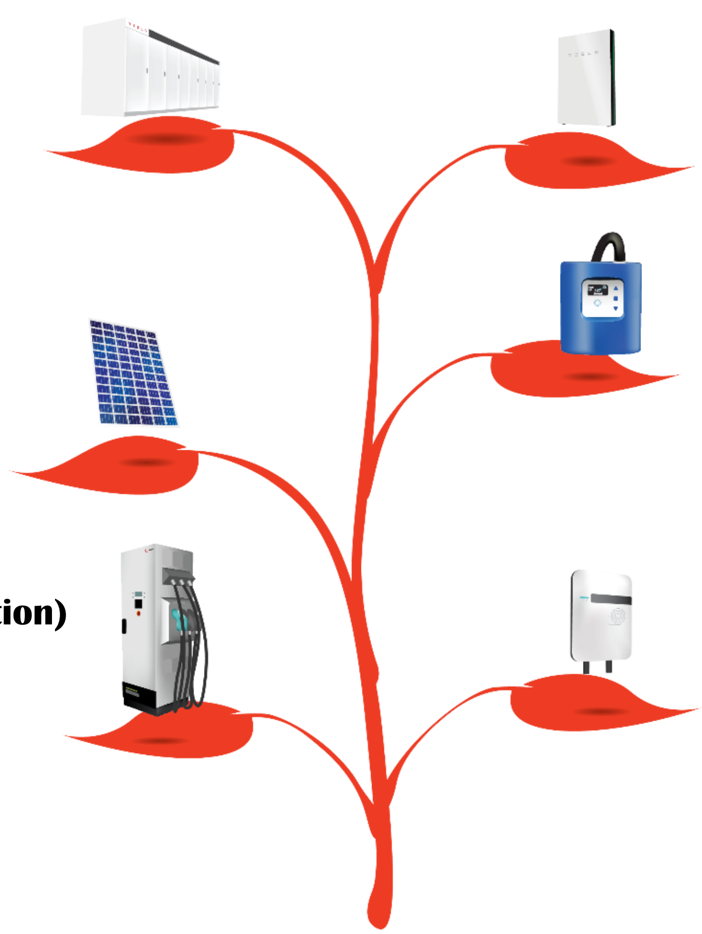
PROJECT SPEEDIER

FINAL PUBLIC REPORT



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(division of Bracebridge Generation)

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Introduction

Project Overview

The objective of Project SPEEDIER is to create a Smart, Proactive, Enabled, Energy Distribution - Intelligently, Efficiently and Responsive grid that builds towards a net zero smart community in the Town of Parry Sound, Ontario.

Project SPEEDIER addresses the issue of reducing load on a constrained transmission system. It is a hybrid demonstration/deployment project, deploying commercially available products while demonstrating technologies still under development. The project focussed on building a seamlessly islanded microgrid that incorporates renewable energy and storage addressing the municipality's net-zero goals. SPEEDIER accomplishes this through integrating diverse Distributed Energy Resources (DERs) using a GridOS® DERMS (DER Management System) and GridOS® MEMS (Microgrid Energy Management System) to balance energy consumption and electricity generation from renewable sources.

Partners and stakeholders

Lakeland Holding Group: Lakeland Solutions (a division of Bracebridge Generation Ltd.), Lakeland Power Distribution Ltd., Lakeland Networks

Bracebridge Generation is the lead organization for Project SPEEDIER. The company maintains 9 hydro-electric plants in Ontario and Quebec, producing 15 MW. Bracebridge Generation began as the first municipality in Canada to generate electricity utilizing water, dating back to 1894.

Lakeland Power Distribution Ltd. (LPDL) distributes electricity to over 14,000 customers in Bracebridge, Burk's Falls, Huntsville, Magnetawan, Parry Sound and Sundridge. Project SPEEDIER is built within the Lakeland Power service area.

Lakeland Networks is a provider of internet services, connecting the SPEEDIER microgrid equipment through their fibre network.

Opus One Solutions Energy ULC:

Opus One Solutions Energy ULC (Opus One) is a software and solutions company with the vision of a digitalized, decentralized and decarbonized planet. Its intelligent energy network analysis platform, GridOS®, optimizes complex power flows to deliver operational time-frame energy management and integrated planning to distribution utilities and other managers of distributed energy resources. GridOS® is modular, scalable and integrates seamlessly with existing data systems to unlock greater potential for distributed energy resources, including renewable generation, energy storage, and responsive demand.

GridOS® DERMS provides the controls and algorithms necessary to achieve the objectives of this project. Opus One as a key project partner supports the project from the design and architecture phase to implementation, testing, commissioning and operationalization. GridOS® DERMS integrates with the various data sources available to provide visibility and control instruction to the various DER to achieve the optimal control strategies – peak demand management, ensuring net zero energy management, voltage support, and microgrid islanding coordination.

Town of Parry Sound:

Working with Lakeland Power to reach the goal of becoming a net-zero community, Parry Sound has supported Project SPEEDIER in many ways. The town contributed unusable land at a closed landfill site for the 500 kW solar PV installation, and this determined the location of the microgrid. Mayor Jamie McGarvey is a project champion, taking part in the residential asset demonstrations.

Ownership structures

The SPEEDIER assets are owned by Bracebridge Generation. Grid infrastructure that is installed on the Lakeland Power Distribution Ltd (LPDL) system will be maintained by LPDL.

Project timeline

Project Kickoff	March 2019
Phase 1 – Project Planning and Design	Through March 2020
Phase 2 – Procurement	Through June 2020
Phase 3 – Infrastructure Development	July 2020 through May 2021 *Impacted by COVID restrictions.
Phase 4 – Testing and Commissioning	July 2020 through Mar 2022 *Impacted by COVID restrictions.
Phase 5 – Project Closure.	Mar 2022. Reporting and Knowledge Dissemination ongoing.

Table 1: SPEEDIER Project Timelines

In Dec 2020, a secondary project was developed to utilize the SPEEDIER Assets. Project DEMOCRASI (Dispatchable Energy Market Optimized Constrained Real-Time Aggregated System Interface) was designed to provide a solution to the problem of increased numbers of DER assets that are not visible to the LDC, and whose deployment could cause grid instability. The solution uses the LDC network model to optimally dispatch assets, balancing bulk and local needs. It unlocks revenue opportunities by providing a way for asset owners to participate in the energy markets. More information is available at www.democrasi.ca

Location: Parry Sound, Ontario.

Located on Hwy 400 approximately 2 hours north of Toronto and 2 hours south of Sudbury, the Town of Parry Sound hugs the shores of the world's largest freshwater archipelago, known as the 30,000 Islands. In 2004, UNESCO designated the area as a World Biosphere Reserve, the Georgian Bay Biosphere Reserve.

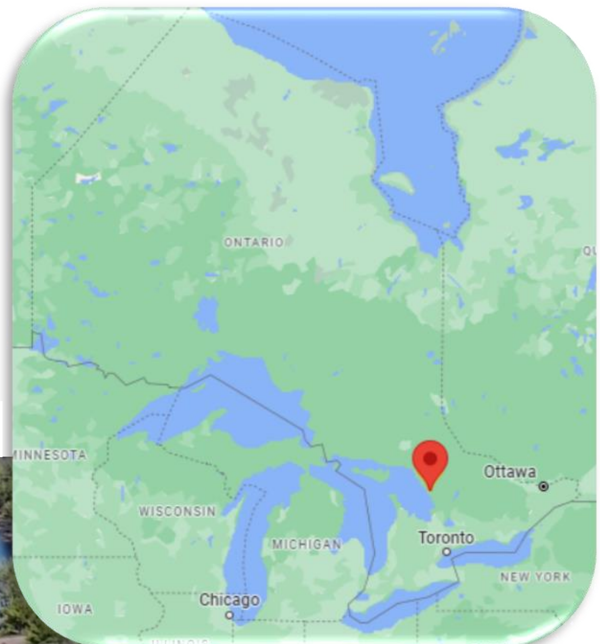


Figure 1: Map showing Town of Parry Sound, Ontario

Figure 2: The main SPEEDIER Site, with Solar PV array built on a closed landfill.

Project Objectives

The objective of this project is to create a Smart, Proactive, Enabled, Energy Distribution - Intelligently, Efficiently and Responsive (SPEEDIER) grid that builds towards a net zero smart community in the Town of Parry Sound. This is a unique opportunity where a rural municipality of 6,000 residents is pledging to be net zero in partnership with the local utility. This project is an opportunity to further leverage existing initiatives and integrate more resources and intelligence into the SPEEDIER grid via Distributed Energy Resource Management System (DERMS). The goals are:

1. Increase solar and energy storage penetration in the Town
2. Reduce loading on locally constrained transmission station identified in the Long-Term Energy Plan
3. EV adoption reducing GHG
4. Develop virtual net metering utilizing solar
5. Develop greater automation and integration within the utility environment
6. Developing smart residential demand management via controllable hot water tanks (HWT), EV chargers and battery storage

Overview of project benefits

Benefits to stakeholders include relieving the capacity constraints on the local transmission station (TS) and proving that scaling the project would have a more tangible effect. This enables the local economy to continue to grow and develop, bringing local jobs to northern Ontario.
Benefits to all Canadians include a cleaner environment, as DERs generally produce less GHG emissions than the standard grid infrastructure at peak times. This project also enables Distributed Generation (DG), creating an environment where DG assets can participate, supporting electrification of the grid. SPEEDIER demonstrates the ability to integrate modern technology into a smarter, SPEEDIER grid.

• **Energy Storage**: This project installed a 2.5 MWh Grid Scale Battery to explore the stacked benefits of energy storage in relation to microgrid island creation, peak shaving and demand management, voltage support and reducing constraints to enable greater renewable interconnections – all controlled by **DERMS.**

• **Grid monitoring and Automation**: The demonstration uses a model-based DERMS system that connects to the digital protection relays at the substation and reclosers downstream of the feeders to create a state-estimated real-time view of the MS3-F1 feeder. This changed from the original proposal to model 5 feeders in Parry Sound because the development of the microgrid area was limited to just the one feeder based on battery size and load.

• **Microgrid:** The project improves reliability and resiliency using a feeder level microgrid configuration at MacFarlane on the MS3-F1 while reducing GHG emissions by using solar and BESS. The microgrid will island seamlessly and blackstart such that it can respond to a variety of outage scenarios, proven on three separate occasions.

Scope adjustment due to Seamless Islanding: The original Scope was to Island in a “Break then Make” method. This would allow the Local Distribution Network to shut down completely and then re-energize from the Battery Energy Storage System (BESS) supply. As the project evolved, the project team explored the possibility of islanding these sections “seamlessly”. This offers advantages over the original design as the customers in the microgrid area will not see any power interruption with a seamless transition from the grid to the BESS. This improves the reliability of the distribution network, improves Ontario Energy Board mandated SAIDI and SAIFI Indexes, and improves the customer experience. Another advantage of the seamless design is the reduced in-rush currents on the BESS. This provides the option of supporting additional loads and expanding the microgrid area. Finally, with a seamless option there is less chance of failure of the BESS as it comes online to support the microgrid, as it will already be in sync with the grid voltage and frequency.

• **Data management and communication**: The key to visibility, control and optimization is the data structure and integration. This project integrates all the critical data sources from SCADA to Metering repository to Operation database to Geographic Information System (GIS) to Distribution feeder model and provide the **DERMS** system with real time visibility, forecast capabilities and the ability to make data-driven control decisions. The integration process ensures the proper firewall rules and network configuration are established in order to maintain customer privacy and overall network security.

