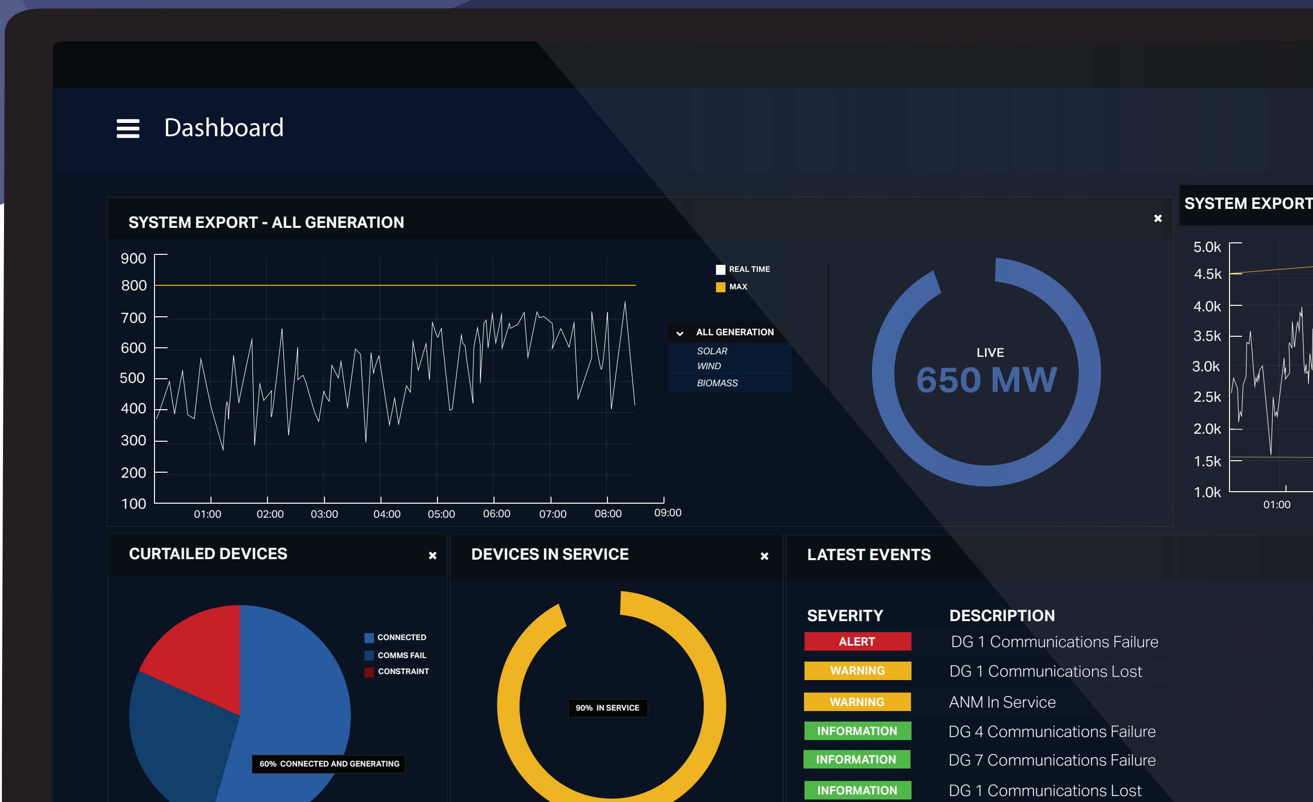
WHITEPAPER

A GUIDE TO MICROGRID DEVELOPMENT AND THE ROLE MICROGRID ENERGY MANAGEMENT SYSTEM (EMS)

This whitepaper provides an excellent starting point for microgrid discovery and development processes, highlights key implementation and operation challenges and solutions while emphasizing the essential role of Microgrid Energy Management Systems.

Tim McDuffie



INTRODUCTION: WHY MICROGRIDS ARE GARNERING SO MUCH ATTENTION

Recent extreme weather events in California, Texas and Louisiana have brought grid resiliency and reliability to the forefront in the United States power sector. A similar picture has emerged in European states in recent years with several widescale power outages. Some of this may be the result of climate change and others may be due to old equipment or supply chain issues. Whatever the cause, electricity is critical to peoples' daily lives and its sudden loss can have major consequences. This has led to communities and utilities seeking new ways to serve their constituents with microgrids.

Microgrids utilize local energy assets that can continue to operate when the grid goes down by utilizing dedicated grid assets and controls. Microgrid developers, financial investors, utilities, and regulators have roles to play to ensure that further development of microgrids progresses in a way that is beneficial to customers and also integrates smoothly into normal operations of the electric grid.

