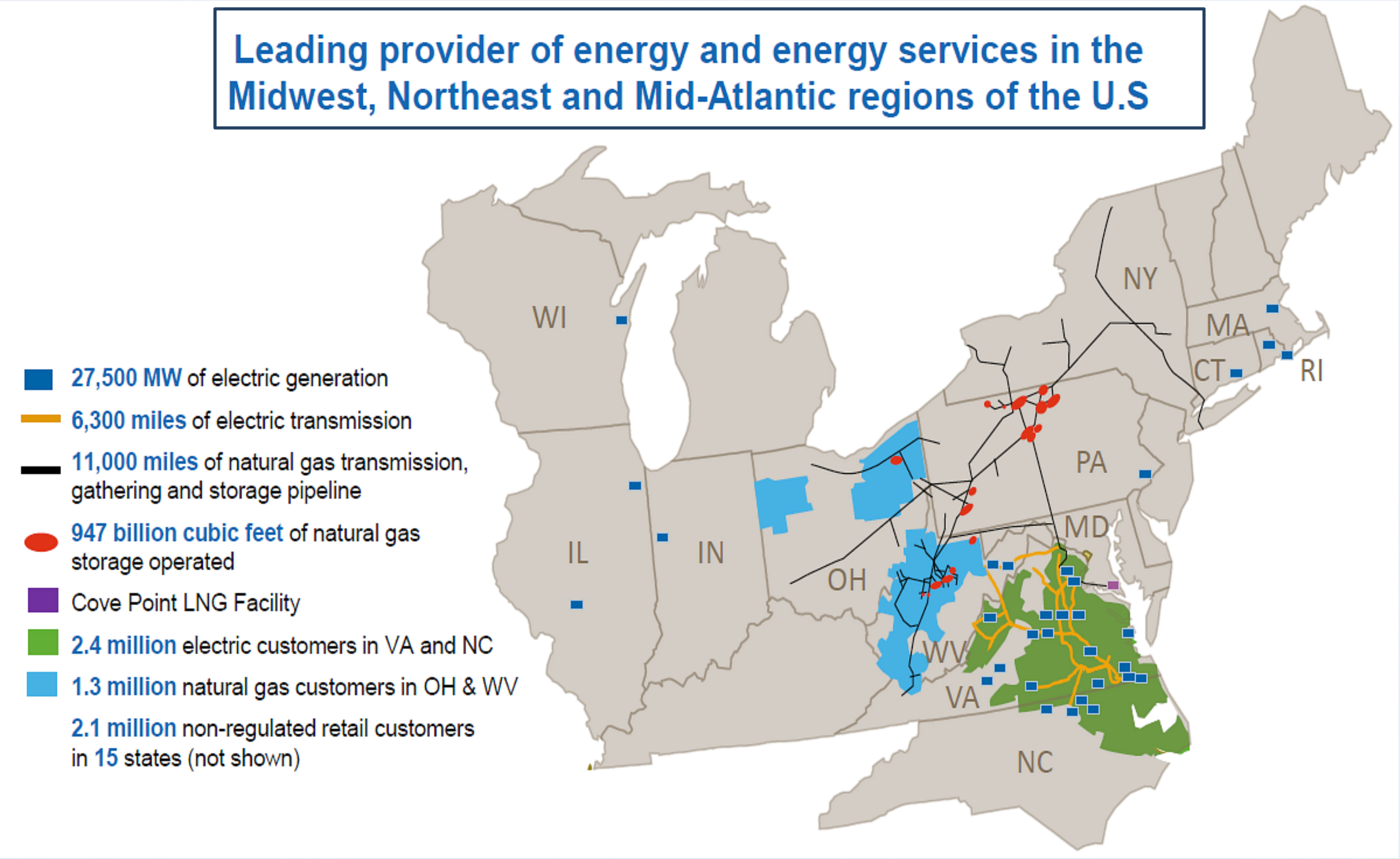
Utility Case Study: Volt/VAR Control at Dominion

Presented to EUCI VOLT/VAR OPTIMIZATION CONFERENCE

June 11-12, 2012

Dominion Voltage Inc.

Dominion
Leading Energy Provider in Northeast U.S.



