



Energy Technologies Area

Lawrence Berkeley National Laboratory

Opportunities and EM&V for Improving Electricity Distribution Efficiency

October 27, 2016

EM&V Webinars Facilitated By:
Lawrence Berkeley National Laboratory
<https://emp.lbl.gov/emv-webinar-series>

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Electricity Policy Technical Assistance Program

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National Association of Regulatory Utility Commissioners
National Association of State Energy Officials

Introduction

- ◆ LBNL is supported by the U.S. Department of Energy to conduct non-classified research, operated by the University of California
- ◆ Provides technical assistance to states—primarily state energy offices and utility regulatory commissions

The presentation was funded by the U.S. Department of Energy's Office of Electricity Delivery and Energy Reliability-National Electricity Delivery Division under Lawrence Berkeley National Laboratory Contract No. DE-AC02-05CH11231.

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Technical Assistance

- ◆ LBNL's provides technical assistance to state utility regulatory commissions, state energy offices, tribes and regional entities in these areas:
 - ❑ Energy efficiency (e.g., EM&V, utility programs, behavior-based approaches, cost-effectiveness, program rules, planning, cost recovery, financing)
 - ❑ Renewable energy resources
 - ❑ Smart grid and grid modernization
 - ❑ Utility regulation and business models (e.g., financial impacts)
 - ❑ Transmission and reliability
 - ❑ Resource planning
 - ❑ Fossil fuel generation
- ◆ Assistance is independent and unbiased
- ◆ LBNL Tech Assistance website: <https://emp.lbl.gov/projects/technical-assistance-states>
- ◆ US DOE Tech Assistance gateway: <http://energy.gov/ta/state-local-and-tribal-technical-assistance-gateway>

Webinar Series

- ◆ Webinars designed to support EM&V activities for documenting energy savings and other impacts of energy efficiency programs
- ◆ Funded by U.S. DOE in coordination with EPA, NARUC and NASEO
- ◆ Audience:
 - Utility commissions, state energy offices, state environment departments, and non-profits involved in operating EE portfolios
 - Particular value for state officials starting or expanding their EM&V
 - Evaluation consultants, utilities, consumer organizations and other stakeholders also are welcome to participate
- ◆ For more information (upcoming and recorded webinars, EM&V resources) see:
 - <https://emp.lbl.gov/emv-webinar-series>
 - General Contact: EMVwebinars@lbl.gov

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Next Webinar

- ◆ Evaluating Non-Energy Impacts of Energy Efficiency Programs – Scheduled for early December
- ◆ More webinars coming for 2017 and beyond...



Today's Webinar

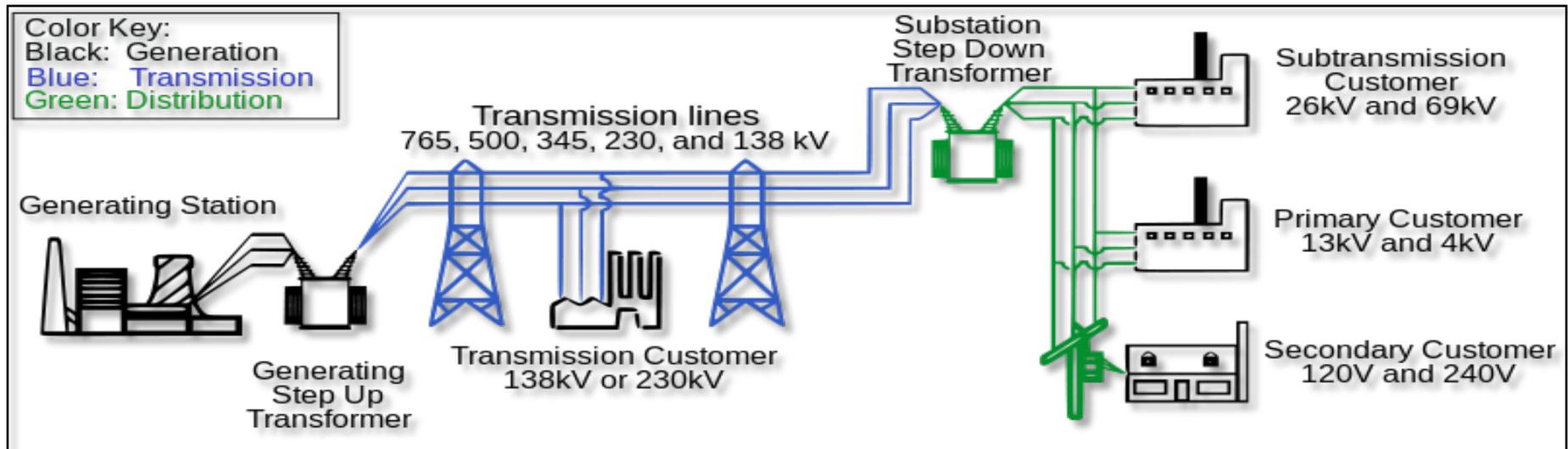
There are many ways to reduce T&D losses and this webinar will provide a high-level overview of the options available for reducing T&D losses with a focus on the distribution system and how savings can be documented for two options that are gaining more attention - Conservation Voltage Reduction (CVR) and Voltage and Volt-ampere reactive (VAR) Optimization (VVO).

Today we will cover:

- ◆ Quick introduction to basics – **Steve Schiller, Berkeley Lab**
- ◆ T&D energy efficiency opportunities and concepts with focus on CVR and VVO, state/utility experience with CVR/VVO – **Tom Short, EPRI**
- ◆ Example CVR/VVO project - **Jim Parks, SMUD**
- ◆ EM&V approaches to CVR/VVO - **Josh Ruston, Northwest Regional Technical Forum**
- ◆ Q&A with panelists

Background

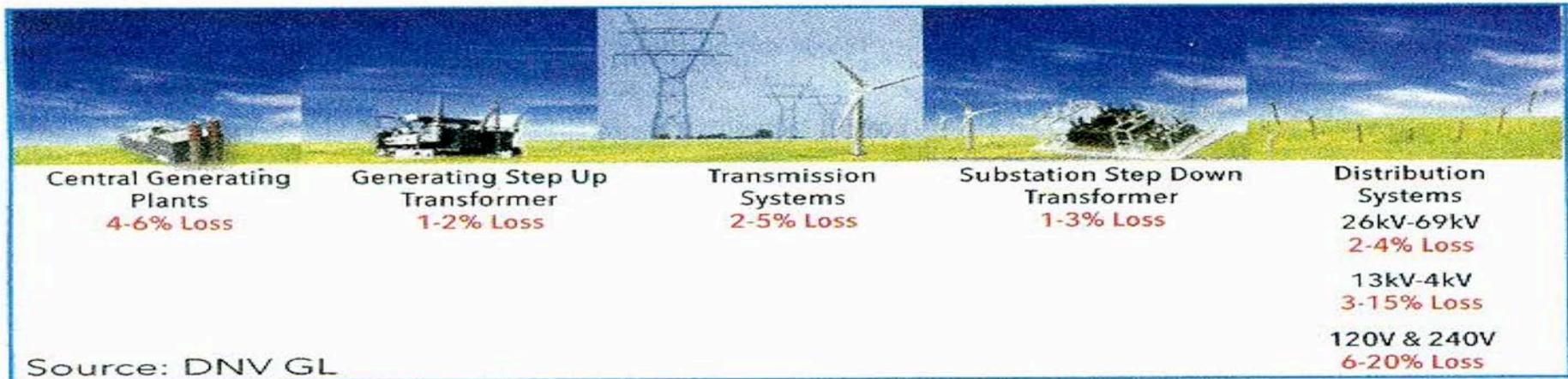
- ◆ The **transmission system** moves large amounts of power over long distances at high voltages.
- ◆ The **distribution system** refers to delivering electricity from the high voltage transmission grid to specific end-use locations such as homes or factories.