With a growing emphasis on clean Distributed Energy Resource (DER) assets to address sustainability as well as carbon reduction goals, renewable generation (solar, wind, geothermal, etc.) paired with battery storage are quickly becoming the technologies of choice in microgrids. Along with these, clear thinking about critical and flexible loads can ensure that available energy resources are optimized to provide the best supply resilience outcomes but also the best financial outcomes.

System integration, operating models, and commercial/business models, each with their required trade-offs in objectives and design, are oftentimes major challenges for customers and developers alike. The intricate web of offtake agreements, financing, feasibility studies, control automation, etc. means there is no shortage of challenge for customers in this rapidly maturing market.

Market analyst Guidehouse has tracked the growing microgrid market with a number of market reports published in the last two years. These show the current scale and expected growth in microgrids. For example, the annual capacity additions in utility led microgrids is projected to rise from around 1GW (2022) to over 3GW capacity additions per year by 2030 with the accompanying investment in utility microgrids growing from $4billion to over $10billion in the same period. The dominant regions for capacity addition and investment is Asia followed by the South American market, with the US at approx. 15% of the total and Europe with approx. 5% of the total capacity additions. Remote microgrids followed by Commercial & Industrial then utility are the three largest segments of the global microgrid market in these years. The control systems share of the microgrids market is projected at $0.5billion per annum in 2022, growing to nearly $3billion per annum in 2030.

One further insight from Guidehouse from 2021 is the growth of the Microgrid Energy-as-a-Service market with the greater appetite for investment in microgrids from the financial community. This stems from the technological and economic advances in Li-Ion batteries and PV with accompanying greater certainty for investors. Annual capacity additions for financed energy-as-a-service microgrids (with power purchase agreements) is projected to rise from 2GW per annum in 2022 to 12GW per annum in 2030 with an accompanying rise of capital deployed from $5b per annum to $30b per annum in that period. This level of investment exceeds significantly the capacity additions and investments in utility microgrids noted above.

This whitepaper addresses the market trends in microgrids, the challenges microgrid developers and customers face, the essential ingredients of a successful microgrid development and the crucial role of energy management and DER management in delivering success.

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SECTION 1.

THE MICROGRID MARKET & EMERGING REQUIREMENTS

Market analysts expect the investments in microgrid deployment to grow substantially in response to the needs for higher energy demand for enhanced services, which is inherently tied to a greater emphasis on resiliency, especially in a period of changing local climates. As we move into the new world of electric transportation, our need for reliable grid energy to sustain our daily lives becomes increasingly more important.
In this section we review the microgrid market to identify the trends and considerations in microgrid development.
The goal is to enable stakeholders to feel comfortable in engaging with the microgrid development industry to take the first steps towards their unique energy resilience provision.

Microgrid Customers and Business Models

The end users of microgrids have unique objectives, but often face similar challenges in meeting their energy needs. Most microgrid development start with a specific energy resilience need, then work to address this need using renewable energy generators in concert with automation technology. Some customers use a microgrid as a means of meeting other local economic development needs while promoting a decarbonized energy future.

There is a large array of customer types for microgrids spanning many market sectors and geographies. This includes:

- Critical infrastructure such as water, telecoms, airport and public services
- Agriculture including growing, food processing and storage
- Campuses for business, government, miliary and academia
- Disadvantaged communities seeking better energy options
- Tribal governments exploring ways to decrease their reliance on outside energy producers

Most microgrid development start with a specific energy resilience need, then work to address this need using renewable energy generators in concert with automation technology.

These customers have unique needs and it is essential that developers take the time to understand each situation and develop a microgrid solution that works for each specific customer.

From such diverse starting points, microgrid developers need to tailor repeatable microgrid designs with input from robust customer engagement. This should align with a balanced capital funding vs revenue generation business model to ensure that the microgrid serves the community need and can feasibly pay for itself through energy sales.

Key elements of the business model for microgrid developers include:

- Clearly defining roles and responsibilities of all partners including the integrator, turnkey microgrid developer, and energy-as-a-service provider
- Commercial agreements for energy offtake (e.g. power purchase agreements, PPA) and microgrid performance agreements
- Enabling grants or tariffs to compliment the financial model
- Identifying a Microgrid Energy Management System (Microgrid EMS) that optimizes assets operations and adapts to everchanging energy needs.

Microgrid user customers look for the right blend of energy resilience, financial return on investment and utilization of clean energy assets. A good Microgrid EMS will balance energy resilience objectives while affording value to the overall business model.

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Microgrid Energy Assets

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The continued advancement of battery energy storage system deployment, complimented and supported by the staggering performance and cost improvements of solar PV and lithium-ion battery technologies, creates low-cost anchor assets for many microgrid applications.