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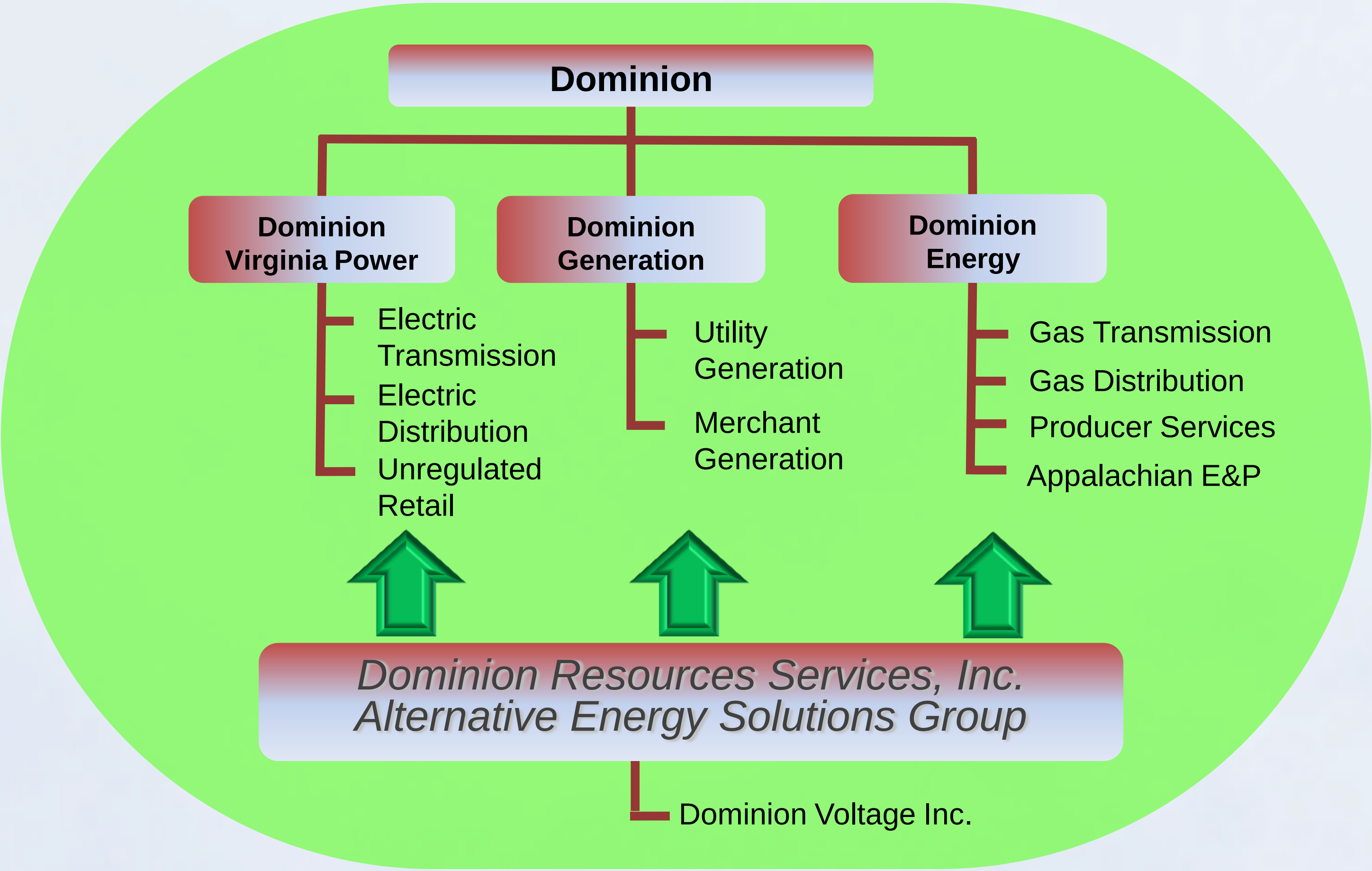
Alternative Energy Solutions:
Supporting All of the Business Units



