

The Naperville Smart Grid Initiative



Looking around the city of Naperville, it's no surprise that it was named one of Fortune Small Business' Best Places to Live and Launch in 2008. A thriving business community, picturesque houses, acclaimed public and parochial schools and the best public library system in the country all speak to the city's success. However, it is also what you don't see that serves as a testament to the city's determination to exist on the forefront of community development.

There is a noticeable absence of above-ground power lines that would otherwise adulterate the city's charming aesthetic. That is because 92 percent of the city's distribution power lines are underground, demonstrating an advancement in electricity infrastructure far ahead of most communities across the country.

In fact, the developments that Naperville's Department of Public Utilities have made in their efforts to update their power grid epitomizes the city's true spirit of innovation. When they set out on their mission to build a more reliable, cost competitive, and efficient grid nearly twenty years ago, they started down a path toward building a smart microgrid before the term even existed.

TOO MANY OUTAGES

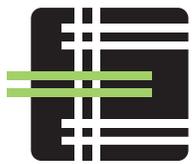
In 1992, Naperville's water utility merged with the electric utility, and Allan Poole, formerly director of the water utility, was named the director of the now combined City of Naperville Department of Public Utilities. What Poole inherited was an aging electricity grid with antiquated technology incapable of meeting the city's rising demand for power, a consequence of rapid population and community growth.

The combination of a power-hungry community and outdated infrastructure meant that Naperville residents were experiencing power outages that were growing more frequent and longer in duration. In other words, the Naperville electric utility had a major reliability problem on its hands.

"We came to a point where upgrading our electricity grid was absolutely necessary," said Allan Poole, Naperville's Director of Public Utilities. "Not only was there a pressing need to build new infrastructure to meet the rise in demand, but we also needed to replace and upgrade the existing, failing grid. Faced with the need to act, rather than simply fix what needed fixing, we chose to plan for future growth and anticipate advancing technologies. This combination of factors became the catalyst for innovation."

The Galvin Electricity Initiative, launched by Robert W. Galvin in 2004, has brought together the nation's leading electricity experts to transform our electric power system into one that is more affordable, reliable and fuel-efficient. The Initiative has created innovative business and technological blueprints for the ultimate smart grid: the Perfect Power System, a smart microgrid that meets the needs of 21st century consumers.





The first thing that Poole and his colleagues at Naperville’s Department of Public Utilities did was to apply continuous improvement methods — the foundation of quality management — to the upgrade process. This led to a fundamental change in design and the complete renewal of Naperville’s electricity system. Leveraging unconventional thinking, Naperville created its own intelligent grid by converting its system into a smart microgrid — a community-based version of the bulk power grid that incorporates the latest smart technology, local power generation, and a configuration that virtually eliminates power outages by identifying and adapting to faults.

This was accomplished by moving the system underground, building in redundant supply to buildings, automating switches to reroute power in the case of a failure, and communications with all devices. A benefit of smart power technology is having the ability to acquire and access data detailing how the distribution system is functioning. In order for Naperville to capitalize on this advantage, they built a centralized location for all of the incoming data to be directed, called the Electric Service Center. From the Electric Service Center’s control room, also known as the “smart grid brain,” a real-time data acquisition system called System Control & Data Acquisition (SCADA) gathered and processed critical data. SCADA is crucial for real-time operation and requires reliable, two-way communication with the substations. Monitoring SCADA from the Electric Service Center’s controls allowed the Naperville team to forecast and plan their system better, fix problems using controls from the Electric Service Center’s control room, as well as dispatch people to address problems quicker. Thus, SCADA became the backbone of Naperville’s power system – and the first step toward improving their grid.

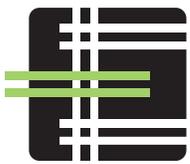
WHO PAYS?

Naperville realized new development was diverting critical investment dollars from the existing distribution system. They took a bold step, charging new customers a temporary special rate or rider that covered the cost of system expansion to serve new customers. This allowed Naperville to apply rates collected from existing customers to the smart grid project.

