Results of the survey on smart distribution systems: An addendum

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Abstract

This document presents a concise listing of the results of a recent survey designed and conducted by Colorado School of Mines (CSM) for identifying some characteristics of a smart electric distribution system. The authors acknowledge the financial support of the grant T-41 from the Power Systems Engineering Research Center (PSerc) at Arizona State University. The authors are grateful to the respondents for their time and effort in answering this survey.

Nomenclature

CDMS	Commercially-operated distribution management systems
DER	Distributed energy resources
DG	Distributed generation
DS	Distributed storage
LEMS	Local energy management systems
RES	Renewable energy systems

Characteristics of a smart distribution system

Based on the results of the survey of respondents from the industry and academia[1], some characteristics of a smart distribution system are defined. **A smart distribution system**:

1. **Optimizes distributed assets** through the use of real-time pricing, smart metering infrastructure, two-way communicating devices, and networked connections between feeders. New market and product opportunities are enabled by plug-and-play methodologies, expected supply of ancillary services, and smart-grid tailored devices

2. **Incorporates DER**[2] at all distribution voltage levels enabled with two-way communications. DER usage will be scheduled in advance and in real-time by the utility. Local management of the DER will incorporate the LEMS[3] at a minimum, but may also incorporate both the LEMS and the CDMS[4]. DER will communicate with the smart meter, LEMS, and one another at least once per minute. Approximately 10-19% of total generation will be met via RES[2], such as photovoltaic, biogas/biomass, combined heat and power, and wind. Less that 50% of new DER are expected to comprise RES, which will be supported by battery storage and fast-starting dispatchable generation sources. DS[2] (primarily batteries) will comprise less than 50% of rated load for up to four hours, and are expected to support up to 50% of non-dispatchable DER. Peak-shaving techniques employed primarily in the 120V class, such as residential load control, will engage within approximately fifteen minutes.

3. **Integrates massively deployed sensors and smart meters**. Digital sensors with incorporated intelligence are used to monitor the directions and amounts of power flow and the locations and usage patterns of DER. The sensors are expected to be located at the 15 kV

[1]H. Brown, S. Suryanarayanan, "A survey seeking a definition of a smart distribution system," in Proc. 2009 North American Power Symposium, Oct 4-7, Starkville, MS.

[2]For the purposes of this survey, distributed energy resources (DER) include conventional distributed generation (DG), renewable energy sources (RES), and distributed storage (DS).

[3]A local energy management system (LEMS) corresponds to load-level management software and is operated by the consumer.

[4]A commercially-operated distribution management system (CDMS) corresponds to feeder-level management software and may be operated by a commercial entity.

class and will communicate updates at least once per minute. The sensors will be able to engage in two-way meshed communications and be enabled with control algorithms to automatically react to measurements. The smart meter acts as a communications link and a local control system and its functionality includes i) two-way communications with the utility, as well as other devices, such as DER or CDMS or LEMS, ii) real-time reads, iii) automatic time synchronization, iv) tamper detection alarms, v) current and voltage profiling, and vi) the capability to download and store time-of-use schedules.

4. **Enables consumer participation in demand response** through the widespread use of dynamic pricing, with real-time signals. The utility gives the consumer limited[5] and total[6] control of load and generation. Demand response will engage within minutes.

5. **Uses adaptive and self-healing technologies** primarily integrated at the 15 kV class. The technologies should be able to engage in all four types of self-healing: restorative, emergency, corrective, and preventative. Self-healing will be achieved through a combination of automatic restoration and utility-supervised actions. Distribution-level self-healing actions should enable the system reliability to reach between 0.9999 (4 nines) and 0.99999 (5 nines). Technologies will activate within several cycles and will restore the system within minutes, once activated. Smart feeders will carry the responsibility for self-healing actions and will be enabled by microprocessor-based with communications capability.

6. **Makes use of advanced tools** (including visualization, analysis, and simulation) to streamline routine operations. A "smart" distribution management system will be customer-driven with the ability to i) automatically report time-stamped smart meter measurements to the utility and use the data to plan and/or predict future usage, ii) use energy price predictions to plan future usage, iii) optimize of DER and load portfolios, and iv) create back-up arrangements as contingency plans for the failure of specific components. A utility-driven distribution management system would store "critical" and "useful" data, with data storage locations distributed throughout substations and/or centralized at the utility center of operations.

7. **Integrates smart appliances and consumer devices**. Smart appliances will be smart-circuit devices[7] and programmable devices. These devices will be two-way communication enabled and will possess control algorithms.

8. **Possesses the ability to operate in either islanded or grid-connected mode**. A system with islanding potential should have control systems for local regulation of voltage, real power balance and reactive power balance. The utility should be able to identify islands. The ability to island would be facilitated by the implementation of controls for grid-like behavior (i.e. measuring frequency and voltage droop to control real and reactive power outputs).

[5]Limited control at the meter means that the customer controls real power supplied by the DER, loads, energy demand, automated controls for smart appliances, DER, demand response, and market participation through supply of ancillary services.
[6]Total control at the meter means that the customer has control of all utility-approved installations, the ability to island, and everything in the "limited" control class.
[7]Smart circuit devices are those in which the "smartness" is in the circuit with learning algorithms, e.g. a device that would be "off" until it was "pinged".