Smart Electric Power Alliance

DERMS Encyclopedia Module Summary

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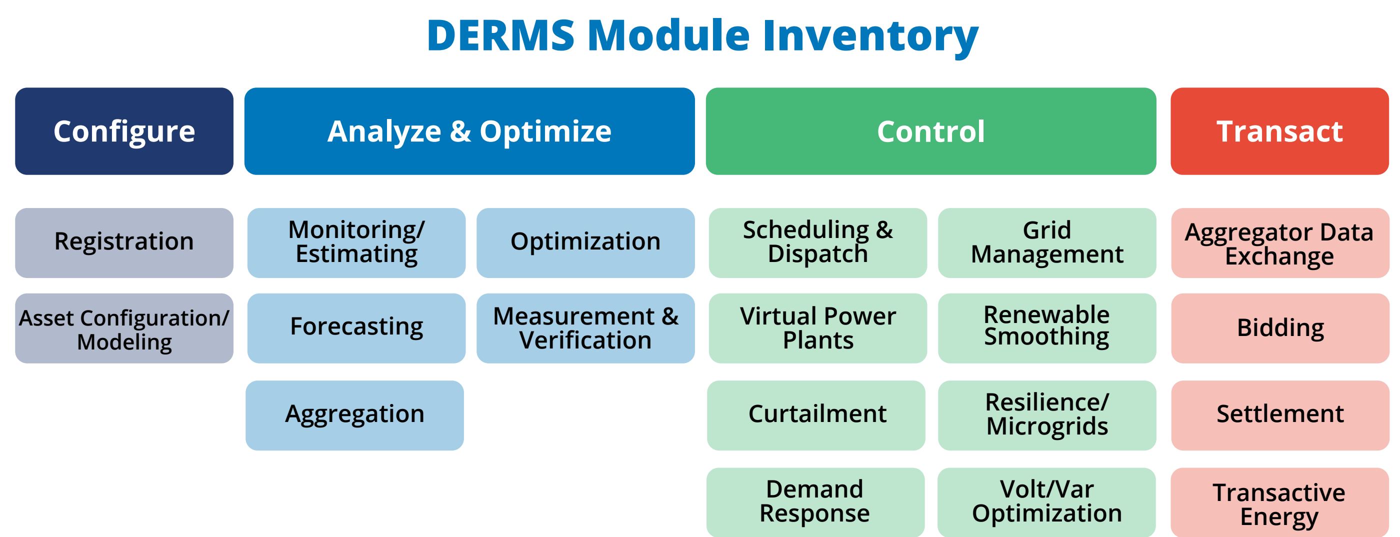
DERMS Module Summaries

SEPA, along with 12 utilities and 11 vendors, developed the "Encyclopedia of DERMS Functionalities" to describe different DERMS use cases and functionalities. This document is a short companion document that summarizes functionalities included in the encyclopedia. The DERMS functionalities were grouped into modules, and each module can be treated as an individual component of a DERMS system. In practice, different DERMS solutions may have functionalities that cross the different modules defined in this guide. For example, some vendor solutions address DER aggregation and the creation of a virtual power plant as one function. This guide identifies discreet modules to clearly identify required functionality with an understanding that actual DERMS solutions may be constructed differently yet provide the same capabilities.

The DERMS Module Inventory (Figure 1) groups the modules into different use cases addressed by the DERMS Collaborative Team and is consolidated into four major categories: Configure, Analyze & Optimize, Control, and Transact. This document provides an overview of the different categories as well as short descriptions of the different modules.

Figure 1. DERMS Module Inventory by Use Case



Source. SEPA, 2023.

Configure

The Configure Use Case includes registration of DERs and the modeling of individual and grouped DERs to support other DERMS functions. This is the first step of integrating DERs into the grid system, viewing them on the network model, and in determining their overall impact and flexibility for grid services. DER configuration involves obtaining registration information, which often includes nameplate capacity, operational set-points, and programmatic information such as participation in demand response or ancillary service programs. By configuring all DER data in the DERMS system, the utility and/or third-party aggregator can view the various devices in the system, especially grid-edge and behind the meter assets. Device configuration also allows for more efficient DER grouping, which improves both utility control over the assets and data exchange between the utility and third-party aggregators and between third-party aggregators and other service providers and the market. Through this use case, a utility operator can visualize the registered DER topographically within the utility's network model.

