Demand Response Through Dynamic Voltage Reduction

Todd Loggins, PE
Clinton Utilities Board
CUB Facts & Figures

- 30,000 Customers
- 1,500 Miles of Line
- 10 Delivery Points
- Serve Parts of Six (6) Counties
- SCADA – 2002 (Survalent Technology)
- Distribution Automation – 2005
- VAR Control Automation – 2006
- AMI Deployment – 2007 (Aclara - TWACS)
- Voltage Control - 2011
Presentation Agenda

- Voltage Reduction Basics
- History
- Why for CUB?
- Integration
- CUB Approach
- Results
- Lessons Learned
Conservation Voltage Reduction (CVR)
- Reduction in voltage results in reduction in energy consumption
- Focus is on efficiency

Dynamic Voltage Reduction (DVR) –
- Voltage reduction only at peak times to help reduce demand
- This is CUB’s focus
CVR factor (applicable to DVR also)
- Ratio of $\Delta E / \Delta V$
- Depends upon load characteristics
  - Constant Z, I, or P
- Many studies have shown CVR factor of 0.6 to 1.0
- CUB Results found to vary by season –
  - Summer – 0.7
  - Winter – 1.0
Voltage Reduction History

- Not a new idea
  - 1948 – PG&E during drought
  - 1970’s – Arab oil embargo
  - Many other studies over last few decades

- Use is becoming more common as G, T, & D resources become stretched

- What is new?
  - Use of Smart Grid Technology
Why for CUB?

- TVA Smart Grid Pilot Project (SGPP)
- Change in Wholesale Rate Structure
TVA Smart Grid Pilot

- TVA looking at ways to reduce demand
- Building “Virtual Power Plants” (VPP’s)
- Must be dispatchable
- Must use Smart Grid Technology with 2-way communications
- CUB and 15 other TVA distributors submitted proposals and were selected
- 10-year agreement
- Paid for capacity and energy
- Must give periodic reports
Wholesale Rate Change

- For last ±20 years our wholesale rate had no demand charge
- “End use billing” – no incentive for peak reduction
- Instituted when TVA had surplus G&T
- April 2011 – Demand charges reinstated
- Monthly demand charge
- Demand charge varies by season
CUB Integration Philosophy

- No longer “islands” of information
- “Everything works together – The whole is greater than the sum of the parts.”
- MultiSpeak has made Smart Grid possible for CUB
  - Not custom interfaces
  - No huge staff or integrators necessary
- Must be real time
AMI-SCADA Integration

- Voltage Reduction – but how far?
  - ANSI – 114V, 110V temporary
- How do we insure 114V EOL?
  - AMI-SCADA Integration
- AMI – Aclara, TWACS
- Aclara had interface – CUB first to use it in this way
- Worked with Survalent on development of interface and provided feedback
CUB’s Solution

- TWACS meters provide EOL Voltage feedback to SCADA
- SCADA changes regulator voltage settings
- Equipment and Comm. already in place
- Each system does what it is designed for
CUB’s Solution

- SCADA “polls” meters to bring back readings just like any other analog point
- TWACS only allows reading every ±15 min.
- 3 meters per phase at end of each feeder
- 3 meters allows for reading every 5 min.
- TWACS UMT modules – meter class accuracy
- Uses MultiSpeak “Initiate” voltage reading
CUB’s Solution

- SCADA uses EOL voltage readings to change regulator set-points
  - Adjust up if EOL <114V
  - Adjust down if EOL >114V
- Goal is for every EOL voltage to be exactly 114V
- Maximizes reduction (and $ savings)
- Centralized logic and flexibility
  - Any number of feeders or points on feeder
  - Summer vs. Winter vs. Transition
CUB’s Solution

- Use capacitors to flatten voltage profile
  - SCADA controlled
  - Close all switched capacitor banks upon initiation of DVR event
Results (Show me the money!)

- Started VR in April 2011
- Average kW Reduction – 4.9 MW/month
  - From 117 MW monthly avg. peak (non-ind.)
  - Average 4.2% reduction in peak
- Average savings - $43k/month
- Savings have increased with additional regulation and system improvements
CUB Non-Industrial Load 2/13/2012
Estimated Reduction 6.41 MW
## Results

