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Aggregator DERMS—Use Cases and Requirements

Reference Language for Implementation and Integration of a DER Aggregation Type/Grid-Service Providing DERMS

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ABSTRACT

A distributed energy resource management system (DERMS) that focuses on the aggregation of distributed energy resources (DER) to provide grid services is sometimes called an aggregator DERMS or ADERMS. This document aims to provide utilities with a detailed list of requirements that can be used as a starting place when utilities are ready to seek out ADERMS vendors and want to specify, define, and draft a request for proposal (RFP) or similar. In addition to adapting content from central/utility DERMS requirements, content relating to different types of DER including energy storage and electric vehicles was made more customized through the application DER integration visions shared in discussions with EPRI and utility staff. In its completed form, this reference document aims to include functional and non-functional requirements surrounding DERMS architecture, integration with utility enterprise back-office systems, user interfaces, integration interfaces with DER, operational and computational capabilities, scalability, reliability, speed, performance, alarms, visualization, placement, and security.

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PRIMARY AUDIENCE: Utility staff responsible for acquiring (and/or defining expected capabilities of) an aggregator DERMS

SECONDARY AUDIENCE: Aggregator DERMS vendors and utilities interested in road mapping potential ADERMS integration

KEY RESEARCH QUESTION

This research primarily addresses the following questions:

- What complete list of functional and non-functional capabilities should an Aggregator DERMS be required to have?
- What grid services is an ADERMS able to provide?
- What capabilities correspond to a given ADERMS use case?

RESEARCH OVERVIEW

The different steps followed by the project team involved:

- Identifying different scenarios or use cases for which a utility might deploy an aggregator DERMS (based largely off previous DERMS work)
- For each use case, documenting the detailed process to execute each use case, wherein, identifying the required functional modules
- Developing a control system architecture to identify different control entities and the interfaces between them
- Developing other non-functional requirements (system behavior, features, and general characteristics that affect the DERMS user) for DERMS

Organizing requirements in a logical manner and developing mapping tables between requirements and the one or more use cases it may belong to

KEY FINDINGS

- Since pertinent requirements to include in a request for proposals (RFP) depend upon intended utility uses/applications of the DERMS, a mapping between the two needed to be developed.
- Requirements pertaining to both “opportunistic” type DER such as wind and solar PV and “contingent flexibility” type DER such as battery energy storage and EVs need customized language to clarify different needs from each type.
- These requirements assume that the utility is the primary owner/operator of the DERMS. Third party aggregator DERMS may share some of the interface and forecasting type requirements, but need more modification for other requirements (such as to cost-based dispatch or historian type requirements)

WHY THIS MATTERS

With DERMS being a nascent technology, several utilities are in the early stages of looking for documented DERMS technical specifications to support utility requirements documents and request-for-proposals. Commercial companies that aim to provide DERMS products are uncertain what features to implement and are searching for consistency so that they can provide products that meet needs and integrate in an efficient and effective manner. Leveraging several years of industry engagement and leadership activities, EPRI subject matter experts (SMEs) from various research programs worked together to develop a reference set of requirements. By compiling these requirements, EPRI is saving members’ valuable time and cost to prepare such requirements from scratch.

HOW TO APPLY RESULTS

Utilities can use the requirements defined in this report to specify it in their DERMS RFP. DERMS vendors can cross reference capabilities with this document to determine gaps in their DERMS capabilities, interfaces, performance, etc. and add to roadmaps for improved future product offerings.

LEARNING AND ENGAGEMENT OPPORTUNITIES

Any utility interested in making use of this document can pair with EPRI in a one-off supplemental project to apply it to their specific needs, and in so doing, helping to improve upon the work by providing their feedback and/or finalized language.

EPRI also hosts a number of interest groups and working groups through webcasts in which utility members and industry partners share experiences related to technical topics, identify gaps, prioritize research needs, and devise strategies. Those related to DERMS include the following:

- TSO/DSO Coordination for DER Management Working Group (Formerly the DERMS Working Group)

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PROGRAM: DER Integration, P174

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1
INTRODUCTION AND SCOPE OF DOCUMENT

This document provides the detailed list of requirements for systems that aggregate distributed energy resources (DER) for the purposes of providing grid services. Such service providing entities will be referred to as aggregator DER management systems or ADERMS. The requirements found in this report include functional and non-functional requirements surrounding DERMS architecture, integration with other utility and DER control systems, scalability, reliability, speed, performance, integration interfaces with ISOs and DER, user interfaces, alarms, visualization, placement, and cybersecurity.

Assumed Perspective

Not to be confused with a centralized DERMS that would have direct access to grid models (among other distinctions), an ADERMS in this report refers to the subordinate entity that manages one or more DER (though typically hundreds or thousands of small DER) to provide a grid service to a service requesting entity like an ISO or the aforementioned centralized grid DERMS.[1] In general, aggregator DERMS can be owned either by a utility or third party. In fact, third party aggregations of DER often provide services to distribution or bulk system electric utilities alongside benefits to DER owners. For the purposes of this document, however, use cases described are focused on practical uses for utilities only and associated DERMS requirements assume that the utility owns and/or manages the ADERMS. Customer-centric applications of ADERMS fall outside the scope of this year's work as do modifications to requirements specific to third-party owned and operated ADERMS.

System Architecture

As shown in Figure 1-1, the aggregator DERMS is assumed to typically reside as an intermediary between individual DER, plant/site controllers, or building level controllers downstream and a centralized grid DERMS or ISO type system upstream, potentially through some sort of utility back-office communication bus.

[1] Other service requesting entities could include a utility energy management system (EMS), a distribution management system with additional DER management capabilities, or a transmission system operator as examples

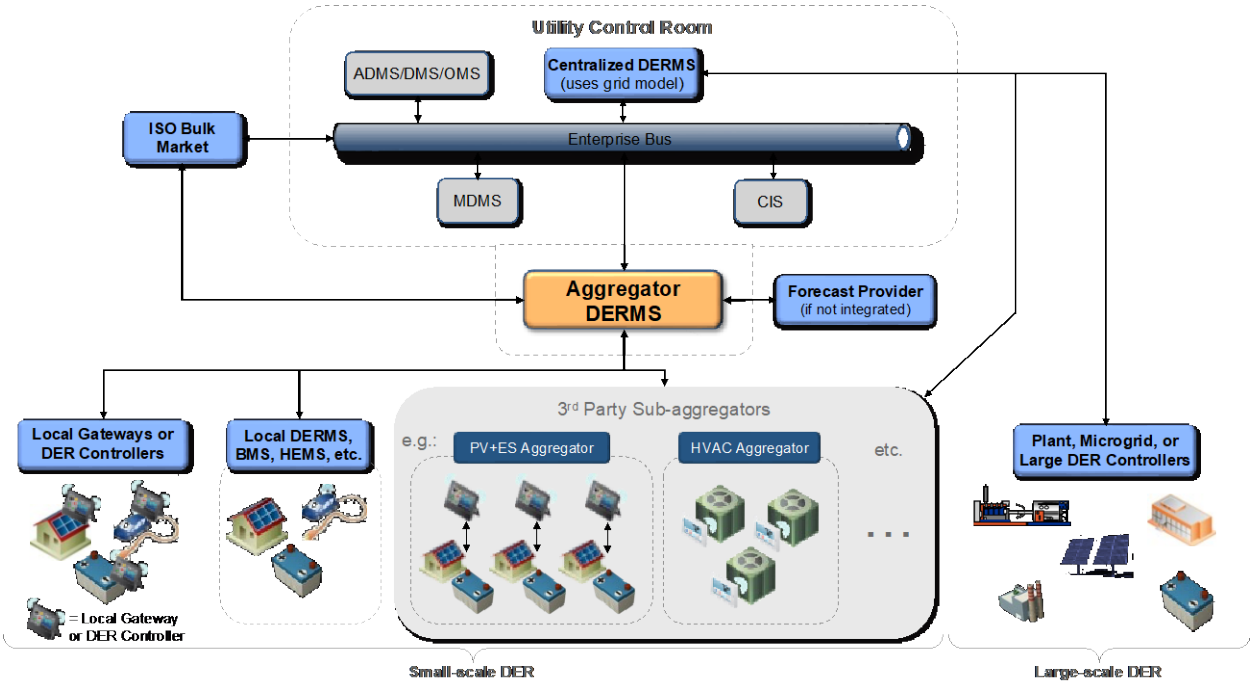


Figure 1-1
Control system architecture diagram to illustrate different entities related to DER management and the connections between them

While the aggregator DERMS is assumed to be utility-owned/-operated, it may or may not reside physically within a utility control room or network, depending upon the utility practices around cybersecurity. The actual computations of the ADERMS could even be accomplished in the cloud.

Different Entities in the DER Management Architecture

It is envisioned that the utility owned or operated aggregator DERMS will enable monitoring, control, and overall execution of functions that will satisfy the use cases identified in the next chapter. To accomplish this, (and dependent upon utility needs/desires), the ADERMS may also need to be capable of querying and receiving data from other utility or external systems such as the following:

- Centralized grid DERMS that has access to a grid model and can simulate power flows
- Grid/distribution management systems (ADMS, DMS, OMS, etc.)
- Third-party forecast services (in applications where such capabilities are not an embedded capability of the ADERMS itself)
- Utility meter data management system (MDMS) for historical meter readings from customer meters
- Customer information system (CIS) for DER registration parameters logged during utility interconnection

On the downstream side, the aggregator DERMS may interact with one or multiple types of devices/controllers including the following:

- Local gateways / DER controllers: devices responsible for communication and potentially translation of commands from DER management entities to the DER
- Local DERMS: controllers residing on-site that coordinate and optimize behavior of multiple local DER
- DER sub-aggregators: third-party entities that manage fleets of DER (usually of like-kind) that may report through the ADERMS or directly to the centralized grid DERMS
- Plant controllers in the case of medium-scale DER

Figure 1-1 illustrates a possible architecture relating the various upstream and downstream components to one another.

Reference Document Orientation and Usage Guide

Requirements aim to be comprehensive of all possible functions and capabilities that could be expected from an ADERMS, but to aid users of this reference guide with implementation, introductory chapters direct those drafting RFPs to only those parts that are likely to be most relevant. To accomplish this, subsequent chapters include the following:

Table 1-1
Description of subsequent chapters and how they are to be used together

Report Chapter/Component	Intended Use
Chapter 2: Detailed list of utility focused ADERMS use cases with definitions of each	Help utilities discover, identify, and define anticipated applications of their ADERMS
Chapter 3: Use case to functional requirement mapping	Identify those requirements that pertain to the desired use cases identified/selected
Chapter 4: Detailed functional requirements (grouped by type, where possible)	Provide draft/starter text that can be copied into a request for proposal (RFP) and adjusted as desired

2
ADERMS USES AND APPLICATIONS

A given utility may have one or several applications for which they hope to deploy an ADERMS. What follows is a list of common ADERMS uses and definitions organized into two groups based on whether the beneficiary of the DERMS service is typically at the distribution or bulk-system level. Users of this guide are encouraged to identify which use cases are desired for their utility (mapping to an existing utility vision for ADERMS, if relevant) for use in the subsequent chapter.

General Services

Smart Inverter Settings Management

Aggregator DERMS sets/updates/verifies arguments for parameters (e.g., Volt/Watt curve points) in the inverters of DERs within a desired (localized) area, enabling DERs to autonomously provide a given distribution grid service.

Measurement, and Verification of Services from DER

Aggregator DERMS may verify that individual or groups of DER have the correct settings, perform in conformance to flexible interconnection agreements, distribution grid service contracts, DR events, etc. The DERMS also calculates the participation level relative to baseline and report findings to a utility system.

Distribution Services

Voltage/var Support

Aggregator DERMS responds to predefined or live utility requests for voltage or reactive power support in a certain area(s) by coordinating the reactive power response of appropriate DER under its management. For example, injecting a certain amount of vars near the end of a feeder during peak load times to correct for generally low voltage there.

Line/Transformer/Equipment Upgrade Deferral

Aggregator DERMS manages DERs to reduce a local demand peak (either daily or annual) and/or excess generation (sometimes caused due to distribution network reconfigurations) with the intent to defer the otherwise-necessary upgrade to traditional distribution/transmission equipment. Service can be performed open loop via a scheduled dispatch agreed upon in advance or closed loop with live regulation of DER responses at a metered point.

Bulk System Services

Day Ahead or Real-Time Energy

Aggregator DERMS can forecast DER availability to support offers into day-ahead or real-time (sub-hourly) wholesale energy markets (including $0 offer curves). Upon receipt of awards, aggregator reserves DER capacity and deploys DERs in response to dispatch signals received from the wholesale market operator.

Contingency Frequency Response (Primary Control)

Aggregator DERMS sets a frequency/Watt curve in the inverters of DERs (can include inverter-based controllable loads) to enable DERs to autonomously provide primary frequency service during frequency excursion events.

Transmission System Voltage Support

Aggregator DERMS manages the real and/or reactive power output of DERs to support to the bulk system operator in maintaining transmission-level voltages within acceptable limits.

Spinning Contingency Reserve

Aggregator DERMS manages DER to ensure that a specified amount of DER capacity is connected/ready, will respond immediately to signals from system operators or balancing authorities, and will ramp up/down to be fully responsive within minutes.

Regulation Reserve

Aggregator DERMS provide regulation reserves to system operators or balancing authorities by responding to live MW signals or tracking the Area Control Error (ACE) signal.

Generation Capacity Deferral (Wholesale)

Aggregator DERMS commits to a certain amount of generation resource capacity at a scheduled time that can be called upon as needed by the utility to shift load, counteract steep ramp rates ("duck curve" management), etc. In the case of deferral, regularly available DER capacity (committed) can allow utilities to defer construction of utility-owned generation that would otherwise be required. In cases where utility buys from wholesale market, committed DER capacity can displace some amount of peak power demand and/or energy capacity that would otherwise need to be purchased.

Wholesale Energy Price Dynamic Response

Aggregator DERMS deploys DERs in response to changes in observed wholesale energy spot prices (LMP) to reduce the overall energy costs (otherwise paid to an energy retailer) on behalf of either a utility or participating customers.

3
USE CASE TO FUNCTION MAPPING

Not every ADERMS use case demands the same capabilities or features from an aggregator DERMS. For example, a DERMS only needing to distribute smart inverter settings to DER need not be capable of integration with energy market systems. Depending upon what a utility intends to use the DERMS for, certain functions may be excluded from RFPs to elicit more responses from vendors and focus attention on those that are presently needed.

Table 3-1 through Table 3-5 lay out collections of related requirements against the same list of possible use cases. At the intersection of each use case and requirement in the following tables is a letter/symbol. An ‘R’ represents a requirement that is most likely to be required to accomplish the given use case, an ‘O’ represents a requirement that may or may not be necessary to include depending upon circumstances or utility preferences, and ‘–’ symbols indicate requirements that are most likely not applicable to accomplishing the given use case.

To make use of the tables, first identify the use case(s) from the prior chapter that your utility intends to implement. Then, for each requirement, identify whether it is required by any of the selected use cases. If so, plan on including this language in your RFP. If not, the requirement can be excluded. If no use case requires a given requirement but one or more use case lists the requirement as optional, decide whether the requirement is needed for your utility’s circumstances/preferences.

