# *SMART GRIDS: THE FUTURE OF ENERGY TRANSMISSION*

Energy Economics

ECON 2318-001

Professor S. Baksi

Marc Ross

Adam Johnston

April 5, 2011

Word Count: 2,887

*SMART GRIDS: THE FUTURE OF ENERGY TRANSMISSION*

## THE ISSUE

Providing adequate energy to the majority of citizens while not damaging the environment is one of the biggest challenges the world faces. The best way to do this may be in the form of smart grids, a more efficient way to transfer and store energy. This paper will discuss the concerns with the current electrical grid system (efficiency, environmental impact, etc.) and the changes that could be made to it. The discussion will move on to the nature of smart grids, their benefits, their challenges, and recommendations for their implementation and related policies.

## THE HISTORY AND IMPORTANCE OF ELECTRICAL GRIDS

When most people talk about the power "grid," they are referring to the transmission system for electricity (Tech Target.com, 2011). According to the National Council on Electricity Policy (Brown, Sedano, 2004), the concept of an electrical grid started in 1882 in the Manhattan Pearl Street station, with energy flowing through a direct current over copper lines in order to provide electricity. The lack of an efficient power generation system due to copper lines through a direct current, while only a few miles apart, provided non-efficient resources to the stations, according to Brown and Sedano.

The report noted that a more effective way to transmit energy, called alternating currents (AC), had been developed in the late 1890's. The difference between AC and direct current (DC) was that AC was capable of providing longer-distance transfer of electricity. The report pointed out that AC lines allowed 11,000 volts of hydroelectric power from Niagara Falls to Buffalo, New York in 1896, a distance of twenty miles.

George Westinghouse's idea of the AC line helped electricity output increase and costs decrease, while industries and job creation grew. Brown and Sedano's report noted that production went from 5.9 million kilowatt hours (Kwh) in 1907 to 75.4 Kwh in 1927. At the same time, costs went down from $1.56 Kwh in 1907 to 55 cents per Kwh in 1927, a decline of 55 per cent.

The early days of the electricity grid, as shown by Brown and Sedano, demonstrated how rapidly an electrical system can spur the economy through innovation and massive amounts of capital. The same paper also mentioned how quickly energy production from power plants had increased after World War II. In 1972, 122 power plants were producing 500 megawatts (MW), compared to only two in 1948. Based on the research conducted by Brown and Sedano, with more power produced because of higher consumer demand, this would increase the need for electrical grids as the economy grew. However, as the world's energy appetite has increased, many concerns have been raised with regards to current electrical grids, in terms of both efficiency and environmental concerns, specifically relating to the fossil fuel-based economy.

## CONCERNS WITH THE CURRENT ELECTRICAL GRID SYSTEM

When electrical grids first came onto the scene, the world's population, between 1882 and 1900, hovered around the 1.2-1.6 billion mark (Worldometers, 2011). In the 21st century, the population has ballooned to nearly 7 billion by this year; according to an article from MSNBC and the Associated Press, based on United Nations data, the world's population will reach 9 billion by 2050 (2007).

While this has increased demand for energy in countries around the world to fulfill economic needs, it has made many governments take unsustainable energy policies, centered on oil and gas. This has helped contribute to climate change, with current carbon emission levels in the atmosphere around 391 parts per million (ppm) (co2now.org, 2011), far above the "stable" 350 ppm. Many scientists, including NASA climatologist James Hansen, has said that carbon emissions must be below the level of 350 ppm. (Whitesides, Loretta Hildago, 2007).

One of the major concerns with the current electrical grid system is that it cannot handle the existing energy demand. Eric Lerner, (2003) in the academic journal *Industrial Physicist*, notes that we must either change the rules for electrical grids or transform them to meet the new rules of energy transportation through lines. Lerner mentions the August 14, 2003, blackout in the northeastern United States and eastern Canada as an example of how the current electrical system is inefficient. He pointed out that that day, due to extremely hot temperatures, more demand was put on the grid, to the point that even its large size could not sustain it.

There are three "interconnects": Eastern, Western and EROCT (Electric Reliability Council of Texas). Lerner says that the interconnects have a much looser connection between the three interconnects than within each separate one, due to the fact that they are joined by their DC links. As well, the author points to deregulation of the energy industry in the 1990's; before energy companies could have one monopoly in a certain area, they made sure there was enough capacity to provide energy locally and use long-range reserves in a emergency. Deregulation removed this barrier.

Lerner says lines have to operate below a certain capacity, and if they reach over that number, they will overheat. This makes the case that short-term lines are better in terms of transmitting electricity. The aforementioned deregulation changed where electricity would be bought and sold on the market. This created many problems, including long-distance trading of power, which create problems such as the congestion of long distance lines. This is especially risky during peak times, like summer, in which the August 2003 blackout occurred.

