Duke Energy Carolinas
Smart Grid Investment Grant Update

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NASPI Work Group Meeting
October 22-24, 2013

ARRA disclaimer

- **Acknowledgment:** This material is based upon work supported by the Department of Energy under Award Number(s) DE-OE0000374

Project participants

- Duke Energy Carolinas
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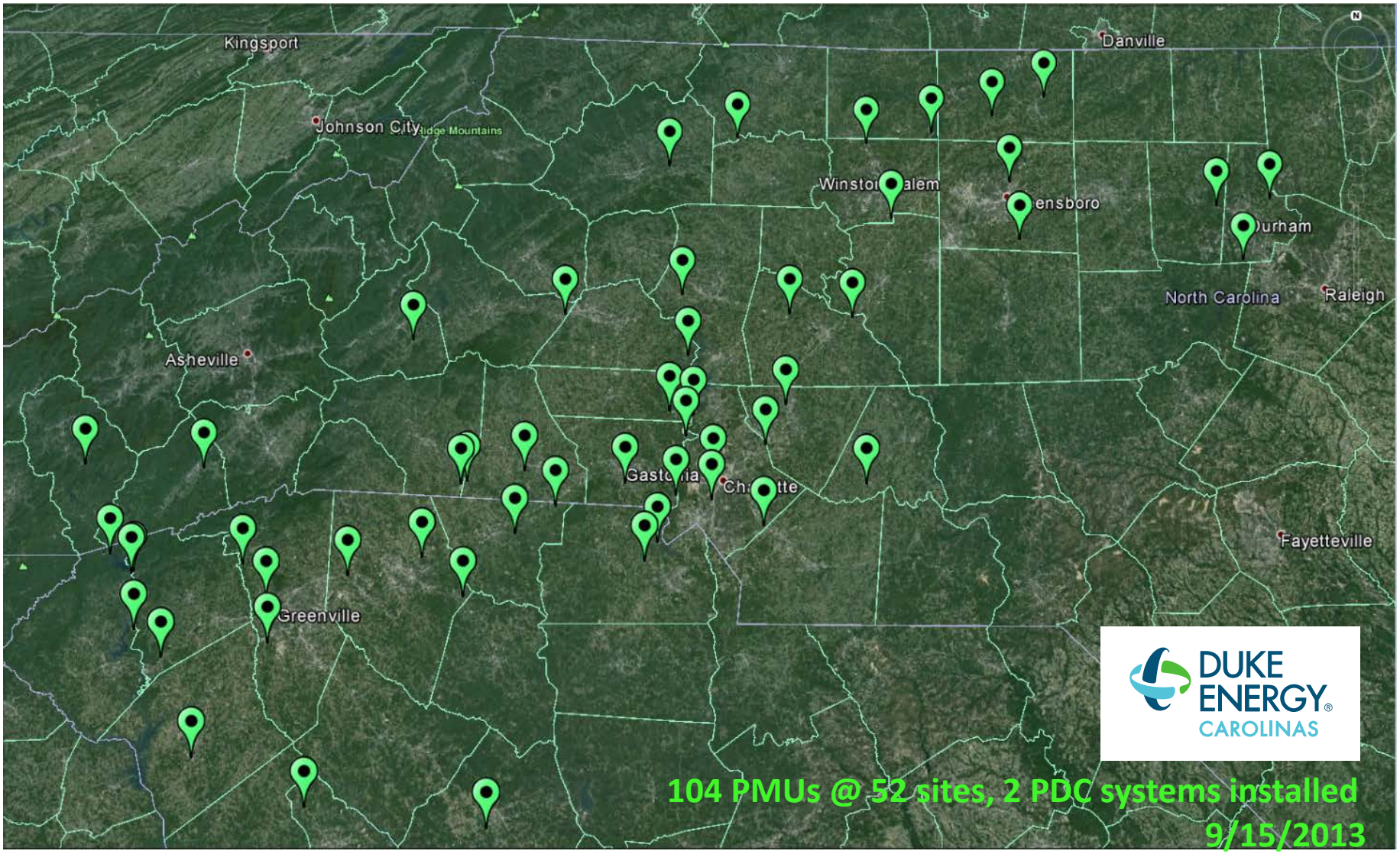
- Vendors: Alstom Grid, SEL, Cisco, OSIsoft, GPA, EPG