- ◆ Difference between the amount of electricity that is generated at an electricity generating unit and the amount that is consumed is made up by losses in the T&D system.

T&D Losses

- ◆ According to EIA data, T&D electricity losses average about 7% of the electricity that is transmitted in the US.
- ◆ Other sources put the losses in the range of 6% to 10%
- ◆ Losses vary depending on a wide range of factors, for example:
 - ❑ Weather
 - ❑ Voltage at which power is delivered to a consumer
 - ❑ Distance that consumer is from generation sources
- ◆ This figure indicates one estimate of typical sources of losses in a T&D system showing even a greater range and higher system loss potential.



T&D EE Opportunities

Distribution Efficiency

- ◆ Conservation Voltage Reduction (CVR)
- ◆ Conductor Replacement
- ◆ Higher Distribution Primary Voltage
- ◆ Transformer Load Management
- ◆ Balancing Loads and Phases
- ◆ Adding Parallel Feeders
- ◆ Seasonally Unloaded Transformers
- ◆ Existing Distribution Transformers with High-Efficiency
- ◆ Power Factor Improvements
- ◆ Reactive Power Management

Source: Long-Term Monitoring and Tracking Distribution Efficiency, Navigant Consulting, For NEEA, June, 2014, Report E14-289

Transmission Efficiency

- ◆ Extra High Voltage (EHV) Overlay/Voltage Upgrade
- ◆ Substation / Transformer Efficiency improvements (auxiliary power loads and transformer efficiency)
- ◆ Use of lower loss conductors
- ◆ Shield wire loss reduction
- ◆ System Loss Reduction through technologies to reduce system losses through the deployment of smart grid systems including Var/Volt control optimization, smart transmission control of power flow controllers, and economic dispatch with loss optimization

Source: The Power to Reduce CO₂ Emissions - Transmission System Efficiency, EPRI, December 2010

T&D EE EM&V Key Points

- ◆ T&D EM&V is **conceptually straightforward but in practice it can be complicated** to determine reliable energy savings values; with the cost and complexity a function of many factors.
- ◆ T&D EM&V practices and protocols describing ‘best practices’ are a **work in progress aided by advances in data collection and analysis tools**.
- ◆ Isolating and documenting the **impacts of distribution system efficiency**, as compared to transmission system efficiency, **are more straightforward**.
- ◆ Two distribution efficiency measures of particular interest are conservation voltage reduction (CVR) and voltage optimization (VO). **EM&V for CVR and VO is probably the most advanced of any category of T&D efficiency actions**, with several ongoing efforts to both develop protocols and actually evaluate programs.

Now - Our Other Speakers

- ◆ Tom Short, Senior Technical Executive, Electric Power Research Institute (EPRI)
- ◆ Jim Parks, Program Manager, Sacramento Municipal Utility District (SMUD)
- ◆ Josh Rushton, Contract Analyst, Northwest Power and Conservation Council's Regional Technical Forum (RTF)

CVR / VVO Overview

LBNL Webinar

Tom Short

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October 27, 2016



Utility Efficiency Improvements

- Conservation voltage reduction (CVR)
- Volt-var optimization (VVO)
- Reduce transformer losses
- Reduce line losses
- Improve efficiency of auxiliary components and services

Utility Efficiency Improvements

- **Conservation voltage reduction (CVR)**
- **Volt-var optimization (VVO)**
- Reduce transformer losses
- Reduce line losses
- Improve efficiency of auxiliary components and services

Industry Work

- NEEA 1207, *Distribution Efficiency Initiative*, Northwest Energy Efficiency Alliance, 2007.

- PNNL, "Evaluation of Conservation Voltage Reduction (CVR) on a National Level," US Department of Energy Pacific Northwest National Laboratory, 2010.
http://www.pnl.gov/main/publications/external/technical_reports/PNNL-19596.pdf

- EPRI 1023518, *Green Circuits: Distribution Efficiency Case Studies*, Electric Power Research Institute, Palo Alto, CA, 2011.
<http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=00000000001023518>

Conservation Voltage Reduction (CVR)

- Reducing voltage to equipment often reduces consumption

Volt-var Optimization (VVO)

- Optimally use voltage control and var control (reactive power control)

Where do most savings come from?

Where do most savings come from?



How much of the savings are on the utility side versus customer side?

How much of the savings are on the utility side versus customer side?

90 – 95 % on the customer side

Online calculator: <http://distributionhandbook.com/calculators/mdpad.html?cvr.md>

How much energy can be saved?

How much energy can be saved?

1 – 4 %

How can CVR/VVO be implemented?

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- Lower voltage regulator settings

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- Add a volt-var control system
- Add line monitors
- Use smart meters (AMI)

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- Lower voltage regulator settings
 - Add a volt-var control system
 - Add line monitors
 - Use smart meters (AMI)

 - Add capacitors
 - Add voltage regulators
 - Balance phases
 - Reconfigure lines
 - Reconductor
- Electric system improvements
- 

What utilities are reducing voltage at peak?

What utilities are reducing voltage at peak?

- Duke Energy, North Carolina
- Georgia Power
- Alabama Power
- Con Edison
- Indianapolis Power & Light
- Oklahoma Gas & Electric
- Several TVA distributors

“Application of Automated Controls for Voltage and Reactive Power Management – Initial Results,” US Department of Energy, Dec. 2012.

https://www.smartgrid.gov/files/VVO_Report_-_Final.pdf

How many utilities are reducing voltage full time?

How many utilities are reducing voltage full time?

- Duke Energy, North Carolina
 - PECO
 - PPL
 - SMUD
 - Many BPA distributors
-
- States who include CVR as an energy-efficiency portfolio option:
OH, MD, WA, OR, NC, and PA

Ronald Willoughby, “Major Findings from a DOE-Sponsored National Assessment of Conservation Voltage Reduction (CVR),” IEEE Volt-Var Task Force Panel Session, July 29, 2015.

[http://grouper.ieee.org/groups/td/dist/da/doc/Major%20Findings%20from%20a%20DOE-Sponsored%20National%20Assessment%20of%20Conservation%20Voltage%20Reduction%20\(CVR\)%20-%20Ronald%20Willoughby.pdf](http://grouper.ieee.org/groups/td/dist/da/doc/Major%20Findings%20from%20a%20DOE-Sponsored%20National%20Assessment%20of%20Conservation%20Voltage%20Reduction%20(CVR)%20-%20Ronald%20Willoughby.pdf)

How can savings be demonstrated?

How can savings be demonstrated?

It's tricky!

What will happen to savings in the future?

What will happen to savings in the future?

Expect benefits to decline

- More electronic loads
- Incandescent lights → LEDs
- Magnetic → Electronic ballasts
- Motors → Adjustable-speed drives

Are there seasonal effects?

Are there seasonal effects?

- Better in the summer
- Worse in the winter

Do savings differ by region of the country?

Conservation Voltage Reduction

Jim Parks

EM&V Webinar

October 27, 2016

Powering forward. Together.



