Secondary Network Export Project (SNEP)

Integrating Distributed Generation into Secondary Networks in Large Urban Centres

Final Public Report

Project Overview

ENMAX Power Corporation completed this innovative first-in-Canada demonstration project in partnership with real estate owner, operator, investor and developer Cadillac Fairview (CF) and with funding support from Natural Resources Canada and Alberta Innovates. The Secondary Network Export Project (SNEP), now fully operational, applied technology to allow highly reliable electricity to flow to and from the electrical grid in a technically challenging area of Calgary. This allowed a customer to export solar energy back to the grid when more was generated than needed and also draw energy from the grid when its solar generation was limited.

This important step in modernizing the electricity system in Canada was previously not possible for customers in certain high-density areas, like large retail and mixed-use complexes or urban core areas. In these areas, customers pull power from an interconnected web of transformers, known as a secondary network. A secondary network typically provides high reliability power but is not able to *receive* exported power from distributed energy resources (DERs). DER often refers to smaller generation units that are located on the consumer's side of the meter; for example, roof top solar photovoltaic (PV) units, wind generating units and battery energy storage systems.

SNEP was successfully operational in April of 2022 and completed in June 2023. ENMAX Power will continue to test and monitor the project performance with ongoing operations, with the goal of making the technology available to customers in Calgary’s downtown and similar high-density areas.

The successful application of this technology will help remove technical and financial barriers to distributed generation, giving residential and commercial customers in urban settings more choice in how they generate and use electricity, while reducing greenhouse gas emissions (GHGs).

Project Partners and Stakeholders

ENMAX and ENMAX Power Corporation

Headquartered in Calgary, Alberta, with operations across Alberta and Maine, the ENMAX group of companies is a leading provider of electricity services, products and solutions. ENMAX Power is the Calgary-based wires utility business through which ENMAX owns, operates, and maintains the transmission and distribution system in and around Calgary. This distribution system serves about 570,000 metered sites (residential and businesses) and approximately 1.3 million people in the city of Calgary.

Cadillac Fairview

Cadillac Fairview (CF) is a globally focused owner, operator, investor and developer of real estate across retail, office, residential, industrial and mixed-use asset classes. Wholly owned by the Ontario Teachers’ Pension Plan, CF manages in excess of $35 billion of assets. Including the project host site at CF Chinook Centre, the company’s Canadian portfolio comprises 69 landmark properties.

CF is dedicated to striving for a net-zero portfolio by 2050 and continues to work toward a 2030 interim emissions target while achieving annual energy reductions per property of one to three per cent per year.

NRCan

Natural Resources Canada is a Government of Canada Department and is committed to improving the quality of life of Canadians by ensuring the country’s abundant natural resources are developed sustainably, competitively and inclusively. SNEP received a total contribution of $1,685,518 from Natural Resource Canada’s Smart Grid Program – Demonstration stream.

Alberta Innovates
Alberta Innovates is the province's largest and Canada's first provincial research and innovation agency. Alberta Innovates is a provincial corporation delivering seed funding, business advice, applied research and technical services, and avenues for partnership and collaboration.

Partnership Structure

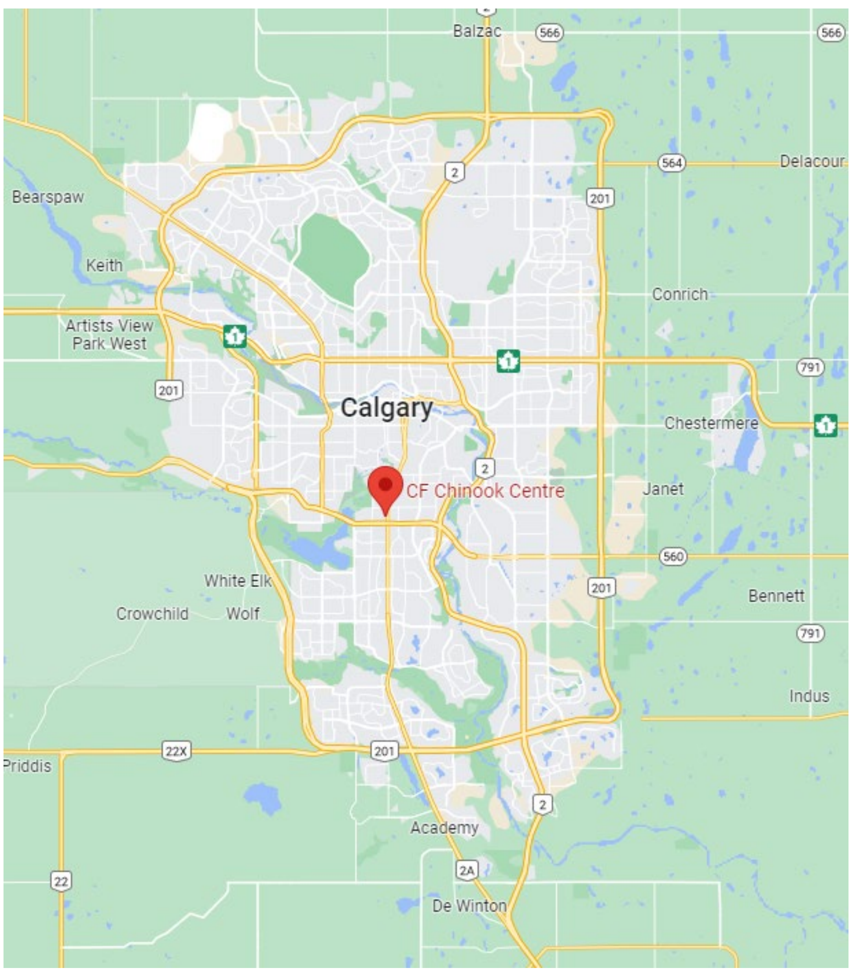
The solar PV system is 100 per cent owned by the customer, CF. ENMAX Power owns the enabling technology.

CF can expect to save energy costs as it generates its own power through the solar PV system. Revenue resulting from energy exports to the grid is guided by [Alberta's Microgeneration Regulation].

