Distribution Voltage Optimization
Energy Savings for All customers through Investment in Grid technology

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90% of homes and businesses receive more voltage than they need.

-US Department of Energy
Average voltages are higher than necessary

**National Standard - Service Voltage Range 126 - 114 VAC**

At customer wall outlet

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<tr>
<th>V</th>
<th>126</th>
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122.5 National Average Customer Service Voltage

Upper Range

| 126 - 114 VAC |

Lower Range
How do excessive voltages waste energy?

A little physics

• Power = Voltage x Current (kW)

• Energy = Power x time (kW hours)
Why Do Utilities Run Voltages High?

• Lack of real time voltage measurements at customer meter
• Don’t want to get low voltage complaints
• Good metering with communication links was expensive in the past
• Lack of vendors for integrated solutions
• Lack of incentives for investments in improvements
The Solution

CVR – Conservation Voltage Reduction
  Also called
VVO – Volt/VAR Optimization
DVO – Distribution Voltage Optimization

Must be done with a software controlled system designed to do CVR
– not with traditional, manual CVR
What is CVR/DVO?

Use a lower voltage range on each feeder
How can voltage ranges be reduced?

Continuously monitor feeder voltages and use Capacitor Banks (CAP Banks), Voltage Regulators and Load Tap Changers (LTCs) to adaptively reduce voltages on each feeder at a substation.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Grid Locations</th>
<th>Grid Functions</th>
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<tbody>
<tr>
<td>Load tap changers</td>
<td>Substation transformers</td>
<td>Adjusts feeder voltages at the substation</td>
</tr>
<tr>
<td>Voltage regulators</td>
<td>Distribution feeders or substations</td>
<td>Adjusts voltages at the substation or along the feeder</td>
</tr>
<tr>
<td>Capacitor banks</td>
<td>Distribution feeders or substations</td>
<td>Compensates for reactive power and provides voltage support</td>
</tr>
</tbody>
</table>
Steps to Construct CVR

• Levelize the voltage along the length of each feeder
• Install voltage meters on each feeder
• Install a communication system for information and control
• Install automated controls at CAP Banks and Load Tap Changers
• Install CVR software to adaptively control voltages on feeders at each substation
Voltages on feeders change with load

- **Time of day** (morning, afternoon, evening, night)
- **Day of week** (weekday, weekend)
- **Season** (Summer, Winter, Spring/Fall)
- **Changes in usage** (PV systems, EV charging, Large TVs)
Modern CVR/DVO adaptively changes voltage

CVR system monitors voltages at multiple points on each feeder
Voltages levels are communicated to central system
Central system considers multiple factors and sends commands to equipment
Voltages are adaptively changed based on voltage levels
Measurement and Verification process monitors energy savings
Does CVR Actually Save Energy

Yes!

Pacific Northwest National Laboratory (PNNL)
- If CVR is implemented on every feeder in the US, annual energy consumption will be reduced by 3.04%

Pilot projects in multiple utilities have demonstrated energy savings and capacity reduction during peak hours

95% of energy savings is behind the customer’s meter, reducing customer bills
Motors operate on frequency, not voltage - higher voltages merely cause resistive loss

Air conditioners (compressors and blowers)
Refrigerators
Heater fans
Washer/drier motors

Lighting – reduction in voltage generally unnoticed as slight dimming in lights

Reduction in energy use for virtually all lighting types

Generally, for each 1% reduction in voltage there is at least a 0.8% reduction in energy use

National average estimate of 2% - 3% reduction in ALL energy use
Additional Grid Benefits

- Reduces grid losses by a small amount
- Building block for other grid improvements
  - Automated Fault location
  - Automated fault Isolation
  - Increased reliability
- Integration of distributed generation
- Improved reactive power correction
Major Advantages for Customer

- Reduces energy use
- Reduces customer bills
- Provides DSM for all customer classes
- Increases rates by small amount, but more than compensated by decrease in energy charges
- Rate payer payback in about five years
Major Barriers for Implementation

Requires a substantial investment by the utility

Reduces utility income in the short term

Needs incentives for utility investment

Needs ongoing incentives for efficient and innovative operation
Status in CO, NV and AZ

Colorado – Xcel Energy
• Piloted in 2007-2009
• Proposed implementation system wide - $94M investment
• PUC ruled DVO is DSM with some DSM incentives
• Investment waiting for better incentives

Nevada
• NV Energy - Large pilot underway in six substations and all subtending feeders

Arizona
• APS – Pilot on 17 feeders
• TEP – Pilot on 4 feeders
Questions??