White Paper

Horizon Power: A Case Study on Integrating Customer DER

Moving the Needle on Utility DERMS Innovation in Australia

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Commissioned by PXiSE Energy Solutions[1]

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Introduction

While once viewed as an isolated energy market with limited relevance to global markets, Australia has progressively stepped forward as an area to watch in the energy transition. Recent power outages, wholesale and retail price spikes, and some of the highest penetrations of distributed solar PV in the world have prompted Australia to become a focal point of innovation, analysis, and lessons learned. This is especially true in Western Australia where a nationalized, vertically integrated utility, Horizon Power, deployed a novel application of a distributed energy resources management system (DERMS) to enable greater renewables integration across its utility territory. The DERMS provides services for the utility, including forecasting the output of unmanaged distributed energy resources (DER); it also optimizes utility assets and behind-the-meter (BTM) customer-owned DER in tandem with a centralized natural gas-fired generator that traditionally powered a remote microgrid, which is the focus of this white paper.

Horizon Power boasts the largest utility service territory in the world——five times the size of California—with the lowest customer per square kilometer ratio of any utility service territory.

What is a DERMS? The following is the Guidehouse Insights definition:

> *DERMS is a software control system typically deployed by utilities to optimize DER assets and maintain the reliability of the distribution system through use cases such as active power management, voltage issues, and other services that support utility operational needs.*

Horizon Power is moving forward with a comprehensive DERMS in addition to remote microgrid optimization, reflecting the unique challenges this utility faces. Horizon Power boasts the largest utility service territory in the world—five times the size of California—with the lowest customer per square kilometer ratio of any utility service territory (1 for every 53.5 km^2). The issues Horizon Power is facing reflect the needs of utilities worldwide—they are just tackling them sooner. While some utilities may question why they need a DERMS, the challenges of integrating customer-owned DER assets will ultimately impact every regional utility in the world. Tackling the first steps of the technology transition now sets utilities up for success as reliance on DER assets continues to grow.

The Challenge

The focus for utilities such as Horizon Power are communities that want to shift away from centralized, carbon-based generation sources and participate in highly distributed and renewable onsite solutions such as rooftop solar PV and batteries. These communities face the challenge of how to foster customer participation with assets sited at their homes and businesses with utility resources (e.g., wind or solar farms) and traditional power plants that rely on natural gas and diesel fuels. As is often the case with renewable energy sources, the communities deal with reverse power flows and intermittency issues that cause the grid's voltage and frequency to fluctuate. They need to identify a reliable solution that sets up a controls framework to accommodate both large and small resources and integrate these assets into supporting infrastructure, such as transmission lines and distribution networks.

The Solution

Horizon Power sought a platform that could enable higher renewables integration for large-scale assets and integrate a fleet of BTM customer DER assets to provide shared value for all stakeholders. Because the customer base demands more solar and battery storage, many grid operators worry about the intermittency of these renewable resources. Rather than finding a way to integrate them, some utilities have tried to limit the amount of renewable energy connected to their networks. These utilities have gone so far as to routinely curtail the output of these resources. While the islanded nature of many of Horizon Power's whole community microgrids necessitated renewable energy hosting capacity limits in some locations, the utility wanted to move beyond this thinking and implement a flexible and reliable solution that also improved operations, shared cost savings with customers, and informed new regulatory standards for renewable energy adoption.

To realize its vision, Horizon Power searched for a DERMS solution, along with a partner ready to take on the challenges of developing a true renewable grid. This white paper chronicles the journey.