Registration

Configuration consists of use cases that give insight into DERs, but do not necessarily allow for direct control.

The modules included in the configuration category are Registration and Asset Configuration.

A key function of any DERMS is capturing relevant asset, programmatic, and network information about the DERs it will manage to provide better utility visibility. This could include utility owned and operated DERs, DERs participating in utility programs, DERs participating in ISO/RTO programs, or DERs aggregated by third-parties including DERs aggregated under FERC Order 2222 tariffs. Information categories include:

- **Asset Information**: Nameplate or Technical Information (including communication and control component information)
- **Programmatic Information:** Ownership and Account Information, programs including operational constraints or requirements, aggregator ID or other third-party identifier, and program limitations that prevent DERs from being utilized in multiple programs
- **Network Information**: Static devices information including location, feeding line/circuit, load zone, access codes, encryption keys etc.

The DERMS utilizes this registration information for the dual purposes of feeding DER information to the other DERMS use cases of Analyze & Optimize, Control, and Transact and to enroll customer DERs into utility programs.

Asset Configuration/ Modeling

A DERMS can provide utilities the ability to digitally model, visualize, optimize, and control front of the meter (FTM) and behind the meter (BTM) DERs. Before a DERMS can visualize, optimize, or control DERs, it must first have data on the DERs connected to the grid. A DERMS typically does this in one or both of the follow ways:

1. Registration and Configuration of individual DER assets
2. Modeling DERs in the larger distribution network connectivity model

Configuration of individual DERs involves collecting DER asset, programmatic, and network data (See Registration Module) for use in other DERMS functions. Obtaining the necessary data is crucial for the DERMS optimization engine to initiate control schemes based on different operational objectives that leverage DER capabilities.

Analyze & Optimize

The Analyze & Optimize modules provide advanced capabilities for utilizing and integrating DERs into the grid. DER Analyze & Optimize modules of a DERMS involve monitoring, aggregating, forecasting, and visualizing data on DER assets for real-time operations and future utility planning. It also includes the optimization engine used to instruct how all subsequent DERMS functions best utilize DER capabilities. Finally, measurement and verification functions provide after the fact analysis used for a variety of commercial and financial transactions.

All of these modules utilize the information from the Configure Modules in order to perform the analysis on the DER. Analyze & Optimize functions need data about the DERs in order to perform their functions, but this category of modules does not send dispatch and/or control signals to the DERs. The primary function of these modules is to understand the historical, current, and predicted capability of DERs and their grid impacts.

Collectively, these modules give utilities a clearer understanding into the expected or real-time status of customer and grid DER assets including information such as location, operational status, and device connectivity. Better DER situational awareness and the ability to optimize DER capability allows utilities to maximize the potential of the many services DERs can provide.

The modules included in this category are Monitoring/Estimating, Forecasting, Aggregation, Optimization, and Measurement & Verification.

Monitoring/ Estimating

DERMS can be designed to monitor, sense, and measure DER outputs and provide real-time information to utility operators and planners. One aspect of monitoring includes visualizing monitored data, which allows distribution operators to manually and/or automatically adjust DERs or alert DER aggregators as needed to assist with maintaining grid stability and energy consumption needs. Monitoring can provide functional data on the connectivity, location, real-time load/output, state of charge, and operating status of individual and grouped DERs to confirm customer compliance with DER programs, ensure compliance with net metering capacity limits (e.g., 25kW AC system size), and send automatic updates to detection and control systems for functions such as anomaly and constraint detection. Effective monitoring requires decision making on the granularity and frequency of the data acquisition. From an operational perspective, aggregation level monitoring is sufficient for grid control, especially for DERs that are aggregated based on location. Locational aggregation allows DERs to be simplified into generation, flexible load resources, and storage resources. From a system planning and measurement and verification perspective, monitoring of individual DER devices is required.

