NAVIGANT RESEARCH

WHITE PAPER

Distributed Energy Resources Management Systems

Defining DERMS Use Cases and Value Propositions

Published 4Q 2018

Sponsored by AutoGrid

Roberto Rodriguez Labastida
Senior Research Analyst

Peter Asmus
Research Director

Brett Feldman
Research Director

Section 1
EXECUTIVE SUMMARY

1.1 Introduction

Distributed energy resources (DER) are starting to proliferate in many regions of the US and around the world. There are numerous technology, policy, and customer-driven factors contributing to this growth. This is a positive trend from an economic and environmental perspective. However, if the location and operation of DER is left up to customer adoption, there could be detrimental effects on the electric grid from an overall operating standpoint unless they are optimized properly. This is where distributed energy management systems (DERMS) come into play.

Electric utilities and other energy service providers use DERMS to manage multiple DER types in a single system. Rather than relying on proprietary communication protocols for each vendor and device, DERMS use common protocol standards to centrally administer all DER on the grid. This construct saves the operator from having to manipulate multiple systems from multiple vendors for multiple device types, which would make DER management almost untenable from a staffing and operational position.

Numerous use cases for DERMS exist depending on the type of energy provider and the regulatory and market environments in which it operates. However, no common definition of DERMS is agreed upon in the industry, and it is often confused with other similar systems that may be used by energy companies to accomplish different goals with DER. This white paper addresses that confusion by first defining DERMS and then lays out the business cases for grid operators to confidently deploy DERMS to meet their operational needs.

Among the solutions to the dilemma described above is the concept of DERMS. While other aggregation, optimization, and control platforms can also address the challenges associated with increased DER deployments, DERMS comes fundamentally embedded with the utility or grid operator perspective. There are a variety of reasons why the electric utility industry is moving forward with DERMS technology.

Perhaps the best way to understand the significance of DERMS is to look at three specific use cases that underscore how this technology evolution is now necessary given emerging market trends. These use cases drive the necessity for new approaches that span behind-the-meter (BTM) assets to utility infrastructure, both being integrated into market applications not previously possible but now viable due to technology advances. Three broad use cases are described below:

- **BTM Optimization and Microgrids – Consumer Level**. Benefits flow primarily to end-use customers: bill management, self-consumption optimization, resilience, and demand charge reduction (primarily for commercial and industrial customers).

- **DER Management – Grid Services.** Benefits flow primarily to utilities and DSO/DNO, such as monitoring (telemetry data, active and reactive power, power quality, voltage, frequency, breaker status, etc.), forecasting and dispatching DER; and can be enhanced by the integration with traditional IT systems such as DMS/ADMS or SCADA.
- **BTM Optimization – Market Applications.** Benefits flow primarily to transmission level and wholesale markets, such as energy trading and ancillary services (i.e., resource adequacy, frequency regulation, peak load management, voltage support, etc.) and include legacy demand response (DR) applications.

Figure 1-1 sums up the full spectrum of DERMS use cases. Note that not all additional use cases were described above, as the platform is still evolving and use cases are proliferating. These include resource adequacy requirements, which are changing due to the shift from a reliance upon centralized generation to diverse DER. Other use cases include interconnection optimization and optimization of BTM assets to the benefit of the utility and larger grid network.

Figure 1-1. Summary of DERMS Use Cases

Beyond the Meter		T&D	System
Customer Engagement	**Site Optimization**	**Grid Services**	**Market Applications**
• Program enrollment • consumption and DER performance reporting • Savings tips	• Time-of-use shifting • Demand charges reduction • Solar self-consumption • Microgrids including resiliency	• Situational awareness (DER monitoring, forecasting) • Peak load management • Targeted congestion relief (e.g., non-wire alternatives, upgrade deferrals) • Interconnection management (e.g., Rule 21) • Renewables integration • Load shaping • Power quality optimization (e.g., VVO) • Integrated grid management (e.g., Outage management and FLISR support)	• Virtual power plant (VPP) management • Capacity contracts and trading • Energy trading • Ancillary services: reserves, frequency regulation, voltage support

(Source: Navigant Research and AutoGrid)

This white paper details the challenges DER poses to the grid. These challenges serve as a catalyst for business model innovation linked to the new capabilities of DER optimization and DERMS. Rather than being the source of a problem, DERMS transforms these DER assets into solutions. DERMS allows utilities to move beyond legacy DR programs to reach out and control a greater diversity of DER assets to provide a much broader suite or grid services. Such assets encompass solutions such as non-wire alternatives, power quality, reliability, and resiliency.

This white paper concludes with three case studies. The first is Xcel, which is using DERMS to consolidate DR/DER information into a single system. Second is National Grid, which is using DERMS to create a single system of record for its DR/DER programs. And finally, New Hampshire Electric Cooperative, which is using DERMS to provide grid services via automated dispatch based on feeder conditions in specific grid locations.

Section 2
INTRODUCTION TO DER AND DERMS

2.1 Definitions of DER and DERMS

Over the last few years, the consolidation of distributed energy resources (DER) has represented a significant component of the energy market. Initially, DER was used at the fringe of the market, where conventional power was difficult and expensive to provide. However, technology advances, business model innovation, changing regulations, and sustainability and resilience concerns have brought DER into the core of the future deployment of energy infrastructure and services. Encompassing a broad set of solutions that include systems and technologies designed to operate closer to customers on the electricity grid, the global proliferation of DER has begun to have a significant—and at times controversial—influence on the electricity system and industry.

The following technologies are considered in the DER definition:

- Behind-the-meter (BTM) and distribution level generation, both considered distributed generation
  - Distributed solar PV
  - Small and medium wind turbines
  - Microturbines
  - Stationary fuel cells
  - Combined heat and power (CHP) generators
  - Backup generators
- Distributed energy storage systems
- Microgrids
- EV grid integration (charging and discharging)
- Traditional demand response (DR)
  - Connected thermostats
  - Electric water heaters
  - Behavioral load shed/shift
  - Flexible commercial and industrial (C&I) loads
- Energy efficiency

In this broad pool of DER assets, rapidly expanding investment represents a major shift away from the centralized, one-way electrical grid that has been the status quo for the past century. This growth has generated both concern and optimism throughout the power industry as regulators and grid operators work to understand the evolving landscape and how it is redefining the relationship between utilities and customers. Specifically, the shift away from centralized generation requires the use of innovative technologies and solutions on the part of grid operators, including advanced software and hardware that enable greater control and interoperability across heterogeneous grid elements that are key components of the Energy Cloud.[1]

DER developments are challenging incumbent grid operating models, requiring a more dynamic and flexible network with advanced communications and orchestration to ensure stability, efficiency, and equality among diverse resources. This new system is now being described as a distributed energy resource management system (DERMS). It is a system capable of aggregating, optimizing, and controlling the long list of previously defined DER assets.

What then exactly is DERMS? Here is a proposed definition.

