Smart Grid Investment Grant Update

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kfranken@misoenergy.org

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Project Participants

• **Lead Sponsors**
  – David Zwergel, Project Sponsor, dzwergel@misoenergy.org
  – Kevin Frankeny, Business Owner, kfrankeny@misoenergy.org

• **Participating Transmission Owners**

<table>
<thead>
<tr>
<th>Ameren</th>
<th>American Transmission Company</th>
<th>Duke Energy</th>
<th>Great River Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hoosier Energy</td>
<td>Indianapolis Power &amp; Light</td>
<td>International Transmission Company</td>
<td>Manitoba Hydro</td>
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<tr>
<td>MidAmerican Energy</td>
<td>Minnesota Power</td>
<td>Montana Dakota Utilities</td>
<td>Northern Indiana Public Service</td>
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<tr>
<td>Ottertail Power</td>
<td>Vectren (SIGE)</td>
<td>XCEL Energy (NSP)</td>
<td>WAPA</td>
</tr>
</tbody>
</table>

As of October 17th, 2013

• **Research and Development Partners**
  – University of South Florida
  – University of Tennessee at Knoxville
Project Map 2013

SGIG Project
- 265 PMUs Targeted
- 197 Installed (current)

Current Overall
- 363 Total PMUs
- 248 Substations
  Including TVA, PJM, NYISO

PMU at Member Substation

As of October 17th, 2013
Background

- MISO is one of 100 DOE Smart Grid Investment Grant (SGIG) recipients

- Original goals met under budget using:
  - Lower-cost equipment
  - Software
  - Project efficiencies

* PEP Version 5
Project Highlights

• Project continues to be managed effectively and efficiently
  – One year extension through March 2014
  – Concentrating on final installations and value-add initiatives

• Baseline solutions deployed in production
  – Deployed applications to Real-Time Operations
    • Real-Time Monitoring and Enhanced displays
    • Continuous staff training
    • MISO-hosted TO applications facilitate data sharing
  – After-the-Fact Event Analysis and Dynamic Model Improvements in 2012
Project Highlights (cont.)

• Over 79% of targeted MISO SGIG PMU devices are verified and streaming data

• Data exchange with 16 TOs, PJM, NYISO, and TVA

<table>
<thead>
<tr>
<th>As of October 17th, 2013</th>
<th>TOs</th>
<th>PMUs</th>
<th>PDCs</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>Participating Stakeholders</td>
<td>16</td>
<td></td>
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<tr>
<td>Signatories to Master Services Agreement</td>
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</table>

| Target Devices | 254 | 40  | 294 |
| Streaming MISO SGIG Devices | 201 | 32  | 233 |

• Devices are deployed on highly available and secure infrastructure

• Working on enhanced data quality, reliable data transfer, archiving, and compliance processes
1. Initiate Project and Complete Pilot
   1.1 Initiate Project
   1.2 Create Baseline to Evaluate Performance
   1.3 Deploy MISO Test PDC
   1.4 Phase 2 Preparation

2. Application Integration
   2.1 Initial Application Deployment
   2.2 Phase 3 Preparation

3. Full Deployment
   3.1 Final Applications Deployed
   3.2 Business Continuity

4. PMU / PDC Deployment (all phases)
   4.1 Phasor Measurement Units (PMU)
   4.2 Phasor Data Concentrators (PDC)

5. Project Support (all phases)
   5.1 Project Management
   5.2 DOE Administration
   5.3 Reimbursement Execution
   5.4 Research and Development Partners
# Devices By Participant

<table>
<thead>
<tr>
<th>Transmission Owner</th>
<th>MSA Executed</th>
<th>MISO SGIG PMUs</th>
<th>Other PMUs</th>
<th>Streaming PDCs</th>
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<td>Ameren</td>
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<tr>
<td>Vectren (SIGE)</td>
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<tr>
<td>WAPA</td>
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<td>0</td>
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<tr>
<td>XCEL Energy (NSP)</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td><strong>17</strong></td>
<td><strong>201</strong></td>
<td><strong>111</strong></td>
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<td><strong>PROJECT TARGET</strong></td>
<td><strong>16</strong></td>
<td><strong>254</strong></td>
<td></td>
<td><strong>40</strong></td>
</tr>
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</table>
PMUs

- **Targets**
  - 254 PMU devices

- **Validated and Streaming**
  - 201 MISO SGIG PMU Devices, 111 Legacy devices

- **Transmission elements monitored**
  - 178 PMUs at 230 kV and above
  - 23 PMUs below 230 kV

