About GridBright

• GridBright (gridbright.com) is a boutique consulting and systems integration company focused on grid management and integration of DER in the utility industry.

• We are not a product company, and we do not sell DERMS.
Introduction

• Distributed Energy Resources (DERs) are energy resources, can provide similar services provided by central generation, are expected to grow, and need to be properly managed.

• Managing high penetration of DERs requires a business transformation involving changes to utility policies, organization, business processes, and technology.

• There have been many utility pilots that you can learn from. But each utility is unique, and may need to organize its own pilots.

• Some of the pilots include DERMS: an emerging (set of) computer application(s) for managing DER.
Seminar Topics

1. The types and characteristics of DER
2. Impacts of DER on utility operations
3. The computer applications used to manage DER operations
4. Existing and emerging DERMS and the solution categories
5. DERMS pilots and reported experiences
6. Implementation considerations for DERMS
Acknowledgement

CEATI Project 3804
1. Eversource
2. HECO
3. Hydro One
4. Hydro Ottawa
5. Minnesota Valley Elect. Coop
6. National Grid
7. NYPA
8. PG&E
9. SDG&E
10. SaskPower
11. Tacoma

CEATI Project 3134
1. Alberta Electricity System Operator
2. BPA
3. Duke
4. ERCOT
5. FERC
6. ENTSO-EE
7. Great
8. IESO
9. ISO-NE
10. PG&E
11. PJM
12. National Grid
13. NERC
14. NYISO
15. NYPA
16. SaskPower
17. SCE
18. TVA
Literature Review Sources

As part of our CEATI projects we reviewed 100+ related reports

- CEATI Publications
- DistribuTech Presentations
- IEEE Publications
- Publicly available EPRI publications
- Publicly available NRECA publications
- DOE/National Lab reports
- DOE Grid Wise Architecture Council
- Standards organizations
- Regulatory Reports (California, Hawaii, New York, Ontario, FERC)
- International (CIGRE)
- Vendor documentation and white papers
1. The Types and Characteristics of DER
Distributed Energy Resource Types

**Category**
- Distributed Generation (DG)
- Distributed Storage (DS)
- Demand Response (DR)
- Electric Vehicles (EV)
- Microgrids

**Fuel Type**
- Non-renewable
- Renewable
  - PV
  - Wind
- Others (e.g., Hydro, Geothermal, Biomass, Biogas, Fuel Cells)

**Ownership**
- Customer
- Utility
- 3rd Party

**Size/ Inter-connection**
- Small/ Behind Meter
- Medium/ Feeder
- Large/ Substation

**Products/ Services**
- Energy
- Storage
- Ancillary Services (T & D Levels)

**Operating Characteristics**
- Scheduling Constraints
- Dispatch Constraints
- Restoration Constraints
  - Operating Reserve
  - Spinning Reserve
  - Frequency Regulation
  - Voltage Regulation
  - Blackstart
  - Power Conditioning
  - Others (e.g., Volt/VAR and Ramp Limits, Ride-Through or Islanding Capabilities)

Source: CEATI Report T164700 - 3804
Utility Attributes Related to DER Integration

Every utility may be different when it comes to solutions for DER management (i.e., One size does not fit all)

Source: CEATI ReportT164700 - 3804
DER Penetration & Growth Rates

• Planning scenario variety
• GIS network modeling accuracy
• DER asset modeling and attributes
• Granular net load forecasting
• Direct metering of DER power, volt/var, charge, status
• CIS rate plan variety and billing complexity
• Work force management of DER assets
DER Penetration & Growth Rates (Cont.)

- Situation awareness analytics including load and gen
- Impact on power flows, switching, restoration
- Behind-the-meter asset communications, control, and constraints
- Substation protection equipment upgrades
- Distributed automation and grid-edge sensor upgrades
- Wholesale flexibility market integration
- Coordination with local DER retailers
DER Asset Mix

• Many small DERs vs a few larger DERs
  – Easier and more cost effective to keep track of a small number of large PVs vs millions of smaller behind the meter units

• Ownership and controllability of the DER assets
  – Utility owned assets are generally controllable, but customer or retailer owned assets may have technical or contractual constraints on using the assets for managing power balance or quality

• Many different DER asset types require more sophisticated solutions
  – Easier to manage a solar program, vs a complex portfolio of DG, DS, DR, EV, and Microgrids, each with its own operating considerations
Grid Flexibility & Strength

• Non-dispatchable DER reduces load following capacity that the grid operators could use for reserves and frequency regulation

• A stronger grid
  – is not operating close to operating limits
  – can better withstand contingencies

