Case Study

Avista
At the Forefront of Smart Grid 2.0

Photo credit: Mark Wagner

Avista is implementing two Smart Grid 2.0 projects. In Spokane, the utility Smart Circuits Project involves upgrading substations and distribution feeders. In Pullman, Avista's Smart Grid Demonstration Project encompasses updating and automating the distribution system, installing an advanced metering infrastructure, implementing a Web portal where customers can monitor their energy use and a demand response pilot project. In both cities, Avista is installing a Tropos GridCom™ private distribution area wireless broadband network for its smart grid communications foundation.

Utilities are moving beyond Smart Grid 1.0 – automated metering infrastructure (AMI) – toward Smart Grid 2.0. Smart Grid 2.0 focuses on Distribution Automation (DA) and AMI. DA can make a self-healing, digitally controlled network for reliable electric power delivery. The concept also encompasses Demand Response, Smart Home Automation, Distributed Generation, Distributed Storage and Automated Control.

Avista, an investor-owned utility headquartered in Spokane, WA, stands at the forefront of Smart Grid 2.0. The company provides electricity to about 359,000 customers and natural gas to about 319,000 customers. Its service territory spans approximately 30,000 square miles in eastern Washington, nothern Idaho and southern and eastern Oregon.

Challenges
- Deploy multiple smart grid technologies, to automate parts of the utility's energy distribution system to increase system reliability and reduce outages
- Establish criteria for smart grid communications that meets requirements for multiple applications: AMI backhaul, distribution automation, mobile workforce....

Solution
- Tropos GridCom architecture: private distribution area network with high reliability and performance; ability to leverage Avista's existing fiber network and mounting asset
  - IP communications for range of distribution automation devices and vendors
  - Support smart grid applications – AMI backhaul, outage management, active Volt/VAR management and conservation voltage age reduction
- Single vendor for smart electric and natural gas meters, increasing operational efficiencies

Systems & Services
- Tropos GridCom architecture and technologies for wireless distribution area network and network management
- Itron OpenWay electric and natural gas meters

Avista's Spokane Smart Circuits Project

While DA originated in the 1960s, today's implementations are largely islands of automation supporting disparate applications. Recently, advances in communication technologies have enabled the Smart Grid 2.0 vision of DA. Devices such as capacitor banks, switches, reclosers, sectionalizers and transformers can be actively monitored and controlled by software at substations and in utilities' data centers.

Taking advantage of these technology advances, Avista's Smart Circuits Project will upgrade 14 substations and 59 distribution feeders serving more than 110,000 electric customers. The $42 million cost is being funded by a $22 million dollar investment from Avista and a $20 million American Reinvestment and Recovery Act (ARRA) grant from the U.S. Department of Energy's Smart Grid Investment Grant Program.

As part of the program, Avista has installed 36 midline reclosers (for measurement, auto-sectionalizing and control/switching), 124 smart switches (for measurement and control/switching) and 64 capacitors (for active Volt/VAR management). Additionally, the utility has deployed wireless broadband routers from Tropos Networks to form the project's communications network.

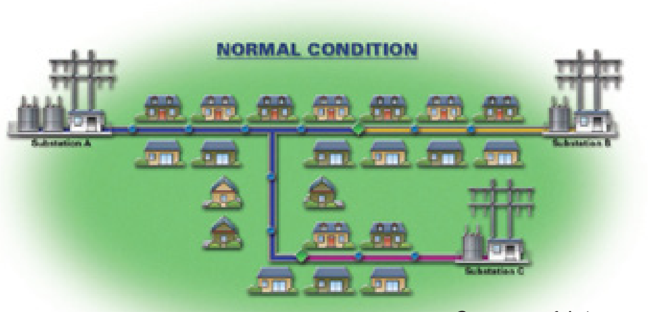
With the Smart Circuits Project, Avista can quickly and automatically pinpoint distribution network faults, reducing the number and frequency of outages and improving system reliability. The project will also enable the utility to reduce energy losses, lower energy consumption and better integrate distributed renewable generation resources.

"The main purpose of Avista's Smart Circuits Project is to learn what makes sense for our customers on a larger scale. With this project, as with all of our Smart Grid projects, Avista is working to improve reliability and make our system more efficient," said Heather Cummins, Director of Avista's Smart Grid Projects.