The coastal town of Onslow (population: 850) is spearheading Horizon Power's effort. Figure 1 shows the service territory of Horizon Power and the Onslow community. The town's microgrid serves as a centerpiece for Horizon Power's long-term plans toward more effective distributed DER management and integration. Having a single platform to optimize the microgrid and a full-fledged DERMS capability illustrates use cases of relevance to isolated systems, such as Onslow, as well as interconnected systems. The latter use cases were described in a previous Guidehouse Insights white paper highlighting grid-tied microgrids deployed by Portland General Electric and San Diego Gas & Electric.[2]

Figure 1 Horizon Power Service Territory and Onslow Microgrid Site

(Source: Horizon Power)

[2] Guidehouse Insights, *How Utilities Can Be Microgrid Leaders*, prepared for PXiSE Energy Solutions, 3Q 2020, https://www.pxise.com/case-studies/how-utilities-can-be-microgrid-leaders-a-new-white-paper-with-guidehouse-insights/.

This Guidehouse Insights white paper tells three different stories:

- The first is the **network story**. Horizon Power is taking a leading edge technology position on DERMS to bolster a constrained network serving an isolated community that the utility will then expand throughout its service territory over time.
- The second is the **technology story**. How can a holistic DERMS address previously unmanaged DER and customer-owned DER assets across the full grid network including a standalone microgrid without access to any traditional additional utility distribution or transmission-level resources?
- Finally, is the **customer story**. New platforms are necessary for customers to become empowered as prosumers. Horizon Power's DERMS implementation and the Onslow microgrid provide an example of how customers can win in the energy transition, contributing to cleaner air and resiliency while reducing their electricity bills in ways that also help their host utilities.

The Network Story

A grid network ideally consists of a robust transmission system linking up to substations and distribution feeders, stepping down electricity voltage all the way down to a customer site, whether residential or commercial or industrial enterprises. This default assumption, however, does not apply to most of Horizon Power's service territory due to its size and the number of remote communities not integrated into a traditional grid network. Yet, this is what most of the world's electricity grids look like, so what works in Australia has wide implications.

Remote communities like those in Horizon Power's service territory mirror grid challenges throughout Asia Pacific, Africa, the Middle East, Latin America, and even parts of North America; this includes the majority of Canada and Alaska, the latter the leading US state when it comes to microgrid deployments. These communities are often powered by fossil fuel generation on isolated electric grids. Volatile and costly diesel fuel imports create a challenge for the utility as it seeks to lower the cost of supply while simultaneously reducing carbon emissions. Horizon Power chose the coastal town of Onslow to explore how solar power, mostly owned by customers, and battery storage could help it meet the three-feeder network needs of an 11 MW microgrid serving a 4 MW peak load. The town had existing generation from natural gas (8 MW) and diesel (1 MW) generators along with a 1 MW lead-acid battery.

The network issues facing the Onslow microgrid were due to the need for a local area control to synchronize frequency and voltage and to balance small and large resources, all within the confines of a remote microgrid. Why is this important? Keeping voltage and frequency from swinging out of range avoids the worst-case scenario: a blackout, a very real prospect given that renewable energy production exceeded the technical hosting capacity by a factor of three. What Horizon Power needed was a new technology capable of split-second decisions to keep the self-contained grid in balance. The small scale amplified these challenges. The smaller the grid, the more susceptible it is to stability issues due to less inertia, resulting in more sensitivity to small deviation disturbances. An analogous integration of a microgrid into a broader DERMS platform addresses similar challenges many communities face worldwide as they seek to shift away from fossil fuels to low carbon options.