Table 3-1
Cross-mapping of system-level interface requirements with ADERMS use cases

R = Required *O = Optional* *– = Not Required or N/A*	**Downstream Interface and Protocol Requirements**	**Enterprise Integration and Protocol Requirements**	**Wholesale Market/ISO/RSO Integration**	**User Interface Requirements**	**Independent Certification and Standards Rqmts.**
Smart Inverter Settings Distribution/Management	R	O	–	R	R
Verification and performance assessment of DER	R	R	–	R	R
Voltage/var Support (DX grid service)	R	R	–	O	R
Line/Transformer/Equipment Upgrade Deferral	R	R	–	R	R
Generation Capacity Deferral (Wholesale)	R	R	–	O	R
Wholesale Energy Price Dynamic Response	R	O	R	O	R
Day-ahead or Real-time Energy	R	O	R	O	R
Contingency Frequency Response (Primary Control)	R	O	–	R	R
Transmission System Voltage Support	R	R	–	R	R
Spinning Contingency Reserve	R	R	R	O	R
Regulation Reserve	R	R	O	O	R

Table 3-2
Cross-mapping of DER group management, visibility, and forecasting requirements with ADERMS use cases

R = Required *O = Optional* *– = Not Required or N/A*	**DER Group Creation, Deletion, Maintenance, etc.**	**Connect/Disconnect DER Group**	**DER Group Capability Discovery**	**DER Group Status Monitoring**	**DER Group Aggregate Telemetry**	**DER Group Forecasting**
Smart Inverter Settings Distribution/Management	R	O	R	O	O	–
Verification and performance assessment of DER	R	R	R	R	R	–
Voltage/var Support (DX grid service)	R	R	R	R	O	O
Line/Transformer/Equipment Upgrade Deferral	R	R	R	R	R	R
Generation Capacity Deferral (Wholesale)	R	–	R	R	O	O
Wholesale Energy Price Dynamic Response	R	O	R	R	R	R
Day-ahead or Real-time Energy	R	O	R	R	R	R
Contingency Frequency Response (Primary Control)	O	O	R	O	O	–
Transmission System Voltage Support	R	O	R	R	R	O
Spinning Contingency Reserve	R	R	R	R	R	
Regulation Reserve	R	R	R	R	R	

Table 3-3
Cross-mapping of grid service functionalities with ADERMS use cases

R = Required *O = Optional* *– = Not Required or N/A*	**DER Group Maximum Real Power Limiting**	**DER Group Ramp Rate Limit Control**	**DER Group Phase Balancing**	**DER Group Active Power Dispatch**	**DER Group Reactive Power Dispatch**	**DER Group Voltage Regulation**	**Curve-based Functions Mgmt.**	**Regulation Service Type Functions**	**Manage Power at a Point of Reference**
Smart Inverter Settings Distribution/Management	–	–	–	–	–	R	R	–	–
Verification and performance assessment of DER	–	–	–	–	–	–	–	–	R
Voltage/var Support (DX grid service)	O	O	O	R	R	R	R	–	R
Line/Transformer/Equipment Upgrade Deferral	R	O	O	R	O	–	–	O	O
Generation Capacity Deferral (Wholesale)	–	R	O	R	O	–	–	–	O
Wholesale Energy Price Dynamic Response	O	O	O	R	–	–	–	–	O
Day-ahead or Real-time Energy	O	O	O	R	–	–	–	–	O
Contingency Frequency Response (Primary Control)	–	–	–	–	–	–	R	–	–
Transmission System Voltage Support	O	O	O	O	R	R	O	–	O
Spinning Contingency Reserve	O	R	O	R	–	–	–	R	–
Regulation Reserve	O	R	O	R	–	–	–	R	–

Table 3-4
Cross-mapping of cost-related functionalities and DER registration/grid service program management requirements with ADERMS use cases

	Cost-related Functionalities			DER Registration and Grid Service Program Mgmt.	
R = Required *O = Optional* *– = Not Required or N/A*	**Receive Price for a DER Group Function**	**Provide Cost of Service Estimate (for a DER Group)**	**Economic (or Similar) Optimization**	**Manage DER Participation Constraints**	**DER Registration (Provisioning) Attributes in DERMS**
Smart Inverter Settings Distribution/Management	O	O	O	R	R
Verification and performance assessment of DER	O	R	–	R	R
Voltage/var Support (DX grid service)	–	O	O	R	R
Line/Transformer/Equipment Upgrade Deferral	–	O	O	R	R
Generation Capacity Deferral (Wholesale)	–	R	O	R	R
Wholesale Energy Price Dynamic Response	R	R	R	R	R
Day-ahead or Real-time Energy	R	R	R	R	R
Contingency Frequency Response (Primary Control)	–	O	O	R	R
Transmission System Voltage Support	–	O	O	R	R
Spinning Contingency Reserve	–	O	O	R	R
Regulation Reserve	–	O	O	R	R

Table 3-5
Cross-mapping of operating and hosting requirements with ADERMS use cases

R = Required *O = Optional* *– = Not Required or N/A*	Historian, Database, Analytics and Storage Rqmts.	Software Updates and Version Control	Software Resource Monitoring	Scale and Performance Requirements	User Roles Management	DERMS Cybersecurity Requirements	Alarm Management and Configuration
Smart Inverter Settings Distribution/Management	O	R	O	R	R	R	O
Verification and performance assessment of DER	R	R	O	R	R	R	O
Voltage/var Support (DX grid service)	R	R	O	R	R	R	O
Line/Transformer/Equipment Upgrade Deferral	O	R	O	R	R	R	R
Generation Capacity Deferral (Wholesale)	R	R	O	R	R	R	R
Wholesale Energy Price Dynamic Response	O	R	O	R	R	R	O
Day-ahead or Real-time Energy	R	R	O	R	R	R	R
Contingency Frequency Response (Primary Control)	O	R	O	R	R	R	O
Transmission System Voltage Support	R	R	O	R	R	R	R
Spinning Contingency Reserve	R	R	O	R	R	R	R
Regulation Reserve	R	R	O	R	R	R	R

4
DERMS REQUIREMENTS

Interface Requirements

Downstream Interface and Protocol Requirements

Requirement No	Requirement
DINTERF:1	DERMS must provide a downstream communication interface to convey device-level messages to DER, DER gateways, local controllers, etc. in the field
DINTERF:2	For *individual* DER like PV and ES units, DERMS must meet the standard information model defined in IEC 61850 -7-420. Today, the following communication protocols support this information model. • SunSpec Modbus • DNP3 AN2013-001, AN2018-001 • IEEE 2030.5 • IEC 61850-8-2 Note on vehicle to grid (VGI) integration: These requirements assume that a DERMS will interact with EVs either through a "smart" EVSE or some kind of charge network operator aggregation platform that converts signals between chargers and EVs (proprietary, OCPP, etc.) to those found in the above protocols. (DERMS may also be able to interface with EVs if protocols like IEEE 2030.5 are used at the EV/EVSE level.)

<table>
<tr><th>Requirement No</th><th>Requirement</th></tr>
<tr><td>DINTERF:3</td><td>DERMS must support all the device-level functions mandated by IEEE 1547-2018 so that it can act as a pass-through point for managing multiple end devices, if desired.
Table 4-1
Mandated functions in IEEE 1547 and their corresponding reference in EPRI's Common Functions for Smart Inverters—4th Edition
<table>
<tr><th>Mandated Communicable Functions in IEEE 1547</th><th>Corresponding Function in Common Functions for Smart Inverter—4th Edition[2]</th></tr>
<tr><td>Nameplate Data</td><td>Ch 4: Basic Device Settings and Limits</td></tr>
<tr><td>Basic Settings</td><td>Ch 4: Basic Device Settings and Limits</td></tr>
<tr><td>Monitoring</td><td>Ch 26: Status Monitoring Points</td></tr>
<tr><td>Adjustable constant power factor mode parameters</td><td>Ch 10: Fixed Power Factor Function</td></tr>
<tr><td>Voltage - reactive power mode parameters</td><td>Ch 11: Volt-VAR Function</td></tr>
<tr><td>Active power—reactive power mode parameters</td><td>Ch 24: Watt-Var Function</td></tr>
<tr><td>Adjustable constant reactive power mode parameters</td><td>Ch 11: Volt-VAR Function (horizontal curve)</td></tr>
<tr><td>Voltage—active power mode parameters</td><td>Ch 12: Volt-Watt Function</td></tr>
<tr><td>Voltage trip parameters</td><td>Ch 16: Low/High Voltage Ride-Through Function</td></tr>
<tr><td>Frequency trip parameters</td><td>Ch 17: Low/High Frequency Ride-Through Function</td></tr>
<tr><td>Frequency droop parameters</td><td>Ch 13: Frequency-Watt Function (modified1)</td></tr>
<tr><td>Enter service parameters</td><td>To be addressed in the 5th edition</td></tr>
<tr><td>Permit service setting</td><td>To be addressed in the 5th edition</td></tr>
<tr><td>Limit Maximum Active Power</td><td>Ch 6: Limit DER Power Output Function</td></tr>
</table></td></tr>
<tr><td>DINTERF:4</td><td>DERMS must be capable of communicating with and receiving an acknowledgement from field general DER devices minimally within 30 seconds (ignoring communication link latencies), and minimally 4 seconds for any DERs participating in markets and distribution services requiring such a response (e.g., frequency regulation).</td></tr>
<tr><td>DINTERF:5</td><td>In the case of a more hierarchical control structure, the DERMS must provide a downstream communication interface to speak group-level messages to other de-centralized DERMS (e.g., feeder level controllers, premise energy management systems, third-party DER Aggregator DERMS platforms / EV charge network owners (CNOs), microgrid master controllers, etc.).</td></tr>
</table>

[2] *Common Functions for Smart Inverters: 4th Edition. EPRI, Palo Alto, CA: 2016. 3002008217*

Requirement No	Requirement
DINTERF:6	DERMS must meet the standard information model defined in IEC 61968-5 for DER *group-level* functions. Today, the following communication protocols support this information model. • IEC 61968-100:2013 "Application Integration for 61968 Profiles" • MultiSpeak 5.0 • OpenFMB • OpenADR and IEEE 2030.5 are considering similar mapping
DINTERF:7	If managing electric vehicles (EVs) and/or EV supply equipment (EVSEs)/chargers, then in addition to foundational parameters covered under IEEE 1547 (see DINTERF:3), either the ADERMS or EV fleet charging station controller(s) (EVFCSCs) may also be required to retrieve or disseminate the following types of parameters with EVs directly: • Presence of vehicle indicator • Customer program participant ID • Currently available capacity for grid services • Expected departure time in UTC or duration from present • Preferred charging requirements upon leaving – Preferred SoC and charging efficiency – Preferred miles, average energy consumption per mile, and average ratio of driving energy to electrical charging energy – Arrival time record • EV charger port/EVSE vehicle is plugged into • Energy capacity usable for grid services (in % of rated or kWh) • Max and min charging/discharging power profile vs. SoC • Optimized, individual EV charging schedules to follow

Enterprise Integration and Protocol Requirements

Requirement No	Requirement
EINTERF:1	The DERMS must have an enterprise integration interface. This interface is used to integrate DERMS with DMS and other enterprise applications as illustrated in Figure 1-1.
EINTERF:2	DERMS must meet the standard information model defined in IEC 61968-5 for integration with a DMS and other legacy DER management systems such as Demand Response Management System (DRMS). Today, the following communication protocols support this information model. • IEC 61968-100:2013 "Application Integration for 61968 Profiles" • MultiSpeak 5.0 • OpenFMB • OpenADR and IEEE 2030.5 are considering similar mapping
EINTERF:3	DERMS must integrate with a geospatial information system (GIS) or customer information systems (CIS) that contains source of information about DER. The attributes to track as part of a DERMS are covered in Table 4-11. Additionally, DERMS must be capable of requesting/receiving and interpreting unique DER device identifiers generated by utility systems during interconnection, program enrollment, or other events.
EINTERF:4	DERMS must integrate with external DER forecasting engines if forecast generation capability is not being performed internally by ADERMS

Wholesale Market/ISO/RTO Integration

Requirements in this section are based on concepts discussed in EPRI-led working group sessions on the topic of TSO-DSO interactions. Requirements are expected to be refined and made more pointed in future iterations of this document. In the meantime, please reference the following report for more specifics: *TSO-DSO Coordination Functions for DER*[3]

Requirement No	Requirement
ISOINT:1	**DER ID Assignment and Discovery** DERMS must be capable of requesting device and resource ID information from the same source (likely a distribution system operator database) as the bulk market operator. Further, the DERMS must be able to store the response from its ID query. When implementations are aligned with the IEC Common Information Model (CIM), the unique IDs are called "master resource identifiers" (MRIDs) which are a globally unique identifier.
ISOINT:2	**DER Meter Data Exchange** Provide telemetry and verification data (such as points outlined in Table 4-10) to the ISO/RTO per their specifications upon request or at an agreed upon interval. Table 4-2 illustrates the type of specification DERMS should be expected to conform to. In this specific example, Table 4-2 outlines the fields within the response message that the DERMS would need to be able to receive and interpret.

[3] *TSO-DSO Coordination Functions for DER.* EPRI, Palo Alto, CA: 2022. 3002021985.

<table>
<tr><th>Requirement No</th><th>Requirement</th></tr>
<tr><td>ISOINT:2
(continued)</td><td>
Table 4-2
Sample DER Meter Data Response Message
<table>
<tr><th>Field</th><th>Description</th></tr>
<tr><td>Action Identifier</td><td>Metering Data Request</td></tr>
<tr><td>Requesting Entity ID</td><td>The unique identifier (MRID) of the entity from which meter data is requested</td></tr>
<tr><td>Aggregation Resolution</td><td>The type/level of data aggregation
#1- DER groups,
#2: LSE breakout within an aggregation,
#3: pricing node breakout within an aggregation,
#4: individual resource</td></tr>
<tr><td>DER Group ID (optional)</td><td>The unique identifier (MRID) of the DER Group for which meter data is requested</td></tr>
<tr><td>LSE ID (optional)</td><td>An array of unique identifiers (MRIDs) of the Load Serving Entities that serve individual customers or loads represented in the meter data exchange.</td></tr>
<tr><td>Pricing Node ID (optional)</td><td>The unique identifier (MRID) of the pricing node for which meter data is requested</td></tr>
<tr><td>DER Device ID(s) (optional)</td><td>An array of unique identifiers (MRIDs) of one or more resources for which meter data is requested.</td></tr>
<tr><td>Offer IDs (optional)</td><td>An array of unique identifiers (MRIDs) related to the offers or bids for which meter data is requested.</td></tr>
<tr><td>Award IDs (optional)</td><td>An array of unique identifiers (MRIDs) related to the service award for which meter data is requested.</td></tr>
<tr><td>Dispatch ID (optional)</td><td>An array of unique identifiers (MRIDs) related to the dispatches for which meter data is requested.</td></tr>
<tr><td>Start Date/Time</td><td>The start date/time of the requested meter data.
The end date/time of the requested meter data.
The time interval (e.g., in seconds) for the interval resolution.</td></tr>
<tr><td>End Date/Time</td><td>An array of unique identifiers (MRIDs) related to the dispatches for which meter data is requested.</td></tr>
<tr><td>Interval Resolution</td><td>The start date/time of the requested meter data.
The end date/time of the requested meter data.
The time interval (e.g., in seconds) for the interval resolution.</td></tr>
<tr><td>Calculated Output</td><td>A descriptor or flag defining whether the exchanged data is calculated
#1: against a baseline (or other method)
#2: the total meter reading exchanged</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>Requirement No</th><th>Requirement</th></tr>
<tr><td>ISOINT:2 (continued)</td><td>

Table 4-2 (continued)
Sample DER Meter Data Response Message

<table>
<tr><th>Field</th><th>Description</th></tr>
<tr><td>Measurement Correction</td><td>A descriptor or flag defining whether measurement correction has been applied to the meter data
#1: VEE
#2: other agreed upon method</td></tr>
<tr><td>Data Source</td><td>A descriptor or flag defining the source of the exchanged data #1: primary meter,
#2: sub-meter,
#3: device level data,</td></tr>
<tr><td>Required Interval Meter Quantities</td><td>An array of references to the metered quantities in Table 11-1 that are required. The array may be empty if no interval quantities are requested.</td></tr>
<tr><td>Required Cumulative Meter Quantities</td><td>An array of references to the metered quantities in Table 11-1 that are required. The array may be empty if no cumulative quantities are requested.</td></tr>
</table>

</td></tr>
<tr><td>ISOINT:3</td><td>

Market Participation Registration

DERMS must be able to register itself with an ISO as a market participant. Example data that might be passed as part of this process is presented in Table 4-3.

Table 4-3
Example Information Exchanged for Market Participant Registration

<table>
<tr><th>Information Name</th><th>Information Description</th></tr>
<tr><td>Action Identifier</td><td>Defining what is being performed:
• Market Participant Registration</td></tr>
<tr><td>Company Name</td><td>The name of the business/entity making the registration request.</td></tr>
<tr><td>Company Address</td><td>The physical/mailing address of the business/entity</td></tr>
<tr><td>Result</td><td>Pass/Fail indicator of the Participant registration process</td></tr>
<tr><td>Group Managing Entity Unique ID</td><td>If passed, a unique identified assigned to the participating entity</td></tr>
</table>