Project Location

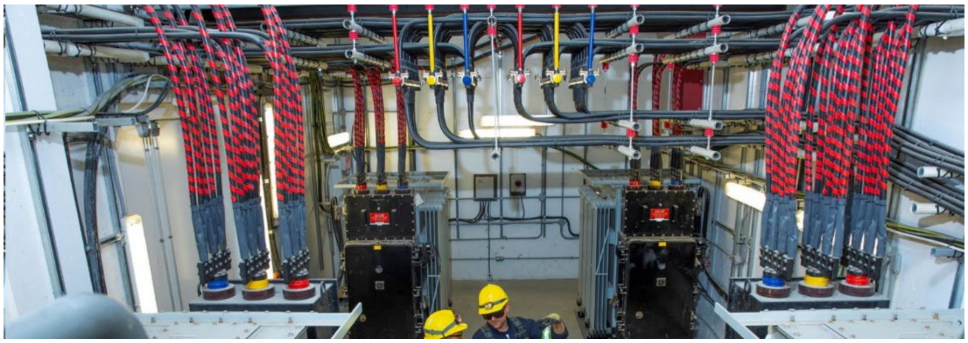
Project site: CF Chinook Centre, 6455 Macleod Trail, Calgary.

Calgary's secondary network includes eight square kilometers that encompass the downtown core and three additional areas outside the downtown core. There is a secondary network spot at CF Chinook Centre.



Location of CF Chinook Centre in the City of Calgary.

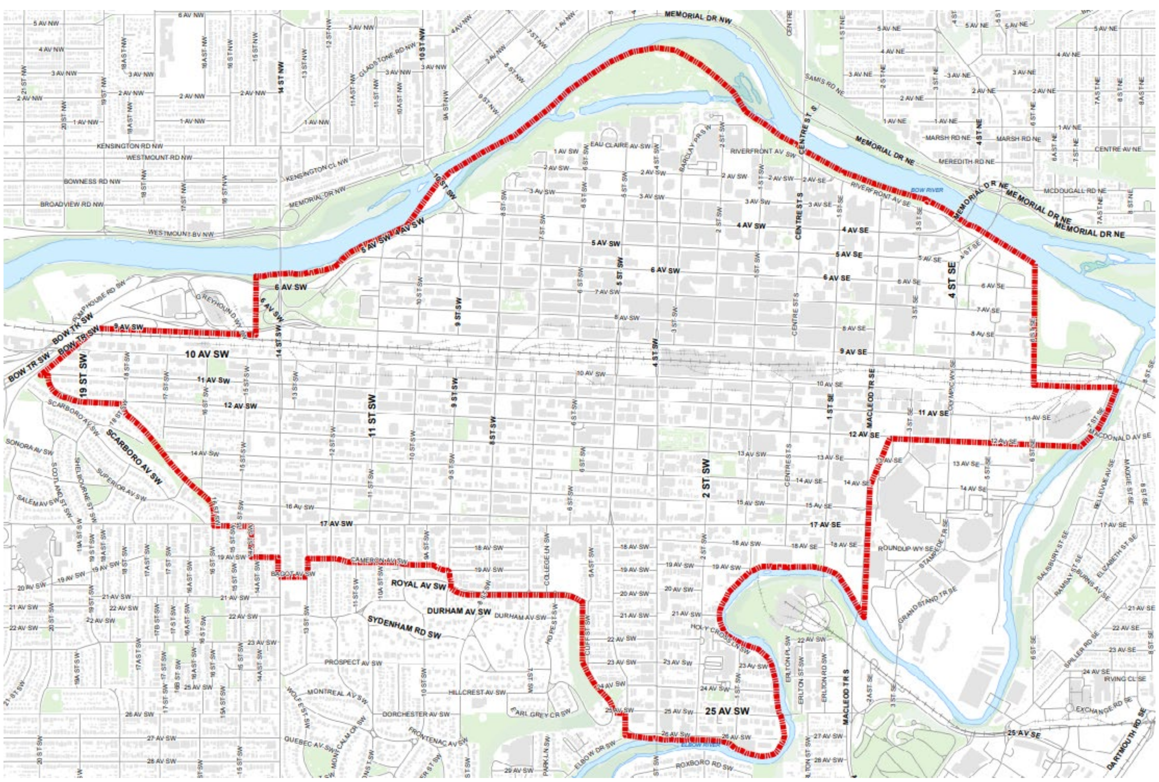
CF Chinook Centre has vaults that house the secondary network. For this project, one of the vaults was enabled with SNEP technology. The image below is an example of a vault. The black boxes shown are network protectors, a key part of the secondary network, with which the technology integrates.



Example of a vault where SNEP technology could be enabled.

ENMAX Power would enable SNEP technology in other vaults that service customers who would like to take advantage of this solution.

An ongoing project goal is to make the SNEP technology available to customers in the rest of the secondary network in the future. The map below shows the boundary of the secondary network around Calgary's downtown.



Calgary Downtown Secondary Network System Boundary

Project Timeline

Project definition and kick-off	Dec 2018
Planning, including partner site selection	Dec 2018 through Dec 2020
Design	Oct 2019 through May 2021
Procurement and construction, including substation, transformer vault and site host solar panel installation	May 2020 through January 2022
Commissioning and go-live	February 2022 through April 2022
Performance testing and commercialization	May 2022 through June 2023

The initially projected completion timeline was delayed one year due to COVID impacts at CF Chinook Centre. ENMAX Power requested an amendment to the Contribution Agreement timeline, which NRCan accepted March 2021.

Project Description

Background

Part of ENMAX's strategy is to meet our customers' expectations by providing them with choices for clean electricity products and a decarbonized grid. This approach created the business driver for SNEP.

Bi-directional power flow, in which a site can alternately be both a producer and consumer of energy, can help unlock the untapped potential of renewable and distributed energy generation for urban centers like the city of Calgary.

While ENMAX Power is already enabling two-way power flow on its standard distribution system, it has not been technically possible on the specialized secondary network. Secondary network systems are designed to provide high service reliability and traditionally interpret any reverse power flow as a problem that needs to be isolated by shutting down the interconnection. This unique engineering design does not allow a customer to export excess energy to the grid.