> *A distributed energy resource management system is a software-based solution to monitor, forecast, and control grid-connected and BTM DER across customer, grid, or market applications in real-time. These assets may be utility, third-party, or customer-owned, and directly or indirectly controlled by the utility.*

2.2 Regulatory Framework Market Drivers

Technologies have advanced to sense, control, aggregate, and optimize DER via DERMS. However, a complementary regulatory framework is required to maximize the value embedded in these asset pools (i.e., compensate DER to provide grid services). The following sections include some key regulatory drivers opening up near-term market opportunities for DERMS.

2.2.1 Variable Renewable Energy Integration

To integrate the new resources safely, an adequate regulatory framework is required. These will be different depending on how the market is shaped by policy and regulations.

Managed DER include customer-owned EVs, storage, and distributed generation such as rooftop PV and backup generators. This capability enables the bidding of diverse DER into wholesale markets, if regulations allow the provision of these grid services. Utilities in states with high levels of distributed and renewables generation—such as Hawaii Electric Company—have limited export of excess solar generation back to the grid due to feeder line saturation, for example. They also began testing DERMS to address the severe frequency challenges present on islanded grids that are not interconnected and therefore cannot shift excess generation to serve loads on nearly islands.

A renewable portfolio standard (RPS) is a policy setting a mandated target to derive a certain percentage of new power supplies from renewable energy sources. As of the

---

[1] Navigant Research, *Energy Cloud 4.0*, 2018.

summer of 2018, 29 states and Washington, DC featured RPS programs, promoting the deployment of variable renewables, including new DER, in this territory. While the RPS has historically focused on wholesale resources, these policy mandates are increasingly directed to renewable DER, hence serving as market drivers for DERMS.

2.2.2 Integrated Resource Planning and Distribution Resource Plans

An integrated resource plan (IRP) is a comprehensive decision support tool and roadmap for meeting a state's or utility's objective to provide reliable and least-cost electric service to all its customers. It also addresses the substantial risks and uncertainties inherent in the electric utility business.

The IRP concept is being applied to DER as they consist of a larger portion of the overall state or utility supply portfolio. In some jurisdictions, this has become known as a distribution resource plan (DRP). Part of the purpose of applying this concept to DER is to better understand where deployment of DER makes the most sense in terms of wider grid stability. From that perspective, a DRP could help map out opportunities for DERMS priority pilot programs.

2.2.3 Non-Wires Alternatives and Capital Investment Deferral

As a result of DRP progress, utilities are starting to look at ways to use DER in place of standard infrastructure projects. Traditionally, when a transmission or distribution system operator needed to upgrade or replace infrastructure due to aging equipment or increased load demand, it would simply conduct poles and wires projects on which it could earn a regulated rate of return. However, as grid management and DER technologies have improved, utilities see some traditional transmission and distribution (T&D) investments not only as risks but also as requiring long lead-times. Policy concerns related to cost and environment impacts attached to large transmission line developments have also grown. In reaction, more creative solutions are being explored to address infrastructure needs at a lower cost with greater customer and environmental benefits. These types of projects are now encouraged by regulators and are known as non-wires alternatives (NWAs).

Policies in US states such as New York, California, Michigan, and Massachusetts promote the exploration of NWAs as alternatives to traditional grid investment to reduce costs to the customer.

2.2.4 Interconnection Requirements

From California, Rule 21[2] highlights the importance of the interconnection requirements necessary to ensure an orderly and smart way to bring online new DER. The new version

[2] California Public Utilities Commission, "Rule 21 Interconnection," http://www.cpuc.ca.gov/Rule21/.

of Rule 21 requires smart inverters, which are embedded with power electronics enabling which can communicate with a DERMS to change various operating parameters.

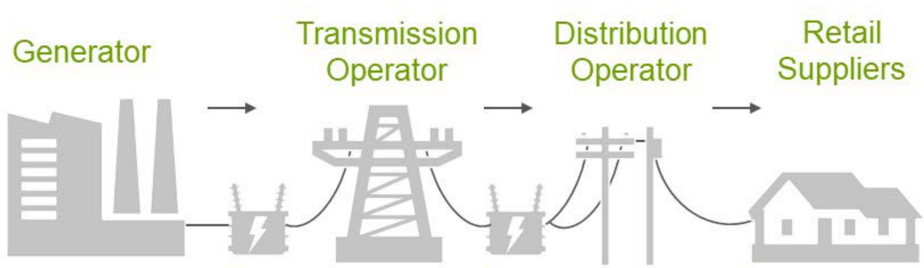
While other states have similar policies, Rule 21 is viewed as the national trendsetter in establishing tariffs that prescribe the interconnection, operating, and metering requirements for new generation facilities to be connected to a utility distribution system. For customers wishing to install new inverter-based DER—including energy storage—on their premises, the tariff provides access to the electric grid while protecting the safety and reliability of the T&D systems at the local and system levels.

2.3 Market Participants

DER open the door for new participants to enter the electricity system. Traditionally, systems with vertically integrated utilities are a regulated monopoly, while unbundled markets have four main type of organizations: generators, transmission system operators (TSOs), distribution network operators (DNOs), and load serving entities (LSEs), or energy suppliers (also known as energy retailers). DER expand the type of participants and the role traditional participants change.

Figure 2-1 shows the typical flow of electricity and where each of these traditional players falls along the chain.

Figure 2-1. Electricity Value Chain and Players



(Source: Navigant Research)

2.3.1.1 Traditional Power Utilities

Traditional players are affected by DER as there is new competition coming directly BTM. This reduces the net load seen in the system and, in some points in time, DER can be a net contributor to the grid. DER also increases the uncertainty in the grid as operators are completely blind with regards of DER-deployed BTM and, for the first time, operators face a two-way flow of electricity with the added problem of having intermittent resources in the network.

To cope with the transitions, operators need new systems that allow them to interact with DER. A smart utilization of DER could allow operators to defer grid reinforcement projects and manage planned and unplanned interruptions with minimal impact to their customers.

Energy suppliers could offer DER solutions to their customers and use them to offer services to the grid. The grid of the future will be a two-way system as shown in Figure 2-2.

Figure 2-2. The Energy Cloud

(Source: Navigant Research)

Some of the new types of players that have entered the DER space are described in Section 2.3.1.2.

2.3.1.2 Community Choice Aggregators

A growing number of local governments in California are taking advantage of a community choice aggregation (CCA) law passed back in 2002. Since California's initial foray into retail deregulation and customer choice ended in the so-called Enron disaster in 2001, the only way for residential customers to choose new power supplies is either to install rooftop solar or be part of a CCA. CCAs are somewhat limited in what they can do in creating community microgrids, since the incumbent investor-owned utility (IOU) still controls the distribution grid, but they do provide a framework for DERMS, especially as CCAs make the transition from a reliance upon wholesale power purchases to integration of DER. However, since incumbent utilities still maintain the grid, the role of CCAs would still need to be coordinated with these utilities. Other states that feature CCA programs include Illinois, Ohio, Massachusetts, New Jersey, New York, and Rhode Island.

2.3.2 Non-Utility Project Developers, Aggregators, and Energy Service Providers

As the BTM options for energy procurement and management increase and utilities open options for grid participation, the role of project developers and aggregators are converging into a new type of third-party energy service providers (ESPs) that optimize customer sites while using excess flexibility for economic value.

