White Paper

Providing an End-to-End Approach to DER Integration

Utility DER Integration Programs Need to Align Their Approaches and Technologies to Create an End-to-End Solution

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Executive Summary: The Evolving DER Landscape

It is widely known that utilities face technological challenges due to the growth of distributed energy resources (DER) and intermittent generation sources. Every utility is experiencing an influx of DER on their grids. This transformation requires a transition from one-way power systems relying upon large centralized generation plants and conventional transmission and distribution (T&D) infrastructure toward a highly networked ecosystem of bi-directional power flows and digitally enabled, intelligent grid architecture. These changes are already occurring. It is just a question of how quickly utilities will leverage these technologies to optimize their operations and adapt to this evolving market landscape.

This emerging ecosystem seeks to redefine traditional market structures and relationships through the blending of traditional assets, services, and interactions to unlock new technologies, business models, and relationships. Changing customer needs, evolving policy and regulation, and accelerating innovation around assets and digital technology will drive the creation of more distributed transactions and dynamic business models. These developments will also spur a more democratized and sophisticated grid platform through a rapidly evolving ecosystem of incumbents and disruptors.

The unprecedented influx of edge-connected DER technologies is predominately driven by rapidly decreasing costs and climate action targets. Federal Energy Regulatory Commission (FERC) Order 2222 will accelerate the value of DER in organized markets in the United States. Order 2222 may further change the relationship between utilities and end use customers that have DERs. Aggregators will move aggressively to take on a role in relation to the customers, potentially leaving utilities at a disadvantage.

Technology is becoming a key enabler to the integration of DER and intermittent resources to the grid. To be successful, DER integration and grid modernization need to align their approach and technologies to improve reliability and resiliency while supporting greater flexibility and dispatchability. Utilities are deploying smart control devices and solutions that will enable them to integrate, control and manage their grid assets. There are three approaches utilities use to manage DER integration; either through the use of tools such as advanced distribution management systems (ADMS) or DER management systems (DERMS), or the strategy of do nothing. While there are differing views within the industry on which is the best approach, there is consensus that the grid must be reinforced with more intelligence and higher resolutions of control. Strategic investments in end-to-end systems must be made upfront and continuously by utilities to collaborate with customers in effectively harnessing the potential benefits of DER, to access new markets and enable new business models

Regulatory and corporate agendas are both driving initiatives to enable the net-zero carbon grid of the future. New technologies and smart automated systems are required to optimize increased renewable energy uptake while still enabling reliable, resilient, and cost-effective energy services. Grid outages due to extreme weather events emphasize the need for grid modernization technologies and solutions.

A new category of clean DER can deliver reliable, flexible power at a lower cost and with lower carbon emissions than competing solutions.

Utilities and industry stakeholders should use this opportunity to advance internal transformations and unlock the door to becoming orchestrators of a network of DER platforms.

Transformation at the Grid Edge

The energy transition is fundamentally shifting the way energy is produced, transmitted, and consumed. Moving from a centralized to a decentralized ecosystem requires the decision makers to manage and optimize disparate distributed energy resources (DER) such as demand response (DR) programs, photovoltaic (PV) systems, battery storage, and electric vehicle (EV) charging. The diversity embedded in these DER portfolios is a challenge and a great opportunity, as these DER assets can support a variety of mutually shared value propositions in the new energy landscape.

Declining technology costs for key DER assets such as solar PV, advanced energy storage systems (ESS), and the growth in EVs are driving widespread adoption of smaller, smarter, and cleaner energy systems. Nevertheless, navigating the energy transformation requires new approaches to integrating DER into the grid and onsite energy networks that bolster resiliency and foster sustainability. It will also require innovative business models that recognize previously hidden value for end users and the larger grid network. A fundamental rethinking of organizational and systems operations that embrace DER networks and their underlying technologies is better attuned to evolving demand and customer needs. The value of DER assets can be fully realized only if they are integrated into markets, customer sites, and the grid in a way that creates shared value.