Increased Reliability

The smart switches and reclosers automatically reroute power to minimize the effect of an outage. They support fault isolation to enable upstream and downstream restoration with no operator intervention. This capability can increase reliability by reducing the length of outages from hours to minutes for many customers.

The example below demonstrates how distribution automation can quickly restore power in the event of a fault. During normal operation, the neighborhood has three distribution circuits, one from each of three substations, as shown in Figure 1.



Courtesy of Avista

Figure 1

Courtesy of Avista

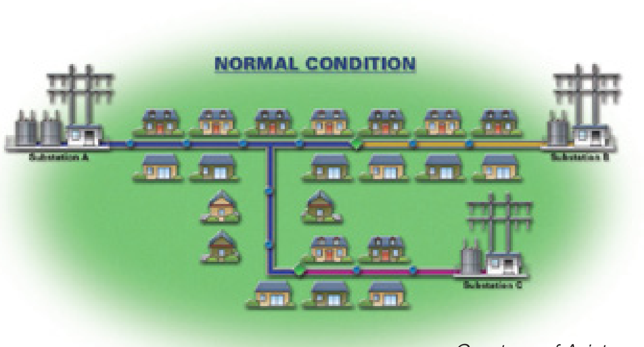
Figure 2

In Figure 2, a fault occurs, perhaps because a car has hit a utility pole. The fault causes all homes served by Substation A to lose power.

Courtesy of Avista

Figure 3

In Figure 3, service between the fault region and Substation A is restored by automatically closing the line switching devices (switches and reclosers) upstream from the fault.



Courtesy of Avista

Figure 4

In Figure 4, service between the fault region and Substations B and C is restored by closing the switches serving as tie points between the distribution circuits and closing the line switching devices between the tie points and the fault. Now the outage is contained to the area between the site of the accident and the nearest line switching device in the direction of each substation.

Prior to the implementation of the Smart Circuits Project, isolating faults was a manual process. Manipulating the reclosers and switches required truck rolls, which could take hours. With smart technology, the process can be computerized and automated – requiring little or no manual intervention – and can be accomplished in minutes.

Increased Efficiency, Reduced Power Consumption

In addition to increased reliability, the Smart Circuits Project promises increased efficiency and reduced power consumption. The project will use active Volt/VAR management and conservation voltage reduction (CVR) to reduce system losses that occur through distribution. (Refer to Appendix A: Conservation Voltage Reduction" for more details about this application.)

Avista estimates that the Smart Circuits Project could save 42,000 megawatt hours of energy annually, or enough to power about 3,500 of its customers' homes, while reducing carbon emissions by 14,400 tons per year.

In addition to reducing carbon emissions from power generation, the Smart Circuits Project will enable Avista to reduce emissions and fuel consumption by reducing vehicle use for switching, outage isolation and service restoration.

Smart Circuits Project Communication Requirements

In choosing a network for the Spokane Smart Circuits Project, Avista conducted a multi-dimensional technology analysis. The technologies considered, the choices that Avista made, and the factors that led them to make those choices are summarized in the following table.

Based on these criteria, Avista elected to deploy a Tropos GridCom network. The Tropos network's capabilities closely match Avista's requirements in each technology dimension considered.

Selected Technology	Alternative	Factors Driving Choice
Wireless Network	Wireline Network	Lower cost, mobile workforce support
Unlicensed Spectrum	Licensed Spectrum	Ease of regulatory compliance
Private Network	Public Network	Best alignment with utility requirement
Broadband Network	Narrowband Network	Required aggregate bandwidth
Proven Technology	New Technology	Proven success and reliability

Spokane's Tropos GridCom Communications Network

Avista's Tropos GridCom network provides a high performance wireless distribution area network for Smart Grid communications. Based on open industry standards, it enables real time communications between the utility's data center, substation controllers and DA devices.

> "This (Smart Circuits) project represents an important step towards the future of energy delivery. "Tropos is a very good fit for outdoor applications, has a strong base, and their reliability/availability design will ensure a high-capacity wireless communications foundation."
>
> Jim Corder
> Director of IT Infrastructure
> Avista

Avista's network can carry traffic for multiple applications. While the initial applications are distribution automation and outage management, the network provides the capacity, reliability, security and low latency to aggregate traffic for additional applications including automated metering, SCADA and mobile workforce automation.