Current trends in microgrid energy assets now also includes electric vehicles (EV) which can play a major role in addressing local resilience. Interest in using Hydrogen Fuel Cells adds further to smaller scale resilient energy assets being considered in microgrids.

Every energy technology has unique characteristics, benefits, and limitations. This includes having a reasonable ROI to secure the benefit of their readiness in emergency situations. This often now involves participation in special tariff arrangements, energy market opportunities and even grid services. This also underscores the need of a Microgrid EMS to balance these factors in real-time.

Technical Requirements for Microgrid Implementation and Operation

Every microgrid customer has unique energy vision that should be clearly defined and articulated. . Developers should spend time to help customers understand this vision and how it meets the need in their particular situation. The best microgrid solution is accomplished by asking questions, listening, and understanding customer needs, then matching those with a tailored design.

Once the vision and need is understood, then begins the task of assessing then providing technical solutions as part of the microgrid development process. The range of DER assets, equipment specifications and how they will operate within the microgrid setting can be challenging, even for seasoned industry professionals.

The dynamics of a microgrid in island mode (as well as the transients while moving from grid-connected to island mode and vice versa) are challenging. Protection and control settings are also challenging. Meeting utility and other technical standards for stand-alone, customer operated equipment which integrates to utility networks can feel like an insurmountable task.

The Microgrid EMS serves as the glue to connect and manage DER assets to optimize both the financial goals and energy resilience needs. Selecting the right Microgrid EMS is an essential step in the development process.

The Microgrid EMS provides the interface between the DER owner/operators and their on-site assets. Additionally, the Microgrid EMS creates the conduit through which information is exchanged with the local utility and the energy marketplace – which expands the ways microgrids can be monetized

Optimizing the operation of the microgrid to be in an agreed state of readiness ahead of any emergency event, and then managing all available resources during the event requires a number of capabilities (see sidebar). These are especially valuable in microgrids with clean energy assets that are both variable in their output, flexible in what they offer, and require more sophisticated business models.

Required capabilities to optimize the operation of a microgrid:

- forecasting
- monitoring
- receiving instructions
- dispatching asset operations
- emergency control
- providing timely information
- bidding into markets
- coordinating control of diverse energy assets (and possibly owners)
- metering energy flows
- financial settlement
- optimization capabilities to balance all of the objectives.

The Microgrid EMS system is assessed on microgrid performance in normal and emergency situations, delivery of the business model and the ability to adapt to new energy needs over time. In short, the Microgrid EMS is the brain for the microgrid, thinking and preparing ahead of time, making the best asset control decisions in the moment and accounting for delivery retrospectively. This does not imply supercomputing, artificial intelligence or machine learning but a set of "best of breed" computer systems that ensure the ensure the Microgrid EMS brain is capable of supporting customer objectives.

California market - CMEP/CMET, SGIP and $200m PSPS mitigation programs.

SECTION 2.

CUSTOMER CHALLENGES, UNIQUE REQUIREMENTS AND FLEXIBILITY

There is a saying in the microgrid industry, "If you've done one microgrid, you've done ONE microgrid". This implies that each microgrid is unique to the extent that there is a lack of uniformity between projects. While this can certainly feel accurate, we see it as a perception, rather than a reality.

The variability between microgrids is due in large part to the discrete makeup of each system. Each one is a mixture of different types of DER (both with and without load management), often from different vendors and involves some interaction with a utility SCADA or ADMS and now energy market. Compounded on this mix of assets and system interactions is the mix of use cases. Some microgrids focus on resiliency while others prioritize economic optimization and most require a mix of both. This can leave even the savviest of DER developers and utility engineers feeling like they are re-inventing the wheel on a daily basis.

So how do Microgrid EMS's make this job of bringing together a unique blend of assets and system interactions easier? Simple: Flexibility.

Often, developers are asked if they have integrated with a specific device from a specific manufacture for a specific purpose. This line of thought is logical but is not how the market should approach integration. Instead, most DERs are built around common communication languages rather than a specific brand. This means that a customer need only specify an industry standard communication medium like Sunspec, Modbus, DNP3, 2030.5 etc., and a flexible, robust Microgrid EMS will integrate it into its operations. Some platforms have been built with a "bring your own device" mentality that does not rely on one-off proprietary integrations. A good Microgrid EMS should integrate any DER that meets basic, industry accepted, communication methods. This enables integration of many different types of DER from any manufacturer into one platform. Once DER devices connected to the Microgrid EMS, the question then becomes how to use them for greatest advantage.