This physical limitation creates financial barriers to customer adoption of DERs. The first financial barrier is that customers must invest in protective equipment to ensure their generation systems do not result in a reverse flow of energy at the utility connection. This protective equipment costs in the order of $10,000 to install and ensures the secondary grid does not turn off their power.

In addition, the size of the DER must be limited – since power export must be avoided – and there must always be some power draw from the secondary grid to ensure power is maintained.

The second financial barrier is that customers are not able to access regulatory incentives for exporting energy, available through Alberta's Microgeneration Regulation. These energy credits are for customers who export excess energy produced through microgeneration back to the grid.

With the success of SNEP, there will no longer be a need for customers to purchase and install such protective equipment and they can access microgeneration credits for which they are eligible.

This limitation of secondary networks also exists in nearly all urban networks across North America. ENMAX Power is the first utility in Canada to successfully provide a solution to this complex technical challenge.

With no existing technical solution to ensure that DERs can be fully integrated and optimized, the potential for integration into the downtown distribution grid has been severely limited. With about 20 per cent of our system load relying on secondary networks, there is an untapped potential for renewable and distributed energy, particularly from roof-top solar PV and combined heat and power (CHP), that could significantly reduce GHGs and result in many other benefits, listed below. SNEP demonstrates a new technical approach to exporting customer-owned generation that is safe, reliable and sustainable.

Project Objectives
The primary objective of SNEP was to develop and demonstrate a new solution to increase power exports from DERs to the secondary electrical grid by removing technical and financial barriers.

Project objectives set out by ENMAX Power, and project partners included:

- A repeatable technical solution, control strategy and safety protocols for the integration of distributed power generation on secondary networks within urban electricity grids;
- Demonstration of potential business cases to accelerate the adoption of customer-owned generation from cleaner, more efficient energy sources;
- A more flexible and sustainable grid allowing for a cleaner mix of generation overall;
- Increased grid resiliency; and
- Providing urban electricity customers the option to export power such as solar PV or other generation technologies onto secondary networks within the distribution grid to ultimately reduce electricity costs and generate revenue.

Performance in meeting these objectives is described in the Descriptions of Results and Anticipated Outcomes section, below.

While project monitoring will continue, all project objectives have been met.

Project Benefits
Benefits to Canadians:

- Maturation of a solution that can be repeated at utilities throughout Canada, reducing technical and economic barriers to the increased adoption of distributed generation on secondary networks within urban electrical distribution systems;
- Training of Highly Qualified Persons (HQP) and inclusive job creation within Alberta as part of the implementation of this demonstration project;
- Reduction to direct and indirect GHG emissions through increased small-scale DERs; and
- Improved asset utilization, increased flexibility, resiliency, and reliability as distributed generation is permitted on secondary networks.

Benefits to Customers deploying DERs and broader Utility Industry Stakeholders:

- Economic benefits as grid upgrade expenses are reduced through successful integration of DER;
- Knowledge dissemination as the method and results of this demonstration are shared so that they can be replicated in other service territories;

- Reduction of technical barriers preventing new revenue opportunities for DER resources on secondary networks; and
- A pathway towards diversifying generation, increasing resilience and reliability.

Additional benefits include:

- Broader deployment of DERs on secondary networks to reduce peak electricity demand with renewable generation while enabling GHG emission reductions; and
- An additional revenue stream for customers (such as CF) connected to the secondary network by enabling them to size their systems to support building needs and sell additional electricity back to the grid.

Project Design

SNEP was a full-scale demonstration at a system level and in a real-time environment. This included the development of protection and control solution, system modelling and testing, interconnection of solar PV, integration of the protection and control systems, system commissioning, system monitoring, and data acquisition and analysis.

Infrastructure Considerations

The site host for the DER was CF Chinook Centre, Calgary's largest retail complex. CF Chinook Centre was chosen because it could meet the project specifications outlined in the Contribution Agreements with NRCan. CF is representative of the types of buildings in our secondary network and was able to generate enough solar power to meet its own internal load and produce export power to test the technology.

The solar installation consists of 1,900 PV modules and panels with a maximum output of 800kW DC and 625kW AC at the inverter terminals.

Aerial view of CF Chinook Centre solar installation

Secondary network systems, like those that service CF Chinook Centre, are designed to provide high service reliability but do not permit electricity to flow in two directions through the network transformers due to their unique engineering design. These systems are specialized low voltage (600V and below) electric distribution systems where electricity is delivered through a mesh of underground cables and network units connected to operate in parallel.

ENMAX Power has an ongoing project to install fibre communication into all network vaults in downtown Calgary for the purpose of monitoring and control. This fibre installation provides an opportunity to use communication-aided protection schemes with a new protection philosophy that would enable DER power to be exported onto the ENMAX secondary network system. SNEP validates that this technology could be implemented in downtown Calgary on a commercial scale. The design solution is scalable and is independent of the DER technology type; that is, it would work effectively with inverter-based resources like solar PV or battery energy storage systems and other technologies like CHP or synchronous generation.

Design Solution

The primary challenge for SNEP was to find a solution to allow reverse power flow while maintaining system reliability and safety. ENMAX Power demonstrated not a single technology, but the integration of multiple technologies to enable customer-owned DER generation into a secondary network.

A key component in secondary network design and in this project was the network protector relay. Most network protector relays from different manufacturers have multiple protection elements available with similar characteristics. ENMAX Power integrated solutions for each of these technologies, with members from multiple engineering teams collaborating to create a design that resolved technical barriers of all essential commercial components.