The current electrical grid in North America, as discussed in the article by Lerner, points to current economic inefficiencies with the system, outside of the deregulation of the energy system in the U.S.  As seen, the August 2003 blackout showed that relying on the three interconnects to provide power in peak times is irresponsible. Economies now rely more on information technology, computers, and mobile phones then it did when the current electrical grid system was set up, thus requiring "smart" energies to match. This correlates with Lerner's position that the current electrical grid is not up to par, noting that "what is nearly certain is that until fixed, the disconnect between the grid's economics and physics will cause more blackouts in the future" (13).

Besides these, another major concern is that the system in place for much of the current electrical grids is heavily dependent on fossil fuels, with heavy environmental consequences. In the *Policy Sciences* journal, author Benjamin Sovacool (2008) lists various reasons for this. He points out that from 1944 to 1998, most research and development (R&D) in the United States went to nuclear energy (57%) and fossil fuels (23%), with renewable energies getting only 11 per cent. In 2006, the federal government's R&D spending on fossil fuels was $580 million, compared to $38.3 million for wind. He argues that because energy policy has mainly focused on the supply side rather then the demand side, along with R&D going to established energy sectors like fossil fuels and nuclear, nothing has been really done to curb energy consumption or inefficiency. The report also mentioned that there is a high social cost with fossil fuels and nuclear energy. The full social costs per kilowatt per hour for non-renewable energies like gas, oil, and nuclear were much higher compared to renewable energies like wind, solar, and biomass. For example, the social cost of a combustion turbine is 42 cents per kilowatt an hour (kWh), while a wind turbine cost 6 cents per kilowatt per hour based on Sovacool's analysis.

With the inefficiencies showcased by the blackout of August 2003 and the high social costs of fossil fuel and nuclear-based energies for the electrical grid system, rather then high-tech renewable energies, plus climate change and increasing demand, one must wonder if the current power grid system can sustain itself in the 21$^{st}$ century.

# WHAT IS A SMART GRID?

While electrical grids have been around for a long time, the smart grid, in terms of transportation of energy, is fairly new. Unlike Thomas Edison's idea of electrical transportation, this grid relies on renewable energies like wind, solar, and biofuels and harnessing them with the power of current information technology that drove the dot-com boom in the late 1990's. According to *Tech Target.com*, a smart grid “seeks to improve operations, maintenance, and planning by making sure that each component of the electric grid can both 'talk' and 'listen” (2011). This new type of grid is hoped to reduce 11.4 billion tons of carbon emissions worldwide each year (Cass, 2011). So what exactly is involved with smart grid technology and how does it work?

For starters, smart grids have many great features: self-healing technology, integrations among energies and devices, consumer participation, and improved reliability. Smart grids also have transcendent self-management and healing capabilities. With the competence of real-time monitoring, problems can and will be easily detected and resolved within seconds. The self-healing feature allows smart grids to maintain a sustainable operation by repairing any problems almost immediately afterwards. These features allow the grid to improve the overall quality of renewable energy, as well as the distribution side of the power firm. With consumer participation, this gives the smart grid the capability to access the demand side of power. Consumers are presented with their consumption pattern; in this manner, they can now manage their power utility much more efficiently. Smart grids also have a notable reclamation on power quality and reliability:

“Two-way communications all across the grid will let utilities remotely identify, locate, isolate, and restore power outages more quickly without having to send field crews on trouble call” (xu).

Besides self-healing technology, sensing and measurement features allow binate communication between the customer and the power firm. It supplies important data such as equipment status, power performance, damage, and temperature to the power firms. At the same time, it allows customers to recognize and react to the electricity grid. All necessary data is accumulated and broken down to help sustain the system in the long run. Transmission and distribution technology becomes much more complex with the integration of real-time and two-way communication. There are five main functions in the information management system: analysis, collection and processing, integration, improved interfaces, and information security (xu). This advancement of information management allows the grid to concentrate and reduce power at peak load times. Transmission and distribution technology of smart grids have many other benefits, which include grasping renewable production and transferring it when capacity is available, relieving blockages, deferring transformer upgrades attributable to peak load growth, and providing down-circuit supply while outages are being fixed (xu).

> “The smart grid is an innovation with the potential to revolutionize the transmission, distribution and conservation of energy. It uses digital technology to improve transparency and to increase reliability and efficiency. ICT’s and especially sensors and sensor networks play a major role in turning traditional

grids into smart grids." (OECD.231).

