SMART GRID NOVA SCOTIA

EXECUTIVE SUMMARY TO THE FINAL REPORT FOR NATURAL RESOURCES CANADA

INTRODUCTION

- **Overview of the Project**

The Smart Grid Nova Scotia (SGNS) Project was designed to assess whether there are customer and grid benefits associated with the deployment of Distributed Energy Resources (DERs) managed by a Distributed Energy Resource Management System (DERMS). These technologies were rolled out together, underpinned by corresponding customer programs, like incentives, participation agreements, and a pilot rate rider for solar garden subscribers.

DERMS is an application platform with ability to manage device information and enrollment into utility programs, to monitor and enable control and optimization of DERs. In this case, the DERMS platform under study was Siemens Energy System Platform (ESP) which was developed throughout the project. DERs under the SGNS project include electric vehicle (EV) smart chargers, residential managed EV charging through EV telematics (ev.energy), residential batteries, commercial and industrial (C&I) solar photovoltaics (PV) paired with battery energy storage systems (BESS), and C&I building management systems (BMS). This is shown below in Figure 1 – SGNS Project Overview.

Figure 1 – SGNS Project Overview

The location of these assets throughout Nova Scotia are shown below in Figure 2 and Figure 3.

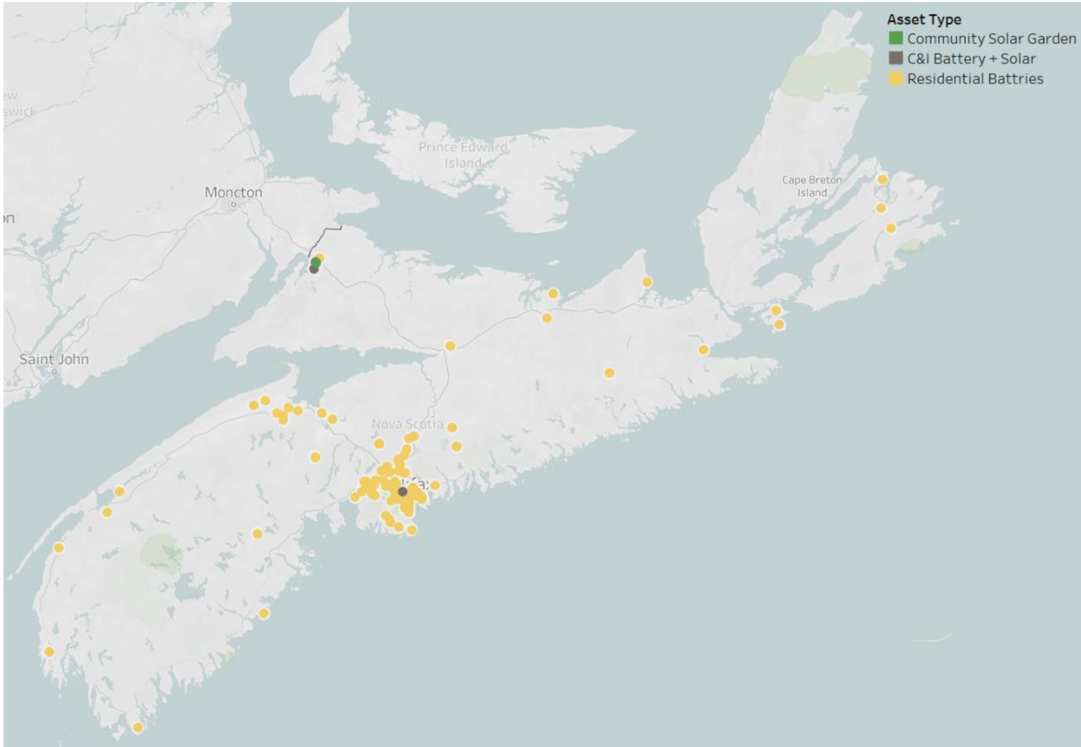

Figure 2 – Locations of the Community Solar Garden, C&I Battery and Solar Locations, and Residential Batteries across Nova Scotia

