Experience with Volt VAR Optimization at PG&E

i-PCGRID

April 1, 2016
PG&E is 2 years into a 3 year VVO Pilot

- **Objective - evaluate VVO’s ability to:**
  1. Enhance grid monitoring & control
  2. Obtain grid efficiencies and Conservation Voltage Reduction
  3. Accommodate growing distributed generation

- **Scope – lab test then field trial 2 competing vendors on 14 feeders**
  - Extensive testing completed at PG&E ATS Facility
  - Varying DG penetration (ranging from 2% – 35%: nameplate / peak)
  - Four feeders with > 25%

- **Preliminary* results to date from 12 feeders:**
  - Summer 2015: 0.1% energy savings
  - Fall 2015: 2.2% energy savings
  - Average CVRf: 0.9

* Results will be refined through course of pilot as new data and analysis methods are introduced
VVO Technology Overview

• VVO incorporates sensing, communications and computing to more tightly control voltage delivered to customers

• Reducing voltage drives energy efficiency through Conservation Voltage Reduction (CVR) – *reducing delivered voltage reduces energy consumption without sacrificing device/appliance performance & customer satisfaction*

• Has the promise to deliver:
  • **1-2% reduction** in energy demand and consumption
  • **Improved voltage control** on circuits with high DG penetration
PG&E DTY Testing Facility at ATS

PG&E utilized the distribution test yard (DTY) to simulate circuit responses to VVO operation, allowing evaluation of vendor solution performance prior to field deployment.

Network Model → Test VVO → AMI Head End

SCADA

Meter Simulator

Distribution Test Yard

UIQ System

Meter Farm
Lessons Learned through ATS Testing

VVO Vendor Related
• Both vendors previously deployed at other utilities, but determined not initially ready for PG&E production system
• Test environment allowed vendors to experience edge situations not seen before at their previous field installations
• Identified and resolved critical and high issues before allowing vendors into production system
• Importance of ACTIONABLE alarms
• Ability to address reverse power through regulators
• Integrating with the nuances of a real feeder and hardware specific to PG&E
• Learning to handle PG&E AMI data and potential data quality issues with it

PG&E Related
• Python scripting of CYME to simulate PG&E feeder conditions for operational testing before field rollouts
• New Field Hardware
• New Communications
• VVO SCADA Integration and Screen Creation
• Value of Super User Training on system before rolling into production
Reverse Power VVO Vendor Strategy Progression through Pilot

No strategy

Disable VVO

Ride-through reverse power for co-gen regs, disable otherwise

Vendors not allowed out of test phase

Caused certain systems to trip regularly around midday

Works well for PG&E’s VVO circuits, no issues so far
DG Penetration Increases on VVO Circuits: 2013 - 2016

- Original VVO feeder selection analysis done near end of 2013
- Observed significant increases in DG penetration on VVO feeders in short span (<3 years) of pilot

VVO Feeder DG Penetration Increases

![Bar chart showing DG penetration increases on VVO feeders from 2013 to 2016.](image)
Reverse power seen at feeder and regulators

Feeder Head

Regulator
VVO’s Effect on Woodward 2106 (has high DG Penetration > 25% of load)

No issues with 2 On days, some issues with 3 Off days

- VVO team will continue studying VVO’s impact on voltage in presence of PV
Lesson learned: Pre-screen VVO feeders with AMI voltage data

- Without conditioning on some circuits that experience both high and low voltages at the same time, it is difficult for VVO to drive benefits
- Circuit conditioning for this VVO bank to be completed this spring expected to improve performance during summer peak load conditions
Lessons Learned: Value from Proactive Issue Identification and Resolution

- Configured Tableau and PI screens and tools to monitor AMI voltages and SCADA data to identify issues proactively and find resolutions
- Almost all issues related to secondary problems, but also used to adjust existing settings on field equipment, and to confirm VVO settings

T-man replaces service drop to customer and resolves problem before customer notices issue
Exploring Value of Smart Inverters for VVO

- **Modeling (complete)**
  - How can VVO control of Smart Inverters improve VVO performance?
  - What value could VVO extract from “VARs at night”?

- **Lab Testing (in progress)**
  - What “VVO friendly” power factor and Volt-Var settings deliver safe “no fight” conditions in the field

- **Field Trial (later in 2016)**
  - Collaborate with 3rd party installers to have Smart Inverters installed in Q2 2016, adjust power factor and Volt-Var settings to improve VVO benefits
Dinuba 1104 Studied due to Challenging Voltage Control Conditions

Complex with concentrated DG
- > 100 circuit miles
- 5 line voltage regulators
- 23% DG penetration
- Three large DGs: 2 x 1 MW, 1 x 0.7 MW

VVO Go Live in Jan 2016 drove interest in predicting performance

(1) Measured as DG capacity / feeder peak load. At time study began, additional DG connection has raised penetration to 34% as of January 2016
VVO control of SI can deliver line loss reduction at low DG penetration, and energy delivery savings at higher penetrations.

Charts below show comparison of VVO savings metrics Case 1 (No VVO) at varying DG penetration levels.

- **Case 2: Traditional VVO**
- **Case 3: VVO plus SI P.F. control**

### Energy Delivery Savings

**Daytime** (8 am – 6 pm)

- **DG Penetration**
  - 23%
  - 47%
  - 70%
  - 94%

- **Energy Delivery Savings**
  - 0%
  - 2%
  - 4%
  - 6%
  - 8%
  - 10%

### VARs at Night

- **DG Penetration**
  - 23%
  - 45%
  - 68%
  - 91%

- **Energy Delivery Savings**
  - 0%
  - 3%
  - 6%
  - 9%
  - 12%
  - 15%

### Line Loss Reduction

- **DG Penetration**
  - 23%
  - 47%
  - 70%
  - 94%

- **Line Loss Reduction**
  - 0%
  - 3%
  - 6%
  - 9%
  - 12%
  - 15%
Case 1: No VVO, PV-DG operates at unity power factor

Case 2: VVO controls LTC, Regs, and Caps, PV-DG operates at unity power factor

Case 3: VVO controls LTC, Regs, Caps, and DG smart inverter power factor (0.95 lead, unity, or 0.95 lag)
Next Steps for SI

VVO Pilot Smart Inverter Field Trial

• Adjust Smart Inverter P.F. and Volt-VAR settings to evaluate impact to VVO performance

Follow technology and regulatory development to automate use of Smart Inverters

• DERMS EPIC Technology Demonstration in late 2016
• Follow ADMS / VVO / DERMS technology developments
• California Distributed Resources Plan – locational value of Smart Inverters?
Post-Pilot Deployment

- 2017-2019 GRC proposed $84M deployment on 228 feeders (7% of PG&E’s system)

- Presently forecasting a benefit-cost ratio of 1.2 – 2.0, and will be updating forecast in April

- Plan dependent on PG&E’s SCADA and DMS plans – Deployment of VVO would be tightly integrated with DMS enabling automated configurations and reconfigurations

- PG&E is not tied to piloted vendors, and will reassess the VVO vendor market place for deployment vendor
Questions?

Rustom Dessai, PE
Emerging Grid Technologies
Pacific Gas and Electric
r1dp@pge.com