• **Demand Management:** This project uses **DERMS** to conduct load control for the customers with hot water tanks at 50 sites as a pilot to automatically respond to the changing load capacity of the feeder. During the project development, it was determined that the curtailment controls of the EV Chargers could also provide Demand Management services, and they were added to the system design.

• **EV Integration**: This project promotes the adoption of EVs in the Parry Sound community as it moves towards the net zero objective by providing charging stations at 3 locations. The project investigated implementing curtailment control capabilities on the EV infrastructures that is based on the system analysis conducted by **DERMS.**

Project Design

Key design criteria and operational features

The objective of the SPEEDIER project is to modernize the Town of Parry Sound's grid and facilitate the shift towards a net-zero smart community. This objective is achieved by integrating Distributed Energy Resources (DERs) into the grid and providing the utility control over the DERs and visibility to the entire grid. The design architecture of this project included installing new DERs and using software solutions and Internet of Things (IoT) technology to integrate, communicate and control the DERs.

The DERs that were installed as part of this project are:

- Tesla Megapack: A 1250kW/2500kWh grid-scale battery energy storage system (GBESS)
- A grid-scale solar photovoltaic (PV) system rated at 500 kW AC
- A fleet of 10 residential batteries (RBESS), 50KW/130KWh total
- 3 x level-2 (7.7 kW) Electric Vehicle (EV) chargers and 1 x level-3 (50 kW) EV charger
- 50 hot water tank controllers (HWTC) providing 180 kW to perform demand response.

Figure 3: Solar PV Array and Tesla GBESS

Figure 4: HWTC, EV Chargers and Tesla RESS

The GridOS® DERMS (DER Management System) and MEMS (Microgrid Energy Management System) software solutions communicate to the DERs through direct connections or IoT and gather telemetered data from the microgrid and protection devices.

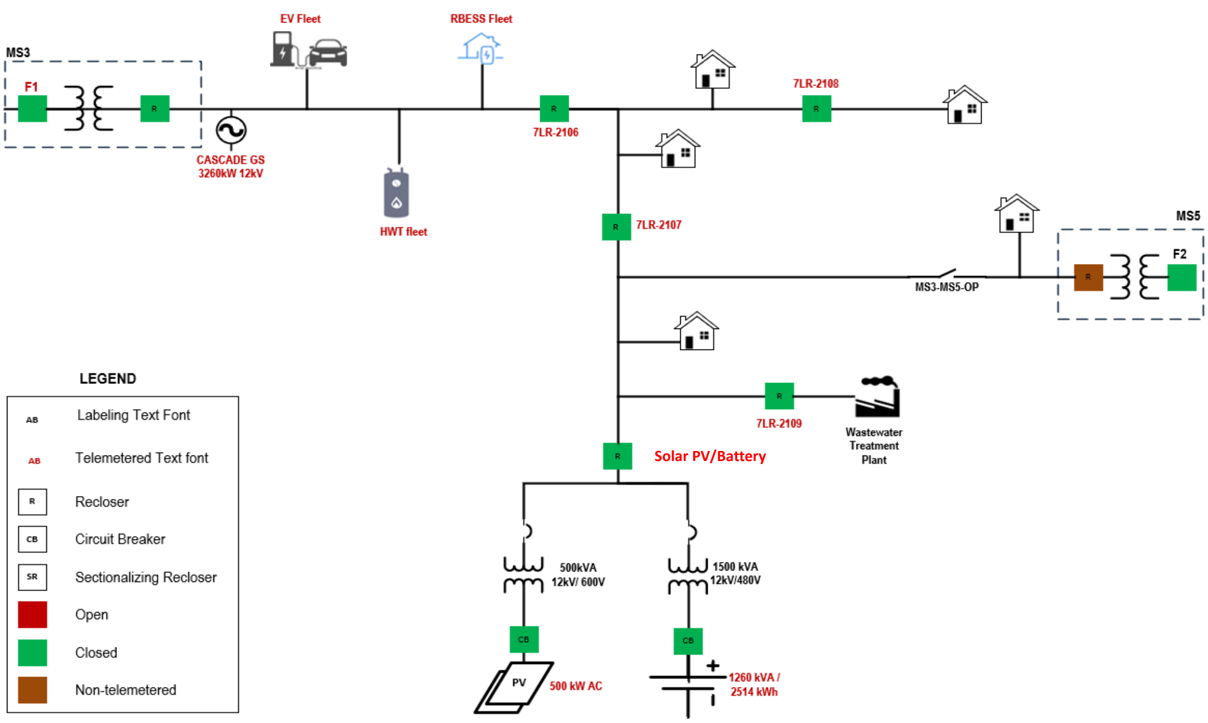


Figure 5: Project SPEEDIER High-level Single Line Diagram (SLD)

Lakeland Solutions (Bracebridge Generation) and Opus One worked together to ensure that the new deployment does not alter the existing IT or OT network configurations. Thus, the GridOS® DERMS and GridOS® MEMS solutions are deployed within existing network configuration utilizing existing communication channels, and behind existing firewalls.

The existing internet connection with IPSEC VPN tunnel, Private VLAN /TLS service over fiber, LAN Connection and the Private 4G cellular network is used to configure the components below:

1. **IoT** - IoT devices are DER utilized for DERMS grid services control strategy. Communication to and from these DER are facilitated by a third-party fleet management aggregator, through internet connection with IPSEC VPN tunnels.
2. **Field devices** - Field devices are microgrid DER that make up the MacFarlane microgrid, their metering equipment, reclosers, and relays. Communication to and from field assets are performed through a private cellular APN.
3. **SCADA** – Lakeland Power SCADA communicates to all the field devices on the MS3-F1 feeder (including the MacFarlane section) through DNP3 protocol. GridOS® accesses the SCADA information through VLAN (behind the firewall), protected by a Cisco ASA firewall.

Figure 6 presents the network architecture diagram and identifies communication channels and the network layout.

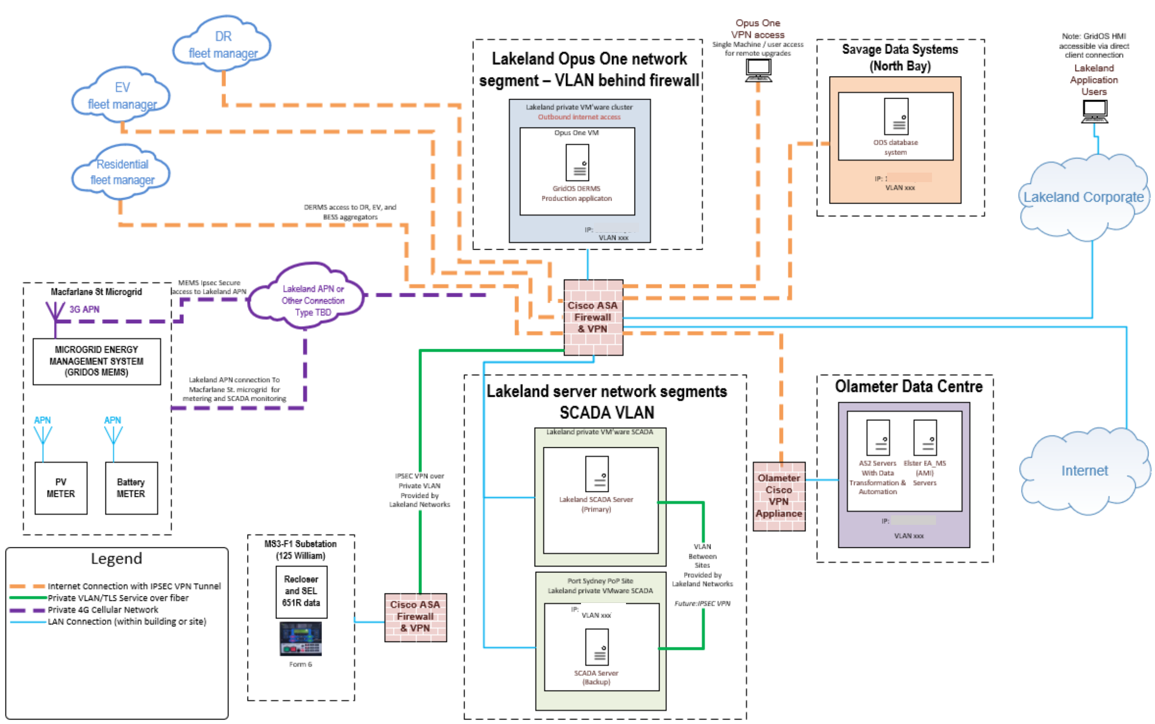


Figure 6: Project SPEEDIER Network Architecture diagram

The network architecture for SPEEDIER Project is designed to facilitate data flows between GridOS® DERMS, GridOS® MEMS, field devices and SCADA.

GridOS® DERMS integrates with:

- **Grid Service DER** that includes Residential BESS fleet and EV charger fleet
- **RTAC,** the Real Time Automation Controller which serves as a protocol translator and data collector from the SCADA on the feeder.
- **GridOS® MEMS** to maintain visibility of microgrid status and DERs

GridOS® MEMS integrates with:

- **GridOS® DERMS** to provide visibility of microgrid permissive
- **Microgrid DER** that includes Grid-scale BESS and Grid-scale solar PV
- **Microgrid Switchgear** to maintain visibility of microgrid status

Figure 7 illustrates the data that is relayed through these integrations.

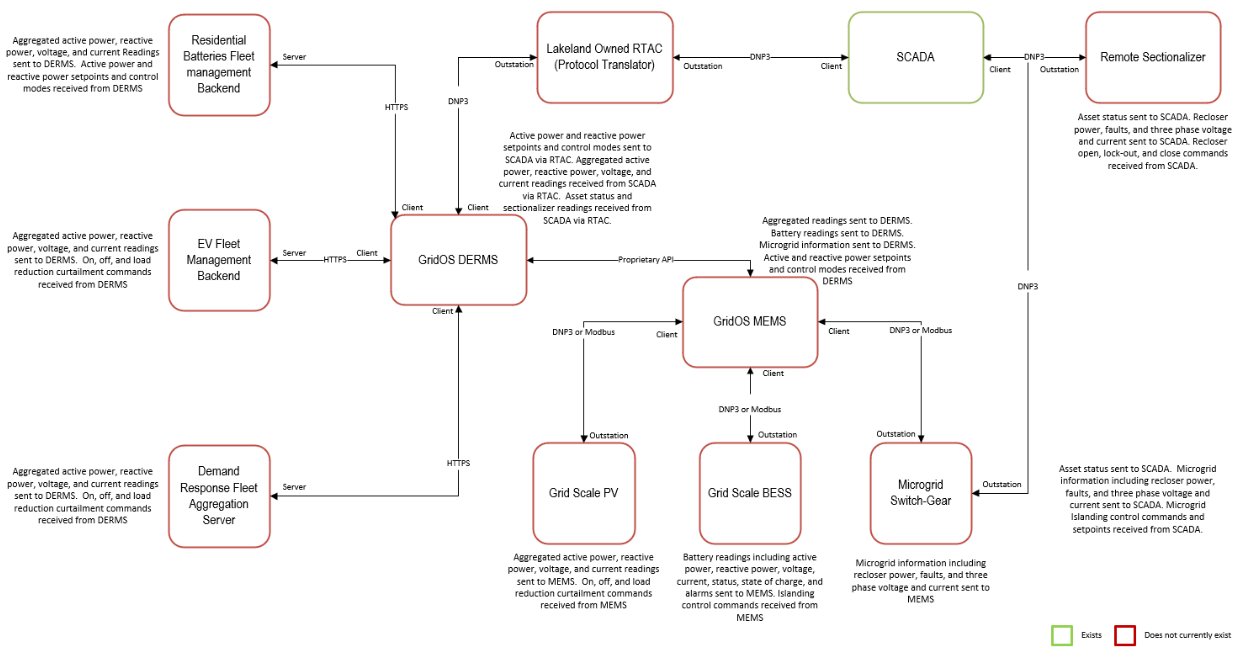


Figure 7: Project SPEEDIER Data Flow Diagram

Technologies Used

The technology developed through this project is a solution suite of multiple technology stacks. This is a novel project that supports Internet-Of-Things based DER integration with an LDC control center.

