Plugging Into the Future: Smart Grids

By Marianne Stanczak

New York City in the 2003 blackout
http://en.wikipedia.org/wiki/File:2003_New_York_City_blackout.jpg

Picture if you will a hot, sunny August afternoon. The day is going well, until suddenly, inexplicably, the power goes out. And stays out. No traffic lights, no TV, no computer. No *air conditioning*. And no one you know has power. No one. This scenario is not so hard to imagine if you were one of the several million people on the east coast during the Blackout of 2003. Due to the heat of the day, a power line sagged into a tree, which in turn caused an outage. And somehow, that caused another outage, and another – a domino effect. This took place on Aug 14, 2003 and affected over 55 million people (45 million across eight northeastern and midwestern U.S. states and 10 million in Ontario, Canada.) The question of the day, and during the weeks to come, was: how could this could have happened? In such a technologically advanced time where anything is possible…how was this? And more importantly, what can be done to stop it from happening again?

Enter the Smart Grid

The smart grid, in a nutshell, is a way to transmit and distribute electricity by electronic means. Data and communication becomes a two-way street, with consumers (you and I) able to control how much electricity we use and when we use it. This means more than being able to switch lights on and off whenever you like. It's about knowing when is the best time to use the electricity in order to save money and reduce the stress and strain on the power grid.

Tree limbs create a short circuit during a storm, typically resulting in a power outage
http://en.wikipedia.org/wiki/Power_outage

Sounds good, but massive, cascading blackouts aside, what, might you ask, is wrong with the current system? While other forms of power and technology have catapulted through the years (think 8-tracks to iPods), electricity has been stagnant, changing very little in the past century. In addition to being outdated, power plants and transmission lines are aging, meaning they have difficulty han-

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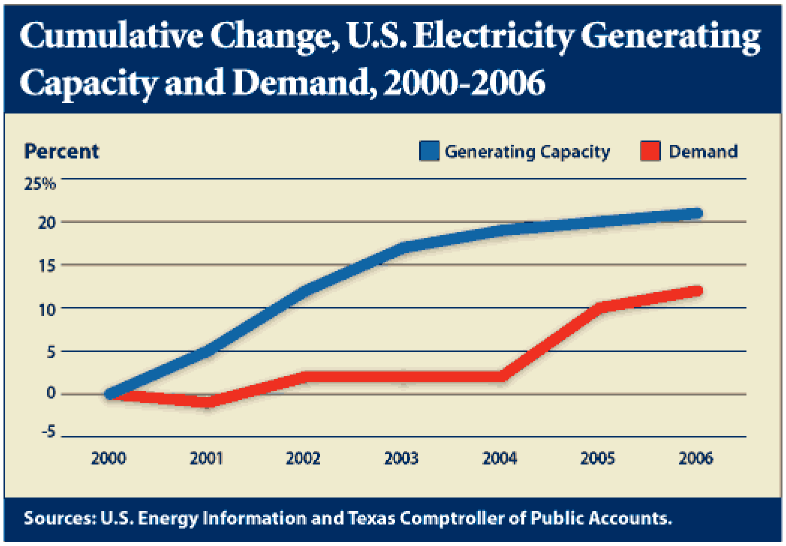
dling current electricity needs, let alone the ever-growing demand. While demand may not be reduced any time soon, it can still be "organized" in that both power companies and consumers can avoid overtaxing the system during periods of peak demand.

> "According to projections from America's Energy Information Administration, electricity around the world will nearly double from about 17.3 trillion kWh in 2005 to 33.3 trillion kWh in 2030."[i]



http://www.window.state.tx.us/specialrpt/energy/uses/electricity.php

The projection for the US alone is 5.15 trillion kWh. Clearly, if we will require fifteen percent of the world's electricity, we need a better system. One solution could be to add more power lines, but the aging system would still be overwhelmed. So instead of a quick fix, a more reliable, permanent solution is needed.

Back to the Smart Grid

More an energy concept than a tangible structure, the smart grid is an electronic means of transmitting and distributing electricity, where both utility companies and consumers will have the ability to interact with each other and regulate the amount of electricity used. Where the current system has been compared to a one-way street, the smart grid is touted as a transparent or two-way line of communication from power source to customers and back again.

Perhaps the most fundamental aspect of transitioning to a smarter electricity system is the smart meter.

