DA AND AMI CONVERGENCE:
ENABLING ENERGY SAVINGS THROUGH VOLTAGE CONSERVATION

By Wei-En Tan

The convergence of distribution automation (DA) and advanced metering infrastructure (AMI) is providing unprecedented opportunities for power grid modernization, from transformer and feeder monitoring, outage management and cost effective fault isolation to electric vehicle integration. Bringing immediate benefits from reduced energy use on power distribution systems, voltage conservation allows for power quality to be maintained throughout the distribution system.

With power quality maintained, the voltage stays in the recommended range and household appliances operate as designed. Requiring no change to behaviour, voltage conservation allows for consumers to use less energy and benefit from lower household electricity bills. The energy reduction translates into less power generation requirements and fewer greenhouse gas emissions.

Historically impractical due to the utility's inability to cost effectively monitor voltage levels continuously at the residential meter, voltage conservation is now possible for utilities with converging DA and AMI technology from Elster – a capability not available from many competing systems.

CONVERGENCE OF DA AND AMI

DA is widely defined as a set of technologies that enable an electric utility to remotely monitor, coordinate and operate distribution components in a real time mode from remote locations. Today, the missing link in DA is effective and pervasive communications systems. Without such systems, "remote" capabilities are nonexistent. Because of this lack of installed communication infrastructure, many utilities today have little or poor visibility outside of the distribution substation down to the customer. Ultimately, no single technology or system meets the combined demands of DA and AMI; technologies and systems must be interoperable and complementary. Smart grid/AMI systems, such as Elster's EnergyAxis® system, provide the necessary multi-technology communications infrastructure, as well as a commercialized voltage conservation application through the convergence of DA and AMI.

VOLTAGE CONSERVATION

Overall, voltage conservation reduces the amount of power needed to service a given customer base. This reduction in voltage has no power quality or service impact on end customers, as the voltage at the meter remains within acceptable ranges. Consumers will use less energy with no additional effort on their part – reducing household costs and improving customer satisfaction. The goal of voltage conservation is to reduce energy losses and consumption by operating at the lower end of these voltage ranges.

Figure 1 shows a typical daily voltage curve for a residential customer. The top line (orange) shows the voltage level over the typical day prior to voltage control. The bottom line (green) shows the voltage level after voltage conservation is implemented (leveraging an appropriate AMI system). Voltage conservation does not lower the voltage level during periods when voltage is already low (e.g. 6:00 am and 6:00 pm). However, it does lower voltage when the level is unnecessarily high. The shaded area between

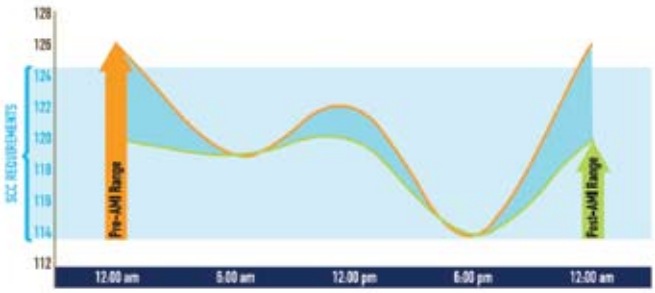

Figure 1 – Impact of voltage conservation on a voltage profile of a typical residential customer

the two lines represents the amount of voltage reduction, and the proportionate reduction in energy use.

Table 1 shows how the amount of energy used decreased for each 1% in voltage reduction at various utilities. For example, Consumers Power Company found that energy use decreased by 0.83% for each 1% reduction in voltage for residential customers. Table 1 also shows that voltage reduction can be beneficial for commercial loads.

Utility	Percent Demand Reduction for 1% Voltage Reduction	
	Residential	Commercial
American Electric Power 1	0.80	0.78
American Electric Power 2	0.90	0.86
Consumers Power Company	0.83	1.38
San Diego Gas & Electric Co.	1.14	0.08

Table 1 – Utility percent demand reduction for 1% voltage reduction (Source: Power System Voltage Stability by C.S. Taylor, McGraw-Hill, Inc.)

Figure 2 compares and contrasts the types of business case benefits that are possible when DA and AMI converge. While installation of meters and ancillary equipment constitutes the primary investment, additional small costs include IT systems and service, IT systems and required distribution system upgrades. The payback from voltage conservation and reduced energy consumption more than compensates for these costs. Additional business case benefits of AMI shown in the figure include improved storm restoration through more rapid response, improved customer service and more accurate and cost effective metering.

Benefits not shown in Figure 2 include minimizing damage to distribution equipment, avoiding rate penalties and adapting to load growth as demand increases. Various qualitative and societal benefits

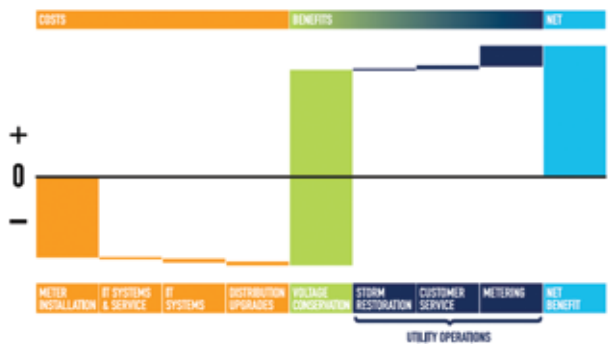

Figure 2 – Benefits of voltage conservation

include deferred construction of new generation, reduced CO_2 and other greenhouse gas emissions and reduced reliance on fossil fuels.