About SMUD



- 617,000 customers
- 1.5 million population
- \$1.47 billion in revenues
- 900 mi², 2331 km² service territory
- 7 member, elected Board of Directors
- Not-for-Profit Utility
- 2nd largest muni in California, 6th largest in the US
- 3299 MW peak load (2006)
- 2121 employees

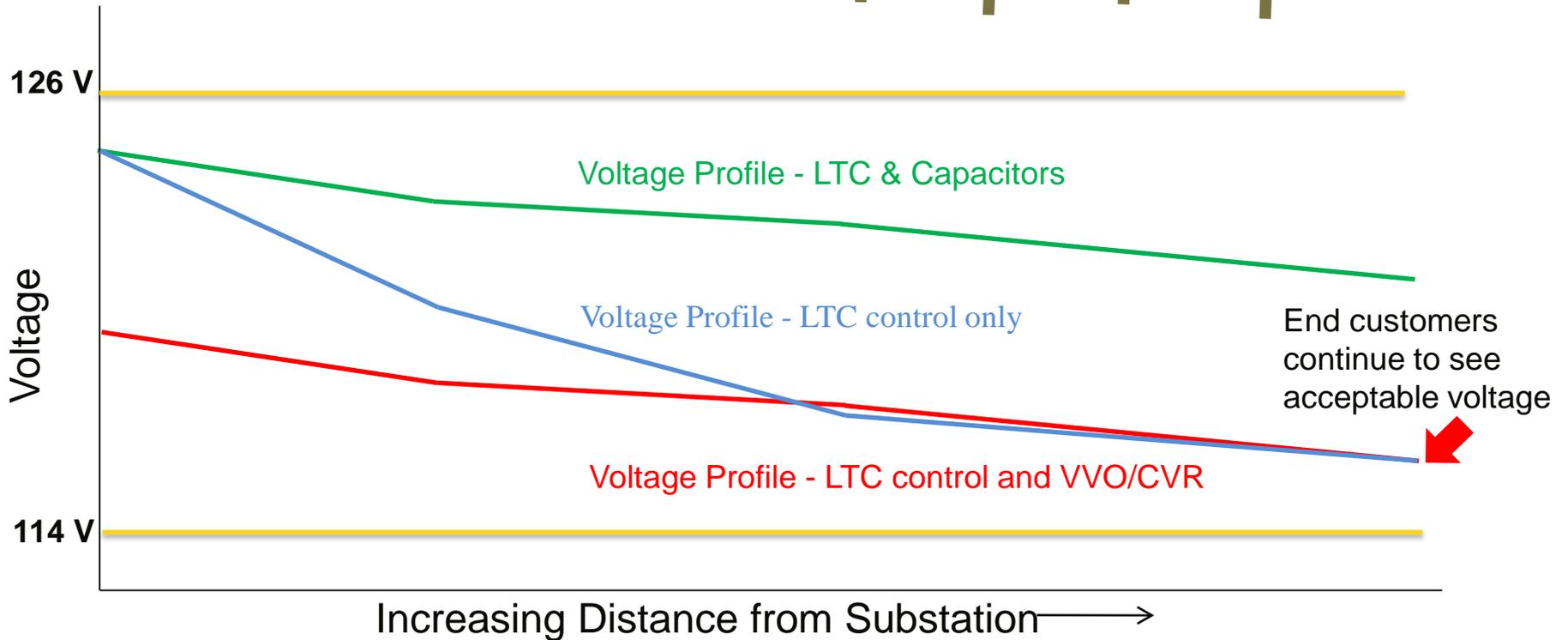
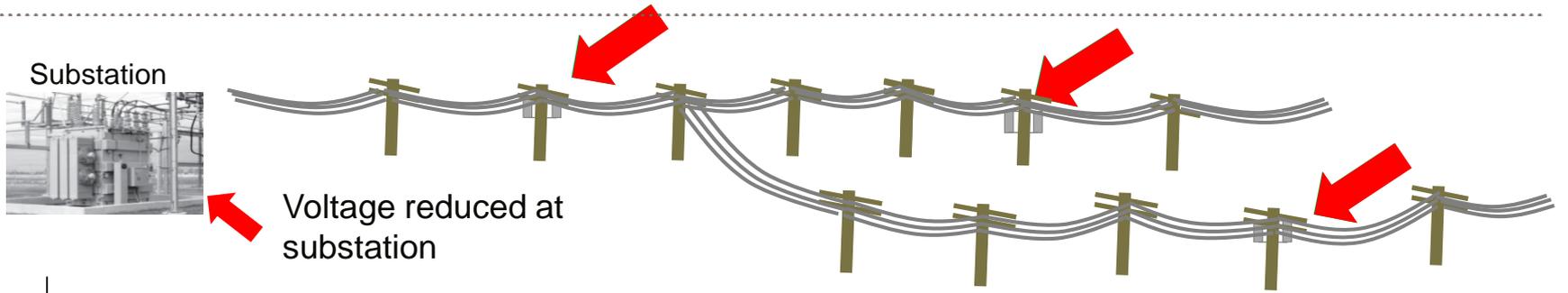
2015 Statistics

	<u>Meters</u>	<u>GWh</u>	<u>Revenues</u>
Residential	546,000	4,655	\$622 M
Commercial	71,000	5,819	\$729 M
Subtotal	604,053	10,474	\$1.35 B
Sale of Surplus Power		1,678	\$ 55 M
Sale of Surplus Natural Gas			\$ 27 M
Total		12,151	\$1.43 B

Average Annual Consumption and Cost

Residential	8,522 kWh	13.5¢/kWh
Commercial	82,000 kWh	12.5¢/kWh

VVO / CVR



CVR Pilot Project

- Automated 118, 12 kV feeders
- Began summer 2011 on two substations.
 - SCADA at 40 subs
 - Addition of switched capacitor banks, motor operated switches and reclosers
 - all w/2-way communication
 - Utilization of existing Capcon control system
- Goal of initial phase:
 - Test both CVR and VVO.
- Hypothesized that an industry average CVRf (0.5 – 0.7) could be achieved.
- Expanded project in 2014 to 14 substations.
 - Wanted to determine operational strategy--peak-period/emergency or 24/7 operation.