• A non-flexible or weak grid will
  – need improved reserve sharing arrangements with neighbors
  – have network carrying capacity limitations
  – want to leverage DER flexibility for system & local reserves, regulation capacity, and power quality services
Market Structure

- Wholesale (transmission) level markets
- Retail (distribution) level markets
- Energy, capacity, and ancillary service markets
- Seasonal, day-ahead, real-time markets
- Bi-lateral contract markets
- Demand & generation aggregator markets
- Retail energy choice markets
- Real-time pricing markets
DER Constraints

• Government or regulator mandates
  – renewable mix, open access, net metering, feed-in tariffs

• Program or contractual
  – seasonal limits on frequency of use, daily limits on time and duration

• Technical or availability
  – intermittent availability, range of flexibility, state of charge, cycle time

• Rights to use & control – Customer, Retailer, Utility
Utility Size

• Small utilities (e.g. COOPs)
  – typically have simpler business processes and fewer DERs
  – may be able to manage their existing business processes manually, deferring the need for automation solutions

• Large utilities (e.g. IOUs)
  – typically more complex business processes and more DERs
  – may have to automate to be cost-effectively scalable
2. Impacts of DER on Utility Operations
Impacts of DER on Distribution Operations*

1. Voltage Related
2. Reliability Related
3. Safety Related
4. Network Observability
5. System Protection
6. Peak Load Management
7. Frequency Regulation
8. Cold load pickup/Phantom Load
9. Interactions with 3rd parties
10. Wholesale and Distribution Markets
11. Operations economics

*Based on information from structured interviews with utilities and literature survey in CEATI Project 3804
**DER Impacts on Transmission Operations**

1. Load Modeling and Forecasting
2. Frequency Control
3. Voltage Control
4. Cyber Security
5. Post-contingency Behavior
6. Real-time Visibility and Controllability
7. Systems Protection
8. Black Start
9. Grid Strength
10. Energy Flows
11. Industry Standards
12. Generation Mix
13. Operational Control
14. Wholesale Markets

*Based on information from structured interviews with utilities and literature survey in CEATI Project 3134*
3. The Computer Applications Used to Manage DER Operations
Common Processes

- **Look-Ahead Analysis** – A medium to short-term operational planning or study process analyzing the viability of a given network configuration for a given future time period.

- **Forward Scheduling** – Typically after a Look-Ahead Analysis, this is the operational process of scheduling network configuration changes and/or DER asset flexibility for a given future time period.

- **Operations Monitoring** – This is a real-time operational process of staying aware of network congestion, potential power flow deviations from operating plans, responding to network violation alarms, and handling abnormal or emergency events.

- **Real-Time Dispatching** – This is a real-time operational process of adjusting or modifying the current operating plan in reaction to unplanned congestion, violations, topologies, outages, or other emergency conditions.

- **Distributed Control** – This is a real-time operational process done automatically by distributed intelligent controls according to predefined objectives, limits, or schedules.

- **Event Recovery** – This is an operational process done after an exception event to recover the normal operating conditions, such as during outage restoration.
Representative Use Cases

- Centralized Voltage and VAR Control
- DER Managed Voltage and VAR Control
- Unintentional Islanding
- Islanded Return to Grid Connection
- Manual Service Restoration – Phantom Load Pickup
- Capacity Firming
- Service Reliability Calculation
- Peak Load Management
- Situational Awareness
- Planned Switching
- Fault Location and Automatic Service Restoration
- Emergency Capacity Reserve
- Markets - Ancillary Services
- Relay Protection Re-coordination
# High-Level Systems Architecture

## Enterprise IT
- **Planning**
  - Scenarios
  - Simulations
  - Studies
  - Analysis
  - Testing
- **GIS**
  - Asset mgmt
  - Topology
  - Connectivity
  - Geolocation
  - Versioning
- **Forecast**
  - Weather
  - Load models
  - DER models
  - Flexibility
  - By location
- **MDMS**
  - Meters
  - Cycles
  - Data VEE
  - Historian
  - Profiles
- **CIS**
  - Customers
  - Services
  - Rate plans
  - Billing
  - Disputes
- **MWMS**
  - Install
  - Maintain
  - Assess
  - Repair
  - Mobile GIS

## Centralized OT
- **Analytics**
  - Situation awareness
  - Analytic mash-ups
  - Geospatial
  - Graphical
- **ADMS**
  - Distribution SCADA
  - Topology, state estimation
  - Switching, plans, tagging
  - OPF, VVO, grid analytics
  - Outage management
  - FLISR & restoration
- **DERMS**
  - Aggregate resources
  - Flexibility tracking
  - Look-ahead analysis
  - Optimal scheduling
  - Price signaling
  - Response monitoring
- **DRMS**
  - Individual resources
  - Program management
  - Capacity registration
  - Device dispatch
  - Baseline calculations
  - Performance settlement

