

Xcel Energy SmartGridCity™

Benefits Hypothesis Summary

UTILITY INNOVATIONS

Introduction

Xcel Energy's business strategy has multiple components, including a focus on our customers and communities. Our strategy of delivering reliable energy is coupled to our commitment to find the *most environmentally beneficial* methods of meeting the energy demands of our customers. One area of opportunity revolves around the concept of a smart grid. While the industry has various definitions of a smart grid and there are multiple efforts underway that are called "smart grid," we believe it is now possible to develop and evolve a fully inter-connected system allowing customers to automatically manage their energy consumption and enabling Xcel Energy to reliably produce and deliver that energy through real-time, automated controls. Xcel Energy's commitment to being the pre-eminent utility leading environmental stewardship underwrites our commitment to evolving the smart grid.

Xcel Energy's vision of a smart grid includes a fully network-connected system that identifies all aspects of the power grid and communicates its status and the impact of consumption decisions (including economic, environmental and reliability impacts) to automated decision-making systems on that network which reflect individual and aggregated choices. This vision leverages the multitude of vertical system solutions currently available and deploys a horizontal integration of these systems into a real-time, automated "sense-and-respond" network that will manage the entire energy pathway. We believe this advanced decision-making system will allow Xcel Energy to more efficiently deliver energy while providing consumers with valuable information for better decisions on when, where and how to consume energy. The result will be a greatly improved delivery system that minimizes environmental impact, ensures the most efficient delivery while also maximizing grid reliability.

Xcel Energy has been recognized in the past for its ability to drive transformation through Information Technology as well as for its ability to bring partners to the table for leveraged development. Our past successes, combined with a continued commitment to innovation, have afforded us a privileged and unique opportunity to be an industry leader in the deployment and evolution of the Smart Grid within the industry. In March we announced our intent to create the nation's first SmartGridCity in Boulder, Colorado, leveraging the densest concentration of smart grid technologies to date. Xcel Energy along with other consortium members Accenture, Current Group, Schweitzer Engineering Laboratories, Ventyx, GridPoint, OSI Soft as well as a other public and private collaborators are committed to bringing its ambitious smart grid vision to life for all the world to see.

The Hypothesis-driven Approach:

Research and development in the utility industry has long been hampered by the need for tried and true "prudent" investments. As a result of this dictum, true boundary-stretching R&D happens too infrequently. Even vendor development tends to focus on well-established, non-controversial areas, since it is easier and less risky to sell "enhancements" rather than new and radical tacks to traditional problems. The smart grid arena has suffered under this paradigm as well and has, in our opinion, accordingly, merely highlighted smart meters and vertical solutions to the detriment of the evolution of the full end-to-end digital grid solution. Xcel Energy's approach to the smart grid starts from a completely different point, by positing new hypotheses to frame our initiatives; hypotheses which will require an established, broad-based infrastructure and real world test grounds. It is far too early to know which of these hypotheses will prove accurate or not. In fact, all we do know is that if we frame our hypotheses too conservatively—and as a result, all hypotheses are proven valid-- we will have missed the opportunity to plow significant new ground in SmartGridCity,

Smart Grid Benefits

While we can determine quantifiable benefits the smart grid will bring in the short term, we believe many other significant benefits will become apparent after a widespread smart grid deployment. Specifically, we believe there is compelling evidence that supports the following long-term benefit **assumptions**:

- Significant reductions in residential peak demand energy consumption achieved by providing real-time price and environmental signals in conjunction with advanced in-home technologies.

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- Potential carbon footprint reduction as a result of lowered residential peak demand and energy consumption, improved distribution losses and increased conservation options.
- Possible reductions in the number of customer minutes out as a result of improved abilities to predict and/or prevent potential outages, and more effective responses to outages and restoration.
- Expected deferral of capital spend for distribution and transmission projects based on improved load estimates and reduction in peak load from enhanced demand management.
- Potential utility cost savings from remote and automated disconnects/ reconnects, elimination of unneeded field trips and reduced customer outage and high-bill calls through home automation.

These aggressive value assumptions have significant interdependencies, not only on technology and its application but, equally importantly, on business strategy, public policy and regulatory adoption. The overall smart grid value first requires proving the viability of technology and then the evolving application of that technology. Xcel Energy intends to use hypothesis validation to confirm the design and capability of the smart Grid and we've outlined those aggressive hypotheses below. As we deliver, test and validate/invalidate the applicability of specific technologies, we will then apply business case economics to each of the hypotheses to finalize the value investment decision.