Some project developers are evolving their solutions, expanding from a development and engineering, procurement, and construction job to offering energy as a service through performance-based power purchase agreements where developers keep ownership and asset management of the project.

DER also benefit customer aggregators. Traditionally, aggregator opportunities were limited to industrial equipment assets with high energy consumption and some flexibility. The wide deployment of DER increases their potential asset pool significantly; for example, including commercial and residential HVAC units through smart thermostats, if the aggregator's device management costs can be reduced.

Unlike the old project developer or DR aggregator, the new ESPs need to understand their customer energy needs to be able to optimize it through the lifetime of the assets. This includes monitoring and forecasting existing assets, validating potential savings through the deployment of new technologies, and capturing opportunities created in grid services. To keep costs down and be able to scale, the new ESPs will need to use fast acting intelligent platforms to enable a fully automated process.

2.3.3 Energy Consumers and Prosumers

Because of a reduction in cost of residential DER technologies like solar PV roofs, batteries, and smart appliances, residential consumers have cost-competitive options to satisfy their energy needs. DER installations also help residential customers mitigate against changes in energy costs, and integrating these assets with the grid opens new opportunities. For example, residential customers on a time-of-use rate can use energy storage to reduce their electricity bill through bill management. The monetary value of such a service flows directly to the end customer.

Like residential customers, DER cost reduction also offers C&I customers ways to reduce need for grid electricity. In addition, the integration of DER allows C&I customers to optimize the use of other installed assets, like CHP units, gensets, or uninterruptible power supply units. C&I customers with DER assets (generation and smart loads) can recoup some value from the assets by participating in DR programs enabled by DERMS. Energy consumers are evolving into prosumers, capable of both producing and consuming energy services.

2.3.4 Challenges DER Pose to the Power Grid

At the bulk-system level, integrating DER requires a greater amount of flexibility and operating reserves. As a result, DER are ushering in a transformation from summer-only DR to 24/7 fast response resources deployable during any season or time of day, greatly expanding their value but also posing the need for more sophisticated monitoring and controls. At the distribution level, unmanaged DER results in localized power quality issues (e.g., voltage variability or reverse power flows) that lower the hosting capacity of a feeder. This requires grid operators to go from a systemwide dispatch to a targeted, granular, feeder-level dispatch. In short, a more surgical approach is necessary to resolve the impacts DER pose to the grid. However, it is also important to offer a pathway for these same DER to help resolve grid issues without turning to traditional centralized fossil generation to fill in gaps.

To provide such grid services, energy service companies need a platform to manage the portfolio of assets connected to their systems. This can be a complex task as companies try to aggregate smaller assets with multiple operational profiles and marshal them to deliver different services in real-time.

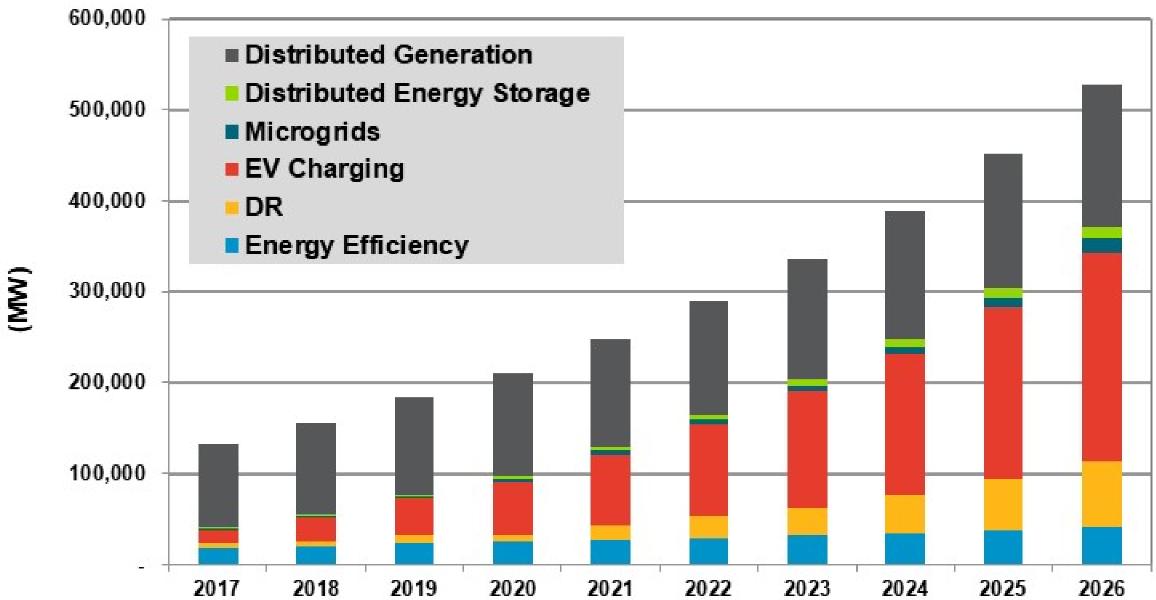
From the customer perspective, it is important that any integrated DER deployment and its management is transparent yet invisible to them. These deployments need to provide the same level of comfort and performance as a traditional energy contract with a minimum of integration hassle. This can only be achieved using advanced communication and analytics tools underlying a fully digitalized secure platform.

- **Interoperability:** Currently, the DER controls and communications space is fragmented with a variety of standards, networking protocols, and proprietary systems. In addition, not all devices talk or work together, which is preventing adoption among consumers and limiting revenue potential.
- **Data Privacy and Security:** Consumers are increasingly wary of adopting technologies that can potentially compromise their personal information, which can limit growth if strict measures are not implemented to protect consumers' privacy. Some of this risk can be mitigated by implementing end-to-end measures to protect customer data.
- **Lack of Public Awareness:** In some regions, there are clear economic benefits integrating DER systems. However, regulators, utilities, and other grid operators have little awareness of the advances made with hardware devices (such as smart inverters) and the new software control products harnessing machine learning to resolve previous negative effects of DER on overall grid reliability.
- **Cost:** Despite declining component costs, the cost of deploying DER is still significant under traditional business models, which hinders potential growth. Integrating these assets into smart grids via smart software systems opens new revenue opportunities, reducing the overall cost of the systems.

2.4 DER Are a Catalyst for Business Model Innovation

In 2017, 132.4 GW of DER capacity were added globally, growing to 528.4 GW in 2026 at a 16.6% compound annual growth rate. Currently, distributed generation leads new installations, but EV charging loads are expected to outpace distributed generation over the next decade. Navigant Research market forecasts also show that, beginning in 2018, annual new capacity additions from DER outpace capacity from centralized power plants.

Chart 2-1. Annual Installed Total DER Power Capacity by Technology, World Markets: 2017-2026



(Source: Navigant Research)

Traditionally, DER technologies have been developed by non-utility third parties, and that is still reflected in current market trends. In North America, there is a clear barrier between technologies pushed within the utility realm and deployments driven by consumer interest. In the European case, the push has been mostly consumer led through aggregators, as regulatory barriers forbid DNOs and TSOs from providing these services themselves.