<table>
<thead>
<tr>
<th>Month</th>
<th>Non. Ind. Peak</th>
<th>Reduction</th>
<th>%Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug. 2011</td>
<td>132.6 MW</td>
<td>3.69 MW</td>
<td>2.8%</td>
</tr>
<tr>
<td>Sept. 2011</td>
<td>129.6 MW</td>
<td>4.47 MW</td>
<td>3.5%</td>
</tr>
<tr>
<td>Oct. 2011</td>
<td>83.6 MW</td>
<td>4.75 MW</td>
<td>5.7%</td>
</tr>
<tr>
<td>Nov. 2011</td>
<td>109.9 MW</td>
<td>5.49 MW</td>
<td>5.0%</td>
</tr>
<tr>
<td>Dec. 2011</td>
<td>113.4 MW</td>
<td>6.26 MW</td>
<td>5.5%</td>
</tr>
<tr>
<td>Jan. 2012</td>
<td>134.7 MW</td>
<td>6.63 MW</td>
<td>4.9%</td>
</tr>
<tr>
<td>Feb. 2012</td>
<td>131.1 MW</td>
<td>6.41 MW</td>
<td>4.9%</td>
</tr>
<tr>
<td>March 2012</td>
<td>107.6 MW</td>
<td>4.81 MW</td>
<td>4.8%</td>
</tr>
<tr>
<td>April 2012</td>
<td>85.2 MW</td>
<td>5.22 MW</td>
<td>6.1%</td>
</tr>
<tr>
<td>May 2012</td>
<td>108.3 MW</td>
<td>4.41 MW</td>
<td>4.1%</td>
</tr>
<tr>
<td>June 2012</td>
<td>132.6 MW</td>
<td>4.45 MW</td>
<td>3.4%</td>
</tr>
<tr>
<td>July 2012</td>
<td>132.8 MW</td>
<td>4.49 MW</td>
<td>3.4%</td>
</tr>
</tbody>
</table>
Lessons Learned

- How do I quantify potential?
  - Existing EOL voltage
    - System Modeling
    - Actual readings
  - Number of customers affected
Lessons Learned

“Customer-Volt” Approach

- What is it worth to reduce 1 customer by 1 volt?

Assumptions:

- Pre reduction voltage – 120V
- CVR Factor – 0.9
- Average Customer (with diversity) – 4.5 kW
- Average Monthly Wholesale Demand Charge ~$9

1 “Customer-Volt” = ~$3.50 Annually
Lessons Learned

- Demonstrates system weak points
- One low meter can keep entire sub from reaching reduction potential
  - Undersized transformer
  - Secondary extremely long or undersized
  - Example – one meter, due to both undersized transformer and long service, was found to be about 4 volts less than others around it
    - Costing CUB $25k annually in potential reductions
Lessons Learned

- EOL voltage differences between feeders
- One weak feeder costing $35k/year
- Install down-line voltage regulator station
  - Short payback

<table>
<thead>
<tr>
<th>Feeder</th>
<th>EOL Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>River 214</td>
<td>116.5</td>
</tr>
<tr>
<td>River 224</td>
<td>116.4</td>
</tr>
<tr>
<td>River 234</td>
<td>116.2</td>
</tr>
<tr>
<td>River 244</td>
<td>116.9</td>
</tr>
<tr>
<td>River 254</td>
<td>116.5</td>
</tr>
<tr>
<td>River 264</td>
<td>114.2</td>
</tr>
</tbody>
</table>
Lessons Learned – TVA SGPP

- CUB first to demonstrate contracted reduction amount and begin calls
- 4 Called Events in June and July 2012
- Hardest thing to do is determine reduction amount

Baseline Calculation Methodology
  - Modeled after Enernoc
  - Based on 3 highest days out of previous 10
  - Highly susceptible to external weather factors
    - Temperature, Clouds, Humidity, Wind
Lessons Learned – TVA SGPP

- 7/24/12 event
  - 2 of 3 “Baseline” days had clouds move through in afternoon
  - Approximate 5 MW Reduction
  - Calculated 0.6 MW Reduction
Clinton Utilities Board - Non Industrial Load
TVA DVR Event 7/24/12 - 2 pm to 8 pm EDT
Clinton Utilities Board - Non Industrial Load
TVA DVR Event 7/24/12 - 2 pm to 8 pm EDT
Lessons Learned – TVA SGPP

7/18/12 event
- Thunderstorms pass through area
- Approximate 5 MW Reduction
- Calculated 34 MW Reduction
- Credit capped at contract amount
Lessons Learned – TVA SGPP

Clinton Utilities Board - Non Industrial Load
TVA DVR Event 7/18/12 - 2 pm to 8 pm EDT

Baseline
Adjusted Baseline
Event Day
Lessons Learned – TVA SGPP

- CUB’s use of VPP for own purposes in prior days decreases baseline
- 6/29/12 event
  - CUB Used VPP each of 3 highest prior days
  - Approximate 5 MW Reduction
  - Calculated 1 MW Reduction
Lessons Learned – TVA SGPP

Clinton Utilities Board
TVA DVR Event 6/29/12 - 2 pm to 8 pm EDT

MW
12:00 PM 1:00 PM 2:00 PM 3:00 PM 4:00 PM 5:00 PM 6:00 PM 7:00 PM 8:00 PM 9:00 PM
EDT

Baseline
Adjusted Baseline
Event Day
Lessons Learned – TVA SGPP

- Both CUB and TVA realize deficiencies in current baseline methodology
- TVA wants to accurately demonstrate effectiveness of program
- CUB wants to be compensated accurately for reduction amount
- TVA working on better statistical methodology
Summary

- DVR not a new concept
- Smart Grid implementation is new
  - AMI-SCADA Interface
    - Multispeak
    - EOL Readings insure ANSI compliance while maximizing reduction and savings
- Quantifiable results, big $
  - Helps payback and justification of SCADA and AMI system
  - Payback for system upgrades
Questions?

Todd Loggins
tloggins@clintonub.com