Integrated Volt/VAR optimization with demand response and distributed energy resources
Changing the game – from traditional to smart grids

TRADITIONAL GRID

- Centralized generation
- One-directional power flow
- Generation follows load
- Top-down operations planning

SMART GRIDS

- Centralized and distributed generation
- Intermittent renewable generation
- Multi-directional power flow
- Operation based on real-time data
- Demand Response/Distributed Resources
### Benefits by value chain

<table>
<thead>
<tr>
<th>Power Value Chain</th>
<th>Applications</th>
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</thead>
<tbody>
<tr>
<td>Electricity Supply</td>
<td>Electric Energy Time Shift</td>
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<td></td>
<td>Electric Supply Capacity</td>
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<tr>
<td>Ancillary Services</td>
<td>Load Following</td>
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<td>Frequency Regulation</td>
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<td>Electric Supply Reserve Capacity</td>
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<td>Voltage Support</td>
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<td>Grid System</td>
<td>Transmission Support</td>
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<td>Transmission Congestion Relief</td>
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<td>T&amp;D Upgrade deferral</td>
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<td>Outage Management</td>
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<td>End-User (behind-the-meter)</td>
<td>Time of use energy management</td>
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<td>Demand Charge Management</td>
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<td>Electric Service Reliability</td>
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<td>Electric Service Power Quality</td>
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Volt/var Optimization

1. ALERT
   - Maintain voltage
   - Identify ways to reduce peak demand or losses

2. OPTIMIZE
   - Volt/Var optimization calculated and communicated to capacitors and regulators

3. REDUCE
   - Voltage flattened and reduced to reduce system demand and loss
Manage peak demand and system losses

1. System load requires demand reductions
2. Operator runs VVO application
3. VVO application determines optimized operation
4. VVO controls capacitors, load tap changers and regulators
5. Voltage is minimized within operating limits
6. Reduction in system demand and losses

<table>
<thead>
<tr>
<th>Old way</th>
<th>New way</th>
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<td>Decentralized Rules Based Heuristics</td>
<td>Methodical Optimization</td>
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<td>Control actions based on local measurements</td>
<td>Considers the as operated state of the distribution network</td>
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The old way:

- Effects of changing network configuration not considered
- Often the only value measured is the flow at head of feeder
- Conditions of the entire feeder not taken into account
- Not suitable for the network of future with disruptive technologies such as PHEV
- Typically not integrated to other systems
Manage peak demand

Forecast demand response capability

System resource need identified

Optimize commercial or distribution operations

Old way | New way
---|---
One way signal to load control switches | Two way flow of information to understand impact
Control actions based on system level needs | Targeted to network topology with changing configuration
Guess at when and how much to use | Optimization
Limited types of programs and resources | Direct load control
| Dynamic pricing
| Environmental signals
| Distributed resources

Track and report results for continuous improvement

Measure and verify events

Signal customers or distributed resources
Managing the lifecycle

- Post-Analysis
- Investment Planning
- Energy Accounting
- Program Design
- Operate & Optimize
Lots of choices, which is best?

- Tradeoffs for both utility and customer
  - Volt/var impacts customers but indirect interaction
  - Demand response engages consumer directly

- Transactions Costs
  - Compute and publish prices and signals
  - Energy management technology
  - Communication of usage, bills
  - Hardware, metering and communication costs

- Benefits
  - Customer better equipped to manage energy
  - An economist’s dream: efficient market for electricity
  - Equity: Cross-subsidies change
  - Improved utility operation and efficiency