From the customer perspective, value from DER depends on the arbitrage (difference) between the levelized cost of energy of the DER system and the retail prices that customers must pay for electricity, including any demand charges. A multitude of transformative energy trends are driving demand for DER technologies in global markets. These drivers result from natural market and technology evolution, as well as top-down initiatives by policymakers and utilities to support integration of DER into the grid to bolster resiliency. The following list includes some of these transformative energy trends:

- **Favorable DER economics:** Declining costs globally spurred DER adoption. Technology innovations, new business models, and incentives that lower the cost of ownership encourage businesses and commercial and industrial (C&I) customers to increasingly adopt DER in a portfolio-based approach.
- **Supply reliability:** Initially an issue raised by primarily C&I customers with critical energy needs (e.g., hospitals), this is a growing trend in disaster-, wildfire- and outage-prone areas such as California, the Pacific Northwest of the US, Australia, Chile.
- **Supportive regulatory and market frameworks:** Policymakers are becoming more invested in expanding the value proposition for DER, albeit at a slow pace. Favorable legislation, such as landmark FERC Order 2222 and comparable market rules in Australia and the EU, will facilitate and ease the integration of DER to the grid.
- **Non-wires alternatives:** One benefit of DER for many utilities is the ability to offset centralized generation costs and capital investment for the grid. A growing number of utilities are eager to explore the benefits of optimized grid management with DER to capitalize on these opportunities for savings.
- **Digitization across the electric industry:** Utilities and customers have become increasingly digital in the last decade. Through enhanced instrumentation and a desiloing of utility operations, digital transformation can help integrate disparate onsite DER like solar, storage, or EV charging

infrastructure. Synergies will emerge between utilities, technology and service providers, and building owners as traditional market roles give way to a more fluid, competitive ecosystem.

The Time for a DERMS Is Now

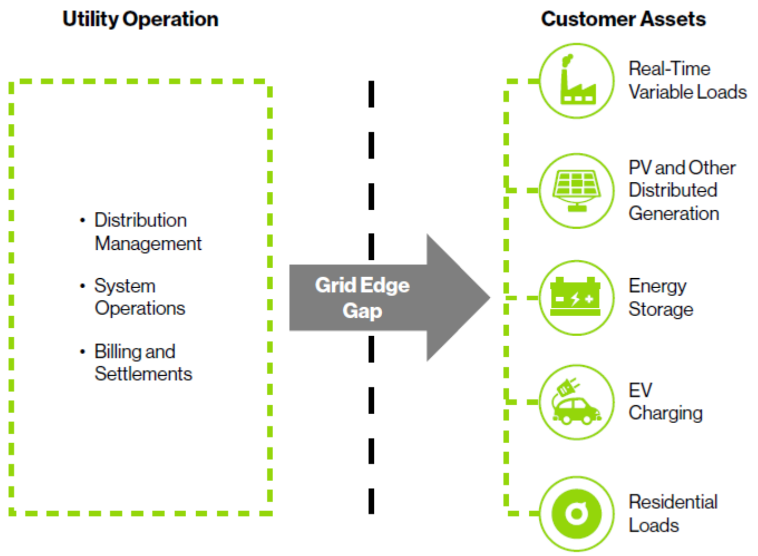
Distribution utilities know that DER growth entails grid-integration challenges including managing capacity constraints, equipment overloads, managing reverse power flow, and mitigating voltage/frequency issues. Leading utilities look beyond these constraint-based drivers in their recognition of the potential value of DER, while ensuring fairness to enable all DER owners to participate in energy markets for DERs in an equitable manner.

These utilities use DER as a means to provide valuable services to retail electricity customers and distribution grids. DERMS solutions enable distribution utilities to integrate high levels of DER penetration and potentially enable DER to increase grid flexibility and hosting capacity, all while increasing the reliability and safety of the system

Distribution utilities frequently ask when the right time is to deploy a DERMS. In many cases, utilities do not have tools, like an advanced distribution management system (ADMS), to actively manage their network. Other utilities look to deploy demand response management systems (DRMS) and are comfortable with the level of control that these tools provide. Finally, there is the pool of utilities with minimal DER pentation in their networks that question why they should invest in a DERMS at all.

There rarely is a need to wait for a complete ADMS deployment to install a DERMS, nor should utilities necessarily wait until they see high levels of DER before planning for a DERMS. Rather than rushing to a solution once a problem occurs, utilities should proactively modernize their grid infrastructure without adding exponential risk to the project. This lessens the probability of a customer-visible problem or crisis to manage, allowing for logical decision-making to prevail ahead of time. Another benefit of DERMS is the transparency and situational awareness it brings to the overall power system and its operators. This enables utilities to have more data-driven discussions with regulators, customers, and DER providers about issues like the impact of distributed solar and how to craft win-win regulations for utilities and DER hosts alike.