</td></tr>
</table>

<table>
<tr><th>Requirement No</th><th>Requirement</th></tr>
<tr><td>ISOINT:4</td><td>
<u>DER Group Registration into Market</u>
DERMS must be able to register (and potentially verify) a group of DER under its management with an ISO as a market participant. Example data that might be passed as part of this process is presented in Table 4-4.
Table 4-4
Example Information Exchanged for DER Group Market Registration Messages
<table>
<tr><th>Information Name</th><th>Information Description</th></tr>
<tr><td>Action Identifier</td><td>Defining what is being performed:
• DER Group Market Registration</td></tr>
<tr><td>Group Managing Entity Unique ID</td><td>The unique identification of the DER Group managing entity making the registration request</td></tr>
<tr><td>DER Group ID</td><td>The unique identifier for the DER group for which this registration is provided</td></tr>
<tr><td>Services</td><td>Identification of the market services for which this DER Group is being registered</td></tr>
<tr><td>Participation Models</td><td>Identification of which market participation model(s) the DER Aggregator is seeking to participate through</td></tr>
<tr><td>DER Group Information</td><td>As required, exchange of the DER Group Capability information as addressed in DER Group Capability Discovery</td></tr>
<tr><td>Individual DER Information</td><td>As required, exchange of individual DER information</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>Requirement No</th><th>Requirement</th></tr>
<tr><td>ISOINT:5</td><td>
<u>Energy Market Participation</u>
DERMS must be capable of making offers to the bulk system markets and providing information such as that listed in Table 4-5 as well as interpreting offer responses.
Alternatively, if working through a scheduling coordinator entity, DERMS must provide said entity with the information to inform its bidding/offer parameters and curves (likely similar to the information needed for direct offers).
Table 4-5
Sample Information Exchanged for Group Energy Offers
<table>
<tr><th>Information Name</th><th>Information Description</th></tr>
<tr><td>Action Identifier</td><td>Defining what action is occurring:
Energy produced/increased service offer
Energy absorbed/reduced service offer
Offer withdrawal</td></tr>
<tr><td>Offering Entity ID</td><td>The unique identifier (MRID) of the entity making this offer.</td></tr>
<tr><td>DER Group ID</td><td>The unique identifier (MRID) for the DER group to provide the offered service.</td></tr>
<tr><td>Offer Tag/ID</td><td>A unique identifier (MRID) for the offer being made.</td></tr>
<tr><td>Startup Cost</td><td>Cost to startup and reach the minimum service level, if applicable. ($/start)</td></tr>
<tr><td>Minimum Energy Offer</td><td>Cost in $/MW to generate-at (or shift-by) the minimum capability level. Note: The “Minimum Capability Level” here is the same as the Status Monitoring parameters:
“Present Range of Adjustability, Minimum, Watts Produced” for energy produced services
“Present Range of Adjustability, Minimum, Watts Absorbed” for energy absorbed services.</td></tr>
<tr><td>Energy Offer Curve</td><td>Monotonically increasing offer curve for price (in $/MWh) and quantity (in MW delivered, MW increased, MW absorbed, or MW decreased). See offer structure in Appendix A</td></tr>
<tr><td>Offer Ramp Time</td><td>The time required for the DER Group to transition from baseline level to new setpoint in association with this offer. Note: may alternatively be fixed for this DER Group as part of the capability discovery (See Chapter 5) or specified by the service-requesting entity as part of the dispatch (See Chapter 19).</td></tr>
<tr><td>Offer Time Range</td><td>The start and end time/date for which this offer is made</td></tr>
<tr><td>Offer Expiration Time/Date</td><td>The time/date at which this offer expires</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>Requirement No</th><th>Requirement</th></tr>
<tr><td>ISOINT:6</td><td><u>Advance Service Notification Receipt</u>
DERMS must receive, interpret, and (optionally) optimize around advance notification signals coming from service requesting entities.</td></tr>
<tr><td>ISOINT:7</td><td><u>Device-level Service Plan Notification</u>
DERMS must inform the DSO/Grid DERMS/etc. of its intended level of service, including the parameters listed in Table 4-6 on a per device level.
Table 4-6
Information Exchanged for Device-Level Service Plan Notification
<table>
<tr><th>Information Name</th><th>Information Description</th></tr>
<tr><td>Action Identifier</td><td>Defining what is being Notified:
Device-Level Service Plan Notification</td></tr>
<tr><td>Individual DER ID</td><td>The unique identifier (e.g., MRID) for the individual DER for which the planned service-level(s) are being identified</td></tr>
<tr><td>Time Window</td><td>The time/date window for which the service plan is applicable</td></tr>
<tr><td>Planned Service-Level(s)</td><td>Array identifying the planned service(s) and quantities:
<table>
<tr><th>Service</th><th>Planned Quantity</th><th>Reserve Quantity</th></tr>
<tr><td>Active Energy (Generation Up)</td><td>Value (Watts)</td><td>Value (Watts)</td></tr>
<tr><td>Active Energy (Generation Down)</td><td>Value (Watts)</td><td>Value (Watts)</td></tr>
<tr><td>Active Energy Demand Up</td><td>Value (Watts)</td><td>Value (Watts)</td></tr>
<tr><td>Active Energy Demand Down</td><td>Value (Watts)</td><td>Value (Watts)</td></tr>
<tr><td>Reactive Energy</td><td>Value (vars)</td><td>Value (vars)</td></tr>
<tr><td>Regulation Service</td><td>Max Value (Watts)</td><td>N/A</td></tr>
</table></td></tr>
</table></td></tr>
<tr><td>ISOINT:8</td><td><u>Device-level Constraint Notification</u>
In response to the intended-level-of-service message, the aggregator DERMS must be ready and able to receive back device level constraints calculated by the DSO/Grid DERMS/etc. with time and date windows for which the constraint is applicable.
Additionally, the DERMS must now share updated planned DER profiles with bulk market operator (de-rate notifications).</td></tr>
<tr><td>ISOINT:9</td><td><u>DSO Real-time Device-level Limiting and Notification</u>
At any moment, DERMS must be ready to receive and immediately relay real-time constraints to specific DER, even if the new constraint command supersedes with previously shared limits. This is to allow last-minute adjustments to DER behavior due to unforeseen circumstances arising. Again, DERMS must also share updated planned DER profiles with bulk market operator (de-rate notifications).</td></tr>
</table>

<table>
<tr><th>Requirement No</th><th>Requirement</th></tr>
<tr><td>ISOINT:10</td><td><u>DER Group De-rate Notification</u>
DERMS must notify market operators of reductions in services from DER groups, whether in response to distribution constraints, communication limitations, or any other situation that will result in service commitments not being met. Such information is expected to take a form similar to that shown in Table 4-7.
Table 4-7 Sample Information Exchanged for DER Group De-rate Notification
<table><tr><th>Information Name</th><th>Information Description</th></tr><tr><td>Action Identifier</td><td>Defining what is being notified:
DER Group De-Rate Notification</td></tr><tr><td>DER Group ID</td><td>The unique identifier (e.g., MRID) for the DER Group for which this de-rate notification applies.</td></tr><tr><td>Time Window</td><td>The time/date window for which the de-rate is applicable (may be future or immediate)</td></tr><tr><td>Service De-rated</td><td>Indication of what planned or present service is de-rated:
Active Energy (Generation Up)
Active Energy (Generation Down)
Active Energy Demand Up
Active Energy Demand Down
Reactive Energy
Regulation service</td></tr><tr><td>New/Reduced Service Level</td><td>Updated level of service (Watts or Vars). May be any value from the planned/present level to zero.</td></tr><tr><td>De-rate Cause</td><td>Enumeration of causes of the de-rate:
Changed distribution system constraint
DER device limitation
Communication/aggregation system</td></tr></table></td></tr>
<tr><td>ISOINT:11</td><td><u>DER Group Settlement</u>
Following a market cycle in which services have been rendered, DERMS will share meter data from its database with the market operator in accordance with procedures outlined by the market operator, potentially iterating the process in response to updates, refinements, disputes, etc.
In cases where the level of service cannot be directly measured (e.g., where the service was reduced usage of an HVAC system), DERMS will be capable of either providing the measured behavior and a calculated baseline profile or providing measured behavior and sufficient data for the market operator to calculate the baseline behavior based on prearranged methods.</td></tr>
</table>

User Interface Requirements

Requirement No	Requirement
UI:1	DERMS must include a user interface through which users of the software can manage and monitor the overall DER population.
UI:2	Users of various types (DERMS Engineers, Operators, Observers etc.,) must be able to securely access DERMS with access and permissions that are limited and consistent with their role.
UI:3	DERMS administrators must be able to setup user access and to flexibly configure the range of permissions extended to each user.
UI:4	DERMS must provide a flexible DER selection capability. This might be presented to the user in map form, by graphical one-line diagram, or by list/menu. Users must be able to select individual DER, groups of DER (based on power system hierarchy or based on other attributes like DER type, ownership, location, aggregator-wise, market participation/not etc.), or combinations thereof for subsequent actions. Selecting a DER group shall highlight all the associated DER in the one-line diagram or the map.
UI:5	DERMS must enable control of DER based on user privileges and the permission to operate the DER. Certain DER with local control systems or gateways can have different permission levels that determines DERMS control. 1) *Local* (controlled locally, preferred for maintenance operations), 2) *Permissive* (not currently controlled, but permitted to be controlled by DERMS), and 3) *Remote* (currently controlled by DERMS). Once the DERMS user gains control of the DER (mode change to remote), the user should be associated with the ownership of controlling the DER.
UI:6	Background: Human operators may need to periodically take DER offline for corrective or preventive maintenance. Requirement: DERMS user interface must provide operators the option to take a DER offline and individually query/test it to remotely determine if an individual asset can participate in normal operation. This also requires that the system provide the capability for operators to re-register the DER into the asset pool following any preventative or corrective maintenance actions. The system may optionally use the UI to notify operators if DER are malfunctioning and automatically placed into an offline mode
UI:7	The DERMS UI must provide the operator with the ability to identify, select, and verify DER for decommissioning or removal from a resource pool (as specified by the capability in GRPMGT:1).
UI:8	The user interface must support DER group creation, deletion, Version, Member Query and Maintenance (Adding, Updating, and Deleting Members) as defined under section 4 in this RFP
UI:9	*DER Status Monitoring:* Using the user interface, DERMS users must be able to monitor the individual DER status (W, VAR, VA, PF etc.,) defined in Table 4-1 for communicable DER. This could be done by using face plates for individual DER. The faceplate shall contain information about all the monitored properties of the selected DER. Users must be able to view the most recently collected data, or to force an immediate read from the devices in the field to get real-time data.
UI:10	*DER Group Status Monitoring:* Same as above but for DER groups or other complex selections. The list of monitorable DER group-level parameters is defined in Table 4-8

Requirement No	Requirement
UI:11	*DER Forecasting:* Using the user interface, DERMS users must be able to monitor forecasted information (Max and min capabilities) for individual and group of DER.
UI:12	*DER Function/Mode of Operation and Setpoints Management:* Using the user interface, DERMS users must be able to change functional settings on DER, modifying individual functions/operating modes, sending setpoints, sending new curves, new schedules, or new complete configuration data sets as defined in Table 4-1
UI:13	*DER Group Function/Mode Management:* DERMS must allow users to update the operational functions of DER in groups. Different operational functions to manage DER in group are defined in Section 4.3, Grid Service Functionalities.
UI:14	*DER Capability (Name plate) and Settings:* Through the user interface, users must be able to monitor name plate information and configuration information that allow the setting and reading of currently active values of individual DER.
UI:15	*DER Group Capability Discovery:* Through the user interface, users must be able to read/report the as-built or installed capability (e.g., static, nameplate, non-variable quantities) of DER groups defined in Section 4.2.3.
UI:16	DERMS UI must display the communication status between DERMS and the connected DER/other DERMS with a time stamp, which updates at a specific rate.
UI:17	DERMS shall have the capability to update the operator with alarms from different sources. Alarms shall be categorized as DER alarms (individual and group of DER) and system alarms. DER alarms are alarms generated by the DER and System alarms are generated internally by the DERMS. Both these types of alarms must be configured to be acknowledgeable or resettable through the user interface. Criticality of each alarm should also be displayed/accessible.
UI:18	DERMS must provide a detailed trend view with time stamps to view different DER (individual and grouped) measurements. This includes, • DER/DER group present status • DER/DER group forecasts • DER/DER group historical data DERMS must be capable of analyzing DER performance values with recorded measurements.
UI:19	DERMS users shall be able to create and save curves for individual DER or group of DER.
UI:20	DERMS users shall be able to create and save schedules for individual DER or group of DER.
UI:21	DERMS shall provide authorized operators to configure the operational constraints of DER e.g., capacity constraints, run hour limitations, time of day limitations, fuel level limitations, SOC limitations etc.
UI:22	DERMS must have the ability for operators to view real-time and historical DER performance (e.g., history of alarms and requested need vs provided need)
UI:23	DERMS must alert an operator if a desired control is not possible, and the reason it is not possible
UI:24	DERMS must provide microgrid management interface

Independent Certification and Standards Requirements

Requirement No	Requirement
CRTSTD:1	Background: As mentioned in DINTERF:6, DERMS must meet the standard information model defined in IEC 61850 -7-420 for its device-level DER interface. Requirement: To verify compliance for the DER device-level interface, DERMS must pass the communication protocol tests defined in IEEE 1547.1
CRTSTD:2	Background: As mentioned in DINTERF:6, DERMS must meet the standard information model defined in IEC 61968-5 for its interface to DER groups. Requirement: To verify compliance for the DER group-level interface, DERMS must pass the communication protocol testing criteria defined in UCAI Users Group, CIM for DER compliance testing

DER Group Management, Visibility, and Forecasting

DER Group Creation, Deletion, Maintenance, Version Tracking, and Member Query

Hierarchical management of DER depends upon being able to monitor and manage groups of DER at a higher level with a focus on the attributes, impacts, and opportunities as they relate to the group-level rather than individual DER plants or devices.

Requirement No	Requirement
GRPMGT:1	An Aggregator DERMS must be able to create DER groups and have the ability to receive group configurations from an upstream DMS/DERMS.
GRPMGT:2	DERMS must be able to support different methods of grouping. Examples include the following: *Grouping by Power System Level* • By Substation • By Circuit/Bus • By Feeder • By Feeder Segment (contiguous conductor between switches) • By Island or micro-grid (campus, industrial facility) • By Individual Device • By Lat/Lon Rectangle • By Bulk System Nodes (e.g., CAISO Sublaps) *Grouping According to Other Attributes* • By Circuit Phase - For example, a DMS could define separate groups for single phase DER that are connected to A, B, and C phases, and could request the status of these individually from a DERMS. • By DER Type. For example a DERMS could create separate groups for PV systems, battery storage systems, EVs, or any other DER type. • By DER Owner. For example, all the DER owned by the utility, or a particular customer, could be viewed and managed collectively. • By Program enrollment (e.g., DR program enrollment) or contractual arrangement. • By zip code • By voltage level • By tariff class • By user/customer class (residential, commercial, large C&I, agricultural) • By response characteristics (response time, directional change time delay if any, etc.) • Any combination of aggregation level or additional attributes
GRPMGT:3	Groups of one or of many DER must be possible.
GRPMGT:4	Groups must be able to accommodate different types of DER and potentially mixes of individual DER with exiting aggregations of DER in such a way that control and dispatch of all members of the group can occur near simultaneously.
GRPMGT:5	One DER could be a member of any number of groups

Requirement No	Requirement
GRPMGT:6	Due to the potentially dynamic nature of distribution circuit configurations, DERMS must support arbitrarily defined groups for DER aggregation. This is applicable in scenarios where the DER cannot be statically associated with a given power system component like substation, and the concept of a “feeder” is dynamically defined by the switch positions. Example: Figure 4-1 illustrates this issue in which two substations are involved. As shown, an open switch is separating the system into two sections, one associated with each substation. In arrangements of this type, different switches can be opened or closed, shifting segments of line (load and DER) from one substation to another. In scenarios such as this, DER cannot be statically associated with a given substation, and the concept of a “feeder” is dynamically defined by the switch positions.
GRPMGT:7	DERMS must also support manual DER group creation
GRPMGT:8	Each group created should be assigned a unique Group ID number and identified using this ID when reporting to an upstream entity (e.g., DMS/DERMS) or requesting a downstream entity (e.g., sub-aggregator).
GRPMGT:9	DERMS must maintain a version number for all DER groups that is updateable every time a DER group makeup changes. For example, the membership of a DER group may be established and maintained by the DERMS that directly communicates to the individual DERs. In such a case, the membership could change as new DER are constructed and/or enrolled in grid programs and the calling entity (e.g., DMS) may wish to learn of such changes.
GRPMGT:10	Depending on the arrangement, DERMS must be able to report/request the current version number of a DER group when reporting to an upstream entity (e.g., DMS/DERMS) or requesting a downstream entity (e.g., sub-aggregator).
GRPMGT:11	Depending on the arrangement, DERMS must be able to report/request the membership of a DER group when reporting to an upstream entity (e.g., DMS/DERMS) or requesting a downstream entity (e.g., sub-aggregator)
GRPMGT:12	Just as DER group creation, a standalone DERMS (without being integrated to a DMS) must be able to delete DER groups. A DERMS working integrated with a DMS should be able to receive and update deleted group configurations from the DMS.
GRPMGT:13	DERMS must be able to support DER group maintenance—the adding and deleting of members to/from an existing group. Just as DER group creation and deletion, a standalone DERMS (without being integrated to a DMS) must be able to add or delete DER form DER groups. A DERMS working integrated with other upstream entities (e.g., DMS or DERMS) should be able to accept/reject the addition or deletion of a DER member to/from the group.
GRPMGT:14	DERMS must have the ability to take a DER offline and individually query/test it to remotely determine if an individual asset can participate in normal operation. The system will need to periodically take DER offline for corrective or preventive maintenance. This also requires the system to be able to re-register the DER into the asset pool following any preventative or corrective maintenance actions. In a mature implementation, the system will also be capable of automatically moving malfunctioning DER into an offline mode and notifying appropriate parties.
GRPMGT:15	DERMS must be capable of decommissioning or remove a DER from the resource pool permanently such as for DER end-of-life considerations. This process could be manual or semi-automatic (with DER removal being verified and approved by the appropriate role).

