PEAK DEMAND MANAGEMENT WITH CLOSED LOOP VOLTAGE REDUCTION (CLVR)

A white paper on the tangible benefits of real-time voltage data from the grid edge

Tantalus

Helping local communities thrive for over 30 years.

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AN INTRODUCTION TO DVR AND CLVR

Demand voltage reduction (DVR) is one of the simplest, most cost-effective ways a utility can manage loads to reduce peak electrical demand. Unlike traditional conservation voltage reduction (CVR), in which voltage is lowered 24x7 to decrease overall annual energy consumption, DVR provides event-based reduction only during peak times, which primarily shifts load to off-peak periods. The goal is to reduce demand as much as possible during peak times while completely avoiding any negative customer impacts. Tantalus closed loop voltage reduction (CLVR) accomplishes this using the Tantalus Utility Network (TUNet), an automated metering infrastructure (AMI) platform for smart grid applications.

Morristown Utility Systems (MUS) in Tennessee has been leveraging CLVR for almost 10 years to collect extensive real-time voltage data from the field to close the loop between customer service locations and utility operations. The result has been effective and sustained demand reduction with improved power quality. Furthermore, by integrating with SCADA, CLVR has enabled fully optimized and automated DVR that runs without operator intervention. This paper describes the benefits of CLVR and how it was deployed with TUNet by MUS.

RESULTS AT A GLANCE

2.1% Typical peak demand reductions from DVR without feedback from the grid edge	**4.0%** Demand reduction achieved at MUS using CLVR
$37,600 Average monthly costs savings attributable to DVR with CLVR	**$4.2 million** Total costs avoided to 2020 with this program

The key benefits of CLVR with TUNet for utilities include:

- Reduces demand charges immediately and substantially
- Is virtually invisible to the consumer
- Does not require any consumer marketing programs or buy-in
- Achieves the best possible voltage reduction possible without risk of customer impact
- Identifies unrecognized inefficiencies in the existing power grid

CLVR is designed to decrease a utility's total electrical load in anticipation of a peak event by making reductions in the feeder voltages coming from substations. For example, on a hot summer day when the demand on a utility's supply is approaching peak, the utility can call an event and immediately act to temporarily decrease voltage. Many loads will immediately draw less power and reduce demand, while still performing within expectation. Although the reduction is small and power quality remains within required regulatory tolerances, the cumulative impact of thousands of electrical loads simultaneously using less power has a significant impact on reducing a utility's demand.

Voltage control as a means of demand management is not a new concept and has been deployed by many utilities over the years. Recently, however, there have been advances in the quality, automation, and real-time nature of certain AMI communication and data management technologies that have substantially improved the results that are possible. At the same time, these technologies are able to virtually eliminate the chance that customers would experience power quality issues due to voltage reduction, which has been one of the major obstacles in the past.

REDUCING PEAK LOADS BY SHIFTING DEMAND WITH CLVR

At times of peak demand, every kilowatt can result in a number of potential adverse impacts:

- Higher demand charges
- Need to purchase expensive wholesale power
- Brownouts or blackouts
- Overloaded substations and distribution assets
- Additional transmission costs

These risks make the pro-active management of peak load critical to both maintaining grid reliability and managing utility costs. AMI-enabled tools like CLVR help the utility manage peak load by responding to peak reduction requests with immediately dispatchable voltage reduction. Furthermore, instantaneous feedback from the AMI system on the voltage impact of CLVR provides utility decision-makers with the real-time system visibility needed to make additional

decisions to adjust voltages as needed. With direct SCADA integration, CLVR goes even further to enable SCADA to fully automate voltage reduction decisions.

DURING A SUMMER PEAK DAY, MUS DEMONSTRATED THAT IT COULD USE CLVR TO SUCCESSFULLY LEVEL DEMAND THROUGHOUT THE PEAK EVENT.

CLVR utilizes TRUPUSH™ data streaming functionality from TUNet throughout the day to manage reduced voltages during peak periods and increased voltages during off-peak periods. Continuous data feedback allows operators to monitor line voltages and alerts while making adjustments as necessary. When integrated with a utility's SCADA system, CLVR pro-actively monitors, notifies, and enables the fully-automated control of feeder voltages within seconds.

