GE VERNOVA

ADMS & DERMS: ORCHESTRATING DERS AT THE GRID EDGE

The global energy landscape is undergoing a remarkable transformation, marked by the accelerated adoption of renewable energy sources and the proliferation of Distributed Energy Resources (DERs). This transformation is fundamentally reshaping the power sector and presenting significant challenges for utilities.

To navigate the complex, dynamic interplay of these energy resources, integrating both an Advanced Distribution Management System (ADMS) and a Distributed Energy Resource Management System (DERMS) has become paramount. Interoperability between the two solutions both enhances situational awareness and grid reliability while also capitalizing on the full potential of DERs.

In this whitepaper, we explore the significance of integrating ADMS and DERMS and how GE Vernova's GridOS porfolio introduces grid orchestration for the next era of the energy transition.

GridOS® Orchestration Software

GRID IN TRANSITION: NAVIGATING THE ERA OF DISTRIBUTED ENERGY

TODAY'S ENERGY TRANSITION BRINGS UNPRECEDENTED COMPLEXITY

The global energy landscape is undergoing a seismic shift as utilities worldwide are moving away from conventional fossil fuels and towards more sustainable energy sources in pursuit of decarbonization. This shift is marked by several key developments:

RECORD-BREAKING RENEWABLE GROWTH

- The International Energy Agency (IEA) has forecasted a record-shattering surge in global renewable capacity, amounting to 107 gigawatts (GW)—the largest absolute increase ever. This surge brings the total capacity to over 440 GW in 2023.[1]
- Solar photovoltaic (PV) capacity, which encompasses both large (i.e. utility-scale) and small distributed systems, accounts for two-thirds of the aforementioned surge in global renewable capacity.[1] This unprecedented PV growth is propelled by expanding policy support, heightened energy security concerns, and increasing competitiveness compared to fossil fuel alternatives.

EXPLOSIVE GROWTH IN DERS

- Wood Mackenzie estimates that the US DER market will nearly double from 2022 to 2027, to reach $68 billion per year. An estimated 262 GW of new DER and demand flexibility capacity will be installed over this period, nearly matching the 272 GW of utility-scale resources to be installed.[2]
- Behind-the-meter capacity will grow 3.7 times more over this period than it did in the previous five years, and electric vehicle (EV) charging infrastructure is responsible for much of that growth. EV charger annual installed capacity will overtake distributed solar for the first time in 2023 and will reach 3.5x solar annual additions by 2027.[2]
- Between 2023 and 2027, the US storage market will install almost 66 GW of capacity, with grid-scale installations accounting for 83% of the total additions.[3]

While this transition promises a greener future, it also introduces an unprecedented level of complexity to the grid. Central to this transition is the widespread adoption of DERs which are disrupting the dynamics of how energy has traditionally been generated, distributed, and consumed. The once unidirectional power grid has evolved into a dynamic and intricate network with bi-directional power flows and decentralized energy sources. The proliferation of grid-connected and behind-the-meter DERs, coupled with their bi-directional power flows, introduces immense challenges:

- **Network capacity strain**
  The influx of DERs strains grid capacity, requiring innovative strategies to accommodate the variance in energy generation and demand.
- **Backfeeds and high voltages**
  Bi-directional power flows introduce challenges such as voltage issues and the potential for backfeeds, which can compromise grid stability.
- **Intermittency and balancing issues**
  Renewable energy sources like solar and wind are inherently intermittent. This makes grid management across transmission and distribution more complex as the power supply becomes less predictable.
- **Security concerns**
  Safeguarding the grid from a cybersecurity perspective while managing power flows becomes paramount, especially in light of decentralized energy sources—each of which represents a potential infiltration point. Utilities are currently experiencing an average of 1,200 weekly cyberattacks, further amplifying this urgency.[4]

As the energy sector navigates these complexities, distribution system operators and utilities are at the forefront of the transformation. To harness the full potential of DERs, the grid must both expand its capacity and modernize its underlying infrastructure. Moreover, as the push towards electrification gains momentum as a stepping stone in the journey to decarbonization, the grid's reliability becomes more critical than ever.

UNLOCKING THE FULL POTENTIAL OF DERS

Integrating high levels of DERs into the grid poses a distinct set of challenges for system operators. Utilities must simultaneously support grid stability and ensure power quality, manage the inherent variability and complexity of DERs, and navigate the additional challenges layered on by electrification and extreme weather events.

But what if these DERs could play a pivotal part of the solution to overcome the exact challenges they create?

To address these challenges and optimize grid management, advanced solutions that enable real-time and forward-looking grid operations are essential. It's important to recognize that no single technology category can serve as a one-size-fits-all solution for these requirements. Instead, the integration of **Advanced Distribution Management System (ADMS) and Distributed Energy Resource Management System (DERMS)** provides utilities with a viable solution to effectively navigate the intricacies of the evolving energy landscape, facilitating a smoother and swifter transition towards a new energy future. By leveraging the combined capabilities of ADMS and DERMS, utilities gain the tools to elevate situational awareness, increase grid reliability, and efficiently manage the influx of DERs.

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*What if DERs could be a pivotal part of the **solution** to the challenges they create?*

ADMS: THE FOUNDATION OF MODERN GRID OPERATIONS

The **ADMS** is the foundation for modern distribution utility operations. It functions as a dynamic software solution that equips distribution system operators with real-time monitoring and control capabilities for the entire distribution grid, while also optimizing and enhancing grid reliability and resiliency. The best solutions operate as an integration framework that harmonizes multiple enterprise-wide utility IT/OT systems, including geographic information systems (GIS), customer information systems (CIS), meter data management (MDM) systems, and energy management systems (EMS), among others.

Running on an "as-operated" network model, an ADMS aggregates data from smart meters, next-generation sensors, grid equipment, and SCADA-connected storage and generation assets to provide operators with comprehensive control. It captures real-time data including voltage, current, equipment status, and smart meter information, spanning the entire distribution network. By harnessing this data and its control capabilities, an ADMS optimizes asset utilization, executes switching operations, minimizes losses, and proactively and safely manages outage restoration activities. Key functions of an ADMS include Fault Location, Isolation & Service Restoration (FLISR), Distribution State Estimation, switch order management, outage management and recovery, and Volt/VAR Optimization (VVO).

Severe Weather Events

+75%

increase in last 20 years

2x

more outages due to weather over the last 5 years

Electrification of Everything

50%

electricity will flow directly through distribution by 2030

10

US states with 100% clean energy targets

DERMS: ENHANCED GRID MANAGEMENT, OPTIMIZATION, AND CONTROL

A **DERMS** is a comprehensive software solution designed to manage, control, and optimize DERs within the grid, whether utility-driven or customer-owned. These resources include solar PV systems, wind turbines, energy storage units, EV charging stations, and demand response resources. A DERMS complements an ADMS by addressing use cases beyond the latter's conventional core capabilities. As a result, seamless interoperability between the functions of ADMS and DERMS becomes essential.

At its core, a DERMS maximizes the value and potential of DERs by uniting their planning, operations, and program participation behind a single pane of glass. It offers an integrated suite of applications and components to fit virtually any specific need, regulatory requirements, geographic constraints, or customer preferences. A robust DERMS solution provides an all-encompassing view into DER performance and enables sophisticated control strategies, thereby facilitating their integration into a variety of grid services and markets. A DERMS plays a crucial role in upholding grid reliability and future-proofs utilities from evolving uncertainties, facilitating a seamless transition in the rapidly evolving energy landscape.