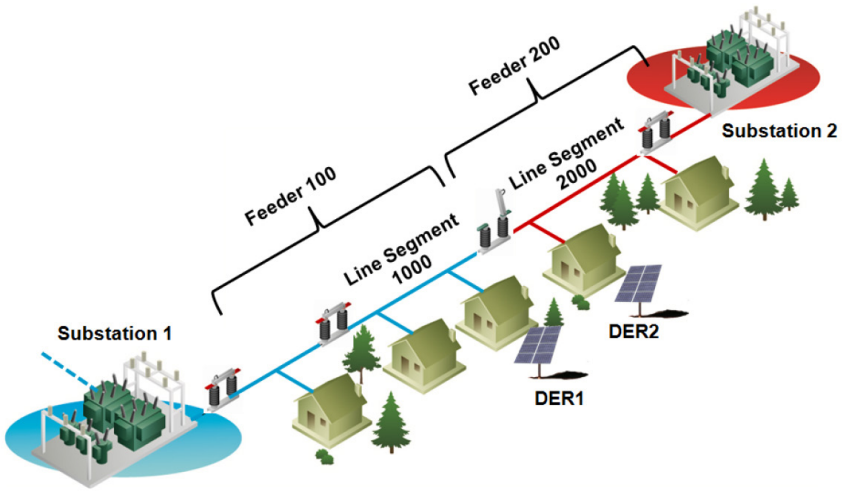


Figure 4-1 Example Illustrating the Challenges Posed by Dynamic Distribution System Configurations

Connect/Disconnect DER Group

Requirement No	Requirement
CONDIS:1	DERMS must be able to connect or disconnect individual DER or a whole group of DER using this function. Notionally, a DERMS could do so by leveraging the standard "Enter Service and Remote Cease to Energize" functions that has been identified in IEEE 1547
CONDIS:2	DERMS must ensure that it can connect/disconnect individual DER or a group of DER over a specific schedule. This schedule is the time/date window for which this request is effective. This includes the start time/date and end time/date or duration.
CONDIS:3	DERMS must also have the capability to execute this function starting immediately and for indefinite durations.
CONDIS:4	DERMS must incorporate a delay time over which a random delay is to be placed prior to starting the connect/disconnect action
CONDIS:5	DERMS must also provide the option for a configurable time-window over which the DER group members are to be disconnected or connected (as linearly as possible given DER sizes)

DER Group Capability Discovery

Requirement No	Requirement
DERCPB:1	DERMS must be able to read/report the as-built or installed capability (e.g., static, nameplate, non-variable quantities), not real-time status data which are time-variable in nature of DER groups.
DERCPB:2	Depending on the type of arrangement, DERMS must be able to support read/report/read and report functions of installed capabilities of DER groups. In one scenario, DERMS may be presenting this function to an upstream DERMS or DMS when it is required to report the installed capabilities of DER groups. In this scenario, DERMS must have information regarding the installed capabilities of individual DER, and the intelligence to translate this into the capabilities of the group. On another case, if the DERMS is requesting this function from another type of DERMS it should have the capability to read the installed capabilities of DER groups.
DERCPB:3	The following are the different DERMS functions for which capabilities may be discovered using the DER group capability discovery function • DER Group Status Monitoring - List of monitorable parameters • DER Group Forecasting - List of parameters for which forecasting is available • DER Group Historical Interval Meter Data - List of metered parameters for which interval data is available • DER Group Real Power Dispatch - Max Real Power (W), Min Real Power (W) • DER Group Reactive Power Dispatch - Max Reactive Power (VAR), Min Reactive Power (VAR) • DER Group Maximum Real Power Limiting - Range over which real power can be limited. • DER Group Ramp Rate Control - Range of ramp rate adjustability • DER Group Voltage Regulation - Range of voltage regulation • DER Group Curve Functions - List of curve types • Receive/Respond Based on Price Signals - List of services for which responses to price are supported • Provide Bids/Cost of Services - List of services for which bids/costs can be provided • Connect/Disconnect DER Group - Identifying whether or not this service is provided. • DER Group Regulation Service - Identifier of which regulation services are available and the scale (Watts) of each

DER Group Status Monitoring

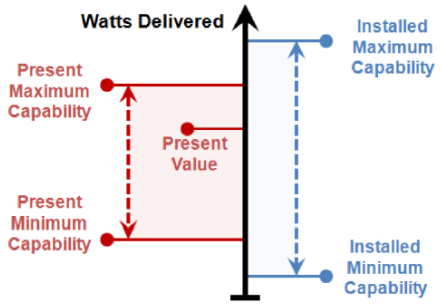
<table>
<tr><th>Requirement No</th><th>Requirement</th></tr>
<tr><td>GRPSTA:1</td><td>
DERMS managing a group of DER must be able to read/report the present status of a DER group. In this context, “status” refers foremost to the present operating point/value and range of feasible real and reactive power level adjustment (i.e., red components in Figure 4-2). It can be time-variant, in the sense of the potential for moment-to-moment changes during operation.
“Capabilities” (in blue in Figure 4-2) are name-plate oriented. Capabilities change when infrastructure is added or deleted, and the associated new installed capabilities are entered into GIS (or other system of record)


Figure 4-2
Installed Capability and Present Status Parameters

Table 4-8
DER Group Status Monitoring Points—Present Value
<table>
<tr><th>Monitoring Parameter</th><th>Description</th></tr>
<tr><td>Watts Total, W</td><td>Present AC active power imported or exported from the DER group (signed quantity)</td></tr>
<tr><td>Watts, Per Phase, W</td><td>Same as above but for Phase A, B, and C.</td></tr>
<tr><td>VA</td><td>Present apparent power imported or exported from the DER group</td></tr>
<tr><td>VA Per Phase, VA</td><td>Same as above but for Phase A, B, and C.</td></tr>
<tr><td>VAR Total, VAR</td><td>Present reactive power, capacitive or inductive, produced by the DER group</td></tr>
<tr><td>VAR Per Phase, VAR</td><td>Same as above but for Phase A, B, and C.</td></tr>
<tr><td>PF, %</td><td>Aggregate Power Factor for the DER group</td></tr>
<tr><td>PF, Per Phase, %</td><td>Same as above but for Phase A, B, and C.</td></tr>
<tr><td>Cumulative Watt-hours Exported, Wh</td><td>Aggregate energy exported from the DER group (arbitrary starting point value)</td></tr>
<tr><td>Cumulative Watt-hours Exported, Per Phase, Wh</td><td>Same as above but for Phase A, B, and C.</td></tr>
<tr><td>Cumulative Watt-hours Imported, Wh</td><td>Aggregate energy imported to the DER group (arbitrary starting point value)</td></tr>
</table>
</td></tr>
</table>

Requirement No	Requirement
GRPSTA:1 (continued)	**Table 4-9 (continued)** **DER Group Status Monitoring Points—Present Value**

Monitoring Parameter	Description
Cumulative Watt-hours Imported, Per Phase, Wh	Same as above but for Phase A, B, and C.
Cumulative VA-hours Exported VAh	Cumulative apparent energy exported from the DER group
Cumulative VA-hours Exported, Per Phase, VAh	Same as above but for Phase A, B, and C.
Cumulative VA-hours Imported VAh	Cumulative apparent energy imported to the DER group
Cumulative VA-hours Imported, Per Phase, VAh	Same as above but for Phase A, B, and C.
Cumulative Var-hours Imported Q1, Varh	Cumulative Reactive Energy imported to the DER group, Quadrant 1
Cumulative Var-hours imported, Q1, Per Phase, Varh	Same as above but for Phase A, B, and C.
Cumulative Var-hours imported Q2, Varh	Cumulative Reactive Power imported to the DER group, Quadrant 2
Cumulative Var-hours Imported, Q2, Per Phase, Varh	Same as above but for Phase A, B, and C
Cumulative Var-hours Exported Q3, Varh	Cumulative Reactive Power Exported from the DER group, Quadrant 3
Cumulative Var-hours Exported, Q3, Per Phase, Varh	Same as above but for Phase A, B, and C.
Cumulative Var-hours, Exported Q4, Varh	Cumulative Reactive Power Exported from the DER group, Quadrant 4
Cumulative Var-hours Exported Q4, Per Phase, Varh	Same as above but for Phase A, B, and C.
Phase Voltage AB, V p.u.	Average per unit phase voltage AB for the DER group
Phase Voltage BC, V p.u.	Average per unit phase voltage BC for the DER group
Phase Voltage CA, V p.u.	Average per unit phase voltage CA for the DER group
Phase Voltage AN, V p.u.	Average per unit phase voltage AN for the DER group
Phase Voltage BN, V p.u.	Average per unit phase voltage BN for the DER group
Phase Voltage CN, V p.u.	Average per unit phase voltage CN for the DER group
Hz	Average line frequency of the DER group
Present Energy Stored, Wh	Present stored energy by the DER group

<table>
<tr><th>Requirement No</th><th>Requirement</th></tr>
<tr><td>GRPSTA:1 (continued)</td><td>

Table 4-9
DER Group Status Monitoring Points—Present Range of Adjustability

Monitoring Parameter	Description
Present Range of Adjustability Maximum, Watts Delivered, Total, W	Maximum real power level a group can presently deliver (Real power generated cannot presently be dispatched to a level greater than this)
Present Range of Adjustability Maximum, Watts Delivered, Per Phase, W	Same as above but for Phase A, B, and C.
Present Range of Adjustability Maximum, Watts Received, Total, W	Maximum real power level a group can presently receive (Real power absorbed cannot presently be dispatched to a level greater than this)
Present Range of Adjustability Maximum, Watts Received, Per Phase	Same as above but for Phase A, B, and C.
Present Range of Adjustability Minimum, Watts Delivered, Total, W	Minimum real power level a group can presently deliver (Real power generated cannot presently be dispatched to a level less than this)
Present Range of Adjustability Minimum, Watts Delivered, Per Phase, W	Same as above but for Phase A, B, and C.
Present Range of Adjustability Minimum, Watts Received, Total, W	Minimum real power level a group can presently receive (Real power absorbed cannot presently be dispatched to a level less than this)
Present Range of Adjustability Minimum, Watts Received, Per Phase, W	Same as above but for Phase A, B, and C.
Present Maximum Capacitive Var available, Total, VAR	Maximum capacitive reactive power level a group can presently produce
Present Maximum Capacitive Var available, Per Phase, VAR	Same as above but for Phase A, B, and C.
Present Maximum Inductive Var available, Total	Maximum inductive reactive power level a group can presently produce
Present Maximum Inductive Var available, Per Phase, VAR	Same as above but for Phase A, B, and C.
Max Increasing Ramp Rate, Watts, W/sec	Maximum present rate at which the Watt output for this DER group can increase in response to dispatch command.
Max Decreasing Ramp Rate, Watts, W/sec	Maximum present rate at which the Watt output for this DER group can decrease in response to dispatch command.
Maximum Increasing Ramp Rate, Capacitive Var, VAR/sec	Maximum present rate at which the Capacitive VAR output for this DER group can increase in response to dispatch command

</td></tr>
</table>

<table>
<tr><th>Requirement No</th><th>Requirement</th></tr>
<tr><td>GRPSTA:1 (continued)</td><td>Table 4-10 (continued)
DER Group Status Monitoring Points—Present Range of Adjustability
<table>
<tr><th>Monitoring Parameter</th><th>Description</th></tr>
<tr><td>Maximum Decreasing Ramp Rate, Capacitive Var, VAR/sec</td><td>Maximum present rate at which the Capacitive VAR output for this DER group can decrease in response to dispatch command.</td></tr>
<tr><td>Max Increasing Ramp Rate, Inductive Vars, VAR/s</td><td>Maximum present rate at which the Inductive VAR output for this DER group can increase in response to dispatch command.</td></tr>
<tr><td>Max Decreasing Ramp Rate, Inductive Vars, VAR/s</td><td>Maximum present rate at which the Inductive VAR output for this DER group can decrease in response to dispatch command.</td></tr>
<tr><td>Maximum Present Energy Storage Capability, Wh</td><td>Maximum energy that can presently be stored by the DER group</td></tr>
<tr><td>Minimum Present Energy Storage Capability, Wh</td><td>Minimum energy that can presently be stored by the DER group</td></tr>
</table></td></tr>
<tr><td>GRPSTA:2</td><td>DERMS must be capable of providing two types of DER group status requests
Latest Available: A request for the latest status available for the DER group. This would notionally be based on information that the DERMS already collected from individual DER. The response to this kind of status request could typically be provided immediately.
Refreshed Status: A request that instructs the DERMS to go out and get updated status information from the DER group before responding. The response to this kind of request would be delayed until the refreshed status could be collected from the DER in the field.</td></tr>
<tr><td>GRPSTA:3</td><td>DERMS must be able to provide present status of a DER group for any group make up specified by the requesting entity, including individual DER, DER associated with a specific resource ID, DER belonging sharing common attributes specified below, or any other arbitrary grouping.
Grouping by Power System Level
By Substation
By Circuit/Bus
By Feeder
By Feeder Segment (contiguous conductor between switches)
By Island or micro-grid (campus, industrial facility)
By Individual Device
By Lat/Lon Rectangle
By Bulk System Nodes (e.g., CAISO Sublaps)
Grouping According to Other Attributes
By Circuit Phase - For example, a DMS could define separate groups for single phase DER that are connected to A, B, and C phases, and could request the status of these individually from a DERMS.
By DER Type—For example a DERMS could create separate groups for PV systems, battery storage systems, EVs, or any other DER type.</td></tr>
</table>

<table>
<tr><th>Requirement No</th><th>Requirement</th></tr>
<tr><td>GRPSTA:3 (continued)</td><td>

By DER Owner—For example, all the DER owned by the utility, or a particular customer, could be viewed and managed collectively.
By Program enrollment (e.g., DR program enrollment) or contractual arrangement.
By zip code
By voltage level
By tariff class
By user/customer class (residential, commercial, large C&I, agricultural)
By response characteristics (response time, directional change time delay if any, etc.)

Any combination of aggregation level or additional attributes.

</td></tr>
<tr><td>GRPSTA:4</td><td>DERMS must be capable of calculating the Present Real Power of a DER group using the following method. This method is also applicable for calculating the reactive power of a DER group. A step-by-step approach to this method with an example is available in the EPRI report with product ID 3002014467.[4]
<table>
<tr><td>Present Real power—Simple Sum (GrpPrP-SS)</td><td>This method calculates the present real power of a DER group as the sum of present real power readings from the individual devices in the DER group.</td></tr>
</table>
</td></tr>
<tr><td>GRPSTA:5</td><td>For unreachable DER, DERMS must be capable of estimating the group real/reactive power using one of the following methods. A step-by-step approach to these methods along with examples is available in the EPRI report with product ID 3002014467.[4]
<table>
<tr><td rowspan="5">Present Real power—Estimation for non-reachable DER (GrpPrP-Est)</td><td>This method enhances the simple sum method by assuming the full nameplate ratings for unreachable DER.</td></tr>
<tr><td>This method enhances the simple sum method by assuming the group average % of nameplate rating for unreachable DER.</td></tr>
<tr><td>This method enhances the simple sum method by assuming that the last read value is still valid for unreachable DER.</td></tr>
<tr><td>This method enhances the simple sum method by assuming that the last sent schedule is still valid for unreachable DER (e.g., energy storage).</td></tr>
<tr><td>This method enhances the simple sum method by using historical data to estimate the present value for unreachable DER</td></tr>
</table>
</td></tr>
</table>

[4] https://www.epri.com/#/pages/product/000000003002014467/?lang=en-US

<table>
<tr><th>Requirement No</th><th>Requirement</th></tr>
<tr><td>GRPSTA:6</td><td>DERMS must be capable of calculating the maximum and minimum real power capability of a DER group using one of the following methods. A step-by-step approach to these methods along with examples is available in the EPRI report with product ID 3002014467.[4]
<table>
<tr><td>Present Maximum Adjustability, Watts Delivered– based on last known present value (GrpPrMaxPDEL-PrVal)</td><td>This method calculates the maximum present level at which real power can be generated by the DER group. Two cases are discussed under this method (1) DER group with all un-curtailed DER (2) DER group with curtailed DER</td></tr>
<tr><td rowspan="4">Present Maximum Adjustability, Watts Delivered– estimation based (GrpPrMaxPDEL-Est)</td><td>This method calculates the maximum present level at which real power can be generated by the DER group either centralized or at DER devices based on weather sensor data (irradiance, temperature, cloud-view, etc.) for PV/wind or based on predicted behavior models for DER like storage and EVs.</td></tr>
<tr><td>This method calculates the maximum present level at which real power can be generated by a DER group as the sum of present maximum capabilities read from the individual DER in the group. This could be, for example, supported by future PV systems able to perform estimation of AC capability based on DC volt/current sensing and advanced analytics or EVs that share what they could contribute if enrolled in a DER-type program.</td></tr>
<tr><td>This method calculates the maximum present level at which real power can be generated by a DER group using a DER model and estimation based on present time of day and historical production data from prior or like-days.</td></tr>
<tr><td>This method calculates the maximum present level at which real power can be generated by a DER group through randomized momentary release of any curtailed DER devices to full power (or a momentary request for 100% dispatch at full power) to determine present power capability.</td></tr>
<tr><td>Present Minimum Adjustability, Watts Delivered by a DER group (GrpPrMinPDEL)</td><td>This method calculates the minimum present level at which real power can be generated by the DER group[5]</td></tr>
<tr><td>Present Maximum Adjustability, Watts Received by a DER group (GrpPrMaxPREC)</td><td>This method calculates the maximum present level at which real power can be absorbed by the DER group[4]</td></tr>
<tr><td>Present Minimum Adjustability, Watts Received by a DER group (GrpPrMinPREC)</td><td>This method calculates the minimum present level at which real power can be absorbed by the DER group[4]</td></tr>
</table></td></tr>
</table>

[5] Can use similar approaches as those listed for Present Maximum Adjustability – Watts Delivered; however, some modifications will be needed (e.g., may completely curtail some units momentarily instead of releasing their constraints)

<table>
<tr><th>Requirement No</th><th>Requirement</th></tr>
<tr><td>GRPSTA:7</td><td>DERMS must be capable of calculating the present maximum reactive power capability of a DER group using one of the following methods. A step-by-step approach to these methods along with examples is available in the EPRI report with product ID 3002014467.[4]
<table>
<tr><td>Present Maximum Capacitive VAR available for a DER group – (GrpPrMaxQCAP)</td><td>This method calculates the maximum present level at which capacitive vars can be provided by a DER group based on the sum of the individual DER present status and capabilities. The result of this status monitoring parameter depends on whether the individual DER and DERMS control methods are Watt or var priority.</td></tr>
<tr><td>Present Maximum Inductive VAR available for a DER group – (GrpPrMaxQIND)</td><td>This method calculates the maximum present level at which inductive vars can be provided by a DER group based on the sum of the individual DER present status and capabilities. The result of this status monitoring parameter depends on whether the individual DER and DERMS control methods are Watt or var priority as discussed here.</td></tr>
</table></td></tr>
</table>

DER Group Aggregate Telemetry

<table>
<tr><th>Requirement No</th><th>Requirement</th></tr>
<tr><td>METER:1</td><td>DERMS managing a group of DER must be able to provide the aggregate metered data for a DER group and individual DER within a group in real time for on-going verification of performance. Additionally, the DERMS must be able to provide a historical record for a DER group upon request.
Provision of telemetry data from groups of dispersed DER is complex and could be accomplished in a range of ways as summarized in Table 4-10.
Table 4-10
Example Methods for DER Group Telemetry
<table>
<tr><th>Method</th><th>Accuracy</th><th>Latency</th><th>Cost</th><th>Comments</th></tr>
<tr><td>Aggregation of Site Meters</td><td>High</td><td>Slow</td><td>High</td><td>Regular revenue meters (AMI) may not be fast enough. Built-in metering in the DER may not meet accuracy requirements.</td></tr>
<tr><td>Aggregation of Sampled Site Meters</td><td>Medium</td><td>Medium</td><td>Medium</td><td>Might not be applicable to all forms of DER.</td></tr>
<tr><td>Single Meter</td><td>Medium</td><td>Fast</td><td>Low</td><td>Applicability depends on DER Group alignment with the power system configuration. Third parties may not be able to place such meters.</td></tr>
<tr><td>Sensor Based Estimation</td><td>Medium</td><td>Fast</td><td>Low</td><td>For DER such as PV, using weather /sky sensors. Might not be applicable to all forms of DER.</td></tr>
<tr><td>Historical Data Based Estimation</td><td>Low</td><td>Fast</td><td>Low</td><td>May not meet system operator accuracy requirements.</td></tr>
</table></td></tr>
</table>

Requirement No	Requirement
METER 2	Metered historical values should also include summary real and reactive energy production for the group, energy stored, and any status or error codes observed over a time period defined by the requesting entity. Example use case: A utility CIS is in a settlement operations relationship with a third-party DER aggregator. In this relationship, the utility requests services to be rendered at the group-level, without concern for how the service was distributed among the members of the group. Confirmation of success would be based on data that the aggregator directly collects from their fleet of smart inverters and meters. The utility CIS, acting as the requesting entity, uses the methods set forth by this function to query the ADERMS for certain aggregate historical data for the DER group.