## Distributed
- **Substations**
  - IED/Sensor telemetry
  - Automation, controls
  - Alarms/logging
  - Operator HMIs
- **AMI**
  - Meter reading
  - Connection status
  - Alarms/logging
  - Connect/disconnect
- **RTO/Markets**
  - VPP registration
  - Bidding interface
  - Clearing prices
  - Shared EMS/AGC
- **Retailers**
  - Load/DER aggregates
  - Flexibility forecasts
  - DR/DER dispatching
  - Transactive price feeds

## Grid Edge
- **Feeder DA**
  - Sensors & Micro PMUs
  - Grid edge controllers
  - Microgrid controllers
  - Protection/islanding
- **Meters**
  - Load, Gen, PQ
  - Status alarms
  - Remote reads
  - HAN gateway
- **DER Assets**
  - Load/gen/storage/inverters
  - Local energy management
  - PCC/microgrid controllers
  - Meters & sensor telemetry
- **IoT Gateways**
  - Behind-the-meter
  - Telemetry & control
  - Forecasts, scheduling
  - Local intelligence

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Source: CEATI Report T164700 - 3804
### Variation Factor Table Example

<table>
<thead>
<tr>
<th>System</th>
<th>No DER Flexibility Markets</th>
<th>DER Flexibility Markets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td>No significant impact</td>
<td>Planning needs to account for the coincident nature of load, generating capacity, and price spikes with respect to their own needs for flexibility. Or the utility may have to compete for flexibility since it could be otherwise committed into other markets.</td>
</tr>
<tr>
<td>Forecasting</td>
<td>No significant impact</td>
<td>Operations may have to consider price in their forecasts, and its effect on price responsive loads and available flexibility.</td>
</tr>
<tr>
<td>CIS/Billing</td>
<td>No significant impact</td>
<td>Potential for real-time pricing tariffs using published market clearing prices, flexibility incentives that take into account whether there is dual use of the resource by central markets</td>
</tr>
<tr>
<td>DERMS</td>
<td>DERMS may be used to operate local DER capacity or flexibility markets in the absence of central markets.</td>
<td>DERMS will need to coordinate and co-optimize the use of DERs for local services and/or bid the residual flexibility into central markets.</td>
</tr>
<tr>
<td>DRMS</td>
<td>DRMS may be used to manage contracted capacity or behind the meter flexibility in the absence of central markets.</td>
<td>DRMS will need to coordinate and co-optimize the use of utility managed behind the meter DERs for local services and/or bid the residual flexibility into central markets.</td>
</tr>
<tr>
<td>RTO/Markets</td>
<td>No interfaces to a central RTO or market are required if they do not exist, though there may be similar integrations required to the equivalent utility transmission operations and economic dispatching functions internally.</td>
<td>Existing interfaces need to be expanded to support forecasting, bidding, scheduling, dispatching, monitoring, and settlement of DER flexibility. Additionally, where both parties might use the same flexibility, a system of coordination and co-optimization needs to be implemented</td>
</tr>
<tr>
<td>Retailers</td>
<td>The utility might still manage direct capacity or flexibility contracts with Retailers, and as such may need to provide interfaces for registration, forecasting, scheduling, dispatching, and settlement.</td>
<td>Additional interfaces may be required to coordinate the use of the same resource by both local and central operators.</td>
</tr>
<tr>
<td>DER Assets</td>
<td>DER assets may need the ability to take prioritized scheduling and dispatch instructions from the Retailer, Utility operations, and Distributed intelligence.</td>
<td>DER assets may additionally need to support making localized schedule and price responsive dispatch decisions using market clearing prices or transactive price feeds.</td>
</tr>
</tbody>
</table>
Application Requirements*

See CEATI Report T164700-3804 for new requirements for applications impacted by DER

