Cyber Infrastructure for the Smart Grid

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Smart Grid Use Cases: Part 2
• Xcel Energy – A public Service company of Colorado is headquartered in Minneapolis, MN.

• It started its implementation of Smart metering and Smart Grid projects for the city of Boulder, CO in 2008.

• Xcel Energy established the Smart Grid Consortium, which includes Accenture, Current Group, Schweitzer Engineering Laboratories and Ventyx, to work in partnership to provide products and services throughout the project lifespan.

• The project cost is about $100 million to install 100,000 electric smart meters in the city of Boulder, CO, which is now called the ‘Smart grid city’ derived from the project’s name.

• The utility is now able to read customer’s meters remotely and reduce power outages as well as quickly identify false power outage calls.
The Xcel Energy's Smart Grid implementation involves a three-phased approach:

(I) Quick-hit projects -- This is to quickly demonstrate smart grid concepts within each component of Xcel Energy's utility value chain. This includes, for example, smart substation, smart distribution assets, smart outage management, plug-in hybrid electric vehicles, and consumer web portal.

(II) Smart Grid City (2008-2010) -- This is a 100% deployment of all of elements from the quick-hit projects in one location, including all premises and the monitoring and control of all resources on the grid. The technology deployed consists of two-way high-speed communications served as the backbone of the entire smart grid system, smart meters that collect home electricity usage data in 15-min increments; MyAccount website and in-home smart devices.

(III) Xcel-wide deployment of proven technologies (dependent on the learning from the first two phases)
Pacific Gas & Electric, based in San Francisco, CA, serves about 5.2 million electric and 4.8 million natural gas consumers in the state of California.

In summer 2006, the Commission approved PG&E’s AMI project with a budget of $1.74 billion.

Power Line Carrier technology is selected for providing communications between the utility and its electric meter network (5.1 million meters); and fixed radio frequency network is selected for its 4.2 million gas meters.

The company expects to take 5 years until it reaches the full AMI deployment (fall 2006 through end of 2011).

In December 2007, "PG&E filed a request for an additional $624 million in funding to upgrade its metering technology."
PG&E proposes to install new advanced meter technology with the following added functionality:

- an integrated load limiting connect/disconnect switch to remotely connect and disconnect customers’ electricity, and also limit the amount of power that can be used at any given time;
- a Home Area Network (HAN) gateway device to link PG&E’s AMI network to the customer’s HAN; and
- solid state meters with advanced micro-processing capabilities and memory to support the above functionality, and remote software and firmware upgradeability.

As of June 2010, there have been 5.9 million smart electric and gas meters installed.

- PG&E has bought advanced meters from General Electric and Landis+Gyr to be installed as part of the smart grid project.
PJM Interconnection, LLC, located in Norristown, Pennsylvania, has been awarded $12.6 million in funding to develop a smarter energy grid.

The stimulus funds will be used to deploy over 90 phasor measurement units and other digital monitoring and analysis technologies across 10 states that will provide real-time data on the operating conditions of the transmission system, improving reliability and reducing congestion, the efforts for which began in 2010.

**Equipment:**
- 81 Phasor Measurement Units
- 17 Phasor Data Concentrators (company-level)
- Super Data Concentrator (PJM)
- Synchrophasor Communications Network

**Targeted Benefits:**
- Increased Electric Service Reliability
- Optimized Generator Operation
Installing PMUs at 81 substations; Building support for 150+ substations
12 Transmission Owners installing measurement devices at 81 substations
  - TO’s selecting their own vendors
Transmission Elements Monitored
  - 64 > 345kv; 17 < 345kv
Approx. 20% of regional footprint monitored
Installing PMU’s, Relays, DFRs, DDRs
Installation rate
  - 24 as of 09/2011; 47 by EOY 2011
  - 81 by EOY 2012
PJM SG

• PDCs
  – 11 TO Control Centers with Central PDC
  – Archive Database Status
    • Storage Size - TBD
    • Data retention
      – 90 days real-time; 1 year near-real-time; 7 year archive

• Communication System
  – 11 dedicated links to TOs (T1 lines)
  – 2 dedicated MPLS Clouds; 1 Verizon and 1 AT&T
• Architecture, Design, & Communication
  – Confidence in performance of PMU/PDC equipment
  – Ensuring the architecture is scalable
    • Add more PMU’s in the future
    • Database sizing and format
  – Complexities of sharing data between RTO/ISO, etc.
  – Internal IT architecture design
    • High-availability
    • Software limitations
    • Latency and throughput
    • UDP vs. TCP Communications
71% of PMUs with “Good” (or better) rating
45% of PMUs delivering Timely data
  - With latency under .5 seconds
35% of PMUS are both “Good” and “Timely”