Customer Voltage Based VVO

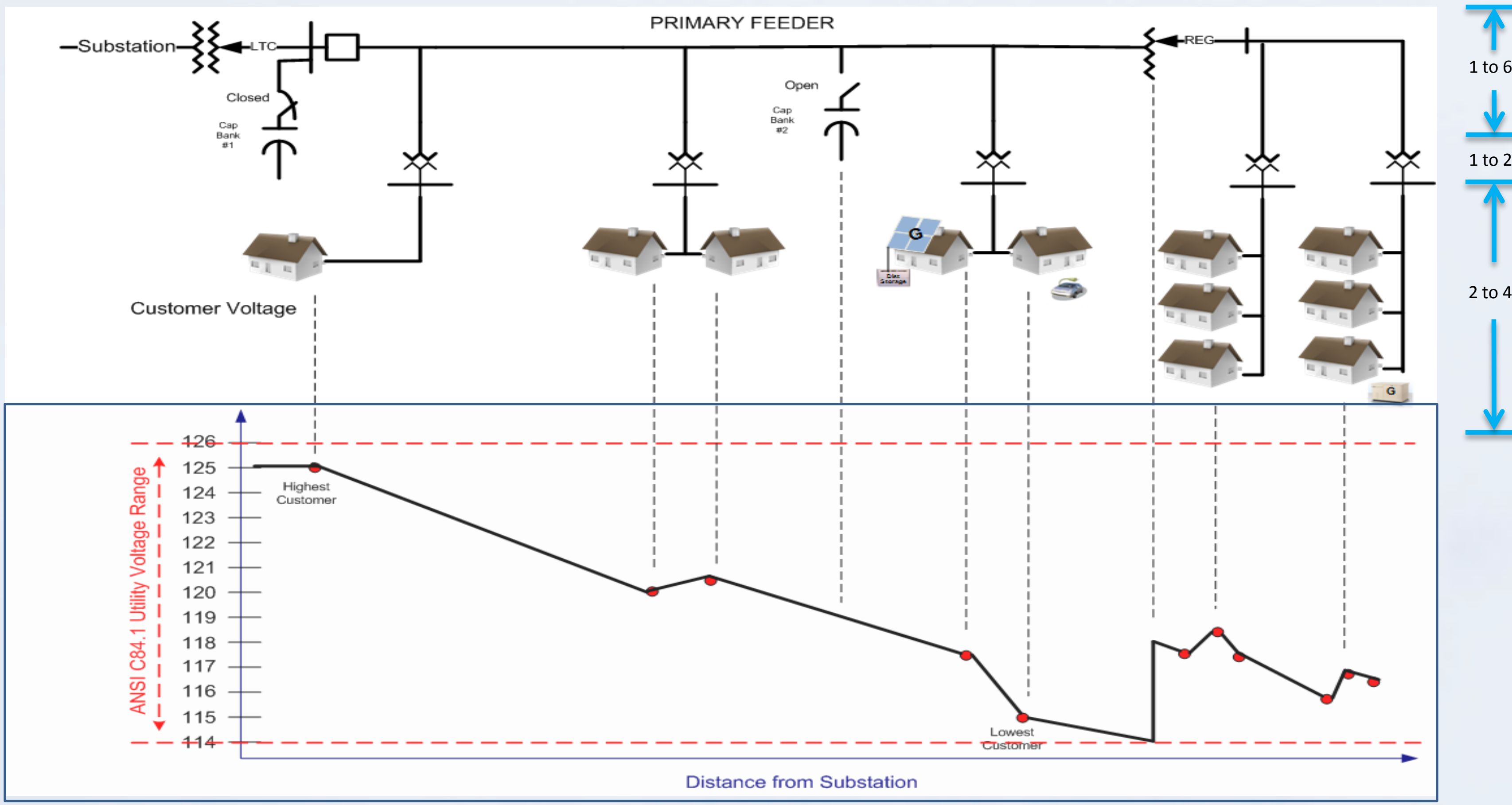
Program Highlights

- Achieves precise customer voltage control.
- Provides substantial customer savings.
- Requires no change in customer behavior
- Requires no customer purchases or incentives.
- Benefits all customer classes.
- Justifies investments in distribution and metering infrastructure.
- Integrates with other direct load control programs.

Key Deliverables

- Delivers significant and sustainable energy savings.
- Delivers significant and sustainable demand savings.
- Reduces demand, conserves energy, and reduces impact on the environment.
- Adapts to real-time system changes.

Traditional Circuit Voltage Design



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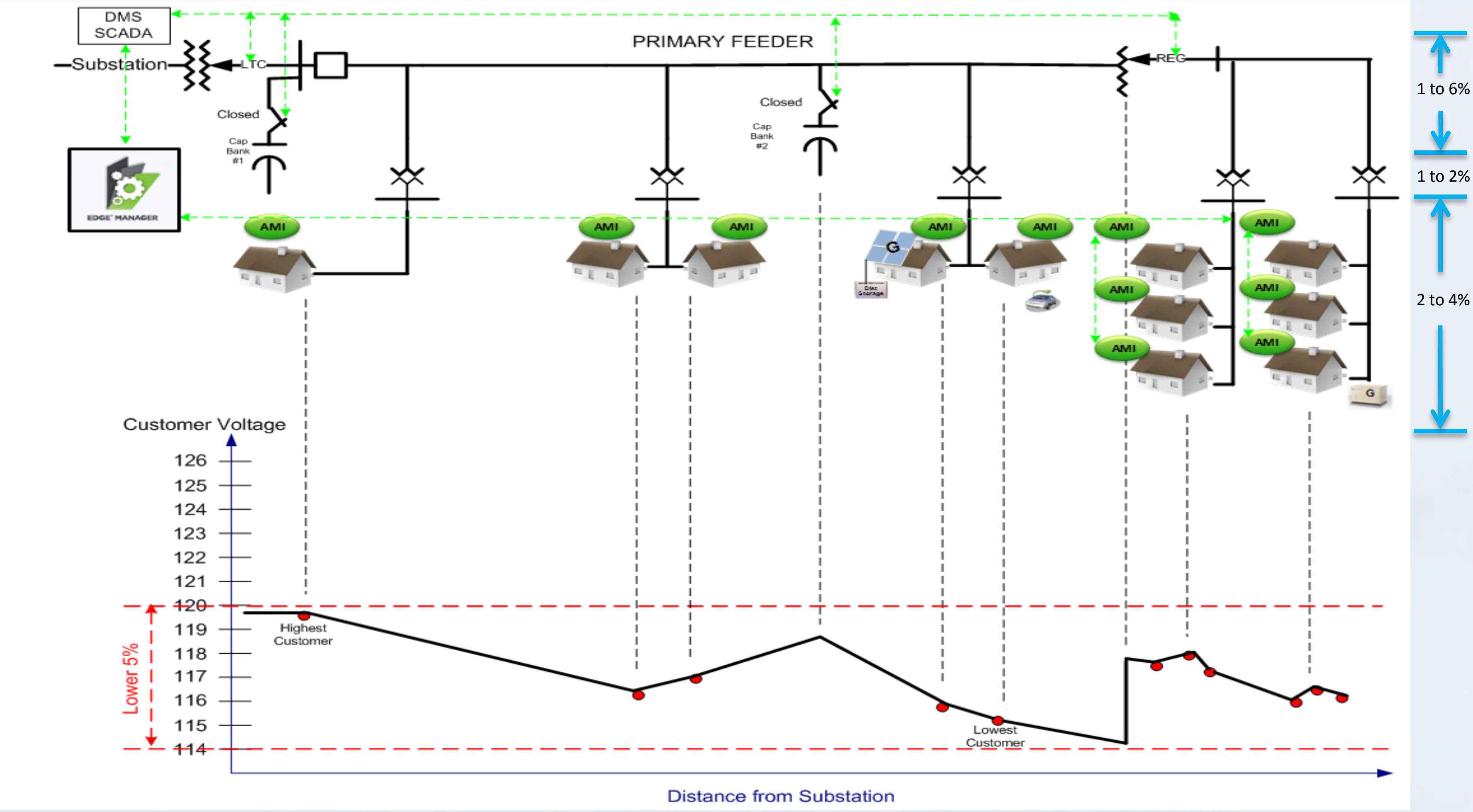
Customer Voltage Based VVO