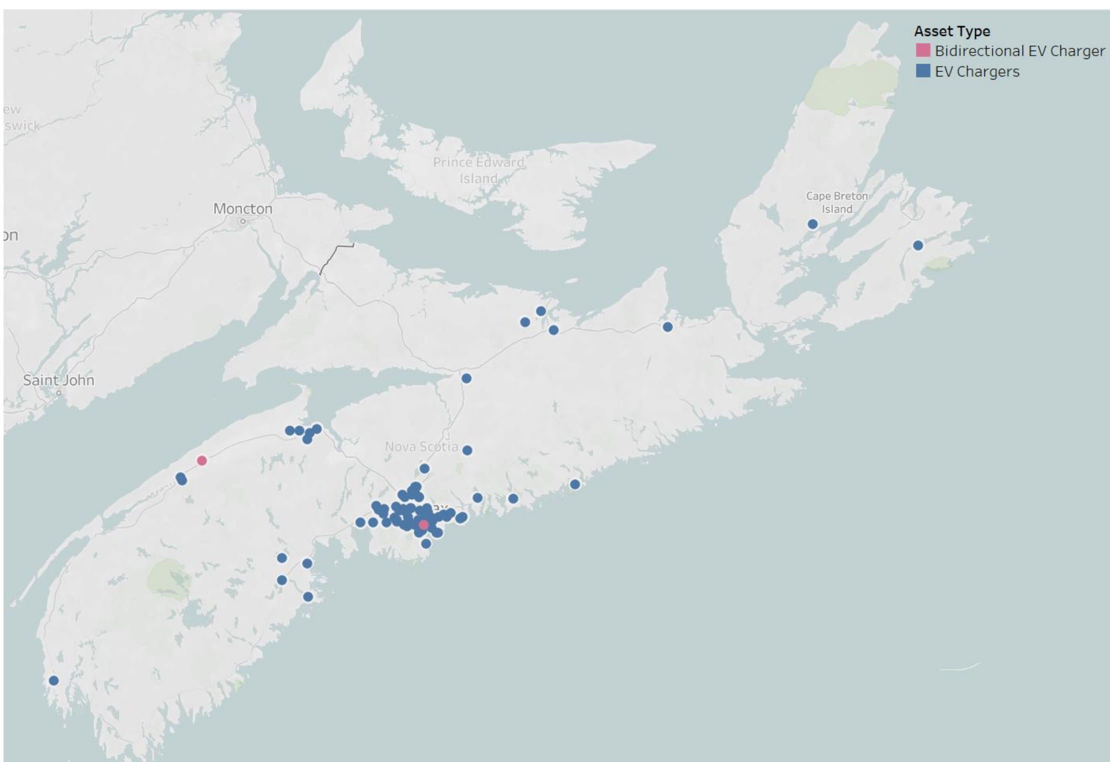

Figure 3 – Locations of the Bidirectional EV Chargers and Residential EV Chargers across Nova Scotia

The project timeline is represented by major milestones in Figure 4 below.

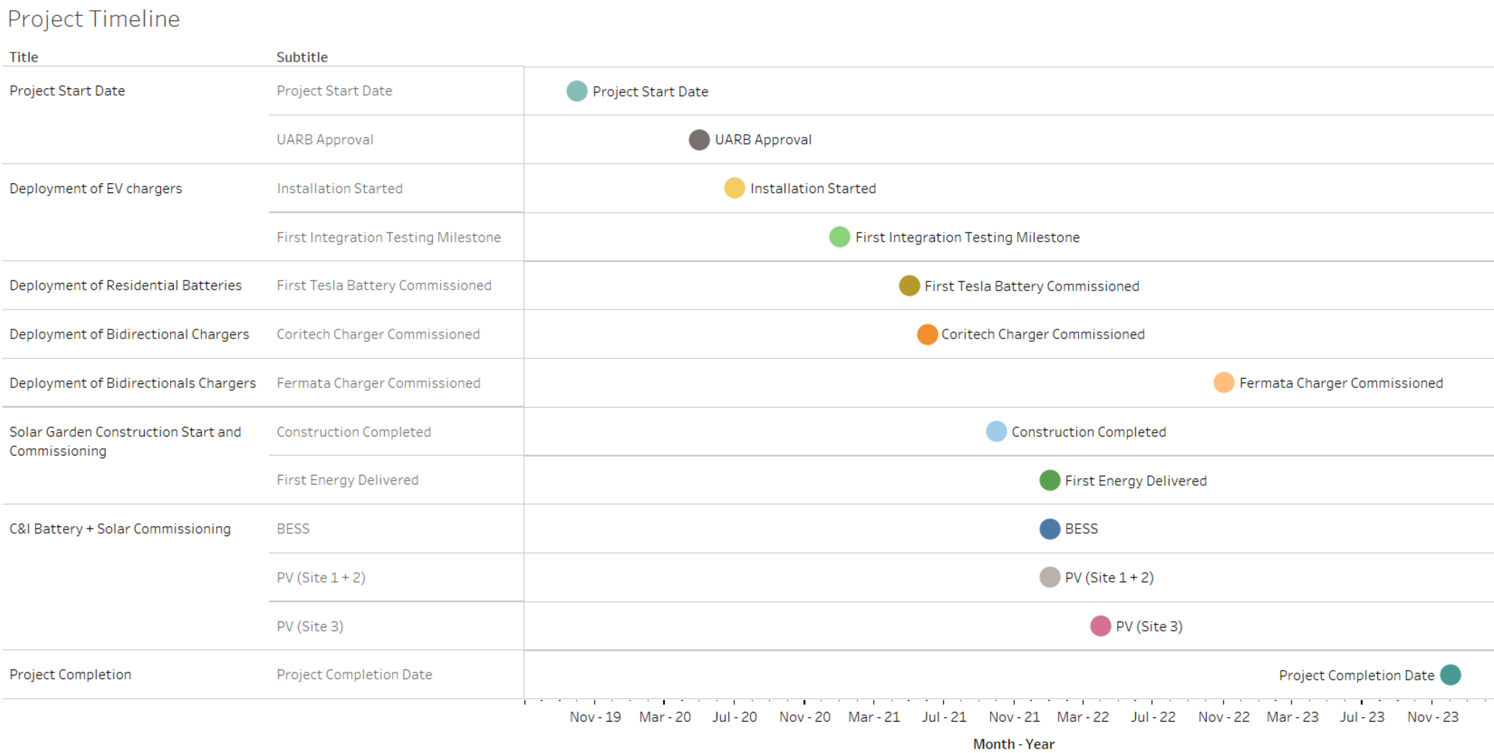

Figure 4 – Project Timeline in Major Milestones

- **Partners and Stakeholders**

The Project is part of the larger Smart Grid Atlantic (SGA) initiative, developed in partnership with the Government of Canada, the Province of Nova Scotia, New Brunswick Power (NB Power), Siemens Canada (Siemens), the Nova Scotia Community College (NSCC), and the Town of Amherst. The Project is supported by, and received funding from, the Province of Nova Scotia, Natural Resources Canada's (NRCan) Electric Vehicle Infrastructure Demonstration (EVID) fund, NRCan's Smart Grids fund, and Innovation, Science, and Economic Development Canada's (ISED) Strategic Innovation Fund (SIF). External project funding comprised 64 percent of the total 19.9-million-dollar budget. In addition to support from project and funding partners, various partnerships made the Project possible, including EfficiencyOne (E1), Dalhousie University, residential and commercial customers, installation contractors, and various vendors, who provided invaluable contributions including research, assets, property, labour, and more.

