CHATTANOOGA, TN

As one of Tennessee's largest and most diverse cities, Chattanooga was determined to become the premier location for innovative technology businesses in the South. With stiff competition from their neighbor to the East – North Carolina and its famous "Research Triangle" – the city of Chattanooga knew it would need a bold initiative to capture the attention of new industry. A large part of their solution revolved around the smart grid and the effort to give Chattanooga one of the most efficient and reliable electricity systems in the country.

As a municipal utility, with ownership of their electricity system, they recognized that they could attract new businesses by reducing the number and duration of power outages while improving power quality. However, as with electricity systems around the US built a hundred years ago, Chattanooga faced the challenge of providing these advantages with an electricity system designed with primarily above ground wires, antiquated equipment and little communication infrastructure.

Led by Harold DePriest, Chattanooga EPB began to transform its organization about a decade ago, cultivating a culture of learning and continuous improvement, eliminating the fear of failure, and establishing processes that streamline work across departments. The empowered

leadership team and employees pursued an innovative approach to improving electricity service that enhanced reliability, reduced operating costs and freed resources to continue improving power quality. The modernized electricity system was tested this past summer by strong winds and performed better than expected by avoiding 42,000 customer outages and speeding restoration for those that did lose power.[1]

Chattanooga took a measured approach to the common concerns surrounding grid improvements – that they are too expensive, too complicated, and will take too long show financial benefits. Rather than becoming dissuaded by these issues, the city instead decided to step back, plan carefully, and develop a smart grid deployment that emphasized customer value and strategic investment. Chattanooga focused on three investments that would dramatically improve reliability:

1. Build a city-wide, fiber-optic communications backbone
2. Install intelligent, self-healing switches
3. Transform the existing system into a looped network with redundant circuits to each customer

The electricity system improvements will help Chattanooga realize its goal of a 40 percent reduction in outage durations

The first improvement was made to modernize the communications infrastructure to support speedy, two-way transmission of information that the intelligent grid devices would require and provide system operators with system condition monitoring data. Chattanooga built one of the country's first completely fiber-optic networks giving residents and local businesses access to simultaneous upload and download speeds up to 1 gigabit, which is roughly 200 times faster than the national average.[2] This investment ensured a virtually limitless data capacity for the next phase of improvement plan – building an intelligent, sectionalized, redundant, self-healing, and interactive grid.

The team at Chattanooga sought out innovative technologies that were proven to dramatically improve reliability, leading them to S&C Electric Company, a worldwide leader in power reliability solutions. Chattanooga installed nearly 1,200 S&C Electric Company IntelliRupter switches, which enable condition monitoring, distributed intelligence, and automatic isolation or bypass of faults.[3]

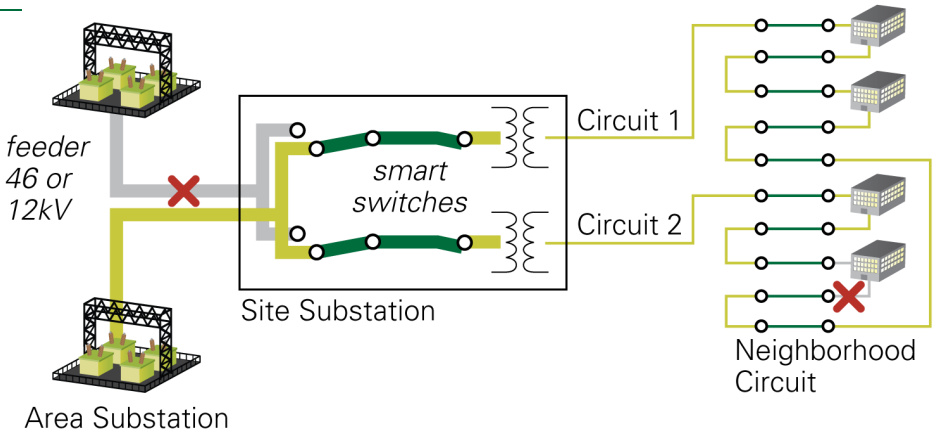
[1] Wade, D. (2012). Chattanooga Shows Smart Grid Can Deliver Results. Retrieved 2012, from http://www.elp.com/articles/2012/09/chattanooga-shows-smart-gird-can-deliver-results.html
[2] Baker, L. (2012). *EPB Deploys America's Faster Fiber-Optic Smart Grid*. Retrieved 2012, from Electric Energy Online: http://www.electricenergyonline.com/?page=show_article&mag=68&article=550
[3] Fastcoexisit.com. (2012). *Chattanooga:A Small City With a Smarter Grid*. Retrieved 2012, from Smartgrid.gov: http://www.smartgrid.gov/recovery_act/news/chattanooga_small_city_smarter_grid