The following protection elements were studied in detail to understand functionality, with solutions designed for each:

- Insensitive Reverse Power Protection
    - The standard network protector relay setting for sensitivity was decreased to permit a predetermined level of current to flow in the reverse direction. The threshold for the protector to trip is specific to the network fault configuration and is calculated on a case-by-case basis.
- Direct Transfer-trip Scheme
    - A protocol was programed into a programable automation controller to permit DERs to export power onto the secondary grid when conditions were acceptable and to isolate DERs when they were not.
    - For conditions to be acceptable, there must be communication between the grid and the customer's DER, and the grid must be in a good system state with a minimum number of transformers operational.
- DER Communication
    - The network vault PAC was set up to transmit communication signals to the DER facility to communicate when it is approved to export power, when it is not approved to export, and when generation must be tripped. To ensure reliability and safety, if communication between the DER and the secondary grid is lost, then the DER will trip.
    - Further SCADA communication was also established with the customer's DER plant controller so that the operating settings and grid support functions of the customer's

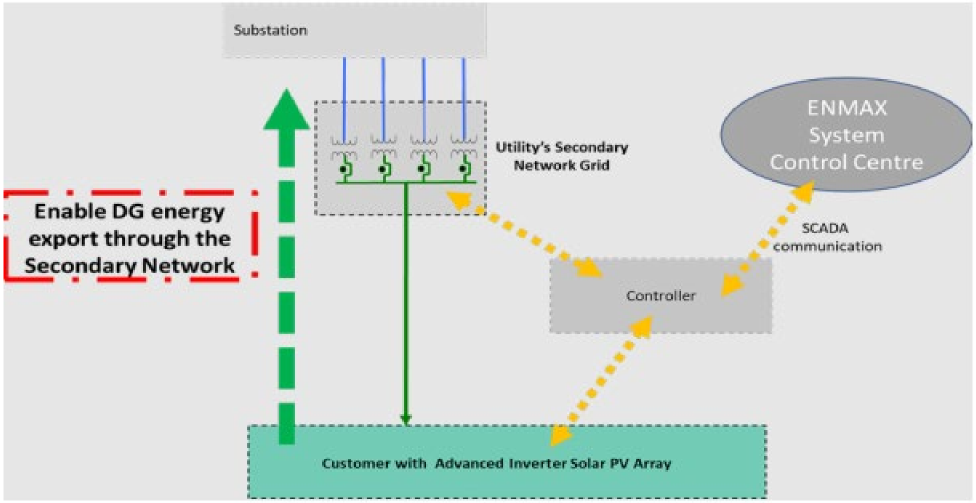
DER could be reprogrammed in real time. This further enabled ENMAX Power to test DER management system capabilities with the customer's DER.

Several criteria and challenges were identified during the project initiation that the engineering team addressed, including:

- The reliability of the electrical grid would need to be maintained.
    - The project design would desensitize the protection control of the electrical system to permit a two-way flow of electricity. The system was designed so that the increased threshold for system trips was still sensitive enough to ensure continued reliability and safety.
    - The auto reclosing function of the network protector relay would not work when DER is exporting power. The team investigated this scenario and concluded there were no adverse impacts to the electrical grid and that the issue would correct itself automatically.
    - GOOSE (IEC 61850) messaging and SCADA (IEEE Std 1815) data are communicated on the same telecommunication network, potentially leading to network traffic congestion that could affect the performance of the Direct Transfer Trip scheme. The team investigated this scenario and concluded that there were no operational concerns.
- Water ingress was a well-known concern for network vaults, so new equipment needed to be submersible. New equipment selection also had to consider space limitations, discrete input/output requirements, IEC 61850 protocol compliance and the absence of a DC source in the vault.
    - Space limitations were handled by choosing a separate cabinet for new equipment. The new equipment was compact in size, AC powered and installed in a submersible wall-mount encloser. Submersible smart external cables were included in the design for watertight external connections. Local and remote control to enable or disable the export was included in the design for the vault cabinet and at the substation.
- Field crews needed to fully understand and accept the solution before it would be implemented.
    - Change management and communication tools engaged field crews before, during and after implementation. Field crews accepted the solution and were instrumental in the success of the demonstration project.

ENMAX Power presented our technical solution at a number of engagements to receive feedback on the design concept from North American power utilities and broader industry, including a Western Energy Institute Conference, an Electric Power Research Institute meeting, an IEEE Power & Energy Society workshop and to the Alberta Smart Grid consortium.

The following image shows the system model that was implemented.

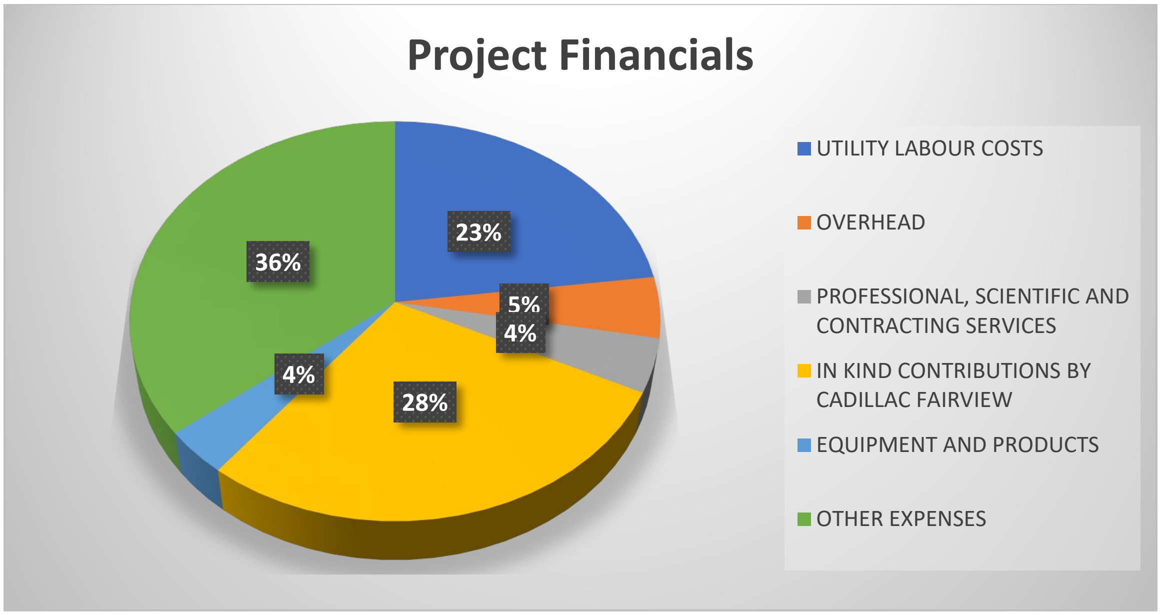


SNEP System Model

For detailed information on the project's design, including descriptions of system design and results, see [CIGRE 2022 Paper 522](#).

