FirstEnergy DER Update & Smart Grid Cost Benefit Analysis

AEIC – DER
Spring 2020

Mark Vallo PE
Brian Makulinski PE
January 2020
FE AEIC DER Topics

- Who is FirstEnergy?
- FE DER penetration
- OH Grid Mod I approval
- Doing a CBA, Cost Benefit Analysis
- FE ADMS aDAPT project (DERMs requirements)
FirstEnergy Electric System

- 6,000,000 customers
- 65,000-square-mile service territory
- 10 electric utility operating companies in six states
- 35,000 MW peak load
- 24,000 miles of transmission lines
- Approximately 273,000 miles of distribution lines
- Approximately 12,600 employees

### Customers and Square Miles

<table>
<thead>
<tr>
<th>State</th>
<th>Customers</th>
<th>Square Miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ohio</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ohio Edison</td>
<td>1,036,000</td>
<td>7,000</td>
</tr>
<tr>
<td>The Illuminating Company</td>
<td>745,000</td>
<td>1,600</td>
</tr>
<tr>
<td>Toledo Edison</td>
<td>308,000</td>
<td>2,300</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Met-Ed</td>
<td>558,000</td>
<td>3,300</td>
</tr>
<tr>
<td>Penelec</td>
<td>588,000</td>
<td>17,600</td>
</tr>
<tr>
<td>Penn Power</td>
<td>163,000</td>
<td>1,100</td>
</tr>
<tr>
<td>West Penn Power</td>
<td>721,000</td>
<td>10,364</td>
</tr>
<tr>
<td>West Virginia/ Maryland/Virginia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mon Power</td>
<td>389,000</td>
<td>13,005</td>
</tr>
<tr>
<td>Potomac Edison</td>
<td>397,000</td>
<td>5,500</td>
</tr>
<tr>
<td>New Jersey</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jersey Central Power &amp; Light</td>
<td>1,103,000</td>
<td>3,200</td>
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</table>
### Net-metered applications (Based on DOE Report)

<table>
<thead>
<tr>
<th>Operating Company</th>
<th>State</th>
<th>DERs</th>
<th>Customer Count</th>
<th>% of FE Customers</th>
<th>% of Total DER</th>
<th>% Customer</th>
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<tbody>
<tr>
<td>Potomac Edison</td>
<td>Maryland</td>
<td>5,497</td>
<td>406331</td>
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<td>11%</td>
<td>1.4%</td>
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<tr>
<td>Jersey Central Power &amp; Light</td>
<td>New Jersey</td>
<td>34,701</td>
<td>1116141</td>
<td>18.5%</td>
<td>71%</td>
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<tr>
<td>The Cleveland Electric Illuminating Co</td>
<td>Ohio</td>
<td>550</td>
<td>744463</td>
<td>12.4%</td>
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<td>0.1%</td>
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<tr>
<td>Ohio Edison</td>
<td>Ohio</td>
<td>1039</td>
<td>1039788</td>
<td>17.3%</td>
<td>2%</td>
<td>0.1%</td>
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<tr>
<td>Toledo Edison</td>
<td>Ohio</td>
<td>310</td>
<td>302467</td>
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<td>1%</td>
<td>0.1%</td>
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<tr>
<td>Metropolitan Edison</td>
<td>Pennsylvania</td>
<td>4284</td>
<td>561715</td>
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<td>9%</td>
<td>0.8%</td>
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<tr>
<td>Penelec</td>
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<td>579465</td>
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<td>0.1%</td>
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<tr>
<td>Penn Power</td>
<td>Pennsylvania</td>
<td>181</td>
<td>172090</td>
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<td>0%</td>
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<td>Monongahela Power</td>
<td>West Virginia</td>
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<td>387207</td>
<td>6.4%</td>
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<td>0.1%</td>
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<tr>
<td><strong>FirstEnergy Totals</strong></td>
<td></td>
<td>48,571</td>
<td>6022629</td>
<td>100.0%</td>
<td>100%</td>
<td>0.8%</td>
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<table>
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<tr>
<th></th>
<th>DOE</th>
<th>June-19</th>
<th>To Date</th>
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<tbody>
<tr>
<td><strong>TOTALS - ALL Operating Companies</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MW</td>
<td>46,159</td>
<td>2,744</td>
<td>107</td>
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<tr>
<td>MW</td>
<td>372,491</td>
<td>342,939</td>
<td>93,482</td>
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<tr>
<td><strong>Storage Installed</strong></td>
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<td></td>
</tr>
<tr>
<td>MW</td>
<td>210</td>
<td>6</td>
<td>0</td>
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<tr>
<td>MW</td>
<td>2.557</td>
<td>0.572</td>
<td>0.000</td>
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### Number of DG Applications (Through Jan 2020)