Naperville leadership also asked a different question, “ What would we rather pay for: a steady stream of waste or an investment to stop it?” Naperville’s power system was out in the open prey to weather, animals, and accidents. A significant portion of what residents pay for distribution improvement is diverted to putting this exposed system back up, every time it falls down. More importantly, electricity outages exert a tremendous economic and emotional toll on residents and businesses.

Today, electricity is critical to life safety for many residents who require electricity for heating, cooling, and/or medical support. At greatest risk are senior citizens. During an outage, police and fire are dispatched to determine the extent of the outage, ensure traffic safety, assist senior citizens with building egress, protect vulnerable businesses and homes, and begin recovery/response activities. Many residents utilize candles for light, a significant fire and safety hazard. Overall, a power outage is a significant safety risk to communities.

Power outages also have a significant economic impact. Local business is interrupted, causing thousands of dollars in lost productivity, sales and spoiled food. A multiday outage costs residents, as a minimum, several hundred dollars for lost food. In some cases, parkways are littered with furniture, carpets, and other personal items that were damaged because of inoperable sump pumps. Flooded basements, spoiled food, and lost production costs U.S. taxpayers billions in waste and the increased cost of goods .



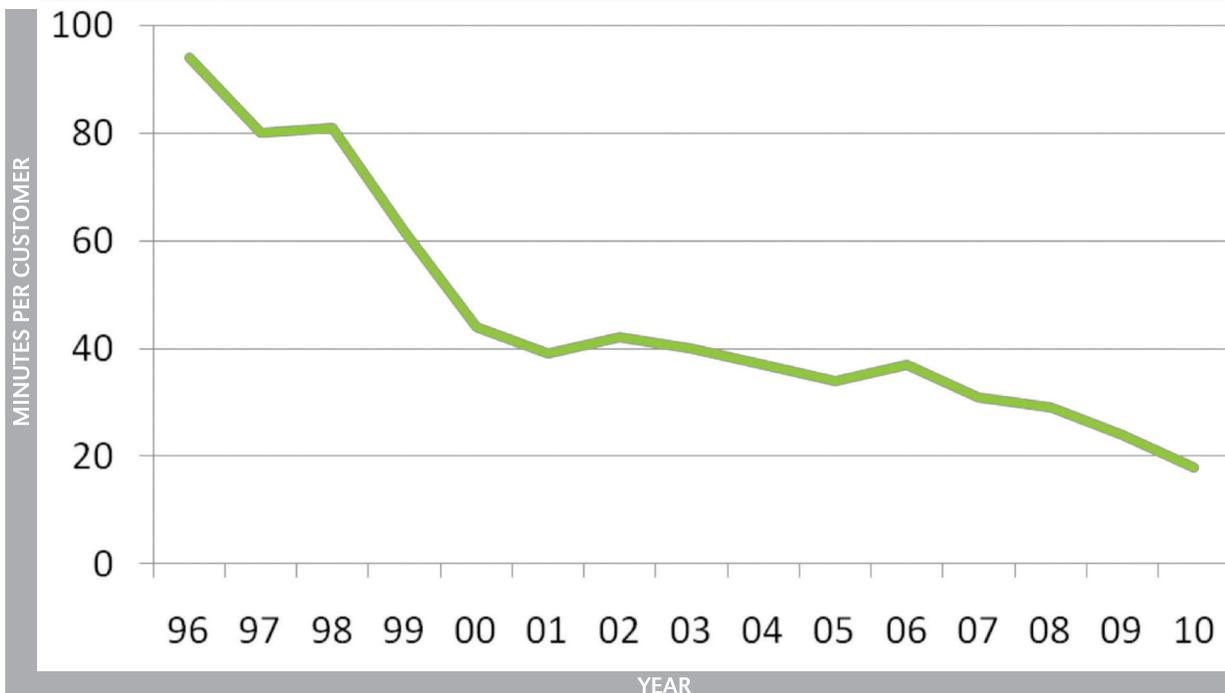
THE COMMUNITY ADVANTAGE

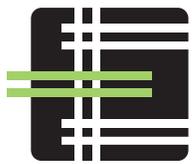
A number of variables contributed to Naperville’s success in developing their smart microgrid. As a public power utility, Naperville had greater control and lower costs of capital and interest than would be the case with a larger utility. Equally important, however, was the foresight shared by the Mayor, City Council, and majority of the community that pushed the limits of technology to achieve something truly innovative and ahead of its time.