Every microgrid feels unique because every customer is unique. A hospital will have a different use for a microgrid than a commercial campus and that will differ from an industrial facility. This underscores why Microgrid EMS flexibility is so

important. Any microgrid operational need can be plotted on a spectrum with 100% Resiliency / 0% Optimization at one end and 0% Resiliency / 100% Optimization on the other. this is the "R/O Spectrum" and rarely are customers at an extreme end. For example, an agricultural processor in California may have a R/O need of 20/80 for most of the year, except for the three months during harvest season when their R/O need changes to 90/10. This is so that the facility is ready to withstand power outages that could impact their ability to process and deliver product. Another example is a community microgrid owned by a third-party owner/operator under a Power Purchase Agreement (PPA). The main use case is providing energy resiliency during peak fire season. The community allows the owner/operator more leeway during non-fire season to maximize their returns with an R/O of 40/60. However, during fire season, the R/O adjusts to 80/20 to afford the community the best chance of serving its citizens through an outage.

As with flexible device integration, the flexibility to adjust R/O operating parameters is a key characteristic of any good Microgrid EMS. Microgrid developers should work with all stakeholders to implement Microgrid EMS platform that provides the R/O flexibility while providing the reporting capabilities needed to assure delivery of the business model and also demonstrate compliance with any contractual requirements. The process of understanding customer needs and meeting these with a flexible, reliable software solution is what can make or break the modern microgrid.

SECTION 3.

MANAGING THE ENERGY ASSETS IN A MICROGRID

More than just a source of energy during a power outage, a microgrid is an essential piece of any "at-site" energy operation. This could be for a utility, community, or industrial customer, each with their own needs and different ingredients that they bring to the mix. The preferred or best value mix of generation, energy storage and load management (together, diverse DER) all play a role in a microgrid that works for a specific customer application. There are a few key ingredients that are common to all successful microgrids.

Every microgrid seeks to achieve the balance of generation and load management. Energy usage and renewable generation are by their very nature variable and this is why the Microgrid EMS plays such a critical role. Each discrete DER has a control device to manage its own operation and the Microgrid EMS serves as the aggregator of these devices to operate them towards a common goal. For example, a Battery Energy Storage System (BESS) device comes with a Battery Energy Management System (BEMS). This BEMS is designed to operate the BESS within certain parameters and warranty obligations. The BEMS typically provides some basic scheduling or dispatch functionality, but this is not integrated with other DER assets and systems. Another example is a PV array with a discrete inverter interface system that is monitored and operated to its unique needs. As with the BEMS, the PV inverter typically serves as the main point of protection, visibility, and control of the PV system as a standalone asset. Yet another set of devices are protection or load sectionalizing devices such as circuit breakers or reverse power relays. And finally, there's typically may be a conventional

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synchronous generator that runs on fossil fuels and has yet another controller of its own. Without a capable Microgrid EMS, the control scheme can be complicated and uncoordinated or sub-functional to say the least.

The Microgrid EMS allows all DER and microgrid control devices to work together to serve a common goal. For example, if a microgrid has an overabundance of PV energy and an empty battery, the Microgrid EMS schedules energy flow from the PV to the BESS, recognizes when the BESS is fully charged, then takes action to ensure that excess power from the PV is routed in the best way (e.g. flexible demand, grid export).

Another example would be when the system needs to move quickly to restore power from a black start event. The Microgrid EMS manages DER production, inverter operation (load following vs. grid forming), along with other parameters to allow multiple DER to work in harmony in each microgrid operating mode from grid-connected to island and back to grid-tied.

Another emerging ingredient in microgrids is fuel cells, powered by either natural gas or direct hydrogen. Fuel cells have very slow ramp rates (i.e. they can't react to sudden load changes quickly) and so they are best used to serve relatively consistent "base" load. To manage flexible loads, BESS devices are typically incorporated to react to sudden changes in electrical demand. As with the previous example, each device is operating in its own discrete vacuum, and this is where Microgrid EMS manages the overall operation of all assets.

The Microgrid EMS's programming scheme reads and reacts to the everchanging load conditions in real time to sustain a microgrid as long as possible. The ingredients of microgrids will continue to evolve but the key is having a software platform that orchestrates all DER operations to balance load and generation, optimize the operation of DER and react to sudden changes and rare events that are certain to occur.