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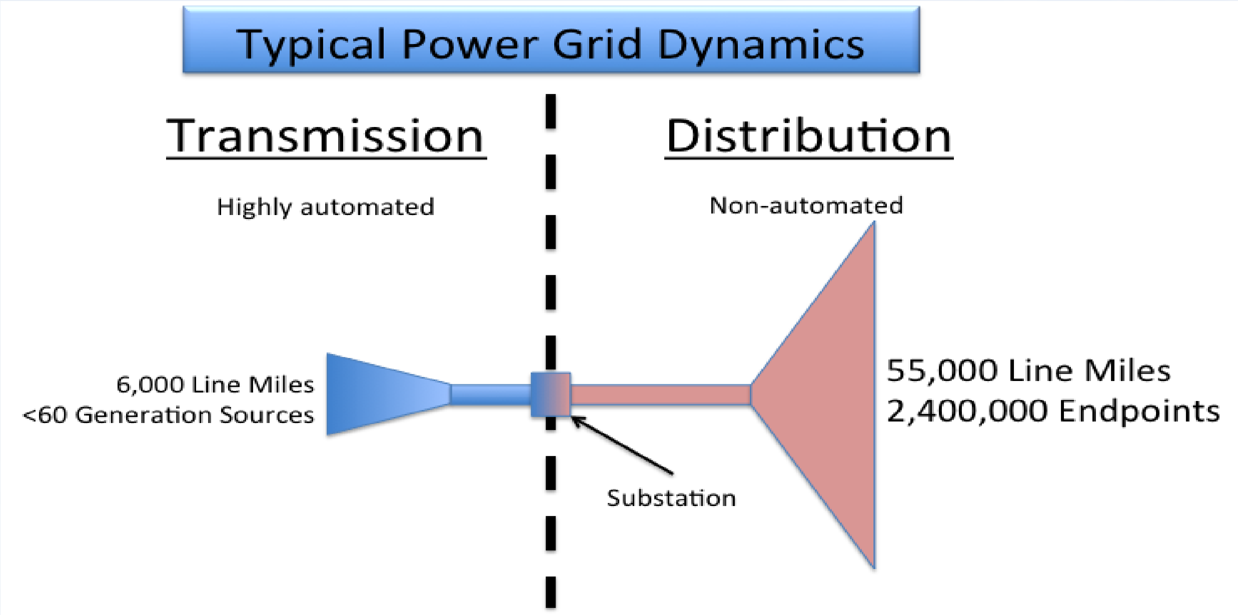
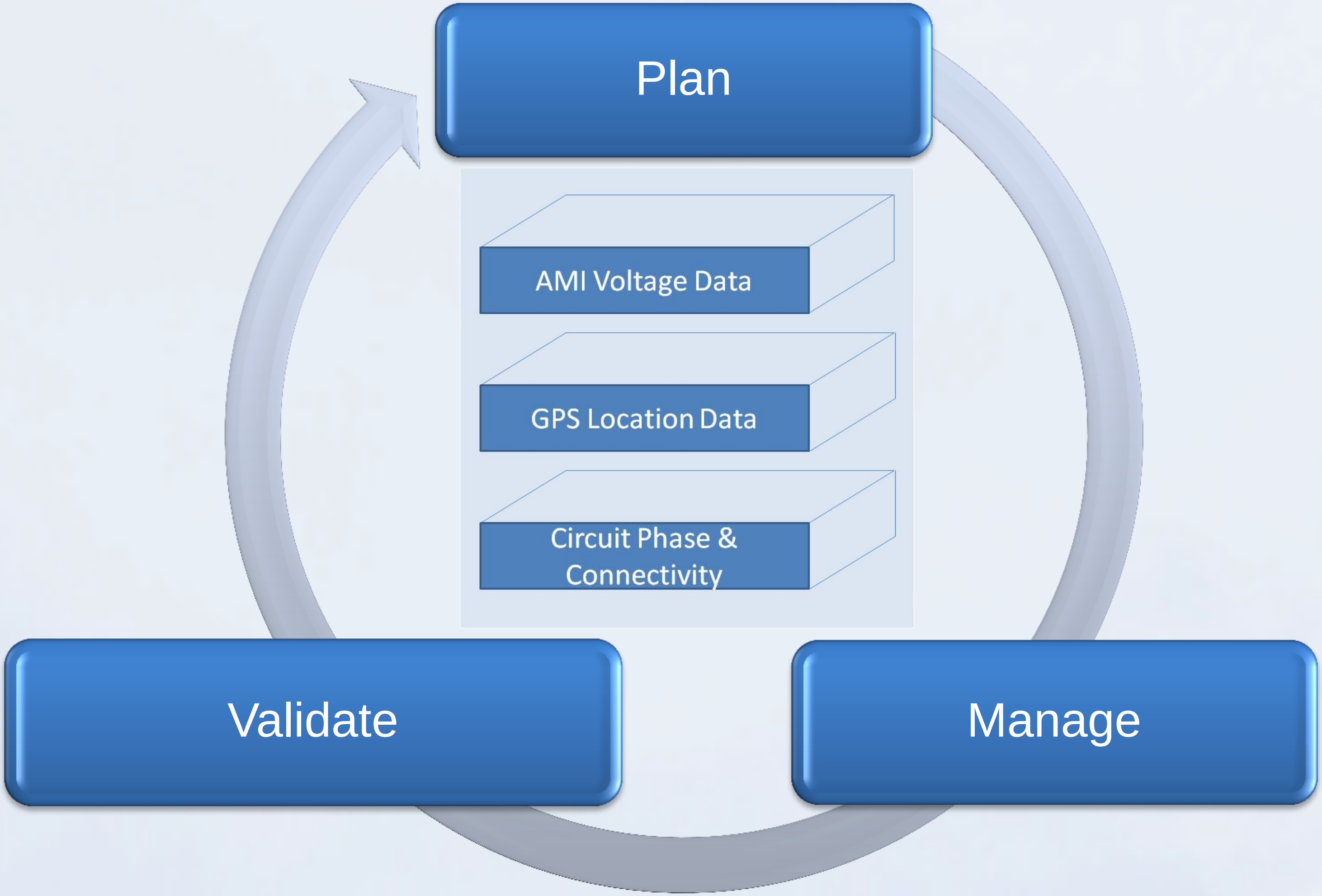
The Problem with Distribution Grids