A UNIFIED APPROACH TO GRID MANAGEMENT: ADMS & DERMS

THE POWER OF ADMS & DERMS

As the energy landscape transforms, the seamless integration of ADMS and DERMS functionalities is no longer a nice-to-have. Rather, it's a requirement for supporting and facilitating the modern energy transition. In general, ADMS provides real-time management and optimization capabilities for the entire distribution grid. DERMS, on the other hand, complements ADMS by integrating, forecasting, and optimizing DERs, effectively harnessing them to curtail power and manage reverse power flows. This comprehensive visibility of all distribution grid assets, including behind-the-meter and customer-owned equipment, empowers grid operators to swiftly make informed decisions, proactively identify and respond to issues, and minimize disruptions to the grid. The full range of benefits for an ADMS and DERMS pairing includes:

1. **Enhanced situational awareness**

   Operators unlock a comprehensive view of grid conditions at any given moment, with real-time insights into the operational statuses and behaviors of DERs. This allows operators to assess the impact of DERs on various aspects of the grid including voltage, flows, fault currents, and outage restoration.

2. **Optimized grid operations**

   The ability to monitor and control both traditional grid components, like transformers and breakers, and DERs enables efficient load management, Volt/VAR Optimization, and outage management. As a result, utilities experience substantial cost savings in terms of labor, maintenance, and energy procurement.

3. **Improved grid resilience and reliability**

   The combined power of ADMS and DERMS bolsters grid resilience against adverse situations and enhances reliability in day-to-day operations, maintaining continuity of power.

4. **Efficient DER interconnection**

   With an integrated solution, utilities can streamline the process of interconnecting the growing number of DERs into the grid. This includes semi-automating DER registrations, modeling, and communication checkouts.

5. **Easier compliance with standards and regulations**

   Ensuring compliance with essential industry standards such as IEEE 1547, as well as regulatory mandates like FERC 2222 in the United States and the European Union's Clean Energy Act, allows utilities to not only maintain operational integrity but also contribute to a sustainable energy future.

6. **Scalability and future readiness**

   An integrated ADMS and DERMS solution addresses present needs while also offering a scalable foundation for the future. Utilities that leverage these combined solutions can easily adapt to emerging technologies, changing grid dynamics, new DERs and grid configurations, and evolving market structures without extensive system overhauls.

ADMS and DERMS were once seen as disparate systems, each with their own distinct role in the management of the distribution grid. Today, that is no longer the case; the modern utility needs the combined capabilities of both ADMS and DERMS to provide holistic insight into grid operations and unlock effective management of new energy sources. As the energy landscape continues to change, combining the two function sets helps to ensure seamless coordination of the distribution grid. However, with numerous options available in the market, choosing the right solutions is essential to navigate grid challenges without putting undo strain on grid operators or compromising operations.

GE VERNOVA'S ADMS

GE Vernova's DER-aware ADMS moves beyond the traditional bounds of SCADA, DMS and OMS to support customers in their digital transformation journey. The solution not only provides distribution utilities with a single pane of glass for operations across a shared distribution network model, but also delivers the operational agility to effectively leverage the power of data. It ensures the safe and secure management and orchestration of the distribution grid, providing outcomes that matter to your personnel in the control center and the field. GE Vernova's ADMS enables dispatchers to transition to grid controllers through the deployment of advanced power flow-driven applications for reliability. Its advanced applications are field-proven and scalable, are used operationally around the world 24/7, are quickly and easily deployed, and leverage and operationalize analytics-derived insights. Unlike other vendors who provide a SCADA with some automation features, only GE Vernova's integrated ADMS platform provides the foundational infrastructure that is both reliable and scalable for today and the future.

GE VERNOVA'S ADMS

DISTRIBUTION OPTIMIZATION (DMS)

Building on traditional SCADA and DMS functions – delivers adaptive and optimized advanced applications and greater use of automation as a solution for solving growing grid complexity

- Bus Load Allocation
- Integrated Volt/VAR Optimization (IVVO)
- Distribution Power Flow
- Fault Location, Isolation & Service Restoration (FLISR)
- Automated Feeder Reconfiguration
- Contingency Analysis
- Load and Voltage Management
- Protection Validation
- Study Mode
- Surgical Load Shedding
- Switching Management
- Mobile Switching

OUTAGE RESPONSE (OMS)

Mobility, damage assessment, and predictive analytics to reduce/minimize disruptions and support centralized and decentralized outage restoration

- Outage Prediction and Restoration
- Planned and Unplanned Outage
- Crew Dispatch Management
- Historical Outage Correction
- Trouble Call Management
- Reliability Reporting
- Outage Assist
- Disruption Prepare
- Mobile Outage
- ADMS Archive
- Wildfire mitigation capabilities
- Near Real-Time Database

DER-ENABLED CAPABILITIES

Built-in capabilities and native interoperability with GridOS DERMS to seamlessly connect, visualize, control, and optimize DERs

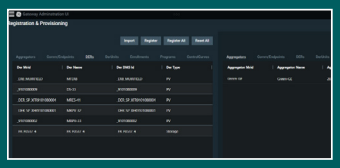
- Centralized DER Modeling
- DER-Enabled Situation Awareness
- DER-Aware Powerflow
- DER-Enabled FLISR
- DER-Enabled VVO
- Adaptive Network Management
- Interoperability with GridOS DERMS

GE VERNOVA'S GridOS DERMS

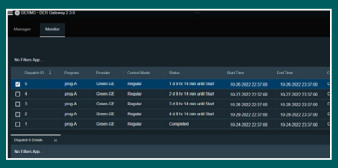
GridOS DERMS is a purpose-built enterprise solution with over a decade of innovation, designed to empower utilities with the orchestration needed to efficiently manage the rapid expansion of DERs. With a global presence, serving more than 90 customers and facilitating the management of over 127 million utility service points, GridOS DERMS equips grid operators with a comprehensive suite of modular applications to oversee every aspect of the DER journey, from their initial integration, visualization, and ongoing operation; to their control and optimization. Rather than adopting a one-size-fits-all approach, GridOS DERMS prioritizes flexibility through a modular design to accommodate the diverse and evolving needs of utilities, regardless of their grid specifications, regulatory environments, geographical locations, or customer demands.

GridOS DERMS offers a range of essential features, including advanced forecasting, robust system violation resolution, real-time DER management and dispatch, and economic optimization through access to wholesale and local services markets. Built on the foundation of GE Vernova's GridOS, the industry's first end-to-end grid orchestration platform and application suite, GridOS DERMS embraces a modern software approach with an innovative, secure architecture tailored to accelerate grid modernization.

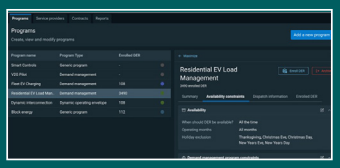
GridOS DERMS: THE LEADING MODULAR DERMS FOR GRID OPERATORS



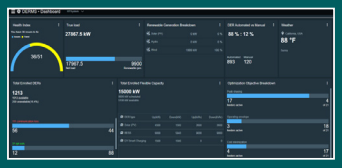
Model Manager: Maintain and ingest network and DER asset data into a model that ensures a single source of truth.



Gateway: Single point of communication to and from DERs and aggregators for monitoring and control. IEEE 2030.5 certified.

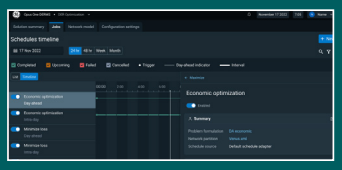


Program Manager: Source of truth for programs, contracts and enrollment data. Report on program performance and constraints.

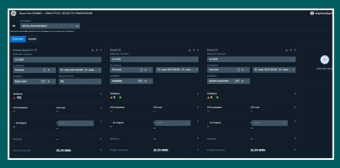


Operations: A single view enabling situational awareness, alerts, and the ability to manage grid operational issues.

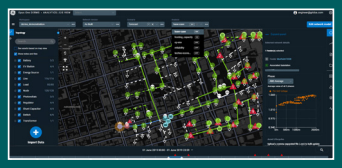
Forecasting: Continuously predict load and generation using a library of models. Aggregate data to different levels of the grid.