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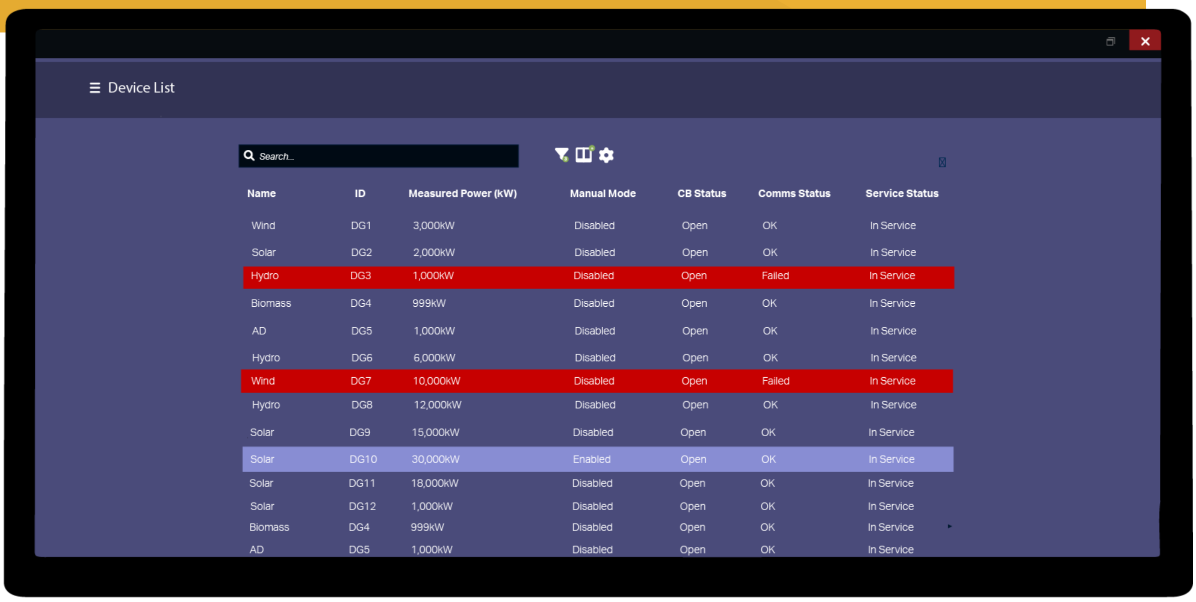


SECTION 4.

THE ROLE OF MICROGRID EMS IN THE TURNKEY MICROGRID

Turnkey microgrid projects are like any other turnkey projects with one new ingredient: the Microgrid EMS. This type of supervisory and orchestrating control is new to many developers and so it is important to understand what should be expected from a Microgrid EMS. The three main functions of a Microgrid EMS are Automation & Control, Reporting, and Integration with host utility but other functions such as market or energy retailer integration are becoming more frequent.

AUTOMATION AND CONTROL

This term encompasses several control techniques, but the two most common are forecast optimization and real time control. The key difference between these techniques is operating timescale. Forecasting-optimization techniques are based on "look ahead" daily, hourly, or 15-minute forecasts for load, weather and prices. In contrast, real time control occurs between the faster protection timeframes (usually less than 2 seconds) and the rolling 15-minute forecast-optimization timeframe. Real time control functionality fills an important gap that reduces the number of protection device operations by adjusting to conditions that do not accord with the forecast. A Microgrid EMS should be capable of layering forecasting and optimization atop real time automation and control. This means that the microgrid will operate per the forecasting and optimization model unless unexpected conditions arise that require the real-time automation algorithm to take control temporarily. In practice, the forecasting and optimization script is in control much of the time, and the real time automation is providing enhanced stabilization of the generation/load balance of the microgrid system in reaction to abnormal operating conditions and keeping the microgrid network and assets withing their physical and commercial limits.

REPORTING

Like any other infrastructure and utilities services project, a microgrid has its unique set of stakeholders, each with their own interests and expected returns from the microgrid. A utility, for example, may expect a microgrid to function as part of a wider grid services program during an outage whereas an owner/operator may want to ensure that financial returns are being realized. Both require unique reporting mechanisms (e.g. custom reports, dashboards) synchronized to microgrid operation and contractual obligations. Each individual stakeholder can then know that their objectives and interests are reflected in the microgrid operation but also in easy-to-use dashboards that identify and correct any problems and deliver regular performance reports. A Microgrid EMS must be flexible enough to address each need individually, while not destabilizing operations of the broader microgrid.

INTEGRATION WITH HOST UTILITY

Advanced controls are being utilized by utilities at an increasing rate for voltage optimization, service restoration and customer connection to name a few applications. This is due in large part to the increased integration of DERs, including electric vehicles. While the needs of the turnkey microgrid developer are important, it is equally important that the microgrid have a Microgrid EMS system that is complimentary to local utility operating practices. Utilities will, with good reason, delay interconnection of a microgrid system if they feel it strains their capacity to maintain safety and reliability to all other customers on their system. Therefore, it is important that the Microgrid EMS is integrated into a utility operating scheme to allow for visibility and supervisory control of the microgrid, especially during outages. Simply knowing that the microgrid has been separated from the grid is a critical piece of information to any grid operator. The Microgrid EMS should integrate into any utility operating scheme to enhance energy management of the surrounding area.