- As of October 17th, 2013

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**PMU Devices by Transmission Owner by Year**

- 2011
- 2012
- 2013

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**Pie Chart**

- 230 kV: 28%
- 345 kV: 59%
- 115 kV: 5%
- 138 kV: 4%
- 161 kV: 2%
- 69 kV: 5%
- 500 kV: 1%

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**Bar Chart**

- AMRN
- Duke
- GRE
- HE
- IPL
- ITC
- MDU
- MEC
- MHEB
- MP
- NIPS
- OTP
- SIGE
- WAPA
- XCEL

PDCs

- 40 total PDCs under contract
  - 32 validated devices
  - 16 Transmission Owners have PDCs with contracts for Highly Available PDCs
- MISO has both a “local” and “regional” PDC
  - Local PDC receives transmission owner data
  - Regional PDC receives data from other Regional Entities
- Incorporating existing infrastructure, where applicable
  - Sampling rate of 30 Hz
  - Approximately 313 GB of data streamed per day
  - Majority of PDCs are above 99.9% availability
  - Less than 5% of data is lost due to prolonged issues

As of October 17\textsuperscript{th}, 2013
Data

• Data Quality
  – Existing WAN connections for internal transmission of data
  – 96% of data is Excellent
  – 4% of data lost due to long term or GPS issues
  – Data check process implemented to address quality issues

• Data Archive
  – Oracle-based archive solution
  – Designed to store at least 7 years of Phasor data
  – Redundancy and security
Operational Applications

Deployed enhanced solutions in production:

Centralized Situational Awareness
- *Enhanced Real-Time Displays (eRTD)*

Wide-Area Monitoring and Visualization
- *Phasor Point*
  - Oscillation Detection and Monitoring
  - Frequency Stability Monitoring
  - Voltage Stability Monitoring
  - Disturbance Detection and Alarming

After-The-Fact Event Analysis and Model Validation
- *Phasor Grid Dynamics Analyzer (PGDA)*
Operational Applications (cont)

• **Renewable Generation Integration**
  – Several PMUs near wind resources
  – Study affects of increased wind on system-wide small signal stability

• **Line Monitoring and/or Dynamic Line ratings**
  – Out of scope

• **State Estimation**
  – Plans to integrate data into EMS platform in the future
Centralized Situational Awareness

- Internally developed Enhanced Real-Time Displays (eRTD)
  - Aggregates alerts into a single display
  - Provides more information in less space at lower cost and higher flexibility
- Deployed in 2013 after parallel operations and staff training
- Correlates with EMS and stability monitoring alerts
Wide Area Monitoring and Visualization

• Uses PhasorPoint software
• Helps verify Phase Angles are within thresholds
• Helps alert operators when oscillations not being damped

• PowerTech Voltage Stability Assessment Tool (VSAT) and Transient Stability Assessment Tool (TSAT) monitor the dynamic state of the Grid
After-The-Fact Event Analysis and Model Validation

- Helps to understand system reaction to actual events by comparing dynamic responses to simulated responses
  - Diagnose problems and illustrate impacts to the area transmission system
  - Improve planning models and gain better efficiencies and protections
- University of South Florida working to automate the current manual process

Ringdown Analysis

<table>
<thead>
<tr>
<th>Square Butte – Arrowhead HVDC line trip</th>
<th>Voltage dip observed in simulation at restoration</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP FORBES 01.L500FORBTEFIV1.VM</td>
<td>66799 FORBES 2006</td>
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</table>

Electric Power Group, LLC Prepared by PGDA
Challenges and Lessons Learned

• Implementing a process to ensure the highest quality data is used in applications
  – Member data quality checks prior to streaming data
  – Availability and reasonability checks before the applications
  – Customizable, application-specific bad data detection
Project Next Steps

• **Value-Add Initiatives In-Progress**
  – Increase collaboration with Transmission Owners
    • Add additional PMU devices and highly available PDCs
  – Continued enhancement of Real-Time applications
  – Deploy a modeling tool to automatically analyze event data
  – Integrate phasor data from Entergy

• **Additional Opportunities**
  – Integrate data into the state estimator tool
  – Share data and collaborate with the entire Eastern Interconnection
  – Maximize data quality by incorporating mitigation and validation processes
  – Continue reliable data transfers and redundancy
  – Compliance processes and cyber security