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Valuation and Integration of DERs

DOE-EAC Panel Presentation

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The Future Grid – Conventional Wisdom

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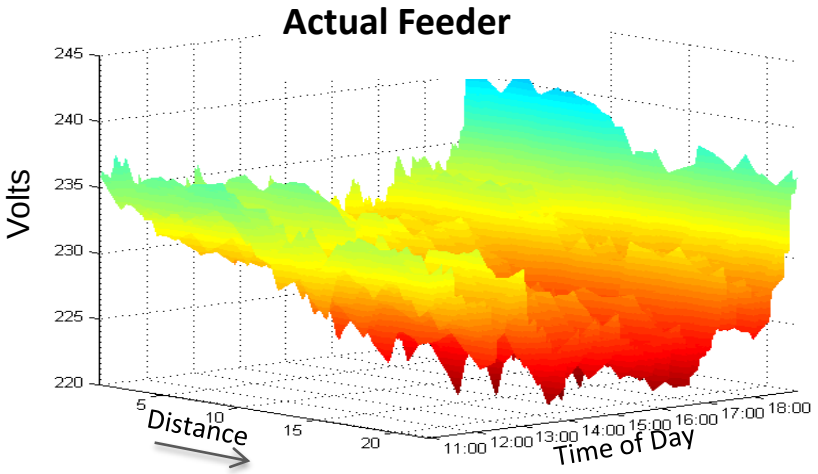
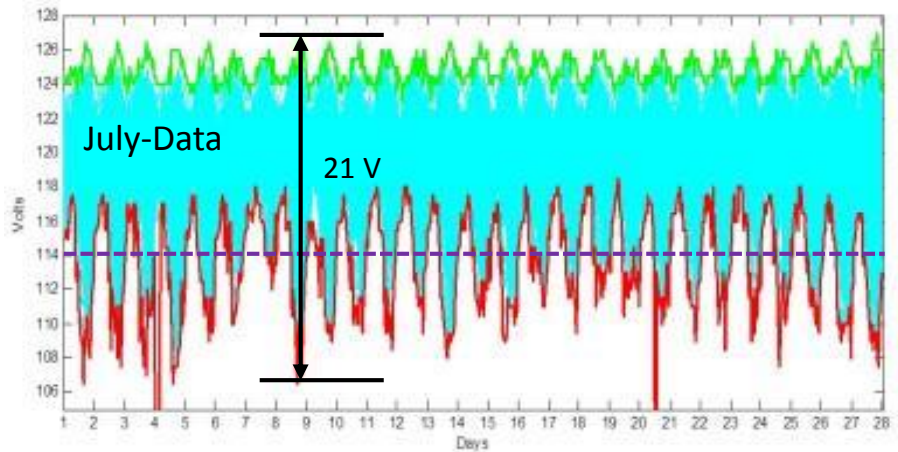
- Power infrastructure is poised for dramatic change. Drivers include:
  - ✓ growth in non-schedulable distributed generation
  - ✓ improved economic, operational and energy efficiency
  - ✓ grid resiliency under cyber-attacks and natural disasters
  - ✓ emerging markets as a leapfrog opportunity
- Smart Grid initiatives augment centralized command & HV side control with sensors (AMI, V/I), back-office data mgmt & demand/system optimization
- The Internet of Things (sensing, comms, predictive analytics, control) targets diagnostics, prognostics & management of asset fleet and flexible demand

Gaps in Utility Models Emerging





5446 AMI meters over 30 days

- **Secondary Voltage Volatility**: Voltage volatility & ANSI violations not explained by current models
- **Distributed Problem:** Different control action needed at different points, cannot fix with centralized control
- **Slow Central Control**: Primary equipment can only respond to slow variations (caps switch 3 times/day)
- **Distributed Controllers Interact:** Local autonomous control needed – cannot be dispatched/scheduled
- **Solar PV**: Voltage violations limit PV hosting and high PV severely degrades benefits of VVC investments

Source: Southern Company and Varentec

Impact of Grid Edge Volatility

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Lack of grid-edge control, and the resulting voltage volatility, has dramatic impact on the value derived from the grid.