If you take a look at your current electricity meter, you will see that it is very mechanical, humming along blindly, waiting to be read by a technician (or – gasp! – *estimated*), to determine the amount of electricity used in a given month, at the end of which you receive a bill. Very straightforward. Also not very transparent. Other than shutting off electricity-using devices, you as the consumer currently have no way of controlling your electric bill. A smart meter utilizes what is known as real-time monitoring (RTM). A display lets the consumer know how much electricity is used and even when it is less expensive to use it. In essence, a message can be sent to the consumer (in the home or via cell phone or email) that alerts them of a better time to use a certain appliance. Like the stock market and certain cell phone plans, electricity has daily ups and downs; it is not one flat rate through the entire day. However, the consumer is currently being billed as if there were one flat rate. In contrast, a smart meter will let customers know when it is cheapest to use electricity, so they may hold off using non-essential appliances such as dishwashers, clothes washers and dryers until later in the day, a "non-peak" time. Not only does this RTM save homeowners money, it allows them more control over their overall electricity usage. Many people currently have programmable thermostats, for example, used to keep temperature at a level preferable to the homeowner and lessen heating and cooling when not at home. The smart meter acts in a similar way, just on a broader scale; with the smart meter you can control – and even program, in some cases – several appliances. In addition, demand response, wherein consumers base energy usage on non-peak demand, may even serve to give back to the consumers, as a credit on an electricity bill. Demand response is simply the *response* a consumer has (e.g., holding off running the dishwasher) to the level of *demand*. Mid-afternoon is the normal peak demand for power, so the response would be to run the dishwasher later in the evening. Real-time monitoring and demand response work together to benefit the consumer.

A Smart Meter
http://www.americanprogress.org/issues/2009/02/grid_101.html

> "Studies have shown that when people are made aware of how much power they are using, they reduce their use by about 7%."[ii]

Smart meters are part of a larger concept known as advanced metering infrastructure, or AMI. The smart meter acts as a sort of middle man between the customer, utility company and original power source. A sort of back-and-forth goes on in AMI, where sophisticated devices such as smart meters and software are constantly monitoring the voltage and current for electricity, not only to assess what is peak demand, but to allow power companies to monitor the power grid itself. This is done by items called synchrophasors, which measure current and voltage in various places on the electric grid simultaneously. Synchrophasors collect this data 30 times a second, as compared old methods that collected data once every 4 seconds. In turn this "real-time" data may be used by a utility company to keep track of its power usage as well as to adjust levels so less energy is wasted.

So this sounds pretty good for you as the consumer, but what about the utility companies – what makes them want to get involved with the smart grid? On a very basic level, utilities will be able to profit from installation of smart meters, which currently cost around $125 each. And like consumers, utilities can benefit from demand response and RTM. Because the consumers are using less power during peak demand times, lessening the load on the power grid, the flow of electricity is more efficient and there is less need to put up new poles or even to build new power plants. A smart grid also prevents the entire system from becoming overloaded, lessening the chance for a power outage.

Device to monitor power grid and turn appliances off for a few seconds or minutes in response to overload. Developed by Pacific Northwest National Laboratory. http://www.oe.energy.gov/DocumentsandMedia/Electric_Vision_Document.pdf

In addition, a process called distributed automation would allow power companies to operate more remotely. This would allow them to fix outages or other problems remotely rather than sending a technician, thereby saving money and getting the job done faster. Distributed automation also allows a company to switch power usage – if it notices that a certain area is not using a lot of electricity, power can be "moved" to an area that does. If a system is working inefficiently there can be a bottleneck of electricity that, if not relieved, can cause an overload. In distributed automation, the system remotely monitors power distribution, and if it sees such a bottleneck an alarm or alert is sent out and the electricity can be rerouted by the opening or closing of a switch or circuit breaker. This rerouting may be done by a human, or the computer system could reroute automatically based on a predetermined "danger" level.

Another important factor from the utility point of view is that, with a smarter, more transparent electronic system, if a transformer is in danger of "blowing," the power company can quickly assess the situation and act accordingly, a process known as event avoidance. As well as averting the need to send technicians to an outage site, the transparency allows companies to pinpoint a problem's location rather than having to wait until many people call to report an outage.

