CPET 581 Smart Grid & Energy Management
Friday 6:00-8:45PM
2013/11/15

Lecture 15

Topics of Discussion

- Smart Energy and Energy Management
- Power Grid Management Issues
- Smart Grid Technology [3]
- Electric Power & Energy Management System
- Smart Energy Management Equipment and Infrastructure
- Communication Systems and Networking Infrastructures for Smart Grid, Renewable Energy Resources
    - EV Charging Infrastructure
        - Open Charge Point Protocol (OCPP) – Europe's opne communication platform
    - Power Line Communications (PLCs)
    - Home Area Networks (wireless)
        - ZigBee Home Automation
        - Wi_Fi (IEEE 802.11 WLAN)
        - Smart Energy 2.0
    - Wireless Wide Area Networks
    - Broadband-over-power-line with fiber backbone
    - CISCO Utilities/Smart Grid, http://www.cisco.com/web/strategy/energy/external_utilities.html
        - GridBlocks Architecture
        - Substation automation/integration (SAI), Neighborhood area network (NAN), Business area network (BAN), Home area network (HAN)
- Smart Grid Standards
    - IEEE P2030 Draft Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS) and End-Use Applications and Loads

Smart Energy and Energy Management (Goals)

- Affordability (affordable cost)
- Reliability (reliable service)
- Sustainability
    - environmental sustainability ⇔ sustainable electric power service ⇔ sustainable renewable energy ⇔ sustainable electric grid
    - Growing volume of distributed renewable generation: Solar, Wind, etc
    - Sustainable electric grid

Electric Power & Energy Management Systems

- Client-Side Energy Management System
  - Residential energy management
  - Industrial energy management
  - Commercial energy management
- Supply-Side Energy Management
  - Distribution management

Power Grid Management Issues

- Stochastic generation (DER – distributed energy resources/VER)
- Transactive loads and markets
- Grid control

EV System & Communication Infrastructure

- "Courting and Sparking," Consumers & EV Market, by N. C. Kar, K.L.V. Iyer, et. al., IEEE Electrification Magazine, Sept. 2013, pp. 21-31
- "Cutting the Cord: Static and Dynamic Inductive Wireless Charging of Electric Vehicles," S. Lukic and Z. Pantic, IEEE Electrification Magazine, Sept. 2013, pp. 57-64
- Southern California Edison Offers Insights about Its Electric Vehicle Customers, T&D World, 2013/8/12, http://tdworld.com/distribution/southern-california-edison-offers-insights-about-its-electric-vehicle-customers
- National Grid Launches EV Charging Project in Upstate New York (ChargePoint and National Grid), 2013/5/28, http://tdworld.com/distribution/national-grid-launches-electric-vehicle-charging-station-project-upstate-new-york
- ChargePoint, EV Charging Network, http://www.chargepoint.com/
- Enel, http://www.enel.it/it-IT/
- Oregon Electric Vehicles and Infrastructure Program, http://www.oregon.gov/ODOT/HWY/OIPP/Pages/inn_ev-charging.aspx
- Canada's first Fast Charger network, British Columbia, CA
- EV Charging Networks
  - Greenlots San Francisco, CA; Sky Network, 13 countries, http://greenlots.com/
  - PlugShare, http://www.plugshare.com/
  - AV Subscriber Network, http://evsolutions.avinc.com/services/subscriber_network
  - Blink HQ EV Chargers, http://www.blinknetwork.com/
    - ECOtality Bankruptcy Blink EV Charging Network …, by Jeff St. John, Oct. 11, 2013, http://www.greentechmedia.com/articles/read/ECOtality-Bankruptcy-Blink-EV-Charging-Network-Changes-Hands-But-Not-Bad-R
  - NRG eVgo, http://www.evgonetwork.com/

Smart Energy Management Equipment

- Utility company ⇔ Customers

- Smart Meter (embedded computer, power measurement electronics, radio networks)
- AMI
- Computer Servers, Database, Software programs
- Home Area Networks
- Customer energy generation
- Home energy control system

