ENABLING TECHNOLOGIES FOR THE DISTRIBUTION GRID (2013-2)

Research Opportunity Notice

Overall Objective

The objective of this Research Opportunity Notice (RON) is to solicit R&D proposals for research and enabling technologies development for the distribution grid. Proposed R&D may address part or all of the technologies and/or any related technologies which further the goals described in this RON. R&D projects should focus on research or enabling technologies development as opposed to commercial product development.

There is also a need for research in the above focus area to be applied towards addressing the State's policy goals for greenhouse gases and renewable energy goals. In particular, research into technologies with applications that are smart grid-related or renewable energy integration-related will help with the State's goals.

Background

California's progressive global climate change and clean energy goals are resulting in a rapid increase in the penetration of distributed generation from renewable energy sources. As one example, Governor Brown's Clean Energy Jobs Plan calls for adding 20,000 MW of new renewables including 12,000 MW of distributed generation (DG) by 2020. The resultant change in the state's electric distribution system along with the ongoing impacts of changes in customers' energy service requirements, such as electric vehicles, will impose new demands on the design, planning and operation of the electric distribution grid that cannot be met with current methods and technologies. Failure to appropriately address the needs for new technology to meet these challenges will form a significant barrier to meeting California's policy goals, and threaten the integrity of the electric system and ultimately the health of the California economy and the well-being of its citizens.

Typical distribution systems are radial in form, extending outward from a substation, which provides the power. As distributed generation increasingly penetrates the distribution system, the basic concept of outward only power flow is increasingly violated and systems designed to maintain operating parameters and safety are increasingly stressed in ways that they were not designed for. New technologies must be incorporated to better deal with the new requirements.

Today's electric distribution systems are noteworthy for just how much of their operation is not digitized or automated. Many of the devices and procedures in common use were designed in the last century. This is important as we consider introducing new layers of information and control technology, all of which is now digitized. New tools will have to be integrated to fit seamlessly within the real day-to-day operating context of distribution systems.

For the most part, substations are fairly automated, but the distributed feeders are much less so. Many of the feeders and feeder equipment are maintained either on a conservative scheduled basis or when there is a failure. For lack of effective monitoring, utilities are often unaware of the failure until notified by customers. A more efficient proactive approach is to monitor the equipment and dispatch the maintenance based on the condition of the equipment (condition-based maintenance, CBM). CBM will be greatly enhanced and cost-effective with distribution automation (DA)

Advanced Metering Infrastructure (AMI) is rapidly being installed in all the California investor owned utilities (IOUs). DA can potentially leverage the 2-way communications infrastructure of the AMI system to back-haul data back to the control centers. More importantly, that data from both systems can be integrated to form a common information data base. This common information base can be shared and used by any utility application. For example, the data can be used in applications to pinpoint faults in the distribution system, to provide automated outage notification, and to provide automated dispatch from the utility outage management system. This is the principle of data being measured once and the resulting information used many times.

There are perceived and real barriers to upgrading distribution systems. One is the perceived high cost of equipment, equipment installation and maintenance, and real-time 2-way communications (needed for effective automation). For technologies that are currently available and deployed, vendors have been slow to adopt interoperability (e.g., communications) standards. Finally, current SCADA systems need to have new paradigms to include distributed energy resources (DER).

Enabling Technologies

Enabling technologies have the potential to mitigate the barriers by making possible new products and applications that result in:

- Cost-effective equipment, installation and maintenance.
- Improved methods for voltage control at the distribution level
- Mitigation of the impacts of the variability of distributed generation resources
- Improved reliability with condition-based maintenance and faster location and isolation of faults, equipment failure, and fallen lines.
- Better knowledge of the health and condition of the distribution grid with a more information rich environment.

- Early indications of distribution congestion (or slack) for assisting long-tern distribution planning.
- Ability to provide insight into the characteristics of customer load patterns.
- Faster, more efficient, and more reliable control and operation of the distribution grid (e.g., lower frequency and shorter time failures through self-healing paradigms). Better coordination of area-specific demand response.