<table>
<thead>
<tr>
<th>Req. ID</th>
<th>Short Description</th>
<th>Long Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>001</td>
<td>Model all types of demand</td>
<td>Ability to model real and reactive loads at each network node</td>
</tr>
<tr>
<td>002</td>
<td>Model true (or phantom) demand</td>
<td>Ability to model or decompose the observed net demand into underlying load and generation contributions</td>
</tr>
<tr>
<td>003</td>
<td>Model demand aggregation groups and disaggregation factors</td>
<td>Ability to either roll-up demand data and forecasts to different aggregate network hierarchies, or disaggregate demand data and forecasts to specific network nodes</td>
</tr>
<tr>
<td>004</td>
<td>Model demand with profiles</td>
<td>Ability to model and calculate demand forecasts from predefined customer load profiles by type, season, and weather</td>
</tr>
<tr>
<td>005</td>
<td>Model demand with regressions</td>
<td>Ability to model and calculate demand forecasts from historically derived regression models and forecast variables such as weather</td>
</tr>
<tr>
<td>006</td>
<td>Model demand through machine learning</td>
<td>Ability to use machine learning techniques to derive demand models automatically from historical behavior</td>
</tr>
<tr>
<td>007</td>
<td>Utilize external models and derived forecasts</td>
<td>Ability to use external models or integrate demand forecasts calculated by retailers, customers, or other third parties</td>
</tr>
<tr>
<td>008</td>
<td>Utilize multiple overlapping forecast models for different time horizons to enhance accuracy</td>
<td>Ability to model and calculate different forecasts for different look-ahead time-horizon windows (e.g. weeks ahead, days ahead, hours ahead, minutes ahead) to revise the forecasts with incrementally better data</td>
</tr>
<tr>
<td>009</td>
<td>Utilize sensor data to validate forecasts</td>
<td>Ability to improve or monitor the accuracy of forecasts by integrating or comparing against sensor data</td>
</tr>
<tr>
<td>010</td>
<td>Calculate demand model and forecast performance</td>
<td>Ability to measure and verify the model and forecast accuracy, and its contribution to overall power flow accuracy</td>
</tr>
</tbody>
</table>
Applications Interfaces are Impacted Too

Forward Scheduling

- Planning
- GIS
- Forecast
- MDMS
- MWMS
- CIS

Load, Gen, Flexibility Forecasts

- Analytics
- ADMS
- DERMS
- DRMS

Network Schedules

Needs, Availability

Substations

AMI

Markets

Retailers

Feeder DA

Meters

DER Assets

IoT Gateways

*Source: CEATI Report T164700 - 3804
4. Existing and Emerging DERMS and the Solution Categories
DERMS: An Application, or a Set of Applications?

• All key operational systems will eventually need “DER logic” of their own
• But there may be a need for a new ‘DERMS’ solution to fill operational gaps between existing applications
• Experience:
  – Easy to make the scope of DERMS too big
  – Requirements will be dynamic and will change over time
  – Vendor landscape will be changing too
  – Need for flexible DERMS solutions to minimize cost of “Change Orders” and “Total Cost of Ownership”
DERMS Solution Categories - OT vs. IT

• Grid Operations DERMS (OT)—Multiple Level
  – Transmission level
  – Substation level
  – Feeder (or sub-circuit) level
  – “Edge Solutions” to manage a set of DER (e.g., a Microgrid, or a fleet of DER resources)

• Enterprise DERMS (IT)
  – Planning and interconnection approval process
  – Program enrollment and control device provisioning
  – Asset and work force management
  – Performance measurement & verification, and billing & settlement
  – Analytics to identify target areas & assets, and monitor effectiveness
DERMS Solution Categories - Centralized vs Decentralized

- Not so much a question of ‘either-or’, but ‘what and where’?
- DERMS solutions are likely to have some field logic & components
  - Sensors & Controls
  - Distributed Intelligence (autonomous in island or interrupted comms mode)
  - Distributed Optimization (solve for economic objectives vs utility reliability)
  - Network Automation (protection, VVO, FLISR, islanding coordination)
- Utilities are likely to leverage third-party controlled resources
  - Multiple providers, each with their own geographically sparse networks
  - Networks of DR, batteries, or intelligent inverters controlled through NOCs
  - Complicates the distinction between centralized or decentralized
DERMS Solution Categories - Steady State vs Dynamic

• Normal Operations
  – Accurate 24/7 net load forecasting to predict and avoid network congestion
  – Ability to schedule DERs as a resource to improve reliability and efficiency

• Contingency States/Restoration
  – Real-time power balance, voltage, var, or frequency limit violations
  – Pre-defined automated behavior, and/or real-time dispatch through recovery
DERMS Solution Categories - Enterprise vs Cloud

• Enterprise
  – Core operational reliability elements tightly integrated with DMS
  – Maintaining independence across multiple third-party aggregators
  – Cost efficiencies and security running larger scale programs

• Cloud
  – Individual programs or assets managed by third parties via cloud
  – Open, cloud based markets of competitively provided flexibility
  – Non-core, supporting functions like marketing, forecasting, asset mgt
  – New DA and IoT data collection, management, and analytics