PRACTICE SAFE CLVR

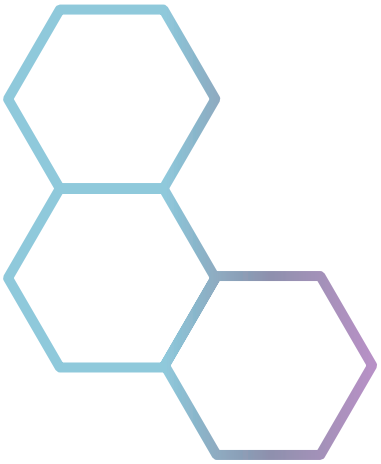
Properly conducted voltage reduction is safe for electrical equipment, which is designed to operate with some voltage flexibility in mind. In North America, electrical service voltages typically need to be maintained in the range of 114 V to 126 V as designated by ANSI C84.1. This range provides the operating room needed for voltage reduction to be effective.

However, electrical services along a feeder will see different voltages along its length depending on load, line impedances, and distribution equipment along the path. Furthermore, because loads vary by time of day and season, voltages along the feeder also vary accordingly. The challenge for the utility is this: **whenever DVR is active, it must be operated in a way that ensures all customers along the feeder see voltages within the prescribed range.**

Traditionally a utility would take some manual measurements to attempt to estimate service voltages being seen by customers at typical peak times, and then guess conservatively at appropriate voltage reduction amounts. This almost always meant that demand reduction results did not meet potential. In cases where the guess was not

conservative enough, customer power quality complaints were the main form of feedback, along with the risk of equipment damage and financial losses customers can experience due to undervoltage.

The ideal solution to this is to monitor customer voltages in real time, and operate voltage reduction as a closed-loop control system. This is what CLVR is all about.



Because smart meters live at customer service locations, they are ideally placed to monitor service voltages. When connected through a robust real-time communications network, the collected data from these meters ensures that levels remain within a prescribed range for all customers. As such, demand management features like CLVR are one of many high-value benefits offered by a flexible, reliable Smart Grid communications network. TUNet is designed in a way that supports safe, effective voltage reduction. With TUNet's AMI network, each meter continuously monitors many aspects of power. For instance, TUNet-powered meters check line voltages many times a second, 24 hours a day, 365 days a year. If the voltage exceeds or drops below preset thresholds at any end point, the meter can immediately report this change in power quality by utilizing TRUPush to push alerts and status updates in real-time. In addition, streaming voltage data from key meters are collected in real-time with one-minute resolution. The ability to optimally manage thousands of smart devices on an electric grid in this manner is historically unprecedented.

Different Load Types Respond Differently

Here are some examples of demand reductions that are seen with a 5% voltage reduction:

- Resistance electric heating appliances: 10% reduction (when running)
  - Electric water heaters
  - Electric space and plenum heaters
  - Baseboard heaters
  - Pool heaters
- Lighting: 7.5% (incandescent) to 0% reduction (LED)
- Refrigeration: 3.7% reduction
- Pool equipment: 3.5% reduction
- Central air conditioning and heat pumps: 1.0% to 2.9% reduction (depending on outdoor temperature)
- Auxiliary strip heating: 10% reduction (when running)

AUTOMATED CLVR, THE TUNet ADVANTAGE

A cornerstone feature of TUNet is its ability to acknowledge and transmit real-time notifications. This feature ensures that during a DVR event, the utility receives real-time voltage alerts from any meter that is reaching its threshold. To take this a step further, integrating a TUNet Voltage Reduction interface with existing SCADA systems provides an automated way to ensure maximized CLVR savings while maintaining reliable customer power quality.

CLVR provides a DNP3 data link to SCADA. This is important because DNP3 is the primary native protocol for SCADA systems, and this link essential converts CLVR meters into SCADA sensors.

The main advantages of fully-automated CLVR integrated with SCADA include:

- labor savings from eliminating the need to have operational personnel continuously monitor and react to voltage and load
- the ability to operate and optimize multiple substations and feeders independently and concurrently
- the ability to handle unanticipated load changes
- insurance that any voltage excursions that may occur are brief and well within allowable limits

TUNet's Voltage Regulation interface requires no other infrastructure beyond AMI and SCADA. CLVR is compatible with all DNP3-capable SCADA systems including ACS, Survalent and OSI.

CASE STUDY: MORRISTOWN UTILITY SYSTEMS AND CLVR EFFECTS ON UTILITY OPERATIONS

Because of the flexibility that TUNet provides, MUS can utilize a suite of advanced metering and demand management solutions while relying on a common, unified network. This advantage is clearly demonstrated by MUS' use of various features of the TUNet demand management suite. Not only can MUS use the network to leverage CLVR, it can

expand its demand management options to include the management of distributed energy resources, commercial and industrial applications, and utility water pumping demand. This program allows MUS to strategically pursue multiple business goals at once while multiplying the effectiveness of their overall demand management initiatives.