EVID-1017 supported the EV charger and bidirectional charging scope. NRCan Smart Grids Fund GISG-3085, Demonstration and Deployment streams and SIF supported the Amherst Community Solar, residential batteries, C&I Solar and Battery sites, and the ESP scope. A breakdown of the contributions can be seen below in Figure 5.

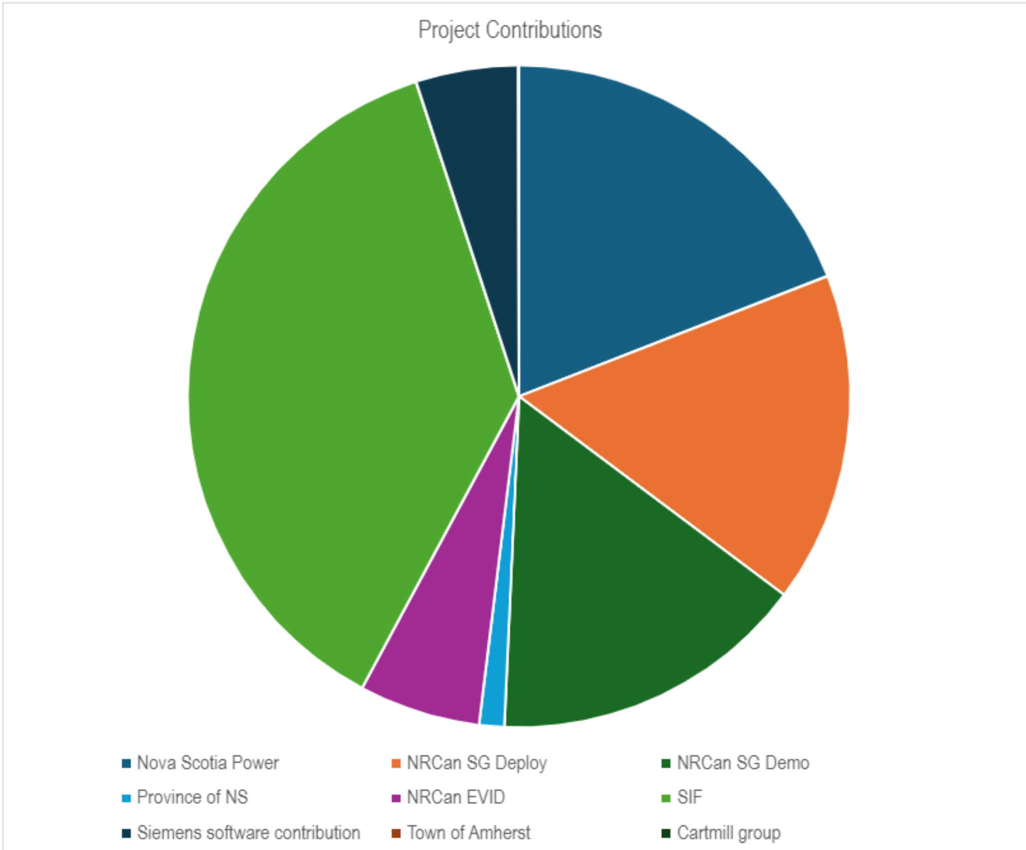

Figure 5 - Contributions by funding partners

PROJECT OBJECTIVES

The desired learnings from this project included:

- Customer behavior insights, support design, and development of future programs
- Understand the capability of integrating a variety of DER assets to execute use cases
- DERMS experience, benefits framework, and valuation
- Advance utility experience with behind the meter emerging technologies
- Electrification & Renewable Integration enablement

Figure 6 provides an at-a-glance view of the components within the Board-approved scope of the Project as compared to the components of the final scope of the Project following amendments and refinements to asset classes and use cases over the course of the Project. These amendments and refinements were made to adapt to various circumstances and learnings as they arose, and to take advantage of unique opportunities to augment the Project while staying within the approved budget.

