

Grid Edge Control

- Grid Optimization (VVO/CVR)
- Grid Integration of Distributed Dynamic Loads (PV)
- Power Quality & Weak Feeders

Presentation to LBNL

February 14, 2014

Deepak Divan, President & CTO, Co-Founder



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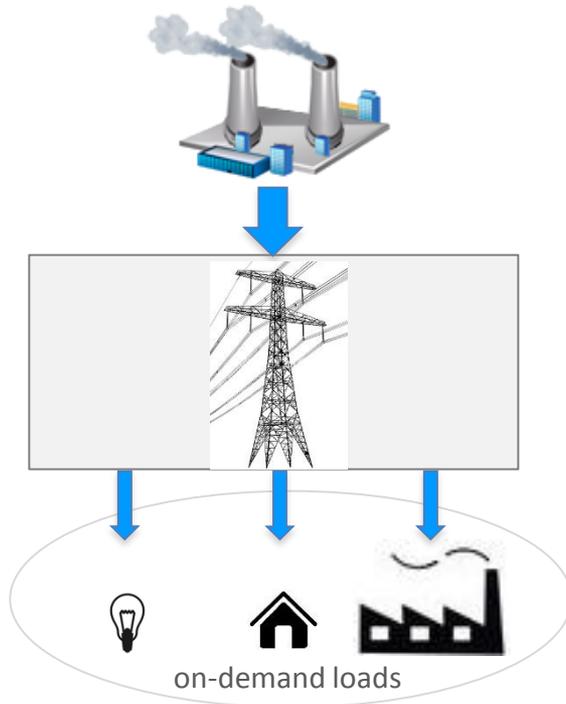
- **Distributed, decentralized, dynamic control at the grid edge**
- **Complements existing centralized command & control**
- **Absorbs dynamics of distributed PV**
- **Allows many Smart Grid initiatives to deliver on promised value**
- **Delivers visibility and analytics at edge**



Edge of Network Grid Optimization

Dispatchable Generation

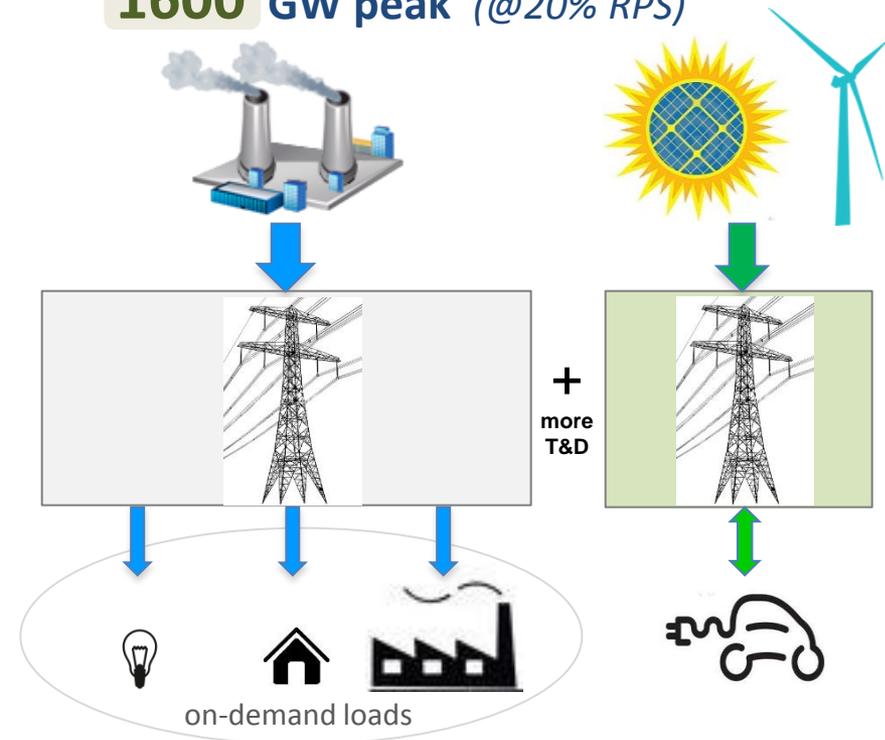
1000 GW peak



- 100' s of generators
- Poor visibility at periphery
- Control is central, slow

Intermittent + Dispatchable Generation

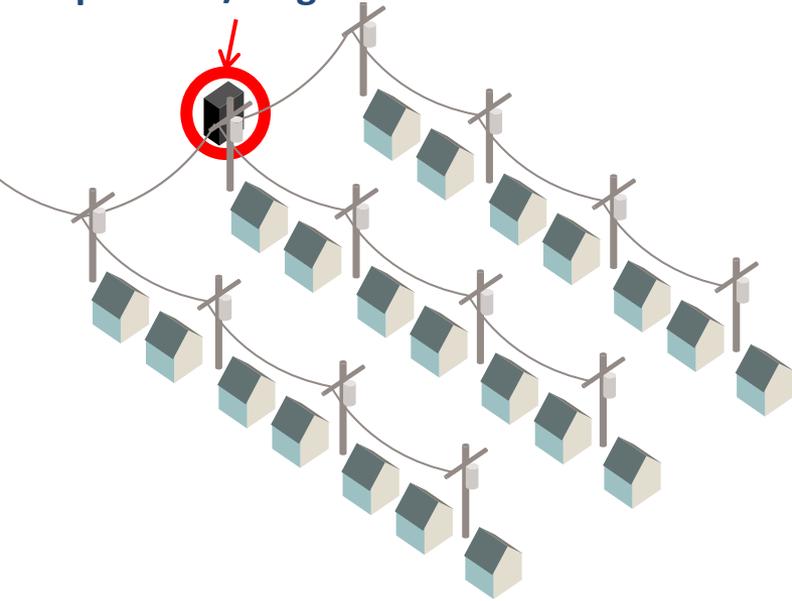
1600 GW peak (@20% RPS)