If this is not the end of blackouts, at the very least they will be much shorter-lived. In addition to possible event avoidance, a preemptive strike, if you will, the smart grid can restore power, which currently is done manually. This automatic restoration of power would be accomplished by a combination of sensors, computer analysis and advanced substation components, as well as by the ability to reroute power to outage locations.

Another component to the smart grid would be the replacement of the aging power lines (with the tendency toward sag) with high-temperature superconducting lines. These wires, in addition to withstanding higher temperatures than the current wires would also help utilities by delaying installation of power plants, or even by doing without them all together. And, the new wires could be installed underground to avoid cluttering up the already congested cityscapes.

So we have a more transparent, reliable system that allows consumers to save money and utility companies to more accurately control electricity. A win-win situation.

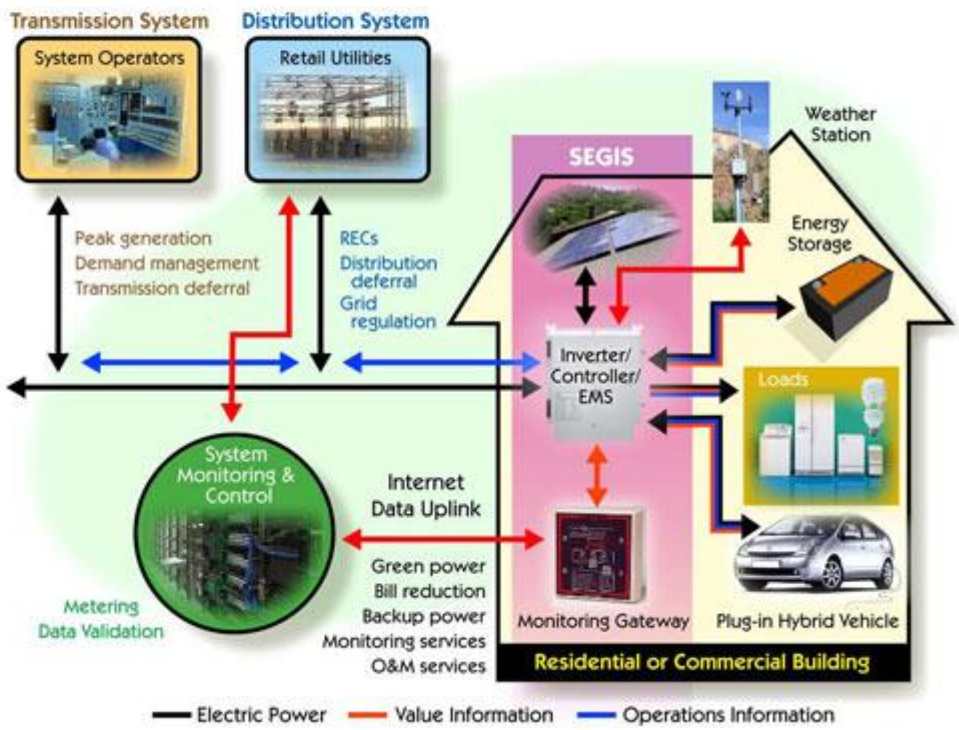
Renewable Energy & The Smart Grid

Wind power, solar power and high tech grid controls including net meterings and off-peak hours energy usage will soon help consumers save energy dollars. https://www.eere-pmc.energy.gov/PMC_News/EERE_Program_News_3-08.aspx

The smart grid can be seen as an alternative energy source, certainly a change from the current way of doing things. How does the movement toward a greener environment come into play? That is, how can the smart grid be made into a win-win-*win* situation for the consumers, the utilities, *and* the environment?

Solar, wind and hydropower are still relatively rare in this country. One reason is because these are "intermittent" sources of power. What does this mean? Well, what if the "Windy City" of Chicago is not so windy one week and wind turbines stop spinning? Or what if the blazing sun of Arizona is suddenly overcome by a spell of gloomy, rainy days, and the solar plants that people depend on go dead? In addition to rerouting electricity, the smart grid would be able to fill in the gaps of these alternative energy power sources. One way this could be accomplished, surprisingly enough, is with another alternative energy technology – the electric car, specifically, the plug-in electric hybrid (PHEV). This would work through the concept of energy storage, in the case of the PHEV, specifically referred to as V2G or vehicle to grid. When a PHEV is plugged into the grid it acts as its own power plant. It would receive power from a wind turbine, for example, and in a period of still air could "give back" to the power grid (having collected the electricity) and thereby fill the gap of intermittent sources. A possible scenario involves wind turbines, which currently are most efficient in the early hours of the day: a PHEV is charging during this time, then driven off to work where it is plugged in again, in an office building garage filled with other PHEVs. Since they, in theory, have already absorbed the morning wind energy, they can now be used as mini powerhouses, providing electricity to the office building.