<table>
<tr><th>Requirement No</th><th>Requirement</th></tr>
<tr><td>METER 3</td><td>DERMS should be able to provide any subset of the parameter types specified in Table 4-10.
Table 4-11
DER Group Historical Meter Data Quantities
<table>
<tr><th>Interval Quantity</th><th>Cumulative Quantity</th><th>Description</th></tr>
<tr><td>Wh Delivered</td><td>Total Wh Produced</td><td>Interval data (e.g., 5-minute intervals) and the cumulative total of the real power produced by the DER group</td></tr>
<tr><td>Wh Received</td><td>Total Wh Absorbed</td><td>Interval data (e.g., 5-minute intervals) and the cumulative total of the real power absorbed by the DER group</td></tr>
<tr><td>N/A</td><td>Peak Interval Watt Produced Demand</td><td>The maximum demand value (Watts) of real power produced by the DER group. Maximum demand is typically based on a given interval length (e.g., 5 minutes) and over a given time period (e.g., a billing month).</td></tr>
<tr><td>N/A</td><td>Peak Interval Watt Absorbed Demand</td><td>The maximum demand value (Watts) of real power absorbed by the DER group. Maximum demand is typically based on a given interval length (e.g., 5 minutes) and over a given time period (e.g., a billing month).</td></tr>
<tr><td>Varh Injected</td><td>Total Varh Injected</td><td>Interval data (e.g., 5-minute intervals) and the cumulative total of the reactive power produced by the DER group</td></tr>
<tr><td>Varh Absorbed</td><td>Total Varh Absorbed</td><td>Interval data (e.g., 5-minute intervals) and the cumulative total of the reactive power absorbed by the DER group</td></tr>
<tr><td>Interval Q1 Varh</td><td>Q1 Varh</td><td>Interval data (e.g., 5-minute intervals) and the cumulative total of the Q1 reactive power produced by the DER group</td></tr>
<tr><td>Interval Q2 Varh</td><td>Q2 Varh</td><td>Interval data (e.g., 5-minute intervals) and the cumulative total of the Q2 reactive power produced by the DER group</td></tr>
<tr><td>Interval Q3 Varh</td><td>Q3 Varh</td><td>Interval data (e.g., 5-minute intervals) and the cumulative total of the Q3 reactive power produced by the DER group</td></tr>
<tr><td>Interval Q4 Varh</td><td>Q4 Varh</td><td>Interval data (e.g., 5-minute intervals) and the cumulative total of the Q4 reactive power produced by the DER group</td></tr>
<tr><td>Interval Average Voltages at Point of Reference</td><td>N/A</td><td>Interval data (e.g., 5-minute intervals) for the average voltages (Phase A, B, C) at a specified point of reference that is significant for the DER group. For example, the point could be specified as a control point of reference for DER Group Volt-Watt curve control.</td></tr>
<tr><td>Interval Max Voltage at Point of Reference</td><td>N/A</td><td>Interval data (e.g., 5-minute intervals) for the 1 second maximum voltages (Phase A, B, C) at a specified point of reference that is significant for the DER group.</td></tr>
<tr><td>Interval Min Voltage at Point of Reference</td><td>N/A</td><td>Interval data (e.g., 5-minute intervals) for the 1 second minimum voltages (Phase A, B, C) at a specified point of reference that is significant for the DER group.</td></tr>
<tr><td>Interval Energy Stored</td><td>N/A</td><td>Interval data (e.g., 5-minute intervals) for the usable energy (Wh) stored in the DER Group. For example, battery DER groups.</td></tr>
</table></td></tr>
</table>

Requirement No	Requirement
METER 4	Metered historical values should also include summary real and reactive energy production for the group, energy stored, and any status or error codes observed over a time period defined by the requesting entity.
METER 5	DERMS must have the ability to exchange the requested meter data in Table 4-10 with the following configuration parameters: • Interval Resolution: The time interval (e.g., in seconds) for the interval resolution. • Start Date/Time: For use with demand calculations, the start date/time of the analysis window. • End Date/Time: For use with demand calculations, the end date/time of the analysis window. • Demand Reset: Reset maximum demand values to zero.

DER Group Forecasting

Some of the below forecast requirements are broken into sub requirements based on the type of DER being managed. For the purposes of this report, the distinction is as follows:

Opportunistic Type DER: DER like PV and wind generation whose instantaneous availability are often weather dependent and whose usage in one timestep usually has minimal to no impact on the availability in the next timestep.

Contingent Flexibility Type DER: DER whose adjustments to behavior in one timestep will impact capabilities in future timesteps. These resources can usually store and dispatch energy on demand. Typical examples of such DER include battery energy storage systems (BESSs), plug-in electric vehicles, and even controllable water heaters and HVAC systems/thermostats when paired with thermal models or other ways of predicting alternate scenario behaviors.

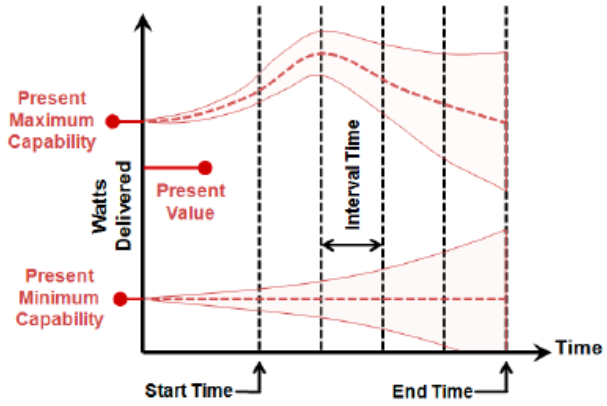
Requirement No	Requirement
DERFORE:1	**Ingesting and Using Disparate Forecast Sources** Background: Aggregated DER forecasts can be generated by different sources including the following examples: 1. Utility-owned aggregator DERMS 2. Generic third-party sources such as EV fleet forecasting services from a charge network operator or a satellite-based PV production estimation service 3. Centralized grid DERMS systems 4. Third-party sub-aggregator DERMS 5. Some combination of the above Requirement: Unless otherwise specified by the utility, however, the ADERMS should be able to provide an aggregated DER forecast using one or more of the following techniques: 1. Take in data from the following sources to generate its own forecast a. Sub-aggregators of DER b. Local/plant controllers or energy management systems (EMSs) c. Smart DER controllers d. Satellite data/forecasts e. Weather stations f. EVSEs/Charge Network Operator g. Utility devices/sensors (if access is provided) 2. Take in a forecast generated by another system 3. Pick between/merge forecasts coming from both internal and external sources
DERFORE:2	**Group-specific Forecasts** DERMS must be able to provide forecasted information for any DER group based on the group make up. A DER group can be a group of one or more types of DER. Examples of possible group types are specified in GRPMGT:2.
DERFORE:3	**Forecasting Group Availability** DERMS managing a DER or a group of DERs must be able to forecast and support the exchange of forecasts of DER group availability. Availability forecasts must be obtainable upon request for active power services, reactive power services, and other relevant services that the DER groups can provide. Values can be binary (available/not available) or on a spectrum (e.g., 85% nominal active power available) at a given timestep.
DERFORE:4	**Forecasting Baseline and/or Expected Behavior** Background: For a DMS or central DERMS to be aware of any potential constraint violations, it must first have an estimate from sources like the ADERMS for what the DER's behavior is expected to be. Requirement: For whatever groupings are specified by the DMS (see grouping requirement GRPMGT:2, the DERMS must be able to provide a forecast of expected baseline DER behavior (what the DER would do in the absence of any DER management). In general, expected behavior forecasts should include the following information:

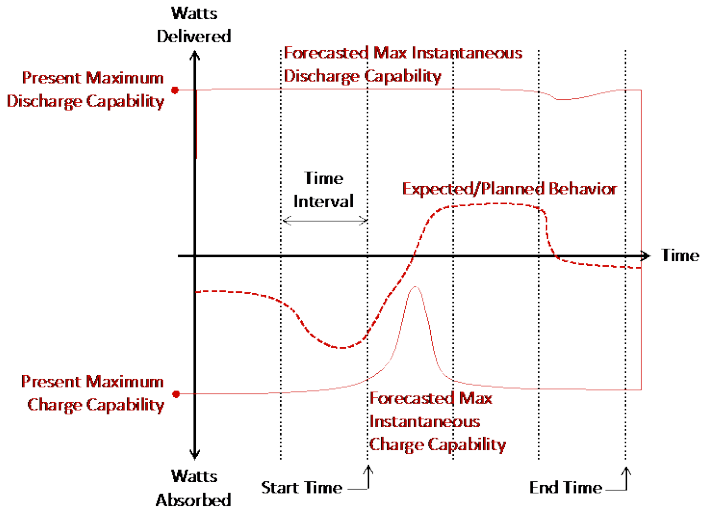
Requirement No	Requirement
DERFORE:4 (continued)	1. The forecasted quantity a. Expected Active Power Delivery, Total b. Expected Active Power Delivery, Phase A, B, C c. Expected Reactive Power Injection, Total d. Expected Reactive Power Absorption, Total e. Expected Reactive Power Injection, Phase A, B, C f. Expected Reactive Power Delivery, Absorption A, B, C 2. The date/time at which this forecast was made 3. An enumeration that identifies the format of the forecast array, supporting, at a minimum, these types: a. Best guess, midpoint only[6] b. Best guess, plus high/low confidence points (e.g., 10th and 90th percentile forecasts) c. Normal (Gaussian) distribution - providing mean and standard deviation d. Central Chi-square distribution - providing midpoint and degrees of freedom, K 4. The array of points representing the forecast for the requested capability quantity, group, and timeframe. 5. Forecast array interval time: The requested time interval between points in the array of returned forecast data 6. Prediction start time: The number of intervals will indicate the duration of any given forecast; this attribute indicates the date-time the prediction period begins 7. If XML files are used, any given instance of the forecast. (This allows the values passed in the XML to be placed in the correct order) The DERMS should also specify whether estimates already take into account expected availability of the resources or not (particularly important for electric vehicle resources) <u>Opportunistic Type DER</u> Default forecasts for these DER may often resemble the 'maximum available' capability forecast but should consider past DER behavior and forecasted availability to provide a more realistic estimate of expected generation/consumption. (e.g., PV production may have been lower than normal recently due to dust accumulations across the area) <u>Contingent Flexibility Type DER</u> When it comes to groups of energy storage type DER, DERMS is to provide a forecast of expected behavior which outlines expected dispatch and consumption values for the aggregate resource. Expected behavior of the aggregate energy storage resource may be a result of various inputs such as the following: • Planned behavior as reported by individual DER or sub-aggregations (such as a planned charge/discharge profile in response to market signals) • Typical behavior of individual or groups of DER based on historic telemetry data • Forecasts from a third-party aggregation/controller platform for some subset of the relevant DER • Any default, contractually agreed upon dispatch schedules

[6] *Common Functions for DER Group Management, Third Edition.* EPRI, Palo Alto, CA: 2016. 3002008215

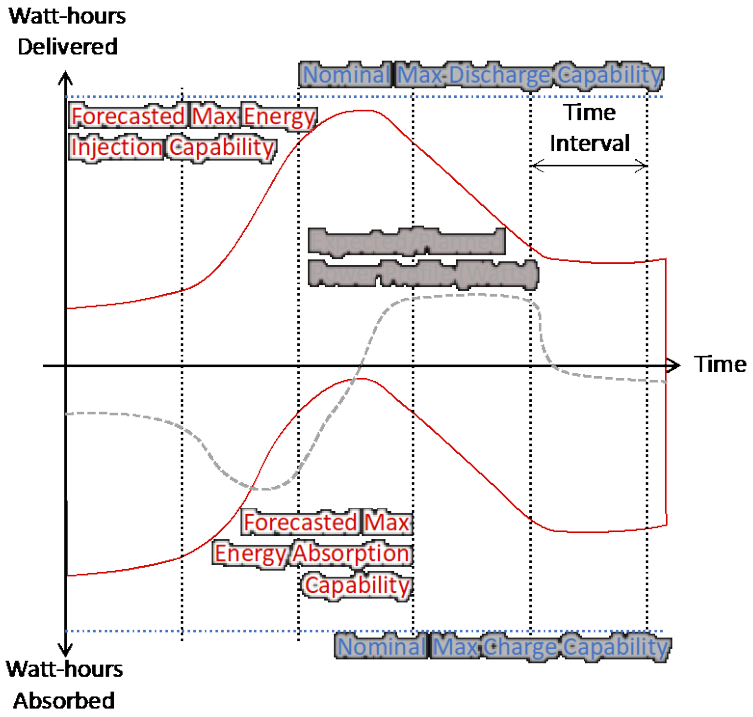
Requirement No	Requirement
DERFORE:5	**Forecasting Expected Constrained Behavior** Background: For a DMS or central DERMS to be aware of likely/persistent constraint violations, it must first have an estimate from sources like the ADERMS for what the DER's behavior will be in response to previously requested constraints. Requirement: For whatever groupings are specified by the DMS (see grouping requirement GRPMGT:2, the DERMS must provide updated/revised forecasts of DER behavior in a similar format to those described in DERFORE:4, but now considering the latest set of DER constraints.
DERFORE:6	**Forecasting Maximums and Minimums** Per the request of a DMS or other utility system, DERMS may be required to provide forecasts of maximum and minimum instantaneous capabilities for future timesteps. Such forecasts could be used to anticipate proximity to infeasible solutions, utilization of renewable resources, or other uses. Opportunistic Type DER When it comes to PV, wind, or DER without storage capabilities, DERMS is to provide maximum and minimum values for all forecasted (future) timesteps including a most recent estimate for the "t=0" or "current" timestep. When a DMS is the entity making the forecast requests, that DMS should request (and the DERMS must be able to provide) the following types of information: 1. The quantity to be forecasted[7] a. Maximum or Minimum Capability of Active Power Delivered, Total b. Maximum or Minimum Capability of Active Power Received, Total c. Maximum or Minimum Capability of Active Power Delivered, Phase A, B, C d. Maximum or Minimum Capability of Active Power Received, Phase A, B, C e. Maximum or Minimum Capability of Reactive Power Injection, Total f. Maximum or Minimum Capability of Reactive Power Absorption, Total g. Maximum or Minimum Capability of Reactive Power Injection, Phase A, B, C h. Maximum or Minimum Capability of Reactive Power Absorption, Phase A, B, C 2. A forecast start time: The requested start time of returned forecast data 3. Forecast Array Interval time: The requested time interval between points in the array of returned forecast data 4. Forecast End time: The requested end time of returned forecast data

[7] Values should represent capabilities of typical/expected DER aggregations that would be connected and communicating at any given time, not simply a total of all known DER in a group.

Requirement No	Requirement
DERFORE:6 (continued)	 **Figure 4-3** **Arrays of Data to Represent Forecast Data** Forecasts for maximum and minimum values may include confidence intervals like those shown by the light red regions in Figure 4-3, but it is not yet a requirement to do so. <u>Contingent Flexibility Type DER</u> Background: Alternative forecast requirements are needed for energy storage and hybrid DERs that include storage since maximum and minimum capability values depend heavily upon how the resources were used in prior timesteps. For this reason, only conditional forecasting of instantaneous max power and energy capabilities is required for energy storage type resources in this requirements document. Requirement: More specifically, a DERMS must be able to provide forecasts of its maximum potential bidirectional capability (that could be sustained for one time step) for its planned/expected behavior profile. Capability figures should include maximum charging and discharging power profiles such as those in Figure 4-4 as well as maximum charging and discharging energy capacity profiles such as those shown in Figure 4-5.