- 10,000' s of generators
- Visibility to dynamics required
- Dynamic control needed at periphery

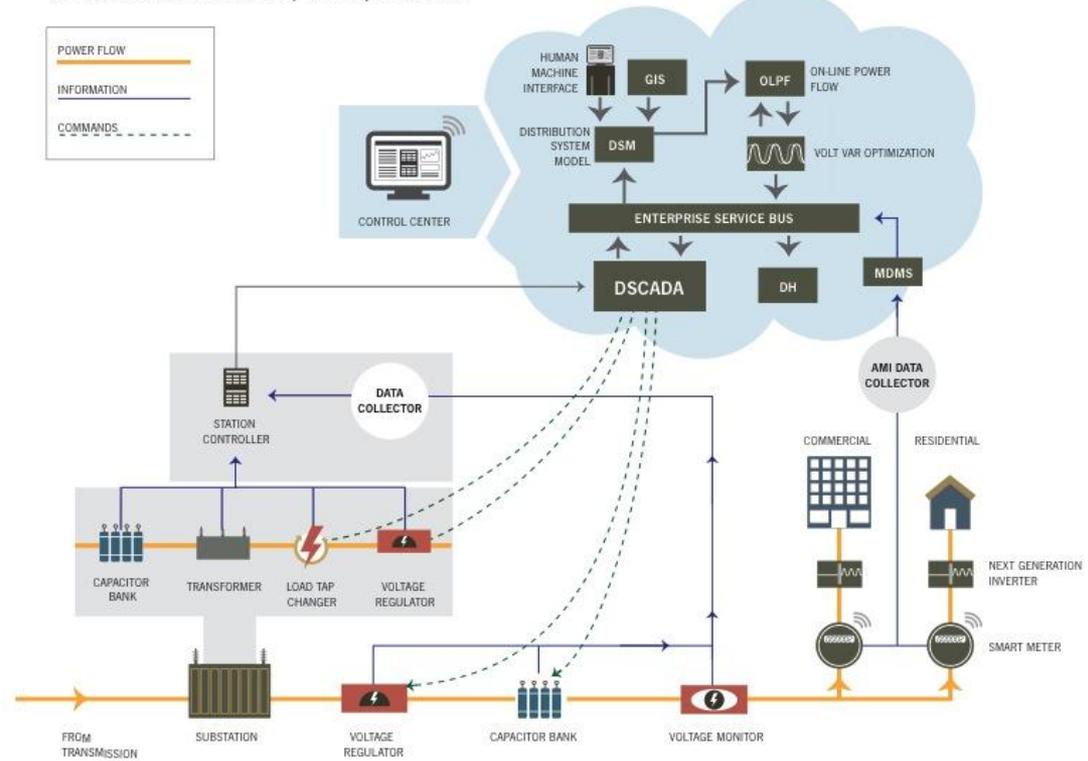
CONVENTIONAL Volt VAR Control

Electromechanical Cap Banks / Regulators

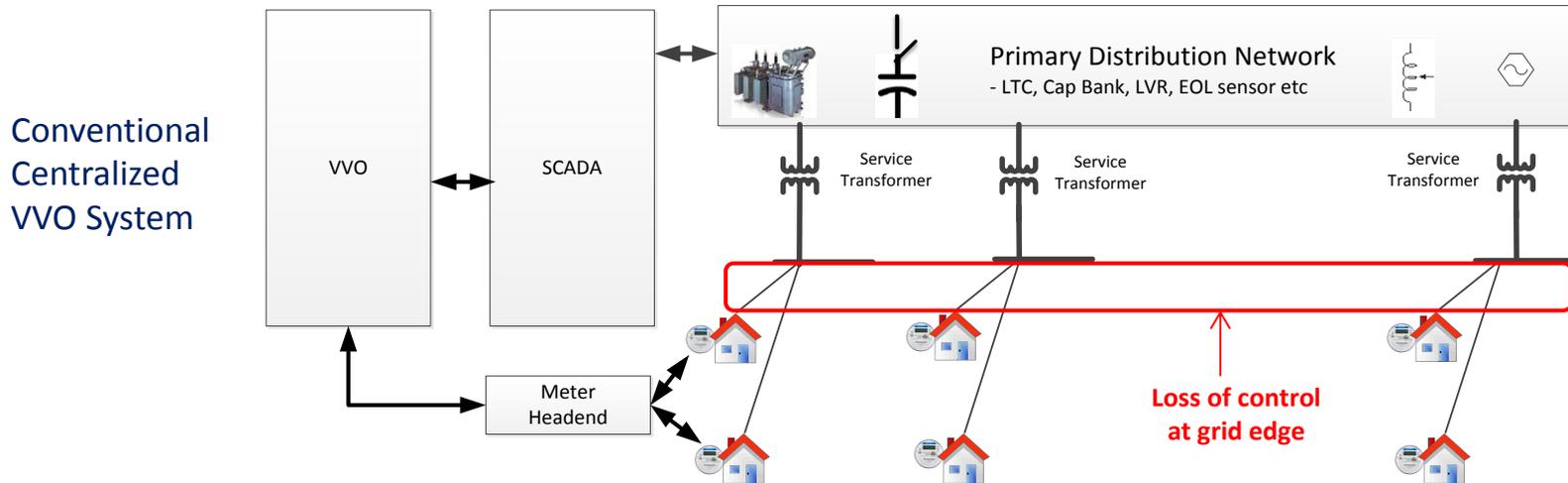


- Primary side control
- Centralized & complex
- Slow (5-15 min) response
- Limited switchings per day