• Likely to have a little of both in the long term
DERMS Solution Categories – ADMS vs DMS Supplements

• Two big schools of thought – but largely driven by product economics
  – Vendors with ADMS solutions want to use DER as a forcing function
  – Those who invested in DRMS are now trying to pivot to DERMS
• The real answer will probably include both
  – The ADMS will need some embedded capability to model assets, consider impacts in switching/outage plans, and monitor net load effects
  – Supplemental systems will be necessary to help create more accurate and granular forecasts, to track availability and constraints, to optimize schedules, to communicate with assets, to measure performance, etc.
• Your answer depends on where you are relative to ADMS procurement and DER penetration (and/or pilots)
DERMS Solution Requirements

• Requirements depends on what you want to do
• Some of the most important requirements are related to:
  1. Look-Ahead Analysis
  2. Forward Scheduling
  3. Operations Monitoring
  4. Real-Time Dispatching
  5. Distributed Control
  6. Event Recovery
• Not to discount...
  – Program registration, device provisioning, communications, health, lifecycle
  – Performance measurement & verification, and billing & settlement
  – Integration and coordination with OT/IT applications, markets, providers
# DERMS Requirements

**System:** DER Scheduling/Optimization/Pricing

**Summary:** This requirement is to support the forward scheduling of DERs.

<table>
<thead>
<tr>
<th>Req. ID</th>
<th>Brief Description</th>
<th>Detailed Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>001</td>
<td>Scheduling all types of DERs</td>
<td>Ability to schedule all types of DERs – PV, wind, storage, controllable loads, backup generation, microgrids, etc.</td>
</tr>
<tr>
<td>002</td>
<td>Scheduling all types of DER services</td>
<td>Ability to schedule reserves, real and reactive power, emergency energy, ancillary services, and other DER capabilities.</td>
</tr>
<tr>
<td>003</td>
<td>Scheduling multiple time domains</td>
<td>Ability to schedule in the future for various time periods and granularities. For instance, capacity reserve products might be yearly, seasonal, or monthly. Energy products might be day or hour ahead, with hourly to 5 min granularity. Ancillary services might be reserved a day in advance, but activated with 5 min to 4 second lead times.</td>
</tr>
<tr>
<td>004</td>
<td>Scheduling for all types of optimization objectives</td>
<td>Ability to schedule using different optimization objectives, including network reliability, economic efficiency, volt-var efficiency, co-optimal SCED, or some other composite objective function (such as one that considers wear and tear on substation and secondary transformer asset life).</td>
</tr>
<tr>
<td>005</td>
<td>Scheduling comprehensive operating plans</td>
<td>Ability to define the complete, 24-hour operating plan for a DER asset, to be effective for the day, month or season.</td>
</tr>
<tr>
<td>006</td>
<td>Scheduling events</td>
<td>Ability to schedule periodic events, which are interpreted as temporary deviations from the normal operating plan.</td>
</tr>
<tr>
<td>007</td>
<td>Scheduling indirectly via prices</td>
<td>Ability to send an indicative or committed forward price schedule (aka price curve) or incentive payment amount to DERs, which can then make individual decisions on operating plans or event participation.</td>
</tr>
<tr>
<td>008</td>
<td>Scheduling integration with operational systems</td>
<td>Ability to integrate with an ADMS, bidirectionally. Typical integrations include receiving real or reactive power adjustment needs by location, providing draft DER dispatching schedules to validate power flows, and providing final dispatched operating schedules.</td>
</tr>
</tbody>
</table>

*Source: CEATI Report T164700 - 3804*
## Examples of Commercial DERMS Software

<table>
<thead>
<tr>
<th>ADMS Vendors</th>
<th>Other Vendors</th>
</tr>
</thead>
<tbody>
<tr>
<td>• ABB</td>
<td>• Advanced Microgrid Solutions</td>
</tr>
<tr>
<td>• GE/Alstom</td>
<td>• Doosan</td>
</tr>
<tr>
<td>• Oracle</td>
<td>• Enbala</td>
</tr>
<tr>
<td>• OSI</td>
<td>• Lockheed Martin</td>
</tr>
<tr>
<td>• Siemens</td>
<td>• OATI</td>
</tr>
<tr>
<td></td>
<td>• Opus One</td>
</tr>
<tr>
<td></td>
<td>• Smarter Grid Solutions</td>
</tr>
<tr>
<td></td>
<td>• Spirae</td>
</tr>
</tbody>
</table>
5. DERMS Pilots and Reported Experiences
Interest in DERMS