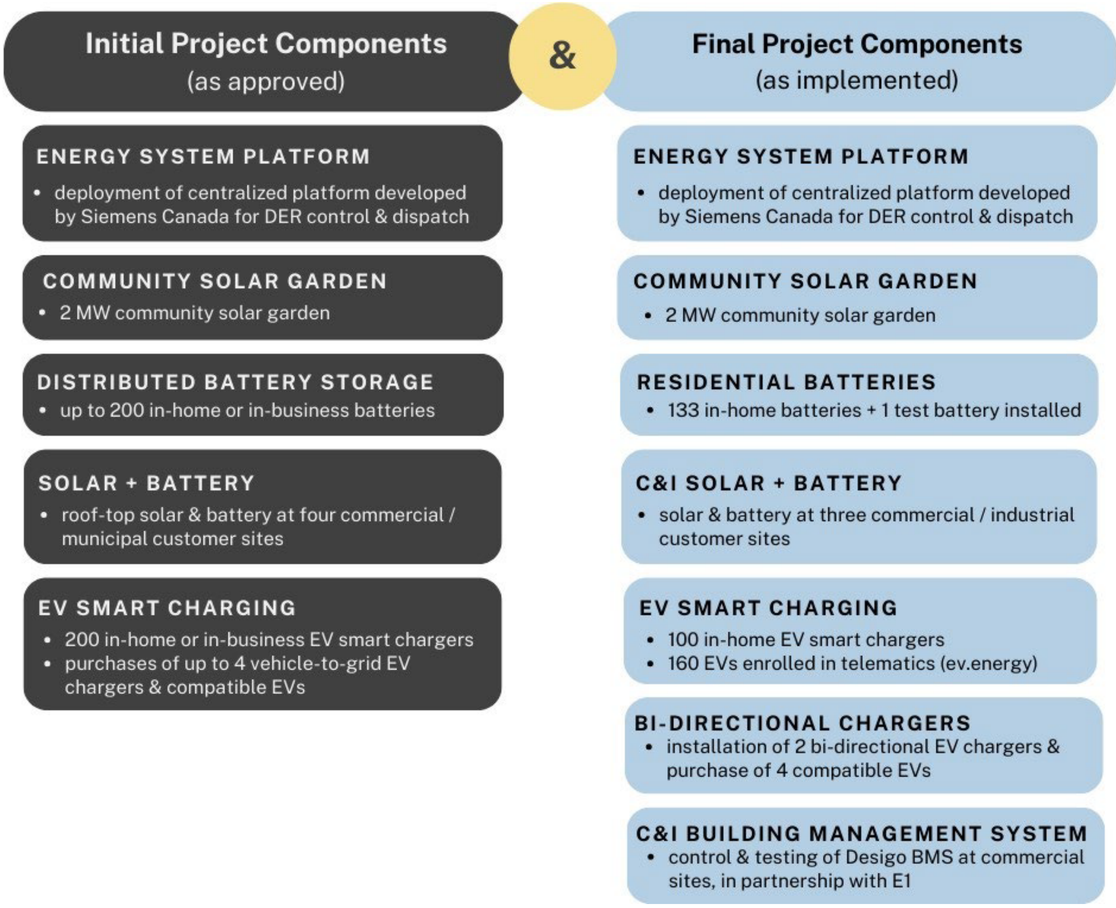

Figure 6 - Initial and Final Project Components for the Smart Grid Nova Scotia Project

At the end of the Project, the primary differences between the initial and final project scope were:

- Installed 134 of the maximum 200 batteries, 133 of which were installed in-home, while one battery was installed for signal and integration testing.
- Commissioned three of the planned four C&I solar + battery sites, and two of three sites had ground-mounted (as opposed to roof-top) solar commissioned.
- Installed 100 of the maximum 200 EV smart chargers.
- Implemented ev.energy to provide an enrollment option for vehicles not compatible with smart chargers, and extended enrolment in the EV Smart Charging program for ev.energy EV telematics to additional customers. As a result, the project onboarded an additional 125 customers to ev.energy, in addition to the 100 originally recruited for EV Smart Charging. In total, 160 customers were enrolled in EV telematics.
- ‘Vehicle-to-grid chargers’ scope removed from EV Smart Charging and retitled ‘bidirectional chargers.’
- Installed two of the planned four bi-directional chargers; lack of availability and/or certification in Canada prevented more installations.
- Addition of a joint E1/NS Power pilot integrating Siemens’ Desigo BMS with Siemens ESP to control various equipment at three commercial customer sites.

PROJECT BENEFITS

The Project tested the effectiveness of management of DERs to deliver benefits related to affordability, reliability and environmental compliance, with or without ESP integration. As noted in NS Power's application Compliance Filing and reply to Compliance Filing comments, the Company developed several use cases and associated metrics in order to evaluate those potential benefits by asset class. The use cases were updated over time and reported on in NS Power's semi-annual reporting. At Project end, various use cases by asset class were successfully tested and evaluated, with the following levels of outcome confidence:

- 'Extensive Quantitative Results' – benefit outcomes were robustly supported by a significant data set.
- 'Limited Data Results' – benefit outcomes were supported by a more limited data set due to certain constraints.
- 'Proof of Concept' – benefit outcomes were directionally demonstrated to work in principle through empirical testing.

The SGNS Program Use Case Testing categories are shown in Figure 7.

- **Load Leveling**
  - Economic Dispatch
  - Peak Shifting
- **Demand Response**
  - Reserve Capacity / Generation Contingency
  - Critical Peak Response
- **Renewable Integration**
  - Wind & Solar Following
- **Grid Support Services & Reliability**
  - Feeder Congestion Relief
  - Cold Load Support
  - Smart Inverter Modes
- **Customer**
  - Resilience / Backup Power
  - Demand Reduction

Figure 7 – SGNS Smart Grid Use Case Categories

The testing benefitted Stakeholders of the project and Canadians through data and learnings, as well as through partnerships and collaborations funding partners, other utilities, Siemens, and other partners. These learnings and relationships will support the development of future projects and DERMS platforms. This project has allowed for the creation of a sustainable Customer Engineering and Innovation team. As well, it has allowed for the career and leadership progression of multiple key personnel from the project. Table 1 summarizes the benefits and outcome confidence for each stream by DER asset class.

