

Smart Grid and Water Challenge

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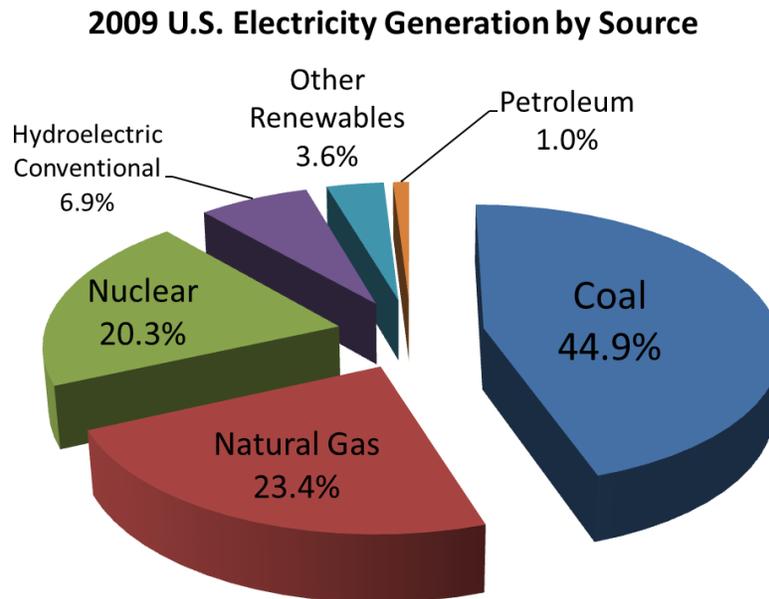
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We are now on a course for over hauling our electric generation, measurement and control system. This will lead to the so called Smart Grid system. The Smart Grid system will potentially measure real time consumption, charging more for electricity during peak periods of usage. This will be time-of-day billing. Whenever performance is measured, it will improve. This is axiomatic. The consuming public will be more aware of how they are using electricity. They will conscientiously manage their own time using discretionary power loads, such as for drying clothes. This will lessen peak demand usage, which correlates to power plant sizing and power margin. The latter margin can help out in successfully dealing with an anomalous operating conditions or peaking loads. The Smart Grid will also have to integrate different power sources, including more alternative energy sources such as wind, solar, and geothermal. Here excess energy generation can be back fed into grid (the customer meter will run backwards) and the customer given credit for supplying excess energy. This energy feedback into the grid can be used by other customers or stored for later use.

Diversity of Sources for Electrical Generation

Wikipedia gives this current breakdown of power generation sources in the United States. For comparative purposes please note that France generates 80% of its electrical power from nuclear energy. The United States main power source has been from burning coal, where the US has the largest coal reserves in the world. Figure 1 shows the breakdown of sources of electrical energy in the US. Coal is the most plentiful and cheapest energy source, but there is movement to go to other fuels, which is believed to be more environmentally friendly and lessen the carbon footprint to our atmosphere. <http://en.wikipedia.org/wiki/Coal>.

Figure 1: Breakdown of Electrical Generation Sources in US for 2009



- The SG manages and integrates these diverse power sources. This is input side management. Electric rates are projected to jump 46% over next 5 years as Power companies are required to move to green sources and natural gas vs today's reliance on coal for energy: <http://www.cbc.ca/canada/toronto/story/2010/11/18/ontario-duncan-economic-update234.html>.

Today's Electrical Utility Challenge

Two years ago at the annual IEEE USA meeting in Salt Lake City, the CEO of Rocky Mountain Power stated his company two biggest challenges:

1. He would like to upgrade the sensors and controls, from analog to digital, in the coal fired generation plants. But to do this would require a complete re-justification of the facility. The weight of this regulation would drive the cost of such an upgrade to millions of dollars, making such an upgrade unaffordable.
2. The population centers are shifting making the need to transport power to new areas. There is a constant push back from residents to preclude having power generation (mining) and distribution (power lines) going through their back yard (not in my back yard, NIMBY).

Smart Grid and Water Challenge

One interesting aspect is that we often see "Smart Grid and Water" couplet tied together. There are four reasons for this:

1. Hydroelectric plants can proactively use its excess power generation during the night time, when it generates more power than its customers require. It takes this excess power to pump water back into the dam. This raises the power potential power generation of the hydroelectric plant during the day time to help meet the higher peak period power demand..

2. Asian facilities will make ice at night when energy is cheaper. Then use this ice for day time cooling when electrical costs are higher. This is peak shifting the power need.
3. There is a strong interaction between energy generation and water distribution and consumption. For instance, Colorado has some of the largest oil reserves in the world, but it is in the form of oil shale, which requires lots of water to extract the oil from the shale. Water is also used to cool nuclear generators but this process changes the state of the water by heating it up. We don't know the long term effect of heating water up will have environmentally: it certainly will warm the river water that it returns to. This could change the life forms that habitat that river. A third, more direct interaction between electricity and water can be shown in California. Here almost 20% of the electric consumption in California is consumed in the processing and delivery of water. Read more: http://news.cnet.com/8301-11128_3-10345122-54.html#ixzz19e5TPuCT
4. Both Electrical usage and water consumption are critical resources that can be significantly improved through better metering. The Environmental Protection Agency has estimated that approximately 71 percent of the runoff from commercial and residential landscaping could be eliminated through better landscape irrigation planning (and water metering). <http://www.greentechmedia.com/articles/read/a-smart-grid-for-water-5743/>