Project Financials

SUMMARY: ENMAX POWER CORPORATION GISG-3015	PROJECT ACTUALS	
EXPENDITURES		
UTILITY LABOUR COSTS	**$**	**1,077,263.65**
OVERHEAD	**$**	**235,194.74**
PROFESSIONAL, SCIENTIFIC AND CONTRACTING SERVICES	**$**	**208,614.01**
TRAVEL INCLUDING MEALS AND ACCOMODATIONS	**$**	**-**
EQUIPMENT AND PRODUCTS	**$**	**175,343.58**
OTHER EXPENSES*	**$**	**1,400,988.08**
TOTAL EXPENDITURES	**$**	**3,097,404.06**
IN KIND CONTRIBUTIONS		
IN KIND CONTRIBUTIONS BY CADILLAC FAIRVIEW	$	1,357,351.00
TOTAL IN KIND CONTRIBUTIONS	**$**	**1,357,351.00**
TOTAL PROJECT COSTS	**$**	**4,454,755.06**
PROJECT FUNDING PARTNERS		
NRCan Funding	$	1,685,518.00
Alberta Innovates Funding	$	823,602.00
TOTAL PROJECT FUNDING	**$**	**2,509,120.00**



*Other Expenses:

Most of the cost under Other Expense" is made up of the contribution that ENMAX made to Cadillac Fairview ($1,357,351.00). The remainder of the cost is made up IDC (Interest during Construction) that ENMAX incurs during project execution.

Descriptions of Results and Anticipated Outcomes

ENMAX POWER set out high-level objectives and benefits at the beginning of SNEP, described earlier in this report. As the project and work plan progressed, the team further developed the objectives and benefits, so they were more specific and measurable. The headers below represent the topics that categorize our high-level objectives and benefits, with a detailed description of targets and results.

The primary objective of SNEP was to develop and demonstrate a new solution to increase power exports from DERs to the secondary electrical grid by removing technical and financial barriers. SNEP successfully met this objective.

Supplementary monitoring was added at the project site to validate that electricity was being successfully exported to the secondary grid using the new protection scheme. Two high-resolution power quality meters, with remote access capability were installed at the test site to collect data and monitor DER activity.

Demonstrate a Repeatable Technical Solution

SNEP demonstrated a repeatable technical solution, control strategy, and safety and system reliability protocols for the integration of distributed power generation on secondary networks within urban electricity grids. For detailed information on the project's design, including the technologies used, see CIGRE 20022 Paper 522.

This technical solution reduces financial and technical barriers, allowing for the acceleration of customer-owned generation from cleaner, more efficient energy sources. It is important to note, however, that for SNEP technology to be utilized, a utility must have a high-speed communications system in place, such as fibre optic communications.

Scaling and repeating this solution is anticipated to require significantly less for each customer given that the initial solution development and standardization costs were part of this pilot project. Future customer costs for this solution are expected to be less than $90k, depending on site requirements.

Asset Utilization

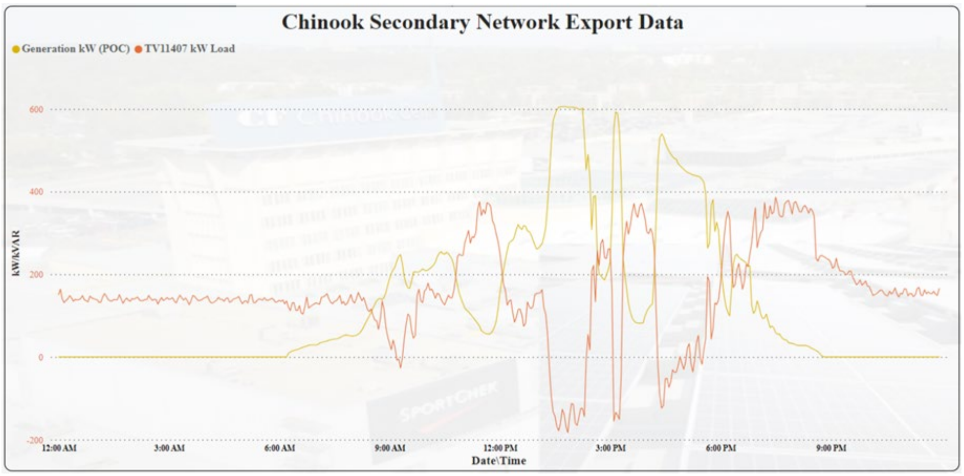
SNEP demonstrated the ability to monitor and control DER devices on a secondary network, enabling energy export and increased DER hosting capacity. This improves grid utilization and efficiency.

Process indicators included increased DER hosting capacity in the secondary network, which enables customers to reduce electricity import during peak-demand periods, resulting in reduced load factor for secondary network transformers. This both extends the life of existing transformers and improves their asset utilization by allowing additional customers to be connected. Increased DER hosting capacity also enables increased customer self-supply, reducing delivered energy and associated technical losses on the electrical distribution system.

Quantification: Measured peak demand, expecting a reduction as a result of SNEP. There is a direct correlation of this metric to increased transformer life and/or freed capacity to accommodate load growth.
Result: SNEP has removed the network protector barrier that limited hosting capacity to the level at which customers could only offset their internal power consumption. With this barrier removed, it is now technically possible for a customer to produce power back into the secondary network system. As a result of SNEP, the hosting capacity at this spot of the secondary network has increased significantly, at least 33 per cent. If the site host installed more DER, then hosting capacity could increase further to 100 per cent of the network transformer rating. The increase in hosting capacity will vary depending on the typical

electrical equipment constraints, which is similar to ENMAX Power's distribution system outside of the secondary network.

On peak production days, SNEP has reduced the site's peak demand by over 600kW, from requiring approximately 480 kW from the electrical grid to, instead, producing approximately 125 kW back to the secondary network, as shown in the chart below. A main benefit of this decrease in demand and energy consumption is energy savings for the customer. For the utility, the reduction in peak demand reduces the demand on the equipment while the solar PV is operation. This is a benefit as long as other power quality factors, such as reactive power production, are also kept within the appropriate ranges. The advanced inverters used for this project were certified to provide a number of these capabilities.