DERMS Projects Cross U.S. With Concentrations in CA, HI, NY

Key
- 7 projects
- 5 projects
- 3 projects
- 2 projects
- 1 project

Source: GTM Research

Midsize Utilities Lead in DERMS Project Count

Source: GTM Research
# ENERGISE Projects

## Program Kickoff on October 11, 2017 in Washington, D.C.

<table>
<thead>
<tr>
<th>Project Title</th>
<th>Recipient</th>
<th>Topic Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhanced Control, Optimization and Integration of Distributed Energy Applications (Eco-Idea)</td>
<td>National Renewable Energy Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>Grid Optimization with Solar (GO-Solar)</td>
<td>National Renewable Energy Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>Voltage Regulation and Protection Assurance using DER Advanced Grid Functions</td>
<td>Sandia National Laboratories</td>
<td>1</td>
</tr>
<tr>
<td>Scalable/Secure Cooperative Algorithms and Framework for Extremely-high Penetration Solar Integration (SolarExPert)</td>
<td>University of Central Florida</td>
<td>2</td>
</tr>
<tr>
<td>Integrated Distributed Energy Management System at RPU</td>
<td>University of California: Riverside</td>
<td>1</td>
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<tr>
<td>Keystone Solar Energy Future Project</td>
<td>PPL Electric Utilities</td>
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<tr>
<td>Data Driven Modeling and Analytics for Enhanced Systems Layer Implementation</td>
<td>University of Southern California</td>
<td>2</td>
</tr>
<tr>
<td>Electric Access System Enhancement (EASE)</td>
<td>Southern California Edison</td>
<td>1</td>
</tr>
<tr>
<td>Robust Distributed State Estimator for Interconnected Transmission and Distribution Networks</td>
<td>Northeastern University</td>
<td>2</td>
</tr>
<tr>
<td>Robust and resilient coordination of feeders with uncertain distributed energy resources: from real-time control to long-term planning</td>
<td>University of Vermont</td>
<td>2</td>
</tr>
<tr>
<td>Phasor-Based Control Scalable Solar Photovoltaic Integration</td>
<td>The Regents of the University of California</td>
<td>2</td>
</tr>
<tr>
<td>Integration of Solar Energy into Power Grid Operation via Wide-area Data Management Systems and a Hierarchical Control Architecture</td>
<td>Quanta Technology, LLC</td>
<td>2</td>
</tr>
<tr>
<td>Security Constrained Economic Optimization of Photovoltaic and other Distributed Assets</td>
<td>Advanced Microgrid Solutions</td>
<td>1</td>
</tr>
</tbody>
</table>
Examples of DERMS Projects

<table>
<thead>
<tr>
<th>DRMS</th>
<th>DERMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BPA</td>
<td>Advanced Microgrid Solutions</td>
</tr>
<tr>
<td>CAISO</td>
<td>Berkeley/LBL/PG&amp;E</td>
</tr>
<tr>
<td>Midwest ISO</td>
<td>City of Riverside/UC Riverside</td>
</tr>
<tr>
<td>PECO</td>
<td>ConEd</td>
</tr>
<tr>
<td>PJM</td>
<td>Nice</td>
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<tr>
<td>PG&amp;E</td>
<td>PG&amp;E</td>
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<td>PGE</td>
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<tr>
<td>NVE</td>
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<tr>
<td>SCE</td>
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<tr>
<td>SDG&amp;E</td>
<td></td>
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<tr>
<td>Transpower</td>
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</tr>
</tbody>
</table>
Lessons Learned

- There is little consensus around terminology and scope of DERMS.
- DERMS is complex. New skills needed to operate future control centers.
- Can learn a lot from others but also need to experiment yourself.
- Creating test substation/feeder is a large undertaking.
- DER customer acquisition could be more difficult than expected. May need to engage 3rd party aggregators.
- Need laboratory testing (e.g., HIL testing) to simulate the future.
- Setting up a simulation testbed is a lot of work. Publicly available grid models and testbeds can help (e.g., see bettergrids.org).
- DERMS applications are still evolving and could have a short shelf life if they are not flexible. Apply “Flexibility Test”.
- Traditional utility applications procurement policies and processes may need to change in the DER era. In particular you may need to consider leasing vs buying, open source software, and cloud solutions.
6. Implementation Considerations for DERMS
DER Operational Maturity Levels