#### Net-metered applications (Based on DOE Report)

<table>
<thead>
<tr>
<th>Operating Company</th>
<th>State</th>
<th>Jun 2019</th>
<th>Jan 2020</th>
<th>7mo. Diff</th>
<th>% of cust</th>
<th>Customer Count</th>
<th>% of FE Customers</th>
<th>% of Total DER</th>
<th>% Customer</th>
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</thead>
<tbody>
<tr>
<td>Potomac Edison</td>
<td>Maryland</td>
<td>5,497</td>
<td>5,747</td>
<td>250</td>
<td>0.06%</td>
<td>419,182</td>
<td>6.9%</td>
<td>12%</td>
<td>1.3%</td>
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<td>Jersey Central Power &amp; Light</td>
<td>New Jersey</td>
<td>34,701</td>
<td>37,280</td>
<td>2,579</td>
<td>0.23%</td>
<td>1,133,960</td>
<td>18.6%</td>
<td>77%</td>
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<tr>
<td>The Cleveland Electric Illuminating Co</td>
<td>Ohio</td>
<td>550</td>
<td>714</td>
<td>164</td>
<td>0.02%</td>
<td>749,498</td>
<td>12.3%</td>
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<td>Ohio Edison</td>
<td>Ohio</td>
<td>1,039</td>
<td>1,352</td>
<td>313</td>
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<td>1,048,373</td>
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<td>3%</td>
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<tr>
<td>Toledo Edison</td>
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<td>310</td>
<td>362</td>
<td>52</td>
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<td>306,683</td>
<td>5.0%</td>
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<tr>
<td>Metropolitan Edison</td>
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<td>4,284</td>
<td>4,962</td>
<td>678</td>
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<td>570,725</td>
<td>9.4%</td>
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<tr>
<td>Penelec</td>
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<td>755</td>
<td>992</td>
<td>237</td>
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<td>579,972</td>
<td>9.5%</td>
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<tr>
<td>West Penn Power</td>
<td>Pennsylvania</td>
<td>970</td>
<td>1,195</td>
<td>225</td>
<td>0.03%</td>
<td>720,055</td>
<td>11.8%</td>
<td>2%</td>
<td>0.1%</td>
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<tr>
<td>Penn Power</td>
<td>Pennsylvania</td>
<td>181</td>
<td>248</td>
<td>67</td>
<td>0.04%</td>
<td>173,728</td>
<td>2.9%</td>
<td>1%</td>
<td>0.1%</td>
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<tr>
<td>Monongahela Power</td>
<td>West Virginia</td>
<td>284</td>
<td>317</td>
<td>33</td>
<td>0.01%</td>
<td>389,656</td>
<td>6.4%</td>
<td>1%</td>
<td>0.1%</td>
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<tr>
<td><strong>FirstEnergy Totals</strong></td>
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<td>48,571</td>
<td>53,169</td>
<td>4,598</td>
<td>0.08%</td>
<td>6,091,382</td>
<td>100.0%</td>
<td>109%</td>
<td>0.9%</td>
</tr>
</tbody>
</table>

#### TOTALS - ALL Operating Companies

<table>
<thead>
<tr>
<th>RES</th>
<th>MW</th>
<th>COM</th>
<th>MW</th>
<th>IND</th>
<th>MW</th>
<th>TOTAL</th>
</tr>
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<tbody>
<tr>
<td>COUNTS</td>
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<td>50,649</td>
<td>2,891</td>
<td>116</td>
<td>53,656</td>
<td></td>
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<td></td>
<td>411.367</td>
<td>407.537</td>
<td>96.087</td>
<td>914.991</td>
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#### Storage Installed

