Office of Electricity Delivery
and Energy Reliability
Smart Grid R&D Program

Summary Report:

2014 DOE Resilient Electric Distribution Grid R&D Workshop

June 11, 2014

Upton, New York

Acknowledgment

The U.S. Department of Energy (DOE) acknowledges the support provided by the organizations represented at the Resilient Electric Distribution Grid R&D Workshop. The report content is based on the workshop session discussions, with session summary descriptions taken from the report-out presentations by individual teams during the closing plenary. Contributions to this report by all workshop participants, via expressed viewpoints during the workshop and review comments on the draft report, are duly acknowledged. The preparation of this workshop report was coordinated by Energy & Environmental Resources Group, LLC (E2RG).

This workshop was sponsored by the DOE Office of Electricity Delivery and Energy Reliability and hosted by DOE's Brookhaven National Laboratory in Upton, New York.

Workshop Summary

The U.S. Department of Energy (DOE) Office of Electricity Delivery and Energy Reliability (OE) held the Resilient Electric Distribution Grid R&D Workshop on the morning of June 11, 2014, at DOE's Brookhaven National Laboratory (BNL) in Upton, New York. The objective of this half-day workshop was to engage stakeholders to identify an initial set of R&D needs and associated R&D projects critical to enhancing electric distribution grid resilience to natural disasters. The resulting set of needs and projects from the workshop will be further defined and developed by the DOE into a full program plan in 2015 to guide future investments by the Smart Grid R&D Program. The full program plan will incorporate information gathered for the 2015 Quadrennial Energy Review (QER) Report, as pertaining to resilient electric distribution grid R&D.

The workshop was held opportunely in between two other events with gatherings of key stakeholder groups in electric distribution grids. The preceding event was the Workshop on Resilience Metrics for Energy Transmission and Distribution Infrastructure that was sponsored by the DOE Office of Energy Policy and Systems Analysis, which leads in the DOE QER effort. The ensuing event was the DOE Smart Grid R&D Program 2014 Peer Review meeting. Registrants for this workshop could also register for these two joining events.

The workshop began with a host welcome by Dr. Gerry Stokes, Associate Laboratory Director – Global and Regional Solution, at BNL. Mr. Dan Ton, Acting Deputy Assistant Secretary of Power Systems Engineering Division, DOE's Office of Electricity Delivery and Energy Reliability (OE), briefed on the emergence of enhanced resilience as a focus area of increasing emphasis within the OE. The resiliency focus area directly supports the OE's lead role in implementing the DOE Climate Action Plan strategy in the following three areas: supporting communities as they prepare for climate impacts; grid expansion and modernization; and rebuilding and learning from hurricane Sandy. He then provided an overview of the workshop, including the purpose and the agenda, followed by introduction of the four panelists on an opening plenary.

The plenary panel comprised subject area experts representing utilities, national labs, and academia. The panelists presented on current and best practices, current capabilities and ongoing R&D, and gaps and benefits, all relating to resilient electric distribution grids. Their presentations (available via the web links on each presentation title below) were delivered in the following order:

- Electric Distribution Resiliency for Major Storm Events, Mr. Edward Gray, PE, Director-Transmission and Distribution Engineering, Public Service Electric and Gas Company
- The Future Grid: Engineering Dreams, Dr. Craig Miller, Chief Scientist, Cooperative Research Network, National Rural Electric Cooperative Association
- Electric Power Distribution System Resilience: Federal Government and National Lab Perspective, Dr. Russell Bent, Los Alamos National Laboratory (LANL)
- R&D Needs in Resilient Distribution Systems, Professor Chen-Ching Liu, Energy Systems Innovation Center, Washington State University

The workshop then proceeded into two concurrent breakout sessions, each moderated by a national laboratory expert on a different set of R&D topics. The moderators generally followed a similar process in session discussions, which began with brainstorming on critical R&D needs, followed by voting to determine the top R&D needs, and then, for each top R&D need,

brainstorming on and/or determining the top R&D projects in support of the need. The topics for each breakout session are listed below, along with the session moderator and scribe:

Breakout Session 1: Design and planning for a resilient electric distribution grid (Moderator: Dr. Russell Bent, LANL; Scribe: Mr. Mustafa Biviji, E2RG)

Breakout Session 2: Operational response and system recovery R&D (Moderator: Dr. Jean-Paul Watson, Sandia National Laboratories (SNL); Scribe: Dr. Cesar Augusto Silva Monroy, SNL)

The workshop concluded with a combined session in which the session moderators reported the summary of their session discussions to the entire group. The report-out presentations (1, 2) and session discussion notes (1) are summarized in the section Breakout Session Findings below.

Mr. Ton thanked the attendees and indicated that this workshop report will be made available to all attendees, including all presentations at the workshop. He further stated that follow up with the attendees would be done to further define and develop the R&D needs and projects resulting from this workshop.

The workshop was open to all interested parties, with a total of 85 registrants representing vendors, utilities, national laboratories, universities, research institutes, and end users.

Breakout Session Findings

The R&D needs and the R&D projects in support of each top-3 voted need, identified from Breakout session 1, are listed in Table 1, in priority order. The votes casted by attendees to determine the top-3 R&D needs are shown in parentheses; similarly, the votes casted to show the top-2 R&D projects for each top-voted need are also shown in parentheses.

Table 1. R&D Needs and Projects Identified from Breakout Session 1 - Design and Planning for a Resilient Electric Distribution Grid

Breakout Session 1: Design and Planning	
R&D Needs	**R&D Projects**
1. Design of segmented and agile distributed system (18-20 votes)	1. Emergency controls, segmentation, communications (14 votes) – Tools for adaptive settings 2. Microgrid to feeder integration (11 votes) Others: • Economical protection scheme: Affordable hardware (10 votes) • Load participation/prioritization (9 votes) • How to have an economical changing typology? (7 votes) – N-1 does not capture… fundamental problem: Design operation awareness • Define microgrid/classes/types/markets (5 votes) • Why are we doing it … What is the policy?

Breakout Session 1: Design and Planning	
2. Big data & analytics (16 votes)	1. Multi scale modeling: DIST+TRANS (16 votes) 2. Real-time database – speed (15 votes) Others: • Data validation & dealing with uncertainty (14 votes) • Open database (13 votes) • Power flow solving (10 votes) – Real-time stochastic/stackable power flow • Data reduction (8 votes)
3. **Stochastic and uncertainty (15 votes)**	1. Robust control to uncertain data (18 votes) 2. Predictive models (13 votes) – Threats – Loads – Assets – Real-time data Other: • DER/Renewable/ uncertain generation (10 votes)
Other R&D needs identified: • **Protection, power electronics and switching control – hardware (15 votes)** • **Resource management – inventory/crews and operator preparedness (8 votes)** • **Impact assessment (9/10 votes)** • **Interdependency architecture with fuel supply (2/3 votes)**	

Breakout session 2 comprised brainstorming the R&D needs, consolidating similar R&D needs into one, and then applying a range of 1-5 to represent the total votes cast (with 5 being the most votes). Afterward, for each top-voted need, R&D projects were discussed, but without determination of their relative priority. Table 2 below lists the R&D needs, in voting order, and the associated, unprioritized R&D projects.

Further, breakout session 2 had general discussions on operational assessment and response; these discussion notes are included in the report-out presentation.