Forecasting

DERMS forecasting functionality can be used to improve visibility of DERs in aggregate or at an individual level. Forecasting capabilities vary based on vendor, but often include load and/or capacity forecasting. These forecasts can be constructed based on real-time data, historical data, or a combination of both. In some cases, the DERMS will also communicate with weather predictions and external pricing data, such as wholesale prices and TOU rates, to better estimate future energy demand and DER behavior. Coupled with state estimation functions that can collect data on voltage and power flow, forecasting allows for greater situational awareness for system operators and aids in both long-term and short-term distribution planning processes.

The advanced forecasting capabilities DERMS employ are often conducted in real-time, requiring interaction with DER metering devices to collect data. Forecasting can be conducted for load, capacity, and power quality data such as voltage and frequency. Forecasting engines can communicate with weather sensors or externally collected weather data, especially for DERs such as solar panels that heavily depend on those parameters. The calculations used for forecasting can rely on daily and seasonal variation such as weather, temperature, solar irradiance, wind speed, and usage profiles varying from near real-time to longer periods. Load profiles based on historical data, and DER operational capabilities can also be used in the forecasting process. Price signals may factor into these capabilities, so some forecasting solutions include a market interface. Forecasts are used by system operators to predict the ability of DERs to meet demand and schedule DER interconnection accordingly. The software should have some connection with the utility's scheduling and dispatch abilities to maximize the value of these forecasts.

Aggregation

The increasing number of DERs connected to the grid presents new challenges for the utilities tasked with managing them. DERMS aggregation functions allow grid operators to view and control many different assets as simplified groups. In many cases, the actual DER aggregation is performed by a third-party who then interfaces with the utility DERMS. As more third-party aggregators enter the DER space and/or become more mature in their capabilities, it has become more common for utilities to work with these aggregators to obtain access to customer BTM and to form the DER aggregations.

In this case, the DERMS would need to maintain a mapping of these third-party provided aggregations. Aggregation functionality can also allow utilities to create virtual power plants (VPPs) to streamline dispatch of assets and market interaction functions. Aggregations can take many forms based on DER type or technical characteristic, location or system connectivity, ownership, communication method, third-party aggregator, etc. ISO/RTO FERC 2222 compliance tariffs may also require additional aggregation requirements.

Optimization

Different types of DERs (e.g., storage, electric vehicles, or solar + storage) can provide different services and may make more sense in one operational circumstance than in another. For inverter-based DERs, different smart inverter functions may be best utilized at different locations or times. A function of a DERMS is to provide requested grid services in the optimal way using the best combination of DER assets to save cost, reduce wear, and optimize asset value. This optimization includes determining sequencing or prioritizing DER operations. A DERMS optimization module considers the capabilities and operating status of the DER under utility control and optimizes those assets to accomplish different control objectives established by operators. Economics, reliability, or environmental goals drive optimization strategies. Support for multi-objective optimization is required.

This optimization is similar to security constrained economic dispatch (SCED)[1] of large generation resources conducted in generation management systems. In the case of a DERMS, optimization is only performed for DERs under its management. Utilities that have implemented advanced distribution management systems (ADMS) may utilize them for the security constrained optimization for reliability and the core DERMS optimization engine for economic and grid constrained dispatch.

Measurement & Verification

A key function of a DERMS system is to evaluate the performance of DERs in providing grid or customer services. Typically, these services are provided by the flexibility DERs can offer through adjusting load or output. DERMS Measurement and Verification (M&V) functions help utilities gain insight into the overall DER performance and into the specific performance measures needed for contract and interconnection agreements. The M&V function compiles the performance and customer meter data and sends that data to the settlement module for processing and billing.

An M&V application can quantify energy savings by comparing previous energy use with energy use during utility-initiated events and during grid interconnected conditions. A DERMS system applies its M&V functionality to evaluate the performance of small DERs participating in utility programs, large individual DERs against the terms of interconnection agreements, and third-parties utilizing DERs to provide contracted services to the utility.

Control

DER control is the act of automatically or manually adjusting the output of certain DERs to achieve a desired operational objective. One of the primary drivers to implementing a DERMS is gaining control over both BTM and FTM DERs to manage load and provide grid and ancillary services. Control of this type may only be used on certain DER types and requires communications between the DERMS and the applicable DER assets.