Reduced Volt-VAR Control range limits the ability to:

- Use the distribution grid as a resource for demand management and energy conservation
- Maximize reduction of technical loss & lost revenue
- Host high level of distributed PV/DER on the grid
- Absorb high penetration of microgrids to improve supply resiliency and reliability
- Implement effective centralized DERMS or planning based DLMP programs
- Use the distribution grid as a predictable dispatchable dynamic virtual resource (generation, storage, ramp rate, contingency management, DER balancing, VAR support, FIDVR)

Distributed Control … *a new paradigm*

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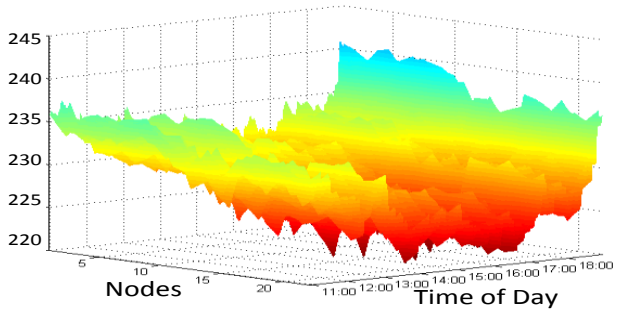
Centralized Control

Now …

- Scheduled Generation
- Centralized Top-Down Control
- Planning Based, Dispatched
- Unidirectional Flows, Consumers
- Redundancy, N-X Contingencies

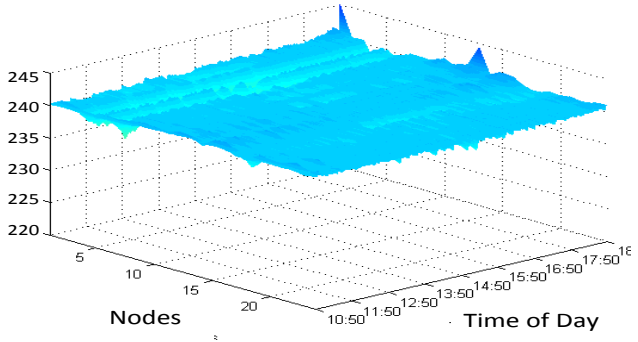


Centralized top-down control – poor system performance

Distributed Control

Need …

- Non-Dispatchable Variable Generation
- Distributed Edge-Up Real-Time Control
- Flexible, Secure, Predictable Virtual Resources
- Bidirectional Flows, Prosumers
- Support Transactive and Ancillary Services



Edge-up real-time control - local & system level control

Source: Southern Company and Varentec

Distributed Grid Architecture Elements

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Legacy Grid Systems

New Elements

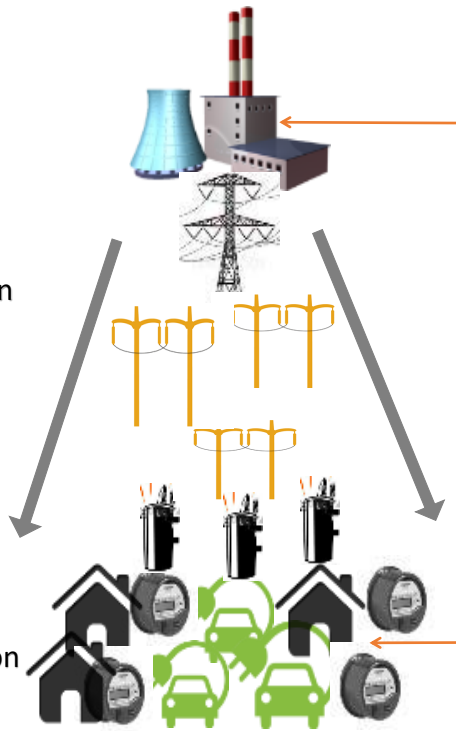
'Edge Up' Control

Generation

Transmission

Distribution

Consumption



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System Control
Interface w/ Legacy Systems