Table 1- Benefit Table by Asset

DER Asset Component	Benefit Stream	Outcome Confidence	Summary of Observations	Commentary
EV Smart Charging	Affordability	Extensive Quantitative Results	• Long-term affordability benefit through load-smoothing once EV adoption is high. • Realized energy cost savings for participants that managed their own charging to take advantage of time-varying tariffs.	Use case testing provided a dataset indicating benefit over a shortened timeframe.
	Reliability	Proof of Concept	–	Use case testing provided data from home installation onward.
	Environmental	Extensive Quantitative Results	Short- and long-term greenhouse gas (GHG) benefits from load shifting.	Use case testing provided a dataset indicating benefit over a shortened timeframe.
Vehicle-to-grid (Bi-directional) EV Charging	Affordability	Proof of Concept	• Grid level affordability benefits particularly related to fuel costs as a result of load shifting and demand response. • Direct participant bill benefits as a result of demand charge management.	Proof of concept results expected as this is nascent technology not widely available at this time. Reliability was not tested.
	Reliability	Not Applicable	–	
	Environmental	Proof of Concept	GHG reduction through shifting higher loads to off-peak periods.	
Residential Distributed Batteries	Affordability	Limited Data Results	For peak events observed during the Project, fuel savings ranged from \$2,400 to \$4,775 per year per MW of installed capacity.	Use case testing provided a dataset indicating benefit over a shortened timeframe.
	Reliability	Extensive Quantitative Results	Battery back-up power was provided throughout 94.1 percent of verified hours of grid interruption that occurred outside of weather events (blue sky), and 91.2 percent of participants avoided all hours of interruption.	Use case testing provided data from home installation onward.
	Environmental	Limited Data Results	For peak events observed during the Project, estimated marginal emissions reductions ranged from 49.9 to 62.5 tCO_2e per year per MW of installed capacity.	Use case testing provided a dataset indicating benefit over a shortened timeframe.

DER Asset Component	Benefit Stream	Outcome Confidence	Summary of Observations	Commentary
C&I Batteries	Affordability	Limited Data Results	Extrapolated annual fuel savings on the order of $4,800 per year per MW of installed capacity at evening peak events.	Use case testing provided a dataset indicating benefit over a shortened timeframe.
	Reliability	Proof of Concept	Advanced inverter functionality was successfully demonstrated under the Project for interactive grid support services such as power factor correction, voltage and frequency response which contributes to reliability.	C&I battery designed for power factor use cases, not full power back-up, and demonstrated under the Project.
	Environmental	Limited Data Results	Extrapolated marginal emissions reduction potential of 69.50 tCO_2e per year per MW of installed capacity for evening peak events observed during the Project.	Use case testing provided a dataset indicating benefit over a shortened timeframe.
C&I Solar Smart Inverters	Affordability	Proof of Concept	Power factor correction, where distributed solar is more prevalent, may drive affordability through cost-effective integration of renewable energy.	Proof of concept results demonstrate benefits of the nascent advanced inverter function despite ESP integration challenges.
	Reliability		• Advanced inverter functionalities contribute to reliability by reacting to grid conditions to support over- and under-voltage events and deliver frequency response. • Advanced inverter functionality was successfully demonstrated under the Project for interactive grid support services such as power factor correction, voltage and frequency response which contributes to reliability.	
	Environmental		Advanced inverter functionality modes may support increased integration of on-site renewable energy, which could lead to a net reduction in carbon emissions overall.	
C&I Building Management Systems	Affordability	Limited Data Results	Clear opportunities for demand response savings that contribute to affordability during morning and evening events across three building archetypes.	Benefits demonstrated under the Project for three facilities with unique characteristics

DER Asset Component	Benefit Stream	Outcome Confidence	Summary of Observations	Commentary
	Reliability	Proof of Concept	–	and connected equipment.
	Environmental	Limited Data Results	Fuel savings and corresponding emissions reduction potential from load shifting are expected to occur in a similar manner to other DERs tested so long as dispatch is closely optimized to cost and emissions curves.	
Community Solar Garden	Affordability	Extensive Quantitative Results	Clean energy at marginal cost.	–
	Reliability	Not Applicable	–	Solar Garden provides intermittent energy production not available for direct reliability benefits.
	Environmental	Extensive Quantitative Results	Estimated reduction in carbon emissions of 2,078 tCO_2e from February 1, 2022 to December 14, 2023.	–

The benefits summarized below in Figure 8, while not exclusive to the SGNS project, demonstrate overarching benefits that can be unlocked by DER management and shared by utility and customer.

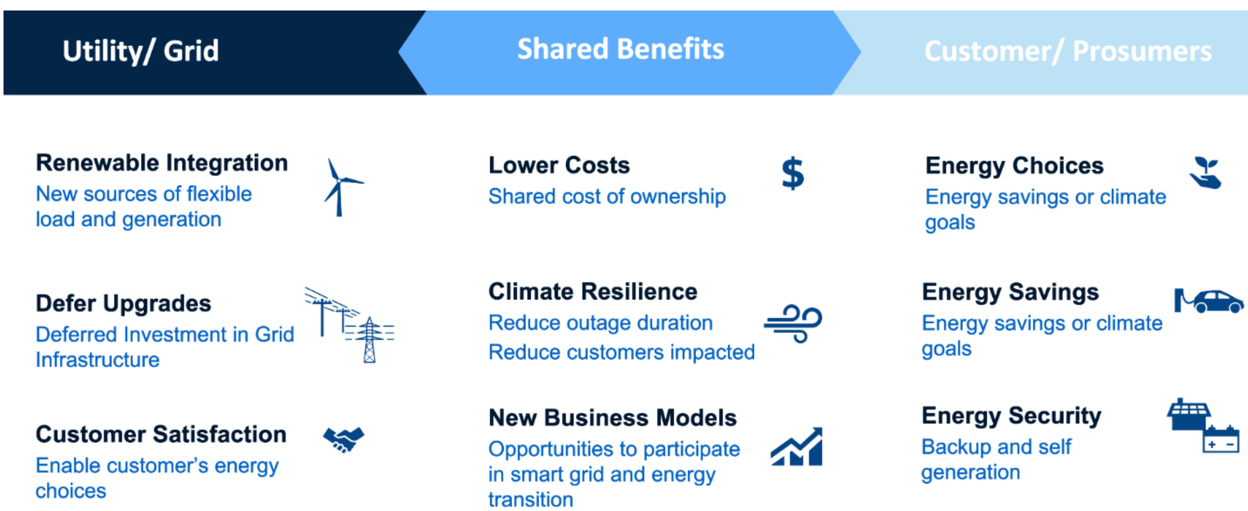

Figure 8- Benefits to the Utility/Grid, Customer/Prosumers, and Shared Benefits of DERs management.