Control Center Based Volt/VAR Optimization



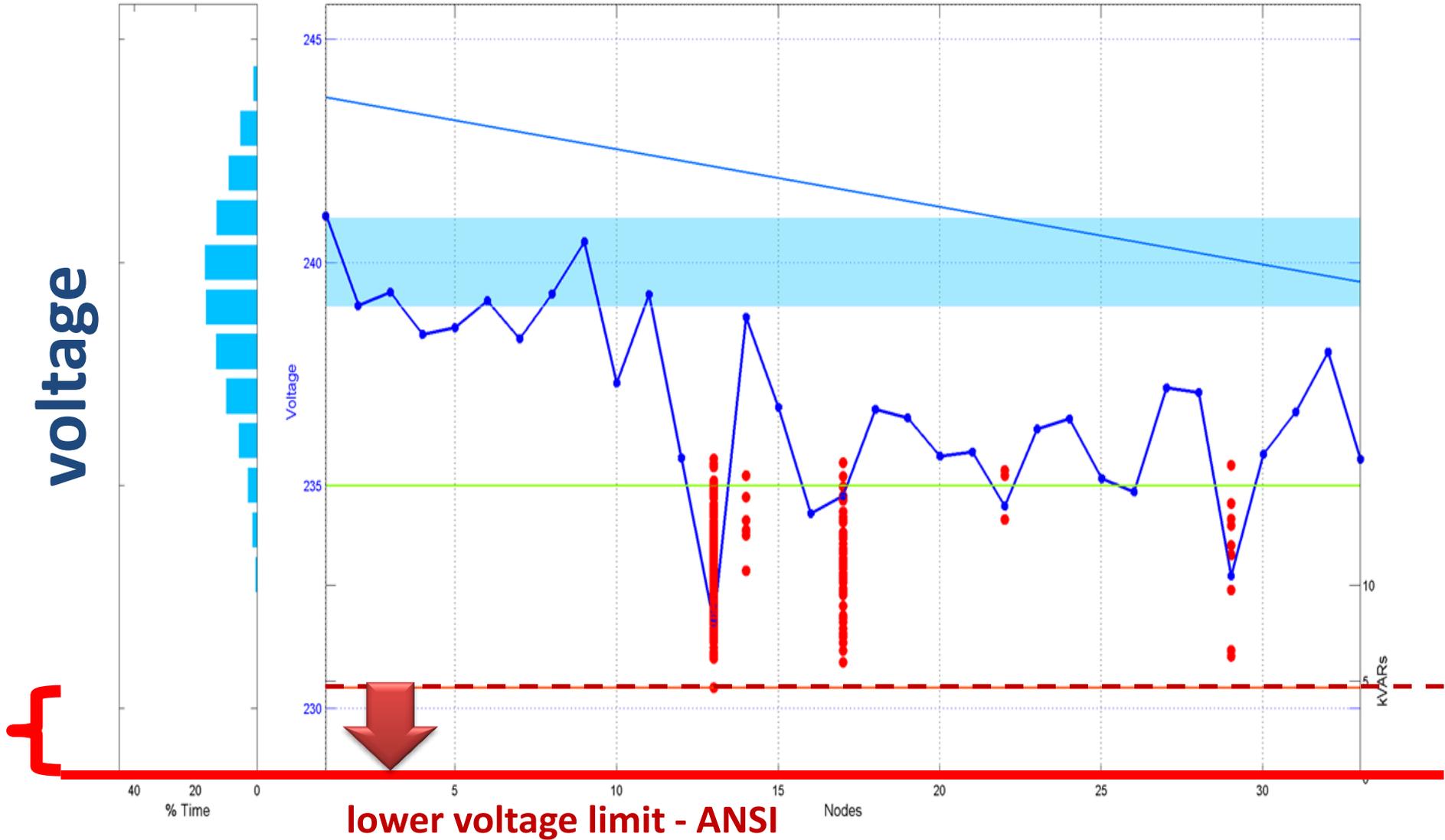
Best Practice: Distribution Operations Support
Source: GTM Research