The cost reductions of solar and wind generation, advanced batteries, and the digitization of the grid and loads offer a significant opportunity. However, that is only the case if these technologies are integrated. Integration is accomplished by optimizing different revenue streams, like self-consumption, electricity sales, and provision of grid services, to offer wide-ranging benefits to energy ecosystem stakeholders.

Integrated DER needs the backbone of an Internet of Things (IoT) infrastructure to operate at both the local and grid level. At the same time, key to ensuring these DER assets function properly is the ability to derive information from the data generated from integrated DER and external sources. Artificial intelligence and machine learning are playing a pivotal role in gathering insights from data to predict future behavior.

DER deployments have multiple potential sources of revenue, that energy service companies are targeting with new business models. DER can provide services to the whole electricity value chain, including BTM optimization, grid and ancillary services, and targeted flexibility to the electric system. For instance, for the grid operator, managing integrated DER offers an opportunity to optimize network use at a low cost and to defer grid upgrades by using NWA.

Despite the interest around the opportunity associated with integrated DER deployments, significant challenges still hinder growth in this market.

Section 3
THE JOURNEY TOWARD DERMS ADOPTION

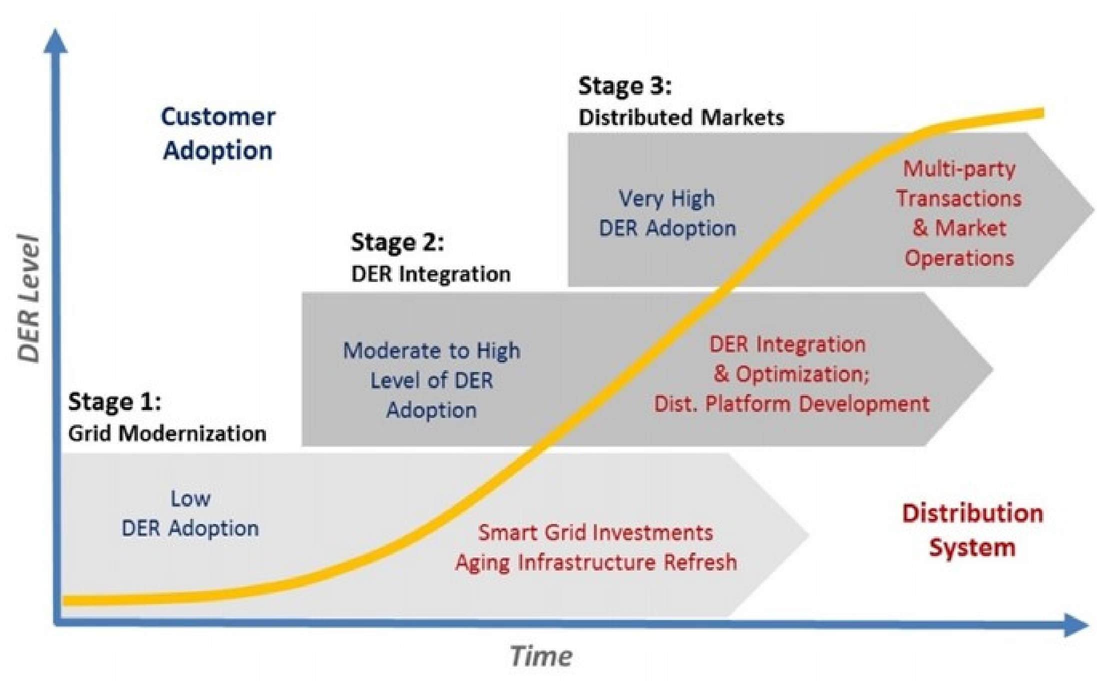
3.1 DER Management Technology Overview, Evolution, and Adoption

Navigant Research market forecasts show that beginning in 2018 annual new capacity additions from DER outpace capacity from centralized power plants. This trend only accelerates over time. As utilities and grid operators grapple with the challenge of managing a much more diverse array of DER, new technology and new business models are required.

The technologies designed to manage the increasingly diverse pool of potential DER assets being integrated into distribution grids range from hardware devices (such as smart inverters, SCADA systems, switchgear, and sensors) to software informed by increasingly sophisticated data analytics. As penetrations of DER increase over time, the focus of management technologies has tilted toward software that can initially help distribution level platforms through DER integration and optimization.

As DER levels increase, the focus shifts to distributed market creation involving multi-party transactions and integration with market designs (see Figure 3-1).

Figure 3-1. Prescribed DER Management Cycle

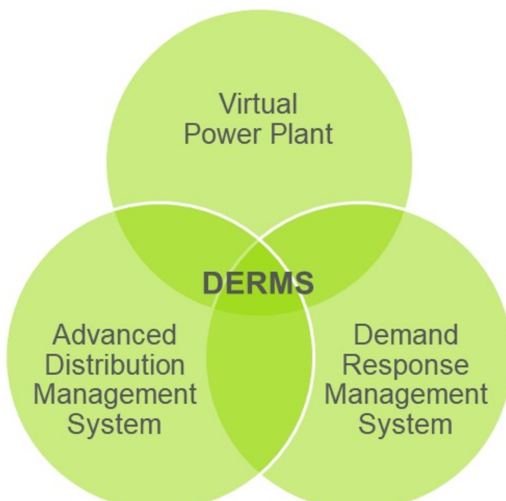


(Source: Lawrence Berkeley National Laboratory)

There are many different technologies that are marketed under the name DERMS. As such, a request for proposal for a DERMS is likely to see respondents that may not actually consider each other competitors. Incumbent IT/OT vendors, new entrants, and startups have each approached product development from different perspectives. One vendor stated that “[IT/OT] incumbents approach the market for DER as if it will be a bolt-on to a DMS or advanced DMS (ADMS), while startups have had to approach the problem in a ground-up manner, and you find non-traditional architectures.” Another vendor, commenting on the expansion of DR vendors into the DER management market, stated that these companies “apply a DR management philosophy to DER management, labeling it DERMS or VPP instead of demand response management system (DRMS).”

Figure 3-2 shows how these various vendors and systems are converging into DERMS. DERMS may have all of the capabilities of the other systems, but the vendors approach it differently.

Figure 3-2. Convergence to DERMS from All Sides



(Source: Navigant Research)

Interoperability is a linchpin to success. As the ecosystem of solutions becomes populated with long-standing and new vendor products, a level playing field whereby all devices can talk to one another becomes the end goal.

Centralized DERMS solutions are available from some vendors. Others have taken a distributed approach and are placing more of the intelligence closer to DER; still other vendors are incorporating this functionality into DMS or ADMS. To date, few actual DERMS solutions have come to market in standalone form. While the focus of DERMS is often on BTM assets, such systems can also optimize front-of-the-meter resource management and improve the overall grid stability.

3.2 DERMS Use Cases Overview

The key to understanding the purpose of DER management technologies flows from which side of the meter one might be focused on. For a utility, saddled with the obligation to serve, the top goal is always the provision of reliable and affordable electricity. To the consumer—and increasingly, the growing population of prosumers—the goal is often focused on reducing energy costs. As the costs of energy storage technologies continue to decline, resiliency has emerged as a new market driver for DER integration strategies at the customer site.

