CASE VATTENFALL: AUTOMATING THE DISTRIBUTION NETWORK

Viola's Smart Grid Solutions Increase Efficiency in Vattenfall's Distribution Network

Vattenfall is a €15 billion energy company serving electricity customers in northern Europe. Since 1994 Vattenfall has grown its distribution network in Finland but the aging equipment and poor communication reliability pushed Vattenfall to initiate in 2009 a modernization of the distribution network automation to incorporate the emerging Smart Grid functionalities said to represent the power network of the future. By incorporating Viola's Smart Grid devices, Vattenfall has gained remote control and monitoring of electricity stations out of reach from previous technologies, thus reducing costs across the board, increasing efficiency of the network, and reducing maintenance calls to remote locations.

Vattenfall's Challenge: Differing Technology Standards Inhibited Effective Communication

By acquiring several small local utility companies in Southern and Central Finland Vattenfall has over the years grown to become one of the leading energy companies in Finland. The large amount of acquisitions, however, resulted in a diverse set of technologies, products and standards being inherited from the previously independent companies. The plethora of different technologies made the integration of the companies and, above all, the communication inside the network an impossible task. *"Maintaining the level of expertise with such a diverse equipment base is very challenging, not to mention costly"* comments Jarmo Järlström, Sales Manager at ABB, the party responsible for the installation and maintenance of Vattenfall's network. In addition to this, many of the solutions were built on proprietary technology and the licenses for some of the standards were coming to an end, requiring large-scale investments to maintain operational. Contemplating its options Vattenfall also identified that the number of nodes in the network could be expected to grow in the future, making a higher degree of automation at the stations essential to keeping costs down.

It was thus obvious from the start that merely an incremental improvement of the distribution network would not be sufficient. Primary substations and reclosers connected via fixed-line connections such as fiber optics were mainly equipped with GSM or radio data-modems which posed difficulties to frictionless communication – the connection needed to be re-established every time information was needed, communication costs were high and due to modems relying on physical lines in SCADA, the communication capacity ended up being very limited. Radio modems also required that the network be built from scratch which would have involved large up-front capital expenditure. Since the majority of Vattenfall's secondary substations are scattered around a large geographical area maintaining a network of modem-based communication would have resulted highly complicated and rigid, not to mention costly. The problems of the old network are illustrated in Figure 1.

As a result, Vattenfall ended up renewing the entire telecommunications network, with the intention that the majority of primary and secondary substations be controlled remotely and wirelessly. *"Architecturally, our old network simply did not support present or future needs"* summarizes Ville Maksimainen, project leader of the communication network modernization at Vattenfall.

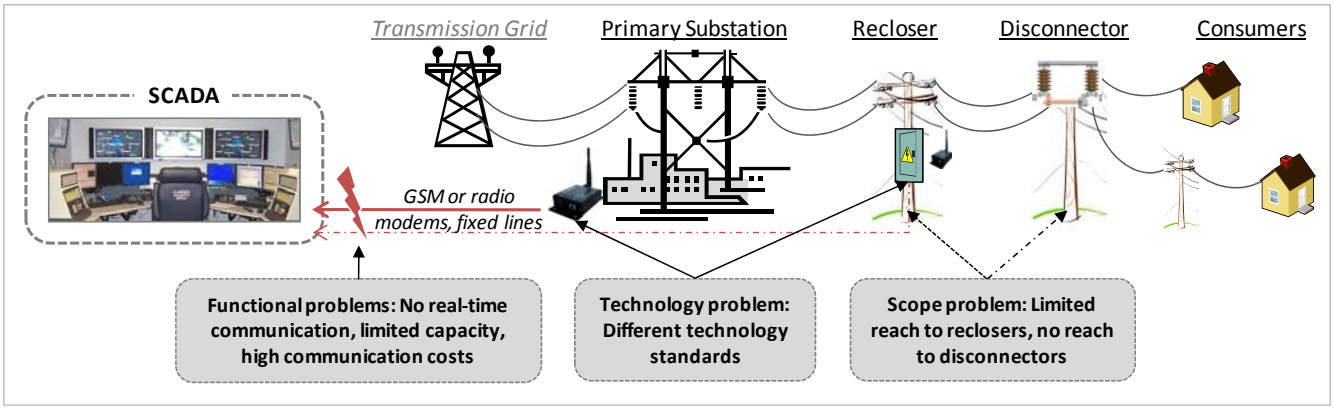

Figure 1: Illustration of the problems in Vattenfall's old distribution network design