Project Map


Kingsport
Johnson City
Danville
Asheville
Greenville
North Carolina
Raleigh
Fayetteville
DUKE ENERGY CAROLINAS
104 PMUs @ 52 sites, 2 PDC systems installed
9/15/2013

BIG PICTURE

Project Priorities From Here?

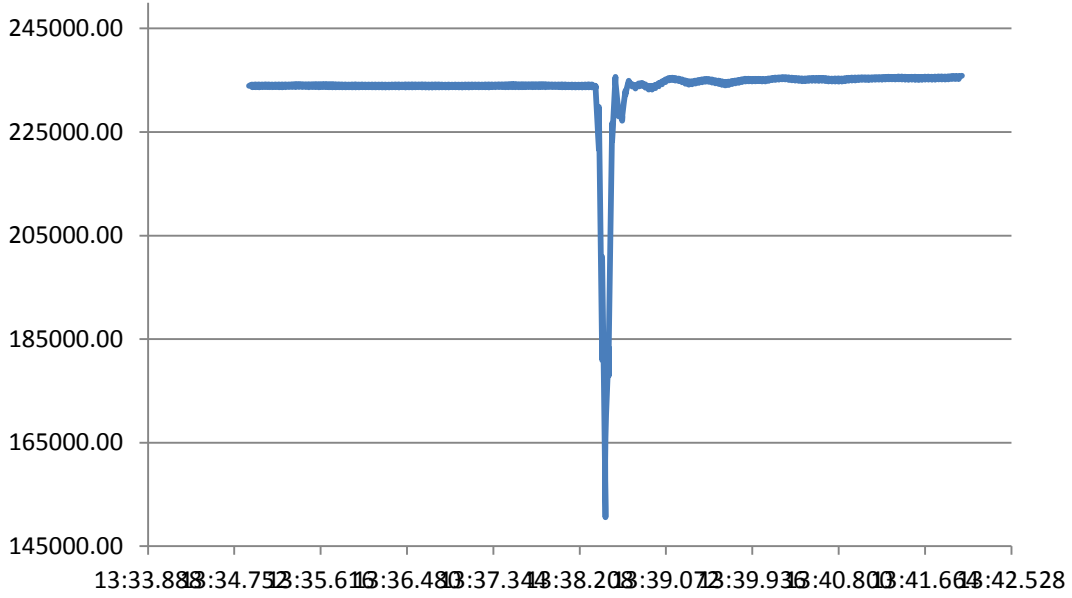
- Important tasks and applications ahead
  - Baselining and meaningful alarms
  - Rolling out synchrophasor applications to operators
  - Encouraging use of phasor data in event analysis process
  - Inclusion of PMU installations in new Interconnection Agreements
- Control Room Usage
  - Visualization software deployed spring 2014,will include alarms sent to EMS
  - Integration with State Estimator
  - Redundant measurements in SCADA applications
- Planning Usage
  - Event analysis
  - Model tuning

Project Priorities Cont'd

- What outcomes will mean success by the end of 2015?
  - User acceptance
  - Integration of phasor applications into daily routines and event analysis
- What are the key obstacles?
  - Lack of "killer" applications that are production ready
  - User acceptance