GridOS® software solution enables the utility to monitor the grid and control the DERs and other field devices on a single platform. GridOS® is a multi-tiered platform that provides layered functionality. The GridOS® solution implemented for the SPEEDIER project comprises two components:

1. GridOS® Microgrid Energy Management System (MEMS)
2. GridOS® Distributed Energy Management System (DERMS)

GridOS® DERMS and MEMS are used to identify the physical operating parameters via real time telemetry pages and manage the participation of DERs for both grid services and microgrid services.

GridOS® MEMS

GridOS® MEMS provides local energy management using fast closed-loop control of DERs on the microgrid, receiving and applying supervisory commands from GridOS® DERMS. GridOS® MEMS also collects and aggregates telemetry, relaying it back to GridOS® DERMS.

GridOS® MEMS takes part in islanding coordination, providing resiliency for the feeder, and providing headless local energy management. GridOS® MEMS manages the MacFarlane microgrid extending up to the MS3-F1 feeder. It controls the DERs and coordinates with local and remote switchgear for control and protection. GridOS® MEMS controls the GBESS and the grid-scale Solar PV for creating an island. Other DERs (RBESS fleet, EV fleet and HWTC fleet) do not participate in the GridOS® MEMS scenarios.

The boundaries of the microgrid are shown in Figure 8. Microgrids are generally in one of two states in relation to the grid:

1. Grid-connected mode
2. Islanded mode

Grid Connected Mode

In grid-connected mode, GridOS® MEMS primarily ensures the electrical operation of the microgrid. It enables the microgrid and DER by providing a heartbeat for the GBESS. GridOS® MEMS monitors for abnormalities and reports abnormalities through alarms. It also passes on the remote-control signals from GridOS® DERMS.

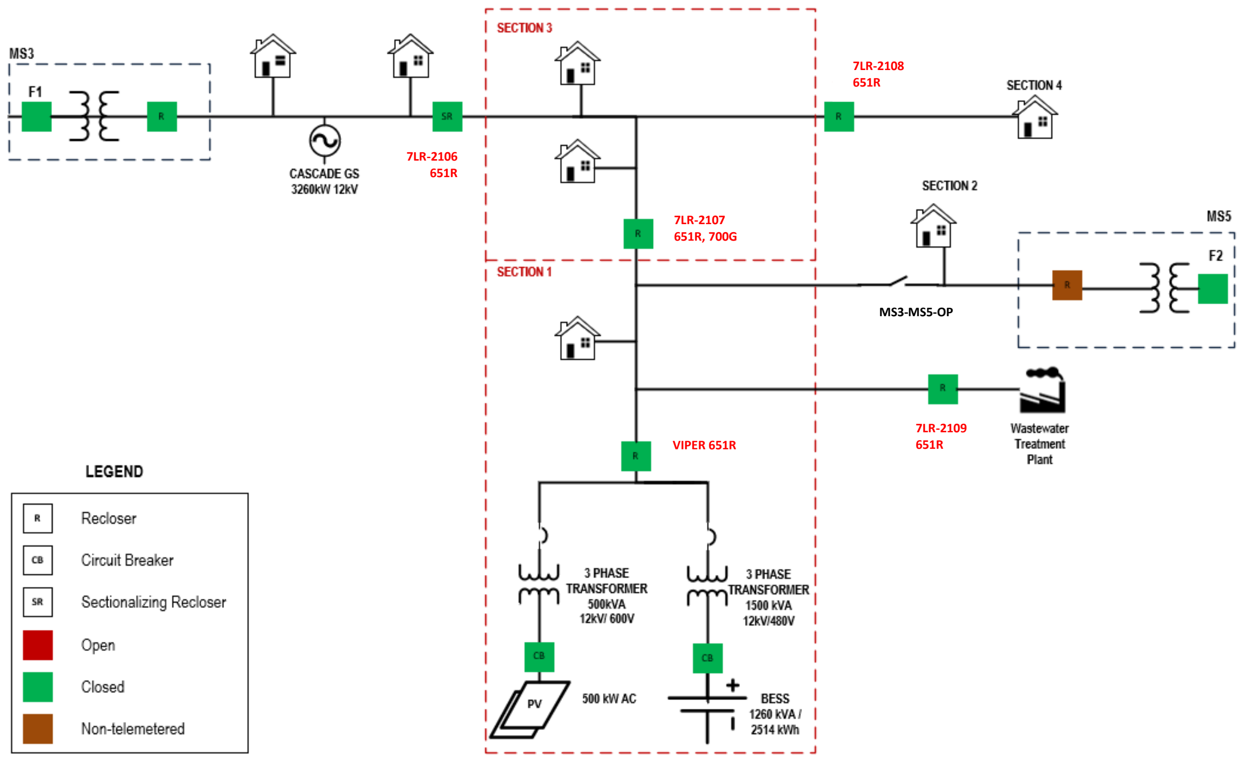


Figure 8: Project SPEEDIER Grid Connected Single Line Diagram

Microgrid Islanding Control Strategy

Feeder-level reliability and resiliency are key project goals. GridOS® MEMS achieves this by implementing a microgrid system capable of isolating itself and sustaining itself with a grid-forming generator. This system acts as the first layer of defence during an outage scenario. MEMS is able to island and pickup loads in section 1 or Section 1+3 depending on the loading expected during the island event and the available capacity of the DERs. Figures 9 and 10 below show the single line diagram (SLD) for the system when in islanding mode.

Islanding can be established intentionally by an operator or unintentionally in the case of a grid fault or outage.

When the microgrid is in the islanded mode, GridOS® MEMS will be the master controller managing all the controllable resources within the microgrid. This includes solar curtailment (reducing PV production by sending signals to smart inverters) in cases where GBESS batteries are sufficiently charged, and solar PV generation capacity is high.

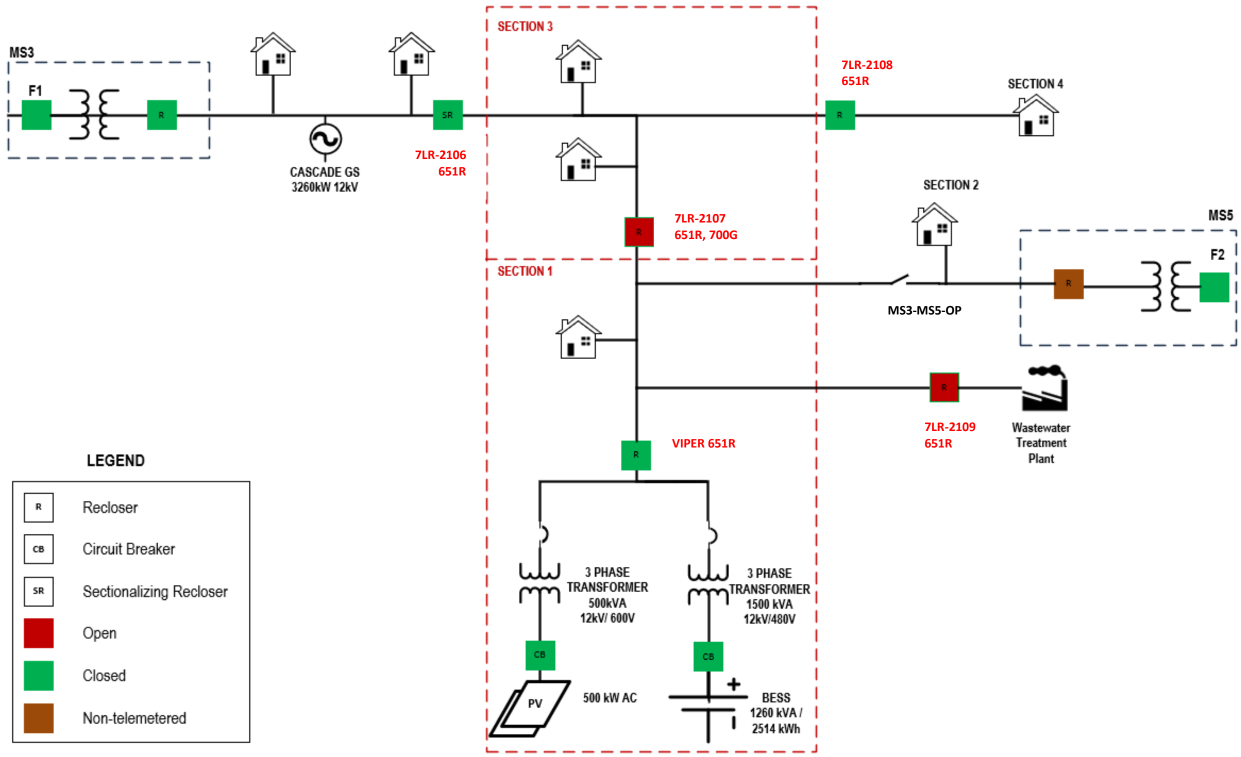


Figure 9: Project SPEEDIER Single Line Diagram for Section 1 islanded.