• Issues

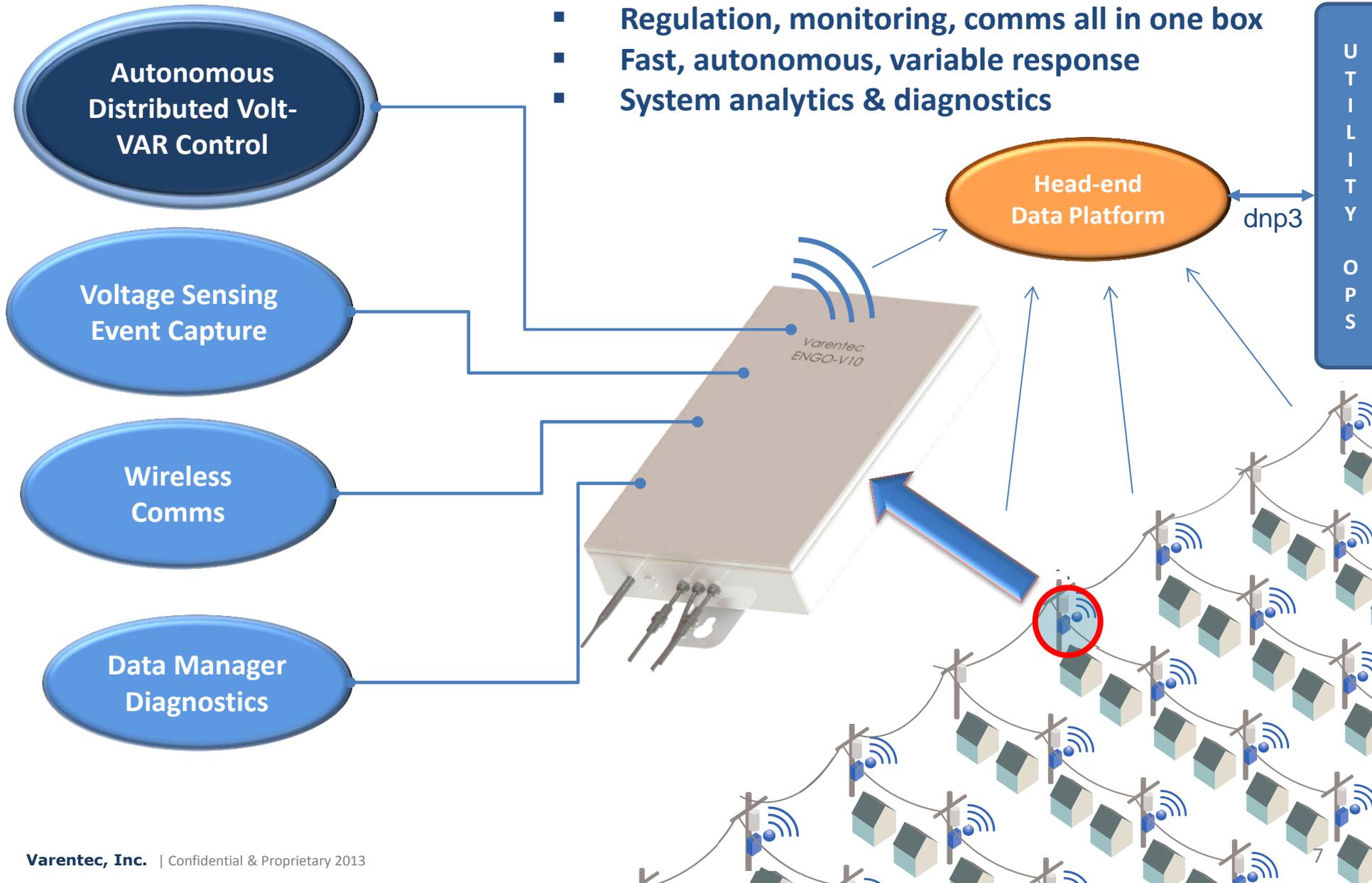
- Voltage drop across distribution transformers 2 - 8 volts, AMI data confirms
- Cannot manage secondary voltage variations using primary side control
- Distributed control required, not possible with central command & control
- Erodes value proposition of CVR/Demand Management systems
- Poor VVO/CVR performance has negative impact on entire market segment