Aggregated System Control

Data Management & Analytics
Communications Platform

Cloud & Cellular Based

Communications

Smart Autonomous Devices
Local & System Control

Distributed Grid-Edge Control

Grid Sensing/ Dynamic Control

PV/Wind Storage Integration

Mobile Energy Apps

Energy Efficiency Energy Conservation

Off & Poor Grid

Edge Devices Local Action

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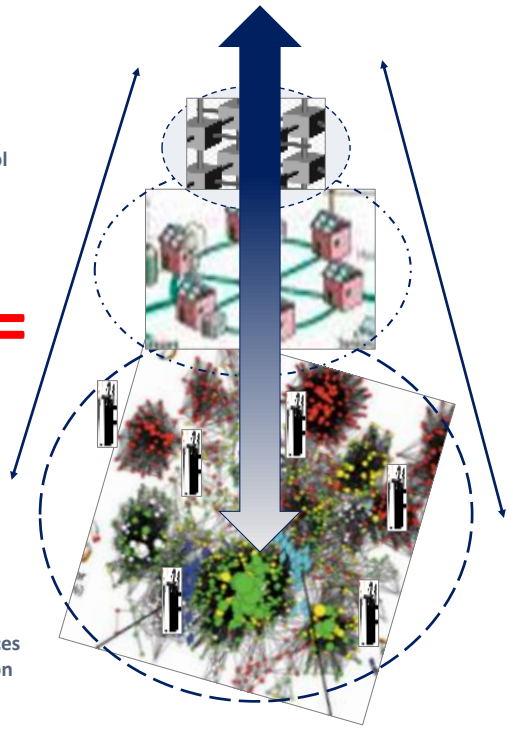

Simple, Scheduled, Slow

Overlay, Augment, Incremental

Complex, Flexible, Dynamic

Implementing Grid-Edge Control

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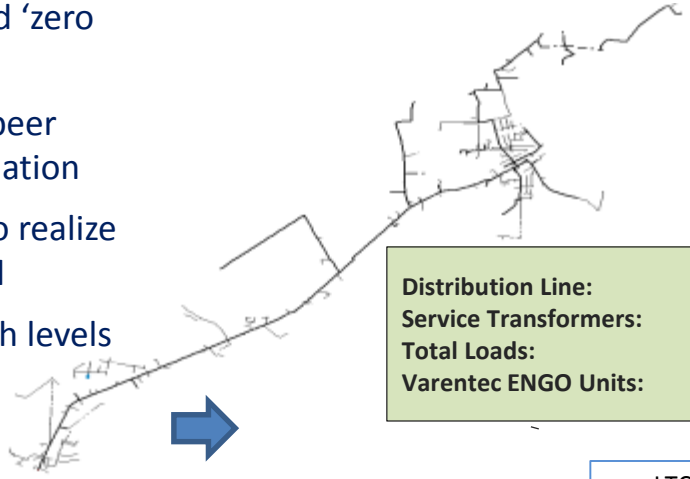
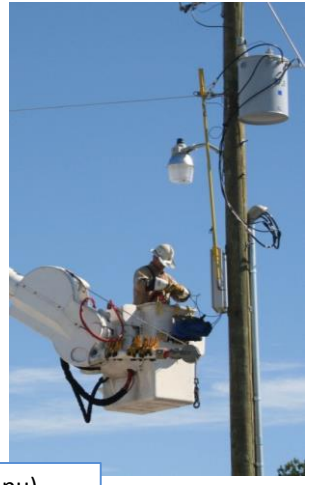
Source: Southern Company and Varentec

- Local dynamic VARs with 'no-fighting' and 'zero droop' algorithm → flat voltage profile
- Autonomous operation with no peer-to-peer comms, but with slow comms for coordination
- Coordinate with utility assets (LTC/LVR) to realize unprecedented grid-side volt-VAR control
- Eliminate voltage constraints to allow high levels of PV hosting