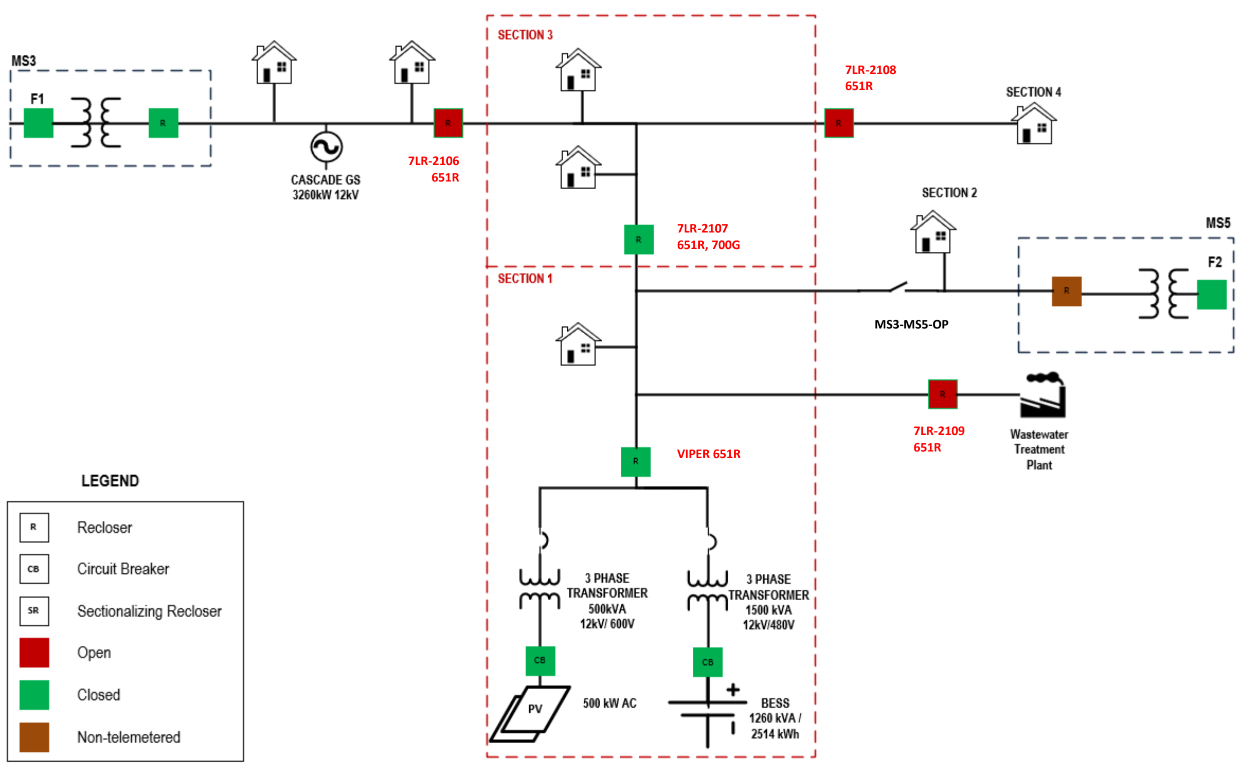


Figure 10: Project SPEEDIER Single Line Diagram for Section 1 and 3 islanded

GridOS® DERMS

While GridOS® MEMS is to provide local microgrid services and is installed locally at MacFarlane Microgrid site, GridOS® DERMS will also view and control the distributed DERs to achieve high-level objectives such as Peak Shaving and Power Factor Support.

GridOS® DERMS provides supervisory control of the GridOS® software solution to the utility operator. The role is that of a high-level system coordinating overall system strategy and sending low level commands to GridOS® MEMS as well as high level commands to devices accessible through IoT fleet management services.

GridOS® DERMS receives and stores telemetry from IoT devices and devices aggregated through GridOS® MEMS. It exposes a web-accessible front-end that is protected through RBAC (Role Based Access Control) attached to utility identity services, such as Active Directory. GridOS® DERMS improves network conditions by allowing the operator to select control strategies for DER (Via GridOS® DERMS interactive User Interface), then view network performance at a glance with graphs showing factual and counter-factual information based on the selected control strategies.

GridOS® DERMS User Interface allows the operator to select one of the 3 Modes of Operation for the system (Manual, Recommended or Automatic), and one of the control strategies defined (in the SPEEDIER project, these are Peak Shaving, Power Factor Correction or Standby). Each controllable asset in the field can be set to a different control strategy so the user can achieve the maximum benefits from each asset. Details about GridOS® DERMS modes and strategies are presented in Grid OS Section under

Verification and validation processes that were used

Asset	Validation (Built the Right System)	Verification (Built the System Right)
Solar	Solar system is producing clean low carbon energy that could offset the load at the Waste Water Treatment Plan (WWTP) as well as support the microgrid.	The solar system is on track to produce enough energy annually to cover 50% of the WWTP load. To date, no microgrid event during a sunny day means the solar contribution to a microgrid event has not been verified yet.
GBESS	GBESS is sized appropriately to power the microgrid. It also has the capabilities for Peak Load shifting and Power Factor correction on the MS3 F1 Feeder.	GBESS supported three small microgrid events to date. It has successfully contributed to Peak Load reductions and Power Factor correction on the feeder.
RBESS	RBESS is sized appropriately to power individual residential participants' load. It also has the capabilities for Peak Load shifting and Power Factor correction on the MS3 F1 Feeder.	RBESS supported three small microgrid events to date, providing power to the home. It has successfully contributed to Peak Load reductions and Power Factor correction on the feeder.
EV	Four chargers are providing free charging to EV vehicle operators to encourage the move from ICE to EV.	The chargers are being used regularly and word is spreading. Charger usage is increasing month over month.
HWTC	HWTC provided demand response capabilities which reduced the peak load on the feeder.	HWTC were able to reduce peak on the feeder with a HWTC demand response event through June/July/August 2021
MEMS/ Microgrid	The microgrid and MEMS are designed appropriately to power two sections of the feeder for emergency backup power.	Testing proved that the microgrid can island one or both sections and power up part of the grid from the GBESS. The microgrid islanded automatically during three microgrid events to date.
DERMS	The DERMS provides control over all assets for a variety of uses.	The DERMS has been successfully used for Peak Load shifting and Power Factor Correction on the feeder.

Table 2: Verification and Validation

See Appendix A: SPEEDIER DERMS Peak Shaving Performance which shows that the microgrid performs Peak shaving according to the control strategy.

Metrics	
GHG Emission Reductions and other Environmental Benefits	**Process indicator(s):** 175kw reduction in peak demand from HWT control; 21kw reduction in peak demand by controlling EV chargers, 500kw addition to system from solar. **Impact indicator(s)**: Reduced GHG by adding local Distributed Generation (DG) to reduce the requirement for gas peaking plants. **Verification process:** GHG Information System takes DER data and applies emission factors and calculations as outlined in the GHG Reporting.
Economic and Social Benefits	**Process indicator(s):** Improved Economic Development opportunities through transmission station capacity constraint relief from load reduction. Jobs to implement the project, training, utilizing local college program, development of new business model for other LDCs, customer engagement/education on funding opportunities. **Impact indicator(s):** Savings on energy for consumers (HWT reduce partial peak rates, Powerwalls charge off peak and deploy at peak). Green community through GHG reductions. **Verification process**: engagement with the project by public, industry and education; participant feedback;
Improved Asset Utilization and Increased Efficiency	**Process indicator(s):** Proper modeling of the feeders with load reduction and increased DG and efficiency of the system will mitigate overbuilding of the infrastructure. **Impact indicator(s):** Reduced/deferring system upgrades. **Verification process:** number of events where DERs are deployed; impact of deployment.
Increased Reliability and Resiliency	**Process indicator(s):** Improved modeling of the system to handle the DGs while making sure fusing/relaying and improved data acquisition. Demonstration of microgrid area. **Impact indicator(s):** Customers experience less outages. **Verification process:** SCADI and SAIFI numbers.
Increased System Flexibility and Renewable Energy Penetration	**Process indicator(s):** Modeling the system and installing the relays and monitoring to enable more DG and DER to penetrate the system, will allow the system to be more flexible. **Impact indicator(s):** Feeder models in software available to Operators. **Verification process:** increase of DERs installed.
Cyber Security	**Process indicator(s):** Lakeland Networks Cyber Security Team evaluates the addition of interconnected modules. Opus One is completing their ISO 27001. Testing will occur at each integration phase. **Verification process:** Lakeland Internal Cybersecurity processes.

Table 3: Project SPEEDIER Metrics

Project Financials

Salaries and Benefits	$	388,030
Travel and Accommodation	$	23,523
Professional / Technical Services	$	652,479
Software Contract Services	$	1,000,000
Grid Scale Battery Storage	$	1,759,282
Solar PV Array	$	1,654,505
Residential Batteries	$	191,278
EV Chargers	$	101,629
Hot Water Tank Controllers	$	15,360
Microgrid Equipment (incl. Fibre)	$	846,487
Overhead	$	116,138
Other Expenses	$	1,479
Sub-total	**$**	**6,750,190**
In-kind Support	$	1,530,622
Total	**$**	**8,280,812**
Federal funding	-$	3,757,049
Other funding	-$	86,000

Table 4: Cost Table from Project SPEEDIER.

The project received a total contribution of $3,757,049 from Natural Resource Canada's Smart Grid Program ($1,669,800 from the Demonstration stream, and $2,087,249 from the Deployment stream).

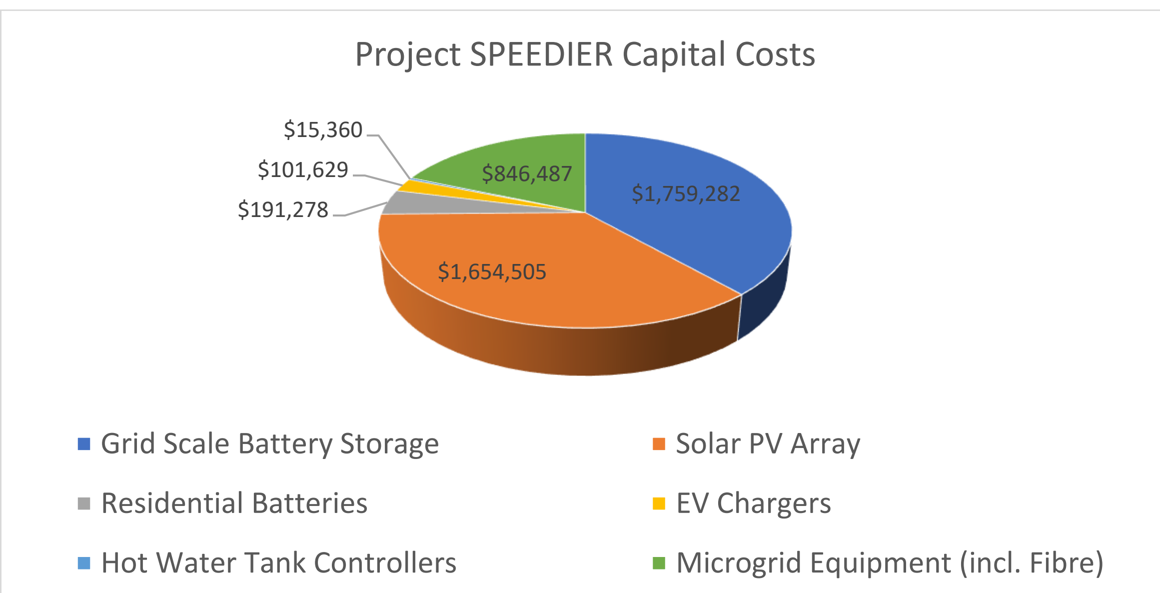


Figure 11: Project SPEEDIER Capital Costs

Descriptions of results to date and anticipated outcomes

Project Task 1: Project Planning and Design

The initial stage of the project was to perform analysis of the loading data on the Parry Sound MS3-F1 feeder. This feeder was chosen because the Town of Parry Sound had land available on this feeder for the solar installation, a decommissioned landfill that was otherwise unusable. This land was adjacent to other town facilities whose load could be offset by the solar generation, once net metering policies allowed.

The battery analysis looked at factors like lead time, maturity of the technology, available support, and price. Tesla had two options, the Powerpack and the Megapack. The Megapack was a better fit, and the price was within the project budget.

The load analysis combined with the capacity of the battery storage system provided the parameters for the project physical scope, and the microgrid architecture design was completed with the incorporation of seamless islanding technology. This improves the reliability of the distribution network, improves Lakeland Power's Ontario Energy Board mandated SAIDI and SAIFI Index, and improves customers' experience.

The local utility, Lakeland Power Distribution, was consulted for grid connection and Lakeland Networks for Fibre network communications. The utility had to complete a Connection Impact Analysis (CIA) with Hydro One, which proved more expensive than expected, and could be considered cost prohibitive for innovation projects. Eaton Industries was awarded the contract for professional engineers responsible for protections. These two partners started the CIA with Hydro One as the connection approval is a primary task in the project.