<table>
<thead>
<tr>
<th>COUNTS</th>
<th>MW</th>
<th></th>
<th>MW</th>
<th></th>
<th>MW</th>
<th></th>
</tr>
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<tbody>
<tr>
<td>315</td>
<td>4.773</td>
<td>0.369</td>
<td>0.109</td>
<td>5.251</td>
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<td></td>
</tr>
</tbody>
</table>

AEIC - DER Spring

March 5, 2020
Service Area

36,000 Interconnections (564 MW – 10% of peak) (3.3% of Customers)

About 0.3% Cust./Year Add DER

15,000 Interconnections
FirstEnergy DER Current State

- **Fully Regulated Wires Company**
  - No DER ownership currently
  - Open to future rate-based company owned DER
    - But not aggressively pursuing
    - Working on battery storage pilots
  - Conservative Approach

- **Priority For Capital Spend - Distribution**
  - Grid automation
    - ADMS Oracle
    - DA
    - VVO
    - AMI
    - Dx Grid Filings in 5 of 6 states

- **Customer Driven Net-meter DER**

- **Most Wholesale “utility scale” DER on Transmission**
  - No concerns/issues…yet
## FirstEnergy Interconnection Objectives (Next 0-3 years)

<table>
<thead>
<tr>
<th>Objective</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regulatory Compliance</strong></td>
<td>• Accommodate DER on the system</td>
</tr>
<tr>
<td></td>
<td>• Looking to stay consistent with standard industry practices</td>
</tr>
<tr>
<td></td>
<td>• Meet customer expectations</td>
</tr>
<tr>
<td><strong>Limit Exposure to Reliability/PQ Risk</strong></td>
<td>• Maintain a conservative approach to modeling parameters</td>
</tr>
<tr>
<td></td>
<td>• Workable witness testing / Customer commissioning process</td>
</tr>
<tr>
<td></td>
<td>• Open Single-phase issue</td>
</tr>
<tr>
<td><strong>Maintain Operational Flexibility</strong></td>
<td>• Auto-tie schemes becoming very prevalent</td>
</tr>
<tr>
<td></td>
<td>• Not analyzing N-1 today. I think we may need to start</td>
</tr>
<tr>
<td><strong>Keep It Simple</strong></td>
<td>• As few inverter setting variants as possible</td>
</tr>
<tr>
<td></td>
<td>• Preferably one “do no harm” setting for &lt;1MW +/-</td>
</tr>
<tr>
<td></td>
<td>• Keep staffing requirements as low as possible</td>
</tr>
</tbody>
</table>
FirstEnergy Interconnection Perspective

In the next 0-3 years, simplicity of interconnection for both the Customer and the Utility is a much higher priority than maximizing hosting capacity, or any other benefits smart inverters can provide.

Adopt IEEE-1547 2018 compliant settings package when certified equipment becomes available (Mid-2022?)
FirstEnergy DER Objectives
EPRI Support

Regulatory Compliance
- Continued Utility benchmarking – all aspects of DER
- Encourage regulations that avoid attempting to engineer the grid
- Technology advancing quickly – need flexibility and engineering judgement

Limit exposure to reliability/PQ risk
- Workable witness testing / Customer commissioning process
  - Recommended procedure
  - Open Single-phase issue
  - Short-term – define the extent of the problem
    Longer-term – Low cost solutions, potential IEEE1547 revisions?
- Less expensive 3Vo options?
- Grounding calculation methodology
  - Circuits with high % motor load

Maintain Operational Flexibility
- Functionality already available in DRIVE for N-1 analysis

Keep It Simple
- Modeling to prove out settings that make sense everywhere
  - Possibly by voltage class, X/R, Fault Current, etc.
- Settings don’t have to be optimal…..yet
- Field Validation Tool Supplemental - Joining
FirstEnergy DER Future State 3-6 yrs