The network was constructed using Tropos wireless broadband routers. The Tropos routers were mounted on utility pole horizontal mast arms and overhead neutral conductors throughout the coverage area. The routers provide wired 10/100BASE-T Ethernet connectivity to Smart Grid devices co-located with the routers and a communications path to Avista's core fiber optic network, connecting at the utility's substations.

Using the network and sophisticated head-end system software, Avista can manage the distribution system and provide both automated and operator initiated responses to faults in distribution circuits. The combination of intelligent devices in the field, a high-performance communications network and head-end software enables Avista's Smart Circuits Project to deliver increased efficiency and reliability.

"I am excited to see the Tropos solution evolve and anticipate alignment with our distribution area network vision. Implementation of a single network to virtually host multiple applications is a critical success factor. Performance expectations are very high and can only be met with an intelligent, adaptive distribution area network solution," said Jim Corder, Avista's director of IT infrastructure.

Avista's Pullman Smart Grid Demonstration Project

The Pullman Smart Grid Demonstration Project takes Avista deeper into Smart Grid 2.0 implementation. It includes DA as well as AMI and a Demand Response Customer Pilot. The project automates much of Avista's Pullman electric distribution system using intelligent devices and two-way communication. The goal is to understand the value Smart Grid technology can bring to Avista and its customers as well as the cost of providing those benefits so that the utility can perform a cost/benefit analysis of various Smart Grid applications. In addition to understanding the viability of each service in Demonstration Project, Avista seeks to understand how to best expand Smart Grid applications to the rest of the company's customers.

Avista's Pullman Smart Grid Demonstration Project is part of the Pacific Northwest Smart Grid Demonstration Project that involves 11 utilities and the Bonneville Power Administration. Taking part in the regional effort allows Avista to leverage the efforts of other participants to, for example, develop cyber security standards and participate in national Smart Grid organizations.

The overall program is led by Battelle under the auspices of the U.S. Department of Energy (DOE). The project is architected for interoperability to demonstrate the benefits of deploying Smart Grid technology across a region. The project's cost will be split between the DOE and the project's participants. The availability of federal matching funds improved the project's business case.

Under this umbrella, Avista is implementing the Pullman Smart Grid Demonstration Project in cooperation with local cost share partners Itron, Washington State University, Hewlett Packard and Spirae. The total cost of the project is expected to be $38 million. Avista is contributing $14.9 million, Avista's cost share partners an aggregate of $4 million and the DOE is supplying a matching grant of $19 million. Other partners include vendors and contractors such as Scope, Efacec Advanced Control Systems and Schweitzer Engineering Labs.

> "Avista is looking forward to implementation of the OpenWay-Tropos smart grid communications solution, which aims to bridge the two network technologies and reduce the number of devices we have to manage and support. We're expecting the network will meet or exceed all of our performance requirements for the initial smart grid applications."
>
> Jim Corder
> Director of IT Infrastructure
> Avista

Avista selected Pullman for the Smart Grid Demonstration Project because it is the right size and offers a good mix of industrial, commercial and residential customers. Pullman is also the home of Washington State University, which has an excellent Power Engineering program. WSU's current research areas include Smart Home, Wind Integration, Electrical Grid Security and Electric Grid Stability. The city is also home to Schweitzer Engineering Labs, a leading vendor of protective equipment. An important aspect of SEL's and WSU's participation is that both have small scale electric generation capability, critical for testing distributed generation integration and net metering.

The goal of the Pullman Smart Grid Demonstration Project is to demonstrate and evaluate Smart Grid applications and technologies. It is expected to show how the electric grid can react to sudden changes in power supply and demand. Finally, it can help prepare Avista as well as its customers and suppliers for the transition of the electrical grid to a Smart Grid.

The project will:

- Upgrade electrical facilities and automate the electrical distribution grid to support intelligent devices and two way communication between the utility and all parts of the system.
- Demonstrate technologies and tools, including advanced metering, in home devices and web tools, which will enable customers to actively monitor and better manage their energy usage.