Figure 1 Future DERMS Designed to Close the Grid-Edge Gap



(Source: Guidehouse Insights)

Value Propositions Overview

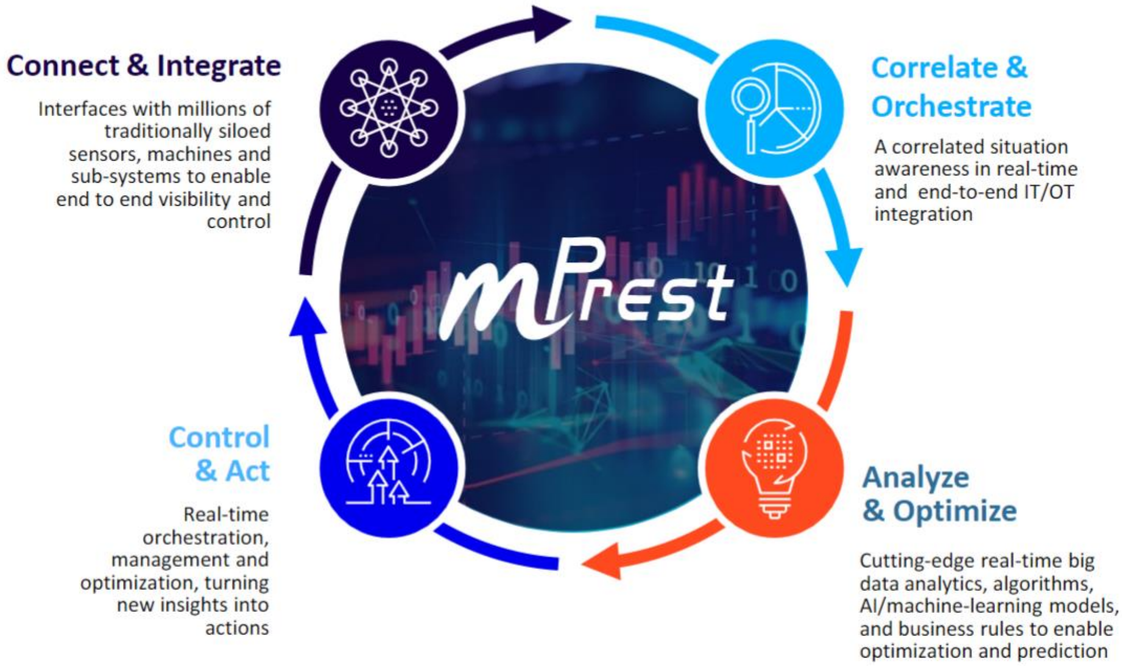
Although pockets of high penetration DER remain geographically isolated, steady improvement in adoption drivers have begun to support a more even distribution in many areas. This resulted in new opportunities and challenges for utilities, and DER vendors are keenly focused on how they can participate in this changing market. But as the roles of stakeholders evolve (from the end customer to the utility and all the way up to policymakers), many questions remain as to the optimal management of DER.

What is DERMS and how does it make such a great fit in today's evolving DER landscape? Consider the following definition:

> *A DERMS is a control system that enables optimized control of the grid and DER (to the extent that a utility may be able to dispatch and control DER). To minimize disruptions and the presence of phantom loads, utilities need to manage the grid more proactively. Common use cases include volt/var optimization (VVO), power quality management, and the coordination of DER dispatch (when possible) to support operational and emerging market needs.*

The best way to delineate segments of DER management technology is to associate them with families of complementary use cases. Over time, the market is likely to settle and demand will impose more consistent boundaries around different solutions. Local and regional market dynamics drive DER adoption, so adoption varies considerably across geographical locations. Although the average penetration of DER may be low in some local markets, its uptake across other regional hubs could be relatively high and significantly benefit investments in integration and control solutions. Figure 2 presents the breadth of capabilities and use cases enabled within the DER management continuum.

Figure 2 DER Management Continuum



(Source: mPrest)

Traditional ADMS Will Be Insufficient

Incumbent IT/OT vendors, new entrants, and startups have approached the orchestration of DER from different perspectives. IT/OT incumbents approach the market for DER as if it will be a bolt-on module to ADMS, while many startups have approached it in a ground-up manner using nontraditional architectures.