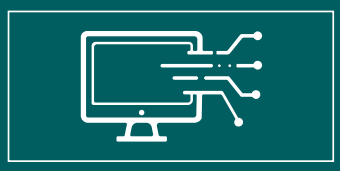
Optimization: Optimally schedule DERs based on grid constraints, economics and more. Generate safe operating limits.



Markets Orchestration: Provides DERMS information to support intelligent decision making for techno-economic optimization.



Simulation: Study mode capabilities for short-term operational planning and long-term scenario planning including non-wires alternatives optimization.



APIs and Partner Interfaces: Modern interfaces designed to enable partners to integrate and communicate with the DERMS platform.

GridOS®

Part of GridOS®: Built on GE Vernova's zero trust security model, and presented in single, modern UI/UX.

THE GridOS® APPROACH: END-TO-END GRID ORCHESTRATION

Unlike conventional grid management tools, which often operates in silos, our approach to grid management adopts a holistic perspective encompassing the entire grid ecosystem. We recognize that the various assets that make up the grid are not just individual components, but integral parts of the grid, demanding a higher level of orchestration.

At its core, grid orchestration is the process of coordinating actions across multiple systems, leveraging integration, automation, and modern technologies to streamline and optimize the flow of electricity from generation through consumption. This alternative to traditional, reactive grid management offers a proactive approach to drive stability in a complex environment resulting from increased penetration of renewables, severe weather, cyberthreats, and other challenges.

At the center of this innovative approach lies GridOS, the industry's first grid software portfolio designed for grid orchestration. GridOS unites energy data, network modeling, and AI-driven analytics together across the grid, powering a suite of composable applications from GE Vernova, utilities, and partners. These applications empower utilities to seamlessly orchestrate an integrated, flexible, and secure energy grid.

GridOS combines grid planning and operations with market solutions to more seamlessly manage the grid from an operational and an economical perspective. This supports the safe, reliable, and affordable delivery of electricity to consumers and ensures that utilities can unlock the economic value of DER and renewables flexibility. Whether the objective is to enhance safety during outages, optimize DER integration, or strengthen grid resiliency, grid orchestration technology lets our integrated ADMS and DERMS solution empower utilities to overcome challenges and seize opportunities effectively.

As a leading provider of both ADMS and DERMS solutions, GE Vernova has carefully considered the interoperability of both. Fundamentally, GE Vernova's GridOS DERMS is a modular platform that supports two flexible deployment approaches with ADMS:

1. **Combined ADMS and DERMS.** For utilities seeking a single control room solution, GridOS DERMS modules can be directly added to the ADMS solution. Through this approach, GridOS DERMS applications are natively integrated into the ADMS user interface to provide a unified operator experience and the deepest level of application integration. This approach accommodates on-premise, air-gapped installations suitable for operations technology (OT) environments with no internet access. (Figure 1)

2. **Standalone DERMS interconnected with ADMS.** Alternatively, for utilities envisioning a separate DERMS operations desk, GridOS DERMS can be decoupled from ADMS. This approach deploys DERMS as a standalone solution with a dedicated UI, while still maintaining tight, real-time integrations with ADMS. Such an arrangement enables GridOS DERMS to reside in a non-OT network zone, utilize cloud hosting, and cater to a broader user base. (Figure 2)

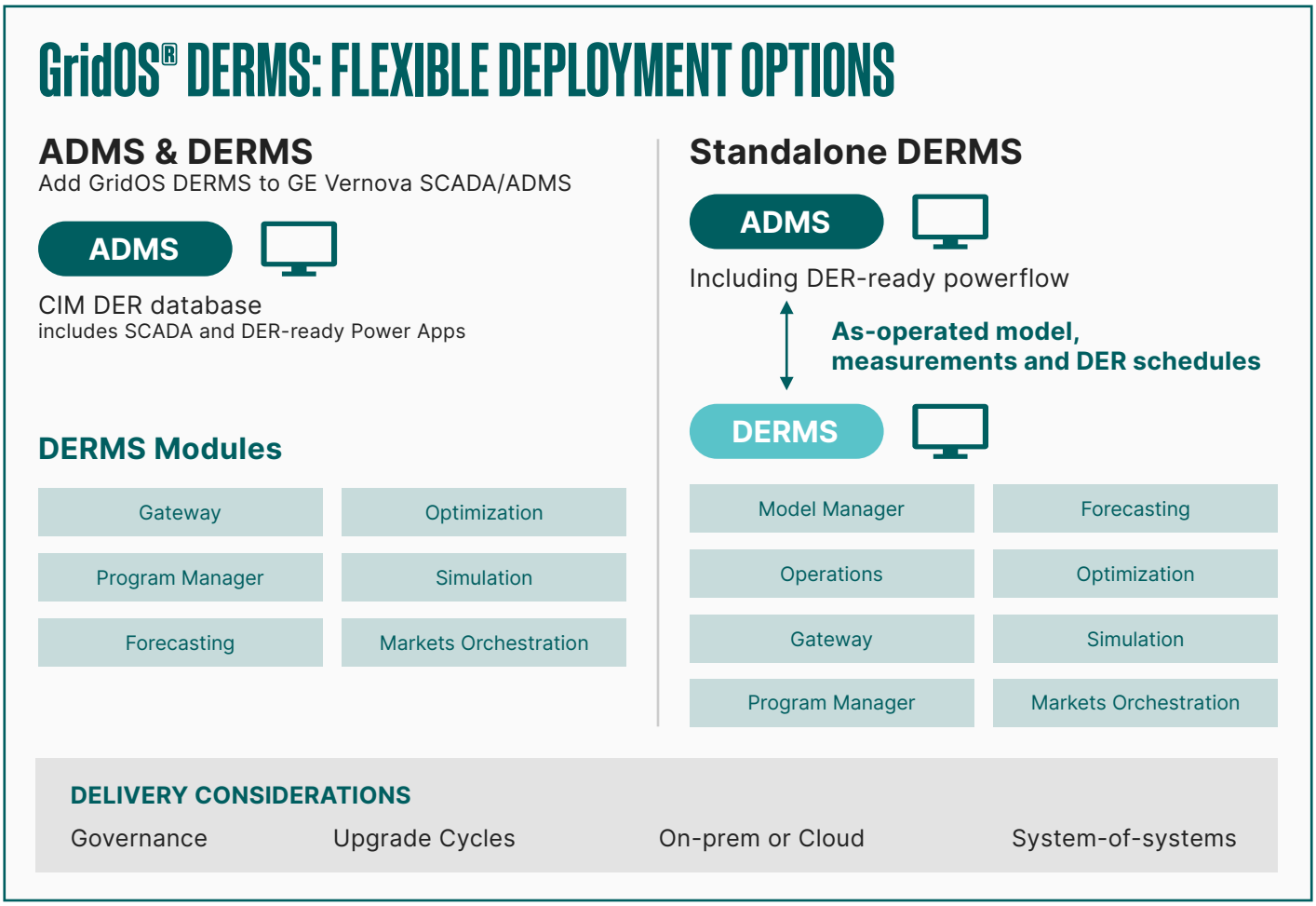


Figure 1: Delivery options for GE Vernova's ADMS & GridOS DERMS

In either approach, GridOS DERMS complements ADMS by enhancing its capabilities, rather than competing with them. ADMS remains the system of record for network topology, energization, real-time grid equipment loading and limits, online power flow, switching, and outage restoration, while also providing the primary user interface for core operational functions such as alarming and SCADA control. GridOS DERMS complements the functionalities of ADMS by:

- Introducing DER telemetry and control capabilities, including behind-the-meter and aggregator-managed DERs, using protocols such as IEEE 2030.5 and OpenADR.
- Providing a high-definition view of DER models and behavior as well as aggregating DER data and control functions to a level that makes sense for grid operators.
- Ensuring awareness of contractual constraints associated with the control of third-party DERs.
- Enabling DERs access to energy markets to ensure compliance with regulatory requirements, such as FERC 2222, and adequately account for economics.
- Offering DER forecasting, look-ahead optimization, and dispatch scheduling to empower grid managers to anticipate and mitigate issues proactively.
- Implementing programs at the Grid Edge, such as flexible interconnection programs with dynamic operating envelopes. It also monitors, alerts, and automatically enforces compliance if DERs operate outside agreed-upon limits.
- Complementing ADMS' real-time applications, such as VVO and FLISR, by adding battery scheduling, solar PV curtailment, and EV dispatch functions as additional control levers.
- Enhancing ADMS Study Mode and Distribution Operator Training Simulator (DOTS) functions with DER simulations.

