DER Group Management Functions

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Ajit Renjit
Technical Leader - DERMS
EPRI
Framing the discussion: DER Devices are Ready

- UL 1741SA products available now, IEEE 1547.1 products ~ 1-yr out
- UL 1741SA (published) IEEE 1547.1 (in process)
- IEEE 1547-2018 and regional codes like CA Rule 21 and Hawaii Rule 14H
- Multiple available: SunSpec, DNP3, 2030.5, 61850-8-2
- Based on IEC 61850-7-420 / 61850-7-520

Common Functions for Smart DER

- Standard Device Communication Interfaces and Protocols
- Grid Codes
- Test Procedures
- Certification
What is DER Group Management?

- Volt-Var Function
- Power Factor Control
- Frequency-Watt Function
- Dynamic Reactive Current
- Ramp Rate Control
- Maximum Power Limiting
- Voltage Ride-Through
- Frequency Ride-Through
- Charge/Discharge Management
- Load and Generation Following

Device Connectivity

- Sensors, Switches, Capacitors, Regulators
- Solar
- Battery
- PEV
- Load

Device-Level Standards & Connectivity

IEC 61850 Standard
Communication Protocols
Grid Codes
Common Function for Smart Inverters
2008 - 2012
DER (common DER grid-supportive functions)
What is DER Group Management?

Need for DER Group Management Functions

- **Aggregate**: Express DER capabilities as manageable resources aligned with the grid configuration (aggregation by substation, feeder, transformer, etc.)
- **Simplify**: Functions at individual inverters are not relevant to the higher level goals of distribution system management.
- **Optimize**: Manage DER members in a group the optimal way, saving cost, reducing wear, and optimizing asset value.
- **Translate**: Speak the language spoken by the DER and present to the upstream calling entity in a cohesive way.
What is DER Group Management?

2008 - 2012

Sensors, Switches, Capacitors, Regulators

SOLAR  BATTERY  PEV  LOAD

DER (common DER grid-supportive functions)

2013 - 2017

Utility Applications

Integration

DERMS

DMS  MDMS  GIS  Markets

Device Connectivity

DMS  MDMS  OMS

Utility Applications

GIS

Integration

AMs
Need for DER Group Management Functions

Device-Oriented Functions are Ready

- Many individual devices
- Complex settings
- DER-type-specific interactions

Grid-Oriented Services are Needed

- Grid-aligned DER services
- Simple control actions
- Energy-centric interactions

DERMS
# DER Group vs Device Level Functions

**DER Group Level Interface** — DERMS

**DER Device Level Interface**

## Attribute

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Group-Level Interface</th>
<th>Device-Level Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Connections</strong></td>
<td>Groups may be fewer in quantity</td>
<td>The number of individual DER is likely to be large</td>
</tr>
<tr>
<td><strong>Frequency of Interactions</strong></td>
<td>Group-level interactions may be less frequent.</td>
<td>At the device-level, interactions may happen frequently.</td>
</tr>
<tr>
<td><strong>Device-Type Awareness</strong></td>
<td>Group-level services are energy and grid-centric agnostic of the type of downstream DERs</td>
<td>Device-settings oriented. Function commands are described in a way that tells devices exactly what to do</td>
</tr>
<tr>
<td><strong>Function Complexity</strong></td>
<td>Group-level services are simple in nature.</td>
<td>Grid support functions at the device-level can be complex and involve a wide range of settings.</td>
</tr>
</tbody>
</table>

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**Upstream DER Service Requesting Entity** (e.g. Utility, DERMS, DMS)

**DERMS**

**DER Device Level Interface**
DER Group vs Device Level Functions

**DER Group Level**
- DER Group Status Monitoring
- DER Group Real Power Dispatch
- DER Group Reactive Power Dispatch
- DER Group Voltage Regulation Function
- DER Group Maximum Real Power Limiting
- DER Group Ramp Rate Limit Control
- DER Group Phase Balance Limiting
- Set DER Group Curve Functions
- Provide Price to DER Group
- Manage Power at a Point of Reference
- Connect/Disconnect DER Group

**DER Device Level**
- Status Monitoring Points
- Limit DER Power Output Function
- Fixed Power Factor Function
- Volt-Var Function
- Watt-Var Function
- Volt-Watt Function
- Frequency-Watt Function
- Low/High Voltage Ride-Through Function
- Low/High Frequency Ride-Through Function
- Connect/Disconnect Function
Common Functions for DER Group Management
Architectural Extensibility Provided by DER Group Management Functions
### Communication Protocols for DER Group Management