Export through network achieved as DER electricity production exceeds 600kW

Since the beginning of this project, industry has gained further understanding that there are multiple factors from DERs that impact transformer life. In addition to enabling bi-directional flow, this project was also able to demonstrate that the advanced capabilities of the customer's inverters could be used to increase hosting capacity and reduce stress on the distribution transformer, even while increasing the amount of DER installed in the system.

Impact indicators included increased DER adoption, deferral of transmission and distribution upgrades, reduced utility demand and energy charges to the customer.

Quantification: Measured on-site generation (kWh). This data was then used to contrast the transmission and distribution upgrades that would have been required if this project were not installed. Reduction in electrical distribution system losses were calculated in a similar manner.

Result: On-site annual generation production was estimated to be 912.2 MWh per year. From April 4, 2022 to September 15, 2023, the site has produced 1,356.2 MWh.

While the variable nature of DER solely reliant on solar energy does not allow it to be a reliable approach to defer transmission and distribution upgrades, it does reduce the customer's energy costs. Through Alberta's Microgeneration Regulation, customers are also able to receive credits on their energy charges.

This project has shown that while the customer's DER is producing power, it can reduce system demand. Since renewable DERs, including solar PV, are variable, it will take more time to understand their quantitative impacts on long-term system losses.

Flexible Grid
SNEP directly improved the flexibility and DER hosting capacity of the secondary network distribution system by enabling energy export from customer-owned generation, which was not previously possible.

Process indicators included increased generation capacity (kW) in the secondary network and the opportunity to incorporate other DER technologies such as energy storage, CHP, and Vehicle-to-Grid (V2G).

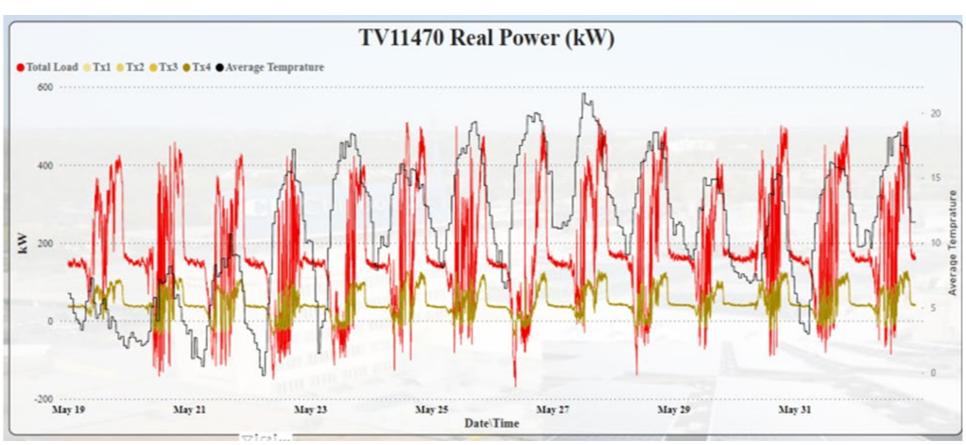
Quantification: Measured increased DER export capacity enabled by SNEP and extrapolated results to develop a model for system-wide deployment.

Result: SNEP has allowed the customer's DER to achieve full export capacity for their installed system, with their DER having exported more than 600 kW to the electricity system. This new technology has removed the secondary network protector limitations so that capacity can increase up to the typical distribution system limitations, such as system thermal and voltage limitations. This design is also DER-type agnostic, meaning it can be used for renewable technologies such as solar PV, energy efficiency technologies such as combined heat and power systems, or in the future vehicle-to-grid applications. The broader implications of this are that customers will be able to export power from whichever type of DER technology they prefer.
Impact indicators included the reduction in fossil fuel-based central generation required to serve the secondary network load.

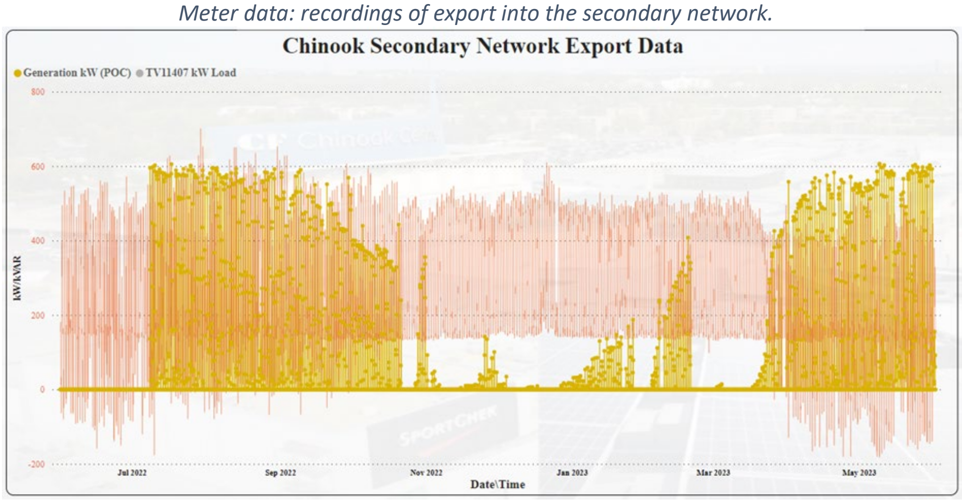
Quantification: Measured the amount of renewable power generated (kW and kWh) and compared it against the non-renewable generation that would have supplied the power. In addition, ENMAX Power measured associated direct GHG reduction.

Result: This project has generated over 600 kW of power during peak production and 1,356.2 MWh of renewable energy, from April 4, 2022 to September 15, 2023. If the SNEP system were not installed, the energy would have been provided by the various generation sources supplying the Alberta electricity system. AESO reports that in 2022, installed capacity of non-renewables was 60 per cent gas, seven per cent coal and two per cent other sources. Solar PV arrays are becoming a greater proportion of the renewables supplied to the system.