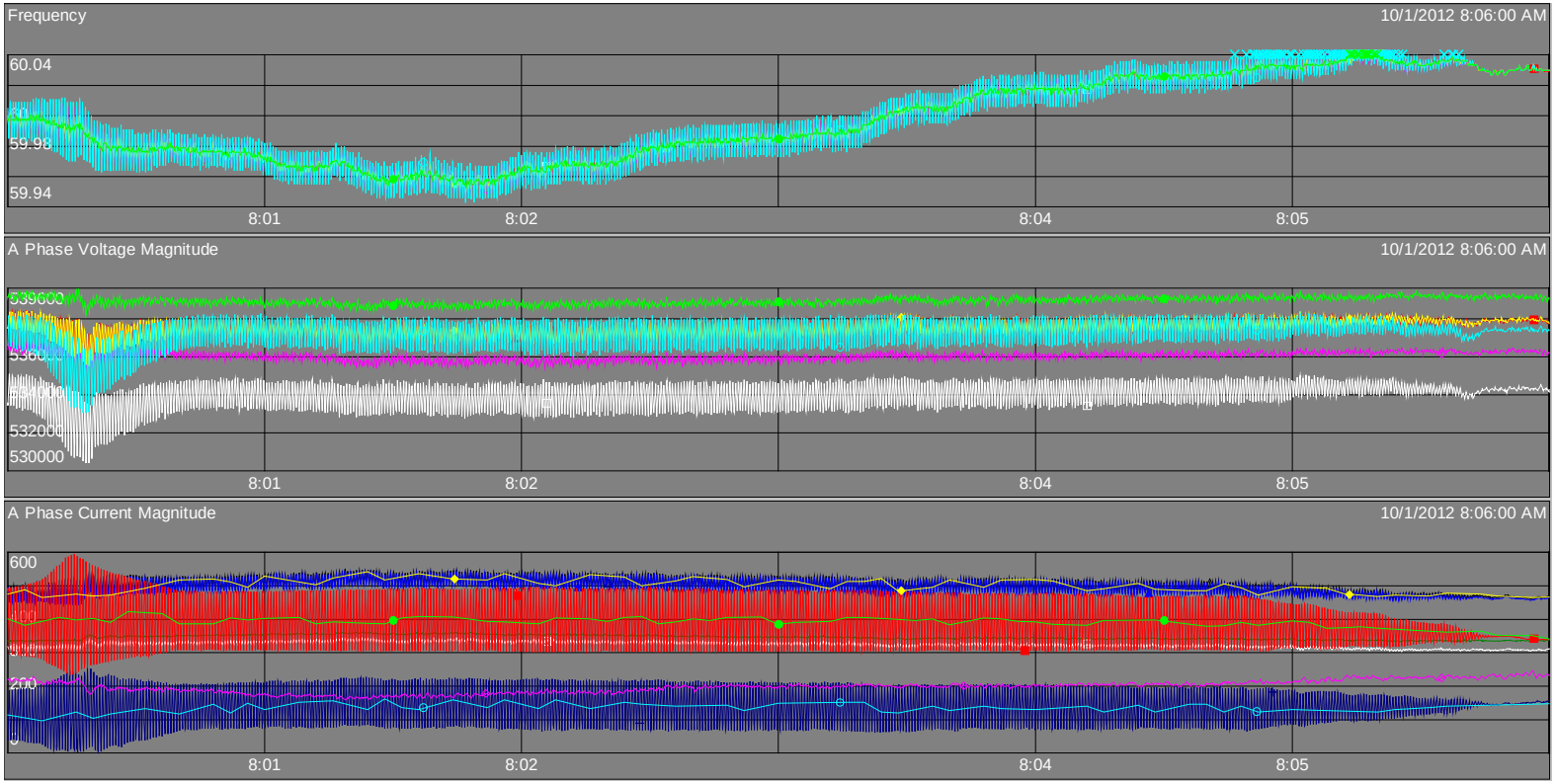
Success Stories

- A unit's control system (AVR) misbehaved as a result of a low voltage transformer fault. The plant wanted to know how low the voltage dipped and could not see via SCADA. Using phasors, we were able to determine the voltage on the 230kV dipped to 150.6kV momentarily, well outside the control system tolerances.



Success Stories

- A nuclear station reported MW oscillations created by the Transmission System when the 500/230kV transformer at a nearby station was outaged. Using the PMU data, we were able to determine that a nearby hydro unit was oscillating and use this information to tune some setpoints within the units to limit the oscillations.