The Solution: Smart Grid Technology Revolutionizes Energy Distribution

The modernization of Vattenfall's distribution network communication is built on Smart Grid technology, a technology sometimes referred to as the "Internet for electricity" due to its potential to revolutionize the way electricity is produced, distributed and used. Smart Grid encompasses a variety of tools, techniques and technologies that will allow energy suppliers to more accurately measure electricity flows and remotely control each point of the transmission and distribution network using two-way digital technology.

Smart Grid solutions will greatly increase the transparency and responsiveness of the electricity network, and the European Commission has chosen Smart Grids as a key investment area for the future. *"I am confident that if we consider a time span of 5-15 years, the largest challenges in power distribution will definitely have to do with Smart Grid technology and the Smart Grid -mindset."* Vattenfall's Maksimainen says.

Viola Provides Vattenfall with Smart Grid Functionalities

The Vattenfall project required the collaboration of a number of different stakeholders such as Emtele, ABB, Digita and Viola Systems – each with a specific role in the project. Viola delivered the devices that provide the Smart Grid functionalities to the network, i.e. the routers in the field and in the network control center (SCADA, *Supervisory Control and Data Acquisition)* which enable two-way wireless communication and remote control of field equipment. Remote control of field devices had previously been largely limited to the primary substation level and to some recloser stations, but due to the compactness and cost efficiency of Viola's products it was possible to extend the modernization beyond primary substations to all disconnectors and reclosers. A rough visualization of the Vattenfall Smart Grid solution is illustrated in Figure 2.

At recloser and disconnector stations the main need was to gain always-on two-way communication to allow for remote control and monitoring of the stations. The fundamental element in the modernization was the Arctic Control, the only intelligent device at disconnector sites, which allowed Vattenfall to gain communication contact to the previously isolated disconnectors.