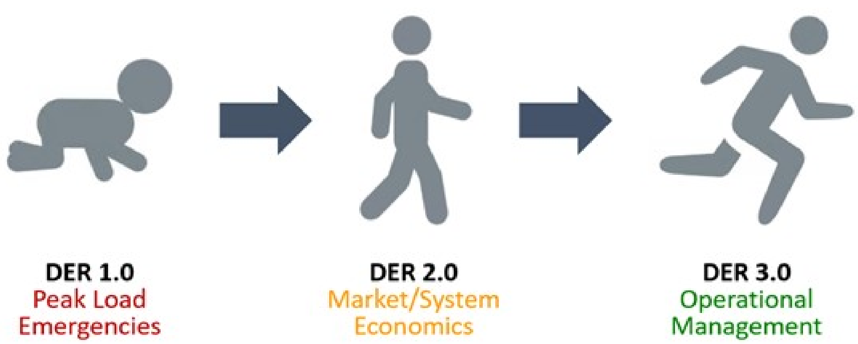
These two perspectives may seem in conflict, but it is not necessarily so. In tracing the evolution of DER management technologies a fragile consensus is discernable, revolving around a strategy shifting from a more top-down, centralized hierarchy informed by the long-standing centralized generation paradigm to something more distributed. A hybrid management approach may make the most sense, pushing out as much intelligence as possible to the edge, while still respecting the control requirements of the utility or other grid operator managing fleets of resources both old and new.

3.2.1 Moving Beyond Legacy DR Programs

Arguably, the most mature market among DER aggregation and optimization platforms is DR. A DRMS has some level and combination of DR program enrollment, device tracking, forecasting, dispatch, data communications, and settlement capabilities. Some vendors offer comprehensive DRMS solutions while others have systems that focus on specific parts of the value chain, specific customer segments (residential or C&I), or specific utility user types (IOU, municipal/cooperative, or retailers).

DR and DER more-broadly are evolving along a path, as shown in Figure 3-3. DER management technologies must grow along with the resources themselves by incorporating faster and more discreet capabilities.

Figure 3-3. Distributed Energy Resource Evolution



(Source: Peak Load Management Alliance)

One of the main purposes of the DRMS is to communicate with and control customer-owned assets at the customer premise. State-of-the-art DRMS systems allow for full automation of the entire DR call, respond, and settlement process. These systems can respond quickly to changing market conditions whether those changes are related to generation profile, sudden changes in weather, or more predictable daily or seasonal load swings.

Nevertheless, when automated DR is combined with energy storage to firm up contract commitments, the result is a more predictable and firm resource. If distributed generation is added to the resource pool a much more dynamic portfolio comes into play, enabling grid operators to reduce reliance on the centralized fossil fleet, which is in the process of being phased out in many major markets. The ability to add both generation and storage to DR is a common pathway to DERMS.

3.2.2 Grid Services Possible with DERMS

A variety of grid services are made possible with DERMS. Here are three of the most important:

- **NWAs.** A classic challenge to developing new power infrastructure is the large capital outlay required to finance such long-term investments. This capital outlay often does not consider the risk to future environmental regulation that may occur over the 20- to 30-year life of the project. The beauty of an emerging energy economy dominated by DER is that the risk associated with large long-term investments in T&D infrastructure could be stranded as markets evolve in an uncertain future. The ability of DERMS to control and optimize previously disconnected DER assets can substitute for larger scale and riskier investments in T&D infrastructure. With DERMS, these DER assets can be marshaled in support of grid reliability, which allows utilities and grid operators to defer any large capital investments until time regulatory certainty is better defined. Such DER aggregations, with the right DERMS, can also provide congestion relief at the distribution level, which then can also cascade value up the to the transmission system.
- **Power Quality:** DERMS offers a path forward in creating mechanisms by which the physical properties of electric current are managed safely and reliably. DERMS technology can foster a system whereby a full portfolio of grid regulation service, including voltage and frequency regulation, can be provided by the same DER components that were once feared to be the primary contributors to grid imbalances. One possibility is allowing smart inverters to provide voltage regulation services. EV charging systems could be tapped to resolve frequency deviations within a DER pool.
- **Resiliency and Reliability.** The ultimate purpose of DERMS is to fundamentally improve resiliency and reliability. For metrics, this means improving utility SAIDI (system average interruption duration index) and SAIFI (system average interruption frequency index) scores, but it also means improving the service to customers even

while threats to grid stability from extreme weather, wild fires, and potential earthquakes increase over time.

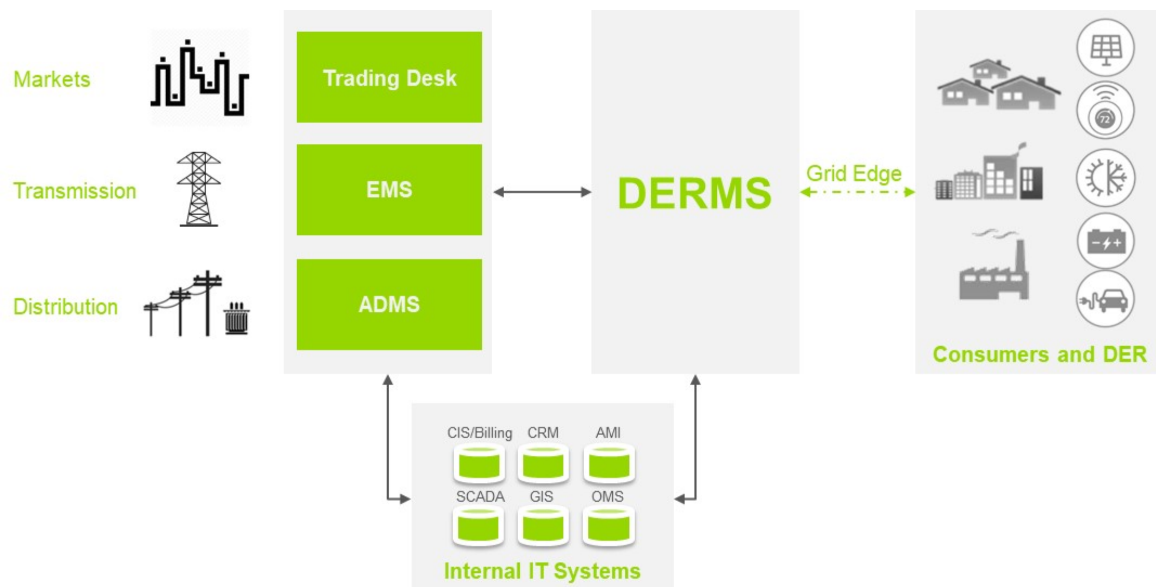
3.2.3 Microgrid Integration and Support

DERMS enables microgrids to improve resiliency through the application of islanding functionality from the larger grid when it is interrupted by weather, terrorist strikes, or accidents. This is a beneficial use case for microgrids deployed by utilities, which are designed to support the larger distribution grid. As microgrids offer up grid services from excess generation, they can be viewed as evolving into VPPs, as well as a DERMS framework as they may orchestrate with DER outside the boundary of the microgrid.