Environmental Regulations were met through Ministry of the Environment review of the site and included a species at risk analysis which resulted in the installation of bat boxes. The project required a reformatted layout for the solar installation due to the discovery of a stick nest of a broad-winged hawk.

The general concept of the operation and maintenance plan was developed, and the details deferred to a later point in the project, when the system installer could use the completed installation as a reference.

Project Task 2: Procurement

The DER assets were sourced in parallel with the microgrid design, with significant research into the available options for each category. Decisions were based on ability of the potential solution to integrate into the project, cost, maturity of the technology and reputation. All vendors went through a screening based on Lakeland Holding's Cybersecurity Policies.

The microgrid equipment was procured once the microgrid design was finalized. The impacts of COVID-19 on the lead time of some of these elements caused adjustments to the original timelines.

The complete drawing packages were part of the contract with the Eaton Industries, the engineering company who was responsible for the protections and controls.

Project Task 3: Infrastructure Development

With more COVID-19 delays to the project timelines, as there were many residential and public facing assets, the installations and commissioning plans were completed either by the asset vendors or third-party contractors.

The utility-scale battery was delivered according to the schedule set prior to COVID-19 and had to be stored at a secure location until the pandemic restrictions allowed for installation. This included summer months, and as excessive heat will degrade the battery, environmental controls in the form of reflective tarps had to be researched, procured and installed. The battery was transported to its final location in the late fall, and once installed, provided its own temperature regulation.

The solar installation was similarly delayed due to COVID restrictions. The installation team resumed planning as soon as the weather allowed outdoor, distanced meetings. The environmental approvals had been completed the previous year, and construction began immediately.

Changes to design were required, based on civil engineering and the topography of the site. Bedrock under parts of the substation meant concrete pads had to be altered.

During deployment and installation of the microgrid equipment, schedules had to be agreed on with Lakeland Power Distribution, who installed the switches and reclosers on their network, as other operational priorities and customer impacts had to be considered. Delays to supply chain, equipment repairs and COVID labour impacts resulted in ongoing updates to timelines.

The Greenhouse Gas Emission Reduction reporting was developed through a partnership with Georgian College. Scott McCrindle, as part of his thesis, created a baseline for GHG Project reporting.

Project Task 4: Testing and Commissioning

ESA inspections were completed per asset, rather than all at once. The battery storage system and solar installation were the first DERs to be commissioned.

The commissioning of the smaller residential DERS was completed at or soon after installation.

EV chargers were commissioned separately as they were installed. The Level2 chargers required testing of the communications to the provider. The vendor was on site for the L3 DCFC commissioning.

The Factory Acceptance Testing for the Lazer Viper was performed virtually, as COVID restricted travel to Chicago. The initial stage of commissioning of the microgrid was bench testing with Opus One and Eaton. It was scheduled for 3 days in July of 2021 and had to be rescheduled due to a damaged 700G relay. The delayed test was pushed back to accommodate other projects.

During site commissioning for another piece of microgrid equipment, it didn't work at all and a new one had to be ordered. Unfortunately, the new one was damaged in transit, and commissioning had to wait for the third one to arrive.

The commissioning finally progressed to testing with the utility-scale battery, the solar PV and new microgrid equipment, proving control during microgrid event, solar curtailment and battery operations.

Project Task 5: Project Closure

Live monitoring and controlling were performed for both MEMS and DERMS software. User Acceptance testing and training were held before transferring software controls to the utility Operations department. Training of non-operations electricians was also held to ensure all necessary staff were educated. Emergency processes were written to ensure that operations staff had a reference during normal (and extraordinary) operations.

Over the course of the project, there have been numerous newsletters to participants, a white paper and a research paper, several press releases, one magazine article including the project, and a mention in a local radio program. A university researcher has reached out to get input into his paper on customer experience. The Board of Directors and Municipal Shareholders have been educated throughout the project and are interested in the opportunities to scale this project in other communities.

The speedier.ca website has been live since early in the project and is updated with new information regularly. The project has been presented several times, including the NRCan Smartgrid Symposium as well as at EDIST 2022, where NRCan presented alongside the project team, providing insight into the Smart Grid program. Industry is aware of and interested in the project.

Performance Measures

1. Number of Highly Qualified Persons (HQP) trained during the course of the Project.

Targeting 5 HQP trained.

Goal met with more than 12 HQP trained, both during the project and for operation of the MEMS and DERMS software.

This project encompassed everything from introducing brand new ideas to next-level training for professionals with extensive knowledge. It introduced hands-on use of new innovative technologies to individuals who might not otherwise have had the opportunity to see it in action. It also helped to create a team with a new skill set in designing and implementing microgrids – something not found in the local economy, which will add value to northern communities.

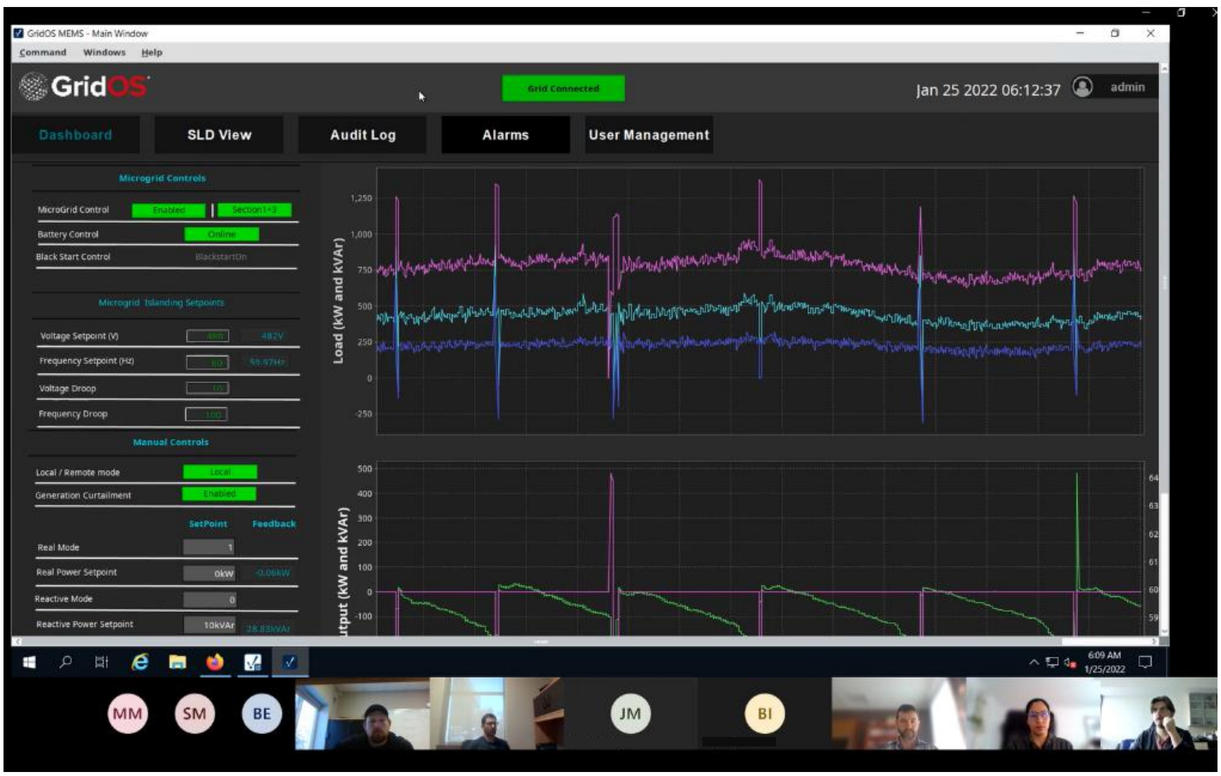


Figure 12: Image from recording of MEMS Training

2. Revised GHG emission reduction estimation and reporting based on methodology to be outlined by NRCan.
Target date: Initial revision due Q1 2019-2020 with details provided in the Annual Report, final revision due Q1 2021-2022

GHG Reporting was done in partnership with Georgian College, Research and Innovation Department.

Greenhouse Gas Protocol for Project Accounting is the primary framework used to build out the Greenhouse Gas (GHG) Information System (GHGIS) to account for and report on the GHG emission reductions made possible by the SPEEDIER project. Guidelines for Grid-Connected Electricity Projects provided additional guidance when building out the GHGIS.

Following these guidelines, the process began with creating a baseline to show the emissions that would have been generated in order to provide services equivalent to those proposed by the project assets.

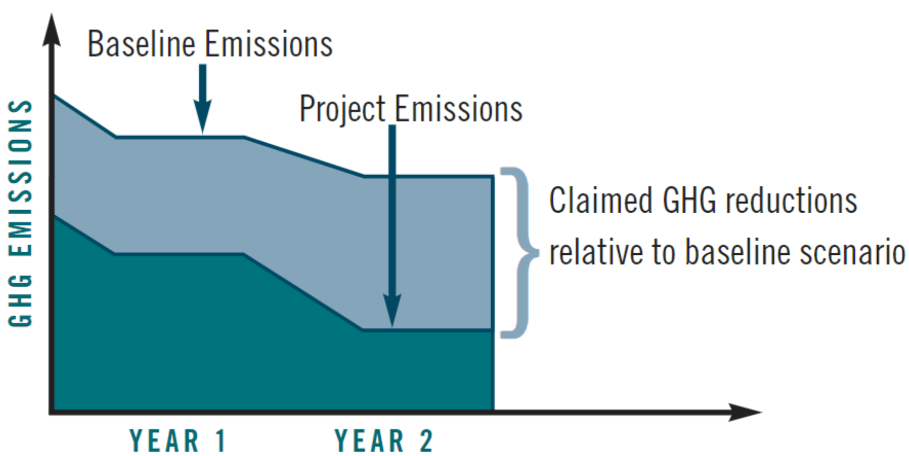


Figure 13: Comparison against a baseline scenario for project accounting (GHG Protocol, 2005, p. 13).

In the absence of Project SPEEDIER, equivalent capacity would have been required, affecting utilization of the existing capacity – referred to as the Operating Margin (OM). Decisions regarding the deployment of new capacity are known as the Build Margin (BM). Each project asset (or activity) was evaluated to assign its baseline a weight against the BM, and a reciprocal OM weight.