Potential benefits of the project include:

- Reduced power loss in the transmission and distribution system, lowering operating costs and conserving power to help meet demand
- Increased reliability and decreased impact of outages by deploying self-healing distribution technology, which detects and isolates outages, reducing outage frequency and duration
- Decreased energy use by enabling customers to actively monitor and better manage their energy usage
- Environmental benefits by integrating variable renewable power, such as wind and solar, into the electricity grid

Distribution Automation

The DA portion of the Pullman Smart Grid Demonstration Project encompasses 13 distribution feeders. Along these feeders, Avista has installed 34 reclosers and 30 capacitor banks.

The goals of deploying reclosers and capacitor banks in Pullman are the same as in Spokane. They will increase efficiency while providing electric customers with greater reliability by limiting the scope and duration of outages.

> "Distribution automation applications require reliable, high-performance wireless communications, which Tropos and Itron provide. It made economical sense for us to extend the Tropos wireless broadband network and is expected to simplify management of the network."
>
> Heather Cummins
> Smart Grid Projects Director
> Avista

In addition, Avista is installing smart transformers in Pullman. These devices provide integrated telemetry, including voltage and current measurement as well as thermocouples to determine internal temperature. Avista will use the telemetry data to perform conservation voltage reduction calculations for automated Volt/VAR management and to proactively determine when transformers need to be replaced. And, when coupled with the project's AMI deployment (see below), smart transformers will help the utility detect electricity theft by comparing the amount of power passing through a transformer to the aggregate power consumption mesasured by the smart meters downstream from that transformer.

Advanced Metering Infrastructure Deployment

All Avista electric and gas customers in Pullman, including residential, commercial and industrial customers, have been outfitted with Itron OpenWay meters. In total, approximately 13,000 electric and 5,000 natural gas meters were upgraded to the OpenWay meters in spring 2011.

Advanced metering will offer benefits to Avista and its customers alike. The utility will be able to decrease labor costs by reducing the number of employees who must travel into the field to manually read meters.

For new tenants and homeowners, the process of transferring utility service from the previous occupant will become faster because Avista will be able to conduct the required meter reading from a central location rather than having to schedule a truck roll to perform a manual, in-field reading. Service connection and disconnection can also be accomplished from a central location, without a truck roll.

The advanced metering infrastructure will also assist Avista with outage management. The meters will notify Avista when power to individual homes and businesses is interrupted. Proactive notification will enable the utility to promptly detect outages and accurately determine their scope. As power is reestablished, the meters will notify Avista of restoration at individual locations, allowing the utility to ensure that power is available to all customers without remaining isolated pockets of outage.

The advanced meter technology will enable Avista to provide information to customers about their ongoing energy usage. After logging in to a secure website, customers will have access to enhanced tools to monitor and better manage their energy usage.The information collected by the meters and available to customer via the web portal will include interval usage data available within 48 hours of collection. Using this information, customers can make more informed decisions regarding their energy consumption.

Demand Response Customer Pilot

The Demand Response Customer Pilot enables customers to actively participate in the Pullman Smart Grid Demonstration Project.This voluntary pilot project will provide a home area network (HAN) and smart thermostats so customers can better manage electric usage. Avista plans to recruit up to 1,500 volunteers to participate in this program.

Using the HAN, the volunteer customers will be able to view their usage information in near real time in their home. This will enable customers to detect spikes in energy use almost immediately.

Another aspect of the Customer Pilot is demand response. When demand begins to outstrip supply, the demand response system will adjust smart thermostats in the homes of Customer Pilot volunteers to conserve power and better balance demand with supply. Customers can override settings or opt out at any time. (Refer to Appendix B: "Transactive Signaling" for more details).

The demand response portion Smart Grid Demonstration Project will show how the electric grid can react to sudden changes in power supply and demand. This is important for making the grid renewables-ready, demonstrating how it can adjust to intermittent renewable power sources such as wind and solar.

Smart Grid Demonstration Project Communication Requirements

The communications requirements for the Pullman Smart Grid Demonstration Project are largely the same as those for the Spokane Smart Circuits Project (see above). Perhaps the biggest difference is that, while the need to simultaneously run multiple applications on the network is a future consideration is Spokane, it was a necessity in Pullman from day one.