ADMS

Monitor & Control Distribution Grid

- Monitors the condition of distribution grid assets and front-of-the-meter grid devices, providing direct control
- Real-time operational status of the grid and control over utility assets (transformers, capacitor banks, switches, etc.)
- Runs power flow models on an "as-operated" network
- Prioritizes grid stability, safety, and reliability
- FLISR, Outage Management, Volt/VAR Control applications
- Predicts future load patterns for better grid planning
- Implements strategies to withstand disturbances and disasters
- Supports on-premise utility security deployment

GridOS DERMS

Optimize & Manage DERS

- Focuses on managing front-of-the-meter/ behind-the-meter DERs. Enables visibility and management of customer-owned assets
- Manages programmatic information related to DER devices, including registration/enrollment
- Supports DR aggregated programs and direct device control (scheduled/real-time)
- Optimizes DERs based on economic, environmental, and grid conditions
- Integrates and utilizes real-time data from SCADA as well as DER-specific protocols such as IEEE 2030.5 and OpenADR
- Can perform advanced functions: peak load management, DER import/export limiting, optimal DER scheduling, curtailment, and transactive energy exchanges

Figure 2: Capabilities of GE Vernova's ADMS & GridOS DERMS

KEY USE CASES UNLOCKED BY GE VERNOVA'S ADMS & DERMS

The combined capabilities of GE Vernova's ADMS and DERMS solution unlocks many new use cases. These use cases represent an innovative approach to accessing the full potential of distribution grid orchestration, addressing critical challenges, and facilitating a new era of grid management efficiency. Each use case focuses on distinct aspects of grid operations and highlights how the integrated solution empowers utilities to unlock unmatched levels of situational awareness, control, and flexibility.

DER SITUATIONAL AWARENESS

Utility Challenge

DERs present a distinctive challenge due to their diverse ownership, dispersed locations, and variable communication methods. Often located behind the meter and operated by customers or third parties, these DERs may not be modeled in conventional utility asset management systems like GIS or support traditional grid asset communications such as SCADA. Some DER data may be captured as part of an interconnection process, while non-injecting resources, such as electric vehicle supply equipment (EVSE), are typically installed without utility awareness. In addition, some DERs can self-register. This creates a complex landscape where data on DERs and their network locations reside in different utility back-office systems, leading to incomplete modeling, monitoring, and aggregation within existing grid management systems. As a result, grid operators are left grappling with fundamental questions such as:

- Where are the DERs located on my network?
- What types of DERs are in operation, and what are they doing now?
- How do DERs impact power flow to the grid, and to what extent can they be controlled?

To effectively answer these questions, a comprehensive solution must centralize DER model management, offer real-time visualization and seamless telemetry integration, and intelligently incorporate DERs into network applications.

For grid operators, a solution encompassing these elements translates into enhanced operational efficiency. With complete visibility into DER locations, types, and their real-time status, operators can promptly make well-informed decisions, proactively identify and address issues, and reduce grid disruptions.

GE Vernova Approach

Together, GE Vernova's ADMS and DERMS offer a comprehensive solution to address the challenges associated with achieving DER situational awareness. In the control room, this means that when there's a sudden spike in renewable energy generated by various behind-the-meter DERs, as solar PV output might on a very sunny day, operators using the combined solution gain real-time visibility into the exact location, type, and injection of these DERs. This critical data is presented in an intuitive format within the network's geographic and schematic views, treating DERs just like any other grid asset. This enables operators to easily differentiate between native load and generation.

By combining telemetry, forecast data, and static models, operators can effectively monitor network conditions and the capacity of controllable DERs during periods of high generation. In the event of capacity violations or unwanted backfeeds, alarms pinpoint the issue's time and location. Armed with this information, operators can quickly and confidently determine the best remedial action, whether it's curtailing or redirecting excess energy, performing switching, or something else.

Moreover, the solution accommodates switching studies that account for DER behaviors under various conditions, including steady state, short circuit, and temporary disconnections due to switching or momentary outages. The outcome is an elevated level of situational awareness, proactive grid management, and streamlined decision-making right in the control room. An integrated solution with real-time data exchange can potentially deter the need for hundreds of millions of dollars' worth of infrastructure upgrades that would otherwise be needed to meet the demands of electrification.

Solution Highlights

1 Centralized DER Modeling

- GE Vernova's ADMS models various DER types, including solar PV, battery energy storage, EV charging stations, and co-generation facilities.
- Modeling encompasses both front-of-the-meter and behind-the-meter DERs. While not mandatory, modeling of individual DERs in ADMS provides granularity and one-to-one integration with GridOS DERMS data sources.

2 Real-Time Visualization and Telemetry

- DERs can be visualized within ADMS, just like other network assets.
- The ADMS and DERMS solution enables operators to view as-built, engineering and real-time attributes of DERs, such as power flow results.
- With the combined solution, users can monitor the real-time connected DERs and communicate the status, along with nameplate and dynamic rating information.

3 Topology and Fault Consideration

- ADMS intelligently incorporates DERs into its calculations for network energization status, ensuring safety in grid operations. For instance, it can indicate if a line is normally energized from its transmission source, regardless of a reverse flow due to DER injection.
- ADMS also accounts for DER fault current contributions, supporting short-circuit analysis, protection validation and FLISR applications
- ADMS identifies DERs that can act as "grid-forming" resources (such as network microgrids), and locally provide energization and voltage to areas experiencing power outages.

4 Hierarchical Grouping

- Together, ADMS and DERMS supports the creation of DER groups based on hierarchical network topology, asset type, ratings, and connection status. Users can view real-time data for each DER in the group or aggregate values.
- GridOS DERMS extends these capabilities by providing additional information about aggregators, programs, contracts, and more via its Program Manager module.

5

Modern Communication Protocols

- GridOS DERMS ensures compliance with modern DER communication protocols like IEEE 2030.5 and OpenADR.
- GridOS DERMS enables seamless communication with behind-the-meter DERs, whether through aggregators or direct connections to utility systems. Communications may be over the internet or via dedicated communications paths.
- Telemetry data ingested into DERMS is immediately published to ADMS for various applications, such as visualization or trend analysis, and can be used to override static or forecasted DER injection data, thus improving power flow analysis quality.

6

Enterprise Summary Dashboard

- The integrated ADMS and DERMS solution seamlessly incorporates GE Vernova's Enterprise Summary dashboard – an advanced tool that aggregates and presents data in a highly customizable manner. This dashboard is tailored to the specific needs of control room users. Whether presented on a display wall or an operator's workstation, this intuitive and user-friendly dashboard ensures that critical data is presented in a readily digestible format.

FORECASTING & LOOK-AHEAD ANALYSIS

Utility Challenge

The increased integration of DERs and renewables introduces unpredictability into grid loading patterns. The intermittent nature of renewable sources, such as wind and solar – along with the variability brought by new DER devices like heat pumps, controllable loads, and EVs – can disrupt the traditional real-time operations of grid management. This increasing intermittency makes it hard for grid operators to respond effectively to in-the-moment grid conditions and anticipate future grid states. The need to transition from exclusively real-time grid operation to a more proactive and anticipatory approach is increasingly imperative.