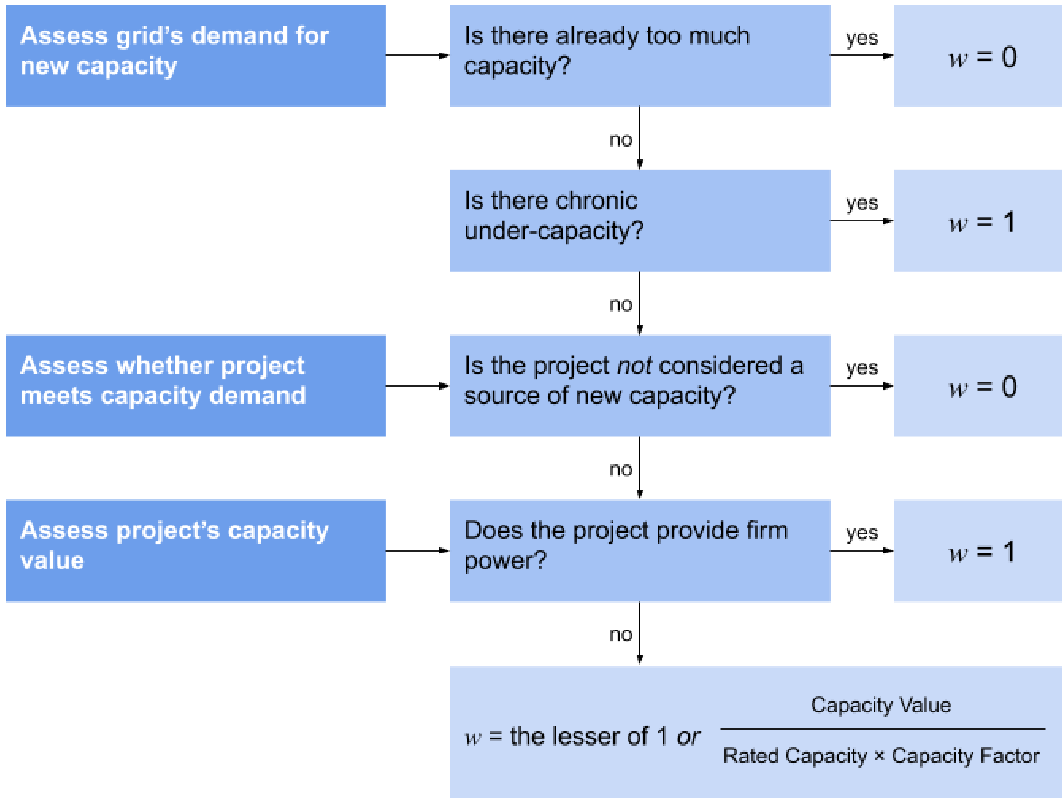


Figure 14: Chart detailing the process for determining an appropriate weight to the BM, adapted from "Guidelines for Grid-Connected Electricity Projects," GHG Protocol, 2007,

Using the protocol, it was determined that using representative baseline candidates would provide a typical rate of emissions to represent what would have been generated in the absence of the project. These were narrowed down to generation facilities in similar locations, providing outputs to offset similar system constraints. In all cases during the accounting process, best efforts were applied, with justifications and explanations noted as a defensible baseline scenario was reached.

The end result was a series of formulas that could be applied to each asset's activities, resulting in GHG emission reductions representing the difference between the baseline GHG profile and the emissions generated by the operation of the asset itself as the alternative. The individual data is collected, run through formatting, applied to the formulas, and used to create outputs: tables, graphs and pictographs.

The final outcome is a projected annual savings of 261 tCO2/yr.

For GHG Reporting details, please reference **https://www.speedier.ca/ghg-the-process/** and **https://www.speedier.ca/ghg-reductions/**.
These web pages contain links to the protocols, the paper outlining the SPEEDIER accounting in detail, and the monthly reports.

GHG Reporting Conclusions:

- Qualifying and justifying the GHG baselines for project activities is time and resource intensive
- Obtaining appropriate data to quantify GHG baselines can be a significant challenge
- Assessment boundary must be very clear, or there is a risk of double-counting of GHG savings
- Determination of one-time/secondary GHG effects can be very difficult to assess
- Effective mitigation of GHG emissions will require verifiable and stringent measurement processes

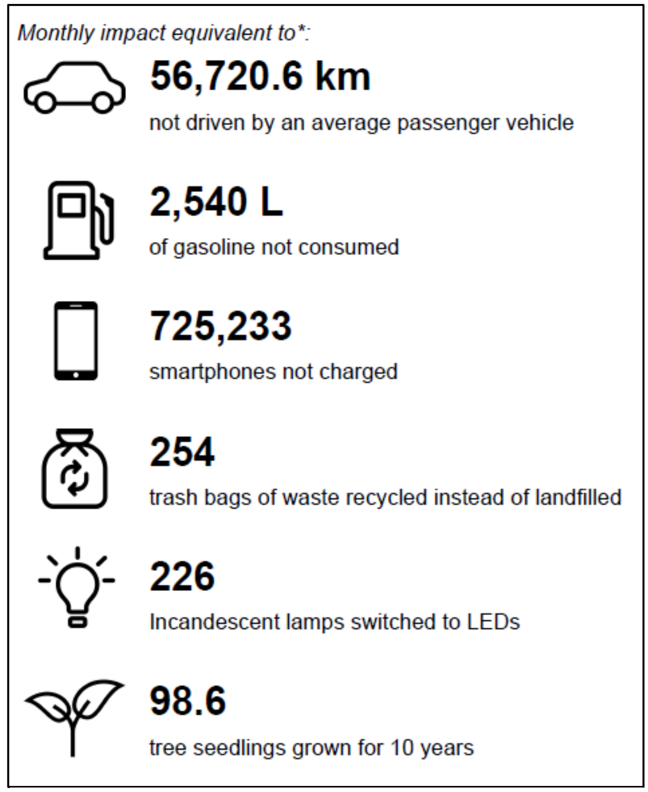


Figure 15: Sample GHG Monthly Reporting Equivalence

Project outputs regarding the GHG emission reductions are being incorporated into discussions by environmental groups. Most recently, the economic and environmental impacts of the project are of interest to a large financial institution, the authors of a net-zero paper.

3. Knowledge dissemination activities.

Targeting 5 knowledge dissemination activities which may include presentations at industry conferences/meetings, public reports, software source code made publicly available, documentation of algorithms and software design made publicly available, contribution to industry standards, and scientific publications. To be completed by the end of the Project outcome period with details provided in annual outcome reports.

Presentations on the project started very early and have proven very successful. Starting with local municipalities, meetings have been held with all levels of government to discuss project concept, outputs and future plans. Several municipalities are looking at replicating the MEMS solution.

Many LDCs, from mid-sized to the largest, have shown interest in the project, and Lakeland Holding has entered (or are reviewing) NDAs to establish future use cases and deployment opportunities. Other LDCs with microgrid projects have reached out to share successes and challenges.

The team is exploring opportunities with other vendors to both integrate and analyze data from this feeder. These conversations are also under NDA.

The following activities were included as they disseminate project accomplishments, not merely project plans, which several presentations during 2019 and 2020 covered.

Type	**Activity**	**Date**	**Presenters**
Broadcast	Hunters Bay Radio – Muskoka Drawdown Ep.10	Mar 18, 2021	N/A
Broadcast	CTV Earth Day Coverage	Apr 23, 2021	Lakeland, Georgian College
Presentation	OEB	Aug 11, 2021	Lakeland
Presentation	Georgian Bay Biosphere	Aug 26, 2021	Lakeland, Georgian College
Presentation	NRCan Smartgrid Symposium	Oct 22, 2021	Lakeland Management, Lakeland Technical, Opus One Technical
Panel	CANREA Panel	Nov 18, 2021	Lakeland Executive
Presentation	CHEC AGM	Nov 24, 2021	Lakeland Executive
Article	"Making Big Things Happen", The Distributor (Pub. By EDA)	Winter 2021-2022	N/A
Award	EDA Excellence in Innovation Award 2022	March 30, 2022	N/A
Published Paper	GHG Research Paper	May 1, 2022 (v2)	Authored by Scott McCrindle, Georgian College; input and review by Lakeland.
Panel Discussion	Power of Water Canada Conference, OWA	May 12, 2022	Moderator: Lakeland Director Panel: Lakeland Executive, Lakeland Technical, Georgian College, NRCan.
Presentation	EDIST 2022, EDA	June 2, 2022	Lakeland, Opus One, Georgian College, NRCan

Table 5: Knowledge Dissemination Activities for Project SPEEDIER.

Lessons learned

There were many lessons learned through the SPEEDIER Project, from design and procurement, through installation, commissioning and funding. For the initial funding application, build time in for the detailed project planning. Once funding is confirmed, be prepared to spend time clarifying Contribution Agreement details and budgets, and be aware of Fiscal Year requirements. Allow extra resources (during and post project) for reporting, especially if two funding sources are linked. Establish financial reporting expectations with the funder(s) and document fully, preparing internal processes.

Clearly define partner (in-kind) reporting requirements, including data specifics and frequency. Secure in-kind as soon as possible and communicate any changes to funder(s) immediately. Prepare any economic expectations (settlements). Continue work while waiting for non-financial feedback or approval from funders, if possible, and if funder agrees.

Establish ownership of assets early in the planning and set up contracts as soon as possible, including land access agreements. Set up regular communications between site owner and developer to avoid surprises during installation.

Include the LDC in all aspects of the planning. Consider the impacts to the organization in the long term, such as additional staffing after project. Start the CIA process early and keep records in case of staff turnover. Firm up budgets as early as possible as costs may be so high as to impact the feasibility of the project. Expect any regulatory changes to take longer than expected and have contingency plans.

When project planning, clearly define scope of work for all phases when there are several different organizations providing support. Finalize all communications. Ensure clarity of roles and that no steps are assumed to belong to another vendor. Ideally, the microgrid engineer would also do the P&C design.

Brainstorm with the larger team when making scope decisions, such as feeder choice, as decisions may have unforeseen consequences, such as limited participation or generation causing backfeeding, that a larger brainstorming session might have identified. Be prepared for change of scope when new information is introduced, such as change of vendor, or innovation such as seamless islanding. Set up a process for making scope changes. Consult widely to see if scope changes have other impacts, and if there are additional resource or reporting requirements from partners and vendors. Communicate to funder(s) immediately.

Order equipment as early as possible – perhaps even earlier. Especially in a pandemic. This means starting the whole procurement process as soon as possible and taking procurement timing into consideration when doing a scope change. Be aware of vendor support limitations such as location and time zones of techs and engineers. Clearly communicate expectations around permits, approvals and testing – who has the knowledge, who does the application, who is responsible for signatures. Consider the licencing of existing software and services in the procurement process.

Be aware of facility requirements, such as access to site, and consider weather when setting up outdoor access such as a lockbox that can freeze shut. Schedule time for site specific approvals and permits, and expect extra work in this area. Keep a log of site visits, including deliveries, vendors, technicians, and visitors. Set up insurance ahead of time, and flag for hand-off. Be aware of safety requirements from all contractors, vendors, partners and land-owner.

Introduce a troubleshooting log – keeping track of what attempts have been made eliminates duplication and allows for better solution definition.

Lessons learned from the software side of the project included similar points: build in extra time for unexpected things like staffing changes, clearly define scope of work and responsibilities, consider long-term requirements, and over-do the testing.

Next steps

Funding and rate case justification is a key barrier to expanding on this project. This project is designed to be scalable to other service territories and there is need in other parts of Lakeland Power Distribution's service territory. To build on this project, next phase would be to identify (two) locations where substation size battery storage would help relieve constraints and store excess generation. Another phase would be to build out the behind-the-meter demand management program as to allow for batteries, EV chargers and hot water tank controllers to be installed and controlled by Lakeland as an expansion of the existing capabilities.

Lakeland has three potential municipalities interested in moving forward with duplicating the SPEEDIER microgrid.

Regulatory barriers relating to Virtual Net Metering, and general metering of DERs are huge barriers to the progression of projects such as SPEEDIER. Costs associated with connecting components of the project to the Grid are extremely high and can negate any potential ROI.

Continuous Improvement Plan

As part of the software agreement, Opus One Solutions Energy ULC is committed to providing Lakeland Holding with updates that Opus One distributes to its other clients, with any applicable amendments of associated documentation. Opus One will also make available to Lakeland any conversion programs that Opus One has developed to assist in upgrading to new software versions.