Below you can see examples of the system permitting export into the secondary network as the solar PV's production exceeds the buildings electricity consumption. Export is achieved each time the red line is crossing below 0 kW.



Meter data: recordings of export into the secondary network.

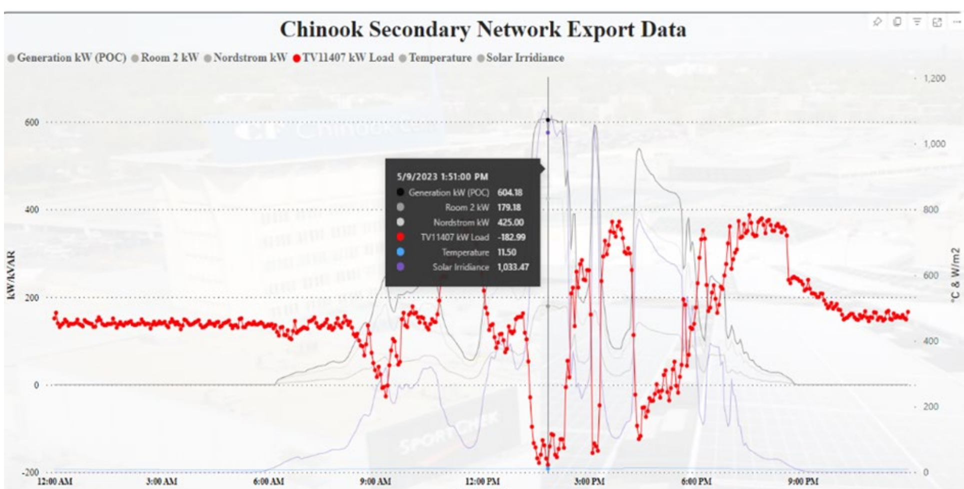


DER power production and net load seasonal variation

The above chart shows the total DER power production from July 2022 to June 2023 in yellow. The red line is the net load (electricity demand minus electricity produced) recorded at the DER's interconnection with the secondary network (within the spot network vault). The data shows that solar production reduces in winter, especially with lower sun angles and snow accumulating on the rooftop solar panels, and peaks in the summer, which leads to power exported into the secondary network (where the values are shown as negative).

Sustainable Grid

A sustainable grid allows for a cleaner mix of generation, including renewable energy. During the project reporting periods in 2023, SNEP exported at least 182 kW of renewable energy to the grid as shown in the graph below. Power exports exceeding 100 kW occurred over 15 times.



Example of customer's DER exporting power into secondary network

Exporting renewable energy to the grid results in a reduction of GHGs. SNEP achieves GHG reductions by enabling customers in ENMAX Power's secondary network to interconnect DERs, such as solar PV and CHP. SNEP targeted GHG emissions reductions of 600 tCO_2e/year for the demonstration site. The emissions reductions during construction were modelled as 721 tCO_2e/year. The 2023 recorded emissions reductions were 450 tCO_2e/year. The 38% lower emissions reductions are due to both the reduction in Alberta's electricity grid displacement factor over the duration of the project as well as the reduced energy output seen from the solar PV arrays in 2023.

The reduction of Alberta's electricity grid displacement factor is due to less energy being produced from power plants with higher emission fuel sources such as coal. This has resulted in an electricity grid displacement factor that is 25% lower compared to calculations originally made when the project started. Additionally, as previously stated in Project Success Metrics, the reduced energy production from the solar arrays is likely due to fire smoke and weather conditions has also reduced the energy production by 16%.

It is anticipated that GHG emissions reductions will increase when solar PV production is less impacted by wildfire smoke and weather conditions as it was in 2023.

Grid Resiliency
Increased DER capacity in the secondary network decreases the customer load on the system. When the load on the system is decreased, transmission and distribution outages can be restored faster – leading to a more reliable and resilient electrical grid.

While the recording systems to track real-time incident data are in place, to date an event impacting the system has not occurred. The data recording systems have been very helpful during site commissioning and maintenance activities to further confirm that the system will operate as intended to maintain the reliability and resiliency of the secondary network system. For example, the system has correctly stopped renewable production when communications were lost between the utility and the customer's site.

Although not in the scope of this project, SNEP installed foundational technology that has the potential to enable intentional islanding of secondary networks in the future, should adequate quantities of DER be deployed. Intentional islanding will provide improved reliability and resilience in the event of a loss of utility supply (future benefit).

Process indicators included improved resilience during transmission and distribution system outages.

Quantification: Measured substation and feeder peak power demand, expecting a decrease as a result of SNEP.

Result: Reporting data has shown that over four per cent demand reductions at the feeder can occur. This smaller observed impact at the feeder reflects the relatively small size of this DER to the feeder's loading. The reductions are negligible at the substation level as the demand exceeds 40 times the output capacity of the project's DER. If the DER were a more comparable capacity to the substation demand, more significant reductions would also have been recorded at the substation level.

Impact indicators included an increase in the transmission and distribution systems' ability to withstand equipment failures and to accommodate maintenance-related outages.

Quantification: Measured restoration capacity, expecting an increase based on project load reduction through increased DER adoption.

Result: In addition to enabling bi-directional power flow in the secondary network systems, SNEP also proved that communication could be directly established with a customer's DER system to change how the DER operates in real time. This increases the predictability of how renewable DERs operate.

Having more predictable orchestration of renewable DERs during system events, such as equipment failures, can increase the restoration capacity of the system. For example, DER operation can be changed in real time – either adding or reducing power demand on the secondary grid – in order to increase the restoration capacity of the system. The amount of restoration capacity increase possible will depend on amount of electricity the DER can produce when it is required to adjust its operation. For a solar PV system such as the one in SNEP, that value could be over 600 kW depending on solar production at the time.

Training
Six Highly Qualified Persons were targeted for training during SNEP. Throughout the project, 36 HQPs were ultimately trained. The increase in HQPs is due to people trained through CF and their contractors working on the project.