IMPLEMENTATION OF SMART GRIDS

Implementing the smart grid has seen some success. One example is Austin, Texas with the Pecan Street Project. This was created in 2008, with partners including the City of Austin, the Environmental Defense Fund, the Austin Tech Incubator, the University of Texas, and the Austin Chamber of Commerce (Pecan Street Project, 2010). The founding partners, alongside various tech companies like IBM, Oracle, General Electric, and Microsoft, started working on a local grid system for the city that provided a cleaner energy grid. According to Austin Energy, the first phase, Smart Grid 1.0, serves over 1 million individual consumers and 43,000 businesses (2011). The second phase saw the implementation of web-based meters, allowing consumers to track their energy consumption over the Internet and smart phones. This allows for more integration with renewable energies like wind and solar. The project aims to reduce carbon emissions by 17% below 2005 levels by 2020, and produce 35% of the energy in Austin from renewable resources by then. The report also recommended helping ramping up the smart grid to produce 20 megawatts (MW) of renewable energy by 2012.  Austin clearly shows an example of how smart grid technology can be done effectively when various stakeholder groups work together.

THE CHALLENGES OF SMART GRID IMPLMENTATION

There is an array of different challenges facing smart grids, mostly relating to their development and implementation. There must be a wide variety of different technology that works collectively and economically in order to resolve this. Advanced Metering Infrastructure or AMI technology is one of the most important development factors in smart grid infrastructure: "AMI has a communication networks that consists of many advanced metering and sensing devices, including smart meters. Smart meters provide interval usage (at least hourly) and collect at least daily," (Taniar, 371).

AMI systems are able to provide valuable analyses from all different types of locations within the distribution network in just a matter of minutes. This considerably improves the perceptibility of the distribution system and enables its operators to have the correct data almost instantly, to make appropriate actions during critical situations. The AMI system demonstrates a great opportunity in today's economy, with an extensive, inexpensive system of connections redistributed across the power grid. This is an exceptional contingency from which to glean valuable information on outages, voltage, power, etc. (Laplace, 2).

> "AMI will provide consumers with better control over their energy consumption. For utilities, it will provide more accurate billing and financial statements. Customer service will be supported with this infrastructure as faster – and, in some cases, immediate – service can be provided, as in the case of a connect order, which, with AMI, can be done without field involvement" (Conner, 175).

Besides some concerns with technological implementation, another major concern is privacy. With smart grids relying so heavily on information technology infrastructure, they have access to such information as a consumer's use of energy, allowing utilities to find out how they use it. This may cause a consumer and political backlash. A 2009 article from *Smartgridnews.com* noted that because the lines would be blurred between telecommunication and energy utilities with smart grids, they "raise questions about which entities will have access to individual user data and whether individual devices may be identified or tracked" (Polonetsky, Wolf, 2009). The authors point out that there needs to be a "respectful use of data" policy in effect for consumers using smart meters.

## POLICY RECOMMENDATIONS FOR SMART GRIDS

As seen, smart grids could be a focal point for any renewable energy policy that will wean nations off fossil fuel addiction. For this to occur and smart grids to be successfully implemented in a province like Manitoba, some events must occur on both the supply and demand sides. On the supply side, it is financing. While the cost of information technology infrastructure has gone down, capital and financial tools to access it have proven to be barriers. One way to do this could be an increase in the Green Energy Tax Credit, which currently gives a break of up to 10% on the purchase of green energy equipment including solar, geothermal, and wind (H&R Block, 2010). By increasing the rate to 20% to 35% for businesses, and including businesses willing to supply the infrastructure for smart grids in Manitoba (i.e. information technology), the province could spur the growth of smart grids.

Besides increasing the Green Energy Equipment Tax Credit, Manitoba could also implement a Green Energy Act, similar to one in place in Ontario. The Act allows for feed-in tariffs that encourage a pricing scheme benefitting producers of renewable energy, who heavily rely upon smart grids. The Act also allows more small-scale producers to be involved, which would benefit potential new utility outlets (Vasil, 2009).

On the demand side, affordability and consumer benefits will need to be addressed. Tax incentives or credits similar to the Manitoba Green Technology Tax Credit could be used. As well, partnerships between Manitoba Hydro and local telecommunication companies could give consumers a better rate if they signed up for these technologies. Privacy and IT issues will also need to be addressed. With lines blurred between energy utilities and telecommunication companies with the smart grid, the government could expand current online privacy rules to consumers using smart grids.

## CONCLUSION

While sufficient in previous years in transmitting energy to power homes and spur national economies in the 20$^{th}$ century, the current electrical system is not sufficient enough in this century, due to increased population, demand, and concerns relating to climate change. This was seen in the August 2003 blackout; due to the grid's long transmission lines that support fossil and nuclear-based fuels, continued R&D into these types of fuels do not address the current grid system's inefficiencies.

The smart grid has the potential to reduce carbon emissions and support renewable energy. Its self-healing technology and integration of other devices, namely Internet-based devices, will create more efficient energy use. Austin, Texas, is a successful example of smart grid implementation. By working with businesses, environmental groups, and high-tech companies, the city plans to cut 2005 emission levels by 17% by 2020. However, despite the success in a city like Austin, various challenges remain, including capital costs, technology concerns, and privacy.