Apart from general upgrades, Opus One is adding two new features for the SPEEDIER DERMS:

Monthly Energy Data reporting feature

This report will be added to the existing SPEEDIER DERMS UI (User Interface) to enable users to download energy reports with one click. The report data will be generated for each of the different assets in the format that the operators use for generating the GHG (Green House Gas) reduction reports. This will save manually downloading and formatting the data from different platforms.

Improvements in connecting to Lakeland's Active Directory Server

This improved version of connecting to the Client's Active Directory (AD) server is based on a recent GridOS® DERMS Deployment in another project. This improved way of connecting to the main AD server will allow the software to poll user groups and automatically authenticate users against these groups, which in turn reduces the amount of offline work required for adding users.

Opus One also looks forward to hearing from Lakeland Holding system users. Client inputs and feedback help Opus One to continuously improve the GridOS® products. Lakeland, at any time after the project completion, can reach out to Opus One support team via submitting a ticket in DERMS helpdesk or directly in order to present any comments, feedback, errors or questions.

Hardware Improvements

Opus One is committed to ensure accuracy and enhanced performance both in terms of hardware and software solutions. There might be a requirement to replace or upgrade the hardware used for this project to make sure the GridOS® MEMS and GridOS® DERMS systems function as intended.

Within the project commitment, Opus One is planning to upgrade the Real Time Automation Controller (RTAC) used in the MEMS system. This upgrade is to overcome the intermittent communication issues that may occur due to RTAC size being on the edge of its max usage/operating limits.

Conclusions

The objective of this project was to create a Smart, Proactive, Enabled, Energy Distribution - Intelligently, Efficiently and Responsive (SPEEDIER) grid that builds towards a net zero smart community in the Town of Parry Sound. This project has proven through deployment and demonstration how microgrids work to improve reliability of the grid infrastructure, while reducing peak loads to address constraints. The project assets that were deployed will provide an on-going benefit to the local grid.

The project goals that were met include:

- ✓ Increase solar and energy storage penetration in the Town to address constraints.
- ✓ Reduce loading on locally constrained transmission station identified in the Long-Term Energy Plan.
- ✓ EV charger infrastructure installation, promoting EV adoption and reducing GHG emissions.
- ✓ Develop greater automation and integration within the utility environment, addressing the growing deployment of DERs and the resulting need for visibility.
- ✓ Developing smart residential demand management via controllable hot water tanks (HWT), EV chargers and battery storage.

Work is still underway to educate policy makers on the need for virtual net metering to best utilize solar and waterpower.

Contact Information

Please visit www.speedier.ca for more information

Or send an email to info@speedier.ca

Appendices

A: SPEEDIER DERMS Peak Shaving Performance from report by Opus One Solutions Energy ULC

opus one solutions

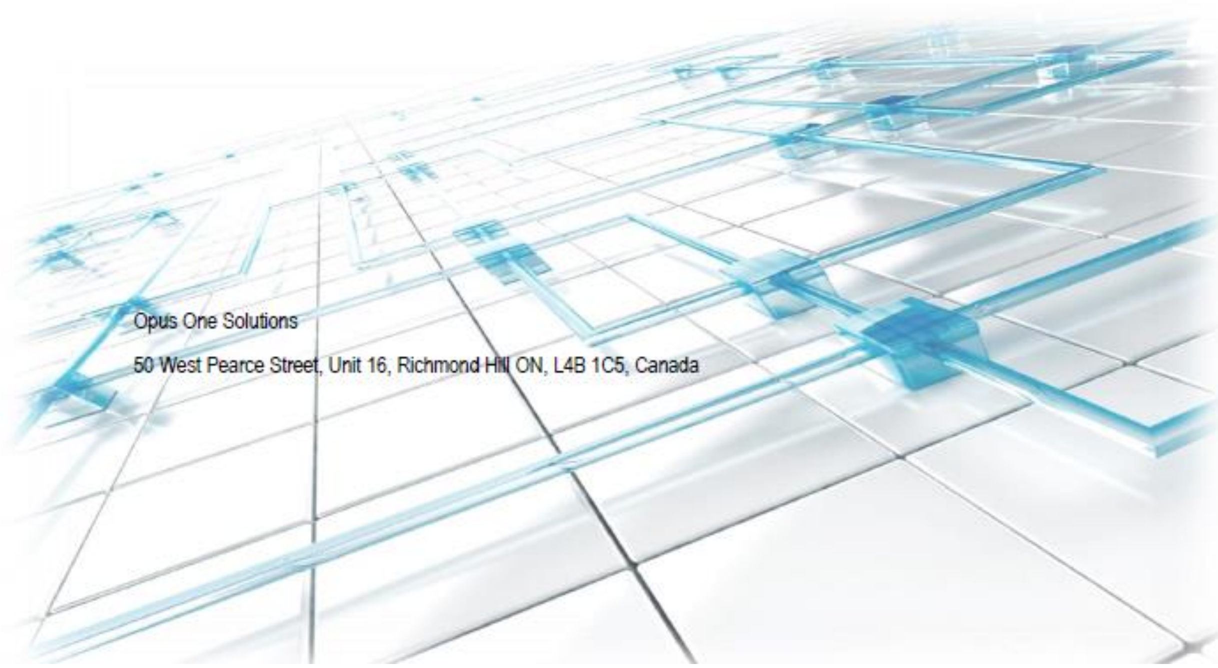
Powered by Opus One GridOS®

SPEEDIER DERMS Peak Shaving Performance Analysis

For Bracebridge Generation

Lasted updated: 2022-06-28

Version: 2.0



Opus One Solutions

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SPEEDIER DERMS PEAK SHAVING PERFORMANCE ANALYSIS

1 INTRODUCTION

In late March of 2022, the GridOS DERMS platform deployed for the SPEEDIER project was given complete autonomous control over controllable distributed energy resources (DERs) on MS3, specifically the fleet of Tesla Powerwalls (RBESS) and the Tesla Megapack (GBESS). These assets operated under a peak shaving control strategy continuously for a period of a week. The assets are still operating under a peak shaving control strategy as we continue to gather performance data.

This report will detail our data collection and analysis methodology as well as the peak shaving performance results from our first week of operation.

2 METHODOLOGY

For this report, our analysis is split into two parts: a primary analysis of DERMS' actual impact on the feeder load profile, and a secondary analysis of what the DERMS optimizer forecasted impact on the load profile would be. This two-part analysis is crucial because while the primary analysis can be used to evaluate the overall performance of the DERMS peak shaving control strategy, the secondary analysis can be used to identify weaknesses and areas for improvement in the control strategy.

For the primary analysis, we collect two timeseries datasets: the feeder active power feedback (the load measured at the feeder-head), and the aggregated asset active power feedback (the sum of the GBESS and RBESS active power telemetry). From these two datasets, we construct a 'true load' dataset by adding the feeder load and the aggregated asset power feedback at each timepoint. We add the asset power feedback because this dataset has the same sign convention as a generator, meaning a positive value indicates that the batteries are discharging, meaning there are loads that are not accounted for in the feeder dataset.

With the calculated 'true load' dataset and the telemetered 'feeder load' dataset, we can now compare the two profiles to determine whether DERMS had a positive or negative impact on the system's load profile for a given day. To quantify DERMS' impact on the profile, we calculate the change in four important values from the 'true load' profile to the 'feeder' profile: peak load, valley load, the difference between the peak and the valley (max load – min load), and the average absolute difference between the load at a specific point in time and the average load for that day. These metrics can be used to evaluate how successful DERMS was in identifying and offsetting peaks and valleys in the load profile, with the end goal of making it as flat as possible.

For the secondary analysis, we collect two additional timeseries datasets: the feeder load forecast, which is used by the optimizer to generate the asset dispatch schedules, and the adjusted forecast, which is what the forecasted load profile would become with the optimized asset dispatch schedules.

The secondary analysis we conduct is similar to the primary analysis, the only difference being the datasets used. For this analysis, the 'true load' that we calculated for the primary analysis is replaced with the forecasted load dataset, while the 'feeder load' is replaced with the adjusted forecast dataset.

3 ANALYSIS

3.1 PRIMARY ANALYSIS

March 28 (From 1pm)		
True Load Peak	Feeder Load Peak	-9.60% Reduction
True Load Valley	Feeder Load Valley	-30.01% Increase
True Load Max - Min	Feeder Load Max - Min	-66.41% Reduction
True Load Difference from Load Avg	Feeder Load Difference from Load Avg	-19.42% Reduction
March 29 (Full Day)		
True Load Peak	Feeder Load Peak	-40.60% Reduction
True Load Valley	Feeder Load Valley	1.83% Increase
True Load Max - Min	Feeder Load Max - Min	-92.18% Reduction
True Load Difference from Load Avg	Feeder Load Difference from Load Avg	-12.27% Reduction
March 30 (Full Day)		
True Load Peak	Feeder Load Peak	-1.16% Reduction
True Load Valley	Feeder Load Valley	-28.38% Increase
True Load Max - Min	Feeder Load Max - Min	-65.60% Reduction
True Load Difference from Load Avg	Feeder Load Difference from Load Avg	4.77% Increase
March 31 (Full Day)		
True Load Peak	Feeder Load Peak	-20.27% Reduction
True Load Valley	Feeder Load Valley	-19.50% Increase
True Load Max - Min	Feeder Load Max - Min	-59.32% Reduction
True Load Difference from Load Avg	Feeder Load Difference from Load Avg	-37.28% Reduction
April 1 (Full Day)		
True Load Peak	Feeder Load Peak	-15.17% Reduction
True Load Valley	Feeder Load Valley	-45.83% Increase
True Load Max - Min	Feeder Load Max - Min	-116.90% Reduction
True Load Difference from Load Avg	Feeder Load Difference from Load Avg	-13.46% Reduction
April 2 (Full Day, Weekend)		
True Load Peak	Feeder Load Peak	-8.57% Reduction
True Load Valley	Feeder Load Valley	-10.85% Increase
True Load Max - Min	Feeder Load Max - Min	-36.79% Reduction
True Load Difference from Load Avg	Feeder Load Difference from Load Avg	-27.98% Reduction
April 3 (Full Day, Weekend)		
True Load Peak	Feeder Load Peak	-17.52% Reduction
True Load Valley	Feeder Load Valley	20.08% Increase
True Load Max - Min	Feeder Load Max - Min	-15.51% Reduction
True Load Difference from Load Avg	Feeder Load Difference from Load Avg	-35.23% Reduction