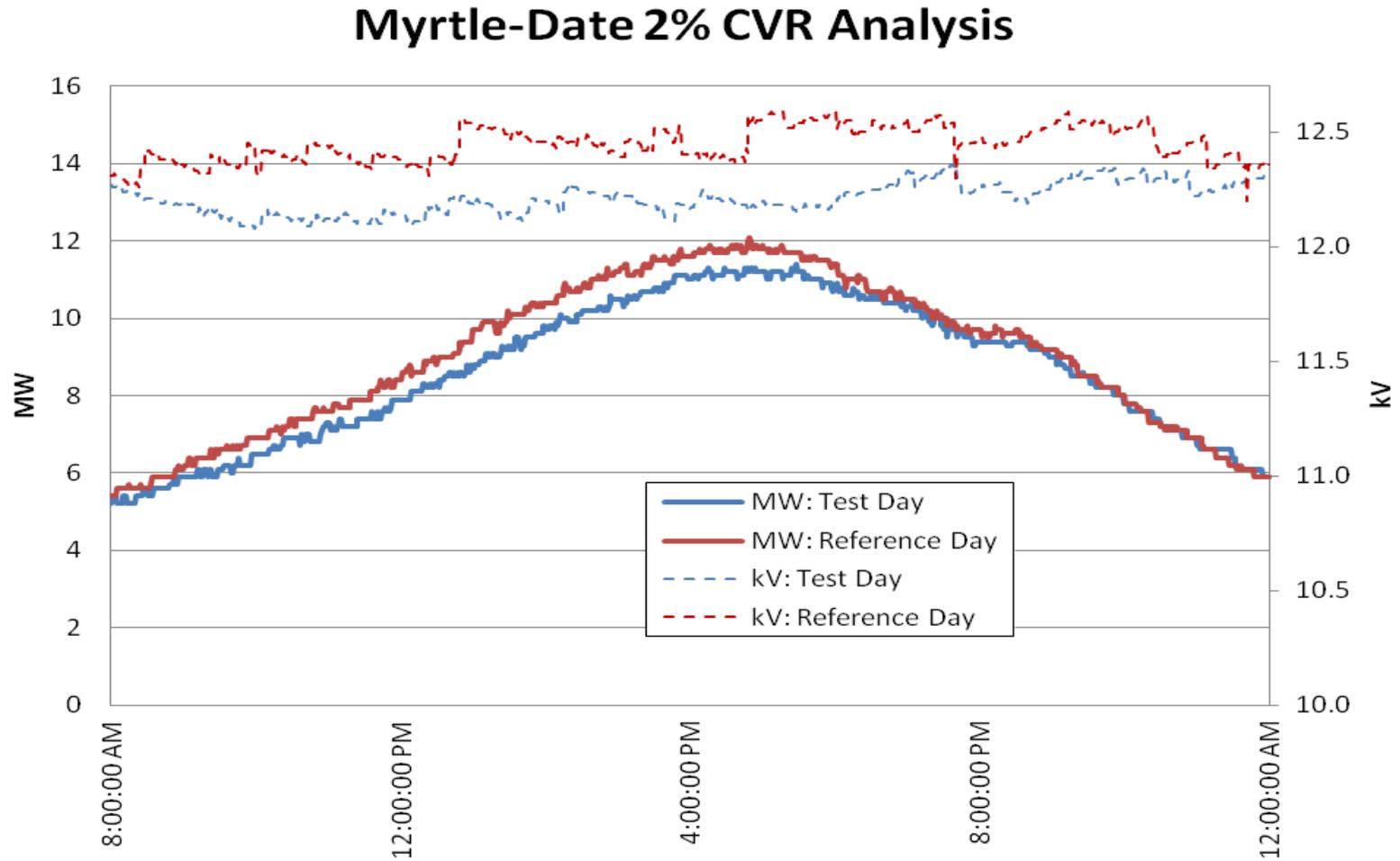
Early Results

Substation	Approximate Avg. Percentage Demand Reduction (2% V reduction)
Substation A	2.5%
Substation B	1.0%

CVR Factor

- Calculated value of CVR benefits
- $\%CVR \times CVR \text{ Factor} = \% EE$

2011 Pilot Deployment - CVR Results



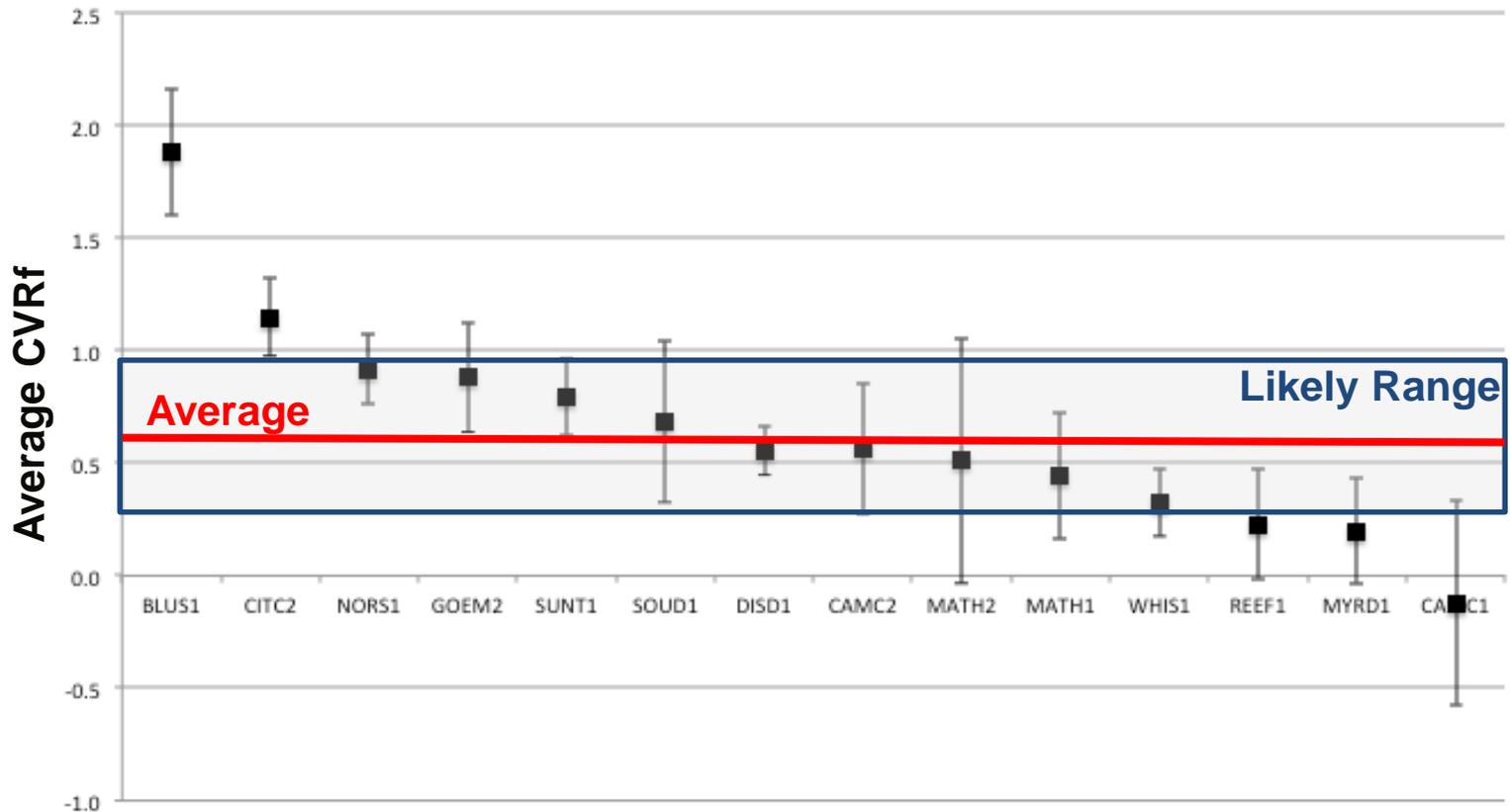
Project Successes - Overview

- Modified control system worked as designed.
- Conducted three years of CVR testing.
- Developed a statistical model to predict CVR impacts.
 - Used a variety of variables, including PV.
 - Two separate regression methods produced similar results.
 - 1.8% average voltage reduction \approx
 - 2% average daily energy (MWh) reduction
 - 1.1 % average load (MW) reduction