• Begin to “Integrate” DER as a NWA – Grid Support
  • Might look to own DER by then
  • DERMS “maybe” in that time-frame, if conditions warrant
  • SCADA communications for DER> 1MW
    • ADMS may trip DER during abnormal conditions
• Pressure to Keep Circuits Unrestricted will Build
  • May propose rate-base projects to increase hosting capacity
Grid Mod I Background PUCO Order

PUCO STIPULATION AND RECOMMENDATION – GRID MOD I

- Submitted: November 9, 2018
- Leverages Grid Modernization Plan from February 29, 2016
- Supports Ohio PowerForward Initiative
- Three-year portfolio of grid modernization capital investment
- Ongoing reporting on metrics
- Collaborative process with interested parties

SMART GRID TECHNOLOGIES

- Distribution Automation (DA)
- Integrated Volt Var Control (IVVC)
- Advanced Meter Infrastructure (AMI)
- Advanced Distribution Management System (ADMS)

<table>
<thead>
<tr>
<th>Circuits &amp; Meters</th>
<th>CEI</th>
<th>OE</th>
<th>TE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>DA</td>
<td>85</td>
<td>85</td>
<td>31</td>
<td>201</td>
</tr>
<tr>
<td>IVVC</td>
<td>87</td>
<td>85</td>
<td>31</td>
<td>203</td>
</tr>
<tr>
<td>Meters</td>
<td>311,304</td>
<td>286,017</td>
<td>110,497</td>
<td>707,818</td>
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<tr>
<td>OpCo %</td>
<td>42.5%</td>
<td>42.5%</td>
<td>15.0%</td>
<td>100%</td>
</tr>
</tbody>
</table>

PUCO order 7.7.19

36-MONTH TARGETED DEPLOYMENT PLAN
OH GRID MOD I – Cost Benefit Analysis

- Regulatory Body expects a Cost Benefit analysis on behalf of
- Total Portfolio NPV = 1.4
  - DA carries the day NPV = 5.1
  - IVVC at 2.5% CVR NPV = 0.9
  - AMI NPV = 0.4
SG Technologies and their sub-benefits

**DA**
1. DOE ICE Tool
2. Estimated reliability improvements in SAIFI and SAIDI on affected circuits (excluding major storm events)
3. Estimated storm restoration improvements during major storms on affected circuits

**IVVC**
1. Energy Savings Estimated savings from lower retail energy sales
2. CO2 Reduction Estimated reduction in CO2 emissions from lower retail energy sales
3. Capacity Reduction Estimated savings from lower capacity obligation attributable to lower retail energy sales
4. Avoided T&D Estimated capacity reduction on T&D system resulting from IVVC

**AMI**
1. Estimated benefits from customers participating in time-varying rate programs.
2. Estimated benefit from the assurance that consumption is recorded accurately
3. Estimated reduction from the customer's better understanding of energy management
4. Estimated reduction in CO2 emissions
5. Estimated benefit from reduction of outage time
Estimating DA Reliability Improvements

- **Existing Circuit**
  - No improvements

- **Circuit Upgrades**
  - Reconductoring
  - Equipment upgrades

- **Ties**
  - Manually operated switches

- **Reclosers (triple / single)**
  - Replace substation circuit exits
  - Install at key tie points

- **SCADA**
  - Add communication
  - Add SCADA indication and control

- **ADMS**
  - OMS, DA, IVVC, IDER, ...
Resource Documents

Quantifying Distribution Reliability Benefits

1015855

Final Report, December 2008

Automated Distribution Automation Switch Placement

3002003238

IEEE Std 1366™ 2003
(Revision of IEEE Std 1366-1998)

1366™
IEEE Guide for Electric Power Distribution Reliability Indices

IEEE Power Engineering Society
Sponsored by the Transmission and Distribution Committee

Published by The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA
14 May 2004

Print: 0190193
PDF: 0200193

FirstEnergy

AEIC - DER Spring March 5, 2020

16
DA Triggers

- Local LOV
- Substation LOV
- Substation Loss of Tx
  - > 300 events in 6½ years
  - ~ 1 event per week

- Quantify all CI / CMI Benefits, even regulatory exclusions
  - Why?