3.2.4 DERMS Use Case Summary

Figure 3-4 illustrates both the grid edge gap that DERMS seeks to build a bridge between, and the integration of a command and control paradigm with a customer choice model seeking to maximize the value of BTM assets. DERMS can perform these seemingly in-conflict goals if designed with state-of-the-art software that is informed by machine learning and artificial intelligence algorithms.

Figure 3-4. Using DERMS to Connect Utility and Customer Systems



(Source: Navigant and AutoGrid)

Section 4

CRITERIA AND TECHNICAL REQUIREMENTS

At a high level, a DERMS addresses where, how, and when DER can be used by a utility. This section summarizes the key functional requirements of a DERMS.

4.1 Energy Consumer

An essential role of a DERMS (as compared to an energy management system, ADMS, etc.) is to provide the context of the energy consumer in managing DER. These provisions are provided in Table 4-1.

Table 4-1. Energy Consumer Technical Requirements

Technical Requirement	Description
Enrollment	In enabling the deployment of a turnkey solution for a customer-facing program, a DERMS should include a simple enrollment portal that offers a complete customer onboarding process.
Engagement	DERMS should also include a customer engagement portal. This includes being the system of record for enrollment, providing billing information and customized energy insights to utility customers.
Customer Tariffs	Accounting for the nuances of customer tariffs is essential both in terms of factoring in any programmatic constraints on when and how often a given customer or DER might be called upon to provide flexibility, but also in terms of performing local optimization (e.g., demand charge management, self-consumption optimization, time-of-use bill management).
Behavior, Preferences, and Contracts	To permit the aggregation and dispatch of demand-side resources, customers often enroll in programs that require a contract between a utility/service provider and a customer. A DERMS needs to be able to display and manage parameters such as load drop commitments, opt-out frequency, and incentive payments.
Measurement and Verification (M&V) and Settlement	This is foundational for any type of load curtailment/shifting/shaping program, as consumers must be appropriately compensated for providing flexibility. Currently, the estimates used in M&V and settlement calculations are typically based on flexibility event calls compared to the historical trends (baselines) defined in a tariff and may not match the actual flexibility required by system operators at a given moment (as a DMS typically calculates). DERMS provide real-time operation data that can be used to measure the actual flexibility provided and inform the settlement calculations.

(Source: Navigant Research)

4.2 Support All Forms of Flexibility

A true DERMS needs to be a system of systems and support energy resources across all DER device types (behavioral DR, bring your own thermostat/device, storage, EV, energy efficiency, variable renewables), behind- and front-of-the-meter, all connectivity protocols, and all customer classes to ensure interoperability between the different assets and equipment providers within the asset class. Customer classes include residential and C&I

end-users as well as regulated utilities, DSOs, and deregulated retail energy suppliers. Resources can range from utility-scale renewables and generation to microgrids to small customer devices.

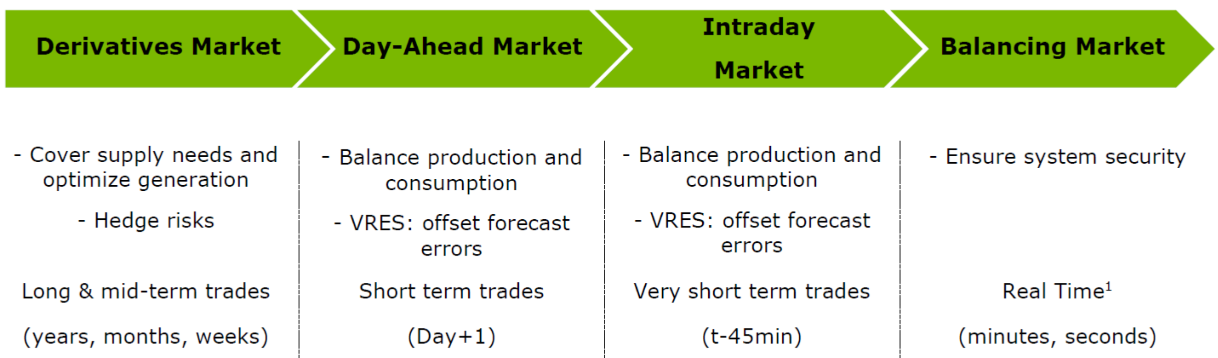
4.3 Scalability for Millions of IoT Devices

One of the challenges posed to the electricity system by DER is the diversity and sheer number of DER assets that will be present in the future grid. For this reason, a DERMS needs to be capable of forecasting and optimizing millions of DER assets and processing high volumes of data in near real-time, all done with high levels of security (as compared to existing DMS products that only consider dozens to hundreds of distribution assets and forecast and optimize a few times a day). This is known in the big data space as the four Vs: volume, velocity, variety, and veracity.

4.4 Real-Time Interactions

To provide functional value, DERMS need to offer solutions for a wide variety of scenarios. Figure 4-1 shows the different timeframes in which a competitive market operates; however, vertically integrated markets follow a similar process internally to create a dispatch order within their grids following technical requirements and economic options. These go from very long-term decisions (trades in the derivatives market in competitive markets), to close to real-time balancing decisions. DERMS need to be able to meet the timeframes and provide the services associated with each of these markets.

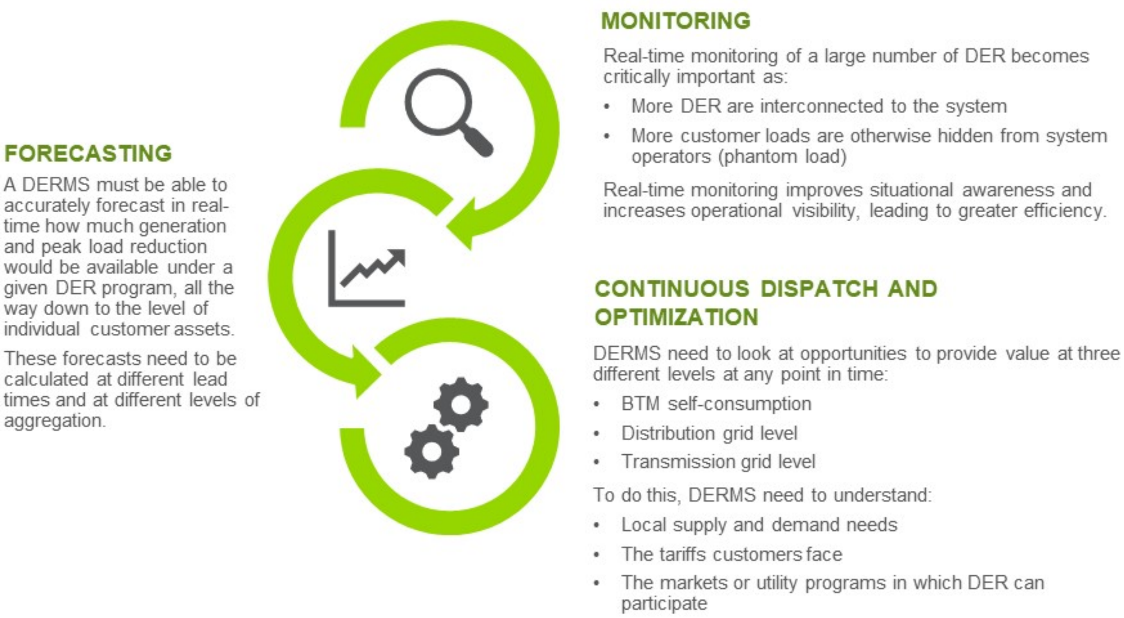
Figure 4-1. Clearing Order in a Competitive Electricity Market



(Source: Navigant Consulting, Inc.)