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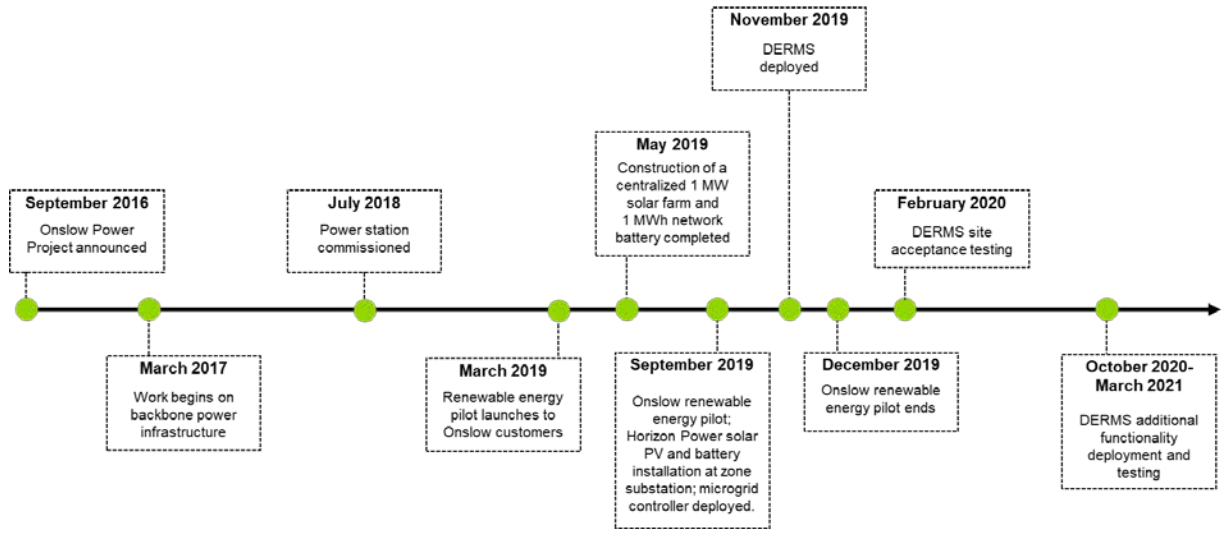
Until recently, many of Horizon Power's customers could no longer add solar PV—even if their neighbor had such a system. Constrained by the physics of grid dynamics, some small remote microgrids had reached solar PV saturation. This not only frustrates customer PV opportunities but also the ability to meet renewable energy strategic goals. Horizon Power wanted to enable the generation of more of its electricity from renewable energy such as rooftop solar PV across its territory. Because rooftop solar PV is expected to emerge as the cheapest form of electricity generation in the future,[3] Horizon Power believes this will place downward pressure on the cost of service for its remote communities. As much as 90% of power generation across its service territory could come from solar resources when conditions are right.

[3] International Energy Agency, *Renewables 2020: Analysis and forecast to 2025*, November 2020, https://www.iea.org/reports/renewables-2020/solar-pv.

Therefore, integrating new customer-sited distributed solar and battery systems is key to achieving this outcome.

Horizon Power partnered with PXiSE Energy Solutions to implement both the company's microgrid controller and DERMS in Onslow, setting the stage to integrate hundreds of solar PV panels and batteries across its vast territory. The overarching DERMS views the microgrid as an individual segment of the overall Horizon Power service territory that becomes, in effect, a virtual DER pool. Though only currently operating at Onslow, the DERMS is enabled to marshal optimization throughout Horizon Power's entire service territory. The advanced control platform provides comprehensive planning and optimization, while the microgrid offers high speed localized control technology. This combined technology approach enables the microgrid to reduce reliance on hydrocarbons and reduce operational costs versus conventional systems.

Figure 2 Onslow Microgrid Timeline



(Sources: Guidehouse Insights, Horizon Power)

The Technology Story

Unlike some conventional grid controls that dispatch DER assets according to a preprogrammed schedule, a state-of-the-art DERMS can use two-way, sensor-based technology to monitor the grid in real time. This controls approach can mitigate disturbances and balance variable solar generation, energy storage, and other available resources, including customer demand. With this configuration, a DERMS uses high speed data from connected DER assets to simultaneously optimize renewable energy output and power quality, thereby reducing solar curtailment, which wastes valuable clean energy production. Lower operating costs are realized as solar power displaces more expensive fossil-fueled generation.

What follows are a few advances key to Horizon Power's Onslow upgrades, starting with a necessary evolution from the forecasting behavior traditionally used for remote microgrids. The forecasting process starts with the system load history to analyze patterns to predict future events. If that was all that was done, Horizon Power would have had a reasonable prediction, but it would be ignoring real-time events. The utility has advanced metering infrastructure (AMI) in place for better visibility of individual customer loads down to the local distribution transformer level. Yet, even with the AMI, it is not enough to fully address all issues linked to the flow of power at any moment. A controls platform must also consider the accumulated energy, especially when dealing with battery resources. In the case of Onslow, the DERMS is designed to forecast out 24 hours in advance while optimizing DER assets every 5 minutes. A DERMS does not just view the generation forecasts of DER assets such as solar—it also monitors customer load forecasts at various points within the network.