0. Immature (Default)

1. Initiating
   First steps towards supporting DER aware operational processes

2. Enabling
   Implementing operational processes to predict and manage DER impacts

3. Integrating
   Creating operational processes for DER that are integrated across the organization

4. Optimizing
   Processes to measure and optimize DER operational impacts

5. Pioneering
   Processes that break new ground in utilizing DERs to predict and manage DER operational impacts

Source: CEATI ReportT164700 - 3804
# DER Operations Maturity Model by Domain

**Source:** CEATI Report T164700 - 3804

## Levels of Maturity

<table>
<thead>
<tr>
<th>People Organization &amp; Structure</th>
<th>Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>0</strong> Default</td>
<td></td>
</tr>
<tr>
<td>Existing grid operations team, no specific DER focus in the organization</td>
<td></td>
</tr>
<tr>
<td><strong>1</strong> Initiating</td>
<td></td>
</tr>
<tr>
<td>Expanding team responsibilities to include DER impact assessments in operations</td>
<td></td>
</tr>
<tr>
<td><strong>2</strong> Enabling</td>
<td></td>
</tr>
<tr>
<td>Creating new operations roles to focus on DER impact prediction and control</td>
<td></td>
</tr>
<tr>
<td><strong>3</strong> Integrating</td>
<td></td>
</tr>
<tr>
<td>Creating roles across the organization to support DER operations</td>
<td></td>
</tr>
<tr>
<td><strong>4</strong> Optimizing</td>
<td></td>
</tr>
<tr>
<td>Creating roles to continuously analyze and optimize DER operations</td>
<td></td>
</tr>
<tr>
<td><strong>5</strong> Pioneering</td>
<td></td>
</tr>
<tr>
<td>Creating roles to integrate and operate DER flexibility markets and price response</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grid Operations Processes</th>
<th>Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>0</strong> Default</td>
<td></td>
</tr>
<tr>
<td>Existing grid operations, no specific DER processes</td>
<td></td>
</tr>
<tr>
<td><strong>1</strong> Initiating</td>
<td></td>
</tr>
<tr>
<td>Processes to account for DER impacts to ensure reliability</td>
<td></td>
</tr>
<tr>
<td><strong>2</strong> Enabling</td>
<td></td>
</tr>
<tr>
<td>Processes to enhance prediction and control of third party DER flexibility</td>
<td></td>
</tr>
<tr>
<td><strong>3</strong> Integrating</td>
<td></td>
</tr>
<tr>
<td>Processes to manage DR/DER programs, enhance monitoring and control</td>
<td></td>
</tr>
<tr>
<td><strong>4</strong> Optimizing</td>
<td></td>
</tr>
<tr>
<td>Processes to use analytics and optimization to enhance DER operations</td>
<td></td>
</tr>
<tr>
<td><strong>5</strong> Pioneering</td>
<td></td>
</tr>
<tr>
<td>Processes to leverage markets and pricing as indirect DER impact control</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technology Systems</th>
<th>Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>0</strong> Default</td>
<td></td>
</tr>
<tr>
<td>Systems lack any specific DER prediction or control capability</td>
<td></td>
</tr>
<tr>
<td><strong>1</strong> Initiating</td>
<td></td>
</tr>
<tr>
<td>Systems have ability to model DER and predict some impacts</td>
<td></td>
</tr>
<tr>
<td><strong>2</strong> Enabling</td>
<td></td>
</tr>
<tr>
<td>Systems have ability to predict impacts and control DER flexibility</td>
<td></td>
</tr>
<tr>
<td><strong>3</strong> Integrating</td>
<td></td>
</tr>
<tr>
<td>Systems have the ability to integrate front and back office DR/DER processes</td>
<td></td>
</tr>
<tr>
<td><strong>4</strong> Optimizing</td>
<td></td>
</tr>
<tr>
<td>Systems to measure, analyze, and optimize DER prediction and control</td>
<td></td>
</tr>
<tr>
<td><strong>5</strong> Pioneering</td>
<td></td>
</tr>
<tr>
<td>Systems to integrate and operate DER markets to co-optimize reliability and economics</td>
<td></td>
</tr>
</tbody>
</table>
# Process Roadmap Example

<table>
<thead>
<tr>
<th>Look-ahead analysis</th>
<th>1 Initiating</th>
<th>2 Enabling</th>
<th>3 Integrating</th>
<th>4 Optimizing</th>
<th>5 Pioneering</th>
</tr>
</thead>
<tbody>
<tr>
<td>DER is modeled but is mainly just considered as a component of net load</td>
<td>DER forecasts considered separate from native and net load, but predictive analysis is on only operator request</td>
<td>Analysis is automated on a rolling continuous look-ahead basis to predict day or hour ahead issues using the latest forecasts and scheduled topology</td>
<td>Analysis is expanded to include both expected and some unexpected or contingency scenarios, and factors in prior performance to improve accuracy</td>
<td>Analysis considers all potential load, DER, switching, and contingency scenarios to predict any potential energy imbalances, network violations, or market price arbitrages</td>
<td></td>
</tr>
</tbody>
</table>