**NO
GRID EDGE
CONTROL**

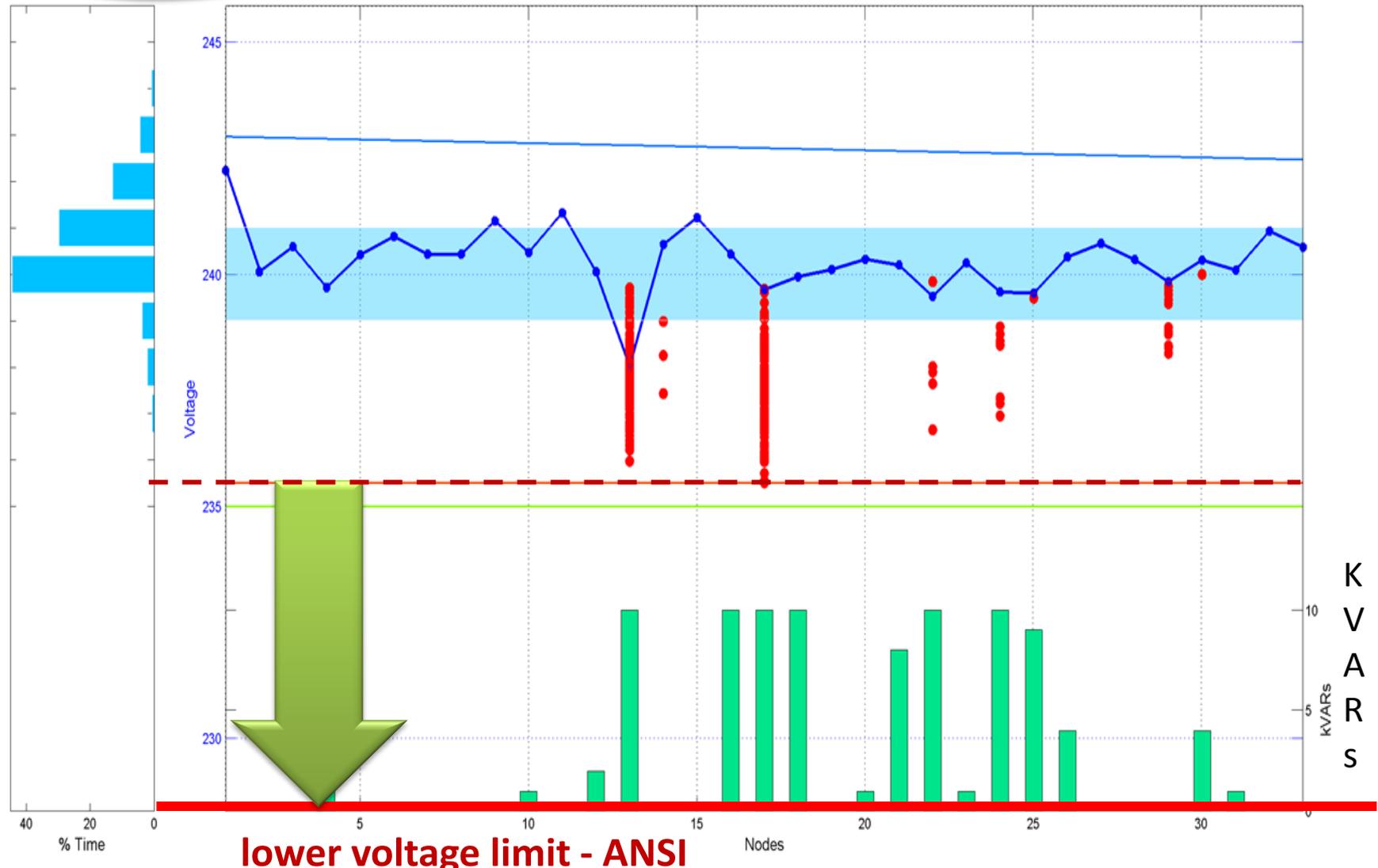


ENGO-V: Distributed Grid Control

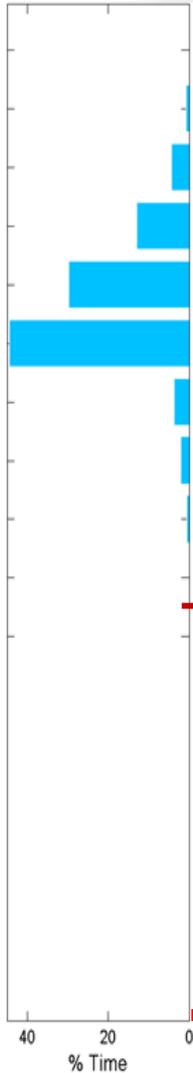
- Decentralized Volt VAR regulator unit
- Regulation, monitoring, comms all in one box
- Fast, autonomous, variable response
- System analytics & diagnostics