Table 2. R&D Needs and Projects Identified from Breakout Session 2 - Operational Response and System Recovery

Breakout Session 2: Operational Response and System Recovery	
R&D Needs	**R&D Projects** (unprioritized)
1. Proactive assessment of damage (automated calls to customers, smart meters) (5, tied with the need below) **Related need:** • **Technologies for rapid damage assessment to facilitate rapid recovery**	• Damage assessment • UAVs to support real-time Google maps • Meteorological tools at micro level (e.g., real-time Google maps/street view) • Low cost ubiquitous monitoring devices • New devices to support degradation identification • Harden communications
1. Situational awareness (5, tied with the need above) **Related needs:** • **State estimation under disrupted conditions** • **Open architecture to allow visualization of event information from multiple information systems in utilities (crews on the field, SCADA, DMS, etc.).** • **Platform for situational and state awareness to coordinate first responders including fire crews, etc.; Technologies for coordination.**	• Develop architecture ▪ to interface with E911 platform used by first responders ▪ integrated with ubiquitous monitoring devices ▪ demonstrated via testbed • State estimation with new data and new devices • Cyberphysical degradation, and the necessary understanding when it occurs to respond to it • 3-phase state estimation
2. Decision support to determine restoration priorities (4 for 1st vote casting, 13 votes from 2nd casting*) **Related needs:** • **Automated analysis for optimal decision support** • **Restoration process simulation to determine optimal recovery best-practices and play-back of previous event for crew training** • **Advancing (cost-effective) automation of distribution system operations** • **DG islanding capabilities and utility visibility into islands, integration into DMS** • **Coordination of resynchronization of islands**	• Develop technologies to find alternative restoration strategies • Cost effective resilient control systems (automation for resiliency) • Understanding islanding in advance vs. islanding in response to an event • Coupling of electric restoration models to other infrastructure models (transportation, communications, etc.) • Integration of microgrids to DMS • Advancing standardization of microgrid resources such as inverters, DGs • Technologies for controllability and observability of microgrids by utilities

Breakout Session 2: Operational Response and System Recovery	
• **Integration of microgrid and DER** • **Having restoration process models to couple back into planning activities to predict how long the recovery efforts will take; Example: crew routing; Can the process then later be improved?**	
Other R&D needs identified: • **Interdependency between communication infrastructure and ability to gather information about system state (4 for first vote casting; 5 votes from second vote casting*)** • **Understand tradeoffs of hardening, self-healing, recovery crews, and automation (3)** • **Technology for safe clearing of debris that poses electrical risks (e.g., entangled wires on trees on the road) because there are not enough electrical crews to clear roads (1)** • **Data analytics, better understanding of data needs** • **Improve resiliency of communications systems and integration/visibility into/from electric operations systems**	

* A subsequent vote casting was done on two R&D needs with similar initial vote counts. The *number* of votes from the second casting is shown in parentheses, which differs from the 1-5 range applied to the first vote casting.

Appendix A: Agenda

Workshop Outline

Resilient Electric Distribution Grid R&D

Office of Electricity Delivery and Energy Reliability (OE)

U.S. Department of Energy (DOE)

Purpose

- To identify key R&D activities for enhancing resilience of electric distribution grids to natural disasters:
  - Share current practices by distribution utilities
  - Share ongoing activities on resilient electric distribution grid R&D
  - Define R&D gaps
  - Identify key R&D activities to fill the gaps

Non-purpose

- Not to discuss issues and activities relating to manufactured events, including cyber attacks
- Not to discuss issues and activities relating to bulk power generation and transmission

Wednesday, 11 June 2014, 8:00 AM to Noon

7:30	**Registration and Continental Breakfast**
8:00 -9:00	**Opening Plenary** ▪ Welcome ▪ Panel session on current practices and overview of R&D activities and gaps, with panelists representing utility, national lab, and academia
9:00-10:30	**Two Concurrent Breakout Sessions –** 1. Design, preparedness, and planning for a resilient electric distribution grid 2. Operational response and system recovery **9:00** Identification of the top-3 most critical R&D needs **9:30** Definition of the top-2 highest priority R&D projects for each critical need
10:30 10:45	**Break**
10:45 – Noon	**Report-out and Closing Sessions** 10:45 Report-out presentations and discussions ▪ Report-out by each breakout session spokesperson (20 minutes) ▪ Facilitated Q&A after each report-out (10 minutes) 11:45 Closing Session ▪ Discussion of paths forward ▪ Final thoughts
12:00	**Adjourn Workshop**

Ver: 6 June 2014

Appendix B: Registrant List

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