Project Successes – 2013 Analysis

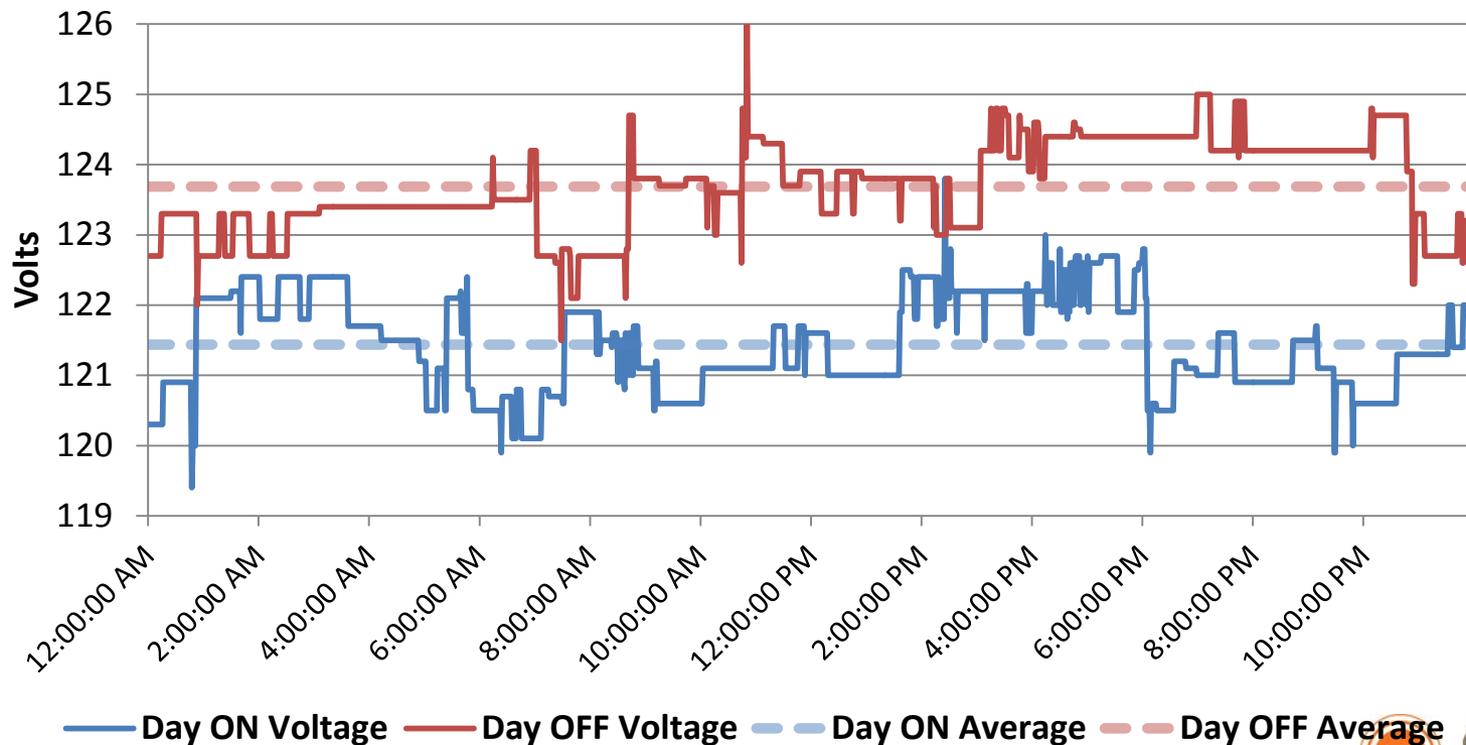
Estimated Substation Average Weekday CVRf (OLS) and Approximate 90% Confidence Intervals



Surprises Related to the Project

- Goal was to test CVR at 3% voltage reduction.
 - Limited target to 2% (actual average reduction was 1.7%).

SUNT1 Voltage Profiles



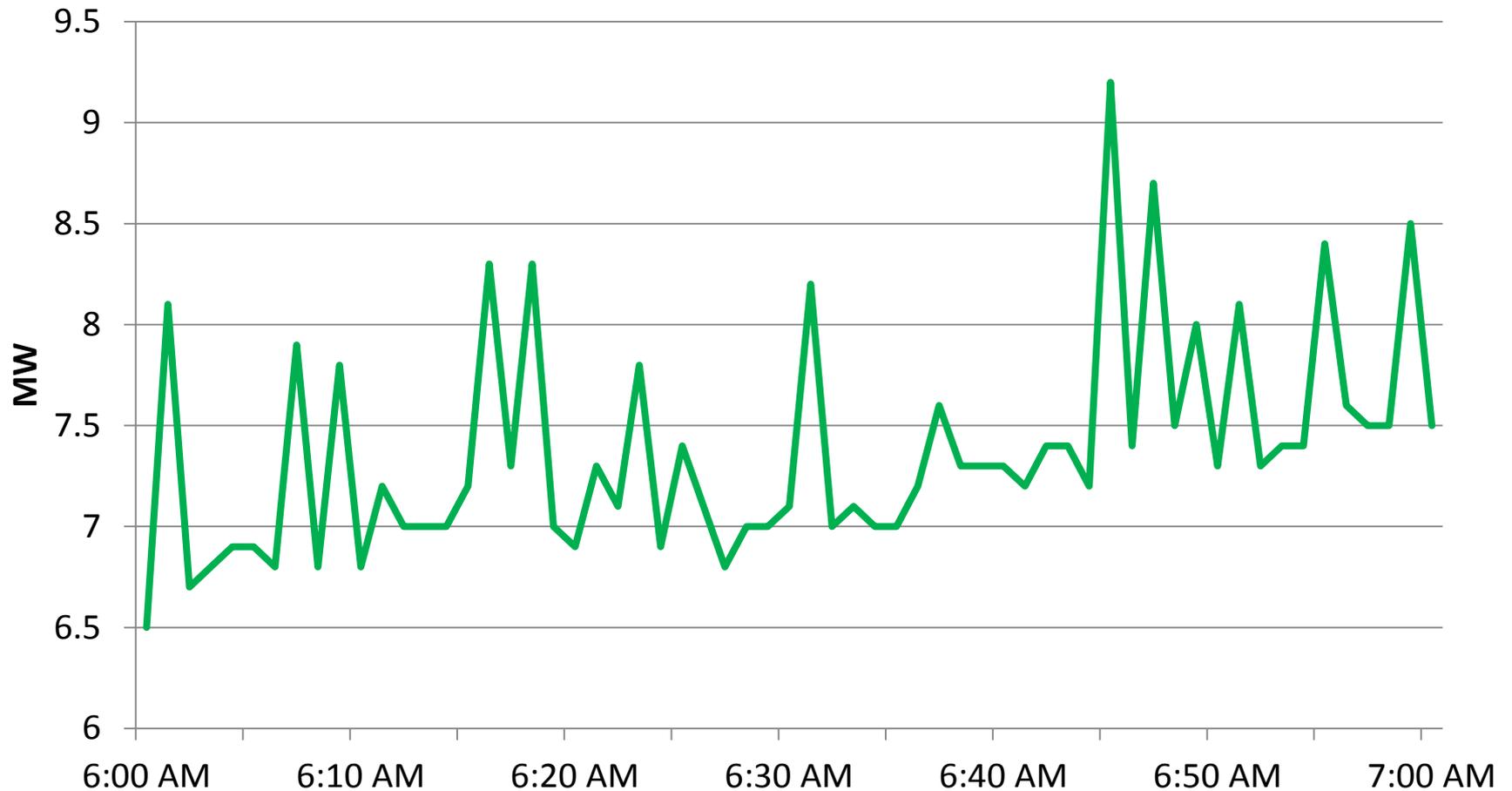
Surprises Related to the Project

- “Distribution data is MESSY!”