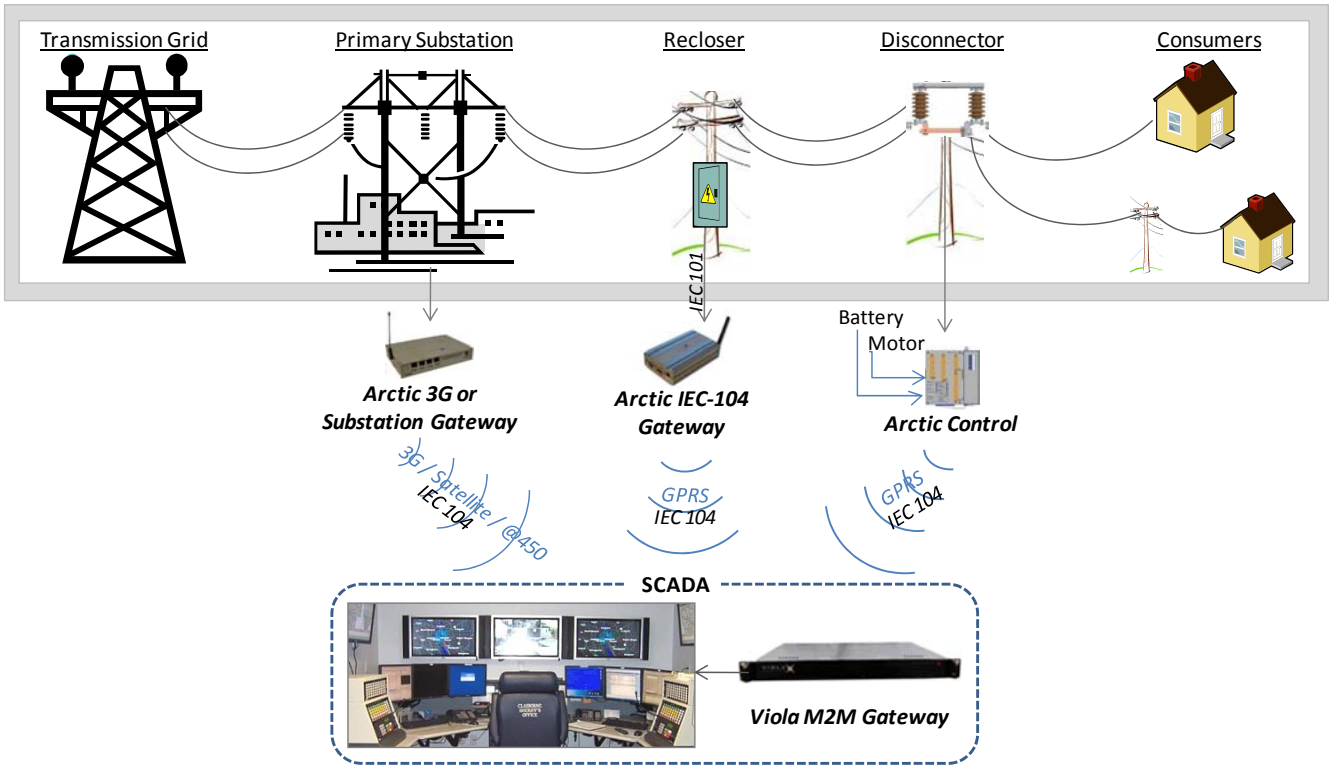

Figure 2: Visualization of Vattenfall's Smart Grid solution

At the substation level the existing communication devices were replaced, and Vattenfall additionally recognized a need for a backup function to incumbent technology. Viola's Arctic 3G Gateway was installed at substations to increase dependability of communication and serves as an ideal backup routing device since it allows for satellite connection and either 3G or an @450- connection operated by Digita to be linked to it.

Integrating the field devices with the local network in SCADA is done with the Viola M2M Gateway. The gateway provides field devices with static IP addresses enabling two-way communication and a secure connection through a VPN tunnel.

Vattenfall's primary concern in the project was the reliability of communication. *"We strive for communication reliability at or as close to 100% as possible, so the dependability and overall usability of the hardware is key"* comments Maksimainen on Vattenfall's requirements. To increase communication reliability all Viola products share the following benefits:

- Provide a continuous connection based on wireless, IP-based technology leveraging cellular networks
- Provide automatic connection monitoring and re-establishment in case of communication failure
- Hold a large communication capacity, allowing Vattenfall to draw and make use of a lot more information from the network
- All field equipment communicate with SCADA using the IEC-104 protocol, and all stations can be controlled from one single control center, thus greatly streamlining communication in the network

Emtele's Martikainen outlines the strength of Viola's products: *"In contrast to competitors' products, Viola's devices were built on an open standard, which makes them much better suited for future demands and*

scalability of the network". Maksimainen goes on to state *"Violas products are unique in the benefits and functionalities they hold in comparison to other products in the market".*

In short, Viola's solution to Vattenfall consisted of the following devices:

Table 1: Summary of the Viola products used in Vattenfall's distribution network

Network Position	Viola Systems Product	Number of Devices	Functionality
SCADA	Viola M2M Gateway Enterprise Edition	3	*Provides fixed IP addresses to all Arctic devices enabling two-way operation, as well as remote maintenance control via a VPN tunnel*
Primary substations	Arctic 3G Gateway and Arctic Substation Gateway	130	*Provides high communication capacity and availability with backup routing function*
Reclosers	Arctic IEC-104 Gateway	200	*Offers real-time remote control and monitoring, thus enabling fast fault isolation and efficient recovery from blackouts*
Disconnector stations	Arctic Control	1300	*Provides a total solution for disconnector control including motor protection, battery charging and monitoring as well heater control*

Close R&D Cooperation Resulted in Improved Arctic Control

The mere scale and size of Vattenfall's communication network modernization resulted in new product innovations emerging as customer needs surfaced. Automating the previously "unintelligent" disconnector stations is a vast project when undertaken, and Vattenfall wanted to make sure that their stations would be state-of-the-art when finished, to avoid having to undertake a similar project in the near future. Even before the project had been started, Vattenfall listed the different functionalities the disconnector sited should be able to perform automatically that up until then had to be cared for manually or left to fate. Based on Vattenfall's needs several new functionalities were developed and added to the Arctic Control by Viola. These functionalities are now either performed automatically by Arctic Control itself or can be accessed remotely from the control center – thus increasing the level of "smart" in the Smart Grid solution for disconnectors.