Some Potential Enabling Technologies

1. ***Storage technologies at the substation, feeder, and end user levels*.** Distributed energy storage is one means of improving the utilization of variable resources such as photovoltaic systems while potentially minimizing the variability of these resources. Many of these technologies are still “emerging,” i.e. relatively new, expensive, and not fully proven. Research is needed for modeling/analytics/optimization, to improve functional performance, reduce capital/installation/operation costs, and at all levels: storage media, inverter/power electronics, cooling/ heating systems (where applicable), and overall integration.
2. ***Direct Current (DC) direct/microgrid technologies***
   Direct current (DC) generated by on-site renewable energy (RE) systems can be used directly in its DC form to supply DC loads in residential and small commercial buildings, for cooling, electronics, EVs, and so on. Challenges include safety and reliability issues (especially with >50VDC in buildings) and cost-effectiveness of DC buses in buildings as well as overall integration of renewables/storage/communication/Building Management Systems or controls technologies.

3. ***Low cost and high quality power monitoring technologies***
   Monitoring the distribution system requires large numbers of monitors and a control system capable of absorbing the information collected and providing situational awareness and/or corrective actions as needed.
4. ***Smart devices that can self-diagnose and self-heal the grid***
   In the event of an outage, rapid and effective fault location and the ability to quickly restore power are keys to minimizing down time. Better yet are devices that can identify the need for maintenance before a failure.
5. ***Technologies that facilitate islanding and resynchronization to the grid after an outage.***
   Controlled islanding can significantly improve the handling of a power system disturbance and reduce its impact. A controlled islanding system will reduce loads and increase or reduce generation in an area of the system, then trip breakers in order to form an island isolated from the rest of the system with a load generation balance.
6. ***Modeling and control algorithms to facilitate integration of renewable energy resources***

The high penetration of a variety of distributed resources including distributed generation and storage, along with demand response (DR), electric vehicle (EV) charging, and possibly use of EVs as distributed storage require models for planning purposes and control algorithms to optimize the overall system.

Summary

The purpose of this RON is to solicit proposals for research and development of enabling technologies for the distribution grid. The outcome of these research and development efforts is not to produce a product but to advance the enabling technology that will contribute to a future distribution grid that is more cost-effective, efficient, and reliable.

Candidate research topics are listed in the prior section. Proposals may address these research topics or other related topics not listed that further the goals described herein.

Acronyms

AMI	Advanced Metering Infrastructure
BMS	
CBM	Condition-Based Maintenance
CDMA	Code Division Multiple Access
DA	Distribution Automation
DC	Direct Current
DER	Distributed Energy Resources
DG	Distributed Generation
DR	Demand Response
R&D	Research and Development
RON	Research Opportunity Notice
SCADA	Supervisory Control and Data Acquisition

Definitions

Advanced Metering Infrastructure	Advanced Metering Infrastructure refers to systems that measure, collect and analyze energy usage, from advanced devices such as electricity meters, gas meters, and/or water meters, through various communication media on request or on a pre-defined schedule. This infrastructure includes hardware, software, communications, customer associated systems and meter data management software.
Condition-based Maintenance	Equipment maintenance is based on the equipment’s health, rather than based on a schedule or equipment failure.
Demand Response	Reducing demand in response to a curtailment notification or short term price signal
Distribution Automation	The use of communications along with remotely operable equipment and computer-based equipment to monitor and control the electricity distribution grid

Distributed Energy Resources	Distributed energy resources are small-scale power generation technologies (typically in the range of 3 to 10,000 kW) located close to where electricity is used (e.g., a home or business) to provide an alternative to or an enhancement of the traditional electric power system
Islanding	The creation of isolated areas where load and generation are in balance as a means of minimizing the impact of a grid disturbance.
Microgrid	