For this, DERMS need to provide visibility through monitoring for real-time operations and forecasting for longer term balancing mechanisms, and control to optimize and dispatch assets in real-time. Figure 4-2 shows the interactions than need to happen in real-time to balance the grid using DER.

Figure 4-2. Real-Time Interactions



(Source: Navigant Research)

4.5 Precision Dispatch (Temporal and Spatial)

- **Time:** Devices must be appropriately dispatched at precise times to take advantage of real-time market pricing, relieve grid congestion, and provide voltage and frequency support.
- **Locational:** Dispatches must be able to be targeted to specific components or portions of the electric grid. With DERMS, operators could target part of the grid under a single substation or even specific transformers on a granular basis, as opposed to an all-or-nothing capability.

4.6 Integration with Existing IT Systems

With the forecast growth in DER assets, utilities must invest in technologies that will mitigate the associated grid disturbances. Grid stability concerns and the resultant utility technology needs will be heavily dependent upon the mix of DER portfolios present in their territories, including their overall capacity, time of availability, and level of intermittency. DER impacts on the grid are unique to each type of resource, desired output, and level of penetration.

Greater visibility and control through a DERMS will help accommodate integrated distributed generation, demand-side management, energy storage, and energy efficiency programs along with (A)DMS systems.

A DERMS enables communications between the (A)DMS or SCADA system and DER and coordinates the portfolio of resources. In this way, it balances wind or solar generation with distributed synchronous generation (natural gas, diesel, or biogas), inverter-based generation, and flexible loads through DR. Electrical or thermal storage may also be integrated for additional flexibility. The DERMS of the future needs to enable real-time control of DER assets, enhancing the traditional capabilities of an (A)DMS.

4.7 Power Quality Support

Power quality is measured by the level in sinusoidal alignment of voltage and current phases. These become imbalanced naturally based on different customer loads, and this can be exacerbated by DER, requiring volt/volt-ampere reactive (volt/VAR) support.

4.7.1 Voltage Support

Voltage instability occurs when there is a high concentration of variable renewable assets pushing power on or off the grid at the same time. It can also occur through voltage drops due to the length of feeders and momentary intermittency that is common with rooftop solar PV. One of the primary use cases for DERMS is to be able to pinpoint localized voltage sags or spikes on the distribution grid, and then inject or absorb sufficient reactive power to resolve such threats to grid stability.

4.7.2 Frequency Support

Frequency support requires rapid response systems. Fast frequency response systems typically require that participants can be activated in seconds and must be automatic (under direct control of the grid operator). The ramping speed is 15 seconds to a deployment of 50% of the reserves and by 30 seconds, it must be fully activated. A slower frequency response market requires that the asset is available within 7 minutes and fully activated within 15 minutes. If DER assets are to participate in frequency support, they need to be coordinated effectively by the DERMS.

4.7.3 Contribute to the Resilience and Security of the Grid

As the DER market advances, new regulatory and compliance requirements are emerging, and will continue to emerge as DER and smart grid assets continue to proliferate. Utilities will need sophisticated IT systems to help meet regulatory compliance requirements around DER and smart grid devices in a regulated environment.

Compliance concerns will vary based on the region and the nature of the utility, but include:

- **Cybersecurity:** With the multiplication of DER devices in the grid, cybersecurity becomes a major issue as the potential attack points multiply. While adding DER will always have some risk, having a DERMS platform with enterprise-level security system and continuous monitoring can increase security significantly. With DERMS and ADMSs, utilities can add security across critical information systems—both behind- and in front-of-the-meter; and could include North American Electric Reliability Council Critical Infrastructure Protection reporting capabilities.
- **Reliability:** DERMS can act to mitigate unplanned outages and disruptive impacts associated with DER proliferation.
- **DER Planning:** DERMS (scheduling, forecasting, dispatch) and ADMS (power flow analysis) can assist with these planning activities.

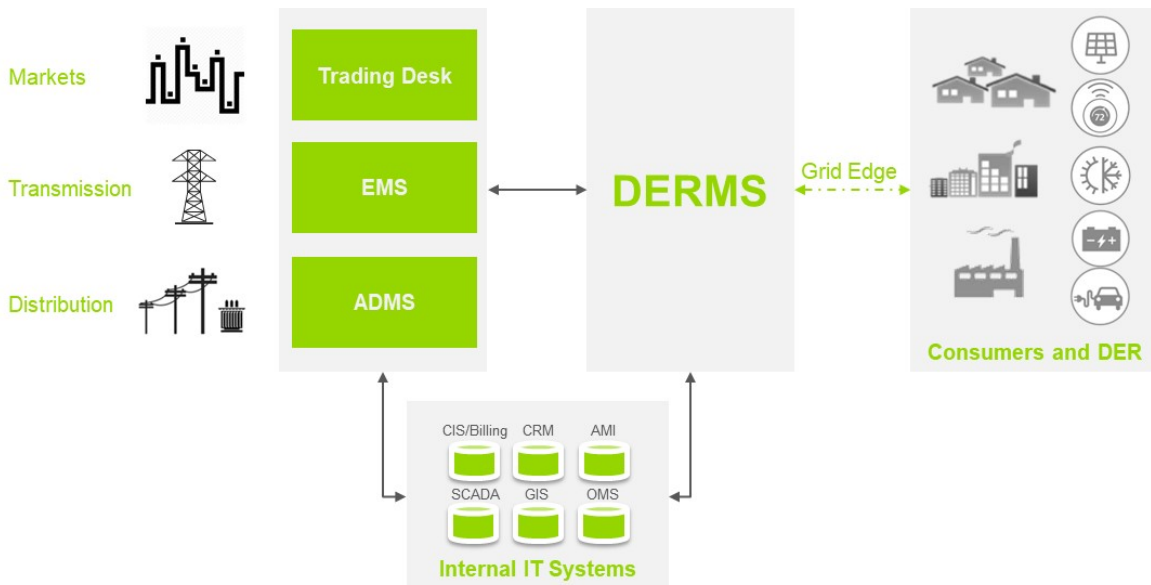
Section 5
DERMS CASE STUDY AND APPLICATIONS

There are several use cases for DERMS, as outlined in previous sections. This section provides case studies of three common cases:

- Consolidation of various DR/DER programs under a single system
- System of record for BTM DR/DER programs
- Grid Services via automated dispatch based on feeder conditions

Figure 5-1 provides some context as to how these use cases and the case studies below help validate DERMS technology for both utilities and grid operators, as well as for consumers with BTM assets.