STRATA RESILIENCE

SGS is a market leader in software-based Microgrid EMS. Strata Resilience deliver the capabilities, flexibility and outcomes for customers described in this whitepaper. This meets the objectives and delivers the business models with a diverse set of DER assets that our customers require.

CASE STUDY:
Lac Megantic project

BACKGROUND & CONTEXT

In 2013, the town of Lac Mégantic in the providence of Québec, Canada suffered a crude-oil train derailment that destroyed part of their town center. As part of their restructuring plans, the town authorities identified a new energy vision project as a key innovation for future smart, decarbonized cities. In 2014, the Lac-Mégantic vision for the town center district entered the planning stage. Simultaneously, Hydro Québec was planning its own energy transition strategy. The convergence of these two visions resulted in the Lac Mégantic microgrid concept, which was jointly developed over the years that followed.

Lac Mégantic and Hydro Québec looked to partner with industry leaders to help them materialize the town's vision and develop the expertise required for a larger, province-wide energy transition based on advanced energy systems and microgrids.

SGS ROLE

Working in partnership with CIMA+, Smarter Grid Solutions was selected as one of Hydro Québec's partners of choice to deploy our microgrid energy management and control platform, Strata Resilience, to enable microgrid and DERMS functionality across a total of 20 Distributed Energy Resources (DERs) and Devices.

Strata Resilience manages both renewable and conventional (diesel, oil, gas) technologies. It incorporates any existing on-site generation or energy management systems into a single dashboard that provides a holistic view and current state of DERs. Strata Resilience also controls any backup power generators on an "as-needed basis" when other energy or resource limited DERs are depleted. Strata Resilience monitors grid conditions and automatically manages the combination of grid power and on-site renewable and conventional energy, prioritizing their use according to prevailing conditions including islanding state and economics.

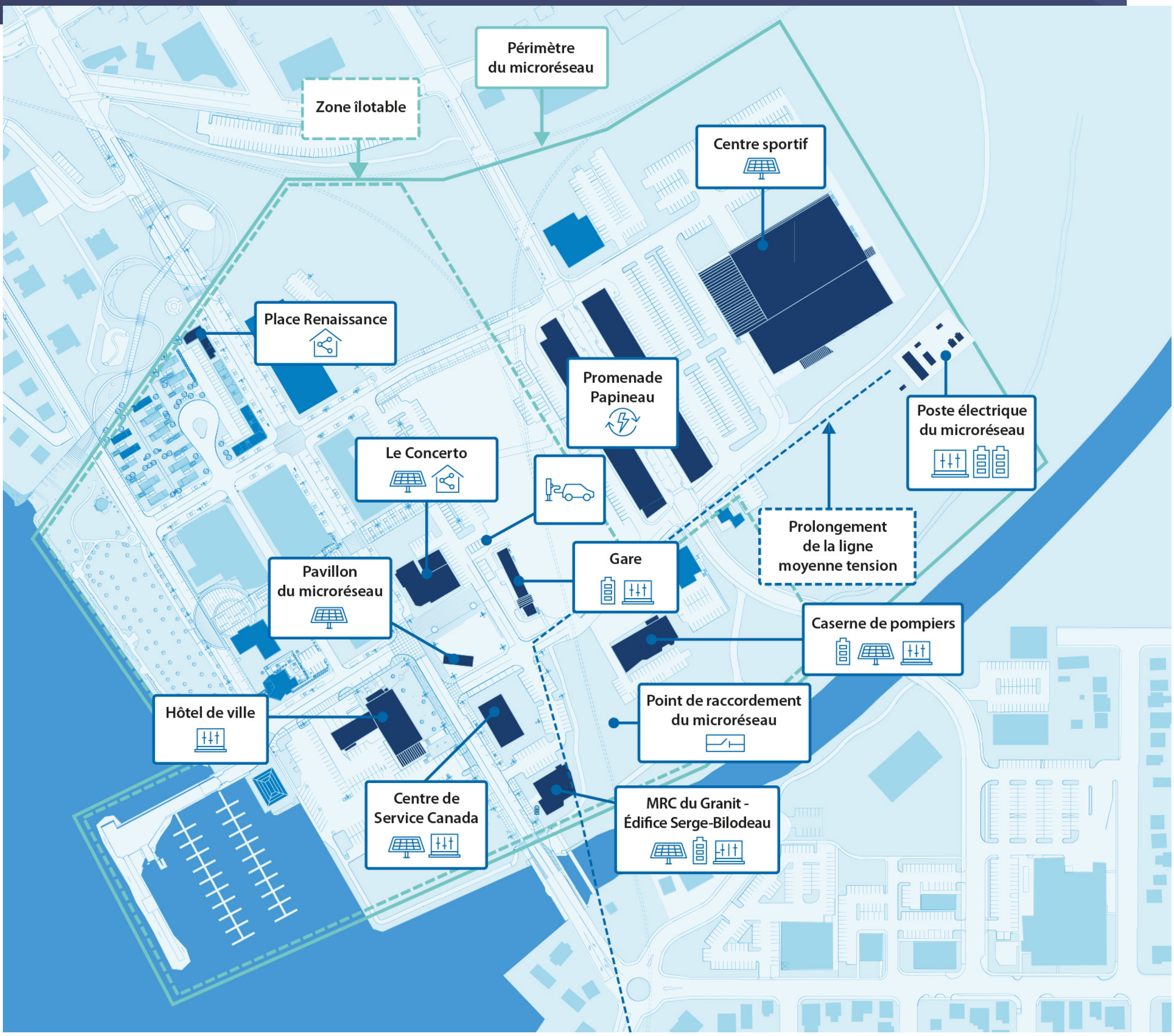
Under all operating modes, Strata Resilience creates financial value for the energy created by communities by continually managing energy sources and demand. This maximizes cost savings and minimizes carbon impacts through sophisticated optimization that incorporates local tariff considerations, the cost of running fossil-fuel generation, and the availability of local renewable energy resources.