This use of alternative energy sources, like wind and solar reduces the nation's dependence on foreign oil and helps keep pollution from car exhaust and power plants to a minimum. Win-win-*win*.



Concept with the two-way flows of power and communication required to enable seamless PV interconnections to the electric grid with high levels of solar energy.
http://www1.eere.energy.gov/solar/segis.html

Conclusion

But considering that far from everyone in the nation is equipped with their own smart meter, let alone a PHEV or wind farm, who's going to pay for all this??

One of the major sources of funding is expected to be the government. The 2009 American Recovery and Reinvestment Act calls for $4.5 billion for advanced electric grid technology. President Obama hopes to have 40 million smart meters installed in homes. The Department of Energy (DOE) is spearheading the Smart Grid Investment Grant Program which will award funds in September 2010 to companies able to help move along the process of setting up a smart grid. These can include the manufacture of specific electronic devices, or work by electric utilities to coordinate the smart grid's installation. In addition to government funding, many venture capital firms and even companies like Cisco, GE, Honeywell and IBM are all "chipping in" to make the smart grid a reality. Smart grid advocates are hoping to create an estimated 280,000 new jobs, ranging from electrical engineers to bureaucrats to installers, and everything in between.

As utopian as happy consumers, happy power companies, a cleaner environment, and a big dent out of the unemployment rate sound, the fact is that a national smart grid is still basically a concept, an idea. There is, however, local smart grid technology already in place. One example is Smart Grid City, otherwise known as Boulder, Colorado, where over 40,000 houses have smart meters and other smart grid technology. The utility Xcel Energy is spearheading this pilot test. Since its inception in mid-2008, there has been a drastic reduction in transformer failures, voltage problems, and even customer complaints due to the equipment utilized, particularly the sensors used for event avoidance. Boulder proves that the smart grid could work on a much broader scale.

Federal energy regulators want a transmission grid that can handle clean energy needs.
Photo: Warren Gretz, NREL
http://apps1.eere.energy.gov/news/archive.cfm/pubDate=%7Bd%20%272009-03-25%27%7D?printfull

In addition to several other test cities in the U.S., Malta, in the Mediterranean, is prepping to become the first smart grid island. IBM hopes to complete the installation of 250,000 smart meters there by 2012.

Every great idea has its pitfalls (or potential pitfalls, as the case may be). And the smart grid is no exception. With every pro someone has kindly thought of a con to keep people on their toes. The biggest obstacle to getting the smart grid powered up is cost. One estimate is that “the testing and installation of such a system for the entire US would cost about $3 billion a year for 10 years.”

Another concern is how accessible such a system might be to potential hackers. It is believed that a hacker can, with very little money and resources, access the data from a smart meter, and possibly break into the smart grid network as a whole. Because the smart grid is proposed to be working with software, sophisticated electronics and the internet, most of the cybersecurity issues arising from their use would also come into play with the smart grid. Suggestions to set up computer systems similar to those used by banks or government agencies have been made, but at the time of this writing, there are no definite solutions or even set cybersecurity standards.

Another likely pitfall is that despite the benefits to the utility companies, they may not comprehend how such an energy efficient device could also make them money. The smart grid is presented to consumers as saving money and using (read as: buying) less electricity, so utilities are hesitant to get onboard.

As new smart meters are being added daily to neighborhoods across the country, it seems that we are getting closer to a nationwide smart grid. Factor in government stimulus funding and the consumer desire to save money and energy, and it would appear that the smart grid is a “done deal”. However, the benefits of any venture must outweigh the risks. Will the stimulus money and venture capitalists provide enough? How will cyber threats be thwarted? And although smart meter applications are working in places like Boulder, Colorado, how will they manage on a nationwide scale? And arguably most importantly, if the smart grid is to become a reality in the United States, will it be completed before another widespread blackout occurs?

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[i] The Economist, "Building the Smart Grid," June 42009, pp.15-17
[ii] Ibid.