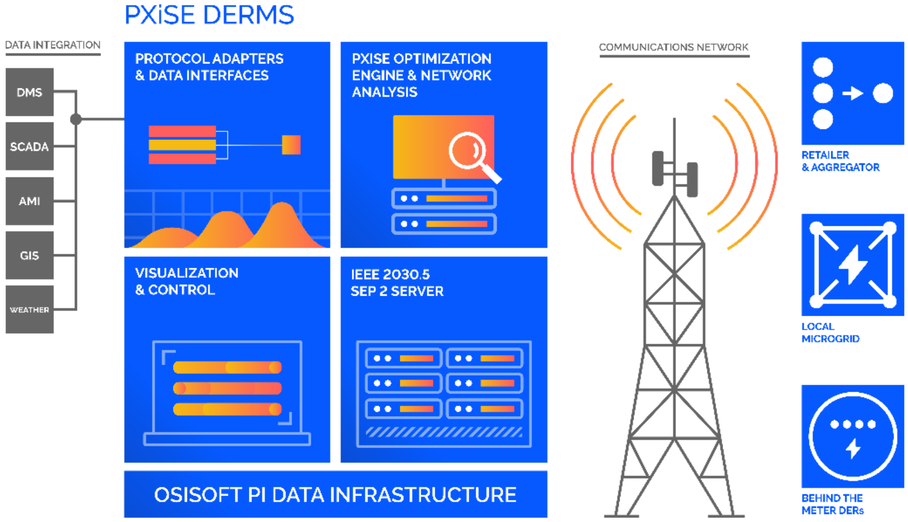
The DERMS uses the information in a multi-objective optimization, balancing different project goals: reliability, economics, emissions, and maximum renewable energy integration. To sum it up, an advanced DERMS reforecasts every 5 minutes via an algorithm that accounts for real-time data and blends it with past patterns to make real-time decisions based on the current available information.

Another key area in deploying the DERMS related to cybersecurity, which is where the importance of the IEEE 2030.5 protocol server certification comes in.

With such a wide territory containing varying weather concerns (i.e., coastal vs. inland), location-specific weather forecasting is critical. Single-value forecasting provides limited data for making optimal decisions. When using a single value, a middle- or worst-case scenario must be used to execute at the sensitivity level required in a low inertia system. Horizon Power introduced probabilistic forecasting data such as customer loads, weather, cloud cover, and other variables to the DERMS' optimization engine, boosting confidence levels (i.e., measures of variance) to take additional steps to improve overall system reliability.

Another key area in deploying the DERMS related to cybersecurity, which is where the importance of the IEEE 2030.5 protocol server certification comes in. The IEEE 2030.5 protocol enables secure communication to any DER asset with enabled gateways (a requirement in California for all new inverters and an emerging worldwide standard). It creates an open marketplace for communication with solar, storage, EVs, and smart home devices without the more common siloed approach to manage these devices. If compared with AutoDR and other dispatch-based communications, the IEEE 2030.5 server protocol provides a more secure and accurate methodology for the control of many thousands of DER assets at scale. PXiSE the first company to acquire this server certification and is also the first company to have one deployed in a production environment at Horizon Power.

Figure 3 PXiSE DERMS Topology



(Source: PXiSE Energy Solutions)

The IEEE 2030.5-certified server uses protocols similar to online banking transactions. The server communicates digitally via standard secure Ethernet connections to individual DER electronic controllers or phasor measurement units and to the point of interconnection (in the case of Onslow, a private 4G network provided by an Australian telecom). What the protocol does not specify is how often and in what ways to use the available communication pathways. Horizon Power pays for server usage based on traffic generated on the 4G network. Horizon Power and PXiSE collaborated to determine the appropriate frequency that clients requested certain datasets from the server. Similar to checking the speedometer or rearview mirror in a car, one does not need constantly check them to maintain safety, but they do need to reference them at key intervals. Ultimately, the DERMS was configured to reduce the bandwidth traffic linked to DERMS optimization usage by 75%, resulting in a direct ongoing cost savings to Horizon Power.