The Lac-Mégantic project has supported Hydro Québec's objectives in transitioning Canada's towns and cities into smart communities. Most importantly, SGS helped transpose the model for a power system in remote areas to reduce fossil-fuel dependency and help our customer gain expertise on managing renewable generation and load demand in urban areas. In operation since April 2021, the Lac Mégantic microgrid is also set to become one of the most sophisticated in North America when all functionality is fully commissioned in 2022.

INSTALLATION

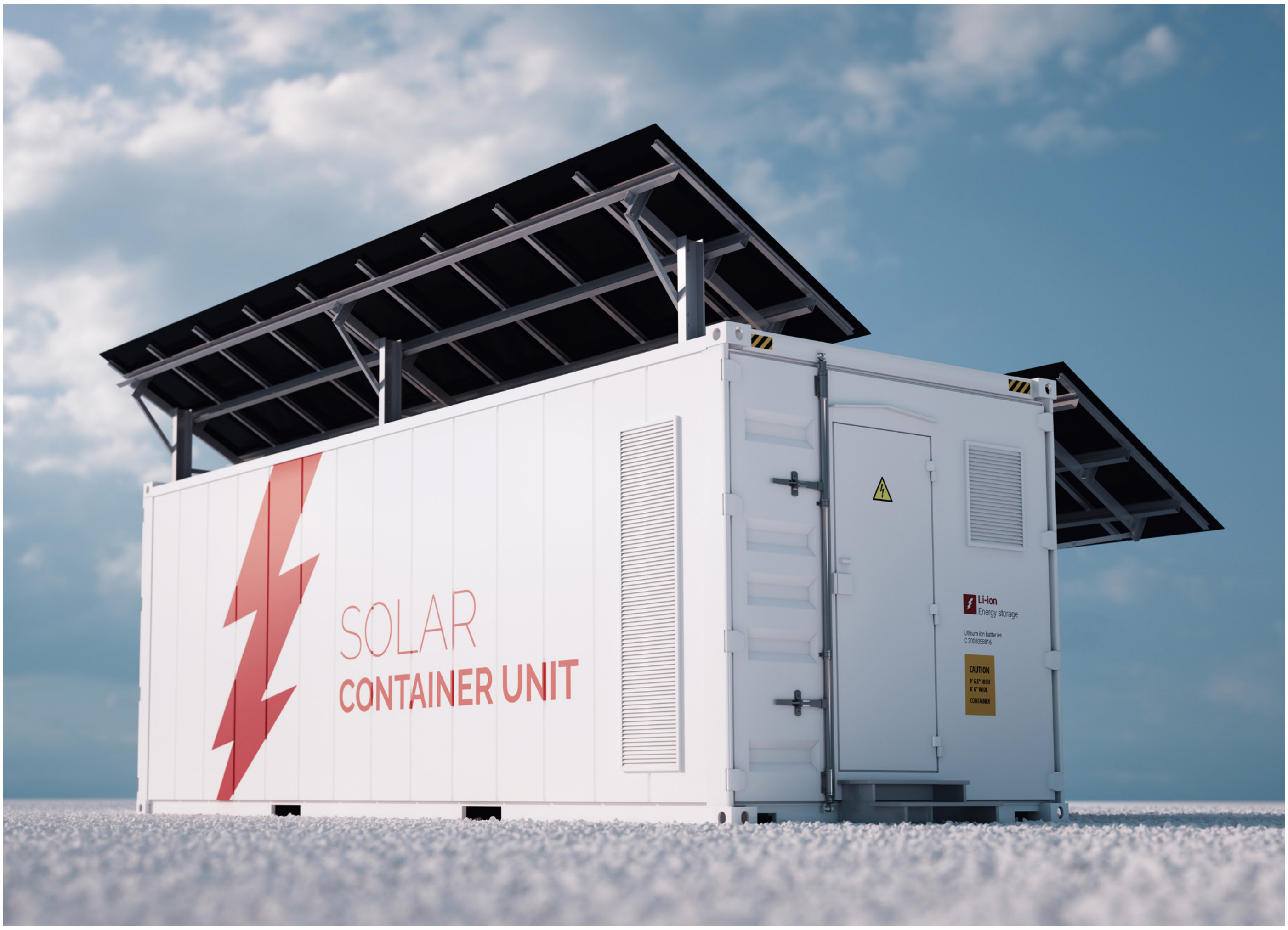
20 DER Assets

- 600 kWh of "At The Meter" plus 53kWh of "Behind The Meter" battery energy storage
- 524 kW of Solar-PV on a single site plus 86kW of additional building integrated PV
- 855 kW synchronous generator
- 4 Building Management Systems representing approx. 325 kW of controllable load



SECTION 5.

DEVELOP YOUR MICROGRID WITH CONFIDENCE



The microgrid market continues to mature and grow and this is expected to continue in the years to come. As energy rates climb and energy resilience becomes crucial, customers continue to turn to alternative ways of sustaining themselves when the utility cannot deliver.

It is important for all stakeholders to understand the key considerations so that they can develop and utilize microgrids to their full advantage. Regulations and standards continue to evolve, as do the programs and policies to support microgrid market growth. As the market matures, it will become easier for customers of all shapes and sizes to access clean, affordable energy that can serve as a backup when the grid goes down.

Turnkey microgrid solutions offered by renewable energy developers will become commonplace and will lead to a repeatable microgrid business model that can be copied throughout the energy sector. The level of complexity for the end user will decrease as new product offerings are built to integrate seamlessly into specific areas.

Flexibility in the Microgrid EMS will continue to be a key feature as energy needs and energy pricing continue to change over time. This flexibility will allow for new DER assets (including fuel cells) to be integrated into operational microgrids without disrupting the critical services they deliver.

The more "plug and play" the microgrid and the Microgrid EMS becomes, the easier it will be to fund and realize expansions and to increase the value of microgrids. Microgrids will develop in parallel to the fast-evolving energy markets, grid services and aggregated wholesale market participation.

The energy grid is becoming a smarter network of centralized and de-centralized energy resources all working in symphony to serve customers in an increasingly decarbonized energy sector. The Microgrid EMS will increasingly play a central role in this energy transition.