3.2 SECONDARY ANALYSIS

March 28 (From 1pm)		
Forecasted Peak	Adjusted Forecast Peak	25.47% Reduction
Forecasted Valley	Adjusted Forecast Valley	0.00% Increase
Forecasted Max - Min	Adjusted Forecast Max - Min	68.95% Reduction
Forecasted Difference from Load Avg	Adj Forecast Difference from Load Avg	28.55% Reduction
March 29 (Full Day)		
Forecasted Peak	Adjusted Forecast Peak	1.61% Reduction
Forecasted Valley	Adjusted Forecast Valley	89.11% Increase
Forecasted Max - Min	Adjusted Forecast Max - Min	50.67% Reduction
Forecasted Difference from Load Avg	Adj Forecast Difference from Load Avg	42.70% Reduction
March 30 (Full Day)		
Forecasted Peak	Adjusted Forecast Peak	23.74% Reduction
Forecasted Valley	Adjusted Forecast Valley	32.58% Increase
Forecasted Max - Min	Adjusted Forecast Max - Min	96.15% Reduction
Forecasted Difference from Load Avg	Adj Forecast Difference from Load Avg	87.95% Reduction
March 31 (Full Day)		
Forecasted Peak	Adjusted Forecast Peak	11.60% Reduction
Forecasted Valley	Adjusted Forecast Valley	64.46% Increase
Forecasted Max - Min	Adjusted Forecast Max - Min	91.68% Reduction
Forecasted Difference from Load Avg	Adj Forecast Difference from Load Avg	45.91% Reduction
April 1 (Full Day)		
Forecasted Peak	Adjusted Forecast Peak	28.40% Reduction
Forecasted Valley	Adjusted Forecast Valley	95.69% Increase
Forecasted Max - Min	Adjusted Forecast Max - Min	98.24% Reduction
Forecasted Difference from Load Avg	Adj Forecast Difference from Load Avg	90.95% Reduction
April 2 (Full Day, Weekend)		
Forecasted Peak	Adjusted Forecast Peak	23.39% Reduction
Forecasted Valley	Adjusted Forecast Valley	45.17% Increase
Forecasted Max - Min	Adjusted Forecast Max - Min	91.60% Reduction
Forecasted Difference from Load Avg	Adj Forecast Difference from Load Avg	73.50% Reduction
April 3 (Full Day, Weekend)		
Forecasted Peak	Adjusted Forecast Peak	25.37% Reduction
Forecasted Valley	Adjusted Forecast Valley	51.40% Increase
Forecasted Max - Min	Adjusted Forecast Max - Min	99.14% Reduction
Forecasted Difference from Load Avg	Adj Forecast Difference from Load Avg	74.25% Reduction

4 CONCLUSIONS AND POTENTIAL IMPROVEMENTS

As shown in the Primary Analysis section, in the first week of continuous autonomous operation, the DERMS peak shaving control strategy did not have the desired impact on the feeder load profile. In fact, for each day in the test period, DERMS actually increased the profile's peak by an average of over 15% during the week and nearly 15% over the weekend. DERMS also reduced the profile valley almost every day by an average of over 20% during the week, though it did significantly increase the valley on one of the two weekend days. In terms of our other success metrics, during the week DERMS increased the difference between the max and min loads in the profile, and the average absolute difference from the profile's average load by about 80% and 15% respectively. During the weekend, these increases become ~25% and ~30% respectively. Overall, based on these numbers, it is fair to say that the feeder would have had a better load profile had the DERMS not been operational.

While these overall results are concerning, the results of our secondary analysis were significantly more positive. During the week (excluding Monday because it did not attempt to schedule any valley-filling), the optimizer expected to reduce the daily peak by an average of over 15% and increase the value by an average of 70%. It also expected to reduce the difference between the max and min load by over 80% and the average absolute difference from the profile's average load by over 60%. Moreover, during the weekend, it expected to reduce peak by an average of about 25%, increase the valley by an average of nearly 50%, reduce the max-min difference by 95%, and reduce the average absolute difference from the average load by over 70%.

This indicates that the cause of the poor overall performance lies in DERMS forecaster rather than the optimizer. One likely cause for the forecaster's poor performance is the fact that it uses previous load profiles to generate its forecasts without accounting for the impact of DERs on those previous load profiles. While this wouldn't be a problem for a system with higher loading or a lower DER capacity, for this particular system, the DERs have enough power to significantly change the feeder's load profile. This means that, if the batteries charged at a high power at some point one day, that increase in feeder loading would be reflected in a future forecast, which would result in the optimizer scheduling the batteries to discharge at a high power to offset the expected spike in loading. However, because the original spike was caused by batteries charging rather than by an actual spike in loading, we likely wouldn't see that forecasted spike in loading, meaning the planned discharging event would likely create a new valley rather than reduce a peak. This in turn would create a new valley in a future forecast, meaning a charging event would be scheduled to fill it, creating yet another new peak.

Additionally, though we didn't observe this during our extended performance testing, in the long-term, a successful day of peak shaving could feasibly negatively impact a future optimization with our current forecasting strategy. For example, if, hypothetically, DERMS was able to completely flatten the load profile for one day, that flattened profile would be used to generate the load forecast for a future day. If that forecast was also flat, the optimization algorithm would not dispatch the assets to do anything because there wouldn't be any peaks to shave or valleys to fill, even though the previous day's profile was only flat because of the asset dispatch schedules it had previously generated.

Therefore, to improve the overall performance of the peak shaving control strategy, we need to improve the DERMS load forecasting algorithm. One obvious change that we plan on implementing in the near future is to use a different dataset, one that only includes actual feeder loading, to generate our load forecasts. By accounting for the impact of DERs on previous load profiles and forecasting the true load we expect to see on the system, we would greatly decrease the likelihood of compounding errors negatively impacting our performance and increase the likelihood of sustainable long-term success in positively impacting the feeder's load profile.

5 ADDITIONAL PEAK SHAVING TESTS (AFTER FORECASTING ADJUSTMENT)

5.1 ADJUSTMENT DESCRIPTION

About a month and a half after our initial round of performance testing, one important change was made to the SPEEDIER DERMS Forecaster. To this point, forecasting had been based on feeder-level load measurements, meaning that the impacts of the batteries was included in the dataset used to forecast future load profiles. This issue was resolved by accounting for the battery dispatch schedules in the load dataset, making it more reflective of the 'true load' of the feeder, thereby making forecasted load profiles more accurate.

5.2 ANALYSIS

5.2.1 PRIMARY ANALYSIS

May 18		
True Load Peak	Feeder Load Peak	-5.25% Reduction
True Load Valley	Feeder Load Valley	58.69% Increase
True Load Max - Min	Feeder Load Max - Min	1.85% Reduction
True Load Difference from Load Avg	Feeder Load Difference from Load Avg	25.35% Reduction
May 19		
True Load Peak	Feeder Load Peak	13.57% Reduction
True Load Valley	Feeder Load Valley	120.76% Increase
True Load Max - Min	Feeder Load Max - Min	37.92% Reduction
True Load Difference from Load Avg	Feeder Load Difference from Load Avg	4.68% Reduction
May 20		
True Load Peak	Feeder Load Peak	2.97% Reduction
True Load Valley	Feeder Load Valley	-4.60% Increase
True Load Max - Min	Feeder Load Max - Min	2.17% Reduction
True Load Difference from Load Avg	Feeder Load Difference from Load Avg	22.49% Reduction
May 21		
True Load Peak	Feeder Load Peak	0.00% Reduction
True Load Valley	Feeder Load Valley	0.00% Increase
True Load Max - Min	Feeder Load Max - Min	0.00% Reduction
True Load Difference from Load Avg	Feeder Load Difference from Load Avg	0.00% Reduction
May 22		
True Load Peak	Feeder Load Peak	-9.45% Reduction
True Load Valley	Feeder Load Valley	3.04% Increase
True Load Max - Min	Feeder Load Max - Min	-15.92% Reduction
True Load Difference from Load Avg	Feeder Load Difference from Load Avg	20.90% Reduction

May 23		
True Load Peak	Feeder Load Peak	-22.97% Reduction
True Load Valley	Feeder Load Valley	32.57% Increase
True Load Max - Min	Feeder Load Max - Min	-20.99% Reduction
True Load Difference from Load Avg	Feeder Load Difference from Load Avg	26.39% Reduction
May 24		
True Load Peak	Feeder Load Peak	1.98% Reduction
True Load Valley	Feeder Load Valley	-1.01% Increase
True Load Max - Min	Feeder Load Max - Min	2.33% Reduction
True Load Difference from Load Avg	Feeder Load Difference from Load Avg	16.51% Reduction

5.2.2 SECONDARY ANALYSIS

May 18		
Forecasted Peak	Adjusted Forecast Peak	24.42% Reduction
Forecasted Valley	Adjusted Forecast Valley	65.49% Increase
Forecasted Max - Min	Adjusted Forecast Max - Min	99.55% Reduction
Forecasted Difference from Load Avg	Adj Forecast Difference from Load Avg	98.78% Reduction
May 19		
Forecasted Peak	Adjusted Forecast Peak	0.00% Reduction
Forecasted Valley	Adjusted Forecast Valley	78.19% Increase
Forecasted Max - Min	Adjusted Forecast Max - Min	44.89% Reduction
Forecasted Difference from Load Avg	Adj Forecast Difference from Load Avg	36.94% Reduction
May 20		
Forecasted Peak	Adjusted Forecast Peak	19.56% Reduction
Forecasted Valley	Adjusted Forecast Valley	55.69% Increase
Forecasted Max - Min	Adjusted Forecast Max - Min	97.34% Reduction
Forecasted Difference from Load Avg	Adj Forecast Difference from Load Avg	93.09% Reduction
May 21 (BESS was Offline)		
Forecasted Peak	Adjusted Forecast Peak	0.00% Reduction
Forecasted Valley	Adjusted Forecast Valley	0.00% Increase
Forecasted Max - Min	Adjusted Forecast Max - Min	0.00% Reduction
Forecasted Difference from Load Avg	Adj Forecast Difference from Load Avg	0.00% Reduction
May 22		
Forecasted Peak	Adjusted Forecast Peak	10.34% Reduction
Forecasted Valley	Adjusted Forecast Valley	59.85% Increase
Forecasted Max - Min	Adjusted Forecast Max - Min	83.82% Reduction
Forecasted Difference from Load Avg	Adj Forecast Difference from Load Avg	51.67% Reduction
May 23		
Forecasted Peak	Adjusted Forecast Peak	25.04% Reduction
Forecasted Valley	Adjusted Forecast Valley	72.57% Increase
Forecasted Max - Min	Adjusted Forecast Max - Min	90.67% Reduction
Forecasted Difference from Load Avg	Adj Forecast Difference from Load Avg	78.83% Reduction

May 24		
Forecasted Peak	Adjusted Forecast Peak	13.60% Reduction
Forecasted Valley	Adjusted Forecast Valley	68.04% Increase
Forecasted Max - Min	Adjusted Forecast Max - Min	68.40% Reduction
Forecasted Difference from Load Avg	Adj Forecast Difference from Load Avg	53.40% Reduction

5.3 CONCLUSIONS OF ADDITIONAL ANALYSIS

As shown in the charts above, the adjustment made to the forecaster resulted in significant improvements in the overall performance of the peak shaving control strategy. While the controller had previously increased profile peaks by an average of over 15%, after the adjustment, it only increased profile peaks by an average of about 3% and actually decreased peak by an average of 1% if you omit May 23rd, when low battery SOC triggered an unscheduled charging event, creating a new peak in the profile.

Additionally, after the adjustment, DERMS was able to increase profile valley and decrease profile peak-to-valley difference by an average of ~35% and ~1% respectively (the peak-to-valley difference reduction becomes about 6% if May 23rd is discounted). These numbers are also a significant improvement from the previous control strategy performance numbers, which showed that DERMS was actually decreasing profile valleys and increasing peak-to-valley differences.

Finally, the most recent round of testing shows that we reduced the average absolute difference from average load on each day by an average of 20%, showing that, overall, the algorithm is successfully shifting loading from high-loading hours to low-loading hours, effectively flattening the curve profile.

Overall, while there are still improvements that could be made to this control strategy, the more recent round of performance testing shows that, after the aforementioned change in the data used by our forecaster, the DERMS peak shaving control strategy can actually be used to reduce peak loading.