Grid operators now require a forward-looking perspective that helps them identify potential grid violations or constraints well before they happen. This proactive approach empowers them to plan and implement remedial actions to ensure grid stability and reliability.

GE Vernova Approach

Forecasting is a GridOS DERMS module that is integrated within GE Vernova's ADMS and DERMS solution. It plays a pivotal role in various look-ahead use cases, aiding grid operators in addressing the challenges posed by intermittent DERs and evolving grid loading patterns. A common use case involves a grid operator or operations engineer reviewing load and generation forecasts to identify violations in advance. If issues are anticipated, they can identify flexible DER capacity at a particular network location. They can then proactively schedule a future dispatch to resolve the grid constraint, while considering contractual constraints.

Forecasting offers a comprehensive solution for delivering accurate, scalable, and versatile forecasts tailored to a utility's operational needs. DERMS uses this forecast data natively for look-ahead DER scheduling and constraint management calculations. The same data can also be transmitted to ADMS and associated with distribution network objects, increasing visibility and enabling operators to incorporate forecast data into ADMS Study Mode.

It's critical to note that proactive planning and issue remediation are only possible with the combined ADMS and DERMS solution. Without the Forecasting module, ADMS can only detect grid violations in real-time.

Solution Highlights

1 Load and Generation Forecasting

- The application generates forecasts for both load and generation, including behind-the-meter DERs, which can be aggregated at any network level.
- Forecasting leverages the hierarchical network model, generated directly from the ADMS network model, ensuring synchronization between the forecast data and the real-time network model.
- Forecasting provides accurate estimates of output for non-telemetered DER, which is used to improve power flow accuracy in ADMS.

2 FLISR and Look-Ahead Analysis

- ADMS uses forecasted load and generation data in FLISR look-ahead analysis, ensuring that recommended switching plans remain valid in immediate and future contexts.
- DER information enables FLISR to compute realistic loading conditions during switching, where DERs may momentarily trip offline.
- ADMS look-ahead power flow analysis uses forecasted load and generation data to automatically compute flows and voltages, as well as violations, for upcoming hours or days.

3 Advanced Planning

- Users can leverage forecasted load and generation data in ADMS study mode to analyze switching scenarios at various future timeframes.
- Operational planners can synthesize potential upcoming violations, including time, grid location, type, and severity to develop remedial actions in advance.

END-TO-END MODEL MANAGEMENT

Utility Challenge

Traditionally, utilities relied heavily on physical maps to manage outage response dispatching and grid switching for their distribution systems. However, utilities have recently begun transitioning towards electronic representations of their networks instead. These digital models are typically housed either in an OMS, (which primarily focuses on switching but lacks power flow capabilities), or in ADMS (which offers a comprehensive view of the network and can provide accurate real-time voltage and flow data across the entire grid).

Compared to ADMS and traditional grid operation systems, DERMS faces different data challenges when addressing a wider range of operational and non-operational use cases. To achieve a holistic representation of the entire grid, encompassing both traditional assets and DERs, DERMS must seamlessly merge DER information with the detailed real-time network model, loading limits and constraints obtained from ADMS. This integration is crucial not only for utility operations staff, but also for empowering program administrators and other DERMS users. Comprehensive visibility into DERs is essential for optimizing operational efficiency and unlocking the full potential of DER-enabled use cases.

GE Vernova Approach

GE Vernova's ADMS and DERMS solution is designed to maximize the utilization of the ADMS model while seamlessly integrating additional DER-related information. Within this integrated ecosystem, ADMS serves as the central repository for network data, operational limits, switching configurations, tagging, loading information, and user-defined overrides. GridOS DERMS introduces specialized modeling workflows to ingest, validate, and manage supplementary DER data, including contractual details, customer information and additional technical information. A core responsibility of GridOS DERMS is to merge this supplementary data with the information mastered in ADMS, ensuring the creation of a unified and consistent grid model. Central to the combined solution is the automation of all model integrations, including synchronization between applications.

Maintaining high-quality, consistent data across systems is critical for getting operations staff to trust this electronic representation of the physical grid and the results it generates. GE Vernova's combined ADMS and DERMS solution ensures data quality by merging model data at the source. The user interface then leverages this data by providing a single-pane view of the grid, including DERs, and extending the current capabilities of the ADMS by adding additional contextual information. For instance, this means that operators can receive alerts when a DER control might violate a contractual constraint for a third-party DER. They can also be assured that DERMS optimization functions are in sync with ADMS by initializing from the latest network loading and switching conditions.

Solution Highlights

1 ADMS Model Export

- ADMS maintains the "as-built" network model in both a generic hierarchical format and a full-impedance network model format utilizing the IEC 61968 Common Information Model (CIM).
- Alterations to the network model within ADMS are automatically communicated to GridOS DERMS applications in the appropriate format, including asset rating information and operational limits essential for day-to-day grid operations. This ensures that GridOS DERMS applications are aligned with the same set of operational constraints.

2 As-Switched Topology

- ADMS, serving as the system of record for switching information, publishes all switch state changes in real-time, whether it is a circuit breaker, a fuse, or temporary elements like cuts and jumpers. This capability can be leveraged to trigger applications and maintain an accurate and synchronized connectivity model.

3 Support for One-to-One DER Relationship

- The integrated solution can establish a one-to-one relationship between DER assets in DERMS and ADMS, extending down to the individual DER asset or service point level. This can provide visibility of individual DER telemetry data within ADMS.
- The one-to-one DER relationship allows viewing of customer-owned DER information directly on the ADMS geographic display, alongside other network data. It also ensures accuracy of distribution power flow results.
- Finally, this approach seamlessly integrates AMI meter data, typically collected at the service point level and enables granular controls which can address issues on service transformers and the secondary network.

4 Aggregated DER Modeling

- In scenarios where individual DER data is unavailable or it is preferable to aggregate data at a higher level, ADMS can model an aggregated DER resource at an equivalent network location. The aggregated values for this resource are provided by GridOS DERMS.

5 Distribution State Estimation and Power Flow

- ADMS can regularly run distribution state estimation and distribution power flow calculations, considering trusted load modeling and the latest measurement data.
- The combined solution ensures that DERMS applications, such as the optimization engine, are properly initialized with this same loading information.

6 Two-Way Information Exchange

- ADMS can ingest high-level modeling information from DERMS, including program enrollments, asset ownership details, and capabilities and settings of telemetered DERs.
- This enhances ADMS's situational awareness features and advanced applications, creating a holistic view of the grid.

AUTOMATED CONSTRAINT MANAGEMENT

Utility Challenge

Ever-increasing DER penetration is straining grid capacity to its very limits. Simultaneously, there is increased public pressure to rely on non-wires alternatives (NWAs) to meet capacity constraints. As the use of NWA amplifies, manual operations become increasingly complex and error-prone. Solely relying on real-time operation with manual interventions both stresses operators and limits their ability to optimize actions. The growing number of simultaneous constraints, events, and contractual limitations calls for a solution that can automatically manage DERs with minimal to no human involvement.

GE Vernova Approach

Automated constraint management involves the automatic detection and resolution of both real-time and forecasted constraints using DERs. This empowers utilities to seamlessly connect, forecast, optimize, dispatch, and monitor DERs to achieve automation objectives such as NWAs, peak load management, and more.

The integrated ADMS and GridOS DERMS solution leads the way in automating constraint management. Both systems are designed to synchronize their respective network models, constraints, and loading conditions to establish a solid, conflict-free foundation. This synergy is achieved through defined roles, data consistency, and management tools for coordinated automation. With this coordination, ADMS can trigger DERMS applications in response to events like topology changes and alarms.