While ADMS and DERMS tend to be used in the same conversations, system objectives are more disparate than some vendors would have their customers believe. For utilities with an ADMS already in place, the next question is typically “why should we invest additional capital into an enterprise DERMS?” The answer is multifaceted and requires understanding of system architecture, scalability, and future requirements:

- **System Architecture:** ADMS typically control front-of-the-meter assets via traditional SCADA systems using a centralized, top-down approach; ADMS-based DERMS tend to focus on utility-scale assets, and often lack the requisite capabilities to extend DER management functionality (forecasting, aggregation, fleet management) to behind-the-meter (BTM) assets. While the core function of an ADMS is to enable the security and reliability of the distribution network and customer resiliency of supply, a DERMS should focus on the end-to-end optimization of both utility-scale and BTM DER assets, including aggregation, flexibility analysis, forecasting, and program awareness. This disconnect across ADMS-based DERMS highlights the need for more holistic DERMS solutions outside of the traditional ADMS architecture.

- **Scalability:** ADMS can optimize the planning and management of the distribution grid at low levels of DER penetration where effects to the grid are minimal. When more active control and monitoring are required, DERMS is required. As DER rapidly proliferate, the sheer number of assets slows down iterative load flow processing time and makes grid management more challenging for utilities. Furthermore, SCADA systems were not built to scale to all the new kinds of residential DER (e.g., EV charging, water heaters).
- **Future Requirements:** An ADMS is focused on substation and primary conductor optimization in front-of-the-meter. Alternatively, a DERMS's boundary extends to the entire feeder as populated with load and supply DER assets. This ability to support BTM DER is increasingly critical as the asset bases continues to grow rapidly. DERMS also has the ability to provide market services for DER assets without reliability constraints. And while nascent concepts like transactive energy receive a lot of industry buzz, their potential is still constrained by the lack of enabling technologies at scale.

Although common industry practice has been to deploy an ADMS prior to a DERMS, this can be misconceived. ADMS is one of the most expensive and complex software endeavors utilities can embark on. The nature of these mission-critical, modular control systems requires careful installation, integration mapping, cybersecurity, and more. The reality is many utilities begin multiyear ADMS deployment and integration projects without a path to actually solving the operational challenges associated with DER integration. Some utilities have flipped this transformation in recent years, instead opting to apply a DERMS to achieve short-term operational goals while identifying additional grid-related needs in support of ADMS deployment planning.

The development of modular ADMS in the mid-2000s pre-dated much of the DER proliferation witnessed today; this has helped create and perpetuate the idea that an ADMS is somehow required prior to exploring a DERMS, or that an ADMS is a sufficient alternative to a DERMS. As evidenced by the emerging concerns around architecture, scalability, and future requirements, this is not always the case. There is an increasing realization that while ADMS and DERMS bring the most benefits when working in unison, these distinct systems are not necessarily substitutes or prerequisites for one another.

DERMS Is Needed to Address Constraints of Today and Tomorrow

The role of utilities is shifting from meter-to-cash and network operations to more integrated service providers. As the industry ecosystem evolves, so does the role of industry stakeholders and utilities. Grid operators need to be cognizant of the changing energy landscape and augment their operations to address the growth in DER penetration and adoption of renewable technologies. This growth results in a need to visualize and operate within dynamic operating envelopes rather than static ratings.

As prices fall for renewable electricity generation assets and connections with the grid proliferate, power output is becoming variable. Although low penetration levels of intermittent power sources such as solar and wind do not have measurable effects on system stability, growing renewable generation capacity will demand DER optimization strategies for proper integration. DER management technologies can address some of the emerging and future challenges that the new energy ecosystem is likely to face.

The advent of the DERMS has created new opportunities to aggregate and dispatch rapid-response capacity across a variety of ecosystems, theoretically supporting use cases for an integrated energy ecosystem. A DERMS control system allows the utility or grid operator to proactively optimize its control of the grid and DER, reducing grid disruption and coordinating DER dispatch (where feasible) to support operational needs.