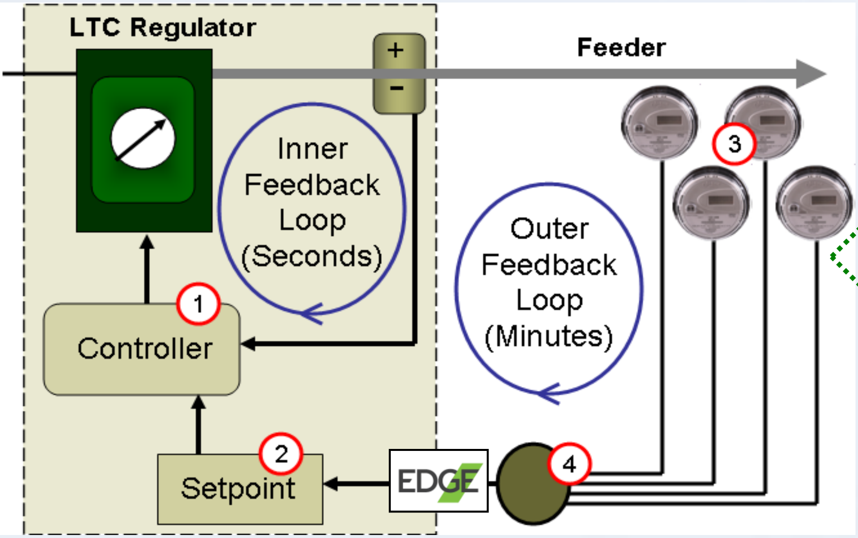
Management and Mapping of a Distribution Assets

- Change volume of assets on distribution is significant
- Common to re-configure distribution connectivity
- Significant change in assets for large storm restoration
- GIS tracking of assets does not address electrical connectivity information
- Distribution GIS systems have significant data problems because of volume, age, size, and location