DER Look Ahead Process Unlocked by Maturity Level
Technology Roadmap

Level 0 Default State

Level 1 Initiating

Level 2 Enabling

Level 3 Integrating

Level 4 Optimizing

Level 5 Pioneering

Source: CEATI ReportT164700 - 3804
# Technology Systems Roadmap (example)

## Levels of Maturity

<table>
<thead>
<tr>
<th>0</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Initiating</td>
</tr>
<tr>
<td>2</td>
<td>Enabling</td>
</tr>
<tr>
<td>3</td>
<td>Integrating</td>
</tr>
<tr>
<td>4</td>
<td>Optimizing</td>
</tr>
<tr>
<td>5</td>
<td>Pioneering</td>
</tr>
</tbody>
</table>

### 0 Default
- DMS/OMS
- GIS
- SCADA
- Load Forecasting

### 1 Initiating
- ADMS and/or DMS extensions
- GIS model extensions for DER
- SCADA integration to large DER

### 2 Enabling
- DERMS
- Forecasting extensions for DER
- Retailer integration
- DER asset integration

### 3 Integrating
- DRMS
- Flexibility forecasting
- IoT gateway integration
- Distributed automation

### 4 Optimizing
- Analytics
- Machine learning
- Look-ahead contingency analysis
- Distributed optimization

### 5 Pioneering
- Central market integration
- Local market operations
- Price responsive DR/DER
- Distributed intelligence
DER Maturity Roadmap (example)

<table>
<thead>
<tr>
<th>Level</th>
<th>Phase</th>
<th>Milestones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immature</td>
<td>Initiating</td>
<td>Implement distribution operations systems with basic DER awareness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Utility able to reliably operate the network despite some DER impact</td>
</tr>
<tr>
<td>Sophisticated</td>
<td>Enabling</td>
<td>Implement DER forecasting and DERMS to use third-party flexibility</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Utility able to predict and manage DERs to enhance reliability</td>
</tr>
<tr>
<td>Pioneering</td>
<td>Integrating</td>
<td>Develop targeted in-house DR/DER programs with monitoring and control technology</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Utility able to use DR/DER for a wider range of reliability and efficiency goals</td>
</tr>
<tr>
<td></td>
<td>Optimizing</td>
<td>Develop operational analytics and optimizations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Utility able to continuously improve DER prediction and response</td>
</tr>
<tr>
<td></td>
<td>Pioneering</td>
<td>Integrate DER into wholesale markets, establish retail DER flexibility markets</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Utility able to leverage DER markets to create incentives and drive efficiencies</td>
</tr>
</tbody>
</table>
Implementation Best Practices

• Clear vision at the top with a commitment to business transformation
• Having a roadmap, and accepting that it will likely change
• Realistic requirements definition
• Organizing pilots including effective customer engagement
• Choosing & procuring the right solutions
• Effective solution implementation/pilot execution
  – PMO, engaging OCM team, adequate reliability and security
  – Designing and implementing interfaces to external systems
  – Maintenance and support.
Organizing Successful Pilots

• Be clear about and focus on the scope of pilot.
• Speed is of essence. You cannot de-risk everything. Failure is an option (i.e., OK to fail fast).
• Customer engagement is a must.
• Do a formal post mortem, draft a report, share it wide (e.g., publish with public data)
• Incorporate what you learned in pilot #2 or full deployment
Procurement Strategy

• Recognize that there are no out of the box solutions.
• OK to use existing procurement processes, but keep them streamlined for faster decision making for pilot projects.
• Evaluate the willingness of the vendor to partner on a journey to a solution.
• If you are paying for significant product development, you should get something for it (e.g., IP).
• Consider both smaller and larger vendors
• Consider leasing, OSS, and Cloud Solutions
7. Concluding Remarks
Summary

• To manage high penetration levels of DER, utilities need to transform their business, making changes to policies, organization, business processes, & technology.

• You can learn from other (pilot) projects, but you may need to organize your own pilots too.

• The pilots typically need some form of a DERMS solution (set). Architecting and procuring the right DERMS is challenging as the technology is evolving.

• The methodology documented in CEATI report T164700-3804 can help you get your arms around the problem.
To Learn More:

• Read CEATI Report SGTF-3804, “Impacts on Distribution System Operations when Integrating DER”.

• Participate in the CEATI project PSPO-3134, “Impacts on Transmission System Operations when Integrating”.

• Join CEATI project SGTF 3805 “Example Roadmaps for Improving Maturity of DER Management at Distribution Utilities”.

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