Home Area Networks (gateway) enables

- Delivering real-time energy cost and usage information
- Trade-off control (best control, optimized control) between comfort, convenience and cost
    - In-home energy control devices
    - New generation of automated appliances
- Support management of
    - Electric vehicle connectivity
    - Customer-owned generation

P&G Smart Meter Program [1]

- P&G SmartMeter™, http://www.pge.com/en/myhome/customerservice/smartmeter/index.page
- Automated meter equipped with two-way radio communication network (low power radio) ⇔ SmartMeter Operation Center
- Actively engage customers in maintaining the balance between "Electric Power Supply", and "Electric Power Demand."
- Smart Meter sends kWh, MWh data to P&G for recording
    - **hourly electric use** (kWh) for residential customers
    - energy usage (kWh, MWh) for industrial customers in **15 minute intervals**
- Smart Meter also receive information and control signals from the utility
- Smart Meter can be remotely upgrade (program, services, etc)
- Also include (Energy Management Equipment)
    - A remote connect and disconnect, load-limiting switch
        - Voluntary load control program
        - New service options such as pre-pay electric service
    - A home area network (HAN) gateway
        - Provide near real-time energy-use information
        - Enable home energy use automation to take advantage of a range of new rate options including
            - Demand-response programs
            - Variable electric prices

Networking Infrastructure for Smart Grid – An Example [2]

- Broadband-Over-Power Line with Fiber Backbone (Oncor power company, http://www.oncor.com/)

- Covers Dallas-area smart grid (65 sq miles/168 sq km), 105,000 premises, 560 miles of fiber-optic cable, and has more than 18,000 network element
- 28 substations, 200 distribution lines for delivering electric power to homes and businesses
- Three types of network elements
    - Backhaul point
        - Transition the data stream from fiber optics to BPL services
    - Powerline bridges
        - Located at single-phase distribution transformer within BPL footprint
        - From medium-voltage distribution primary to low-voltage distribution secondary
        - Pole mounted and padmounted
        - Monitor voltage on both 120-V legs on the distribution secondary, capture readings at 0.1-second resolution and aggregate the data for reporting
        - Interval measurements are shipped back through the network and processed in the back office through several algorithms to produce actionable alarm information
    - Low-voltage repeaters
        - Repeats the BPL signal to each meters on longer secondary runs
        - Both the backhaul points and the bridges use a coupler connected to the network element by coaxial cable to transfer the BPL signal on and off the medium-voltage primary from the element
- Purposes
    - Reads smart meter data
    - Monitoring network performance
    - Supports automated switching
    - Advanced warming
        - Identifies areas of concerns for engineers to pinpoint potential problems
        - Transformer trips
        - Tree-related power disturbances
- Connected to static VAR compensator (SVC) station
    - Apparent Power = Real Power + j Reactive power
        - KVA = KW + j kVAR
        - MVA = MW + j MVAR
- Prototype for the rollout of a standard North American Electric Reliability Corporation
    - Cyber infrastructure protection-compliant substation IP network architecture which includes
        - A standardized station router design with
            - “port management” and

        - multiple “virtual local area networks” for data prioritization and security
    - High-speed fiber connections enable video monitoring and electronic station access control at substation

CISCO Utilities/Smart Grid, http://www.cisco.com/web/strategy/energy/external_utilities.html

- GridBlocks Architecture, http://www.cisco.com/web/strategy/docs/energy/overview_gba.pdf
- Substation automation/integration (SAI), Neighborhood area network (NAN), Business area network (BAN), Home area network (HAN)
- Network Based Architecture for Distributed Control, Jeffrey D. Taft, CISCO, http://www.cisco.com/web/strategy/docs/energy/network_based_architecture_di.pdf