PROJECT FINANCIALS

The project financials are shown in figure 9 which shows the percentage of Nova Scotia Power funding per asset class.

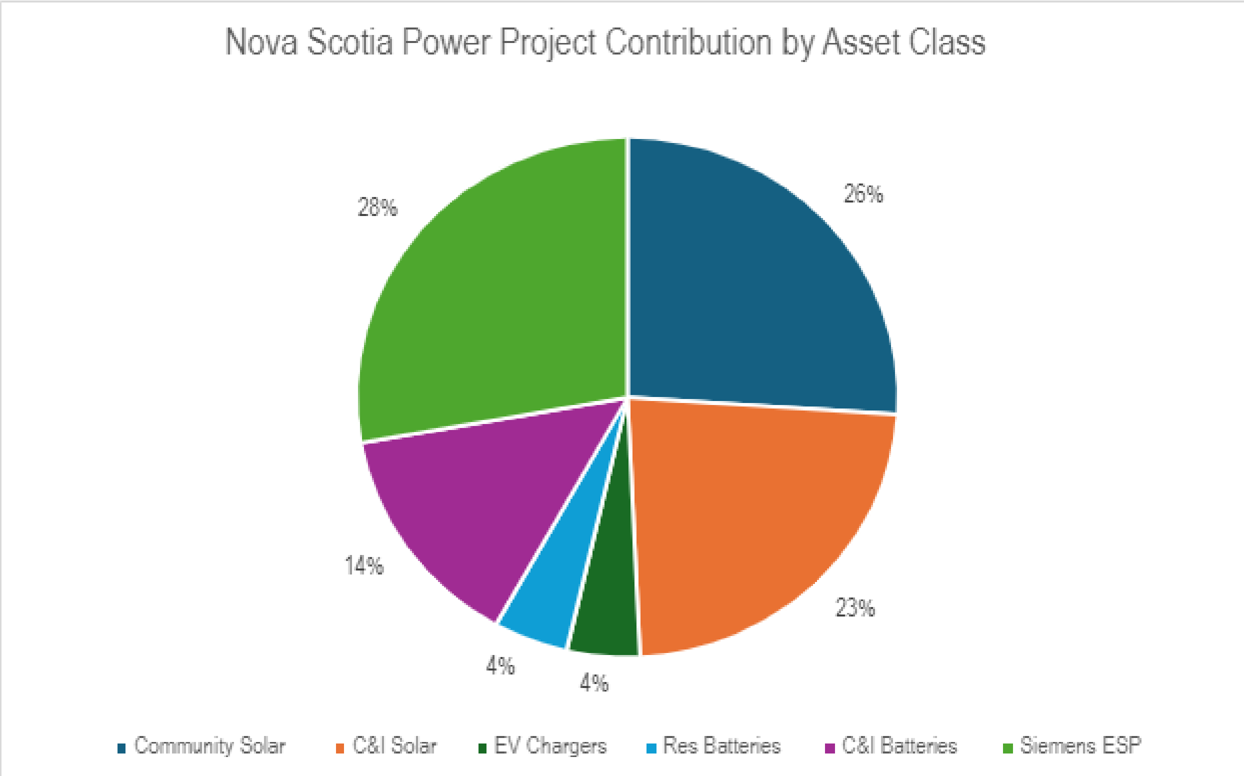

Figure 9 – Percentage of Nova Scotia Power Funding per asset class.

RESULTS & OUTCOMES

There were several Key Performance Indicators (KPIs) the Project worked to achieve. These are summarized with their outcome in table 2.

Table 2 – Summary of KPIs and Status

Key Performance Indicator	Value	Commentary
Number of Customers Involved	505	• 128 - Residential Battery Customers • 3 - C&I Solar and Battery Customers • 212 - Solar Garden Maximum Customers throughout the duration of the project* • 160 – Residential EV Smart Chargers • 2 – EV Bidirectional Chargers
Customer Engagement best practices established		Customer engagement was primarily through customer programs that collaborated on asset utilization.

Key Performance Indicator	Value	Commentary
		Customer programs were developed with the intent of maximizing both the participatory opportunities for customers keen to adopt DER technologies and the value derived from management of DERs. Customer programs/incentives were developed for EV Smart Charging, residential batteries, C&I solar + battery, and the community solar garden.
Amount of Customer Savings		Customers benefitted through customer programs and utilization of DERs. Customer programs included: • $350 contribution toward the cost of the EV charger installation, and an annual $250 inventive to allow Nova Scotia Power to control their vehicle charging. • For residential batteries, participants were provided the option to contribute $3,000 upfront or $25 per month (for ten years) for a 13.5 kWh battery, or $4,200 upfront or $35 per month (for ten years) for a 18.6 kWh battery. • A rider was created for the Community Solar Garden. The rider was designed based on a fee-plus-credit model with two components – a monthly solar capacity charge per subscribed kW of nominal capacity from the Solar Garden, and a credit for each kWh of electricity produced by the Solar Garden reflecting the value of the Solar Garden generation to NS Power's system. • While no direct incentives were paid for the C&I Solar and Battery, the customer received the indirect benefit of potential demand reduction should solar production happen to reduce peak monthly demand and can claim their support of green energy in the province, as a portion of their load is directly fed by renewable energy. These benefits accrue to the customer with no upfront capital or ongoing fee, aside from a monthly charge for an additional meter (approximately $10 per month) to account for the solar generation. • E1 provided an incentive of $125/kW/Year for confirmed demand reduction during scheduled events to the 3 customers with BMS assets.
Amount of leveraged customer assets providing grid services	300	• 134 Batteries • 3 Solar and 3 Batteries for C&I Solar/Batteries • 160 EV Smart Chargers
Increase in energy generated from renewable sources	5,592 MWh	• 2MW Capacity Solar Garden – 4,752 MWh was generated from February 2022-December 2023 • 3 C&I Solar 185 kW, 288 kW, 300 kW Capacity – total 840 MWh was generated from January 2023-December 2023.