Requirement No	Requirement
DERFORE:6 (continued)	When a DMS is the entity making the forecast requests, that DMS should request (and the DERMS must be able to provide) the following types of information: 1. Profile of the quantity to be forecasted8 a. Power b. Maximum Instantaneous Capability of Active Power Injection, Total c. Maximum Instantaneous Capability of Active Power Absorption, Total d. Maximum Instantaneous Capability of Active Power Injection, Phase A, B, C e. Maximum Instantaneous Capability of Active Power Absorption, Phase A, B, C f. Maximum Instantaneous Capability of Reactive Power Injection, Total g. Maximum Instantaneous Capability of Reactive Power Absorption, Total h. Maximum Instantaneous Capability of Reactive Power Injection, Phase A, B, C i. Maximum Instantaneous Capability of Reactive Power Absorption, Phase A, B, C j. Energy k. Maximum Remaining Energy Absorption Capability, Total l. Maximum Remaining Energy Absorption Capability, Phase A, B, C m. Maximum Remaining Energy Injection Capability, Total n. Maximum Remaining Energy Injection Capability, Phase A, B, C 2. Forecast Start time: The requested start time of returned forecast data (if not provided, present timestep will be used) 3. Forecast Array Interval time: The requested time interval between points in the array of returned forecast data; also defines the duration of an "instantaneous" dispatch, should one be required 4. Forecast End time: The requested end time of returned forecast data  **Figure 4-4** **Illustrative Example of Maximum Charing and Discharging *Power* Profiles Relative to the Expected Power Profile**

[8] Values should represent capabilities of typical/expected DER aggregations that would be connected and communicating at any given time, not simply a total of all known DER in a group.

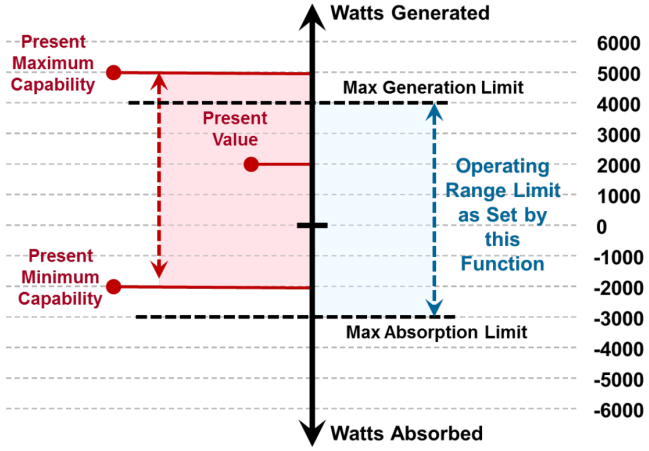
Requirement No	Requirement
DERFORE:6 (continued)	 **Figure 4-5** **Illustrative Example of Maximum Charing and Discharging *Energy Capacity* Profiles with Expected Power Profile Shown for Reference**

Requirement No	Requirement
DERFORE:7	**<u>EV-specific Forecasting</u>** Background: As described in an EPRI deliverable about fleet charge management[9], active management of EV charging is expected to involve producing an optimized charging plan that conforms to constraints issued by a central grid DERMS (or similar) while minimizing the impact to forecasted/desired vehicle charge preferences. Creation of such a plan will require forecasting of expected charging schedules and/or communication of desired charge preferences from individual vehicles. These profiles will then inform potential constraint violations and ultimately, creation of a new charging plan around those constraints (similar to DERFORE:5). Where exactly such optimization occurs in the DER management hierarchy can vary, but two likely possibilities are 1) at an EV fleet charging station controller (EVFCSC) dedicated to this purposes and acting as a sub-aggregator or 2) as a function of the ADERMS. Requirement: If not delegated to a subordinate DER aggregator or an EV fleet charging station controller, the ADERMS must assume responsibility for iteratively calculating/forecasting optimal charging schedules for electric vehicle fleets. Optimized forecasts/plans should consider the following attributes: • Predicted presence of EVs at a given timestep for each EVSE or site in group • Predicted availability windows (for grid services) of the participating EVs • Current and desired SoCs (with target times) • Accessible power and energy curve capabilities of each vehicle or vehicle/charger combination • Constraints coming from the DMS/centralized DERMS In addition, aggregated EV charging plan values for predefined DER groups should be available for communication to upstream UDERMS/DMS (for use in determining further constraints). If a subordinate EV fleet charging station controller (EVFCSC) or similar *IS* present, then the ADERMS only must report forecasted statuses of the aggregate EV/EVSE resource (in a similar manner to other opportunistic type DER like energy storage). In order to do so, the ADERMS must obtain the following component attributes from the sub-ordinate controller: • The latest planned aggregate power demand from the group for each timestep • Predicted energy capacity (kWh) present behind each EVSE/site for each timestep, both total and that likely to be available for grid services (not reserved or off-limits to utility)

[9] EV Fleet Charging Management and Assessing Distribution Impacts. EPRI, Palo Alto, CA: 2022. 3002023696.

Grid Service Functionalities

DER Group Maximum Real Power Limiting

Requirement No	Requirement
MPLIM:1	DERMS managing a group of DER must have the necessary logic to limit the maximum real power (generated or absorbed) output of a DER group below a specified level as requested by the upstream entity (e.g., DMS or DERMS). Figure illustrates how this function relates to the "DER Group Status" and the "Maximum Real Power Limiting" function. The red shaded area identifies the present capability range in which real power dispatch commands may be successful according to the "DER Group Status Monitoring" function. The blue shaded area is the operational limit or constraint sent by the requesting entity to DERMS.  Figure 4-6 DER Group Maximum Real Power Limiting
MPLIM:2	This logic can be implemented on a group of similar or mixed type of DER technologies, according to the group makeup.
MPLIM:3	DERMS must maintain operation of the DER group within the specified limits using a specific control strategy of choice. Example strategies include but not limited to, • Uniform Distribution in Watts • Uniform Distribution in Percentage of Nameplate Capacity • Weighted Distribution • Priority-based Distribution
MPLIM:4	DERMS must ensure that it maintains the DER group output to stay within the limits for a specific schedule. This schedule is the time/date window for which this request is effective. This includes the start time/date and end time/date or duration. Any schedule with a start time in the past should commence immediately upon receipt.
MPLIM:5	DERMS must also have the capability to execute this function starting immediately and for indefinite durations.
MPLIM:6	When serving multiple upstream masters (e.g., DSO, TSO etc.) DERMS must have the capability to serve multiple functional requests based on priority-levels. A *Priority* parameter and the *Requesting Entity ID* should be included in the grid service request to invoke the prioritization scheme implemented in DERMS

DER Group Ramp Rate Limit Control

Requirement No	Requirement
RAMP:1	DERMS managing a group of DER must have the necessary logic to manage the maximum ramp rates at the DER group-level.
RAMP:2	It is recognized that DERMS must have the capability to set ramp limits at the group-level or individual device level, depending on the circumstances and the nature of the DER group. ***Individual Device Ramp Rate Control Mode:*** In this mode of ramp-rate control, DERMS applies the ramp-rate setting of the DER group directly to each member of the group. ***Aggregated Ramp Rate Control Mode:*** In this mode of ramp-rate control, DERMS has the logic to maintain the ramp rate settings applied to the DER group only at the group-level, at a specific point of reference. Here, DERMS may or may not disseminate the group ramp-rate settings to the individual DER equally. An example is a PV + ES group managed by a DERMS. Here the ramp rates of individual PV in the group may not be managed, and yet the aggregate ramp rate at the point of coupling to the grid would meet the group-level goal by the smoothing action of the battery storage system.
RAMP:3	DERMS must ensure that it maintains the DER group output to stay within the ramp rate limits for a specific schedule. This schedule is the time/date window for which this request is effective. This includes the start time/date and end time/date or duration. Any schedule with a start time in the past should commence immediately upon receipt.
RAMP:4	DERMS must also have the capability to execute this function starting immediately and for indefinite durations.
RAMP:5	DERMS must have the capability to configure different types of ramp rates for DER Normal Ramp-Up/Down Rates: The maximum rate at which increases/decreases in DER Group real power output are permitted during normal operation. Emergency Ramp-Up/Down Rates: The maximum rate at which increases/decrease in DER Group real power output are permitted during power system events such as voltage sags and subsequent recovery Soft-Connect/Disconnect Ramp Rates: The maximum rate at which increases/decrease in DER Group real power output are permitted during start-up

DER Group Phase Balancing

Requirement No	Requirement
BLNCE:1	DERMS managing a group of DER must have the necessary logic to maintain the aggregate real/reactive power output of DER group within the phase unbalance limit set by the requesting entity (e.g., DMS or DERMS). Limits on real/reactive power imbalance can be expressed as a percentage of the DER group's total (all phases) real/reactive power.
BLNCE:2	DERMS must have the capability to maintain phase unbalance for real power absorption, real power production, capacitive and inductive reactive power.
BLNCE:3	To maintain phase balance, DERMS must understand which DER are connected to which power system phase. This information can be requested by the DERMS to the entity that has information about the power system model (e.g., DMS)
BLNCE:4	DERMS must ensure that it maintains the DER group output to stay within the phase imbalance limits for a specific schedule. This schedule is the time/date window for which this request is effective. This includes the start time/date and end time/date or duration. Any schedule with a start time in the past should commence immediately upon receipt.
BLNCE:5	DERMS must also have the capability to execute this function starting immediately and for indefinite durations.

DER Group Active Power Dispatch

Requirement No	Requirement
PDISP:1	DERMS managing a group of DER must have the necessary logic to disaggregate a real power dispatch request to individual DER device-level setpoints.
PDISP:2	This logic can be implemented on any DER group, according to the group makeup.
PDISP:3	DERMS must be able to address two form of real power dispatch requests. • Specified Power Level: A request that the real power for the group be set to a specified level • Specified Power Level Adjustment: A request that the real power for the group be raised/lowered by a specified amount
PDISP:4	DERMS must maintain operation of the DER group to meet the real power dispatch request using a specific control strategy of choice. Example strategies include but are not limited to those listed in Table 4-12.

<table>
<tr><th>Requirement No</th><th>Requirement</th></tr>
<tr><td>PDISP:4
(continued)</td><td>
Table 4-12
Potential disaggregation strategies
<table>
<tr><th>Disaggregation Strategy</th><th>Description</th></tr>
<tr><td>Priority-Based Dispatch (PGSPL/PGSPLA -PBD)</td><td>This method sets/limits the real power level of each member of the DER group based on a priority list, in order to achieve the specified absolute power level or adjusted power level for the DER group. In PBD, each DER is completely dispatched/curtailed before proceeding to the next one in the priority list.</td></tr>
<tr><td>Economic Dispatch (PGSPL/PGSPLA -ED)</td><td>This method sets/limits the real power of each member of the DER group to achieve the specified absolute power level or adjusted power level from the DER group while minimizing the total economic impact (e.g., cost or price) across all individual devices constituting the group.</td></tr>
<tr><td>Uniform Distribution in Watts (PGSPL/PGSPLA - UDW)</td><td>This method sets/limits the real power level, of each member of the DER group to the same power level to achieve the specified absolute power level or adjusted power level.</td></tr>
<tr><td>Uniform Distribution by % of Nameplate (PGSPL/PGSPLA -UDP)</td><td>This method sets/limits the real power of each member of the DER group to the same percentage of its Nameplate capacity in order to achieve the specified absolute power level or adjusted power level for the group.</td></tr>
<tr><td>Weighted Distribution in Watts (PGSPL/PGSPLA - WDW)</td><td>This method sets/limits the real power level of each member of the DER group based on weighting factors defined for each device, in order to achieve the specified absolute power level or adjusted power level for the DER group.</td></tr>
<tr><td>Weighted Distribution by Percentage of Nameplate Capacity (PGSPL/PGSPLA - WDP)</td><td>This method sets/limits the real power of each device in the DER group to a % of its Nameplate capacity based on weighting factors defined for each device, in order to achieve the specified absolute power level or adjusted power level for the group.</td></tr>
</table>
</td></tr>
<tr><td>PDISP:5</td><td>DERMS must ensure that it maintains the DER group output to meet the real power dispatch request for a specific schedule. This schedule is the time/date window for which this request is effective. This includes the start time/date and end time/date or duration. Any schedule with a start time in the past should commence immediately upon receipt.</td></tr>
<tr><td>PDISP:6</td><td>DERMS must also have the capability to execute this function starting immediately and for indefinite durations.</td></tr>
<tr><td>PDISP:7</td><td>DERMS must have a configurable ramp time (time window in seconds) over which the group real power is to be adjusted in response to this control action</td></tr>
<tr><td>PDISP:8</td><td>When serving multiple upstream masters (e.g., DSO, TSO etc.) DERMS must have the capability to serve multiple functional requests based on priority-levels.
A Priority parameter and the Requesting Entity ID should be included in the grid service request to invoke the prioritization scheme implemented in DERMS</td></tr>
</table>

DER Group Reactive Power Dispatch

Requirement No	Requirement
QDISP:1	DERMS managing a group of DER must have the necessary logic to disaggregate a reactive power dispatch request to individual DER device-level setpoints.
QDISP:2	This logic can be implemented on any DER group, according to the group makeup.
QDISP:3	DERMS must be able to address two form of reactive power dispatch requests. Specified Power Level: A request that the reactive power for the group be set to a specified level Specified Power Level Adjustment: A request that the reactive power for the group be raised/lowered by a specified amount
QDISP:4	DERMS must maintain operation of the DER group to meet the reactive power dispatch request using a specific control strategy of choice. Example strategies include but are not limited to those listed in Table 4-12.
QDISP:5	DERMS must ensure that it maintains the DER group output to meet the reactive power dispatch request for a specific schedule. This schedule is the time/date window for which this request is effective. This includes the start time/date and end time/date or duration. Any schedule with a start time in the past should commence immediately upon receipt.
QDISP:6	DERMS must also have the capability to execute this function starting immediately and for indefinite durations.
QDISP:7	DERMS must have a configurable ramp time (time window in seconds) over which the group reactive power is to be adjusted in response to this control action
QDISP:8	When serving multiple upstream masters (e.g., DSO, TSO etc.) DERMS must have the capability to serve multiple functional requests based on priority-levels. A *Priority* parameter and the *Requesting Entity ID* should be included in the grid service request to invoke the prioritization scheme implemented in DERMS

DER Group Voltage Regulation

Requirement No	Requirement
VREG:1	DERMS must have the control logic to manage a group of DER to support various voltage needs in the grid.
VREG:2	DERMS must be able to provide voltage regulation when specified a target voltage value or when asked to raise/lower the voltage by a specified amount.
VREG:3	The "Voltage Regulation" function specifies only the intended result, and not the control method by which the result is obtained. DERMS must enable a specific control method of choice to provide voltage regulation.
VREG:4	DERMS must maintain operation of the DER group to meet the voltage regulation request using a specific control strategy of choice. Example strategies include but not limited to, **Single Point Reference:** In this mode, the voltage regulation target that is applied to a DER Group is accompanied by an identifier of a single point of reference for voltage measurement, such as the MRID of a particular meter. DERMS then operates (as possible) to manage voltage at this reference point. **Average Reference:** In this mode, the voltage regulation target that is applied to a DER Group is to be associated with the average voltage at the DER members of the group. Use of this mode is complicated by factors that make the exact voltage uncertain at the individual DER, such as adjustable taps on distribution transformers. As such, use of this mode is driven primarily by the lack of an independent point of reference that might otherwise enable the use of single point reference, and the DERMS is left to use the average of the voltages at the individual DER as a representative indicator.
VREG:5	To delay before beginning to activate a new voltage setting, DERMS must have a randomization time window as defined in IEC 61850-7-420 for many smart inverter functions
VREG:6	DERMS must ensure that it maintains the DER group output to provide voltage regulation for a specific schedule. This schedule is the time/date window for which this request is effective. This includes the start time/date and end time/date or duration.
VREG:7	DERMS must also have the capability to execute this function starting immediately and for indefinite durations.