The Tantalus CLVR application lets us reduce the peak electrical demand over time, while ensuring that all of our customers' service voltages stay inside acceptable levels.

–Jody Wigington, GM, Morristown Utility Systems

As part of a Smart Grid pilot project, MUS partnered with its generator, the Tennessee Valley Authority (TVA), to curtail load at TVA's "day ahead" request for up to 100 hours per year. This initiative kicked-off TVA's multi-year plan to combine energy efficiency and demand response to achieve system-wide savings goals of 5.4% by 2020. This project helped lower TVA's overall peak demand, reduce the need for additional power plant construction and avoid the need for distributors to make costly un-planned power purchases. The project required MUS to perform DVR to deliver load reduction while ensuring operation during the period within the ANSI voltages limits. The more effective MUS is able to make each voltage reduction event, the more it benefits directly through avoided demand costs. Because DVR is called only when needed, there is only minimal impact on revenue.

MUS is utilizing CLVR to shave its own peak-billed demand. TVA bills power distributors for their maximum one-hour peak monthly demand. As with other distributors, because its peak is not coincident with TVA peaks, MUS must track its own load and perform voltage

reduction based on its own assessments. TUNet, coupled with CLVR, provides a data management and control tool for utilities to effectively audit voltage status and reduce its wholesale power bill by many thousands of dollars.

The introduction of alarms and streaming voltage data into SCADA opens the door for automating existing voltage reduction programs. In practice, the ability to stream voltages and port low voltage alarms from TUNet directly into SCADA provides, for the first time, a tool for dispatchers to monitor voltage conditions across the feeders in real time and respond accordingly to maintain adequate voltage.

In achieving MUS' goals over the long term, demand management programs like CLVR will continue to provide a wealth of knowledge to identify weaknesses and inefficiencies in the power grid. In Morristown, all voltage reduction is performed by load tap changers at the substation transformer. This means that all feeders on that substation are reduced by the same percentage voltage drop so the amount of load reduction delivered is inherently limited by the weakest feeder. MUS plans to use this and other lessons learned during CLVR events to improve individual voltage profiles to provide more room for reduction.

In addition to numerous utility benefits, reducing peak demand has long-term benefits for communities and consumers. By implementing effective tools to manage peak demand, the utility is able to avoid significant supply costs while simultaneously improving power quality and stretching the life of distribution grid assets. When several utilities participate in reducing peak demand, it allows generation companies to defer the purchase of expensive new power plants—which works to keep overall rates low. CLVR is both effective and consumer friendly, making it an ideal choice for utilities looking for demand management solutions.

CLVR SUMMARY

With this rapidly deployable CLVR voltage reduction application and interface on the TUNet platform, Tantalus delivers safe, effective DVR.

By further integrating CLVR with SCADA, voltage reduction can become a hands-off solution that is fully automated and optimized, operating simultaneously at multiple

substations without the need for active involvement of operations personnel. With CLVR, voltage regulation is virtually invisible to end users as all service voltages are maintained within regulatory limits. As a result, the utility avoids significant demand costs and improves the quality of customer service at the same time. Further long-term benefits are available as these programs allow utilities to identify and correct inefficiencies within the power grid, leading to improvements in power quality and cost avoidance.

At this point, voltage reduction using CLVR and SCADA is automated and has been a part of our normal day operations for years. It does take engineering expertise to achieve maximum savings but the potential is there for every utility. Aside from the savings, the AMI interval data available for our staff to mine is a game changer that has unleashed many opportunities to improve our operations and solidify our business model. I cannot imagine a world outside of AMI, and Tantalus has been our partner throughout to reach new horizons of commitment to our customers.

–Jody Wigington, GM, Morristown Utility Systems

Ardis, R. & Uluski, R. (2015, August 26). CVR Is Here to Stay: Conservation voltage reduction enables utilities to achieve significant energy and peak demand reduction at little cost and without customer impact. T&D World. https://www.tdworld.com/grid-innovations/smart-grid/article/20965787/cvr-is-here-to-stay

Gaikwad, A., Bush, J., Short, T. & Domitrovic, R. (2014, July 1). Residential split-system performance in utility voltage reduction operation. ASHRAE Transactions.

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