Some policy recommendations for Manitoba include increasing the Green Energy Equipment Tax Credit; creating a Green Energy Act similar to that of Ontario that supports renewable energy and smaller-scale providers; fairer rates and tax incentives for customers who sign on for smart grids; and expanding privacy rules to include consumers' smart grid information.

Sources

**Austin Energy.** 2011. "Austin Energy Smart Grid Program." Austin Energy. (Accessed March 27, 2011). http://www.austinenergy.com/about%20us/company%20profile/smartGrid/index.htm.

**Brown, Matthew, Richard Sedano**. 2004. "Electricity Transmission: A Primer". *National Council on Electricity Policy.* (Accessed February 20, 2011). http://www.oe.energy.gov/Documents andMedia/primer.pdf.

**Cass, Stephen**. 2011. "Smart Meters Must be Backed up by New Transmission lines". *Technology Review.* MIT Press. February, 2011. P 65.

**CO2now.org. 2011**. "Atmospheric Co2". CO2now.org. (Accessed March 13, 2011). http://www.co2now.org.

**H&R Block Canada Inc.** 2010. "Manitoba Tax Supplement." Calgary, Alberta. *H&R Block Canada Inc.*

**LaPlace, Carl, and Robert W. Uluski.** 2009. "Realizing Smart Grid of the Future through AMI Technology." *Elster*. 2-3. (Accessed March 1, 2011). http://www.smartgridnews.com/artman/uploads /1/WP42-1003A.pdf.

**Lerner, Eric**. 2003. "What's wrong with the Electric Grid". *Industrial Physist*. 9 (5): 8-13. (Accessed March 13, 2011). http://www.ece.wisc.edu/~dobson/PAPERS/industrialphysicistNov03.pdf

**McLean-Conner, Penni.** 2009. *Energy Efficiency: Principals and Practices*. N.p.: PennWell, 175. Print.

**MSNBC, Associated Press**. 2007. "World Population Boom Likely by 2050". *MSNBC, Associated Press.* (Accessed March 13, 2011). http://www.msnbc.msn.com/id/17605186/ns/world_news/.

**OECD.** 2010. "OECD Information Technology Outlook 2010." *OECD*. N.p.: 231. (Accessed March 1, 2011). http://books.google.ca/books?id=tt-CCbx2dSUC&printsec=frontcover#v=onepage&q&f=false.

**Pecan Street Project, The.** 2010. "Working Group Reccomendations." Austin, Texas. *The Pecan Street Project*. (Accessed March 27, 2010). http://www.pecanstreetproject.org/wordpress/wp-content/uploads/2010/08/Pecan_Street_Final_Report_March_2010.pdf.

**Polonetsky, Jules, & Wolf, Christopher.** 2009. “How Privacy (Or Lack of it) Could Sabatoge the Grid. *Smartgridnews.com.* (Accessed April 2, 2011). http://www.smartgridnews.com/artman/publish/ Technologies_Metering_News/How-Privacy-Or-Lack-of-It-Could-Sabotage-the-Grid-1352.html.

**Sovacool, Benjamin K**. 2008. “The Problem with the "Portfolio Approach" in American Energy Policy”. *Policy Sciences*. 41 (3): 245-261. Springer. (Accessed on Jstore March 15, 2011). http://www.jstor.org/stable/40270968.

**Taniar, David.** 2010. *Computational Science and Its Applications*. 3rd ed. Germany: n.p.371. Print.

**TechTarget.com**. 2011. “Electrical Grid”. TechTarget.com. (Accessed February 20, 2011). http://whatis.techtarget.com/definition/electric-grid.html.

**TechTarget.com**. 2011. “Smart Grid. TechTarget.com. (Accessed April 2, 2011). http://whatis.techtarget.com/definition/smart-grid.html

**Vasil, Adria**. 2009. “Taking T.O off the Grid”. *Now Magazine.* (Accessed April 3, 2011.) http://www.nowtoronto.com/lifestyle/ecoholic.cfm?content=171668#

**Whitesides, Loretta Hildago.** 2007 December 28. “NASA’s James Hansen says Atmospheric CO2 is Already Beyond Safe Limit”. *Wired.com*. (Accessed April 3, 2011). http://www.wired.com/wiredscience/2007/12/nasas-james-han/#.

**Worldometers**. 2011. “What was the population of the World in the Past?” Worldometers. (Accessed March 13, 2011). http://www.worldometers.info/population/.

**Xu, Zihan**. 2010. "Smart Grid: Trends in Power Market.” *Washington University*. (Accessed March 1, 2011). http://www1.cse.wustl.edu/~jain/cse574-10/ftp/grid2/index.html#sec2.