Demand for these solutions will continue oscillating given the variable nature of financial, regulatory, and technical forces around the globe. Examples of constraints that DER management technology segments can address include:

- **Grid Stability:** With the influx of variable power generation technologies on the grid, utilities will need to manage grid flexibility to avoid price escalations due to an unstable grid and meet regulatory requirements pertaining to grid performance. A DERMS is a grid management tool that is central to a utility's network operations and can help prioritize and aggregate resources to meet demand patterns across the grid. DERMS can be used surgically on the grid to minimize disruptions through use cases including VVO, power quality management, and coordination of DER dispatch to support operational needs. They may be embraced by network operators or utilities looking to coordinate DER such as battery storage and EV service equipment (EVSE) in vertically integrated energy markets.
- **Deferred Capital Costs:** DERMS can help serve the utility industry by supplying transmission and reliability operations solutions. However, the accelerating growth in DER assets can strain grid infrastructure, so it is imperative that utilities deploy DERMS to support capital cost deferral including infrastructure and generation deferrals.
- **DER Aggregation:** The evolution of energy markets is accelerating in the direction of a greater reliance upon DER that generate, store, or consume electricity. DERMS can help transform passive energy customers into active prosumers through the integration and optimization of technologies such as DR, solar PV systems, advanced batteries, and EVSE. Increasing DER adoption requires sophisticated orchestration across these disparate technologies across varied locations. Utilities will have to identify new business models and customer interaction points to support greater aggregation and synchronization across DER assets.

Presenting a System of Systems Approach to DERMS

Traditionally, utilities implemented digital solutions to address one-off use cases or singular challenges they face. This resulted in siloed IT and OT systems with low levels of native interoperability and data sharing. This is also true for the DER approach many utilities have taken, leaving operators with standalone, isolated systems for DER management and control, energy efficiency programs, DR management, or EV charger management. This is on top of traditional utility tools like ADMS, energy management systems (EMS), and trading platforms, creating an increasingly complex landscape for utilities to navigate.

As DER penetration increases in a utility territory, many utilities have encountered the limitations of these siloed approaches when attempting to optimize analytics, forecasting, and dispatching across the grid and utility enterprise.

Utilities face a dilemma. For those that have deployed siloed point solutions to address their DER needs, replacing them would be complex and expensive. At the same time, they limit their ability to integrate new DER and variable generation assets into the grid.

A system of systems approach is a low impact implementation approach and is compatible with a utility's existing systems and data processes

Utilities could deploy another siloed solution managing DER in their territory, but what utilities need is a tool that enables them to manage the new DER and to integrate their previously deployed systems to help them orchestrate old and new assets in the grid. In other words, a system of systems or a single pane of glass orchestration platform.

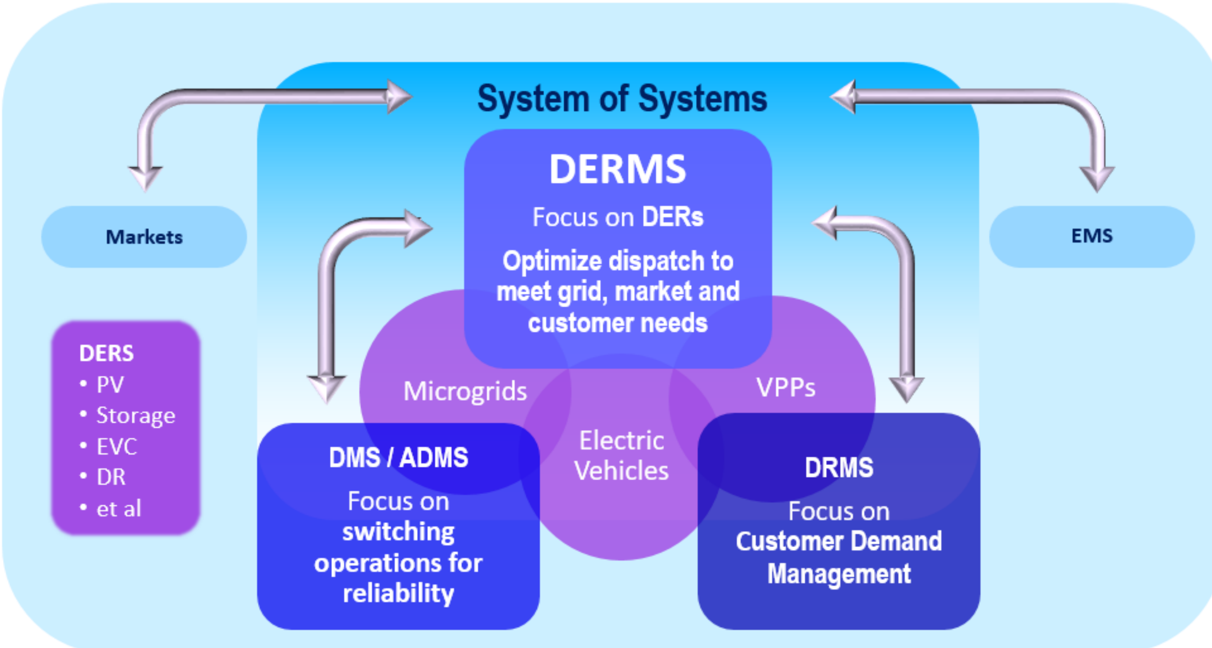
This approach combines a grid topology-aware dynamic network model, data management, integration layer, and automation to enable a single view across a utility's different systems. With a system of systems approach, grid owners and operators can deploy applications more rapidly to launch new services for customers, prosumers, and traditional producers. They can also improve the use of grid assets, provide flexibility services, and collaborate in managing customer-generated electricity.