ABOUT THE AUTHOR

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Tim McDuffie PE is a Senior Business Development Engineer at Smarter Grid Solutions. He has over 15 years' experience as an electrical engineer and has integrated solar+storage systems totalling more than 120 MW over more than 100 individual projects. From 2017-2022, Tim Chaired the California Solar and Storage Association Grid Modernization Committee where he fostered collaborative interactions between California utilities and key industry stakeholders. Tim's current focus are community, Tribal, and C&I microgrid customers who seek a balanced an energy solution that's tailored to their specific need.

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STRATA RESILIENCE

sgsderms.com/microgrids

ABOUT
SMARTER GRID SOLUTIONS
A Mitsubishi Electric company

Smarter Grid Solutions (SGS) is a leading enterprise energy management software company specializing in distributed energy resource (DER) management systems (DERMS) and operating internationally from bases in the UK and US.

SGS manages significant groups of renewable generation, energy storage and flexible loads for customers in North America, Europe, and Asia. Its solutions have already saved customers more than $400 million in avoided grid upgrades.

SGS DERMS products are used by distribution utilities, energy services companies, microgrid operators, energy asset developers and owner-operators, aggregators, and traders to:

- Connect, monitor, control and optimize DER assets and fleets of any type, size and location using secure and standard integration methods.
- Manage and coordinate DER participation in the grid and market in line with FERC Order 2222
- Optimize Virtual Power Plant operating schedules to maximize returns from energy markets and flexibility
- Manage grid capacity and headroom to speed up interconnections and save on grid upgrade investments
- Integrate microgrids and deliver grid-connected, island and black-start functions
- Connect microgrid assets to markets to optimize revenues while delivering supply security
- Track and optimize carbon for 24/7 Carbon Free Energy
- Underpin new business models including 'as-a-service' to deliver customer and partner objectives
- Provide high resolution and high-fidelity data for advanced analytics functions

SHARE YOUR THOUGHTS

We always value inputs and feedback to enable us to better address the diverse, complex and dynamic market. Contact us with your views and opinions at marketing@ smartergridsolutions.com

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