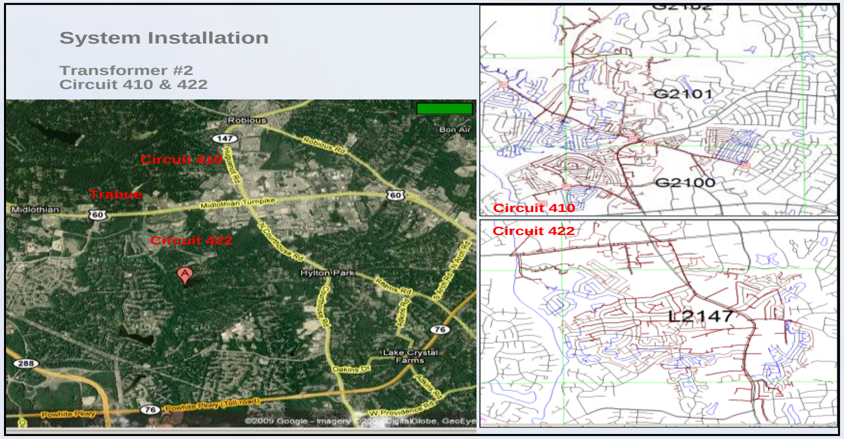
Geospatial Distribution Analysis, Control & Validation

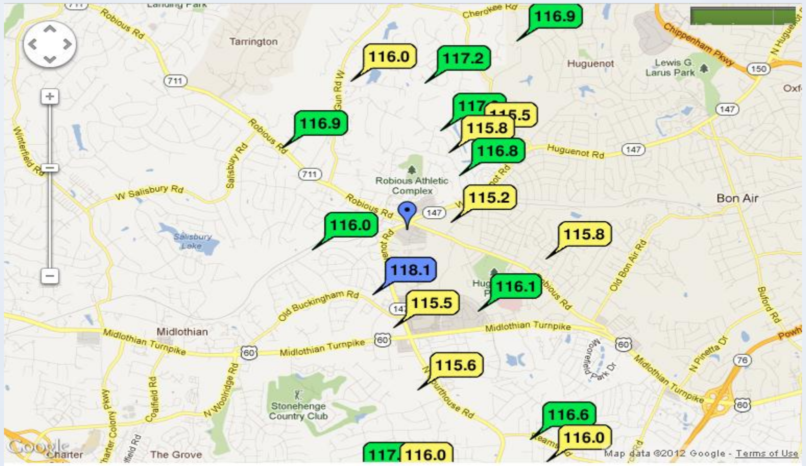


Voltage Management with DMS/SCADA, DA, & AMI



Circuit Geography





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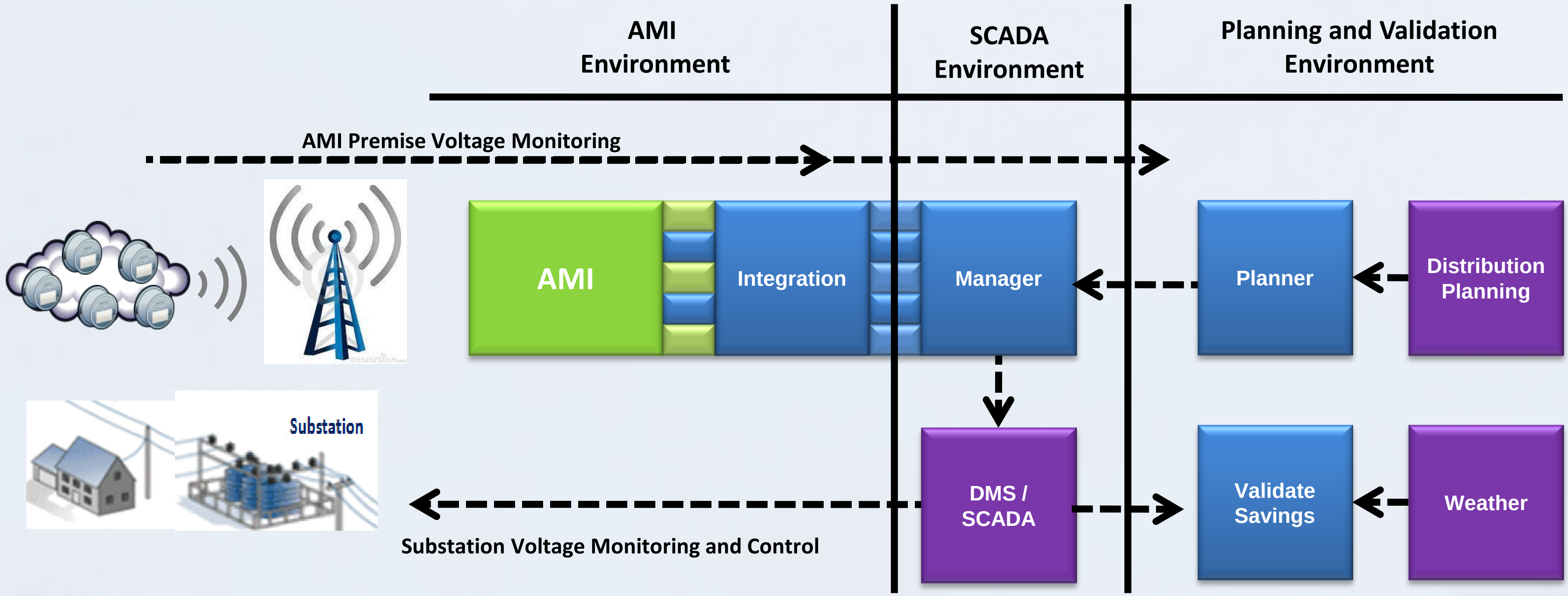
The Energy “EPAD”



