Conservation Voltage Reduction with AMI Feedback

Results from Dominion Virginia Power
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Overview of CVR at Virginia Power

- Target energy savings, not demand reduction
- Incorporate AMI to maximize savings
- Pilot CVR in 3 regions

Dominion’s CVR concept

- Rely on metered premise-level voltage instead of load flow simulation
- Adjust bus voltage based on lowest meters
- Use exception reporting to adjust control meter set
- Improve facilities to lowest-voltage customers to tighten voltage band
Modeled vs. Metered Voltage

Planning software output

AMI voltage data

The Role of AMI

- **CVR read** – 10 meters / circuit, every 15 min
- **Daily read** – every meter, daily at 1:30 a.m.
- **4-hour read** – every meter, every 4 hours, for 7 days, prior to CVR implementation
- **Exception reporting** – every meter, whenever voltage is out of band
Operations Setup

- DMS script adding outer loop to LTC control
- Raise/lower voltage bandcenter
- AMI feedback – minimum, “low average”
- Turn off during switching

Assessing the Voltage Distribution

![Histogram and map of voltage distribution]
Effect of Distribution Upgrades

Measurement & Verification

Pairing Criteria to Determine CVR Factor

<table>
<thead>
<tr>
<th>Record 1</th>
<th>Record 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformer</td>
<td>Transformer</td>
</tr>
<tr>
<td>CVR Status</td>
<td>CVR Status</td>
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<tr>
<td>Day Type</td>
<td>Day Type</td>
</tr>
<tr>
<td>CDD</td>
<td>CDD</td>
</tr>
<tr>
<td>HDD</td>
<td>HDD</td>
</tr>
<tr>
<td>Rel. Humidity</td>
<td>Rel. Humidity</td>
</tr>
</tbody>
</table>

ON day ← %ΔkW/customer OFF day

CVRfactor = %ΔkW/customer %ΔV

Energy Savings Calculation

hourly:

% Δ Voltage = \frac{\text{Volts}_{\text{CVR off}} - \text{Volts}_{\text{CVR on}}}{\text{Volts}_{\text{CVR off}}} \times 100%

% Δ Energy = % Δ Voltage \times \text{CVR factor}

Energy_{\text{total}} = \sum \text{Energy}_{\text{hourly}}

Avoided Cost = \sum \text{Energy}_{\text{hourly}} \times \$\text{LMP}
Pilot Results – Midlothian

- Dense suburban circuits, 34.5 kV primary
- Operational since 2009
- Results:
  - empirical CVR factor of .92
  - voltage reduction 1-4% throughout the year
  - total energy savings over 15 GWh
  - $292,000 annual savings for one year of study
  - annual savings of 2.3% in EPRI Green Circuits study

Bus Voltage – Midlothian
Charlottesville & Alexandria Results

- Voltage reduction 1-3% throughout the year
- More upgrades required in areas with older homes
- Success factors:
  - Circuit length
  - Age of distribution infrastructure
  - Underground primary
  - Primary voltage level

Other Problems Identified

- Overloaded distribution transformers
- Open phase
- Loose connection / damaged meterbase
- Wrong tap on distribution transformers
- Wrong meter type
Summary of CVR Experience

- Low customer voltages are located across the circuit
- Strategic distribution upgrades enable greater savings on entire circuit
- Still determining what factors predict highest CVR savings