Over a span of 17 years, the Naperville department of public utilities staff has been guided by a mantra of continuous improvement and a constant search for new technologies and system design approaches. They recognized the limitations inherent in systems with radial designs — where, because electricity is only connected at the source of distribution, there are few options for real-time correction in case of a failure. Despite the fact that this design was most common, the Naperville team embraced a loop configuration, where electricity is interconnected throughout the system, as it gives electricity an alternate path to follow in case of a disturbance and is thereby much more reliable. Underground infrastructure is appealing for aesthetic reasons as well as reliability, but outages take longer to detect because they are not visible. Automation technology helped counter this limitation as it can instantly locate and isolate the fault.

A look at the reliability metrics demonstrates Naperville’s success in creating a significantly more reliable system. One standard reliability measurement in the U.S. is known as SAIDI, which stands for System Average Interruptible Duration Index (SAIDI) and shows the average outage duration for each customer served. In 1992, Naperville’s SAIDI measurement was 120 minutes. In 2010, it was down to an impressive 18 minutes.

Outage Duration per Customer in Naperville, 1996 - Present





Not satisfied with eliminating outages, Naperville also set the bar high for the integration of renewable energy sources. The new automated grid allows for two way flow of power and net metering of consumer installed low carbon generation (e.g. solar power). When their new substations were being developed, they were built so that solar panels could be installed on the substation rooftops once the technology and funding was ready to support it. This again demonstrated the foresight that has guided the smart grid project to its success.

Today, the current system features the following advanced technology, from leading providers both within and outside the state:

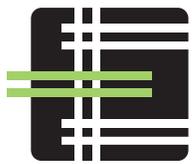
- Substation automation by Siemens
- Distribution automation by S&C Electric
- System control and data acquisition (SCADA) by ACS
- Service request by Cityworks Azteca
- Geographical information system by ESRI/Miner&Miner
- Workflow technical analysis software by SynerGee Stoner and others
- File and application servers by Microsoft and others

A NEW PARTNER: U.S. DEPARTMENT OF ENERGY

In the fall of 2009, the City of Naperville Smart Grid Initiative received an \$11 million grant from the Smart Grid Investment Grant Program, which is part of the American Recovery and Reinvestment Act of 2009. Naperville was the only Illinois project, and one of only a handful of communities, to receive funding. This served as a testament to all that the city has accomplished over the past 17 years. Subsequently, in December of 2009, the Naperville City Council endorsed Naperville's Smart Grid Initiative and committed financial support for the city to match the grant from the U.S. Department of Energy to install the smart grid. This action allows the city to move forward with negotiating and finalizing the award for final City Council approval in early 2010. An inspiration to other municipal utilities, the Naperville Smart Grid Initiative received funding because it was shovel-ready and those driving the project had thoroughly demonstrated through 17 years of work that they were committed to the success of this project.

This next phase of Naperville's smart grid project will include:

- Complete automation of the city's electric grid, by integrating automatic, computerized meter readings. This will enhance system efficiency and reliability, streamline customer billing and increase billing accuracy. The addition of more than 57,000 smart meters will allow residents and businesses to analyze and adjust their energy usage patterns, thus conserving energy and controlling consumption and costs.
- Implement time of use pricing structures that more accurately reflect the actual cost of what it costs for Naperville to buy power for its residents. Most residents don't know that power is much more expensive during the day, than at night.
- Provide consumers with secure wireless access to real time electricity usage data so that they can better understand how they use electricity and seek ways to lower costs.
- Pay consumers to help Naperville reduce peak demand, which increases overall electricity costs for all residents.



- Educate consumers and introduce them to emerging technologies that will assist with managing energy costs
- Based on the availability of real-time feedback, the Department of Public Utilities will increase utility reliability and support two-way communication flow between the customer and the utility.
- Through a better understanding of utility demand and usage, pricing can be lowered accordingly.
- The smart grid will also serve as the initial infrastructure to support electric car usage for the average household.