Finally, Chattanooga established redundant feeds to virtually all customers and to substations that supply power to the customer feeds or circuits. This design consideration, called looping, deployed in most water systems, ensures customers will receive power from a second source when an interruption occurs.

Looping and Smart Switches

1. If a fault occurs at one feeder, looping ensures that no one is affected as power is routed from the other area substation

2. If a fault occurs within the neighborhood circuit, it is isolated by smart switches so only a few experience an interruption



This new self-healing system was tested over the summer with impressive results. While a major windstorm caused massive, multi-day power outages across the South and East Coast, the new Chattanooga intelligent grid automatically isolated faults and rerouted power, avoiding outages for about 42,000 out of 170,000 customers.[4] The typical restoration time, for those affected, was reduced by a day-and-a-half, saving $1.4 million in costs.

Chattanooga also noticed a dramatic reduction in storm recovery costs. The dispatch center only needed two operators instead of six, and significantly less manual resources were needed to inspect and manually reconfigure the power system. Instead of driving around to find damage, the monitoring system pinpointed faults and sent crews directly to the problem areas for immediate repair.[5]

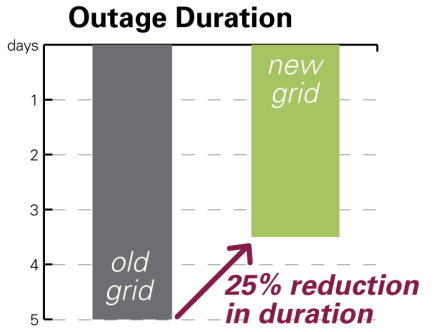
The new system paid off great dividends in smaller events as well. For example, Chattanooga experienced a smaller storm that would have caused damage and interrupted power to about 6,000 customers for 6 to 8 hours under the old grid. Instead, the new self-healing system automatically isolated the fault, rerouted power, and limited the interruptions to just

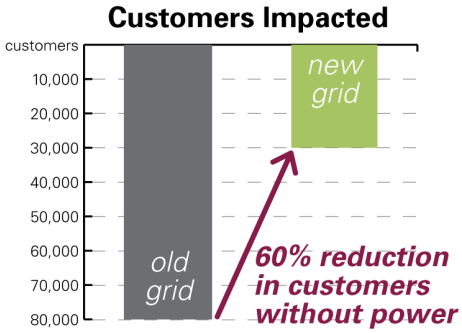
[4] Tweed, Katherine (2012). *EPB Chattanooga Cuts Outages in Half After Recent Storm*. Retrieved 2012, from http://www.greentechmedia.com/articles/read/epb-chattanooga-cuts-outages-in-half-after-recent-storm/
[5] Flessner, D. (2012, 09 22). *EPB Telecom Cuts Power Costs*. Retrieved 2012, from Times Free Press: http://www.timesfreepress.com/news/2012/sep/22/epb-telecom-cuts-power-costs-chattanooga-ctfp/?print

a handful of customers. In another instance, a truck knocked down a 12kV line feeding three substations and customers who would have lost power for hours were restored in seconds due to the smart switches that automatically rerouted power to a backup feed.[6]