Reduce Customer Minutes Out

Preventing customer outages is a critical factor affecting customer satisfaction. A smart grid will proactively identify devices approaching imminent failure. It will also more quickly identify current outages, nested outages, and the locations that need to be attended to most quickly to remedy those outages. The use of advanced metering applications will eliminate costly "okay on arrival" situations by being able to determine if a customer is out. Providing crews with access to this information while they are in the field will vastly improve outage restoration performance by having faster, prioritized responses.

Xcel Energy's smart grid will use the following methods to reduce customer minutes out.

- System reconfiguration using intelligent automated switches coordinated with substation intelligence
- Remote identification of faults
- Remote, real-time identification of outage size and location
- Remote control and aggregation of demand response and distributed energy resources
- Remote outage and restoration detection
- ***By reducing customer minutes out through fault switching, automatic outage notifications and proactive asset replacement, Xcel Energy expects to improve SAIDI by 10 percent***

Customer Benefits

Xcel Energy strongly supports renewable energy and environmental sustainability. Due to the variable nature of renewable energy, particularly wind power, information about availability of renewable energy and emissions of conventional generation will help customers make choices that reflect their own environmental priorities and commitments. The ability to educate and empower customers to automatically manage their energy use with respect to both price and environmental signals will create more options as Xcel Energy's renewable energy portfolio continues to grow.

Real-time pricing programs help manage demand by raising the retail price when our energy cost is high and lowering the retail price when our costs are low. However, these programs have previously been unpopular with customers because they have been complex and inconvenient. A system that automates customer energy consumption based on customer-selected preferences against both price and environmental signals would alleviate both the complexity and inconvenience. A system that enables customers to optimize energy consumption based on emissions reductions would encourage customers to leverage low emissions generation from renewable sources.

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Empowering customers with tools and energy management information will enhance Xcel Energy's ability to manage costs by managing demand. Information about on-peak and off-peak usage with emphasis on energy cost and the reduction of emissions will encourage customers to use energy in a more price responsive, environmentally sustainable way, including the options of using distributed energy resources such as PHEVs, solar, wind turbine, vertical wind turbine, batteries, geothermal, biomass, fuel cells, micro turbine (10k RPM spinning device with harmonics) and stored energy systems.

A decrease in electricity usage by 2.5 percent could cut Xcel Energy's CO2 emissions by over one million tons annually.

Reduced Billing and Customer Service Related costs

Advanced metering applications will enable automated meter reads, assist with revenue assurance, and improve call center performance. Xcel Energy anticipates this could lead to:

- Reduced costs associated with improved meter reading efficiency – ***representing 50% in potential operational savings over manually and interval read meters.***
- Reduced O&M impacts associated with call center –***representing \$1 million in annual operational savings***
- Recovery of lost revenue and reduced costs associated with theft investigation – ***representing up to \$10 to \$20 million in annual savings and recovery***
- Remote Disconnects/Reconnects – ***representing up to \$5 to \$10 million in annual savings from not sending a technician.***

System Losses

Transmission and Distribution losses, caused by impedances in conductors and compounded by inefficient grid operation, are currently between 4 percent and 8 percent. By reducing these losses, utilities can lower power generation outputs and thus reduce emissions. A smart grid enables calculation and minimization of line losses by redistributing power flow and balancing current to maintain optimal balance between voltage, frequency, and reactive power. A decrease in distribution losses by 20 percent could cut Xcel Energy's CO2 emissions by 500,000 tons annually.

The smart grid will use the following methods to reduce system losses via:

- Remote operation of capacitor banks to reduce the current needed to provide reactive power
- Remote sensing of customer power factor at distribution transformer
- Distribution automation to provide load balancing
- Control and aggregation of distributed generation/distributed energy resources

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Asset Optimization

The smart grid will provide awareness of the health, reliability, and functional constraints of the system. Data collection and communication will create a system capable of making automated decisions that will preserve and optimize asset utilization by:

- Avoiding failures by proactively replacing cables, substation equipment and distribution transformers
- Dynamically rating transformers to help defer capital investments
- Extending generation asset life that avoids capital investments for generation capacity requirements

Xcel Energy posits the operational savings resulting from:

- ***Reduced capital investment in distribution and substation system infrastructure—up to \$1,200,000 in annual savings.***

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- *Reduced maintenance costs associated with distribution transformers—up to \$30,000,000 in annual savings.*
- *Reduce maintenance costs associated with substation transformers and breakers—up to \$1,000,000 in annual savings.*

Power Generation

Increased asset utilization made possible by smarter energy management means more efficient power plant operation and fewer peaking units. Utilities stand to benefit from a higher rate of return on capital investment and lower costs. By running at the ideal plant efficiencies, less fuel is burned resulting in fewer emissions. A smart grid manages this by balancing demand to match the optimal power plant operation efficiency.