THE ROLE OF AMI IN VOLTAGE CONSERVATION

Given the many benefits, why haven't more utilities implemented voltage conservation? While many utilities have been monitoring and controlling voltage in substations, on select feeder locations, and at large commercial and industrial customers, extending this capability through the power distribution networks down to the individual residential and small commercial customer level has been problematic. Customer level voltage conservation requires an AMI system that can gather the voltage data and provide various alarm and feedback mechanisms to monitor the voltage in real time at customer end points. Without advanced metering and pervasive communications systems, utilities cannot monitor voltage at the customer level and limited to voltage monitoring and control at distribution substations and a small number of other locations.

Utilities must ensure that all customers receive power at an acceptable voltage. Lacking visibility into the voltage levels of all customers, the utility must operate the system conservatively, resulting in unnecessarily high voltage levels for customers during certain periods of time during the day. Even if a utility has installed an AMI system, they may not be able to effectively implement voltage conservation, as not all AMI systems and smart meters provide the capabilities needed to support voltage conservation.

The crucial enabling technology for adaptive voltage conservation is the ability to monitor individual customer voltage levels and energy use data to operate the power distribution system within a tighter tolerance. To do this, the AMI system must continuously monitor the lowest voltage customer and provide this data with the cycle time necessary to adjust voltage. The system must do this without adding limitations or constraints to other core AMI applications. This requires that the AMI system and its advanced meters be specifically designed for voltage conservation. Transmission and distribution energy losses of up to 7% are common on electric utility systems. Figure 3 shows the locations of these losses. Voltage conservation focuses on the portion of the system where the losses are the greatest and where voltage has not traditionally been monitored and controlled: through the power distribution network to the customer.

Figure 4 shows the role of AMI in facilitating adaptive voltage conservation at the customer level. Reducing the voltage on distribution systems reduces distribution transformer losses and decreases customer energy use. While all generations of distribution systems benefit from voltage conservation, older distribution systems benefit even more than relatively new ones

HOW VOLTAGE CONSERVATION WORKS

In the electric power industry, Elster's EnergyAxis system incorporates customer meters that monitor voltage on a regular

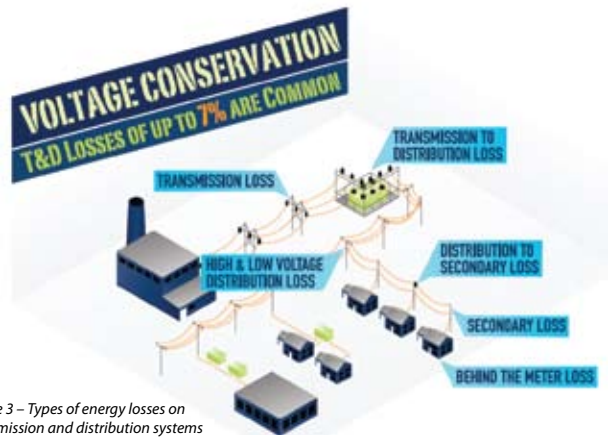

Figure 3 – Types of energy losses on transmission and distribution systems

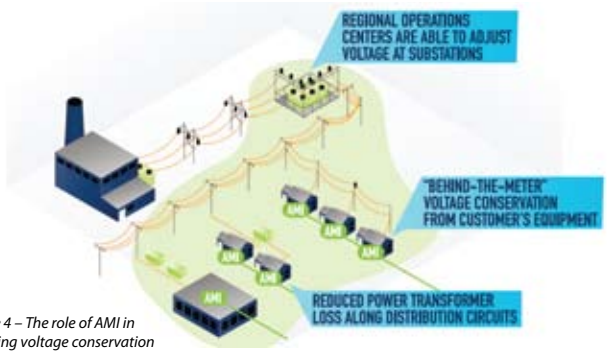

Figure 4 – The role of AMI in enabling voltage conservation

basis. Installation of these meters ensures adequate visibility into the range of customer voltages that occur at various locations on feeders. The Elster EnergyAxis system monitors selected key points frequently and harvests that data in near real time.

Frequent voltage reads also provide immediate feedback to system operators, ensuring that the voltage adjustments had the desired effect. Because voltage and energy are recorded for the same time intervals, the system can document energy reduction for each customer and provide data on a monthly and feeder basis. This data can be used to evaluate the voltage conservation program and demonstrate conservation levels to regulators. Key customers with critical needs, such as hospitals, can be monitored specifically to ensure no change in power quality.

Elster offers a commercially ready system specifically designed for continuous voltage monitoring at residential and C&I customer locations, enabling utilities to implement adaptive voltage control by providing real time voltage visibility across distribution feeders. In addition to allowing proactive voltage monitoring at various points along the feeder, Elster's system provides 100% coverage of the residential base. Through the use of state-of-the-art voltage threshold monitoring, the system provides notification to the utility if any location drops out of prescribed voltage limits. This capability allows utilities to reduce voltages aggressively, with confidence. The Elster AMI system acts as the "eyes" throughout the distribution system, while the DMS/SCADA is the "brain" that makes decisions as to mitigating actions, and the capacitor banks and LTC voltage regulators are the "brawn" to implement these actions.

THE SMART GRID VOLTAGE CONSERVATION ALLIANCE (SGVCA)

Formed in 2011, The Smart Grid Voltage Conservation Alliance (SGVCA) aims to provide utilities with an end-to-end voltage conservation programme. The SGVCA has the two-fold goal of enabling operational efficiency for utilities and advancing the business case for voltage conservation.

Founding members include Elster, ABB, Survalent and Entergy. For more information, please visit www.sgvca.com

Voltage conservation is a proven means of reducing energy consumption on the distribution system with demonstrated technical and economic viability. It is an important application that utilities should consider as part of their grid modernization efforts. MI

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