Automated constraint management functions can operate with one of two levels of automation:

- **Semi-automated mode.** In this mode, executing operating plans requires one-click operator approval before controls are automatically scheduled.
- **Fully automated mode.** In this mode, operators need only verify correct performance and watch for alarms—control scheduling operates in an entirely automated manner. If necessary, operators can temporarily disable automation while they seek guidance from Engineering for troubleshooting, tuning, and restarts.

In either mode, grid operators take on new responsibilities as automation supervisors, overseeing the integrated system.

Automated constraint management offers clear benefits to the operator and control room. It significantly reduces the likelihood of human error and enhances safety in grid operations. Moreover, it allows utilities to maximize the utilization and capacity of their existing grid assets, eliminating the need for costly over-designing to accommodate peak load scenarios. Lastly, it promotes the adoption of prosumer functions and proactive grid support by DERs, minimizing the need for expensive equipment upgrades or new construction.

Solution Highlights

1 Volt/VAR Optimization (VVO) with DER

- ADMS VVO application harnesses DERs' reactive capabilities to manage voltage, power factor, and other constraints.
- DERs complement tap-changing transformers and capacitor banks to implement Conservation Voltage Reduction (CVR), VAR support, and other VVO objectives.
- DER controls can be issued through SCADA or via the GridOS DERMS Gateway's IEEE 2030.5/ OpenADR utility server, either directly or via aggregators.

2 Adaptive Network Management (ANM)

- Available in the integrated ADMS and DERMS solution, ANM dispatches DER real power in real-time to address network constraints, including rapid remediation of flow violations such as overloads and backfeed violations.
- Controls include kW setpoints, kW limits, or disconnect controls, with the capability to return to normal when network conditions improve.

3 **Look-Ahead Optimization**

- GridOS DERMS leverages load and DER forecast information to run multi-interval optimal power flow to proactively mitigate network constraint violations.
- It generates continuous DER operating schedules over a time horizon of hours to days, considering both technical and economic factors.

4 **Dynamic Operating Envelopes (DOEs)**

- GridOS DERMS calculates real-time and forward-looking DOEs dynamic limits for DERs, providing safe maximum import and export operating ranges.
- These DOEs provide a safe "swim lane" within which a DER can operate, allowing for greater customer/aggregator choice in how behind-the-meter assets are managed.
- They enable advanced use cases such as flexible interconnection agreements (aka dynamic connections) and charge limiting of wholesale market participation for third-party battery energy storage systems.
- They facilitate DER-DSO-TSO-Market coordination, which could be a requirement for DSO compliance with regulations like FERC 2222.

FLEXIBLE INTERCONNECTIONS

Utility Challenge

Traditional grid interconnection processes often complicate DER integration for utilities. Utilities typically conduct feasibility assessments for each new DER interconnection, often assuming worst-case conditions, resulting in conservative margins and lower DER hosting capacity. Thus, when a particular portion of the grid becomes saturated with DERs, new connection requests are rejected or require costly network upgrades to connect. This approach has several repercussions: it limits the number of DERs that can connect and their positive carbon impact, leads to the underutilization of existing network capacity, and leaves customers frustrated.

GE Vernova Approach

GE Vernova adopts a more modern approach to grid interconnections through flexible interconnection programs. In these programs, DER owners agree to flexible export and import limits that adapt to changing conditions, thereby optimizing network and DER utilization. These active management programs effectively address challenges posed by increased solar PV penetration, EV adoption, and more, providing utilities with a more flexible and efficient approach to DER integration.

To successfully implement these programs, utilities communicate time-varying limits to DERs through dynamic operating envelopes (Figure 3). These limits are set either on a per-DER basis at the service point level, or at a higher grid level such as a transformer. GE Vernova's integrated ADMS and DERMS solution plays a crucial role in managing these programs by increasing visibility into participating DERs. Operators can capitalize on this visibility by monitoring telemetry data from DERs, regardless of the communication channel used. From there, they can directly integrate this data into ADMS power flow calculations to improve limit monitoring and the results of FLISR and VVO.

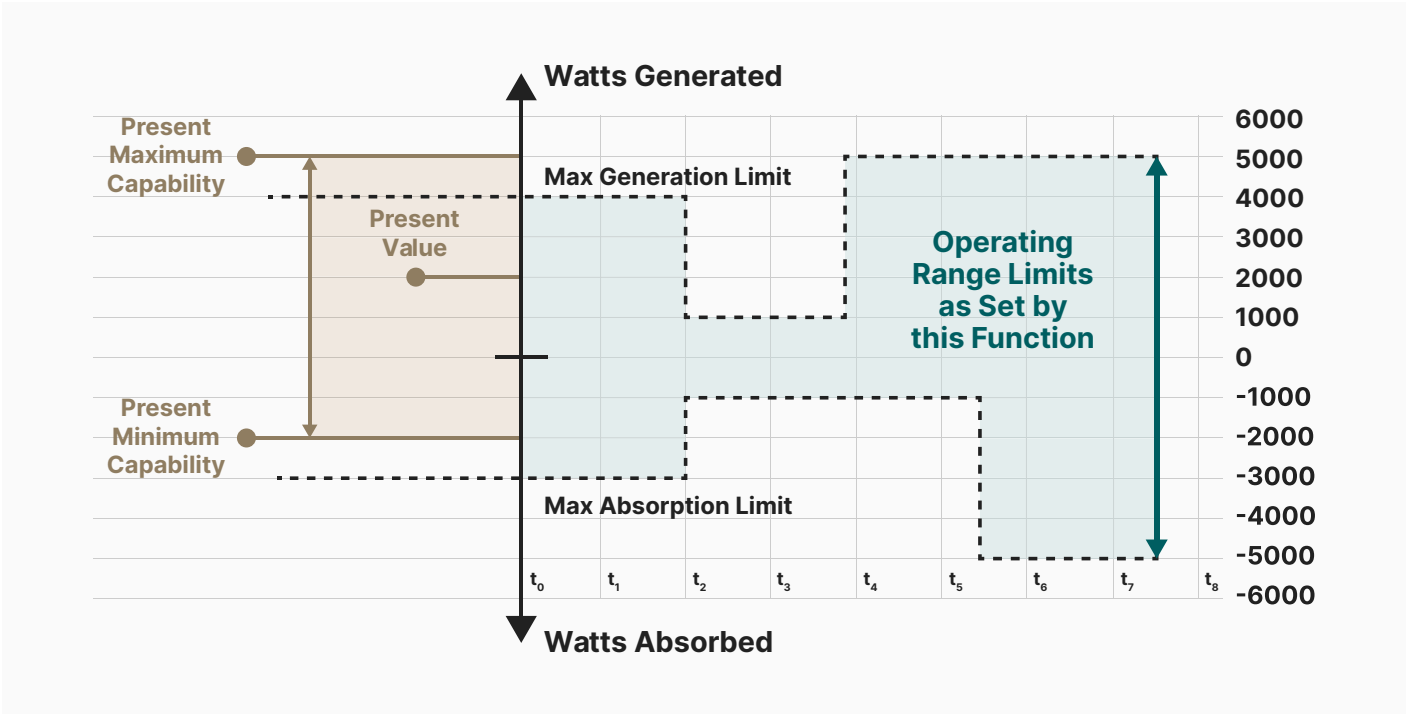
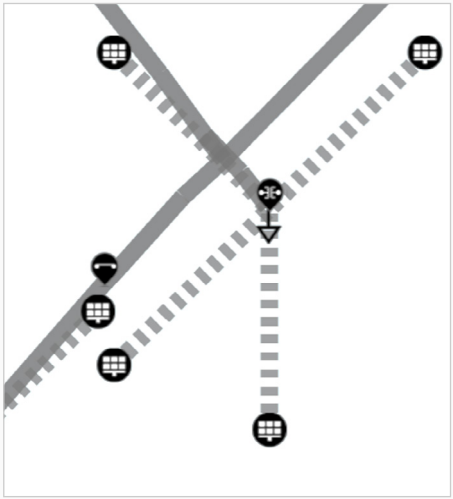


Figure 3: Dynamic operating envelopes can allow greater DER capacity than firm limits at certain times

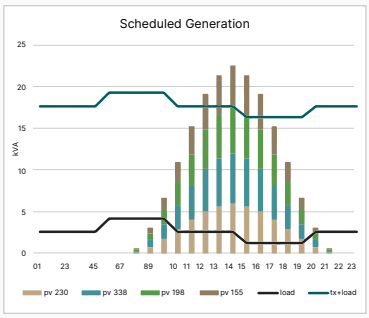
The advantage of these flexible interconnection programs and DOEs, typically implemented at the service point or DER level, is that they require minimal intervention from the grid operator to manage these programs. Instead, these programs and DOEs proactively detect and resolve issues before they can impact the power system. The example case study in Figure 4 demonstrates PV units of aggregated capacity of 22kVA behind a 15kVA transformer. With dynamic limits applied, the PV output is maximized while respecting the transformer loading limit at all times, taking into account changing loading and PV generation.