Poor Quality – Root Cause
- PMU Calibration
- GPS Clock issues
- Data Name limitations
- Loose cables
- Loss of telecom connection
- Server overload
- Aliasing at PDC
- PDC configurations
Pacific Northwest Demonstration SG

What:
• $178M, ($89M private, $89M ARRA-funded), 5-year demonstration
• 60,000 metered customers in 5 states

Why:
• Quantify costs and benefits
• Develop communications protocol
• Develop standards
• Facilitate integration of wind and other renewables

Who:
Led by Battelle and partners including BPA, 11 utilities, 2 universities, and 5 vendors
- **Business case:** Validate new smart grid technologies and inform business cases so utilities can make informed decisions and optimize investments. Quantify smart grid costs and benefits – major focus of the project for BPA

- **Utility installations:** Leave behind $105 million in installed assets at the utility level. This is a collaboration of the region, testing 90,000 assets, across 68 asset system types
The Pacific Northwest Smart Grid Demonstration Project will also test a unique market signal called the Transactive Control System that will tie assets together and use two-way communication to optimize resources.
Evaluating multiple technologies for both reducing and increasing load

- Electric Water Heaters (residential and commercial)
- Cold Storage
- HVAC (thermostats)
- Industrial processes (and electric boilers)
- Irrigation
- Municipal water pumps
- Battery storage
- Building energy management systems
- Space heating (thermal storage)
- In home displays
The City of Port Angeles

- Located in Washington State’s Olympic Peninsula, population 18,397
- The City operates water, electric, sewer, storm water and solid waste utilities
The City of Port Angeles

- 500 AMI-based water heating DR controls
- 90 smart thermostats with home area network capabilities
- 30 thermal storage devices for home heating
- 30 thermal storage water heaters
- 1 thermal storage whole house furnace
• Develop a Metrics and Benefits Reporting Plan, which are documents that describe the smart grid assets, functions, impacts, and related data that will be collected by the recipients and reported to DOE.

• Each project has its own unique Metrics and Benefits

• As the projects are implemented, equipment installed, and functions made operational, recipients begin the process of uploading their information on “build metrics” and “impact metrics” to the Smart Grid Data Hub.

• Build metrics measure progress toward deployment of smart grid assets. Build metrics include, for example, reports from recipients on the number of smart meters installed, the number of substation automated, and the number of dynamic pricing programs offered.

• Impact metrics measure how, and to what extent, these smart grid assets are affecting grid operations and performance, or how they enable customer programs and behavior changes. Impact metrics include, for example, reports from recipients on the magnitude of peak demand reductions, the number of truck rolls reduced, and the amount of maintenance cost avoided as a result of the project’s smart grid activities.
Examples of smart grid metrics include:

- Percentage of customers capable of receiving information from grid operators and the percentage of customers opting to make or delegate decisions about electricity consumption based on that information.

- Percentage of distributed generation and storage devices that can be controlled in coordination with the needs of the power system.

- The number of smart grid products for sale that have been certified for “end-to-end” interoperability.

- The number of measurement points per customer for collecting data on power quality, including events and disturbances.

- The amount of distributed generation capacity (MW) that are connected to the electric distribution system and are available to system operators as a dispatchable resource.

- The percentage of grid assets (e.g., transmission and distribution equipment) that are monitored, controlled, or automated.

- The percentage of entities that exhibit progressively mature characteristics of resilient behavior.
Smart Grid Metrics

The preliminary list of analysis clusters identified so far include:

• Advanced metering infrastructure and customer systems
  • Peak demand reductions and electricity savings, Meter operations and maintenance savings, Consumer behavior studies, Impact of advanced metering, dynamic pricing, enabling technologies, and information treatments on consumer behavior, Effectiveness of marketing, consumer education, and outreach programs

• Distribution systems
  • Impact on reliability, Energy efficiency improvements (e.g., lower line losses), Operations and maintenance savings

• Transmission systems
  • Applications of synchrophasor technologies and systems, Energy storage systems, Technical and financial performance

• Marketplace Innovation
  • Introduction of new products and services
  • Electric vehicle charging

• Cyber security
  • Advancements in cyber security practices
Further Reads

https://www.smartgrid.gov/recovery_act/project_information

https://www.sgiclearancehouse.org/UseCases

https://www.smartgrid.gov/recovery_act/overview