. (See chart.)

To match this lower demand, smaller generation units are brought online. Generators, depending on construction and fuel source, have varying capabilities to respond to load changes. These smaller units typically contribute less inertia than the larger generators they replace. This shift reduces the overall inertia of the grid, making it more sensitive to fluctuations.

Compounding the issue, renewable energy DERs – especially solar and wind – are inherently intermittent. Their output can vary rapidly due to changes in weather or sunlight. Utilities must compensate for these fluctuations in real time using the generators that are currently online. As grid inertia declines, the system becomes less capable of absorbing these disturbances, making it harder to maintain balance and increasing the risk of outages.

Impacts on Grid Reliability

Lower grid inertia presents several critical challenges for maintaining a stable and reliable power system:

- **Reduced power quality**: Lower inertia compromises the grid's ability to regulate voltage and frequency, leading to issues such as voltage fluctuations, harmonics, and other disturbances. These can damage sensitive customer equipment and, in some cases, pose safety risks.
- **Weakened frequency response and stability**: With less inertia, the grid becomes more vulnerable to sudden changes in supply or demand. This increases the likelihood of widespread and more frequent outages.
- **Diminished protection system effectiveness:** Reduced short-circuit strength can impair the operation of protective devices. In extreme cases, faults may remain energized because protection systems fail to detect or isolate them, creating hazardous conditions.

To maintain sufficient inertia under current DER penetration levels, the Utilities are required to operate additional thermal and hydro generation units – even when demand is low. This generation, which could otherwise be conserved for winter, is now used inefficiently.

Ironically, as uncontrolled DER penetration increases, so does the need for conventional generation – leading to higher emissions, increased operational wear, and elevated costs.

Current Restrictions on DER Connections

At this time, **no new DERs** may be connected to the Yukon Integrated System without explicit utility approval. This includes:

- **Zero-export systems** (systems that do not send power back to the grid)
- **Battery Energy Storage Systems (BESS)**, including those paired with solar or other DERs.

If you have questions about the status of a previously submitted application to the MG Program, please contact YG Energy Branch.

While BESS technologies have the potential to smooth and buffer the variability of DERs, their **unmanaged charging and discharging behavior** can introduce similar operational challenges to those described above – particularly when not coordinated with grid needs.

Backup generators connected via an **open-transition transfer switch** (i.e., not operating in parallel with the grid) remain acceptable, subject to Utility approval. Please contact your Utility for details on the required specifications and approval process.

Additionally, any generation source capable of operating **in parallel with the grid** requires an Operating Agreement with the Utility. This is outlined in the *Terms and Conditions of Service*, Section 3.6:

> ***3.6 Customer Generation***
>
> *A Customer must notify the Company and sign an agreement with the Company if the Customer wishes to have service;*
>
> *a) in parallel operation with; or*
>
> *b) as supplementary, auxiliary or stand-by Service to any other source of electric energy.*

Actions Underway and Next Steps for DER Proponents

To address the current grid stability challenges, YG, in coordination with the Utilities, is implementing a system-wide update to inverter settings for all DERs connected through the MG Program. These updates enhance the **frequency and voltage ride-through capabilities** of inverters, helping to reduce the risk of grid instability.

If you own a DER system enrolled in the MG program, **you are responsible for working with YG to ensure your system's settings are updated**. DERs outside the MG Program or IPP

Program will also be required to confirm and possibly update settings. Please contact your Utility for specific guidance.

In parallel, the Utilities are conducting a study to identify viable pathways for safely integrating additional DERs into the YIS. This work is ongoing, and timelines for re-opening DER connections will depend on the outcomes of this study.

DER Integration in Isolated Communities

The same principles of grid stability and inertia that apply to the YIS also apply to the isolated community grids. These smaller systems are even more sensitive to the impacts of DERs.

ATCO Electric Yukon has determined DER capacity limits for each isolated community to help maintain safe and reliable operations. If you are considering installing generation in one of these communities, please contact ATCO Electric Yukon directly for questions about connection requirements.

Looking Ahead

The continued growth of DERs in the YIS will depend on the continued collaborative efforts of the Utilities, Yukon Government, First Nations, and Yukoners.

Glossary

Apparent Load The portion of total electricity demand that is visible to and must be supplied by the utility. DERs reduce apparent load by meeting part of the demand locally.

Battery Energy Storage System (BESS) A system that stores electrical energy in batteries for later use. BESS can help manage energy supply and demand but may introduce operational challenges if not properly coordinated with the grid. In the context of this document, customer-owned and uncontrolled home energy storage systems, capable of storing and exporting power to customer loads in parallel with the grid.

Distributed Energy Resources (DERs) Small-scale electricity generation or storage technologies – such as solar panels, wind turbines, and batteries – typically located close to where electricity is used. An interconnection system or a supplemental DER device that is necessary for compliance with IEEE1547-2018 is part of a DER.

Frequency Ride-Through The ability of an inverter or generator to remain connected and operational during short-term deviations in grid frequency, helping to maintain system stability.

Grid Inertia The resistance of the power system to changes in frequency, provided by the kinetic energy of spinning generators. High inertia helps stabilize the grid during disturbances.

Independent Power Producer (IPP) Program A Yukon Government program that enables third-party entities to develop and sell electricity to the grid under regulated agreements.

Inverter A device that converts direct current (DC) electricity (e.g., from solar panels) into alternating current (AC) electricity compatible with the grid.

Microgeneration (MG) Program A Yukon Government initiative that allows customers to install small-scale renewable energy systems and receive compensation for excess electricity exported to the grid.

Open-Transition Transfer Switch A switch that transfers load from the utility to a backup generator without connecting both sources simultaneously, preventing parallel operation with the grid.

Parallel Operation When a customer's generation system operates in synchronization with the utility grid, allowing energy to flow in both directions.

Power Electronics Devices used in DERs (e.g., inverters) that control the flow of electricity without mechanical motion. These devices typically do not contribute inertia to the grid.

Power Quality A measure of the stability and reliability of voltage and frequency in the electrical system. Poor power quality can damage equipment and disrupt service.

Short-Circuit Strength The ability of the grid to handle fault currents. Reduced short-circuit strength can impair the effectiveness of protective devices.

Voltage Ride-Through The ability of a DER system to remain connected during short-term voltage dips or surges, supporting grid stability.

Yukon Integrated System (YIS) The main interconnected electrical grid in Yukon, serving most of the territory's population and linking major generation and load centers.