All parties were highly satisfied with the end result. *"We intend to use the improved Arctic Control in other projects as well"* says ABB's Järlström. The people involved agree that the success of the cooperative effort was largely dependent on an existing mutual trust and long-term partnership. *"Development of the Arctic Control was initiated already in the tendering phase"* says Vattenfall's Maksimainen.

"Software Fuse" Functionality Reduces Breakdowns and Optimizes Maintenance

The functionalities added to the Arctic Control are based on the device's ability to monitor and control other elements inside the secondary substation, primarily the motor controlling the disconnectors and the battery that keeps the station operational.

The Arctic Control was equipped with a functionality dubbed "software fuse" meaning that by monitoring the power the disconnector motor uses, the device can foresee when the motor is reaching its overload point. Due to corrosion and especially in cold winter weather the disconnectors easily get jammed, and thus require more power to function. In these situations the motor would normally run either until the disconnectors work

properly or until the motor blows its fuse or breaks down. With the software fuse function the Arctic Control protects the motor by shutting off power to it before the motor's own fuse blows. The software fuse thus reduces maintenance calls to replace the physical fuse as well as avoids unnecessary breakdowns of the motor, resulting in large savings both in time and costs, in addition to the increase in operational efficiency. Moreover, by monitoring the power needed to run the disconnectors, Vattenfall can deduce when the station needs to be maintained, and can order corrective maintenance in time. The Arctic Control can also monitor the state of the battery and recharge it when needed, allowing for maintenance calls to exchange the battery to be optimized.

A reduction in maintenance calls affects the bottom line directly – Vattenfall estimates that they can reduce the number of maintenance calls dramatically, resulting in a reduction in maintenance personnel as well as costs associated to the long maintenance distances. *"The distance to a maintenance site can easily be as much as 100 km in one direction"* says ABB's Järlström. In addition to the implications for cost savings, a reduction in maintenance also holds a significant environmental aspect to it. *"Due to remote control we can now handle a lot of issues directly from Tampere, instead of having to drive around the country as we used to do"* states Maksimainen. Vattenfall estimates that thanks to remote control driving can be reduced by around 100 000 km per year, amounting to the equivalence of yearly CO_2-emissions of five four-person single-family homes.

Remote Control Greatly Reduces Blackouts and Cuts Costs

Perhaps the largest benefit of remotely controlled secondary substations emerges when a problem surfaces in the network. Previously when power was cut off in a part of the network it took a long time to find, isolate and fix the problem. And since any fault usually interrupts power distribution along the main feeder, all customers connected to the feeder are left without power, no matter how small or remote the fault may be. To limit the impact of a fault in the network, Vattenfall applied a concept developed by ABB called the "zone concept". The main feeder is divided into different zones using remotely controlled reclosers, sectionalizers and disconnectors, so that when a fault happens, it can be isolated to only the fault zone by turning on and off the zone dividers. Without remote control of the secondary substations enabled by Viola's products, this would not be possible.