The Customer Story

The customer story for Horizon Power is shaped by the topography of Western Australia. The service territory covers more than 888,000 square miles—or 2.3 million km^2—but has a customer base of only 47,000 including those in remote towns, coastal communities, agricultural operations, and remote mining sites. While one might think this customer base would lessen the relationship between utility and customers, quite the opposite is true. Isolated communities, and the need for electricity for cooling and essential services in harsh Western Australia, instead means these customers may have even closer relationships with their utilities, despite the massive physical separation.

A key example of the tight bonds between utilities and their customers is Onslow. The previous system serving this community was dominated by fossil fuel power generation, which was costly and imparted a large carbon footprint. Limitations on new solar rooftop PV had been put in place in some microgrids due to constraints on network hosting capacity, leaving Horizon Power and its customers in a bind. To generate more of Onslow's electricity from renewable sources, Horizon Power, with the help of its new DERMS platform, integrated traditional and renewable power resources to reduce emissions while maintaining the utmost reliability.

Horizon Power wanted to ensure its customers were not limited by reliability concerns in their ability to install rooftop solar panels or batteries.

Horizon Power wanted to ensure its customers were not limited by reliability concerns in their ability to install rooftop solar panels or batteries. With the capabilities embedded in both the microgrid controls and DERMS platform, Horizon Power enabled a three-fold increase in renewable hosting capacity for its Onslow customers. This increase was possible because the DERMS was optimized with pertinent data regarding the distribution network, the weather, the installed customer-owned DER assets deployed, and a host of other inputs (including regulations relevant to Horizon Power), all while increasing the reliability of the system. For Onslow, the microgrid and DERMS combination offers the following benefits:

- Integrated a 1 MW utility-owned solar PV array with two 1 MWh batteries connected at the utility substation
- 260 customer solar PV installations, representing over half of the microgrid customers, totaling another 2.1 MW in clean energy capacity
- 500 kWh of customer-installed distributed battery systems, including smoothing systems (2.5 kW/10 kWh)
- Opportunity for an additional 200 kW of customer-owned DER assets to be interconnected in the near future

The DERMS is enabling its customers to become prosumers by incorporating customer-sited rooftop solar PV bundled with battery storage, which allows these customers to help build a more resilient and sustainable energy future. In a virtuous cycle, the DERMS also provides Horizon Power opportunities for new utility customer offerings for Onslow residents. The utility could perhaps expand out to use of EVs as a grid resource and new innovative demand management programs such as demand response. Moving forward with a DERMS rather than waiting for forecasted growth in EVs and rooftop solar PV paired with batteries allows a utility to anticipate problems likely to arise while capturing the full embedded value of DER assets today. The new combined microgrid controls and DERMS platforms shrink costs to the utility and its customers, while maintaining alignment with government carbon reduction goals.

Lessons Learned from the Three Stories and Next Steps

To decrease generation costs and provide more sustainable electricity to its customers, Horizon Power was looking to install solar power and additional storage to supply more of the region's energy demands with renewable sources and integrate more customer-sited BTM distributed generation assets. This is a network story: Horizon Power wanted to increase hosting capacity for customer-owned renewable DER assets, while maintaining or improving the reliability and stability of the system. It is also a technology story: Horizon Power and PXiSE were challenged to take the newly launched IEEE 2030.5 protocol and bring it to life for the first time worldwide in a production environment. The DERMS had to overcome the challenge of a potentially noisy server passing critical data back and forth. This is a customer story, too. Along with enabling customer-owned clean energy DER assets, the 11 MW microgrid is expected to reduce over 55,000 GJ of natural gas consumption; this reduction translates into a huge decrease in Horizon Power's fuel expenses, lowering costs across its entire network while also reducing 3,000 metric tons of CO_2 annually.