Operators must have visibility into DER status including their operational profile. The Control modules utilize the DER information from the Configure and Analyze & Optimize Modules for a clearer understanding of the current fleet of available capacity and optimal DER dispatching. The Control modules are often closely coupled with the Optimization module in order to achieve the full economic and grid benefit from controlling the DERs. Control of DERs may include economic, resource, or environmental dispatch to maximize pricing or to meet a utility's carbon objectives. Control can also include grid optimization to save costs, reduce wear, address system constraints, and optimize asset value. To enhance system resiliency, DER control also allows for microgrid control either stand-alone or as microgrid aggregation. The aggregation of DER through DER control is essential in increasing DERs penetration to protect grid reliability, optimize supply side resources, and maximize DER assets.

The Control modules include Scheduling & Dispatch, Virtual Power Plant, Curtailment, Demand Response, Grid Management, Renewable Smoothing, Resilience/Microgrids, and Volt-Var Optimization.

Scheduling and Dispatch

Economic Dispatch and Scheduling

1 Security-constrained economic dispatch is an area-wide optimization process designed to meet electricity demand at the lowest cost, given the operational and reliability limitations of the area's generation fleet and transmission system.

Many DERMS offer utilities operational capabilities such as economic dispatch of active and reactive power in response to price signals such as locational marginal pricing (LMP), capacity, and energy price points from the local market interface. This functionality often goes hand-in-hand with scheduling so that utilities can operate assets at the optimal times for maximum economic value. Depending on the software, dispatch may be automated or on-demand.

Economic optimization utilizes price signaling to support a reliability-constrained economic dispatch of the DERs. Either energy or capacity can serve as a price signal. Price signals can be internally generated by the utility or be based on market price signals. The DERMS uses price signals to communicate with and dispatch and individual assets or third-party aggregators. Economic dispatch may also be integrated with scheduling functions to ensure optimal dispatch timing. While determining economic dispatch, the dispatch order of the resources should include resource costs to maximize value. Resource constraints such as operating limits and resource program participation and tariffs must also be addressed.

Environmental Dispatch and Scheduling

DERMS can offer operational capabilities such as environmental dispatch of DERs. Environmental dispatch allows utilities to balance environmental concerns, such as decarbonization efforts or renewable generation coupling with available storage, with grid needs. The objective of this solution is to help utilities optimize DERs in support of carbon emission reduction goals while still promoting reliability. Environmental dispatch can help grid operators ensure the lowest rate of emissions through optimal deployment of clean DERs and minimization of power loss.

Unlike economic dispatch, environmental dispatch relies on resource emission rates and system emissions. Although renewables are emission free, their dispatch can have effects on overall system emissions. For example, charging energy storage at a time of higher system emission rates has an adverse effect when compared to energy storage charging during lower system emission rates. Likewise, other resources can have the same effect. Like economic dispatch, resource cost should be addressed when resources impact system emissions.

Virtual Power Plant (VPP)

Creating a Virtual Power Plant (VPP) involves aggregating DERs into a single, dispatchable resource that can provide grid services such as demand response, provide capacity for reliability or in capacity markets, or reduce peak loads. VPPs can consist of one asset type, such as residential battery storage, or mixed-assets, such as combinations of electric vehicles, smart thermostats, and commercial and industrial battery assets. Both single and mixed-asset type VPPs can participate in capacity and ancillary markets, if desired. Using a DERMS to create a VPP has the additional benefits of integrating with existing enterprise systems such as ADMS, distribution management system (DMS), and supervisory control and data acquisition systems (SCADA) to also provide localized grid services. A VPP was previously considered a supply-side initiative but in practice, VPPs are deployed in DR programs, where the load reduction is often the purpose of the VPP. However, in most cases, the VPP is utilized as a resource to address energy supply objectives.