<table>
<tr><th>Key Performance Indicator</th><th>Value</th><th>Commentary</th></tr>
<tr><td>Additional renewable capacity modelled per substation</td><td></td><td>A wind following case study was completed at a high level that would add additional renewable capacity per substation.</td></tr>
<tr><td>Highly Qualified Professionals and Total Employment on project</td><td>58 HQP and 75 total</td><td>Highly qualified personnel are considered an employee that requires specialized training. This may include scientists, engineers, managers, and specialized trades. It would also typically include employees designated as working in professional or technical occupations in natural and applied sciences or other professional occupations.</td></tr>
<tr><td>% Subscribed customers to the solar garden</td><td>66%</td><td>A commercial subscription carveout was a requirement of the Board-approved Solar Garden Pilot Rate Rider. The Company attempted to recruit and retain commercial customers; however, the value proposition did not resonate with commercial customers.</td></tr>
<tr><td>Renewable forecasting established with analysis on the increase in renewable penetration over baseline</td><td></td><td>No direct analysis was completed on this KPI. Qualitatively, the project saw a higher-than-expected uptake in residential battery customers installing residential solar than anticipated. Discussion on the addition of residential solar to homes that had residential batteries is in section 2.3.8 in Appendix E of the Final Report.</td></tr>
<tr><td>Comparison of forecasted generation to actuals</td><td></td><td>The solar garden forecast vs actual generation is shown below. The asset was commissioned in February 2022.
<table>
<tr><th>Community Solar Garden</th><th>Generated MWh</th><th>Forecasted MWh</th></tr>
<tr><td>February 2022-December 2023</td><td>4,752.1</td><td>5,072.6</td></tr>
</table>
The C&I solar had no export-to-grid capability and was therefore curtailed at times when generation exceeded the power required by the facilities. Therefore, the forecast was not met in two of three locations but is not necessarily representative of the site-specific conditions.
<table>
<tr><th>Site</th><th>Generated MWh 2023</th><th>Forecasted MWh 2023</th></tr>
<tr><td>Compass Mineral</td><td>365.95</td><td>358.07</td></tr>
<tr><td>Maritime Pride</td><td>196.03</td><td>243.92</td></tr>
<tr><td>BIO</td><td>278.25</td><td>327.02</td></tr>
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</td></tr>
</table>

* The solar garden as of March 31, 2024 had 170 Customers

LESSONS LEARNED

Table 3 and 4 are a compilation of the top achievements and barriers from the Smart Grid Nova Scotia Project.

Table 3 - Summary of learnings and achievements of the Project.

<table>
<tr><th>Achievement/Result</th><th>Description</th></tr>
<tr><td>Residential battery – Customer Benefit</td><td>Residential distributed batteries demonstrated that battery back-up power was provided throughout 94.1 percent of verified hours of grid interruption that occurred outside of weather events (blue sky), and 91.2 percent of participants avoided all hours of interruption.</td></tr>
<tr><td>C&I Solar – Smart Inverters</td><td>The solar smart inverters functionality was successfully demonstrated for system load levelling, power quality and grid support use cases.
Curtailment of active solar generation for power factor correction on the example event days ranged between 6-to-12% of active production.
Reactive power injection / absorption was successfully demonstrated for over- and under-voltage conditions, as well as for frequency response.</td></tr>
<tr><td>DERMS</td><td>Significant learnings were achieved with the development and configuration of a DERMS platform:
ESP was successfully used to test the Project's functional, system, and value hypotheses through use cases execution, ultimately demonstrating potential affordability, reliability, and environmental compliance benefits.
The Company better understands what DERMS architecture should be developed from the learnings of the Project, and which DERs benefit the most from direct integration to a DERMS platform.
Efficient data reporting is critical moving forward to future projects. Significant time and effort were employed to store and analyze the data. Data reporting and analysis within the ESP interface was insufficient for the depth of study intended by the project.</td></tr>
<tr><td>Residential Batteries</td><td>As the batteries acted as a virtual power plant, they were able to load shift from higher emission to lower emission periods and from higher to lower cost generation periods.
For peak events observed during the Project, estimated marginal emissions reductions ranged from 49.9 to 62.5 tCO_2e per year per MW of installed capacity.
For peak events observed during the Project, fuel savings ranged from $2,400 to $4,775 per year per MW of installed capacity.
Renewable following was demonstrated with aggregated battery storage being charged at periods of high wind and discharged at periods of low wind.</td></tr>
<tr><td>Community solar</td><td>The learnings from this pilot have informed the provincial community solar program, more details available here: https://energy.novascotia.ca/renewables/community-solar-program
Estimated reduction in carbon emissions of 2,078 tCO_2e from February 1, 2022 to December 14, 2023.
Experience in a customer billing/service environment of paying a flat fee, on each bill, for access to a share of the energy produced, and receive an offsetting credit</td></tr>
</table>