RESULTS: TRANSFORMER LIMITING

- These DERs represent residential PVs behind a service transformer
- In this case study, their export capacity is impacted by the size of the service transformer
- DOE restricts their output for the hours with low loading and high solar output



Asset	Size	Phase
Agg PV (4)	22 kVA	A
T5293480A	15 kVA	A



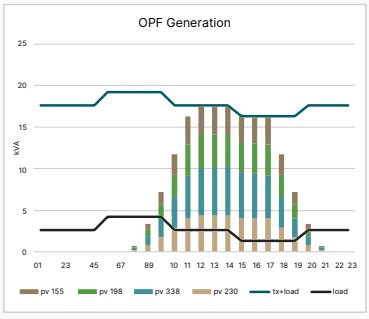


Figure 4: Using DOEs to manage transformer limit

Solution Highlights

1 Equitable Network Access

- Flexible interconnection programs enable all participating DER locations to share constraint management responsibilities, eliminating the need for network upgrades for each new interconnection request.

2 Increased Network Utilization

- By allowing more DER to connect, the existing network capacity is used more efficiently, avoiding overdesign for worst-case/peak scenarios.

3 Enhanced Hosting Capacity

- Flexible interconnections actively support increased DER integration, expanding the grid's capacity to accommodate solar PV, Battery Energy Storage Systems (BESS), EVs, and more.

4 Improved Network Security

- By considering network constraints, loading, switching, and real-time grid conditions, the combined ADMS and DERMS solution ensures that flexible interconnection programs limit DER import and export in accordance with the grid's real-time state.

5 GridOS DERMS Module Support

- Within GridOS DERMS, several modules support flexible interconnection programs throughout their lifecycle:
  - Simulation conducts studies to design flexible interconnection programs and assist in interconnection assessments. The Simulation network model is initialized from the ADMS model to ensure consistency between planning and operations.
  - Program Manager stores information about flexible interconnection programs, including enrolled DERs or customers enrolled in these programs and their particular constraints and operating parameters. Program Manager also supports reporting on program performance and compliance of these programs.
  - Gateway utilizes communication protocols like IEEE 2030.5 to transmit dynamic operating envelopes to DER controllers. It also integrates with SCADA to issue import and export limit controls using protocols like DNP3. Additionally, it serves as a communication front-end for DER telemetry data, which can be routed to ADMS to update the active loading or DER injection used in the ADMS online power flow calculation.
  - Optimization employs power flow and heuristic-based optimization techniques to calculate DOE limits, considering network constraints and real-time conditions.
  - Operations continuously monitors compliance with DOE controls, alerting users when limits are violated.

RESILIENCY AND SAFETY

Utility Challenge

In addressing the challenges of safety and resiliency, the integration of DERs into the grid brings some critical issues to light. Power-generating DERs introduce new injection points at the Grid Edge, posing a major safety challenge. While modern protection functions require DERs to disconnect during grid events like voltage loss, there still remains a risk of failure or accidental energization during outages, posing a threat to public safety and utility field crews. Thus, it's critical to ensure that DERs, especially large-scale ones, are automatically locked out when line workers are restoring power.

Simultaneously, the local injection of DERs has tested the grid's resiliency. DERs can mask native grid load, effectively creating what's called "phantom load." This hidden load can catch operators off guard when implementing switching actions, which may cause cause multiple DERs to trip offline simultaneously and lead to sudden load spikes. Addressing these situations requires a rapid emergency response, which is both risky and time-consuming. These resiliency challenges are further exacerbated by trends such as decarbonization through increased electric power usage and the rise in extreme weather events, like hurricanes and wildfires. Utilities need a solution that not only analyzes and manages such challenges as part of day-to-day operations, but also addresses them proactively.

GE Vernova Approach

GE Vernova recognizes safety is a paramount concern for grid operators. The integrated ADMS and DERMS solution comprehensively addresses this critical objective to protect utility personnel, emergency workers, and the public. It accomplishes this through several advanced features – such as DER lockout, which ensures that large, grid-tied DERs are automatically disconnected during outages to prevent accidental line re-energizations and enhances safety protocols.

From a resiliency standpoint, ADMS and DERMS also provides visibility into disaggregated load and generation to help operators anticipate load changes after switching actions, whether manual or automated. Additionally, the solution also supports microgrid modeling and communication, allowing for intentional islanding and enhanced grid support. This additional layer of microgrid integration not only enhances resiliency but also contributes to grid reliability, empowering utilities to effectively manage DER-related safety and resiliency concerns.

Solution Highlights

1 DER Lockout

- ADMS continuously calculates the energization status of every network asset.
- During outages in a specific area, DERMS function automatically sends trip and lock-out controls to large grid-tied DER to prevent accidental injection.
- After the outage is restored and the line is re-energized, DERs are returned to normal operations.

2 Disaggregated Load and Generation

- ADMS enables grid operators to view disaggregated downstream load and generation at any switch in the network or from any downstream trace, taking into account DER telemetry data provided by DERMS.
- It also provides a quick check for operators to determine the masked load that may pick up after switching.

3 Fault Location, Isolation & System Restoration (FLISR)

- ADMS' FLISR application automatically accounts for the auto-disconnect protection functions of DERs, along with default "enter service" delays after line re-energization.
- In areas with large DERs, FLISR can automatically lock out DERs as part of the switching sequence.

4 Microgrids

- The combined ADMS and DERMS solution enables utilities to model microgrids, including connected behind-the-meter assets.
- The combined solution also supports communication with microgrid controllers, providing awareness of microgrid operating modes, or even scheduling an intentional island for grid support purposes.
- Advanced microgrid controllers, such as those provided by GE Vernova's Grid Solutions, can also integrate with ADMS and DERMS, enabling the reception of real and reactive power setpoint controls and kW limit controls at the point of common coupling. This unlocks additional uses of microgrids for peak load management, outage restoration support, and other bulk grid services.