Success Stories

- Lightning initiated an event where a 100kV breaker was slow to trip, causing a fault to stay on the system for 2 seconds. As a result, the 230 to 100kV transformers at the station tripped by overload and Zone 2 protection was engaged. In addition, a tree was found in a portion of the cleared 100kV lines leaving the station. The magnitude and time duration of the fault was accurately captured by PMU data, making analysis more efficient.

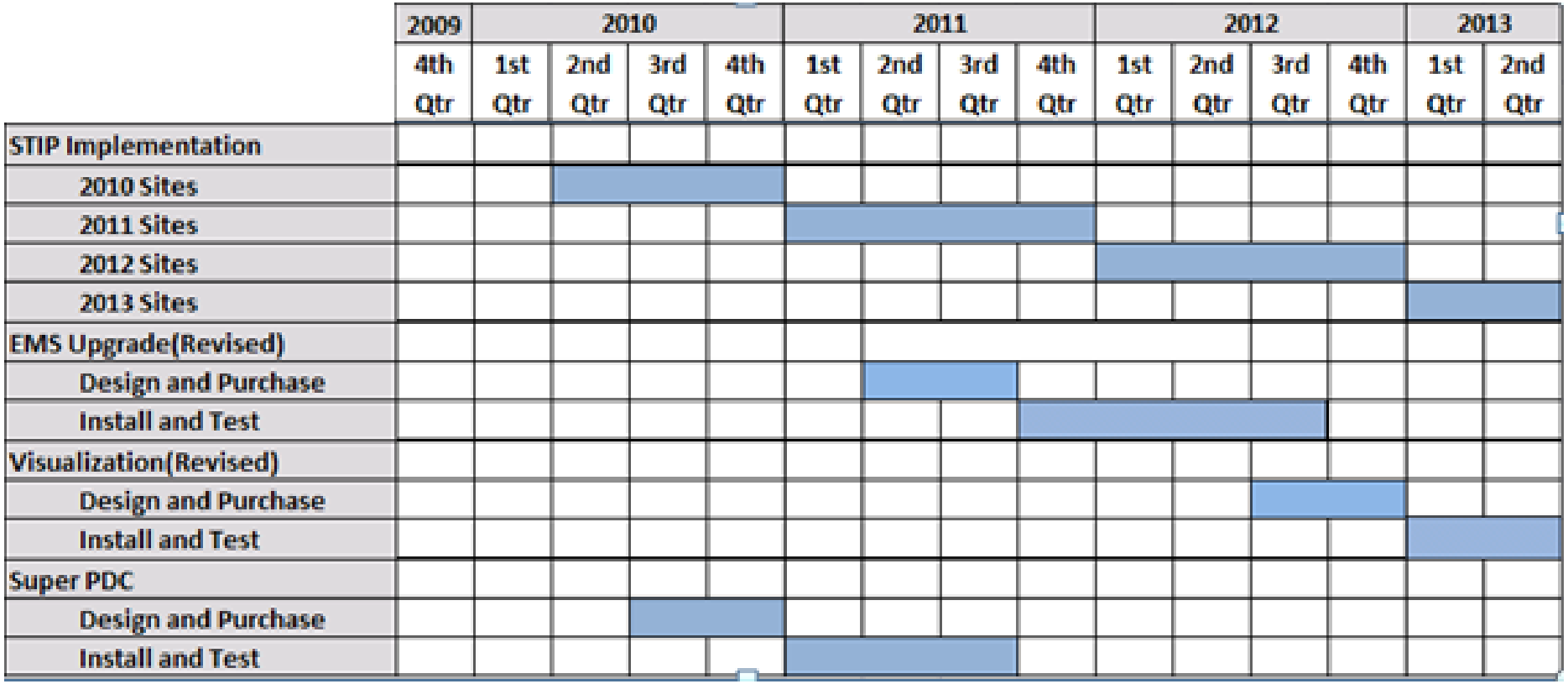
Challenges and lessons learned

- What have been your biggest technical challenges to date?
  - Complex network architecture
- What have been your biggest programmatic or execution challenges to date?
  - Coordination between field personnel and engineering groups
- Other lessons or insights about
  - PMU and PDC Performance – Data flags showing “valid” don’t always mean data is good quality
  - Frequency of new software releases – PDC and Applications
  - Communications system design and performance – High availability has been designed in-house because many vendors have not considered yet; UDP protocol worked best for us because of latency
  - Interoperability – sometimes challenging to integrate different vendors’ tools because of proprietary software
  - Physical or cyber-security – Need to be ready to accommodate ever-changing requirements
  - Data archiving – Difficult to anticipate necessary storage size with compression tuning parameters
  - Time Synchronization – COAX cable limitations
- Research needs – Analysis performed by back-hall operators transitioning to real-time applications that can be used by the control room operators to increase situational intelligence

Synchrophasor Training

- General training on Phasor Technology, specialized on Visualization and Post-Event Analysis tools
- Training Operators, Engineers, and Planners separately
- General training provided in pre-scheduled quarterly sessions (not phasor specific). Specialized training provided as needed (about a day per application).
- Developed by in-house phasor SME's
- Currently no shareable training information

Project Timeline



Phasor data-sharing

- Currently not sharing in industry because edge device not yet installed, plan to share in the future
- Sharing some data for research purposes
  - Universities and Data Analytics companies
  - Various projects including baselining, fault location, stability analysis, situational intelligence, generator model validation