Curve-Based Functions Management

Requirement No	Requirement
CURVE:1	DERMS must have the control logic to enable curve-type functions to be applied to groups of DER
CURVE:2	Set DER Group Curve Function must allow DER groups to be set with the following different curve-type functions as defined in IEEE 1547. • Volt-Var • Watt-Var • Frequency-Watt • Volt-Watt • PowerFactor-Watt
CURVE:3	Curve functions for DER Groups may be called for any of the five modes of operation listed 1. Local Reference: In this mode, the curve settings that are sent to a DER Group are to be distributed as-is to all members of group. For example, the same volt-var curve could be set in all members of the group. 2. Single Point Reference – Even Distribution: This mode involves the identification of a single point of reference as the measurement point for the controlling-variable of the curve function. The DER Group is provided with the curve settings, along with the identification of a particular metering point on the power system that determines the controlling variable (horizontal axis) of the curve function for all DER in the Group. 3. Single Point Reference – Unspecified Distribution: This mode is similar to the previous even distribution one in that a single point of reference is specified. However, Mode 3 does not require or assume that the service provided is evenly distributed among the members of the group. Instead, Mode 3 requires only that the aggregate effect follows the specified curve. 4. Average Reference – Even Distribution: This mode is identical to the second mode (i.e., Single Point Reference – Even Distribution), except that the reference voltage is defined as the average of the local voltages of the members of the DER group. In this mode, the average voltage is to be determined by a simple average, not weighted by the size of the individual DER at each location. 5. Average Reference – Unspecified Distribution: This mode is identical to the third mode (i.e., Single Point Reference – Unspecified Distribution), except that the reference voltage is defined as the average of the local voltages of the members of the DER group. In this mode, the average voltage is to be determined by a simple average, not weighted by the size of the individual DER at each location.
CURVE:4	DERMS must ensure that it maintains the DER group output to meet the curve profile request for a specific schedule. This schedule is the time/date window for which this request is effective. This includes the start time/date and end time/date or duration.
CURVE:5	DERMS must have a configurable ramp time (time window in seconds) over which the DER in the group transitions to the new setting upon activation of the function
CURVE:6	When serving multiple upstream masters (e.g., DSO, TSO etc.) DERMS must have the capability to serve multiple functional requests based on priority-levels. A Priority parameter and the Requesting Entity ID should be included in the grid service request to invoke the prioritization scheme implemented in DERMS

Regulation Service Type Functions

Requirement No	Requirement
REGFXN:1	DERMS must have the capability to provide regulation type services to the system operator or the balancing authority
REGFXN:2	DERMS must be able to regulate power symmetrically in both positive and negative directions for bi-directional regulation or in just one polarity for up or down regulation services
REGFXN:3	DERMS must be able to provide regulation through a combination of baseline power (point of reference) and a regulation signal (bias signal) in both the directions. For unidirectional programs, the regulation signal is limited to be in only one direction
REGFXN:4	DERMS must be able to begin responding to the regulation commands (i.e., induce changes to DER output) within a certain amount of time, usually <4 s
REGFXN:5	DERMS must be able to ramp up/down DER output in response to the regulation commands at a specific ramp rate, configurable by the utility The range of possible ramp rates should span from 1 per unit changes in power instantaneously (<4 seconds) to 1 per unit change over 15 minutes

Manage Power at a Point of Reference

Requirement No	Requirement
MPPoR:1	DERMS managing a group of DER must have the necessary logic to hold, or limit, power to a specified level at a remote point of reference.
MPPoR:2	This is a more complex, higher-level function than the separately defined “Real Power Dispatch” and “Reactive Power Dispatch” functions in that this function tasks DERMS to: • Be aware of a measurement value at a remote point of reference, i.e., a measurement that typically cannot be determined by summing measurements from the DER within the group. • Make ongoing adjustments in order to maintain the remote measurement at the specified value.
MPPoR:3	This logic can be implemented on a group of similar or mixed type of DER technologies, according to the group makeup.
MPPoR:4	DERMS must be able to address two form of managing power at a point of reference • Hold: DERMS acts to maintain real or reactive power at the specified level • Limit: DERMS acts to limit real or reactive power at the specified level
MPPoR:5	DERMS must maintain operation of the DER group to meet the power dispatch request using a specific control strategy of choice.
MPPoR:6	DERMS must ensure that it manages power output at a point of reference from the DER group for a specific schedule. This schedule is the time/date window for which this request is effective. This includes the start date/time and either end date/time or duration specified by the service-requesting entity. DERMS must also have the capability to execute this function starting immediately and for indefinite durations.

Requirement No	Requirement
MPPoR:7	DERMS must be able to accept a live meter data stream either from the service-requesting entity or directly from a meter managing entity (e.g., SCADA or AMI system headend), assuming the relevant meter ID to reference is provided. The DERMS should poll the target meter source at the time interval specified by the service requesting entity.
MPPoR:8	DERMS must have a configurable ramp time (time window in seconds) over which the managed power is to be adjusted in response to this control action
MPPoR:9	When serving multiple upstream masters (e.g., DSO, TSO etc.) DERMS must have the capability to serve multiple functional requests based on priority-levels. A *Priority* parameter and the *Requesting Entity ID* should be included in the grid service request to invoke the prioritization scheme implemented in DERMS
MPPoR:10	DERMS must maintain operation of the DER group to meet the real/reactive power dispatch request using a specific control strategy of choice. Example strategies include but not limited to, • **Uniform Distribution in Watts (PGSPL/PGSPLA -UDW)** This method sets/limits the real power level, of each member of the DER group to the same power level to achieve the specified absolute power level or adjusted power level. • **Uniform Distribution by % of Nameplate (PGSPL/PGSPLA -UDP)** This method sets/limits the real power of each member of the DER group to the same percentage of its Nameplate capacity in order to achieve the specified absolute power level or adjusted power level for the group. • **Weighted Distribution in Watts (PGSPL/PGSPLA -WDW)** This method sets/limits the real power level of each member of the DER group based on weighting factors defined for each device, in order to achieve the specified absolute power level or adjusted power level for the DER group. • **Weighted Distribution by Percentage of Nameplate Capacity (PGSPL/PGSPLA -WDP)** This method sets/limits the real power of each device in the DER group to a % of its Nameplate capacity based on weighting factors defined for each device, in order to achieve the specified absolute power level or adjusted power level for the group. • **Priority-Based Dispatch (PGSPL/PGSPLA -PBD)** This method sets/limits the real power level of each member of the DER group based on a priority list, in order to achieve the specified absolute power level or adjusted power level for the DER group. In PBD, each DER is completely dispatched/curtailed before proceeding to the next one in the priority list. • **Economic Dispatch (PGSPL/PGSPLA -ED)** This method sets/limits the real power of each member of the DER group to achieve the specified absolute power level or adjusted power level from the DER group while minimizing the total economic impact (e.g., cost or price) across all individual devices constituting the group.

Cost-Related Functionalities

Receive Price for a DER Group Function

Requirement No	Requirement
RECPRC:1	DERMS must be able to receive price signals for use in different type of services/functions (e.g., providing a certain quantity of active power). This function is not a bid/offer mechanism but implies that such markets (or other price-determining mechanisms) exist. This function is then useful for subsequent dissemination of settled price signals to downstream DER group managing entities or for use in directly modifying DER group behavior in response to those prices.
RECPRC:2	Different types of services for which price must be received by DERMS and acted upon includes, real power production, real power consumption, capacitive reactive power, inductive reactive power etc.
RECPRC:3	DERMS must be able to receive and act upon the level of service provided (e.g., Watt output) and duration of the service that are required to be met in order for the price signal to be effective. For example, DERMS may be required to maintain a certain minimum output level for a certain duration in order to receive the indicated price
RECPRC:4	DERMS must ensure that it maintains the DER group output to meet the requested service for a specific schedule. This schedule is the time/date window for which this request is effective. This includes the start time/date and end time/date or duration.
RECPRC:5	DERMS must have the capability to be configured with a time over which a random delay is to be applied, following the start time, prior to the provided price signal(s) taking effect.

Provide Cost of Service Estimate

Requirement No	Requirement
CoS:1	DERMS must provide the cost of service (bid/offer) for a DER group to the upstream service requesting entity. This information could be, for example, provided prior to actionable services being requested from DERMS in order to aid in decision making In cases where the level of service cannot be directly estimated (e.g., where the service is to reduce usage of an HVAC system), DERMS will be capable of either providing the estimated behavior and a calculated baseline profile or providing sufficient model data for the requesting entity to calculate the baseline behavior based on prearranged methods.
CoS:2	Different types of services for which price must be received by DERMS and acted upon includes, active power production, active power consumption, reactive power injection, reactive power absorption, etc.
CoS:3	DERMS must be able to provide as part of its bid/offer the level of service provided (e.g., aggregate Watt output), duration, and maximum cost at which it is willing to participate.
CoS:4	In instances where an individual DER is unable to generate a cost of service for itself, the DERMS should be able to provide an estimate for it individually or as part of the DER group for which it is part. Considerations for this estimate should include energy and demand charge costs (if applicable) at the relevant node and time of day (if time-of-use rates are used), customer program participation payment costs, estimated degradation to the equipment (optional), and possibly others.
CoS:5	DERMS must provide as part of the bid/offer on the DER group output to meet the requested service for a specific schedule. This schedule is the time/date window for which this request is effective. This includes the start time/date and end time/date or duration.

Economic (or Similar) Optimization

Requirement No	Requirement
OPTIM:1	DERMS managing a group of DER must have the necessary logic to optimize dispatches based on configurable parameters
OPTIM:2	Parameters that a DERMS could be asked to optimize around could include the following: • Forecasted wholesale market spot prices • Cost of service from DER (see Requirement #4.4.2) • Estimated CO_2 impact • Customer comfort parameters • Induced degradation of equipment
OPTIM:3	Optimizations will be able to conform to constraints including the following: • Types of DER that can participate • Distribution grid constraints (specified by DER group) • Contractual participation limitations • Other maximum individual DER participation limits specified by the customer and/or utility
OPTIM:4	Parameter weightings and constraint prioritizations (in the event that one or more must be violated to arrive at a feasible solution) should be customizable and user configurable.

DER Registration and Grid Service Program Management

Manage DER Participation Constraints[10]

Requirement No	Requirement
PRTCON:1	DERMS must be able to configure DER operational constraints including resource availability which can be driven by asset owner dispatch restrictions or by asset performance (e.g., if the state of charge of a battery is below dispatch limits). Additional operational constraints include ambient temperature limits and contractual obligations for the operation of a resource.
PRTCON:2	DERMS must be able to configure DER contractual constraints including concepts involving the number of times a DER can be recruited (or called upon) within a season, or the total number of hours that a DER can be used within the contract period, or the number of allowable charge/discharge cycles for ES etc. Constraints involved in service-level agreements (SLAs) would typically be related to the contractual class of constraints. Contractual constraints exist due to contract obligations and are largely driven in the customer/asset recruitment process. It is envisioned that service level agreements (SLAs) which represent a specific performance of the asset, e.g., nameplate registration and performance, would also fall into this class of constraints, as the DER owner or contractee is obligated under the terms of the SLA. DERMS must be configurable to customize DER event participation levels (capacity) for each customer based on their equipment (e.g., Energy storage, controllable loads etc.) and preferences within each DER event type.
PRTCON:3	DERMS must be able to configure DER electrical constraints including parameters associated with charging, discharging, ramp rates, throttling limits, etc.
PRTCON:4	DERMS must be able to configure DER temporal constraints include limitations on operations, such as generators only being able to be dispatched between the hours of 8 a.m. to 5 p.m., M-F.
PRTCON:5	DERMS must be able to configure DER economic constraints that are generally determined through economic analysis such that if operation results in positive net revenue, then the unit is recruited; if operation would result in a loss then the unit is removed from the availability pool.
PRTCON:6	Operational, electrical, and temporal considerations are the primary constraints and are required in some form to safely operate an asset
PRTCON:7	DERMS must provide the ability for end-use customers to submit changes to program enrollment information
PRTCON:8	DERMS must notify the operator during scheduling if they cannot schedule an event due to program constraints. This could happen when the DER is assigned program specific rules that prevents it from being scheduled for other types of services through DERMS.
PRTCON:9	DERMS must notify the operator if a previously scheduled event can no longer run due to a change in system status
PRTCON:10	DERMS must allow end-use customers to opt-out of DER programs unless they are under a DER interconnection agreement or other contractual business relationship that mandates their participation

[10] *Adapted from PG&E DISTRIBUTED ENERGY RESOURCE MANAGEMENT SYSTEM (DERMS) RFP for DISTRIBUTED ENERGY (DG) Enablement, REQUEST FOR PROPOSAL No. 52150*

Requirement No	Requirement
PRTCON:11	DERMS must allow configuration and tracking of end-use customer participation limits based on the program in cumulative power limits
PRTCON:12	DERMS must allow tracking of compliance to constraints, and reporting

DER Registration (Provisioning) Attributes in DERMS

<table>
<tr><th>Requirement No</th><th>Requirement</th></tr>
<tr><td>REGIST:1</td><td>DERMS should be able to receive the information specified in Table 4-11 either from manual user interface fields or through data exchanges with integrated sources such as GISs or CISs.

Table 4-13
DER Registration (Provisioning) Attributes

<table>
<tr><th>Attribute</th></tr>
<tr><td>Interconnection Date: Date DER was added to the system</td></tr>
<tr><td>Owner: Business or individual name of the DER owner</td></tr>
<tr><td>Physical/ Street Address: Physical /mailing address of the DER</td></tr>
<tr><td>Point of Connection: Identification of the unique node(s) in the power system to which the DER is connected</td></tr>
<tr><td>DER Type: Solar PV, Battery storage, etc. A list of types, including combination DERs</td></tr>
<tr><td>Additional DER descriptors (could be included in DER Type) For example, for PV, DC:AC ratio, azimuth, tilt, tracking type.</td></tr>
<tr><td>Active power rating at unity PF: Active power rating (Watts)</td></tr>
<tr><td>Active power rating at overexcited PF: The active power rating when at the specified overexcited power factor as described in IEEE 1547-2018</td></tr>
<tr><td>Specified over-excited PF: Power factor at which the as described in IEEE 1547-2018</td></tr>
<tr><td>Active power rating at under-excited PF: The active power rating when at the specified under-excited power factor as described in IEEE 1547-2018</td></tr>
<tr><td>Specified under-excited PF: Under-excited power factor as described in IEEE 1547-2018</td></tr>
<tr><td>Apparent power rating: Maximum apparent power rating in volt-amperes</td></tr>
<tr><td>Normal operating performance category: Indication of reactive power and voltage/power control capability. Category A/B</td></tr>
<tr><td>Abnormal operating performance category: Indication of voltage and frequency ride-through capability Cat I, II, or III.</td></tr>
<tr><td>Reactive power injected maximum rating: Maximum injected reactive power rating in vars</td></tr>
<tr><td>Reactive power absorbed maximum rating: Maximum absorbed reactive power rating in vars</td></tr>
</table>
</td></tr>
</table>

Requirement No	Requirement
REGIST:1 (continued)	**Table 4-13 (continued)** **DER Registration (Provisioning) Attributes**

Attribute
Active power charge maximum rating: Maximum active power charge rating in watts
Apparent power charge maximum rating: Maximum apparent power charge rating in voltamperes. May differ from the apparent power maximum rating
AC voltage nominal rating: Nominal AC voltage rating in RMS volts
AC voltage maximum rating: Maximum AC voltage rating in RMS volts
AC voltage minimum rating: Minimum AC voltage rating in RMS volts
Reactive susceptance that remains connected to the Area EPS in the cease to energize and trip state: Reactive susceptance that remains connected to the Area EPS in the cease to energize and trip state
Manufacturer
Model
Serial Number
Version
Constant Power Factor Control: Indication of whether this DER supports power factor control
Volt-Var Control: Indication of whether this DER supports Volt-Var control
Watt-Var Control: Indication of whether this DER supports Watt-Var control
Constant Var Control: Indication of whether this DER supports Constant Var control
Volt-Watt Control: Indication of whether this DER supports Volt-Watt control
Frequency Droop Control: Indication of whether this DER supports Frequency Droop control
Remote Cease Energize and Trip Control: Indication of whether this DER supports Cease to Energize and Trip control
Adjustable Max Active Power Control: Indication of whether this DER supports Adjustable Max Active Power control
Voltage Trip and Momentary Cessation Configurability: Indication of whether this DER's voltage trip and ride-through characteristics can be adjusted
Frequency Trip Configurability: Indication of whether this DER's frequency trip and ride-through characteristics can be adjusted
Enter-Service Parameters Configurability: Indication of whether this DER's enter-service parameters can be adjusted.
Dispatched Charge/Discharge Control: Indication of whether this DER supports adjustable/dispatch- able charge/discharge control

<table>
<tr><th>Requirement No</th><th>Requirement</th></tr>
<tr><td>REGIST:1 (continued)</td><td>
Table 4-13 (continued)
DER Registration (Provisioning) Attributes
<table>
<tr><th>Attribute</th></tr>
<tr><td>SunSpec Modbus Support: Indication of as-deployed support: Yes/No, version, and port type(s) (Ethernet or RS-485)</td></tr>
<tr><td>DNP3 Support: Indication of as-deployed support: Yes/No, version, and port type(s) (Ethernet or RS-485)</td></tr>
<tr><td>2030.5 Support Indication of as-deployed support: Yes/No, version, and port type(s) (Ethernet or RS-485)</td></tr>
<tr><td>Vendor proprietary protocol Support: Indication of as-deployed support: Yes/No, version, and port type(s) (Ethernet or RS-485)</td></tr>
<tr><td>Communication Lock/Unlock: DER locks comm port? Yes/No. If so, unlock mechanism, duration, and password</td></tr>
<tr><td>Aggregator Name: Identifier of the entity through which a DER is reached, if not direct.</td></tr>
<tr><td>Communication Address(es): Description of how to signal and reach DER via communication networks</td></tr>
<tr><td>Constant Power Factor Control Settings: Constant PF Mode Enable, PF Value, Excitation</td></tr>
<tr><td>Volt-Var Control Settings: Volt-var Mode Enable, V_{ref}, V_{ref} adjustment enable, V_{ref} adjustment time constant, V/Q Curve points, Open loop response time</td></tr>
<tr><td>Watt-Var Control Settings: Watt-var Mode Enable, P/Q Curve points</td></tr>
<tr><td>Constant Var Control Settings: Constant Var Control Mode Enable, Constant reactive power setting.</td></tr>
<tr><td>Volt-Watt Control Settings: Volt-Watt Mode Enable, V/P Curve points, Open loop response time</td></tr>
<tr><td>Frequency Droop Control Settings: Over-frequency deadband and droop slope, underfrequency deadband and droop slope, open loop response time</td></tr>
<tr><td>Remote Cease to Energize and Trip Control Settings: Uses the “permit service” bit in the “Enter Service Settings” function</td></tr>
<tr><td>Adjustable Max Active Power Control Settings: Limit active power enable, maximum active power</td></tr>
<tr><td>Enter Service Settings: Permit service, ES Voltage high, ES Voltage low, ES Freq high, ES Freq low, ES Delay, ES Randomized Delay, ES Ramp Rate</td></tr>
</table>
</td></tr>
<tr><td>REGIST:2</td><td>DERMS must be able to store the information specified in Table 4-11 and retrieve it upon request</td></tr>
<tr><td>REGIST:3</td><td>Properties/attributes specified in Table 4-11 must be able to be updated/overwritten</td></tr>
</table>