With the success of the Onslow microgrid as a focal point, the long-term vision is to enable Horizon Power's 30 or more additional community microgrids and nine new generation and network battery systems, while expanding customer solar and storage. The utility is also exploring the role of hydrogen, which can serve as a form of storage, in the continuing path to a more sustainable energy future. The application of a DERMS in Western Australia zeroes in on grid stability challenges common around the world by applying technology designed for industrial-scale power grids, leveraging DERMS over a fleet of disconnected remote microgrids. The stated goals of Horizon Power for the Onslow project are applicable to utilities around the world: helping customers self-generate with clean renewable energy, improving reliability, and extending the life of exiting utility infrastructure while decreasing costs and emissions.

Horizon Power's Goals

- Increase customer solar hosting capacity
- Maintain or improve reliability and life of assets
- Reduce reliance on natural gas and diesel generation and reduce emissions
- Provide more sustainable electricity from renewable sources to its customers
- Decrease generation costs

The lessons learned in Western Australia have clear implications for developing world markets throughout Asia Pacific, Africa, and Latin America as well as for industrialized markets in North America and Europe. As remote microgrids evolve organically, Horizon Power is showcasing a DERMS application that is expected to grow over time. A DERMS can not only enhance real-time operations, it can define and enable longer-term plans for customer programs that create shared benefits between utilities and prosumers.

Acronym and Abbreviation List

AMI .... Advanced Metering Infrastructure

AutoDR .... Automated Demand Response

BTM .... Behind-the-Meter

CO_2 .... Carbon Dioxide

DER .... Distributed Energy Resources

DERMS .... Distributed Energy Resources Management System

EV .... Electric Vehicle

GJ .... Gigajoule

IEEE .... Institute of Electrical and Electronics Engineers

km^2 .... Square Kilometers

kW .... Kilowatt

kWh .... Kilowatt-Hour

MW .... Megawatt

MWh .... Megawatt-Hour

PV .... Photovoltaic

US .... United States

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Scope of Study

Guidehouse Insights prepared this white paper, commissioned by PXiSE, to provide deep insights derived from a single case study of a remote microgrid operated by Horizon Power in Australia that is testing out new and important applications for DERMS technology. It is designed to provide lessons learned for utilities looking to transform to address growth in DER assets populating their distribution networks.

Whether the primary driver is resiliency or a long-term DER management strategy, this white paper offers a roadmap for utilities to explore both. It summarizes the key elements of success for a project that combines microgrid and DERMS goals to serve the remote community of Onslow, noting the important role of digital controls in meeting the needs of customers and their utilities. This is the second of two white papers commissioned by PXiSE; the first white paper focused on BTM and front-of-the-meter microgrids deployed in the US by Portland General Electric and San Diego Gas & Electric.

Sources and Methodology

Guidehouse Insights' industry analysts use a variety of research sources in preparing research reports and white papers. The key component of Guidehouse Insights' analysis is primary research gained from phone and in-person interviews with industry leaders including executives, engineers, and marketing professionals. Analysts are diligent in ensuring that they speak with representatives from every part of the value chain, including but not limited to technology companies, utilities and other service providers, industry associations, government agencies, and the investment community.

Additional analysis includes secondary research conducted by Guidehouse Insights' analysts and its staff of research assistants. Where applicable, all secondary research sources are appropriately cited within this report.

These primary and secondary research sources, combined with the analyst's industry expertise, are synthesized into the qualitative and quantitative analysis presented in Guidehouse Insights' reports. Great care is taken in making sure that all analysis is well-supported by facts, but where the facts are unknown and assumptions must be made, analysts document their assumptions and are prepared to explain their methodology, both within the body of a report and in direct conversations with clients.

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Note: Editing of this white paper was closed on January 5, 2021.