#### Standard Information Model

- **IEC 61968-5 (CIM for DER)**
- **IEC 61850-7-420**

#### Standard Device Communication Interfaces and Protocols

| UCAI Users Group, CIM for DER certification and listing. | • IEEE 1547.1  
| • UL1741SA  
| • SunSpec Alliance |
| UCAI Users Group, CIM for DER compliance testing | • IEEE 1547.1  
| • UL1741SA  
| • SunSpec Alliance |
| Not Applicable | • Multiple worldwide, unique by region  
| | • IEEE 1547-2018 (specific set)  
| | • CA Rule 21 (specific set) |
| • IEC 61968-100-2013  
| • Multispeak 5.0  
| • OpenFMB  
| • OpenADR (mapping considered)  
| • IEEE 2030.5 (mapping considered) | • SunSpec Modbus  
| • DNP3 AN2013-001, AN2018-001  
| • IEEE 2030.5  
| • IEC 61850-8-2 |
| IEC 61968-5 | IEC 61850-7-420 |

#### Test Procedures

- **IEEE 1547.1**
- **UL1741SA**
- **SunSpec Alliance**

#### Certification

- **UCAI Users Group, CIM for DER certification and listing.**
- **IEEE 1547.1**
- **UL1741SA**
- **SunSpec Alliance**

#### Grid Codes

- **Multiple worldwide, unique by region**
- **IEEE 1547-2018 (specific set)**
- **CA Rule 21 (specific set)**
New Industry Wide Interest Group: DER Aggregations/Group Management for Coordinated T&D Interface Operations

Scope

- Group-level interfaces
- Individual DER interfaces

Focus

1. DER Service Requesting Entity
2. DER Service Providing Entity
3. DER Devices or Downstream Aggregations

Approach

- Weekly meetings: every Tuesday, 1p-2p ET, 10a-11a PT, 7p-8p CET
- Collaborative, incremental learning and specification of gaps, use cases, functions

Background and Context

- Initiative started in 2012
- Open forum, diverse stakeholders, consensus
- Outputs codified in national and international standards, e.g., IEC CIM 61968-5
- Methods developed thus far have been implemented, tested, and certified in test events and workshops
- Latest report “Common Functions for DER Group Management, 3rd Edition”
  - Still lacking in regard to the TSO/DSO interface
EPRI DERMS Activities

Research Initiatives

- DERMS Working Group
  - 2018: Reference Control Methods for Group-to-Device Interactions
  - 2019: Update to DER Group Management Functions
- DERMS Utility Interest Group
- DERMS Reference RFP for Utilities
- DERMS Testbed & Integration Platform
- Evaluation of DERMS Architecture: Centralized vs Decentralized
- Value of DERMS: Active & Reactive Power Management of DER

Active Projects

- PECO Integrated ADMS/DERMS/Microgrid Project (DOE)
- Tucson Electric Power DERMS Interoperability Demonstration Project
- HydroOne DERMS for Dynamic Management of DER
- DOE ENERGISE (NREL, EPRI, Schneider, Varentec, Xcel Energy, Austin Energy)
List of DERMS Related Public References

Thank You
Back-up Slides
DER Registration

Requesting Entity
e.g., DMS/GIS

Providing Entity
e.g., GIS/DER

1. Owner, Lifecycle and Integration Information
2. General DER Nameplate Characteristics
3. DER As-Configured Information
4. DER Control Function Characteristics
5. DER Abnormal Condition Characteristics
6. DER Communication Characteristics

Enterprise Integration

MDMS  OMS  WMS

DMS  GIS (or other system of record)  DERMS

Meters, Switches, Capacitors, Regulators

Initial Discovery or Entry of DER Capabilities

Subsequent Sharing of DER Capabilities

SOLAR  BATTERY  PEV
DER Group Setup

Creating DER Group
- Requesting Entity
  - e.g., DERMS/DMS

Create DER Group (Unique Group Name, List of Members)
- Group Created (Unique Group Name)
- Group Not Created (Reason Why)

Modify DER Group (Unique Group Name)
- What DER Groups Do you Have?
- Who are the Members of this DER Group (Unique Group Name)
- What is the current version/revision of this DER Group?

Providing Entity
- e.g., DERMS

Diagram:
- Utility
- DERMS
- DERMS
DER Group Setup

Requesting Entity
e.g., DERMS/DMS

- Create DER Group (Unique Group Name, List of Members)
  - Group Created (Unique Group Name)
  - Group Not Created (Reason Why)

Providing Entity
e.g., DERMS

- Modify DER Group (Unique Group Name)
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<th>Type</th>
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<th>kW</th>
<th>kVar</th>
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</table>
DER Group Setup – DER Group Creation

Other Grouping Methods
- By DER Circuit Phase
- By DER Owner
- By Program Enrollment
- By Customer Class
- By Zipcode etc.
DER Group Monitoring, Capabilities, Status

What Functions Can this Group Provide (Unique Group Name)