ORCHESTRATE THE DISTRIBUTION CONTROL ROOM OF THE FUTURE

UNLOCK DISTRIBUTION GRID ORCHESTRATION WITH GE VERNOVA

EMBRACE THE FUTURE, NOW

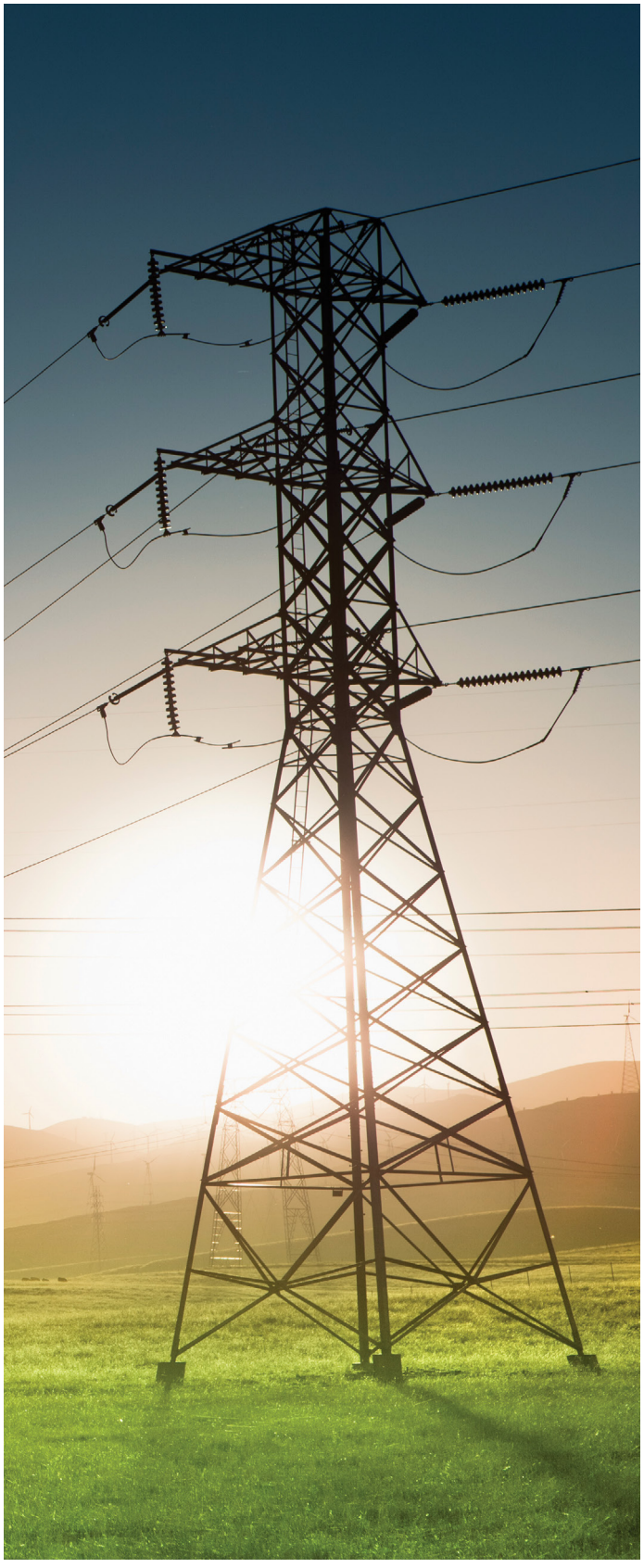
The pace of growth in the energy landscape will only continue to accelerate, and the time to act is now. To stay ahead and thrive in this dynamic environment, utilities must proactively adapt, invest in flexible infrastructure, and embrace change. The path forward is clear: end-to-end grid orchestration. By embracing GE Vernova's integrated ADMS and DERMS solution, utilities can confidently progress toward the distribution control room of the future.

THE CONTROL ROOM OF THE FUTURE

This future control room transcends the conventional, emerging as the epicenter of a proactive and dynamic energy transformation. It requires fewer operators while providing an all-encompassing view of network operations. It propels us towards net-zero goals without the need for massive investments in grid hardware. The deep integration and synergy between ADMS and DERMS combines innovative, intelligent solutions with established assets and operations. This integration offers a modernized grid management system that maintains reliability and resiliency on the distribution grid and supports the integration of renewables and DERs.

THE POWER OF GridOS

Standardizing your operations on a single GridOS deployment is the key to unlocking the future of the grid. It's more than just adapting to change; it's about leading it. Leveraging GridOS' capabilities underlying GridOS DERMS and ADMS empowers utilities to achieve safe, reliable, and resilient energy delivery. It combines grid planning and operations with market solutions, unlocking the economic value of DER and renewables flexibility. GridOS offers horizontal scalability, a Zero Trust grid security model, hybrid cloud deployments, automated testing, and a federated grid data fabric with a common network model across transmission and distribution. With GridOS at the core of the grid's future evolution, utilities leveraging this platform will continuously experience more innovation and value as it evolves.



ACCOMPLISH TANGIBLE OUTCOMES

Future-proof your grid

GE Vernova's combined ADMS and DERMS solution isn't just for today's challenges. It's an investment in a scalable and adaptable foundation that future-proofs your utility in a world of progressively more DERs and renewables. There's no need for extensive system overhauls. By investing in GridOS, you are equipping your utility with a scalable and adaptable foundation that ensures you can keep the lights on for customers while staying ahead of the curve.

Achieve T&D orchestration

Our integrated solutions usher in a new era of transmission and distribution coordination, providing utilities with a comprehensive view and fostering a collaborative approach between the two. The traditional silos and disjointed operations of separate control rooms, groups, and systems are no longer practical. With end-to-end orchestration, you can ensure that your grid operates with a more holistic approach to grid planning and operations.

Strengthen grid cybersecurity

In today's digital age, grid security is paramount. With the implementation of GridOS, sporting a built-in Zero Trust grid security model, you can defend against evolving security threats posed by the proliferation of DERs and increasing cyberattacks on utility infrastructure. You can maintain peace of mind, knowing that your grid remains secure, reliable, and resilient.

Scale for DER and renewables integration

You can utilize a scalable and adaptable foundation for managing the influx of millions of DERs and renewables while keeping the lights on for customers. As the energy landscape continues to evolve, GE Vernova provides the flexibility needed to accommodate new DER technologies, changing grid configurations, and evolving market structures without the need for extensive system overhauls.

Ensure proactive grid management

Proactive grid management is essential to staying ahead of evolving grid demands and challenges. It is essential to adopt a forward-thinking approach that comprehends the current grid state and anticipates the future impact of DERs. This approach enhances grid resiliency and reliability, minimizing the risks associated with unexpected disruptions.

Meet net zero goals

Utilities can implement strategies and technologies to align with Net Zero targets. GE Vernova's solutions enable utilities to seamlessly integrate renewable energy sources, reduce greenhouse gas emissions, and meet regulatory compliance requirements such as the European Union's Clean Energy Act and other international standards.

Realize cost savings and optimized DER utilization

Our combined ADMS and DERMS solution enables efficient load balancing, fault detection, and outage management, resulting in reduced labor, maintenance, and energy procurement expenses. Moreover, our flexible interconnection programs and optimization strategies help utilities defer CAPEX. These cost-saving measures both strengthen the bottom line and also enable utilities to reinvest in further grid modernization and customer-centric initiatives.

Enhance safety and resiliency

Enhance grid safety by preventing accidental energization, ensuring the disconnection of DERs during outages, and safeguarding utility personnel and the public. And improve resiliency with proactive grid management that anticipates challenges, minimizes disruptions, and enhances reliability in the face of evolving grid demands.

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Abbreviations

ANM	Adaptive Network Management
ADMS	Advanced Distribution Management System
BESS	Battery energy storage system
CIM	Common Information Model
CVR	Conservation Voltage Reduction
DERMS	Distributed Energy Resource Management System
DER	Distributed energy resources
DOTS	Distribution Operator Training Simulator
DSO	Distribution system operator
DOEs	Dynamic Operating Envelopes
EVs	Electric vehicles
EVSE	Electric vehicle supply equipment
EMS	Energy Management System
FLISR	Fault Location, Isolation & Service Restoration
GW	Gigawatts
GIS	Geographic Information System
NWA	Non-wires alternatives
OMS	Outage Management System
PV	Solar photovoltaics
T&D	Transmission & Distribution Utilities
TSO	Transmission system operator
VPP	Virtual Power Plant
VVO	Volt/VAR Optimization

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ELECTRIFICATION SOFTWARE

GE Vernova's Electrification Software is focused on providing a suite of software products and services to customers aiming to accelerate a new era of energy by electrifying and decarbonizing the energy ecosystem through intelligent and efficient data analytics, monitoring, and management.