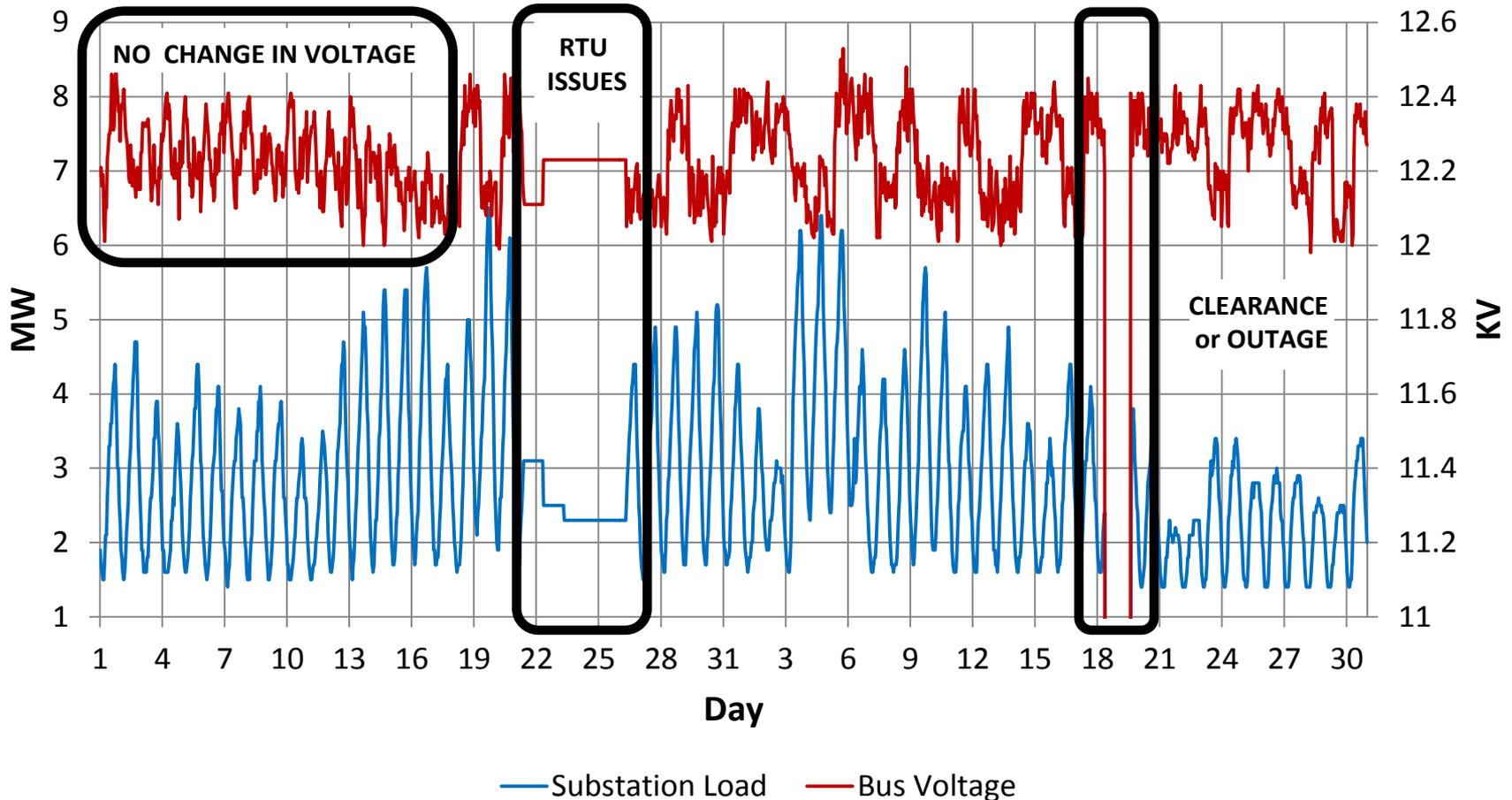
MESSY Data - Episodic Loads

SUNT1 Load



MESSY Data – Clearances and Outages

CAMC1 Summer 2013 (Aug - Sept)



A Few Points...

- Difficulty explaining the CVRf outliers.
- No known customer complaints.
- Possibility of looking at metrics to see if higher performing substations can be identified proactively.

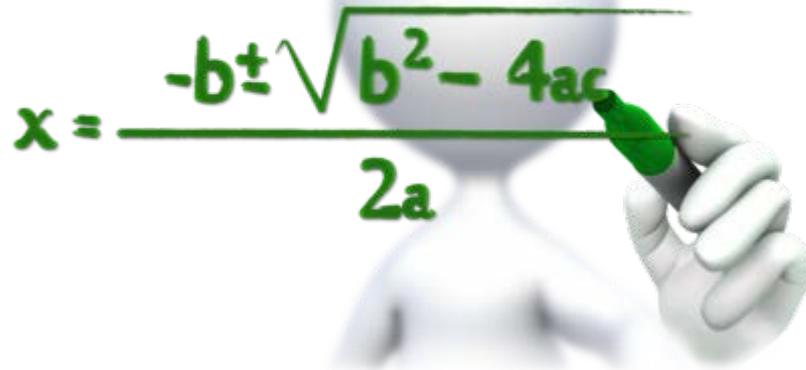
Reaching Beyond

- Challenge is accurately measuring CVR impacts
 - Impact of voltage reduction is small and variable.
 - Normal variation in load is comparatively large.
 - Small moment-to-moment variations may be larger than CVR impact.



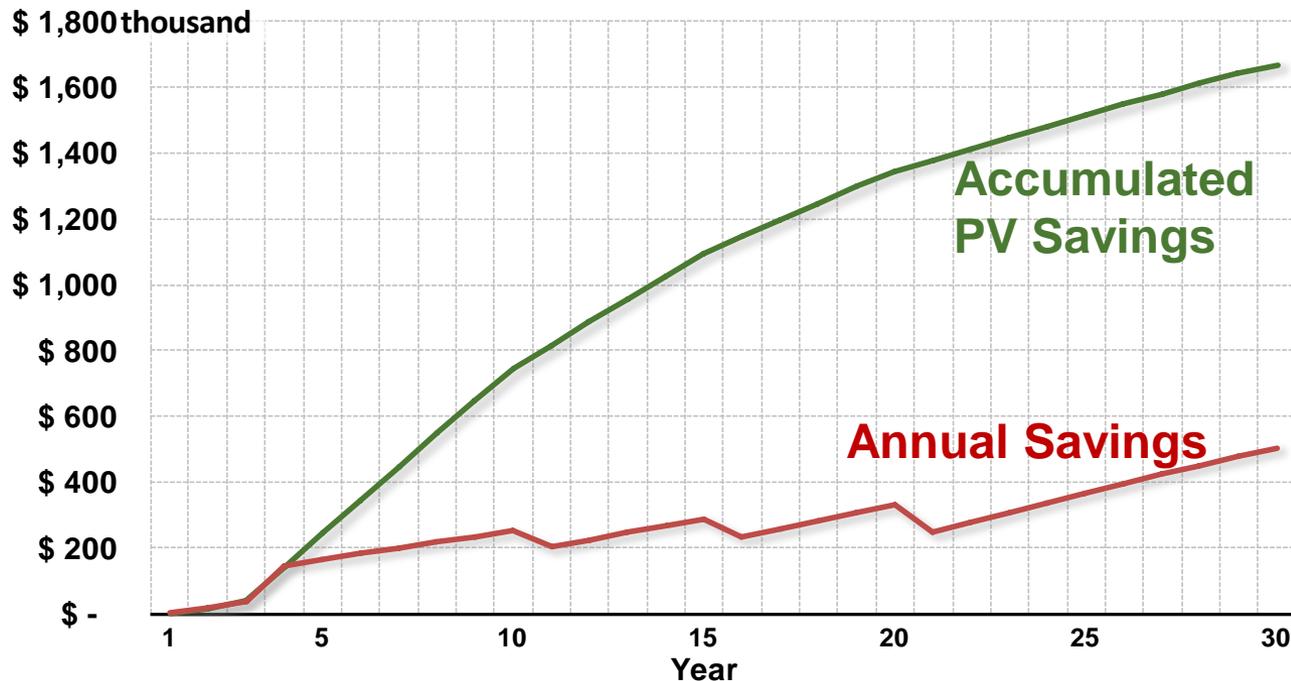
Reaching Beyond

- Model provides good approximation.


$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Reaching Beyond

- Performed a CBA on the 14 substations in the project.



CVR Impact Variation

- Impact of CVR varies depending on a variety of factors including load mix, load level, weather and season.