A 'system of systems' approach is a low impact implementation approach that is compatible with a utility's existing systems and data processes. For example, it allows them to use legacy DR or demand side management programs and systems in their DER strategy. At the same time, this approach supports a rapid deployment of new business capabilities without disrupting procedures. Modularity and scalability also enable clients to take a pragmatic approach to delivering future capabilities.

The mPrest DERMS solution (mDERMS) is an example of a system of systems with an architecture that is simple to install and inexpensive to maintain and upgrade. The system supports all industry standards and is vendor agnostic, easily integrated with existing ADMS, geographic information systems (GIS), customer information systems (CIS), asset management systems (AMS), advanced metering infrastructure (AMI), and other enterprise applications. mDERMS includes model management to support "as-operated" analysis for DER aggregation, susceptibility calculations, and flexibility plans. Deployment on premise, in the cloud, and in a hybrid environment is native by design.

mDERMS provides DER forecasting and flexibility analysis, generation of optimized dispatch plans, dispatch control, and measurement and validation for conformance verification and billing. Registration and aggregation for VPP creation and participation in flexibility markets and other market services is part of the mDERMS platform. DER participation in wholesale and retail markets as well as transactive energy interoperability is also enabled with the mDERMS platform.

Figure 3 DERMS as a System of Systems



(Source: mPrest)

This white paper focuses on the attributes offered by mPrest's mDERMS product that can be applied across small-, medium-, or large-scale deployments. The following sections highlight case studies involving mDERMS. In addition to these large-scale engagements, mDERMS also offers attributes such as support of managed service models that are well-aligned to smaller projects.

Vector

Vector Ltd (Vector) is New Zealand's largest energy distribution company and delivers energy and communication services to more than a million homes and commercial customers across New Zealand, Australia, and the Pacific. Vector worked with mPrest to develop the mDERMS solution. mDERMS provides Vector with DER situational awareness, forecasts, flexibility analysis, and a 24-hour ahead DER dispatch plan to mitigate dynamic system constraints. Vector has around 80MW of controllable water heater demand, a fleet of grid-scale batteries at multiple locations throughout the network, as well as residential PV and batteries. A fleet of public rapid EV charging stations is also connected to mDERMS.

Enel

Based in Rome, Italy, Enel is Europe's largest distribution company with approximately 70 million electric customers. Enel uses mDERMS to integrate transmission and distribution system coordination of DER. mDERMS manages active and reactive power in support of both systems and enables DER control for islanded operation.

Southern Company

Based in Atlanta, Georgia, Southern Company is a large integrated utility in the southeastern US. The Georgia Power subsidiary has an ongoing project with mPrest to provide volt/var control (VVC) of BTM edge devices in support of various objective functions for demand reduction and voltage limits on distribution feeders. Here, mDERMS coordinates tap-switching transformers and capacitor banks on the distribution system with grid edge devices to provide a coordinated VVC capability.