INNOVATION AND OUTCOMES

The path leading to what is now one of the nation's first smart microgrids was set nearly 20 years ago. However, if you ask City Manager Doug A. Krieger about its genesis, he said that "It was simply a question of reliability. How can we improve the reliability of our electricity service?" said Krieger. "Over the last 20 years our reliability has improved tremendously. Having high reliability has transformed from becoming a goal to being an expectation. Now, our goal moving forward with the Smart Grid Initiative is focused on customer empowerment."

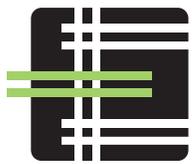
"The future of power is here and Naperville is at the forefront," said Naperville Mayor A. George Pradel at a press event in December announcing the city council's endorsement of the Naperville Smart Grid Initiative. "This is an exciting opportunity for residents and businesses to directly monitor their energy usage and adjust their consumption accordingly. With our electric utility customers empowered to directly control how and when they use energy, we will lower demand on our grid, thus driving down Naperville's cost of purchasing energy on the wholesale market. There is a potential net benefit for the city of \$34 million (\$52 million with societal benefits) over the next 15 years!"

The Smart Grid Initiative will create cost savings by giving the utility and consumers more control over their electric power use. It will reduce the environmental impact of Naperville's electricity use by reducing demand and increasing opportunities to integrate renewable energy sources such as solar, wind and geothermal power. The smart grid will also serve as the initial infrastructure to support electric car usage for the average household. This project has a three-year implementation phase with work beginning in January 2010.

According to the Galvin Electricity Initiative, community-based projects like the Naperville Smart Grid Initiative demonstrate how municipal utilities can incorporate existing technologies to create smart microgrid electricity distribution systems, and in doing so, meet many of the criteria for Perfect Power. The resulting interactive microgrids are the basis for what the Galvin Electricity Initiative calls the Perfect Power System.

"The Naperville Smart Grid Initiative serves as a model for upgrading and automating the electricity distribution system to meet consumer needs, achieve dramatic improvements in reliability and lower operations and maintenance costs," said John Kelly, deputy director of the Galvin Electricity Initiative. "Naperville's achievements over the past 17 years demonstrate what's possible in electric power system transformation. They prove you can raise quality and dramatically improve reliability at lower costs."

Many parallels can be drawn between Naperville's situation in 1992 and what is going on presently with the U.S. power grid. Power outages cost our nation more than \$150 billion each year. Aging, unreliable, inefficient, insecure and incompatible with the needs of a digital economy, the U.S. electric system is in dire need of modernization. With technology that pre-dates the 1950s, the system includes decades-old equipment on the verge of failure. While these



parts can and will be replaced, the situation presents the nation with an unprecedented opportunity — a chance to also reinvent and change America’s electric grid in ways that are profoundly beneficial to consumers, the environment and the economy.

Naperville could have taken a band-aid approach and fixed the infrastructure as problems occurred. Instead, the city decided to go beyond what was expected and build an electricity system for the future. Recognizing the need for and economic benefit inherent in power grid modernization, the current administration has made it a priority to upgrade our power system. As we come around to the reality that updating the U.S. power system to meet the needs of the 21st century cannot wait, we can look to Naperville as a successful model from which to learn. Naperville embraced the opportunity to go beyond what was required and to blaze a trail by incorporating technology and innovation with their sights set on perfection.

The Galvin Electricity Initiative would like to thank all of those that participated in interviews for the purpose of this case study:

Naperville Mayor A. George Pradel

Allan Poole, PE, Public Utilities Director

Olga Geynisman, PE, Electrical Engineering and Technical Manager

Cyrus Ashrafi, PE, Senior Electrical Engineer

Mark Curran, PE, Assistant Public Utilities Director

Daniel Gacek, PE, Senior Electrical Engineer

Kevin O’Grady, Senior Electrical Engineer

¹ Press Release: “Baltimore Gas and Electric Company Unveils Plans for One of the Most Advanced Smart Grid Initiatives in the Nation,” Baltimore Gas and Electric Company, July 13, 2009. <http://www.bge.com/portal/site/bge/menuitem.538792730c68ac667e1e1c10016176a0/>.

² “The Path to Perfect Power: New Technologies Advance Consumer Control,” Galvin Electricity Initiative, 2007.