- Review some recent events
Wires down on L-1 Norway POD1 near substation fence. FISR solution. Very good results.

- Open conductors outside of L-1-NW caused LOV. **No relay operation or lockout.**
- **Correct FISR**, R-54 open, R-58 closes restoring 1437 of 2261 customers within minutes.
- **Net CMI is 300k for a 68.5% impact**
Wood pole containing 13kV 1-NE & 36 kV 15-NT, 16-NT **on fire**.

- **Fire in POD1** of 1-NE called in by safety forces before any faults or relay action.

- **DSO takes quick remote action** by closing R93, opening L-1 & R92. **Pole burns through and falls across Route 306.** Immediate CI savings = 911 customers.

- DSO works with line crews to further restore and isolate. Remotely closes L-1 and R92 to restore all but 2 customers. **Net CMI savings = 62% (Not including 36kV savings)**
Faults on L-2 Nelson. Feeder abnormal.

- L-2-NL feeder abnormal. L-2 substation recloser out-of-service. R10 tie is closed.
- Fault on L-2-NL outside of substation. R10 overtrips and locks out. In another event, L-3-NL substation recloser overtrips. FISR recognizes abnormality and overtrip and correctly isolates fault by opening R7 and closing R10.
- Net CMI is 227906 for a 43.4% impact.
Estimating DA Reliability Improvements

- DOE ICE Tool
  - Department of Energy’s Interruption Cost Estimating Tool
    - Electronic reliability planning tool that estimates interruption costs and/or the benefits associated with reliability improvements
      - Developed by
        - Lawrence Berkley National Laboratory
        - Nexant

CUSTOMER benefits not FirstEnergy
An advanced distribution management system (ADMS) is a centralized software platform that supports a full suite of distribution management and grid optimization. An ADMS includes functions that automate outage restoration and optimize the performance of the distribution power grid.

Platform Highlights:
- Outage management
- Power flow visualization
- Remote control of field devices
- Voltage/Power optimization
- Automated outage restoration
- Smart meter integration
- Training simulator
- Integrated switching plans
- Enhanced visualization
ADMS Timeline

Note:
- Deployment of advanced applications (i.e. distribution automation and voltage/power optimization) will occur in Q3 2022
DERMs Requirements

- DERMS shall be able to support IEEE 2030.5 services for retrieving inverter data, setting data values, notification and updating groups of DER
- DERMS shall be able to identify market participating DERs
- DERMS shall be able to be configured to forecast using weather inputs.
- DERMS shall be able configure forecasts using market prices as an input.
- DERMS to configure a new Aggregator
- DERMS shall provide the ability to schedule modes of operations
- DERMS shall provide the ability to import from, and export to, data from a the Regional ISO
- DERMS shall provide the ability to import and store DER model information
- DERMS shall be able to receive DER and customer data from GIS
- DERMS shall provide DER Control Services, i.e., the ability to remotely dispatch DER
- DERMS shall be able to consume network model status information to determine real time circuit topology.
- DERMS shall be able to include contractual terms of Interconnection Agreements in its operation
- DERMS shall provide situational awareness of DER operation, including a summary of Interconnected Generation Facility Status and Output/Input
- DERMS shall be able to model Energy Storage Devices, with capabilities for monitoring and control
- DERMS shall be able to coordinate with an ADMS
- DERMS shall be able to optimize a DMS-issued command over a group of DERS; e.g., reduce generation by first maximizing energy storage charging and then curtailment of distributed generation
- DERMS shall be able to support multi-objective optimization over multiple pricing curves including wholesale market auction prices, arbitrage, ramp smoothing, regulation, voltage support, spinning reserve, etc.
- DERMS shall be able to forecast/estimate response participation
- The Operational and Non-operational User Interface shall display DER devices in a tabular list per Distribution/Substation Transformers, control area, circuit, active/non-active and current state of devices, and namplate, tag and measurement data (and history) of each device
- The Operational User Interface shall allow a user control of individual DER or groups of DER. Groups should have no limitations on the types of groups that can be defined; e.g., Program, Circuit, etc.)
- The direct control of DER, including setpoint changes, will be governed by user operational role and the permissions granted to each role