Reducing the impact of outages

Chattanooga is seeing improvements in their reliability and efficiency. During the July 2012 windstorm, Chattanooga achieved a reduction in outage time and number of customers without power service while avoiding roughly $1.4 million in restoration costs.[7]





It is important to note that Chattanooga was able to realize these improvements in reliability without first investing in advanced metering infrastructure. This is a growing trend in communities looking to get the most out of limited resources when upgrading their infrastructure. The city of Naperville also found that investing in communications, redundancy, and intelligent switches could pay great dividends in reliability delaying smart meter installations until these improvements were complete.[8]

Smart meters are an important part of a fully functioning smart grid that enables customer participation, and in their final step Chattanooga installed 135,000 advanced meters and is on track to install advanced meters for the remaining 25,000 customers by the end of the year.[9] While the advanced meters reduce meter reading costs, help pinpoint outages, speed restoration, and speed new customer hookups, the real value is yet to come. Chattanooga is researching ways to utilize the advanced meter data to improve power quality, identify system failures that waste power, and lower both operating and capital costs. For example, transformer overload problems can be resolved through system setting changes and automatically rerouting power using the smart switches. Chattanooga will now be able to fully utilize its existing assets, reducing future investment costs.

These improvements just begin to scratch the surface of the true potential for this new grid to improve system reliability and eliminate waste.

[6] Perfect Power Institute (2012). Site Visit and interview with EPB Chattanooga.
[7] Wade, D. (2012). *Chattanooga Shows Smart Grid Can Deliver Results*. Retrieved 2012, from http://www.elp.com/articles/2012/09/chattanooga-shows-smart-gird-can-deliver-results.html
[8] Galvin Electricity Initiative (2010). *Naperville Smart Grid Initiative*. Retrieved 2012, from http://www.galvinpower.org/sites/default/files/Naperville_CaseStudy_Final.pdf
[9] Smith, E. (2012 , 06 16). *Chattanooga EPB's Smart Grid Project Nears Completion*. Retrieved 2012, from Times Free Press: http://www.timesfreepress.com/news/2012/jun/16/chattanooga-epb-smart-grid-nears-completion/

Chattanooga can now collect and analyze massive amounts of new performance data. They are also collecting waveform data at 60 points per cycle approximately every two miles over a system that stretches about 3,500 miles.[10] This will enable them to identify and correct power quality, power losses, equipment mal-operation, and other issues that have remained hidden from view. This includes finding and correcting errors made during maintenance or equipment installation while also predicting and fixing pending failures due to cracked insulators, bad terminal blocks, underground cable degradation, and transformer degradation.

A mesh network system is also capable of two-way power flow that could enable the deployment of clean distribution generation such as solar PV without expensive engineering studies and system modifications. Furthermore, the system could also change coordination schemes based on fault current in real time, which is a flexibility that makes installing solar PV and other local cleaner generation more feasible.

This system also enables Chattanooga to more efficiently execute work orders during normal operation and during outages, increasing the amount of work they can do with the same resources. They experienced an approximate 20% increase in productivity from the new automated work order system.[11]

What have these investments meant for Chattanooga's customers? Residents and businesses have experienced significantly shorter outages, better power quality, and a more efficient utility that can provide new services. A company moving into the Chattanooga area asked for a cost estimate to provide redundant power to their new site, and Chattanooga explained that they already had redundant power and that this cost would be avoided.[12] As a result, businesses are now moving to Chattanooga because, in part, of the improved power reliability.

While it's true that the needs of every municipality will be different and require unique solutions, the steps taken in Chattanooga to update their electric grid provide a model for other communities seeking to implement the same type of changes. By creating the communications backbone for their smart grid, focusing early investment on reliability improvements, and gradually phasing in advanced metering infrastructure, Chattanooga was able to demonstrate the reliability, functionality and cost effectiveness of the smart grid system.

[10,11,12] Perfect Power Institute (2012). Site Visit and interview with EPB Chattanooga.