DOE SGIG Projects – Our start to synchrophasors

• Began with two SGIG projects where we partnered with Virginia Tech, PJM, GPA, Quanta, and many more
  • Deployed 80 Relay PMUs installed across our 500kV network, covering more than 20 substations
  • Developed open source applications, including the LSE, negative sequence unbalance, and more
Finding applications and use cases

- Almost immediately we found additional use cases beyond the initial applications being developed
  - Equipment failures
  - Generator oscillations
  - Impact of arc furnaces on grid
  - GIC/GMD flows via monitoring transformer VAR consumption
  - Overall situational awareness of our grid and the EI
Providing use and value across the organization

- To date most of this is outside of our control center, in our engineering and support departments
  - This has been a success, as many departments are seeing value in the data, supporting many aspects of our business.
  - Synchrophasors are a critical complement to all our data sets, including SCADA data, power quality data, oscillography data, and any other data sets.
- Because of the core fundamentals of synchrophasors, we believed synchrophasors would be essential to the future of electric grids.
  - Observations and events continued to support this
  - We wanted to continue deployment to be ready whenever new users and use cases were realized
  - So we are building “the field of PMUs”
Standardization – Inside the substation

• Standardized synchrophasors inside Transmission Substations.
  • New digital relays installed for protection had PMU capability built in, just needed a few other components
  • Found the cost to do this are typically less than 1% of the overall project costs.
  • We didn’t have all the servers and personnel in place to fully support all these, and we are continuing to build that.
    • But the most difficult part to this is the substation work (outages, planning, coordination)
    • Doing this PMU work during projects prevents a lot of additional work and saves on costs
Standardization – Outside the substation

- We continued “standardization” outside the substation
  - New synchrophasor course in our relay technician training program
  - Installed real-time synchrophasor displays in common areas of a few of our engineering offices
    - Allows us to easily explore, learn, and improve visualizations for grid situational awareness
    - Found certain visualizations can provide fundamental support to the operators
      - System wide voltage trends show step changes in voltage when equipment switch in/out (ex: cap bank)
      - Operator gets immediate verification of a control decision made
Standardization – Outside the substation

- Precise Timing
  - Working to improve our substation and overall timing architecture to be more reliable and highly available
  - Continuing to become more and more important for all the digital systems being installed
- Communications networks from substation to control center
  - Synchrophasors increased our bandwidth usage
  - Working closely with Telecom personnel to improve overall performance across the entire network
- Expansion into other departments & business units
  - Fault Analysis, System Operations Center
  - Distribution
  - Generation (traditional and distributed)
- Analytics & Real-time Control Applications (openECA)
Dear Mr. Jones,

Welcome to The Sheraton Springfield Monarch Place! We are delighted to be hosting you and all other attendees visiting us for NASPI 2017! We got word that you are a COOKIE MONSTER, so we thought you'd appreciate this gift to hold you over while you are away from home!! Don't tell anyone, but there may be a few more cookies in your future over the next few days at the conference, just remember to share! Enjoy!

Best,
The Management & Staff of The Sheraton Springfield
openLSE

- Core libraries: https://www.github.com/kdjones/linear-state-estimator
- openLSE: https://www.github.com/kdjones/openlse
- Features and Improvements:
  - Installation Package
  - Self-hosted
  - Integrated directly with openECA
  - Improved modeling and troubleshooting tools
  - Modeling workflow automation
openECA Demonstration Day

- Dominion is hosting an openECA Demonstration Day on November 8, 2017
  - Presentations and Poster-Demo Session
  - See me today or email me at kevin.d.jones@dominionenergy.com if you are interested in attending.

- Project Provided Analytics
  - Linear State Estimation
  - Oscillation Detection Monitor (ODM)
  - Oscillation Mode Meter (OMM)
  - Topology Estimation
  - Regional VAR Control
  - Local VAR Control
  - PMU Synchroscope
  - PMU Transducer Calibration
  - Line Parameter Estimation
  - Impedance Calculator
  - Synchronous Machine Parameter Estimation Acceleration Trend Relay (ATR) Improvement
If you build it, they will come.
Return on Synchrophasor Technology is Exponential

* Channel count is not solely an effective metric for determining value potential.
Return on Synchrophasor Technology is Exponential

PMU Channel Count \times \text{Normalized Accessibility} \times \text{Historical Volume} \times \text{Experiment Count}
The 10X Rule of Innovation

- Succinctly stated, a technology is only worth investing in if it provides an order of magnitude improvement over existing technologies.
- Is synchrophasor technology 10 times better – in key dimensions – that anything other streaming grid telemetry?

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Existing</th>
<th>Synchrophasors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame resolution</td>
<td>1 frame/sec</td>
<td>30/60/120/240 frames/sec</td>
</tr>
<tr>
<td>Timestamp variance</td>
<td>$10^0$ seconds</td>
<td>$10^{-6}$ seconds</td>
</tr>
<tr>
<td>Value</td>
<td>Scalar</td>
<td>Vector</td>
</tr>
</tbody>
</table>
Macro Trends: Demand For Information Density

• Using higher precision data to understand and control complex systems.
  • Microscopy
  • DNA sequencing
  • Medical Imaging
  • Satellite Imaging
  • Quantum [anything]
The Application Space is Large and Documented
Supporting Organizations in the U.S.

- Department of Energy (DOE)
  - https://www.smartgrid.gov/recovery_act/program_impacts/applications_synchrophasor_technology.html
- The North American Synchrophasor Initiative (NASPI)
  - https://www.naspi.org/home
- The Joint Synchronized Information Subcommittee (JSIS)
  - https://www.wecc.biz/OC/Pages/JSIS.aspx
- NERC Synchronized Measurement Subcommittee (SMS)
“Two Virginia Tech electrical engineers named among the greatest in science, engineering, and technology in the world” - Virginia Tech Engineering News

https://www.fi.edu/laureates/arun-phadke
https://www.fi.edu/laureates/james-thorp
If you build it, they will come.
Data is an “Asset”

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