Three Applications within the Customer Voltage based VVO:

Planner – Studies operating voltages, determines the average expected energy savings for the candidate circuits, and recommends any distribution upgrades required to achieve maximum savings

Manager – Configures CVR and coordinates the operation of Capacitors, Regulators, & LTC’s

Validate – Confirms achievement of expected energy savings through verifiable statistical analysis

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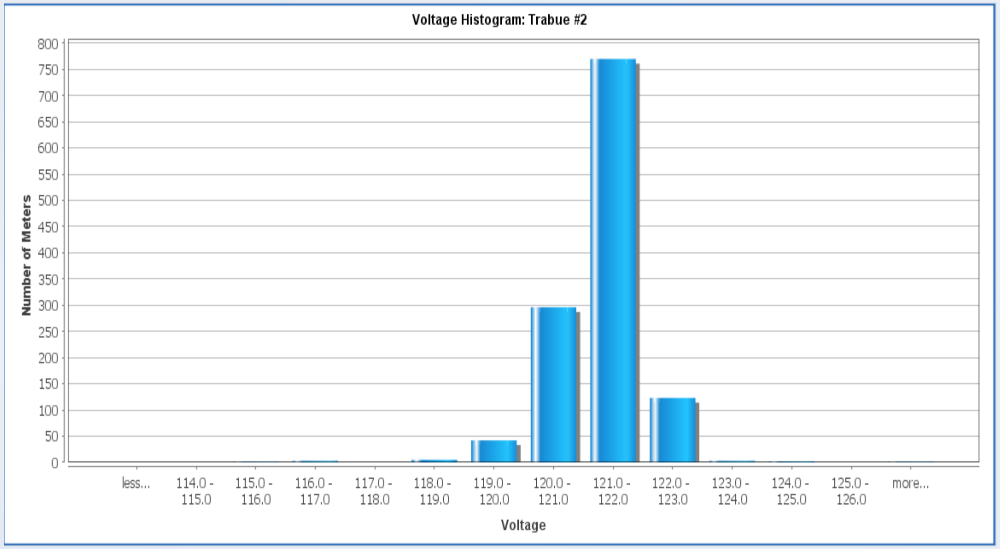
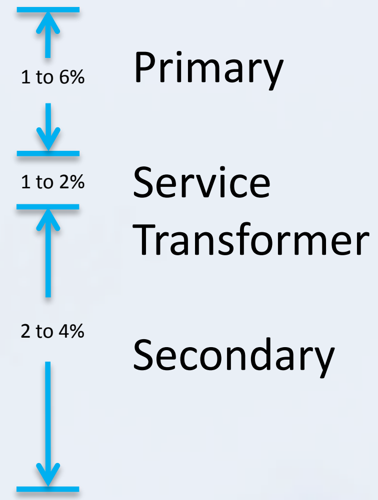
Statistically Analyze Customer Data

Customer Based Planning Model



Meter ID	Phase	Description
0008522405-G	B	Low voltage reading.
0008522405-G	A	Excessive voltage differential.
0008590309-G	A	Excessive voltage differential.
0009375026-G	C	High voltage reading.
0009375026-G	A	Excessive voltage differential.



1. Target worst outliers with best fix
2. Fixing the additional points below 116 V would give additional range for CVR.

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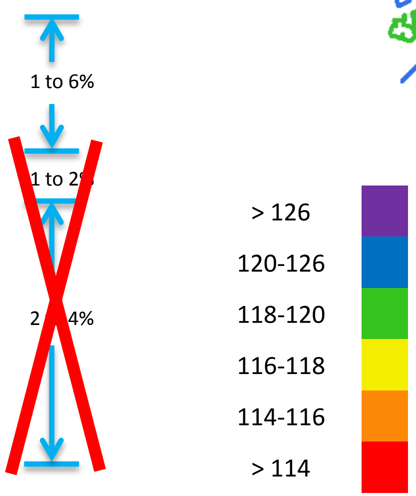
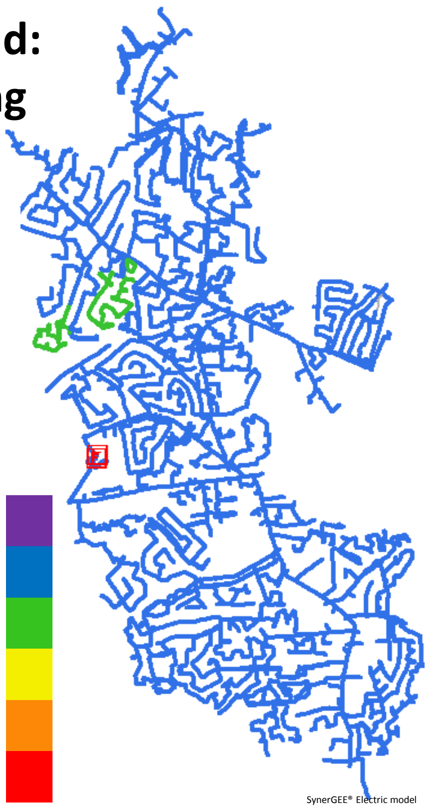
Integrate Customer Data into the Planning Software