Again, Avista chose a network based on the Tropos GridCom architecture. However, in Pullman, the company implemented the network using Itron OpenWay products that combine AMI functionality with Tropos private wireless broadband networking capabilities.

Pullman's Private Wireless Broadband Network

Avista's Pullman network enables real time communications between the utility's data center, substation controllers, DA devices, and AMI collectors and meters. It is implemented using OpenWay Integrated Cell Routers and OpenWay 7320 from Itron.

The Itron Integrated Cell Routers combines the capability of a Tropos broadband router with Itron Cell Relay functionality. The broadband router connects to the GridCom network, which provides backhaul to Avista's fiber network and data center, while the Cell Relay acts as an AMI collector, communicating with Avista's Itron smart meters using Itron's OpenWay radio-frequency local area network (RFLAN).

Additional private wireless broadband network coverage is provided by Itron OpenWay 7320, which also incorporates Tropos broadband networking technology. As in Spokane, these devices provide wired Ethernet connectivity to Smart Grid devices and a communications path to Avista's core fiber optic network.

Avista's GridCom network provides a common communications infrastructure for all of the Smart Grid Demonstration Project's initial applications. It also provides the capacity, security, reliability, scalability and multi-use feature set needed to enable Avista to deploy additional applications, such as mobile workforce automation and substation security, on the network in the future.

The Road Forward

With the Spokane Smart Circuits Project, Avista aims to significantly improve system reliability, reduce energy losses, lower system costs, reduce the frequency and length of customer outages and enhance the company's ability to integrate distributed renewable generation resources.

The Pullman Smart Grid Demonstration Project takes Avista even deeper into Smart Grid 2.0 implementation, includes AMI and a Demand Response Customer Pilot in addition to DA. The Pullman implementation will provide Avista with the data the company needs to perform a cost/benefit analysis of various Smart Grid applications and to understand how to best expand Smart Grid applications to the rest of the company's customers.

In both projects, Avista is using a Tropos GridCom network as the communications foundation. With a GridCom network providing the communications infrastructure, Avista is evaluating the deployment of many Smart Grid applications, including AMI with five-minute interval metering, distribution automation, smart home area networks, demand response, outage management, distributed generation integration, plug-in hybrid electric vehicle support, substation security and more on a single secure, reliable and scalable broadband wireless network.

Appendix A: Conservation Voltage Reduction (CVR)

The concept behind CVR is simple – reduce power consumption by slightly reducing voltage. Implementation, however, is complex.

Nominal 120V power has a +/- 5% tolerance, i.e., as long as the actual voltage delivered to the customer is between 114V and 126V, the power is considered to be within specification. In practice, most utilities transmit power from substations at the high end of this range to ensure that, after distribution line loss, customers at the far end of the distribution feeder receive electric service that conforms to the minimum voltage limit. The net effect is that most customers receive higher than necessary voltage and, as a result, consume unneeded power.

With CVR, utilities lower the voltage of the electricity they transmit from their substations to conserve power while ensuring the supplied power remains within the specified voltage range at all points along the distribution feeder.

Utilities can make certain that voltage remains within specification all along their distribution feeders by installing voltage measurement points. These measurement points can be remotely monitored via a wireless network. By monitoring the voltage along feeders, the utility can implement a feedback system that enables conservation voltage reduction while ensuring all customers receive voltage that conforms to specification.

Appendix B: Transactive Signaling

The demand response functionality of Avista's Demand Response Customer Pilot uses the capabilities of a transactive control system located at Battelle. unneeded power.

This system continually monitors electricity supply and demand, issuing a transactive signal whose value depends on the supply/demand balance. During times when demand outpaces supply, for example when energy use is low and intermittent renewable power sources are on line, the value of the transactive signal is low.

When demand outstrips supply because of, say, a spike in usage or a drop in supply due to, for example, wind-generated power going off line on a calm day, the value of the transactive signal increases. The transactive signal is analogous to price in a product market, which will increase when demand begins to exceed supply.

In the case of Avista's Demand Response Customer Pilot, when the transactive signal rises above a programmable threshold, the demand response system will communicate with the smart thermostats in homes participating in the Customer Pilot. The demand response system will adjust the smart thermostats to conserve power, better balancing supply and demand.

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