Operating and Hosting Requirements

Historian, Database, Analytics, and Storage Requirements

<table>
<tr><th>Requirement No</th><th>Requirement</th></tr>
<tr><td>HISTDB:1</td><td>All monitored data, settings, and errors configured to be recorded during DERMS operation (see examples in Table 4-13) must be logged with time stamps
Table 4-14
Example types of data to be logged
<table><tr><th>Data Type</th></tr><tr><td>Monitored data from DER and DER groups</td></tr><tr><td>Control commands, settings, and/or schedules sent to DER</td></tr><tr><td>Forecasted data from DER/DER groups</td></tr><tr><td>Cancelled commands/settings/schedules</td></tr><tr><td>DER nameplate and registration data (as in Table 4-11)</td></tr><tr><td>DER constraints</td></tr><tr><td>DER/DERMS firmware versions</td></tr><tr><td>DERMS user login/logouts (for access control accountability)</td></tr></table></td></tr>
<tr><td>HISTDB:2</td><td>All events from the DER and DERMS must be logged with a time stamps, event type ID (the unique identifier of the event type) and event specific parameters (information relevant to the specific type of event)
Table 4-15
Example types of events to be logged
<table><tr><th>Event Type</th></tr><tr><td>Errors/alarms (either in DERMS or DER)</td></tr><tr><td>Instances of DER constraint violations</td></tr><tr><td>User interface (UI) launch failures</td></tr><tr><td>Communication to DER lost or restored. and signals specific to the protocol (e.g., DNP3, Modbus etc.)</td></tr><tr><td>DER/customer event overrides</td></tr><tr><td>Changes to customer/DER participation preferences</td></tr><tr><td>Scheduled events (e.g., active power limiting, active/reactive power dispatch etc.)</td></tr><tr><td>Scheduled events that failed to execute or were cancelled</td></tr><tr><td>DER or DERMS firmware update</td></tr><tr><td>Evidence of DER/gateway/enclosure being opened/tampered with (e.g., unexpected communication on DER interface)</td></tr><tr><td>Unexpected DER settings change</td></tr></table></td></tr>
</table>

Requirement No	Requirement
HISTDB:3	Logged information must be archived at the rate defined by the DERMS user (e.g., daily, weekly, monthly etc.)
HISTDB:4	Archived information must be retrievable from the database by the DERMS user as needed
HISTDB:5	Log entries must be categorized based on the severity level of the information Informational data such as enabling or disabling a Volt/VAR curve Warning data – anomalies from which the software can automatically recover Error data – problems that needs to be addressed but the DERMS software continues to run. Not as serious as fatal Fatal – this needs intervention as it means a serious error in the execution of the application Trace – used by developers of the software to debug the execution sequence of the software
HISTDB:6	DERMS should be able to selectively log data based on user-configurable, pre-defined rules (e.g., State of Charge of an ES reaching 10%, PV output drops by 40% within 2 minutes, etc.)
HISTDB:7	DERMS user must be able to retrieve data without disturbing logging and archiving of other data simultaneously
HISTDB:8	Logged data retrieval must be allowed for users based on access levels
HISTDB:9	DERMS should be able to be integrated with external database management systems (e.g., pi)
HISTDB:10	DBMS associated with DERMS must be capable of logging information for more than 5 years
HISTDB:11	DERMS user based on the access level must have privileges to configure logging data. Configuring data can mean (1) setting pre-defined rules for logging (2) specifying logging data based on severity levels (e.g., only error and fata severity levels shall be logged and not types) (3) location of log files etc.
HISTDB:12	DERMS must allow multiple users to configure logging data, each based on user privileges Configuring data can mean (1) setting pre-defined rules/filters for logging (2) specifying logging qualification based on severity levels (e.g., only error and fatal severity levels shall be logged and not types) (3) specifying location of log files

Software Updates and Version Control

Requirement No	Requirement
SOFTUP:1	DERMS must have the ability to track and report the versions of deployed software components.
SOFTUP:2	DERMS must have the ability to deploy software updates to live production systems to ensure there is no down-time.
SOFTUP:3	DERMS must have the ability to manage roll-back of software updates ensuring no down-time.
SOFTUP:4	DERMS must have the ability to manage updates to software configurations
SOFTUP:5	[Additional requirements to be filled in based on utility-specific IT practices]

Software Resource Monitoring

Requirement No	Requirement
RESOU:1	DERMS must have the ability to report status of software, e.g., running or stopped.
RESOU:2	DERMS must have the ability to report application-based resource utilization.
RESOU:3	DERMS must have the ability to display software characteristics, including CPU utilization and memory allocation.
RESOU:4	DERMS must have the ability to set software performance thresholds, for example: application x running 100% CPU for 10 minutes.
RESOU:5	DERMS must have the ability to produce, send, and manage alerts regarding software performance that violates thresholds.
RESOU:6	[Additional requirements to be filled in based on utility-specific IT preferences]

Scale and Performance Requirements

Requirement No	Requirement
PERF:1	DERMS must be able to support connectivity and management of X# of individual DER [utility to specify based on expected needs]
PERF:2	DERMS must be able to support connectivity and management of X# of DER groups [utility to specify based on expected needs]
PERF:3	DERMS must be able to establish control over a DER upon restoration of connectivity within 10 seconds.

User Roles Management[11]

<table>
<tr><th>Requirement No</th><th>Requirement</th></tr>
<tr><td>USERS:1</td><td>DERMS should be set up with different roles/profiles to allow different users access to different levels of information within DERMS. The following is a suggested taxonomy of roles with suggested responsibilities. The roles and associated responsibilities are not meant to be prescriptive but are provided for guidance on separation of actions that users will have to make within the system. In all cases, roles can be manual (e.g., human roles), and in advanced functionality cases, users/roles may be automated

Table 4-16
User roles with their anticipated scope

<table>
<tr><th>Role</th></tr>
<tr><td>Architect: The Architect role is the system creator and maintainer including configuration of DER. The Architect role is a primary role – the actions of other personnel depend on the data created/entered by this role.</td></tr>
<tr><td>Operator: The Operator role belongs to the DER aggregation supervisor. Once the Architect has created the system, the operator is responsible for the day-to-day operations of the DERMS.</td></tr>
<tr><td>Maintainer: The Maintainer role has the ability to perform a comprehensive maintenance test on assets to determine their status and whether or not they meet the required specifications to be included in the DERMS resource pool.</td></tr>
<tr><td>Executive: The Executive role is a read-only or observer role that uses much of the display and reporting functions of the DERMS.</td></tr>
</table>
</td></tr>
</table>

[11] *Adapted from PG&E DISTRIBUTED ENERGY RESOURCE MANAGEMENT SYSTEM (DERMS) RFP for DISTRIBUTED ENERGY (DG) Enablement, REQUEST FOR PROPOSAL No. 52150*

DERMS Cybersecurity Requirements

Communications Security

Requirement No	Requirement
CS-CS.1	A baseline of expected network data exchanges, including protocol, port, source, and destination information, between DERMS and other systems is documented.
CS-CS.2	DERMS shall have the ability to logically segment communications (e.g., dedicated VLANs, dedicated physical or logical ports, dedicated IP addresses) for different network segments which server a unique functional purpose (e.g., administrative network, interfaces to DMS, interfaces to DMS, etc.) These segmentations should include, at minimum: Ability to logically segment internal communications (e.g., DMS interfaces, etc.) from external communications (e.g., Internet, Aggregator DERMS, etc.) Ability to logically segment administrative communications from other communications where possible.
CS-CS.3	DERMS shall support an internal firewall policy to explicitly filter traffic based on protocols, ports, source, and destination to protect against unnecessary traffic which do not serve a functional purpose for the expected operations of the system.
CS-CS.4	Unused services, logical ports, and physical ports are disabled.
CS-CS.5	Role-based access control (RBAC) methods should be used to determine whether a system or user, attempting to communicate with DERMS, is authorized for viewing, reading, writing, creating, or deleting DERMS data or functions.
CS-CS.6	Communication sessions to and from DERMS is logged with metadata information, including timestamps, source, destination, protocols, and ports.
CS-CS.7	Alerts and logs are produced in scenarios where expected time-sensitive data is not received by DERMS.
CS-CS.8	For telecontrol traffic which uses TCP/IP, the DERMS supports security requirements, including confidentiality, integrity protection, and message-level authentication, as specified by IEC 62351-3.
CS-CS.9	DERMS shall have the ability to support the latest state-of-the-art cryptographic protocols, such as newer versions of TLS, and encryption standards, as they become available and supported by interfacing systems.
CS-CS.10	Data-in-transit particularly for administrative traffic, supports cryptographic key management, as specified by IEC 62351-9. Key management functions should include: Methods to generate X.509 public-key certificates and associated cryptographic keys to provide DERMS identification and authentication to interfacing systems. Ability to use certificates signed by the utility or a designated, trusted root certificate authority (CA). Methods to check the status of certificates of interfacing systems (e.g., Online Certificate Status Protocol (OCSP)). Methods to either blacklist or whitelist certificates (e.g., certificate revocation lists (CRLs)) of interfacing systems.
CS-CS.11	Private keys are securely stored through a dedicated security chip, such as a Trusted Platform Module, to prevent from exfiltration or tampering.

Requirement No	Requirement
CS-CS.12	Only DER communication protocols which natively support authentication, authorization, data integrity, and confidentiality at the application layer, such as IEC 61850, Secure Authentication versions (e.g., SA v5 or v6) of IEEE 1815/DNP3, and IEEE 2030.5/SEP2. Protocols which do not natively support these features at the application layer, such as SunSpec Modbus, should not be used for external telecontrol communications unless supported through bump-in-the-wire methods, such as TLS wrappers.
CS-CS.13	For IEEE 1815/DNP3, IEC 61850, IEEE 2030.5, or any other DER, SCADA, or telecontrol protocol, the DERMS has passed security related checks under Conformance Testing procedures to ensure the proper implementation of authentication, integrity checking, device enrollment, key management, and access control list (ACL) features according to the respective communication protocol specification.

Access Control

Requirement No	Requirement
CS-AC.1	Users, whether locally or remotely, are authenticated with user identification (username) and password combination before electronic access is granted. Interfacing systems should also be authenticated though either certificates, tokens, IP-address whitelists, or any other mechanisms that proves identity of the system before being granted electronic access.
CS-AC.2	Users, which have privileged access, such as administrators, must be required to use multi-factor authentication, where additional authentication methods, such as access cards, biometric scan, device tokens, etc. are used in addition to passwords.
CS-AC.3	User password should require: At least 8 characters in length. At least one uppercase and one lower case letters At least one number At least one non-alphanumeric characters (e.g., &, %, $, *, etc.) Additionally, the following password enforcement policies should be supported: At password creation, any violation to the above specifications should fail and require the user to submit a new password which follows required password specifications. Passwords or security tokens should not be displayed in plaintext. Default passwords are removed from the system prior to installation and production. The system should have the ability to determine the lifetime of a password before it expires and requires renewal. Renewed passwords should not be identical or similar to recently used passwords.
CS-AC.4	The system should have a configurable time of inactivity where users are automatically logged out of the systems once the time threshold is met.
CS-AC.5	The system supports methods to add, remove, and update user and system accounts and is able to assign these accounts to roles.
CS-AC.6	The system supports role-based access control, where users and systems are assigned to one or more roles which have the privileges necessary to perform their expected job functions. These privileges for read, write, delete, or create to a data element or execute for an application or function, are defined through access control lists (ACLs) where privileges are mapped and configurable to roles.

Requirement No	Requirement
CS-AC.7	Upon request to perform a privilege to a DERMS resource, the system must first check for successful authentication and if ACLs contains the required authorizations before granting access to the system or user. If authentication or authorization checks fail, the system denies-by-default access to the resource.
CS-AC.8	All user and system actions are logged and time-stamped, such that events can be correlated to other events and audited. Changes to roles, ACLs, and user/system accounts must also be logged and time stamped.

Security Monitoring and Audit

Requirement No	Requirement
CS-SMA.1	Security related events are logged and timestamped. Security logs should include: • Changes to user and system privileges, including roles and ACLs • Successful and unsuccessful login attempts • Use of administrative privileges and functions • Failure to log an event • Detection of malicious code • Installation of firmware, software, or drivers • Other indicators of compromised systems monitored by the utility's security operations centers
CS-SMA.2	The system has the ability to send logs to a centralized Security Information and Event Management System (SIEM) or a log aggregator.
CS-SMA.3	The system's storage is able to retain logs for the utility's specified period of time defined by its security policies or compliance requirements. System alarms or warnings are produced if logs are about to exceed storage capacities.
CS-SMA.4	Modification or deletion of logs should be explicitly prohibited. Insertion of security logs should be restricted to only a need to provide supplemental information and must be restricted to only authorized users.
CS-SMA.5	Configuration changes to critical functions of DERMS should be logged, timestamped, and indicate users or systems which have executed the change. Configuration changes that must be logged should include, but not be limited to: Constraint Parameters, including locations, line loading and voltage limits, etc. Constraint Allocation Methods Formulas to perform constraint calculations DER Group Management Methods DER Control Methods DER Group Dispatch Algorithms

Patch and Vulnerability Management

Requirement No	Requirement
CS-PVM.1	Discovered vulnerabilities to the system's operating system or software should be patched as soon as possible to minimize attack windows. The DERMS vendors should have a patch management and disclosure program to advise utilities of vulnerabilities that impacts its products and to test and distribute required security patches. The vendor has documented approaches to apply patches to ensure seamless operation and availability of DERMS during updates.
CS-PVM.2	A test DERMS system is available to allow for the safe testing of patches before they are applied to production DERMS systems.
CS-PVM.3	The authenticity of patches is verified through digital signatures before they are applied.
CS-PVM.4	The DERMS system is able to undergo vulnerability scanning, including credentialed scanning, with minimal disruption to operational functions or availability.

System Availability and Business Continuity

Requirement No	Requirement
CS-SABC.1	The system supports heartbeat checks from health monitoring systems and standby systems to ensure that critical functions are available.
CS-SABC.2	In the event of a heartbeat check failure, a standby DERMS system is available to seamlessly takeover operations from the primary DERMS system. Once the primary DERMS system is available, the standby DERMS system is able to hand back over operations to the primary system.
CS-SABC.3	Snapshots of the DERMS system and its configurations are periodically updated and securely stored offsite.
CS-SABC.4	The DERMS system automatically sends backups of all its databases, software applications, and OS data to a secure backup storage site.

Supply-chain Risk Management and Security Assessment

Requirement No	Requirement
CS-SCRM.1	The system and its software have been developed using an established secure development life cycle (SDLC) and has undergone independent penetration testing. Results of penetration testing define criticality ratings of identified vulnerabilities and a timeline for resolution. Penetration tests should include, but not be limited to: • Input validation • Code analysis • Race conditions • Privilege escalation • Denial-of-service attacks • Exposed logical and physical ports • Data input fuzzing • Physical tampering • Misconfiguration or insecure default settings • Password cracking • Operating System Vulnerabilities • Certificate validation processes – revocation, update, OCSP, etc.
CS-SCRM.2	The system should be designed to monitor and reject invalid data inputs through parameter setting limit restrictions, that if exceeded, could lead to physical equipment damage or reduced safety.
CS-SCRM.3	The system should be designed to monitor critical system health status checkpoints and upon detection of internal failures, may switch to a default state.
CS-SCRM.4	The DERMS vendor should perform security testing of all hardware components and software libraries used by the system and ensure components are free of vulnerabilities prior to sale of the system.

Alarm Management and Configuration

Requirement No	Requirement
ALARM:1	All alarms must be logged with a time stamps, alarm definitions, and alarm specific parameters (information relevant to the specific type of alarm)
ALARM:2	The list of potential alarm conditions may include most events specified in Table 4-13. In other words, a given condition may be logged, may generate an alarm, both, or neither; and this decision should be user configurable for each event type.
ALARM:3	Alarm functionality shall be configurable to establish filters that limit the frequency and quantity with which the same alarm may be triggered. For example, it may desirable that a noisy or faulty DER gateway cabinet door switch only generate one alarm per day rather than stream the same alarm continuously. To achieve this, the alarm configuration shall include for each alarm type a configurable “Minimum Time Between Alarm” parameter that is configurable from 0 sec (no limit) to 86,400 seconds

Requirement No	Requirement
ALARM:4	Alarm log entries must be categorized based on the severity level of the information • Informational data such as enabling or disabling a Volt/var curve • Warning data – anomalies from which the software can automatically recover • Error data – problems that need to be addressed but the DERMS software continues to run; not as serious as fatal • Fatal – this needs intervention as it means a serious error in the execution of the application • Trace – used by developers of the software to debug the execution sequence of the software
ALARM:5	Alarms must be visible through a UI and communicated to utility systems (e.g., ADMS) [utility to specify which]

Miscellaneous Requirements and Expectations

RFP Process Timeline [left blank for the utility to specify]

Task	Estimated Completion Date
Notification of RFP	
Intent to Bid and NDA Submittal	
Issue RFP	
Pre-Bid Meeting	
RFP Question Period Ends	
RFP Q&A Published	
Proposals Due	
Vendor software demonstration	
Vendor selection	
Go-Live Date	

DERMS Supporting Services – Installation, Maintenance, and Training

[left blank for the utility to specify]

Other Requirements

[left blank for the utility to specify any additional requirements not yet addressed above]

DERMS Testing Requirements Placeholder

DERMS should be expected to demonstrate capabilities described in selected requirements above during acceptance testing. A test requirements document is available as a separate EPRI deliverable here.

About EPRI

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