Videos & Webinar

- CISCO, http://www.cisco.com/web/strategy/energy/external_utilities.html
    - Next Generation Utility Networks (4:30 min), http://www.youtube.com/watch?v=zn7kmMfJPgg&list=PLC9B77E2CF83FB00D&index=3
    - The Cisco Connected Grid (4 min),
    - Going Beyond Electricity, the network powers the energy industry and the Internet of Things (IoT),
- Advanced Distribution Management System, Schneider Electric

References

- Smart Meter and Advanced Metering Infrastructure Deployment
- Edison Smart Connect Operation Center, Southern California Edison (SCE)
- OpenWay by Itron, smart metering system, www.itron.com
- FlexNet, telemetric technology, www.sensus.com/flexnet

References – Smart Meter Deployment

- PG&E Forge Active Customer Relationships, by Jana R. Corey, Transmission & Distribution World, Feb. 2012, http://tdworld.com/smart-energy-consumer/pge-forges-active-customer-relationships
- Oncor Relies on BPL (Broadband-over-power-line), by Larry Kohrmann, Transmission & Distribution World, Feb. 2010, http://tdworld.com/overhead-distribution/oncor-relies-bpl
- ONCOR Smart Grid Technology, Larry Kohrmann, Transmission & Distribution World, Feb. 2010, http://www.oncor.com/EN/Pages/Smart-Grid-Technology.aspx
- Enel Gets Charged Up Over Electric Vehicles, by Deferico Caleno and Paolo Scuro, Transmission & Distribution World, Feb. 2010, http://tdworld.com/overhead-distribution/enel-gets-charged-over-electric-vehicles

- Take Asset Decisions Off the Clock, by Dawn Toporek, Transmission & Distribution World, Feb. 2010, http://tdworld.com/substations/take-asset-decisions-clock
- Communication Systems for Grid Integration of Renewable Energy Resources, F. R. Yu, P. Zhang, W. Xiao and P. Choudhury, http://arxiv.org/ftp/arxiv/papers/1107/1107.3313.pdf
- Optical Fiber Ground Wire (OPGW), http://en.wikipedia.org/wiki/Optical_ground_wire
- OPGW Cable System, Prysmian, http://www.ru.prysmian.com/export/sites/prysmian-ruRU/attach/pdf/pdf_telecom/opgw_system_general_brochure.pdf
- TVA Poineers the Future of Monitoring, by Theo Laugher, Bruce Rogers, Fred Elmendorf, and Mark McGranaghan, Transmission & Distribution World,Feb. 2010, http://tdworld.com/smart-energy-consumer/tva-pioneers-future-monitoring
- CISCO Utilities/Smart Grid, http://www.cisco.com/web/strategy/energy/external_utilities.html
- CISCO Smart Grid: Solution for the Next Generation, http://www.cisco.com/web/strategy/docs/energy/aag_c45_539956.pdf
- Network Based Architecture for Distributed Control, Jeffrey D. Taft, CISCO, http://www.cisco.com/web/strategy/docs/energy/network_based_architecture_di.pdf
- Tennessee Valley Authority Strategic Plan, 2007, http://www.tva.gov/stratplan/tva_strategic_plan.pdf
- Reliability of Islanded Microgrids with Stochastic Generation and Prioritized Load, Scott Knnedy and Mirjana M. Marden, 2009, MIT Open Access Articles, http://www.google.com/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=5&cad=rja&ved=0CEkQFjAE&url=http%3A%2F%2Fdspace.mit.edu%2Fopenaccess-disseminate%2F1721.1%2F59444&ei=c16GUqy8PKPmyQHfsIC4AQ&usg=AFQjCNGl__UxLh4gfSOSfcHF9Qzk8uFUuQ&bvm=bv.56643336,d.aWc
- Power Monitoring and Control System for NEPTUNE, http://Fneptunepower.apl.washington.edu
- OC 6000e Distributed Control System, GE Energy, http://www.ge-energy.com/content/multimedia/_files/downloads/14975_oc_6000_e.pdf