DOE/OE Transmission Reliability Program

Distribution PMU Scoping Study

Joseph H. Eto
Emma Stewart

Lawrence Berkeley National Laboratory

Travis Smith
Mark Buckner

Oak Ridge National Laboratory

Harold Kirkham
Francis Tuffner

Pacific Northwest National Laboratory

David Schoenwald

Sandia National Laboratories

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Overall project objective

- To assess potential uses and benefits of installing phasor measurement units (PMUs) within electricity distribution systems; and

- To identify the associated research and development that is required to realize these benefits.

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Looking back

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Scoping Study on Research and Development Priorities for Distribution-System Phasor Measurement Units

Joseph H. Eto
Emma Stewart
Lawrence Berkeley National Laboratory

Travis Smith
Mark Buckner
Oak Ridge National Laboratory

Harold Kirkham
Francis Tuffner
Pacific Northwest National Laboratory

David Schoenwald
Sandia National Laboratories

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Challenges in distribution

- Customer expectations regarding reliability and power quality are getting higher
- There are more and growing amounts of Distributed Energy Resources in distribution
  - Bi-directional power flow
  - Can trip off, causing frequency or voltage problems
  - Unanticipated loading
- The electrical behavior of load is changing
- The design of distribution is radial so more monitoring/measurements points may be required – at same time, lower revenue per circuit mile (compared to transmission) cannot justify high monitoring costs

To address how PMUs might “play into” the situation, we looked at several Case Studies

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Method

- How (and for what purposes) does **monitoring** presently take place in distribution systems?
- Are present approaches to distribution system monitoring **adequate**?
- If not, why not, and what **role(s)** might **PMUs** play in addressing present inadequacies?
- Do PMUs represent a **superior approach** compared to other alternatives?

And finally

- **What**, if anything, should the U.S. **Department of Energy** (DOE) do to change the present state of affairs?

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Scoping Study Use Cases

- Automated system reconfiguration
- Controlled islanding
- Planning (modeling) for high DER penetration
- Voltage fluctuations and voltage ride-through associated with interconnection of distributed generation and energy storage
- FIDVR detection

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Toward future distribution PMU use cases (1)

- System Operation (normal)
  - 1. Active management of distributed energy resources
  - 2. Monitoring of the performance of the power system itself
  - 3. Control of voltage in the power system
  - 4. State estimation/power flow
  - 5. Reconfiguration of the system for loss reduction or system management
  - 6. Thermal and health monitoring of devices

- System Operation (faulted)
  - 7. Coordination with relaying (especially reverse power flow)
  - 8. Detection of outages and location of faults (including high impedance)
  - 9. Reconfiguration of the system following a fault
  - 10. Islanding (microgrid) detection and operation
  - 11. FIDVR detection and remediation
  - 12. Oscillation (forced or resonant) detection

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Toward future distribution PMU use cases (2)

- Diagnostics and Modeling, (non-real-time functions)
  - 13. Power quality monitoring
  - 14. Model parameter validation
  - 15. Forensic analysis of events or abnormal system conditions
- Planning (also off-line, but has a specific and narrow purpose)
  - 16. balancing of loads for optimal system operation
  - 17. collecting load data for system planning
  - 18. analysis of dynamics (including state estimation)

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Why and How DOE should be involved

National interests are served by deployment of distribution PMUs (reliability, sustainability, efficiency)

Appropriate roles for DOE R&D on distribution PMUs

- Not R&D on devices: PMUs are a relatively mature technology
- Standards, testing/calibration
- Demonstrations with utility hosts
- Information sharing (e.g., NASPI)

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Issues that remain to be addressed

- Technology for PMU is mature - but needs to be cheaper and more easily deployable (i.e. like hot stick mounted devices)
- Distribution PMU latency reduction might be needed; there is a need for data streaming architectures
- PT's and CT's are not as accurate as the device

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Looking forward – related activities

- NASPI Distribution PMU task team formed in Spring 2016

- NETL FOA 970 has funded Hawaii Electric Co to demonstrate distribution PMUs to support PV integration
- DARPA program for distribution PMU on all military bases for resilience applications (RADICS)
- ENERGISE – a recent SunShot solicitation - highlighted the distribution PMU as a new solution for DER control

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Looking forward – follow-on (LBNL)

- ARPA-e distribution PMU project of which LBNL is a part has been extended
- OE PSERD has funded LBNL
  - to work with Riverside Public Utility to demonstrate distribution model validation with distribution PMUs; and
  - to work with Philadelphia Navy Yard Microgrid to deploy distribution PMUs and demonstrate analytics
- GMLC (LBNL is leading)
  - 1.4.9: a multi-lab team will develop distributed machine learning analytics using distribution PMU and building data (ANL, LANL, LLNL, NREL, ORNL, SNL)
  - GMLC Category 2: ADMS platform application project for control of distribution assets, with distribution PMU as data source (NREL, SNL)

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Looking forward – follow-on (LBNL)

- GMLC (supporting LANL)
  - Category 2: Transmission reliability - Machine learning application of distribution PMU for transmission level analytics of frequency event and aggregate load modeling
- GMLC (Supporting PNNL)
  - Category 2: AGRM - load modeling with distribution PMU data
- Sunshot SuNLaMP (LBNL is leading)
  - CyDER integrates distribution PMU data into interconnection process (with LLNL and PG&E)

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Looking forward – follow-on (ORNL)

- GMLC category 1 – Advanced Sensors has funded three ORNL projects:
  - Next generation PMU with National Instruments FPGA
  - GridEye distribution PMU implementing SmartSenseCom passive optical CT/PT sensors
  - Demonstration of PMU based distribution system step distance protection using passive optical SmartSenseCom CT/PT sensors

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Looking forward – follow-on (PNNL)

- GMLC 1.3.9 – Idaho National Laboratory, supported by PNNL and Washington State U:
  - Utilize distribution-level PMUs and reconfiguration switch-gear to improve the Idaho Falls, ID power system's resilience to transmission and distribution-level events

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Looking forward – follow-on (SNL)

- Microgrid Project (with NMSU) funded by OE/PSER&D
  - Adaptive protective relaying for microgrids
  - Possible use case for distribution PMUs in protection
- GMLC Projects (supporting LBNL)
  - GMLC 1.4.9: Distributed analytics for grid management. Project will leverage distribution PMUs as a data source for analytics.
  - GMLC Category 2: Community control of distributed assets for wide-area reserve provision. ADMS platform design will incorporate distribution PMU data.

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