Curtailment

Utilities with high numbers of distributed generation resources may look to DER curtailment to maintain voltage limits and protect power quality. Most commonly used with solar inverters, a DERMS with curtailment functions can swiftly respond to external factors or feeder conditions, granting utilities greater control and avoiding flooding the grid with excess power. More traditionally, curtailment involved reducing the load of (typically) commercial or industrial customers during times of peak load. These customers were typically on interruptible rate structures and were equipped with some degree of automation to reduce load. A DERMS could be used for controlling such customers in addition to other DERs on the grid. Of note, curtailing DERs that have no emissions, such as rooftop solar, may negatively impact any utility emission goals.

Demand Response

The demand response (DR) module of a DERMS includes a variety of functions required for management of a DR program including customer enrollment, event scheduling, DR weather and capacity forecasting, dispatch signaling, and event measurement and verification. Financial settlement with retail customers or with the wholesale market is also part of DR but is considered part of a DERMS Settlement module. Many DERMS used only for DR are marketed as grid-edge[2] systems that allow utilities better control and insight into supply-side resources and the distribution grid both for small- and large-scale DER assets. Complete DR DERMS packages can include all associated subfunctions stated above or are modules added to the vendor's larger DERMS platform. Supported programs include "dispatchable" behavioral DR, where customers only receive notifications and make the adjustments to load as they see fit, or direct control programs, consisting of switched devices and/or smart thermostats. In either case, dispatch strategies often rely on forecasting abilities and sometimes price signals, or other market strategies, to determine when events should be called and to optimize the dispatch schedule. Called events are likely determined by the regional ISO/RTO or individually by the utility, and a signal is sent to the DERMS system to initiate the dispatch of the enrolled DERs. In the case of critical peak pricing or event-based DR, a pre-event communication is typically sent to customers alerting them of the upcoming DR event to prepare them and to give them a chance to opt-out or take other load reduction actions. When communicating with customers, the DERMS system likely interfaces with a utility-customer communication platform.

DR programs can include a variety of DER assets from small, residential smart appliances to larger commercial and industrial assets such as battery storage. DR DERMS platforms are designed to handle a diverse portfolio of assets and to communicate with different customer classes.

Grid Management

Grid management consists of controlling DERs to obtain energy, capacity, and ancillary service objectives. As DER penetrations increase, controlling the energy output and/or load profile of individual and aggregated DERs becomes more important for adequately managing grid supply and demand. A DERMS can provide real time energy usage monitoring, provide visibility into DER impacts on net load, and allow the utility to control energy input/output to balance the grid and to provide load shedding and shifting services.

Energy Management

Controlling DER energy output is often utilized for energy arbitrage purposes. Energy arbitrage can be performed for wholesale market purposes to purchase energy when the prices are low and resale that energy when prices are high. For distribution, energy arbitrage is exercised by the utility through tariffs that depend on the time of day and encourage consumers to shift their energy use from higher priced times to lower priced times or to optimize renewable energy output to best align with load requirements. Managing the energy output from clean DERs can also support the utility's carbon goals and can complement their grid scale generation portfolio. A DERMS can provide energy management by using DERs to deliver a quantity of energy when needed at certain points on the distribution grid. The energy provided can be positive or negative, depending on grid needs.

Capacity Management

The most basic capacity service is to allow the DER to deliver or consume power. The DERMS provides this type of flexible capacity service through control of DER ramp rates. These ramping reserves are power reserves associated with load and resources used for system balancing. The DERMS can also be calibrated to employ load shifting or peak shaving strategies to improve the efficiency of distribution and mitigate problems with intermittent resources. Load shifting and peak load management is often achieved using demand response or energy storage.

Ancillary Services

Utilities may use a DERMS to limit distribution system constraints and violations or to alleviate overloads and power quality issues. The most likely application for this is utilizing DERs to manage voltage and frequency where the DERMS controls DER output to match grid supply and demand. Through a DERMS, DERs can be used to solve the constraint issues caused by integrating DERs into the grid system.

2 "Grid edge is a term used to describe technologies and business models that advance a decentralized, distributed, and transactive energy grid. This includes physical infrastructure assets, network or control software, applications, and data analytics tools." NRDC. 2018.