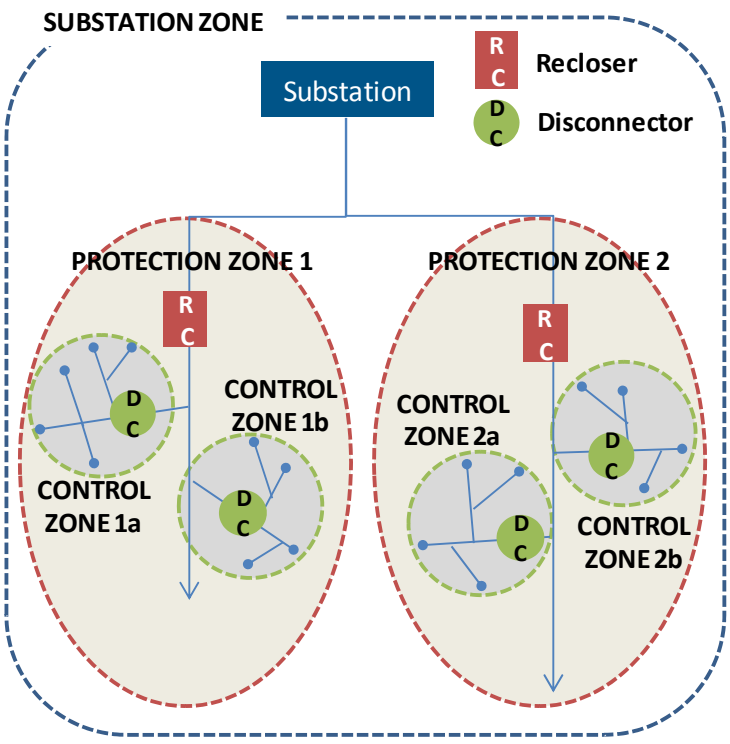

Figure 3: Illustration of the Zone Concept

Adding a recloser to the feeder implies adding a protection zone, and adding a disconnector adds a control zone. When a problem occurs inside a protection zone the recloser will immediately turn off the power from that zone. When the location and nature of the problem are identified, SCADA can take action to isolate the location by opening and closing disconnector switches. By remote control of the secondary substations both the time of the blackouts as well as the number of people affected by the blackouts can be greatly reduced. Research implies that by isolating the fault into one zone the number of customers affected by blackouts is reduced by up

to half. *"One of the largest benefits of the project is to make remote control and fault correction as fast and efficient as possible"* says Vattenfall's Maksimainen. Since blackouts are penalized with sanction payments by authorities, reducing the time and amplitude of blackouts has a direct impact on the bottom-line for Vattenfall.

Pre-Configuration Saves Installation and Commissioning Time

The responsible party for the installation process in the project was ABB, and since Viola's products need to be correctly configured for each individual site, Viola delivered all products pre-configured. That is, all devices were correctly configured and programmed before delivery to the customer site, which reduced the installation process to simply attaching the device in its correct place. *"We don't need to do almost anything to Viola's products in the field – when you connect the power cords the device is turned on, and when you attach the antenna it communicates directly with the control room"* ABB's Järlström exclaims.

Moreover, maintenance of the devices is greatly facilitated as a part of the configuration can be done remotely. Thus, if a device needs to be replaced the maintenance staff does not need to re-configure the device at the site. As long as remote connection is enabled and the device is attached correctly configuration can be left to the control center, thus saving both installation and training time. The expected need of maintenance is, however, very limited since Viola's products are known for being highly reliable. In an electric utility project encompassing 1 000 routers delivered in 2005 not a single communication failure has occurred to this date.

The Electricity Consumer Enjoys Increased Efficiency through Better Quality of Power and Service

A great aspect of the Smart Grid is that it aligns the supplier's and the customer's interests. In the first phase Smart Grid functionalities allow for efficiency improvements in the distribution network. Vattenfall's Maksimainen estimates that the modernization will increase the network's operational efficiency by about 5%, which is a large improvement in such a mature business as electricity distribution. In the short-term this will be visible to the end-customer in the form of better power quality, i.e. a reduced amount of down-time in the network. *"The greatest benefit for the end customer is the reduction in blackouts"* confirms Maksimainen.

Looking to the Future: Increased Application of Smart Grid Functionalities

Vattenfall's Maksimainen has his focus on the long-term: *"Thanks to the increased amount of information we now receive from the field we will be able to develop the network in those areas where it is most needed"*. With the real-time measurement Viola's products allow Vattenfall will gain increased awareness of energy consumption, and Vattenfall already envisions that customer power meters will allow the customer to choose when he consumes electricity based on its price, thus contributing to balancing out demand in the network and increasing its efficiency. According to Terho Into, VP of Viola Systems: *"Smart Grid is basically about getting the most out of the distribution network infrastructure"*.

Vattenfall sees this project as a mere first step to a wider implementation of Smart Grid functionalities, as it expects technologies to improve and authorities to begin demanding higher degrees of automation and communication from distribution networks. Emtele's CEO Hannu Martikainen enhances the novelty of the project: *"This is one of the first projects in this field, and its scale, execution as a turn-key service and high technology make it innovative on many levels."*. Vattenfall wishes, however, to stay ahead of the curb: *"With this project we are laying the foundations for the future, so that we would be able to provide better service to our customers and answer to tougher requirements when they emerge"*, Maksimainen concludes.