**WITH
GRID EDGE
CONTROL**



WITH
GRID EDGE
CONTROL

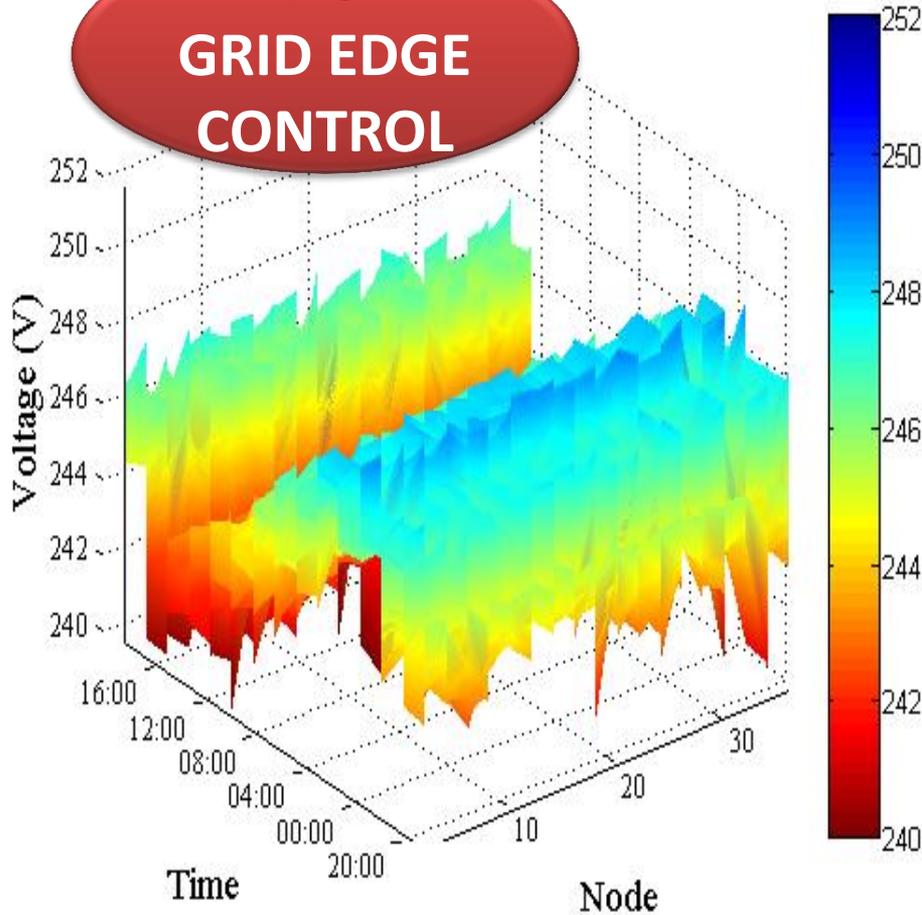


“headroom” is maximized

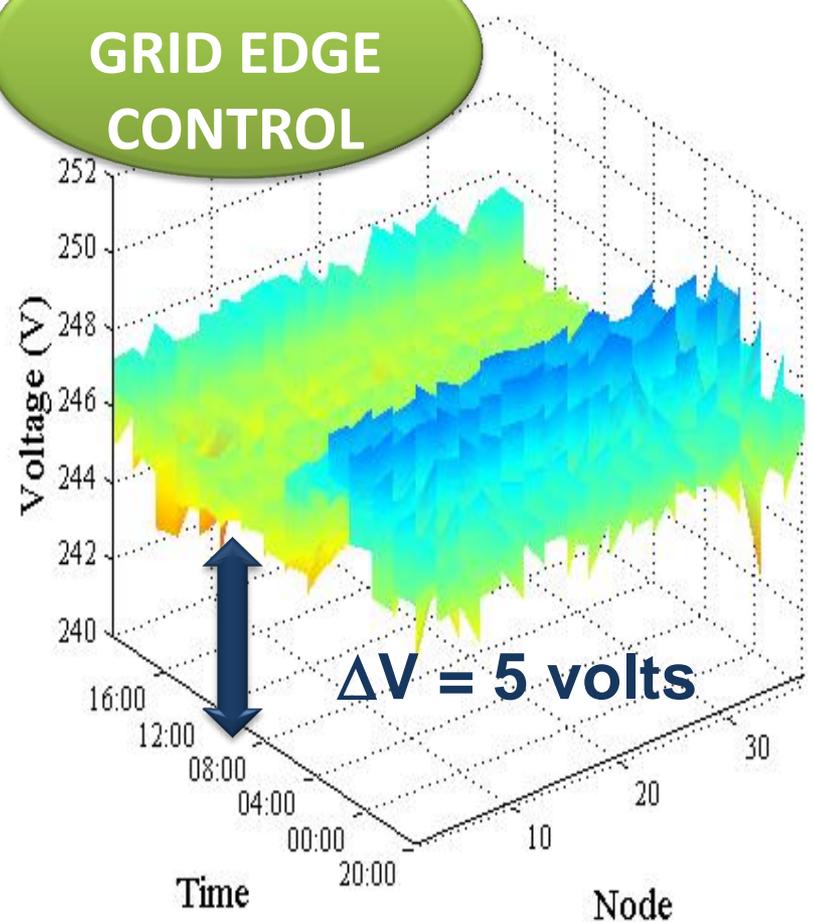
2X greater