DETAILS

PMUs

- 1 transmission owner with total 104 PMUs
- Transmission elements monitored by PMUs
  - 13 elements @ 500kV
  - 91 elements @ 230kV
- 100% of regional load footprint monitored by PMUs
- 52 substations with PMUs
- PMU installation rate
  - 104 installed by EOY 2013

PDCs and Communications

- PDCs
  - 2 RC/BA/TO control centers with PDC Systems
    - primary and contingency locations
  - 0 field PDCs
  - PDC availability rate 99.98%
- Communications system
  - Using IP over T1 lines, network predominantly Duke Energy owned with a few leased circuits
  - Plan to Install a Phasor Gateway Device
  - Communications system availability rate 99.75%/year

Communications and data

- Data flows and speeds
  - Phasor data 30x/second to PDCs
  - PDCs streaming UDP to centrally processed phasor applications and using Alstom ISD to EMS
  - All data flowing to the archive in real time and at least 7 day “buffer” on PDCs
- Data storage
    - Allocated 80 TB of SAN for phasor projects (40/site)
    - Plan for 3 years of data to be readily accessible, with event files archived
    - We currently have the data going to PI, which all our users can access easily
    - Total volume of data being generated by your phasor data system
      - 30x/second
      - 104 PMUs; A,B,C,+ phases monitored/PMU; ~20 data points measured per sample, plan to have ~8 data points calculated per sample (MW/MVAR)
      - Storing about 12GB/day (compressed), works out to 4.3 TB/year

Data quality and availability

- 99.8% of PMUs delivering good or better quality data
- 99.8% of PMUs delivering timely data
- >99.6% of good, timely data relative to total data flow possible
- Issues: Settings in the PDC, PMU clock settings, Protocol limitations
- Lessons Learned: Don’t try to do it all yourself, talk to your vendor and industry contacts

Major operational applications using phasor data

- Wide-area situational awareness (Visualization)
  - RTDMS by EPG
  - Plan to deploy in control room Spring 2014
  - Operational August 2013
- Post-Event Analysis & Model “Validation”
  - PI Processbook
  - PGDA by EPG
  - Operational August 2013
- State estimation
  - Alstom EMS
  - Operational December 2012 (after upgrade to 2.6 Platform)

All applications are being currently deployed to our operations support engineers. We plan to have them in the control room Spring 2014.

Questions?