Services List and Scale

<table>
<thead>
<tr>
<th>DER Group Service/Function Number</th>
<th>DER Group Service/Function Name</th>
<th>Parameters Describing Capability for this Service or Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DER Group Status Monitoring</td>
<td>List of monitorable parameters</td>
</tr>
<tr>
<td>2</td>
<td>DER Group Forecasting</td>
<td>List of parameters for which forecasting is available</td>
</tr>
<tr>
<td>3</td>
<td>DER Group Historical Interval Meter Data</td>
<td>List of metered parameters for which interval data is available</td>
</tr>
<tr>
<td>4</td>
<td>Real Power Dispatch</td>
<td>Max Real Power (W), Min Real Power (W)</td>
</tr>
<tr>
<td>5</td>
<td>Reactive Power Dispatch</td>
<td>Max Reactive Power (W), Min Reactive Power (W)</td>
</tr>
<tr>
<td>6</td>
<td>DER Group Maximum Real Power Limiting</td>
<td>Range over which real power can be limited.</td>
</tr>
<tr>
<td>7</td>
<td>DER Group Ramp Rate Control</td>
<td>Range of ramp rate adjustability</td>
</tr>
<tr>
<td>8</td>
<td>DER Group Voltage Regulation</td>
<td>Range of voltage regulation</td>
</tr>
<tr>
<td>9</td>
<td>DER Group Curve Functions</td>
<td>List of curve types</td>
</tr>
<tr>
<td>10</td>
<td>Receive/Respond Based on Price Signals</td>
<td>List of services for which responses to price are supported.</td>
</tr>
<tr>
<td>11</td>
<td>Provide Bids/Cost of Services</td>
<td>List of services for which bids/costs can be provided</td>
</tr>
<tr>
<td>12</td>
<td>Connect/Disconnect DER Group</td>
<td>Identifying whether or not this service is provided.</td>
</tr>
<tr>
<td>13</td>
<td>DER Group Regulation Service</td>
<td>Identifier of which regulation services are available and the scale (Watts) of each.</td>
</tr>
</tbody>
</table>
DER Group Monitoring, Capabilities, Status

What is the Status of this Function (Function, Group Name)
Status (Max, Present, Min)

Requesting Entity
e.g., DERMS/DMS

Providing Entity
e.g., DERMS

Watts Delivered
- Present Maximum Capability
- Present Value
- Present Minimum Capability

Installed Maximum Capability
Installed Minimum Capability

Present Capability to Deliver
Present Capability to Receive

Installed Capability to Deliver
Installed Capability to Receive
DER Group Monitoring, Capabilities, Status

What is the Forecast for this Group (Group Name)
Forecast (Date Range, Interval, Parameters)

Requesting Entity
e.g., DERMS/DMS

Providing Entity
e.g., DERMS

Diagram:
- Present Maximum Capability
- Present Minimum Capability
- Present Value
- Time Start
- Time Interval
- Forecast Points for Maximum Capability
- Forecast Uncertainty Factor for Maximum Capability

Graph:
- Watts Delivered vs. Time
DER Group Operational Limits Boundaries

Requesting Entity
e.g., DERMS/ DMS

Providing Entity
e.g., DERMS

DER Group Max Power Limiting (Group Name)
Response (Response Codes)
DER Group Operational Limits Boundaries

Requesting Entity

- e.g., DERMS/DMS

Providing Entity

- e.g., DERMS

DER Device Phase Identification (Device ID, Phase)

DER Group Phase Balance Limit (Group Name)

Response (Response Codes)

Real Power Produced

- Imbalance Limit

<table>
<thead>
<tr>
<th>Phase</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
</table>
DER Group Operational Limits Boundaries

- **DER Group Ramp Rate Limits (Group Name, Ramp Type, Values)**
- **Response (Response Codes)**

**Requesting Entity**
- e.g., DERMS/
  - DMS

**Providing Entity**
- e.g., DERMS

**Graphical Representation**
- **e.g. Watts Delivered**
- **Time**
  - Control Command Received
  - Normal Ramp Rate
  - Emergency Ramp Rate
  - Emergency Situation (e.g., sag)
  - Power Up
  - Soft Start Ramp Rate
DER Group Control Functions

Requesting Entity
e.g., DERMS/DMS

DER Group Real Power Dispatch (Group Name, Value)
Response (Response Codes)

DER Group Reactive Power Dispatch (Group Name)
Response (Response Codes)

Providing Entity
e.g., DERMS

Present Maximum Capability to Deliver
Present Value
Present Maximum Capability to Receive

P (W)
0
P (W)
t_0
t_1

Absolute Real Power Level, P_G

time
DER Group Control Functions

DER Group Real Power Dispatch (Group Name, Value)
Response (Response Codes)

DER Group Reactive Power Dispatch (Group Name)
Response (Response Codes)

DER Group Set Curve Function (Group Name, Function Type, Array)
Response (Response Codes)

Requesting Entity
e.g., DERMS/ DMS

Providing Entity
e.g., DERMS
DER Group Regulation Function

- DER Group Assigned Baseline Power (Group Name, Value)
  - Response (Response Codes)

- DER Group ACE Regulation Signal, Ramp Time (Group Name)
  - Response (Response Codes)

Requesting Entity
e.g., DERMS, DMS

Providing Entity
e.g., DERMS

Graph showing Regulation Power [MW] over Time [Seconds] with lines for Regulation Capability, Assigned Regulation, Provided Regulation, and Baseline.