Southern California Edison

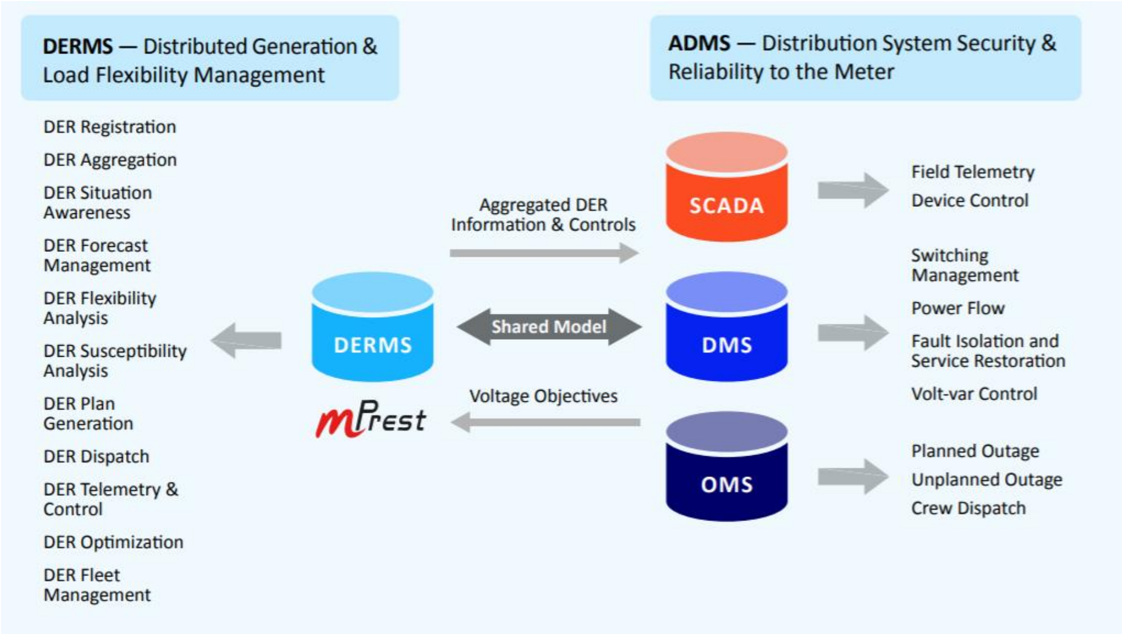
Southern California Edison (SCE) is one of the largest utilities in the US. SCE has multiple feeders with high penetrations of customer-owned PV systems that substantially mask the true amount of load being served, impacting the safety and reliability of switching operations. mPrest provided mDERMS functionality to help SCE understand the amount of PV production that could be impacted (disconnected) by system switching. This susceptibility analysis provides control room operators with the information required to confidently execute switching plans.

Conclusion: Building the Business Case

DERMS has the potential to be a game changer. With wide applications for BTM C&I customers, front-of-the-meter utility deployments, and diverse microgrid applications, DERMS appears to be an ideal technology to help usher in the looming energy transition to cleaner energy. With global DER capacity forecast to pass centralized generation on an annual basis in 2021, the need for dispatchable and flexible solutions is clear.

mPrest's mDERMS features illustrate the innovations necessary for global markets to make the transition to a low carbon, resilient, and more sustainable energy system of the future.

Figure 4 mPrest's DERMS



(Source: mPrest)

There is increasingly realization that a reexamination is required around ADMS and DERMS. While many ADMS vendors claim to offer DERMS as part of their ADMS offering, such a system cannot act as a customer enablement platform, cannot scale to the level required by the DERMS market, and cannot offer the response times expected from a DERMS. This is a technological and infrastructure issue and an operational and architectural issue.

Simply installing a DERMS alongside the ADMS is not an adequate solution either, as there would still not be an end-to-end, single, integrated, and holistic system. The only way to offer a truly orchestrated platform is with a DERMS that integrates with ADMS, DR, and all other systems utilizing a system of systems platform.

Acronym and Abbreviation List

ADMS	Advanced Distribution Management System
BTM	Behind-the-Meter
C&I	Commercial & Industrial
CIS	Customer Information System
CVR	Conservation Voltage Reduction
DER	Distributed Energy Resource
DERMS	Distributed Energy Resource Management System
DLC	Direct Load Control
DR	Demand Response
DRMS	Demand Response Management System
EMS	Energy Management System
ESS	Energy Storage System
EV	Electric Vehicle
EVSE	Electric Vehicle Service Equipment
FERC	Federal Energy Regulatory Commission
FTM	Front-of-the-Meter
OMS	Outage Management System
SCADA	Supervisory Control & Data Acquisition
T&D	Transmission & Distribution
VVC	Volt/Var Control
VVO	Volt/Var Optimization

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Scope of Study

Guidehouse Insights prepared this white paper, commissioned by mPrest, to provide insights, case studies, and advice to utilities looking to address the growth in DER assets and renewable energy generation. Whether the primary driver is resiliency or a long-term DER management strategy, this white paper highlights the role of holistic, system of systems DERMS in adapting to the evolving energy landscape.

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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