Figure 5-1. Using DERMS to Connect Utility and Customer Systems



(Source: AutoGrid)

5.1 Xcel Energy: Consolidation of Various DR/DER Programs Under a Single System

Many utilities have DR programs that have been in use for years with little change or modification. These programs may have been built around a particular technology or platform that served a purpose at the time but has since become antiquated. With new DR technologies such as smart thermostats becoming more popular, utilities now have alternatives that may be more effective and at a lower cost than some of the older approaches to DR. Some utilities like Xcel Energy are looking for a centralized platform for consolidation of current DR programs while also providing a path for innovative DER programs in the near future.

In 2016, Xcel Energy set out to consolidate nine different programs, which are being delivered across a service territory that spans eight states all on a single management platform. These programs include C&I DR, direct load control via paging technologies, smart thermostats, and interruptible gas—among others. The AutoGrid Flex system was selected to manage these programs while also being the platform for future program development. The scope has since expanded to include the control of battery storage, which allows Xcel Energy to test out ideas on how a DERMS can control these versatile assets.

5.2 National Grid: System of Record for BTM DR/DER Programs

In addition to the consolidation of programs, some utilities seek out an enterprise DERMS platform that can act as their system of record for information flow to end customers, aggregators, the ISO, and state regulators. For National Grid, the focus was on robust analytics and comprehensive M&V capabilities that provided the company with a single system for managing the vast amounts of data associated with its DR and DER programs. National Grid saw the need for a system of systems to act as the dispatch control and data management platform for its DR initiatives.

The AutoGrid Flex platform is interfacing with other systems managed by third-party aggregators. The platform acts as National Grid's system of record for these DR programs much as the company's customer information system acts as its repository of all information related to its customers. This concept becomes even more important since National Grid, like many northeast utilities, is exploring more NWA projects that could involve many different DER aggregators and third-party systems.

5.3 NHEC: Grid Services via Automated Dispatch Based on Feeder Conditions

For one utility, the transition from a DRMS to a DERMS started with locational-specific dispatch of DR programs. New Hampshire Electric Cooperative (NHEC) wanted to tie its DR management system to its SCADA platform so that localized DR events could be called based on feeder loading levels. The AutoGrid Flex platform provides a mechanism to receive and monitor those levels and automatically creates direct load control events when thresholds are exceeded. Those events may last up to 2 hours in duration but typically last only for a few minutes until the loading levels decrease. NHEC has chosen to use load reduction to remediate distribution grid challenges with plans to explore the use of Flex to support DER aggregation and dispatch as its needs evolve.

Section 6
CONCLUSIONS

The pool of DER is growing due to numerous market drivers, with no slowdown in global growth in sight. While this trend could carry many benefits in terms of reducing overall supply investment risk, efficiency, and sustainability, there is also risk of it potentially impacting the grid in unintended ways if allowed to progress unmanaged. DERMS can play a key role in successfully preventing such a future, helping transform possible challenges to grid reliability into a more robust framework for resolving reliability concerns in a surgical manner.

DERMS have evolved from other energy management systems, including DRMS, ADMS, and microgrids. Each of those systems address specific needs of the grid operator, but none of them fully accomplish the holistic role envisions by DERMS. Utilities and other grid operators and energy providers are using DERMS to accomplish various goals such as resource adequacy, economic optimization, and grid services, among other cases. By defining what DERMS systems are, and what they can do, this white paper makes the case that new advanced software controls for enhanced asset management helps set the stage for the Energy Cloud vision.

While not every DERMS will meet all the technical requirements discussed in this white paper, those are the criteria that should be used to evaluate whether a system can meet the demands of the desired use case. If not, it will be difficult to accurately compare vendor systems and to then allow the potential customer to choose the best option for the job at hand. The requirements create a yardstick to measure success, paving the way for future upgrades to DERMS that can then be recognized as valid use cases in the future.

Figure 6-1. Summary of DERMS Use Cases

Beyond the Meter		T&D	System
Customer Engagement	**Site Optimization**	**Grid Services**	**Market Applications**
• Program enrollment • consumption and DER performance reporting • Savings tips	• Time-of-use shifting • Demand charges reduction • Solar self-consumption • Microgrids including resiliency	• Situational awareness (DER monitoring, forecasting) • Peak load management • Targeted congestion relief (e.g., non-wire alternatives, upgrade deferrals) • Interconnection management (e.g., Rule 21) • Renewables integration • Load shaping • Power quality optimization (e.g., VVO) • Integrated grid management (e.g., Outage management and FLISR support)	• Virtual power plant (VPP) management • Capacity contracts and trading • Energy trading • Ancillary services: reserves, frequency regulation, voltage support

(Source: Navigant Research and AutoGrid)

Section 7
ACRONYM AND ABBREVIATION LIST

ADMS .... Advanced Distribution Management System

BTM .... Behind-the-Meter

C&I .... Commercial and Industrial

CCA .... Community Choice Aggregation

CHP .... Combined Heat and Power

DER .... Distributed Energy Resources

DERMS .... Distributed Energy Resource Management System

DMS .... Distribution Management Systems

DNO .... Distribution Network Operators

DR .... Demand Response

DRMS .... Demand Response Management System

DRP .... Distribution Resource Plan

DSO .... Distribution System Operator

EV .... Electric Vehicle

gensets .... Generator Set

GW .... Gigawatt

HVAC .... Heating, Ventilation, and Air Conditioning

IoT .... Internet of Things

IOU .... Investor-Owned Utility

IRP .... Integrated Resource Plan

ISO .... Independent System Operator

IT .... Information Technology

LSE.......Load Serving Entity

M&V.......Measurement and Verification

NHEC.......New Hampshire Electric Cooperative

NWA.......Non-Wires Alternative

PV.......Photovoltaic

RPS.......Renewable Portfolio Standard

SCADA.......Supervisory Control and Data Acquisition

T&D.......Transmission and Distribution

TOU.......Time-of-Use

US.......United States

VPP.......Virtual Power Plant

Section 8
TABLE OF CONTENTS

Section 9

TABLE OF CHARTS AND FIGURES

Section 10
SCOPE OF STUDY

This white paper was commissioned by AutoGrid. It contains use cases and case studies highlighting AutoGrid's DERMS solutions capabilities for DER management and grid integration. Navigant Research conducted independent secondary research. Navigant Research white papers are designed to be objective, third-party documents. As such, Navigant Research does not endorse any specific company or products.

SOURCES AND METHODOLOGY

Navigant Research's industry analysts utilize a variety of research sources in preparing Research Reports. The key component of Navigant Research's 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 Navigant Research's 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 Navigant Research's 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.

Navigant Research is a market research group whose goal is to present an objective, unbiased view of market opportunities within its coverage areas. Navigant Research is not beholden to any special interests and is thus able to offer clear, actionable advice to help clients succeed in the industry, unfettered by technology hype, political agendas, or emotional factors that are inherent in cleantech markets.

Published 4Q 2018

1375 Walnut Street, Suite 100
Boulder, CO 80302 USA
Tel: +1.303.997.7609
http://www.navigantresearch.com

Note: Editing of this report was closed on December 13, 2018.