energy savings possible

lower voltage limit - ANSI

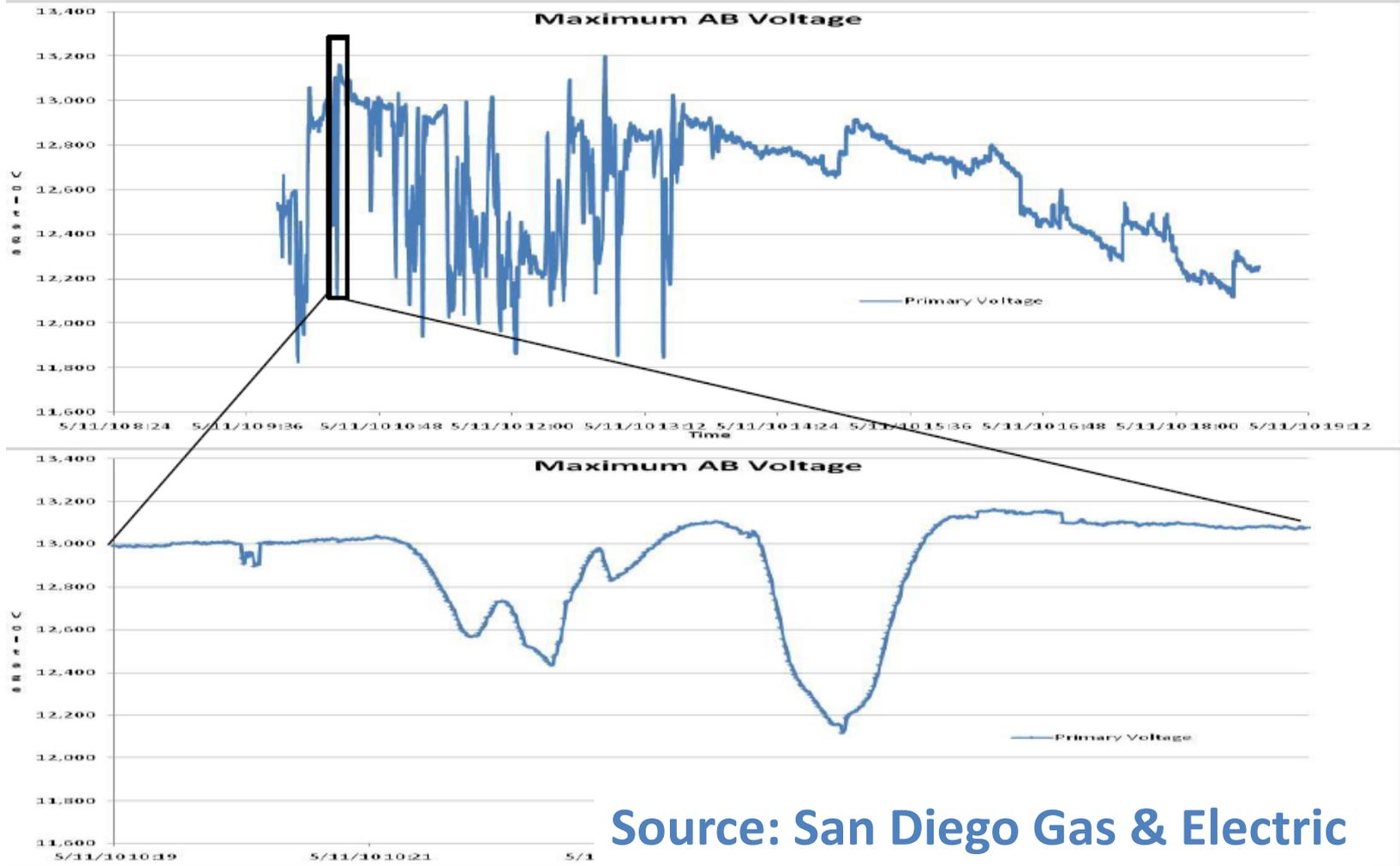
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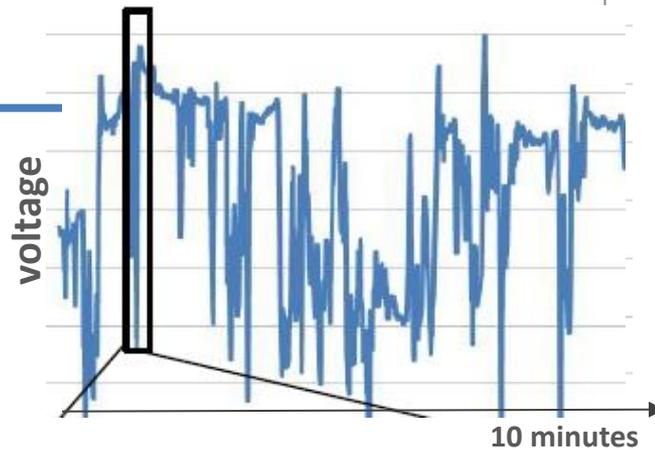