Management of power generation to align with demand will result in:

- Avoided generation capacity investment to meet growing demand
- Asset life extension through better asset management that reduces stress and life degradation
- Avoidance of peak power purchase agreements at higher costs

Reserve Replacement

Demand response and distributed energy resources (such as plug-in vehicles and distributed generation), integrated with advanced communication and monitoring abilities provided by the smart grid could reduce spinning reserve margins. A reduction in spinning reserves results in lower emissions and higher efficiencies. The smart grid can provide demand response and DER dispatch faster than thermal power ramp-up and provide precisely targeted geographic dispatch, while increasing overall system reliability.

Renewable energy integration

According to the European Wind Energy Association (EWEA) integrating wind or solar power into the grid at levels higher than 20% will require advanced energy management techniques. These include load curtailment, demand response, and energy storage. EWEA recently published a report recommending the use of demand response as a natural tool for managing variability in wind resources. This is a key message for wind and solar producers, as it increases the size of their potential market.

The ability to communicate (via a smart grid) and new improvements in storage (cheaper, longer lasting, higher capacity batteries) allows for a creation of a new market instrument. A smart grid with advanced energy storage reduces the variability associated with renewable energy, enabling more renewable energy on the grid, thus reducing emissions.

Stronger integration and dispatch management of renewable energy will result in:

- Avoided generation capacity investment to ensure reliability factors
- Reduced loss of renewable generation due to model averaging
- Labor reduction for real-time analytics required to manage the intermittency generation issue

Vehicle to Grid (V2G)

The Smart Grid is a necessity for enabling the next generation of electric transportation. The lack of an integrated communications infrastructure with corresponding price signals poses a significant challenge to handle the increased load of plug-in hybrids and electric vehicles. Smart chargers, time-of-use rates, and advanced meters will be key components, helping utilities to manage a widespread penetration of residential and commercial plug-in hybrids and electric vehicles. Without a smart grid, electric vehicles and their 24 kW power supply and rapid charging needs could easily overwhelm present distribution and generation supplies.

An electric car running at .5kWh per mile adds approximately 132 fewer grams of carbon per mile to the environment compared to a traditional gasoline car. Plug-in hybrid electric vehicle penetration of one vehicle for every 100 people could generate new revenue while reducing overall societal emissions by up to 50,000 tons per year.

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The vehicle-to-grid concept of vehicles able to charge their onboard battery packs during off-peak periods and to provide power back to the grid during peak demand periods has the potential to provide multiple benefits to utilities in the future. Assuming large enough penetration rates of plug-in hybrids enabled with this technology, a utility could use these resources as distributed generation/storage. The following is a list of some of the potential benefits V2G can offer a utility¹:

- Increase in asset utilization;
- Replacement of conventional spinning reserves and regulation reserves;
- Increase in system reliability;
- Reduction in volatility of electricity prices;
- Deferral of capital investment in generation facilities and T&D infrastructure;
- Enabler of higher system penetration rates for intermittent renewable generation sources; and
- Overall reduction in emissions associated with transportation.

Summary

The utility industry today is faced with not only supplying resources to accommodate the projected growth in demand for energy, but also concomitantly minimizing and reducing the impact we have on the environment from producing that energy. Xcel Energy believes the smart grid provides a key solution component for this challenge. The benefits and payoffs are numerous, but as yet not quantified.

For consumers, a smart grid means they can use electricity more wisely and save money by setting “smart” appliances that slow down or shut down on a hot, sunny day when demand for power and its corresponding cost are high. It means having many different options for using energy, and it means having a much better understanding of their overall energy use. For environmentalists, a smart grid means using technology to help solve climate change by conserving energy and using it more wisely. It also means better integration of renewable resources into standard operations, avoiding the creation of more carbon gases that have been linked to global warming. For investors, it provides additional revenue opportunities, deferral of significant capital infrastructure investments, and enhanced ability to dramatically upgrade systems. It also means significantly improving reliability and increasing customer satisfaction.

The 21st Century energy grid is coming together; however, it will take commitment, determination and innovation to realize the enormous benefits to consumers, to the economy and to the environment. Xcel Energy’s SmartGridCity™ approach will provide a living laboratory to enable us to quantify the range of costs/benefits of evolving Smart Grid technology. Xcel Energy is committed to working together with its Smart Grid Consortium partners to address the weaknesses inherent in today’s regulated market’s approach to R&D and applied development.

¹ “V2G Primer For Utilities”. [Smart Grid Newsletter](http://www.smartgridnews.com/artman/publish/article_206.html). May 28, 2007. http://www.smartgridnews.com/artman/publish/article_206.html