An Introduction to Intelligent Grids for Distributed Generation and Demand Management

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What is a Smart Grid

- Is it intelligent? Is it self-healing?
- Is it at the transmission level or at the distribution level?
- Is it at all a grid? Or it is a collection of sensors and data collection devices?
- At the transmission level today’s grid is efficient, smart, intelligent, etc.
- At the distribution level and at the customer level, there are opportunities for automation, intelligent appliances, advanced data collection networks, etc.
- The Smart Grid makes it possible to integrate large scale intermittent generation through demand response.
**Smart Grid Definition**

- According to United States DOE’s modern grid initiative, an intelligent or a smart grid integrates advanced sensing technologies, control methods and integrated communications into the current electricity grid.

*Source: “Upgrading the Grid”, Nature, vol 454, pp. 570-573, July 2008*
1. Integrated Communications
Electric Power & Communication Infrastructures

1. Power Infrastructure

2. Information Infrastructure

2. Elements at the Customer Level
A Conceptual Smart House

This "energy joule" displays weather forecast, current temperature and current electricity cost.

http://www.ambientdevices.com/products/energyjoule.html
http://www.tendrilinc.com/consumer/products/vantage/
Customer-Focused Applications for AMI and Customer Gateway

- **Pricing:**
  - Choices of dynamic pricing, facilitating demand response.
- **Outage handling:**
  - Automatic response and restoration verification
- **Load controls:**
  - Customers monitor energy use and determine load control strategies in response to price signals
- **Usage information:**
  - Real-time meter reading
  - Web data access
  - Hourly, daily or monthly data for customer education
3. Renewable Resources as Distributed Generation

Solar Photovoltaics
Solar Photovoltaics

Roof-mounted Solar panels, Virginia Tech

Grid-connected Photovoltaics, New York City
**Photovoltaics for Railway Signaling in Tibet**

**Global Installed Solar Photovoltaics**

Source: EPIA, 2008
Wind Turbines

Wind Turbines
Wind Farm in Hawaii

Source: NREL

Worldwide Cumulative Installed Wind Turbine Capacity (End of 2007)

Source: www.bp.com
4. Back-up and Storage Options
A plug-in hybrid electric vehicle (PHEV) is a hybrid vehicle with batteries that can be recharged by connecting a plug to an electricity outlet.

20-40 kWhr of Storage Available
4. Cost and Value of Storage Options

Price ranges from US $2,000 to $4,000 per kilowatt

Return on investment depends on life and usage

Impact of Distributed Generation on the Grid

Large Variations in power outputs cannot be optimally handled by storage and back-up generation alone.

Short term load control for a large number of end-use devices will make it possible to get quick load relief to match fluctuations in generation.
Demand response refers to mechanisms to manage the customer demands in response to supply conditions.

- Shed loads in response to a utility request
- Shed loads in response to market prices
- On-site generation to reduce the demand

Energy usage monitoring tools:

- Kill-a-Watt

- Google PowerMeter
  - http://www.google.org/powermeter/
Grid-Friendly Appliance (GFA) Controller

- GFA is a controller that senses grid conditions by monitoring frequency.
- If a disturbance is detected, the GFA controller will respond by shedding load.
- Example:
  - A GFA-enabled dryer would turn off the heating element but the tumbler would keep turning, resulting in 80-90% load reduction.
  - Appliances are typically turned off for 1-2 minutes.

Source: GridWise

Utility’s Water Heater Controls

- Water heaters can be controlled in a utility load control strategy.
- Water heaters can be turned off when load peaks.
- Water heaters can be turned off for 30 minutes at a time without customer dissatisfaction.
Summary

- Smart grid makes distributed generation more practical through demand management

- Enabling technologies
  - Integrated communications
  - Sensing and measurement
  - Advanced components
  - Advanced control methods
  - Improved interfaces and decision support
  - Time of Use (ToU) rates

Thank you for Your Attention

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