**ΔV of 5 volts enables 2X
demand control**



- Voltage instability at PV penetration > 10-15%
- Dispatched slow Cap Banks cannot solve voltage volatility

- Clouds cause voltage volatility and frequent LVR operation
- Dynamic voltage **control** required **at point of problem**
- Smart inverters have no VAR reference and can fight
- Utilities cannot dispatch distributed VAR commands

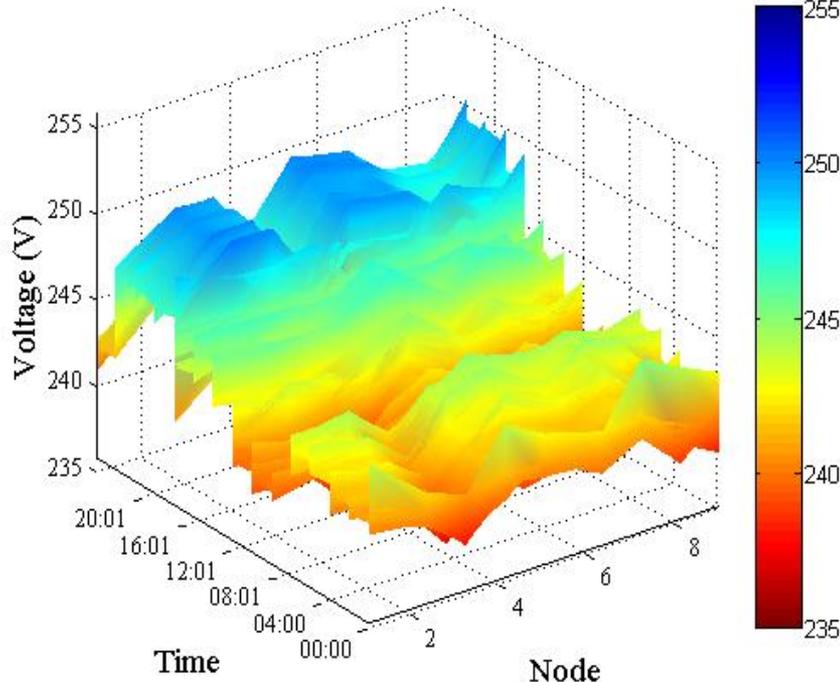


Grid Edge Control Reduces Impact of PV Solar on the Grid

ENGO OFF



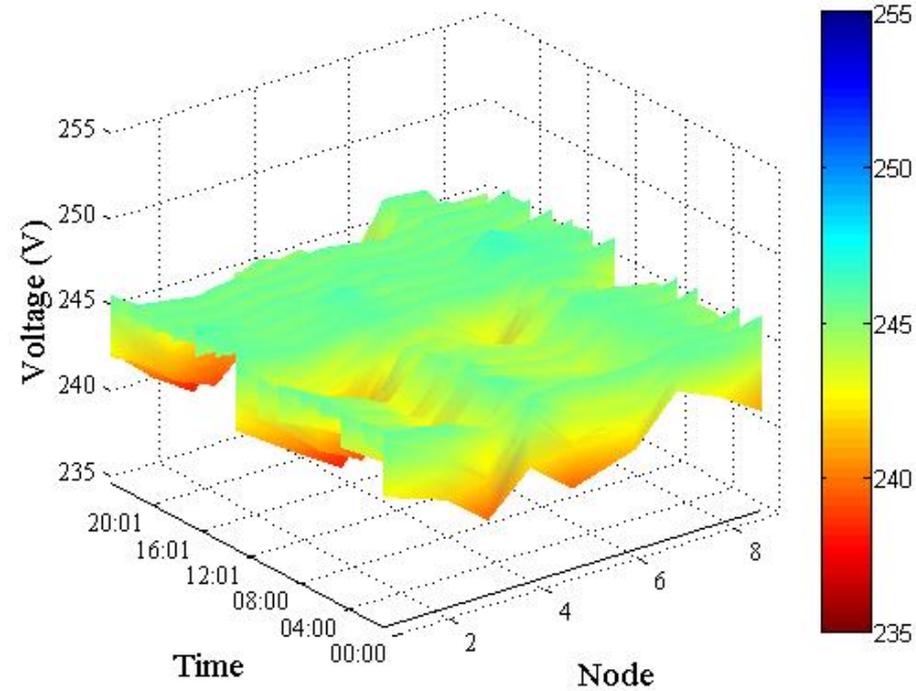
Data for 11/20/13, Setpoint: 0



ENGO ON



Data for 11/19/13, Setpoint: 245



Partly Cloudy Days

Peak Demand Reduction:

- Peak Demand (Base Case) : 3,225 kW
- 5% voltage change at coincident peak: 144 kW reduction
- Cost savings at \$15/kW/month: \$2,197/mo
- Annual cost savings = **\$26,300/year**

Line loss reduction with power factor control:

- Improving PF from 0.95 to 1.0 reduces line losses by 10%
- Est.line losses 10% of energy delivered = 1900 MWhr/year
- **Line losses reduced by 10% = 190 MWhr**
- Savings by utility at \$0.05/kWhr = \$9,500/year

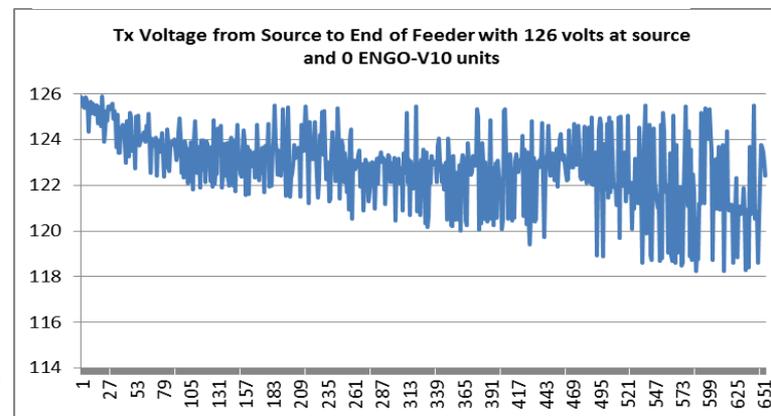
24/7 CVR Savings for utility:

- Energy Delivered estimate = 13,700 MWhr/year
- Estimated Energy Savings **420 MWhr/yr reduced**
(at \$0.05/kWhr = \$21,000/year)

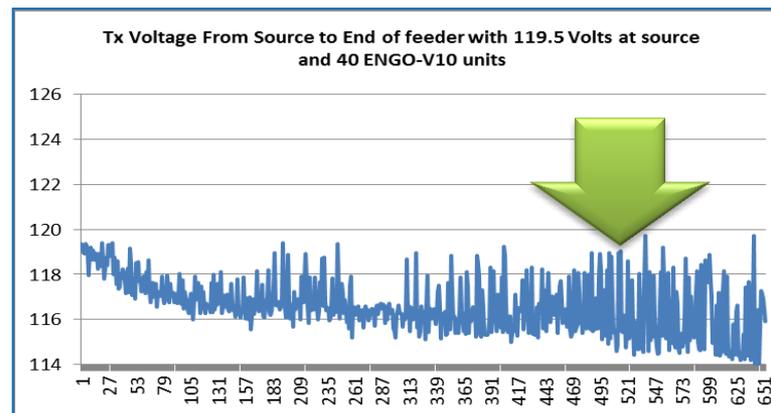
Power Quality Improvement

- Reduce flicker events
- Reduce dynamics or low voltage location
- Lower cost method compared to reconductoring, new transformer, network re-configure

Voltage Profile: Base Case



Voltage Profile: ENGO-V Case



Fixing low voltage nodes with the ENGO units allows the feeder voltage to be decreased without violating ANSI voltage limits

Georgia



Mexico



N. Carolina



Wisconsin



Live install in 15 minutes

Value Proposition	Benefits
CVR/VVO Energy Savings	Fix low voltage nodes, allowing improved energy conservation
Peak Load Reduction	On-demand peak load reduction with no customer involvement
Line Loss Reduction PF Improvement	Dispatch VARs to improve substation power factor and transmission support
PV Dynamics Mitigation	Dynamic VARs can help mitigate primary side voltage volatility due to distributed PV
Dynamic VAR Injection	Dynamic voltage support for momentaries and FIDVR events
Reduced Operation of Primary Assets	Reduce LTC/LVR/cap bank operation for longer asset life
Improved Reliability and Power Quality	Improved voltage compliance, mitigation of low-voltage pockets and reliability/power quality improvements
Feeder Analytics Improved Visibility	Secondary side visibility and feeder level analytics

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