Approx. Load Impacts (for 3% Voltage Reduction)

Load Type	Approx. Demand Reduction Range
Lighting - Incandescent	5%
Lighting - Fluorescent Tube / CFL	2-8%
Lighting - LED	0-6%
LCD TV	0%
Plasma TV	0%
Air Conditioning - Conventional	0.5-1.0%
SOURCE: PACIFIC NORTHWEST NATIONAL LABORATORY	

CVR Benefits

- Provides energy savings across an entire substation
- Small energy savings for each customer
 - Savings are invisible to the customer
- In CA, CVR savings can be claimed towards EE programs per SB 350
 - SB 350 increased RPS from 33% to 50%
 - SB 350 doubles EE goals

Looking Ahead

- Previous CVR pilots were performed ‘blind’
- Wanted to perform another test with bellwether meters and meter pinging
- Performed voltage analysis of system to look for areas that need support
 - Plan was to fix areas of low voltage proactively so we could reduce voltage across the sub
- Models show too many out-of-spec voltages under CVR conditions

Weed Impacts CVR Capability

- We're finding more grows on our system
- These are high-load operations in residential neighborhoods
- Transformers are overloaded, creating voltage problems
- Can't do CVR without correcting voltages, usually at high cost



Next Steps

- Focus over next few years will be on implementation of a Distribution Management System (DMS)
- DMS should enable better CVR control for future projects
- Need analysis to determine CVR levels at different utilities

Questions?



Jim Parks
jim.parks@smud.org

CVR/VO at the RTF

Josh Rushton,
RTF Contract Analyst

What are these measures about?

Basic idea:

Some things use less energy at lower voltages

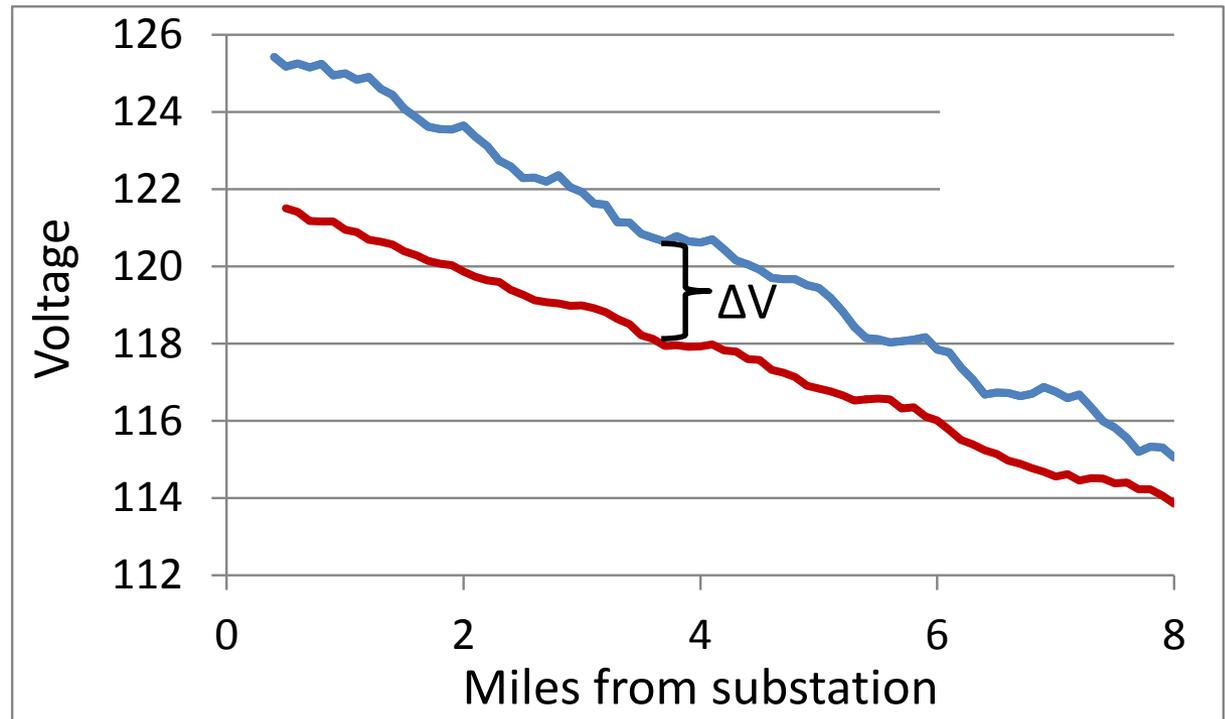
Complication 1:

Average ΔV can be hard to estimate

Complication 2:

Savings factors ($\% \Delta \text{kWh}$ per $\% \Delta V$) depend on end-use mix.

- (PNNL, 2010) gives some lab results;
- (NEEA, 2008) reflects residential mix circa 2006.



Artist's rendering
(fake data)

Overview: Two RTF Protocols

(Simplified) VO Protocol. “Canned” savings factors derived from NEEA DEI research (NEEA, 2008)

- Factors vary by climate, AC saturation, and ER heat saturation
- Factors based on data collected at residential end-user meters
 - Capture savings on customer side of meter (separate calculations for utility side)
 - Apply to mostly-residential feeders

(Automated) CVR Protocol #1. Uses alternating CVR-on/CVR-off data to empirically estimate project-specific savings factor

- Directly measures *switchable* savings (models bring in other components)
- Factors based on feeder-level data (captures savings on both sides of meter)
- Administrative status: *Deactivated*
 - Intention is to move evaluations to custom path
 - Reasonable method but utilities found protocol overly prescriptive

A theme in this work: Very difficult to find the right balance of flexibility, reliability, and ease-of-use

Simplified VO

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Simplified VO Benchmark Eligibility

- Primary electrical systems serving mostly residential and light commercial loads
- For each affected feeder, must be able to record *hourly* averages for a week pre- and a week post:
 - voltage (source and EOL, by phase),
 - kW and Kvar (source)
- Minimum performance thresholds
 - Help define baseline
 - Protect against low-voltage issues
 - Validate assumptions for extrapolation and annualization

Basic idea

- Use “canned” VO factors ($\% \Delta \text{kWh}$ per $\% \Delta V$)
- Values based on NEEA Load Research Project (NEEA, 2008)
 - Vary by climate, saturation of AC and ER heat
 - Reflects residential end-use mix at time of study
- Intent: Simple method for estimating end-user energy savings due to well-defined voltage reduction
 - Savings only meant to be “right on average”
 - Distribution savings calculated separately

The tricky part, ΔV

VO factor only useful if you can estimate ΔV

- Why? Percent savings estimated as: VO factor * $\% \Delta V$
- What? ΔV target is *average annual change in voltage experienced by end users*
- How? That's the tricky part.
 - Easy to estimate ΔV for very linear systems
 - Voltage usually not very linear in the wild
 - System performance thresholds increase linearity but restrict eligibility
 - ***Are reliable ΔV estimates ever possible without meeting all thresholds? (Answer: Probably sometimes)***



Path of least resistance

- Describe “Benchmark” method and circumstances where RTF judges savings to be reliable
- Permit deviations, but point out validity threats to be addressed when Benchmark circumstances fail
 - “Lines on the regulatory playing field”
- Four areas for potential validity threats:
 - Extrapolation
 - Annualization
 - Baseline
 - Persistence
- Good news! Cellular data transmission makes it a lot easier to know what’s going on at different points on a distribution lead



Automated CVR

Overview: Two RTF Protocols

(Simplified) VO Protocol. “Canned” savings factors derived from NEEA DEI research (NEEA, 2008)

- Factors vary by climate, AC saturation, and ER heat saturation
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Automated CVR Eligibility

- **System type.** Primary electric distribution systems serving any combination of res., comm., and industrial loads, operated radially, primary voltage ≥ 12.47 kV
- **CVR control.** CVR can be switched on and off on a daily basis (voltage set points can be changed daily)
- **System model.** Protocol relies on load flow simulation model.
- **Data collection.** For each affected feeder, need to record *hourly* averages for 90 days (alternating CVR on / CVR off)
 - voltage (source and EOL, by phase)
 - KW and Kvar (source)
- **Performance Criteria.** (see Additional Slides)
 - Help define baseline
 - Protect against low-voltage issues
 - Simplify load flow simulation model
 - Validate assumptions for annualization

