Operationalizing Synchrophasor Technology at PG&E

NASPI Workgroup Meeting
September 26th 2017
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PG&E

• There are approximately 20,000 employees who carry out Pacific Gas and Electric Company's primary business.

• The company provides natural gas and electric service to approximately 16 million people throughout a 70,000-square-mile service area in northern and central California.

• Service area stretches from Eureka in the north to Bakersfield in the south, and from the Pacific Ocean in the west to the Sierra Nevada in the east.

• 106,681 circuit miles of electric distribution lines and 18,466 circuit miles of interconnected transmission lines.

• 5.4 million electric customer accounts.

• 7,681 MW generation capacity (hydro, nuclear, fossil, and solar).
PG&E Synchrophasor Program History

- **PG&E Project Development and Proof-of-Concept (POC)**
  - PG&E will participate in WECC wide project meetings and conference calls to coordinate its Synchrophasor project with other WISP participants to leverage areas of expertise and mutual collaborations.
  - PG&E will perform a proof-of-concept to validate interoperability, compatibility, and data integrity of various vendors’ equipment that PG&E intends to use. Real-time Digital Simulators (RTDS) and test equipment will allow PG&E to test various operator and engineering tools.
  - PG&E will perform comprehensive system studies to determine the locations for PMUs, the phasor data concentrators and super phasor data concentrators based on a series of criteria including availability of PG&E’s network.

- **PMU and PDC Deployment**
  - PG&E will design, procure, install and test phasor measurement units and phasor data concentrators at existing electric transmission substations within their service territory.
  - PG&E will use a combination of existing equipment and new equipment.
  - PG&E will upgrade its existing telecom infrastructure to handle the added traffic of transmitting phasor data from substations to its control centers.

- **Data Storage and User Applications**
  - PG&E will store phasor data for both real time (or near real time) operational use and for operational basis, training, system planning, engineering and post disturbance analyses.
  - Storage capacity will be installed at PG&E control centers.
  - PG&E’s existing energy management system will be enhanced to include phasor data into the state estimator and situational awareness systems.
  - PG&E will develop new engineering tools taking advantage of the new phasor data.
  - PG&E synchrophasor system shall be designed to allow applications and functions to be added in the future.

- **Data Sharing**
  - PG&E will collaborate with its neighboring utilities, the CAISO and WECC to gather any additional phasor data to support the operation of the PG&E transmission system. Specifically, the project includes integration of the synchrophasor data from neighboring systems such as BPA, SDG&E, SCE, APS and IPC to engineer solutions for grid monitoring and training tools for PG&E’s system operation and engineering. The footprint for PG&E’s project covers the Pacific AC and DC systems surrounding PG&E and includes monitoring of critical 60kV, 115kV, 230kV, 345kV, and 500kV systems.
  - PG&E will provide an interface for WECC to make use of the phasor data. PG&E is assisting WECC in evaluating alternative solutions that would support data format provided by PG&E. However, WECC is responsible for any data format conversions if data conversion becomes necessary.
PG&E Synchrophasor Program History
PG&E Synchrophasor Deployment Today

- **Transmission**
  - PMUs in 21 substations
  - 202 PMUs, 101 redundant measurement locations
  - 24 Substation PDCs, 12 redundant locations
  - 4 control center PDCs, 2 redundant locations
  - 4 redundant Archives
    - openHistorian, PhasorPoint archive – Hitachi Direct Connect SAN 60 TB (2) 120 TB (2)

- **Generation**
  - 3 PMUs, one each generator at combined cycle plant
  - 1 PDC
  - Archive OSIsoft PI, openHistorian, SEL SynchroWAVE
  - Visualization, SEL SynchroWAVE, open source Grafana

- **Transmission Operations Synchrophasor Test Lab (TOSTL)**
Architecture Transmission
Transmission PMUs and PDCs
Data Availability effort

• Simplify data path
  • Identify all data paths
  • Move point to point paths inside control center where possible using GPA Synchrophasor Stream Splitter

• Switch protocol
  • Switch from IEC 61850-90-5 to IEEE C37.118-2005 Substation PDC to Control Center
  • Switch from UDP Multicast to TCP/IP Unicast

• Review naming convention
  • Internal naming convention consistent and usable
  • Comply with WISP naming convention for sharing data with Peak RC and other entities

• Deploy data availability measurement tools

• Regular interaction with network communication group

• Attend Monthly Peak RC SPDQ meeting
Understand how your architecture effects your availability statistics

The PDC “hides” data availability problems
Availability issues at location 1 appear as data errors at location 2
Availability issues at location 2 are unchanged at location 3 but appear as data errors at location 4
Availability issues at location 2 cause all the PMUs reporting to PDC A to have the same availability issues as seen by PDC B or the PDQTracker
Data Availability 98.21% what does it mean?

• 60 Hz sample rate delivers 5,184,000 samples per day
• An availability of 98.21% means 92,793 samples did not get delivered
• To address the dropped data frames you need to know how they are distributed
Discrete time slices
Spread out over entire day (4407 data errors)
Data to Peak RC

Improvements
## Availability Today

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Previously only 2 PMUs were being sent to Peak RC with availability around 60% and a latency of almost 20 seconds.
Generator Model Validation

Colusa Combined Cycle Plant
Architecture Generation
RAS Event 4-6-2017 (Colusa P, Q, V, and F)
RAS Event 6-23-2017 (Colusa P, Q, V, and F)
MathWorks Simulink Modeling and Parameter Estimation Tool
MathWorks Generator Model
6-23-2017 RAS Event: CTG-1 Original Parameters vs PQVF Optimized Parameters
BPA PDCI Modulation Test 6-6-2017
Ringdown: Malin – Round Mountain #1 500 kV Line
Ringdown: Los Banos – Midway #2 500 kV Line
PhasorAnalytics: Frequency Response
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