Frequency limits can be maintained through frequency control (device-level continuous, autonomous adjustment of DER output in response to a frequency error from scheduled frequency under normal operating conditions) and frequency response (device-level automatic adjustment of DER output in response to a frequency error from scheduled frequency for significant frequency events). Frequency control becomes difficult in relatively small balancing areas (i.e. Hawaii) where grid operators require countermeasures for variable renewable resources to reduce their power fluctuation amplitude. Voltage support is provided by controlling DERs capable of dynamically correcting excursions outside of voltage limits by absorbing/ injecting reactive power as well as by controlling DER power output impact on voltage.

Renewable Smoothing

Renewable smoothing is a critical issue for increasing DER interconnection capacity to the power grid. As renewable generation increases, utilities are looking at multiple technology options to address the variability of these renewable resources. Smoothing the output of variable renewable resources makes the renewable generation look more like baseload generation, which is more dispatchable and reliable. This is also referred to as renewable firming. Similarly, utilities want to smooth the variable nature of renewable DERs such as solar PV to mitigate voltage and frequency disturbances. These different operational needs require smoothing to occur over seconds to address power quality issues, over a day to match power purchase agreement terms, or over year to match generation portfolio requirements.

Resilience/ Microgrids

A DERMS system's resilience use case is centered on maintaining grid stability and access to power during widespread grid pressures that can occur from external events including storms, flooding, wildfires, and other extreme weather. Resilience use cases primarily focus on utilizing microgrid assets during blue-sky and islanded modes. However, resilience benefits can also be gained from integrating an ADMS with a DERMS system to allow DERs to participate in FLISR operations and help manage load transfer.

Depending on their functionality, microgrid controllers may themselves be considered a DERMS or may be separately controlled by an enterprise DERMS system during grid-connected modes. In the latter case, the DERMS can aggregate multiple microgrids, elevating them beyond individual entities into grid assets. When DERMS directly manage microgrids, utilities gain more control over both planned and unplanned islanding events, which improves visibility to ensure microgrids are functioning as effectively as possible. Microgrids managed by DERMS can be primarily designed to operate entirely off-grid in island mode, to provide a resilience benefit to loads within the microgrid, or designed to be primarily connected to the grid and only be islanded at certain times.

If the DERMS serves as the controller itself, it must be able to control dispatch of generation and storage resources and manage data based on conditions within a microgrid. A DERMS microgrid controller requires low-latency, intensive data, and control. More often microgrids are designed using a federated microgrid controller so that a hierarchical architecture allows the utility to interconnect a centralized DERMS to oversee the microgrid and an ADMS to coordinate with the surrounding grid system.

Volt/VAR Optimization (VVO)

DERMS can improve power quality through active grid management strategies. One such strategy involves voltage support through volt/VAR optimization (VVO). VVO focuses on circuit-level operations and reduces energy losses by reducing reactive power flow along the distribution circuit. VVO devices communicate with system-wide voltage measurements to minimize power losses and offer increased system efficiency. Conservation voltage reduction (CVR) is the intentional operation of the transmission or distribution system to provide customer voltages in the lower end of the acceptable range, with the goal of achieving customer energy and demand reductions. CVR is used to flatten voltage profiles and lower overall system voltage while staying within the specified ANSI or IEC voltage limits. When utilities manage and optimize voltage and reactive power simultaneously (combining the voltage management associated with CVR with reactive power management), it is referred to as volt/VAR optimization.

Transact

The Transact modules are a group of economic and transaction modules that aim to produce better coupling with market systems. One function of a DERMS is to facilitate DER transactions with third-parties and energy markets. The systems can monitor, predict, and present information on market conditions for optimized energy purchase/ sales as well as provide utilities with a platform for coordinating with third-parties that may manage BTM DERs. Market-related DERMS applications require monitoring and predictions of LMPs and other parameters to inform DER trading in capacity and/or energy markets. Third-party related DERMS applications are primarily focused on the seamless exchange of DER data and controls. These functions rely on access to DER capabilities and benefit from aggregation functions to create VPPs, group DERs by aggregator, and support FERC 2222 requirements focused on connecting DERs with markets.

Many vendors are still in the developmental phases of the transact services, given the extensive communication needs to exchange information with market systems and with the multiple entities working in the DER space.

The Transact modules include Aggregator Data Exchange, Bidding, Settlement, and Transactive Energy.