Power Outage Experience

[Major Power Outages in the US, and around the World](#) by James McLinn, IEEE Reliability Society's 2009 Annual Reliability Report, characterizes the major power outages in the US, Canada, Europe the remainder of the World. <http://paris.utdallas.edu/IEEE-RS-ATR/>. The definition of a major grid failure is:

- a) An unplanned event (down for maintenance or rotating blackouts don't count)
- b) Affects at least 1000 customers (in this study the number is 30,000 minimum)
- c) The total downtime is at least 1,000,000 customer hours.

Frequency of major power interruptions is tabulated below in table 1 along with the cause of electrical outages in Table 2.

Table I: Power Outages (from Jim McLinn's 2009 ATR Article)

Years	US & Canada	Europe	International
1965-1988	3 fails	3 fails	1 fail
1989-1994	2 fails	None	1 fail
1995-1999	8 fails	1 fail	7 fails
2000-2005	11 fails	7 fails	15 fails
2006-2009	33 fails	16 fails	20 fails
	57 Total	27 Total	44 Total

Table II: A Breakdown of Major Grid Failures by Cause (from Jim McLinn's 2009 ATR Article)

Main Causes	US & Canada	Europe	International
Snow Storm	13fails	3 fails	3 fails
Summer Storms	11fails	2 fails	1 fail
Hurricane	8 fails	None	None
High Winds	8 fails	1 fail	3 fails
Unknown	3 fails	8 fails	11fails
Substation	3 fails	2 fails	7 fails
Transmission Line failures	3 fails	2 fails	4 fails
Lightning strike.	2 fails	None	None
Heat Wave	2 fails	2 fails	3 fails
Other	4 fails	7 fails	12 fails
Total	57fails	27fails	44 fails

“...today’s grid remains largely based on the same architecture of its forefathers, Edison, Tesla, and Westinghouse, where the majority of power is generated at large, centralized fossil-fuel-burning power plants...today’s distribution grids, lacking real-time visibility and control, are largely running blind and consequently costing the U.S. economy approximately \$100 billion to \$150 billion each year in power outages, tomorrow’s grid, much like the human body’s own nervous system, will have sensory intelligence embedded throughout, giving the grid the ability to anticipate disruptions, and even to self-heal...”
<http://gbcn.wordpress.com/2010/12/21/future-of-the-smart-grid/>

To realize the smart grid potential will entail addressing these challenges and risks to the system:

- Manage the seamless integration of power sources (coal, nuclear, wind, solar...)
- Assure synchronous phasing of power sources
- Load balancing at the grid level and the user level
- Leave customer the ability to choose what appliances to be run at any given time (at extra cost during peak demand periods)
- Enable time of day billing
- Power management must anticipate and handle power disruptions and environment and input anomalies
- Smart meters must be installed at user locations
- Gage R&R performed on the system measuring and metering elements to assure measurement repeatability, accuracy, and reproducibility.
- Energy storage capacities must be optimized for cover peak periods and provide adequate buffering capability during periods when power generation and distribution resources are unavailable.
- Communication and management must be available to handle diverse sources and loads, controlling, logging, switching, sensing, off loading, and failure recovery
- Trustworthy metering, logging and billing control software must be installed
- Allow for non-disruptive system growth and system modifications (transition planning)

- Ability to detect and isolate failed networks, allowing other networks' to continue to operate satisfactorily
- Assure secure operations in the face of hackers trying to compromise the Smart Grid

Also, besides improving operating efficiency, the smart grid will provide some nice customer features:

- SG sensory intelligence embedded throughout, giving the grid the ability to anticipate disruptions and even self-heal
- Center point control will allow power can be turned on at your new home remotely, no more waiting for a service man to read the meter and turn power on
- Time stamp of all additions and changes to the SG elements, improving traceability of changes. This will also aid in diagnoses of network problems.
- You can take your electric vehicle to a friend's house, charge it, and the system understands you're the one who should be billed, not your friend.

A smart grid will be able to optimally respond to events which occur anywhere in the power generation, distribution and demand chain. Conversely, today's power grid lacks intelligence and is made up of 12 independent, legacy power grids. These grids were completed in the lower 48 states in the mid-1950s. Parts of these earlier grids have been updated, and four of the US grids are tied to similar power grids in Canada. This technology has not changed much since Edison, Tesla, and Westinghouse. Smart Grid promises to do for our power generation what the interstate highway system has done for transportation. But it will take a constant focus on reliability, security and power management to make this the system that it is capable of becoming. This is very much akin to being a sailor. Anyone can sail a boat satisfactorily 98% of the time. It takes an expert to handle the sail boat in the 2% bad weather. Likewise the success of the smart grid will depend upon it handling the 2% anomalies, environmental challenges, and preventing the hacker intrusions.