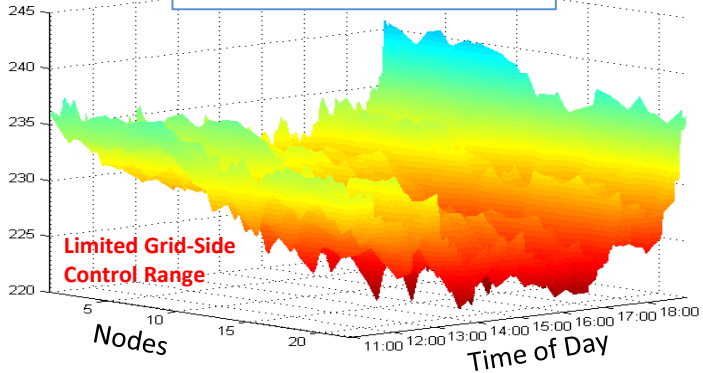
Proven at 20+ utilities

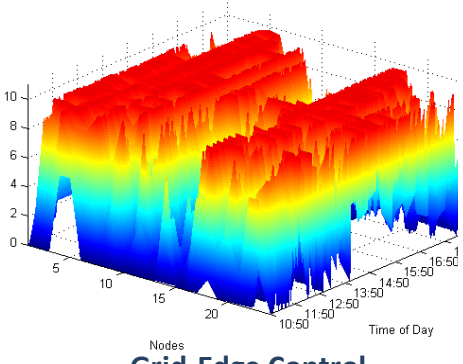


Distribution Line:	5 MW 12 mile
Service Transformers:	421
Total Loads:	4760 KVA
Varentec ENGO Units:	91 * 10 kVARs

LTC set at 240V (1.0 pu)
TOP-DOWN CONTROL

Volatile

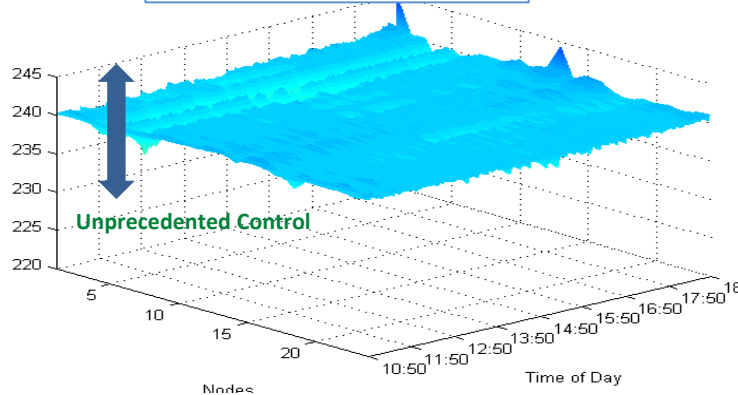




Grid-Edge Control

Smooth

LTC set at 240V (1.0 pu)
EDGE-UP CONTROL



Value Enabled by Grid Edge Control

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- Minimize distribution level constraints and expand size/liquidity of distribution level markets
- > +/- 5% grid-side demand/energy control, dynamic balancing, ramp-rate control
- Improve grid operational efficiency - reduce technical losses & related lost revenue
- Aggregate distribution feeders as a predictable virtual resource for MW/MVAR support
- Increase PV/DER hosting without limiting benefits of VVC investments
- Maximize value of additional market layer including DLMP, local VARs & virtual storage

Recommendations

- Grid is an ecosystem – *incentives to make grid-connected assets (microgrids, loads, sources, DG) inherently grid supporting to preserve investments & maximize value*
- Grid assets need to have distributed real-time control capability – *power electronics research for power flow control, dynamic voltage and VAR control*
- Enhanced dynamic and distributed grid models and simulation tools needed to understand system behavior – *new tools to manage the new system*
- Interaction of massively distributed autonomous assets with each other & with existing grid control poorly understood – *research initiative needed*
- Mixed market model – *centralized dispatch, transactive at mid-level, autonomous at edge*
- Fast real-time grid-edge voltage support enables transactions – *make part of ancillary services*

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Questions?

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