Knowledge Dissemination Activities
Industry technical publications:

- Technical Project Paper published to the International Council on Large Electric Systems (CIGRE)

Participation/presentation to industry stakeholders:

- Centre for Energy Advancement through Technological Innovation (CEATI) DO&A Fall General Meeting, 2022
- Western Energy Institute - Secondary Network Meeting, 2023
- Eaton Corporation - Electrical Network Systems Conference, 2023
- Electric Power Research Institute: LV Secondary Supplemental, 2022
- Alberta DFO/TFO Distributed Energy Resource Forum, 2022

Peer utility company collaboration/engagement*:*

- Alberta Smart Grid Consortium
- Consolidated Edison of New York
- EPCOR
- City of Medicine Hat
- Southern Company
- Southern California Edison

Public stakeholder information:
ENMAX website news
ENMAX and Cadillac Fairview to test network innovation through solar installation

ENMAX Power and Cadillac Fairview’s successful solar pilot at CF Chinook Centre project paves way for increased customer choice and lower carbon future

Media clippings
ENMAX Power and Cadillac Fairview's successful solar pilot at CF Chinook Centre project paves way for increased customer choice and lower carbon future (Cision)

Solar panels atop Chinook Centre able to feed into power grid (Calgary Herald)

Calgary mall solar installation successful in putting power back into grid (Global News)

Solar panels atop Chinook Centre able to feed into power grid (Calgary Sun)

Solar Power Pilot Project Launches at CF Chinook Centre in Calgary (Retail Insider)

Videos
https://www.youtube.com/watch?v=e0BSxBGMsfk&t=23s

https://www.youtube.com/watch?v=WlNTPSAVoJg&t=61s

ENMAX ESG Report
ENMAX 2022 Environmental, Social and Governance Report

Standards, Codes and Regulations
ENMAX Power considered challenging a code early in the project; however, that approach was not feasible as it would have resulted in a significant project delay. Instead, the team was able to collaborate with CF to find alternative methods to proceed that were within the standards at the time and were, therefore, more effective to implement. The code that posed the problem has since been changed and would not create an issue if the demonstration project were started today.

ENMAX Power has created or modified 18 internal standards, including those related to new cabinet layouts, communications and power schematics, wiring diagrams, harnesses and equipment layout diagrams. These standards guided the project's design, described in detail in CIGRE 2022 Paper 522. ENMAX Power's internal standards are not typically shared in detail in order to ensure the protection of critical infrastructure.

Savings for Customers
The project site host, CF, saved $81,000 in total energy costs from September 1, 2022, to August 31, 2023, which is the reporting period for CF's national sustainability program, Green at Work. These savings are divided into two parts: $45,000 in micro-generation credits and $36,000 in avoided energy costs.

Lessons Learned

ENMAX Power continued to learn, assess and adapt as SNEP developed from a lab-tested concept to installation and full operation. Noteworthy learnings related to:

- The value of remote testing. Historically, employee participation in witness testing of equipment with out-of-province laboratories was limited to a couple of employees that could be flown out for testing. Due to travel restrictions in place during the COVID-19 pandemic, ENMAX Power was able to work with their testing lab to conduct all testing online in real time through Microsoft Teams. As a result, ENMAX Power was able to invite many more company subject matter experts and project representatives to witness the testing. This saved travel costs and increased knowledge sharing.
- Construction and design issues that can confront customers and how they can limit customer's ability to proceed with deployment of renewable technologies. ENMAX gained a better understanding of the significant costs associated with upgrading the building infrastructure to ensure the roof where the solar array was installed would be able to handle the additional weight. The cost of roof upgrades was in the same cost range as the deployment of the solar PV system.
- Deployment of the system through the commissioning and testing following installation. This led to further design refinements such as automation and control functionality being included to

enable improved operation and up-time of the system and the customers' ability to safely maximize their renewable energy production.

- The capabilities and potential of remotely communicating with customers' DERs to increase hosting capacity. As part of this demonstration project, ENMAX Power has successfully communicated with the customer's on-site inverters and has sent instructions to change those inverters' operating settings in real time. This capability will become increasingly important as utilities see a growing need to maximize hosting capacity so that customers can connect further DERs.
- Refining the design so the system could be deployed into its real-world operating environment. This included integrating the lab-tested system with existing utility and customer infrastructure and then further refining the project's new standards to reflect the lessons learned during installation.
- As our distribution system becomes more bi-directional, understanding the magnitude and timing of customer electricity production onto the distribution system is key to achieving continued grid affordability. In this project we are understanding customer's electricity use and how it relates to solar production. This empirical information, being measured since the site has been operational, has provided better insight into how and when production of solar PV arrays for commercial customers will export into the utility distribution system.
- Variability in renewable electricity production has been an on-going power quality topic as concentration of DERs increases across the industry. This project's installation of high accuracy power quality meters has allowed ENMAX to gain clarity of how solar PV electricity production varies its output through the days, seasons of the year and how that impacts the power quality of the distribution system. While this analysis is still proceeding, initial data is showing that the solar PV system at this installation is not causing any adverse power quality issues.

Next steps

The project site has continuous monitoring, which will remain in place for at least one year. To measure power quality, secondary voltage (120 V) is monitored on all three phases and current flow (amps) is monitored on each phase of the four network protectors connected to the secondary network. The data collected is being analyzed for proof-of-concept; that is, to verify that electricity is being successfully exported to the grid and to identify any reliability, protection or operational concerns.

Testing and monitoring of project performance will be ongoing with continuing operations, with the goal of making the technology available to customers in Calgary's downtown and similar high-density areas.

Regarding scaling this technology up across ENMAX's service territory, after thorough examination of observations from SNEP, ENMAX Power plans to offer this technology solution to other DER customers who may be interested in exporting power onto secondary network systems. ENMAX Power believes that the cost of this solution would be feasible for many commercial customers; however, the decision to proceed is up to each individual customer as they assess the payback period of the renewable energy and balance that with other economic factors in their business.

This project has helped to modernize key components of ENMAX Power's distribution system, as the organization explores further innovative projects that will build on these learnings.

By solving this challenge and sharing the knowledge throughout the utility industry, ENMAX Power can help enable further customer choice, DER adoption and GHG reductions across the North American utility landscape.