Savings method summary

- **Data collection:** Minimum of 90 days, raise and lower control-zone voltage to get day-on/day-off CVR operation cycles.
- **Savings factors:** Primary data used to empirically estimate feeder-specific savings factor ($\% \Delta \text{kWh} / \% \Delta V$) for each application
 - Factors capture savings on both sides of meter
 - Protocol directly measures *switchable* savings (models used capture other savings components)
- **Energy savings:** Savings estimated as product of savings factor, annualized average ΔV , annual baseline kWh

References

- *NEEA DEI Project Final Report* (NEEA, 2008)
 - Load Research Project (2005-2007)
 - Pilot Demonstration Project (c. 2005-2007)
- *Distribution Efficiency Guidebook* (NEEA, 2008)
- *Long-Term Monitoring and Tracking DE* (NEEA, 2014)
- Energy Smart Utility Efficiency (ESUE) Program (BPA, ongoing)
- PacifiCorp DE Pilot Study
- IEEE P1885. *Guide for Assessing, Measuring and Verifying Volt-Var control Optimization on Distribution Systems* (**Draft - Approval expected 2017**)
- Puget Sound Energy currently implementing VO
- *Avista CVR Program Impact Evaluation* (Avista, 2014)
- *Evaluation of CVR on a National Level* (PNNL, 2010)
- M&V research by PNNL and WSU researchers (2014)
- Green Circuits DE Case Studies (EPRI, 2011)

Additional Slides

Simplified VO: Validity Threats (1)

Annualization

“Is the ΔV estimate based on a reliable approach to annualizing data collected during the metering period?”

“In the benchmark method, the meter-period voltage estimates are scaled up or down in proportion to the ratio (average annual demand)/(average meter-period demand). This kind of scaling assumes that voltage normally rises and falls roughly in proportion to demand; this assumption is supported by the performance thresholds.”

Simplified VO: Validity Threats (2)

Baseline

“Does the ΔV estimate reflect the correct baseline? See *[Baseline Notes, above]*.”

“If the VCZ includes obsolete equipment prior to the Voltage Optimization measure, then the correct baseline is not the same as the base-case system. Instead, it is the system that would result if the obsolete equipment were replaced with components that would be typical choices in the current market.”

Simplified VO: Validity Threats (3)

Persistence

“Can reasonable assurance be provided that the efficient-case voltage settings will persist? In all applications of this protocol, delivery verification requires that a 3-year persistence plan must be documented to ensure that efficient system operation habits become well-established. However, a persistence plan will not be followed if customers experience adverse low-voltage events during some portions of the year.”

“In the benchmark method, the performance thresholds ensure predictable and reliable system performance throughout the year so that efficient-case operations can be designed to reliably avoid low-voltage events.”

Simplified VO: Validity Threats (4)

Extrapolation

“Is the ΔV estimate based on a reliable approach to extrapolating data collected at the selected metering locations (e.g., source and EOL) to customers along the feeder?”

“In the benchmark method, this extrapolation is based on a linear model of voltage decay along the length of each feeder, and the performance thresholds support this linear assumption.”

Simplified VO: Benchmark Method Performance Thresholds (1)

- Power factor (3-phase total, at source):
 - Minimum (hourly) greater than 0.96
 - Average (for week) greater than 0.98
- Phase load balance (3-phase lines, at source)
 - Per-unit unbalance < 0.15
- Max-adjusted voltage drop (3-phase mean)
 - Max-adjusted drop is mean meter-period drop, times (annual peak kW) / (mean meter-period kW)
 - Primary max-adjusted drop $< 3.3\%$
 - Secondary max-adjusted drop $< 4.0\%$

Simplified VO: Benchmark Method Performance Thresholds (2)

- Variation between feeder max voltage drops
 - Compare feeders within substation control zone
 - Must not differ by more than 2 Volts (on 120 V base)
- Primary line minimum hourly voltage
 - Measured near expected low voltage point
 - At least $114\text{ V} + (1/2)\text{ Voltage regulation bandwidth} + \text{secondary max allowed voltage drop}$
- Primary line maximum hourly voltage
 - Measured near expected high voltage point
 - Less than $126\text{ V} - (1/2)\text{ Voltage regulation bandwidth}$
- Conductor loading
 - Source hourly loading (amps) less than design normal spec

Simplified VO: Benchmark Method Savings Method

Step 1. (Identify Savings Factor)

Look up VOf ($\% \Delta \text{kWh} / \% \Delta V$) in table

- Values vary by climate, saturation of AC and ER heat
- Remember: VOf only counts end-user energy savings (distribution losses calculated separately)

Step 2. (Estimate ΔV)

See next slide.

Step 3. (Estimate Energy Savings)

$\Delta \text{kWh (savings)} = \text{kWh}_{\text{ANNUAL}} * \text{VOf} * \% \Delta V$

- $\text{kWh}_{\text{ANNUAL}}$ based on historical data
- ΔV is estimated average voltage difference between CVR-on and CVR-off cases

Simplified VO: Benchmark Method

Formula for Estimating ΔV

For fixed voltage reduction, VO Protocol estimates average voltage as follows, pre and post, and takes the difference:

$$V = V_{Set} - \frac{1}{2} * Ave (V_{Out,i} - V_{EOL,i}) * \frac{D_{annual}}{D_{meter}}$$

V_{Set} = Regulator set point voltage setting

$V_{Out,i}$ = Hour- i metered regulator output voltage on 120 V base

$V_{EOL,i}$ = Hour- i metered EOL primary voltage on 120 V base

D_{annual} = Average annual kW demand (from measured historical data)

D_{meter} = Average kW demand, metered at source

(Formula for line drop compensation and automated voltage feedback control adds correction for volt rise.)

Automated CVR: Performance criteria

Prior to CVR installation, do separately for each voltage control zone:

1. Collect historical data
 - Load shape, total energy, kvar data, customer mix, ER heat and AC kWh estimates
2. Run load flow simulation model for Pre- and Post-CVR cases
 - Base on physical configuration, historical data, and proposed upgrades.
3. Use simulation model to test whether Pre- and Post-CVR systems meet *performance thresholds*:
 - Max. phase load imbalance < 20% (check peak/min kW)
 - Min. hourly power factor > 95% (check peak/min kW, peak/min kVA)
 - Voltage complies with ANSI C84.1 (check at EOL for peak/min kW)

Automated CVR: Persistence

- Measure is operational, so persistence is tricky
- Protocol specifies “post-period re-verification trigger”
- Annual persistence review for three years after installation.
- Check for changes in standard operation
 - Source voltage (min, max, average),
 - Weather-adjusted annual energy
 - Average primary voltage
 - kW, kvar demand

Discussion/Questions

For more EM&V information see:

- Webinars: <https://emp.lbl.gov/emv-webinar-series>
- For technical assistance to state regulatory commissions, state energy offices, tribes and regional entities, and other public entities see: <https://emp.lbl.gov/projects/technical-assistance-states>
- Energy efficiency publications and presentations – financing, performance contracting, documenting performance, etc. see: <https://emp.lbl.gov/research-areas/energy-efficiency>
- New Technical Brief - *Coordinating Demand-Side Efficiency Evaluation, Measurement and Verification Among Western States: Options for Documenting Energy and Non- Energy Impacts for the Power Sector*
<https://emp.lbl.gov/publications/coordinating-demand-side-efficiency>

From Albert Einstein:

“Everything should be as simple as it is, but not simpler”

“Everything that can be counted does not necessarily count; everything that counts cannot necessarily be counted”