Aggregator Data Exchange

Utilities may not have access to smaller BTM DERs owned by customers; many BTM device manufacturers for customer assets such as smart thermostats or electric vehicle supply equipment (EVSE) require the utility to communicate through their channels in order to access and communicate with customer assets. In some cases, aggregators and other third-parties may be managing those DERs on behalf of the customer. Utilities may want to interact with these DERs or have visibility into their operation. These DERs may be more effectively managed by the utility when grouped into aggregation nodes, which allows for more efficient information exchanges between the utility and third-party aggregators managing the individual devices. Grouping of DERs by third-party aggregators creates the need for interactions between the utility DERMS and the aggregator DERMS. These interactions often require customized interfaces to ensure the correct and secure exchange of data. Efficient data exchange can improve operability through collaboration, but industry interfaces need further standardization. A DERMS system should include facilities to manage this exchange of data with third-parties and support standard data formats.

Bidding

Energy market participants such as aggregators, competitive energy suppliers, merchant generators, and utilities submit bids and offers for buying/ selling energy or providing ancillary services. This could include bidding energy provided from discrete or aggregated DER resources. Typically, market participants use a trading system which actually formulates the bids and offers and formats them for submission to each respective market. The trading system is configured with the market participants bid strategy considering all of its assets and contracts in that market. A utility can utilize its DERMS to provide DER related bid information such that the trading system can optimize their wholesale market participation. The DERMS can also be used to simply monitor the status of DERs bid into wholesale markets by third-parties. ISO/ RTO compliance tariffs for FERC Order 2222 will require additional capabilities for utilities to review and approve the DER aggregations formed by third-parties prior to their submission in wholesale markets.

Settlement

Settlement is the process of reconciling actual operations against planned or forecasted operations and development of the associated charges associated with that reconciliation. Settlement has typically been conducted in a Demand Response Management System (DRMS) that conducts the reconciliation after load control events. DERMS systems can also utilize the same information as a DRMS system in order to perform the settlement function. Using data from the customer's baseline energy usage and the energy used during the demand response event, the DERMS system can calculate the delta in energy consumption.

Settlement can occur at the wholesale or retail level, and a DERMS system can provide settlement functionality under either.

An example of retail settlement could include settlement between the utility and a customer after load control events. In this case, the system takes into account customer baseline energy use and energy use during the demand response event. Using this data, rebates and credits for individual customers can be calculated and processed outside of the DERMS. Similarly, wholesale settlement would take place between the utility and the ISO/RTO with settlement charges generated based on the utility's planned energy consumption and that actually provided by the ISO/RTO. A DERMS settlement module could also be used to develop settlement statements between the utility and other third-parties and aggregators.

Transactive Energy

Settlement is the process of reconciling actual operations against planned or forecasted operations and development of the associated charges associated with that reconciliation. Settlement has typically been conducted in a Demand Response Management System (DRMS) that conducts the reconciliation after load control events. DERMS systems can also utilize the same information as a DRMS system in order to perform the settlement function. Using data from the customer's baseline energy usage and the energy used during the demand response event, the DERMS system can calculate the delta in energy consumption.

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DERMS are uniquely positioned to connect DERs with wholesale markets. DERMS can monitor, predict, and present market condition information for optimized purchase and sale of electricity through energy arbitrage. These types of market functions can provide utilities with a platform for trading renewables and other energy.

The distinguishing characteristic of a transactive energy approach to grid management is the use of value signals, such as demand prices, to incentivize customer behaviors. DERMS systems can promote transactive energy by allowing customers, either as individuals or in aggregate, to actively engage in energy markets by responding to value signals based on demand, price, time of day and other considerations. This active engagement occurs through the DERMS sending value signals to customer DER devices with preset and/or automated features that allow them to respond desirably to the market signal. The automated features reflect both the DER device's set points and the customer's personal flexibility and needs. A DERMS enables scalable aggregation and near real-time management of utility-scale and small-scale DERs. Through value signaling, the DERMS is a core component required for transactive control and market-based coordination of BTM DERs. To support transactive energy concepts, a DERMS leverages its DER models, scheduling, and control functionality to optimize DER participation in bulk grid services.

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