Achievement/Result	Description
	on customer electricity bills based on the energy generated by their allocated share. • Experience gained in Asset operations and maintenance (O&M) and Asset Performance.
EV Smart Charging	• Evening demand response (DR) events starting between 17:00 and 20:00 can achieve load reductions of 0.23 to 0.56 kW per enrolled vehicle for the first hour. Due to low average energy requirements, the load reduction in the second hour of an event was up to 50 percent lower. • Whether the vehicle is plugged in and requiring energy plays the most important role in the outcome of smart charging; higher frequency of charging provides greater opportunity to influence charging and provide system benefits. • Resultant fuel savings to the utility were, under the best-case scenario, roughly $0.01 per vehicle enrolled per day in fuel costs at Project scale but would be expected to provide greater benefit under a full-scale deployment. • By incorporating a signal of forecasted wind generation into the ev.energy charging schedule, the Project demonstrated the ability to orchestrate EV charging to follow lower carbon generation, calculating approximately 1.5% fewer tonnes of carbon dioxide equivalent (tCO2e) on the marginal emissions intensity, and 3% fewer on average, by comparing calculated emissions from actual delivered energy to the calculated emissions from the calculated counterfactual scenario (i.e. unmanaged charging).

Table 4 - Summary of barriers faced in the SGNS Project.

Issue/Barrier	Description	Action
Tesla Powerwall integration	Tesla Powerwalls were not able to be integrated with Siemens Energy System Platform (ESP) with the chosen integration configuration method. Project use case testing execution required a third party to manually issue events and grid aware automations were not possible.	Future investment in distributed energy resource management systems will consider alternative and proven integration methods.
C&I Battery	The C&I Battery vendor control systems are not intended nor adequate for execution of practical utility use cases. A utility-integrated DERMS is critical for control, otherwise no value will be captured or there is a risk of damaging the equipment.	Optimizing fuel and capacity savings requires intimate knowledge of cost curves and peak demand conditions. Grid aware control is key to capturing value and avoiding negative impacts of mistiming events.
Community Solar Garden	NS Power received limited demand for subscriptions from commercial class customers. • Offers to large customers are not enticing due to 100kW subscription cap, or preclusion from also participating in net metering.	NS Power will continue to explore ways to address the commercial customer challenges.

Issue/Barrier	Description	Action
	• Offers to smaller customers are not appealing enough due to a stronger focus on core business activities as the payback is long term, finding alignment with these customers has been more challenging. • Smaller customers may choose to install rooftop solar instead, as payback can be more lucrative and financing is available.	
Supply of V2G Chargers and Vehicles	Although the Project was able to secure prospective orders early on from multiple manufacturers of newly announced vehicle-to-everything (V2X) capable EVSE for the residential market, ongoing delays in certification and manufacturing for the North American and, in particular, the Canadian market, continue to persist. In Canada, the Canadian Standards Association (CSA) published CSA C22.2 no. 348:23 for the safety certification of products that will facilitate bi-directional power transfer in September 2023.	
Connector standards of EV Chargers	The effect of emerging standardization had previously contemplated the adoption of CCS1/2 as the global charging standard (and subsequent abandonment of ChaDeMo). However, the outlook remains different than when the Project was originally contemplated and is evolving rapidly. In the spring of 2023, Ford and General Motors (GM) struck deals with Tesla to adopt the proprietary North American Charging Standard (NACS), which effectively tipped the market away from CCS2 in North America with multiple other vendors following suit. The effect on the trajectory of global roadmaps of vehicles and manufacturers that support V2X bi-directional EV charging is unknown – up until this point, V2X with CCS had continued to grow. As more NACS equipped vehicles are announced, EVSE manufacturers are increasingly focusing on this connector for North America, which, in terms of V2X, is more nascent than CCS or ChaDeMo.	
OpenADR 2.0a standard incompatibility with Tesla vehicles	It was found that Tesla electric vehicles (EV) are forced into a low charging power mode by the vehicle if the input power fluctuates when the charger curtails vehicle charging below 50%. The OpenADR 2.0a standard provides simple signal commands only, which limits the ability to control a ramp rate or other more advanced functionality, and thus the sudden curtailment triggers the low charging power mode of the vehicle. To address this issue, NS Power deployed an alternative EV charging management system through project partner ev.energy, which communicates through the vehicles internet connection and controls charging power through the open API (application programming interface).	

CONCLUSION AND NEXT STEPS

The culmination of the Project, as reflected in this final report, has led to several key findings, the most prominent of which are that the management of DERs has been demonstrated to provide benefits in affordability, reliability, and environmental compliance. Highlights include:

- Electric Vehicle Charging – Demonstrated long-term affordability benefit, energy cost savings for participants, and short- and long-term greenhouse gas (GHG) benefits.
- Residential Batteries – Demonstrated high availability of back-up power to participants, fuel savings, and emissions reductions.
- Commercial & Industrial Batteries – Extrapolated fuel savings, emissions reductions, and power factor correction.
- Commercial & Industrial Smart Solar Inverters – Demonstrated power factor correction contributing to cost-effective renewable energy integration, contributions to reliability through advanced inverter functions supporting over-under voltage response and frequency response, and potential for reduction in emissions.
- Commercial & Industrial Building Management Systems – Demonstrated demand response contributing to affordability, fuel cost and emissions reductions through load shifting.
- Solar Garden – Demonstrated provision of clean energy at margin cost and carbon emissions reductions. There are no direct reliability benefits.

Nova Scotia Power is currently in the process of creating an Asset Disposition Plan to submit to the Nova Scotia Utility and Review Board (NSUARB).