Voltage at Peak Load: Traditional Planning Model Results

No visibility of isolated secondary voltage issues

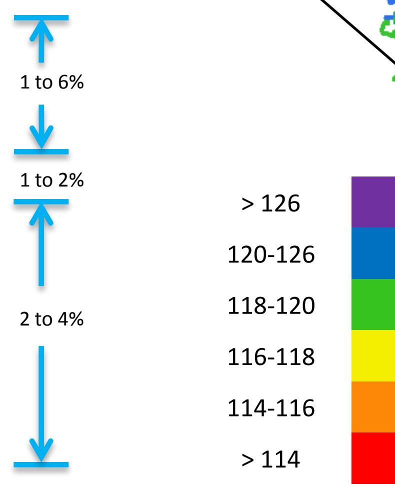




Customer Voltages Mapped in Planning Software

Customer getting 113-114 V

Wrong meter – to be replaced



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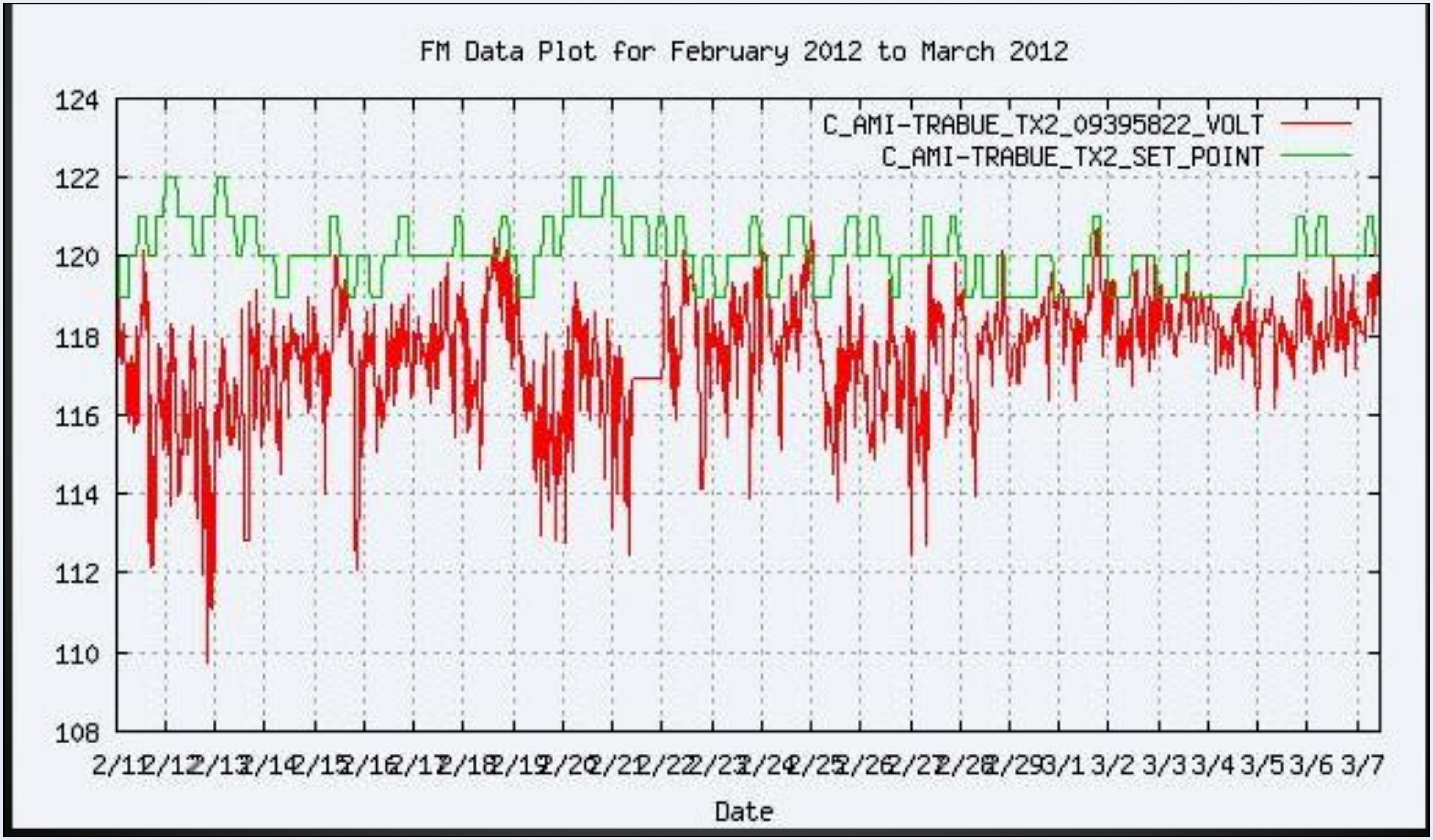
Improvement in Customer Voltage Quality



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Read DMS and Weather Data to Calculate Savings

Average Daily Data Samples

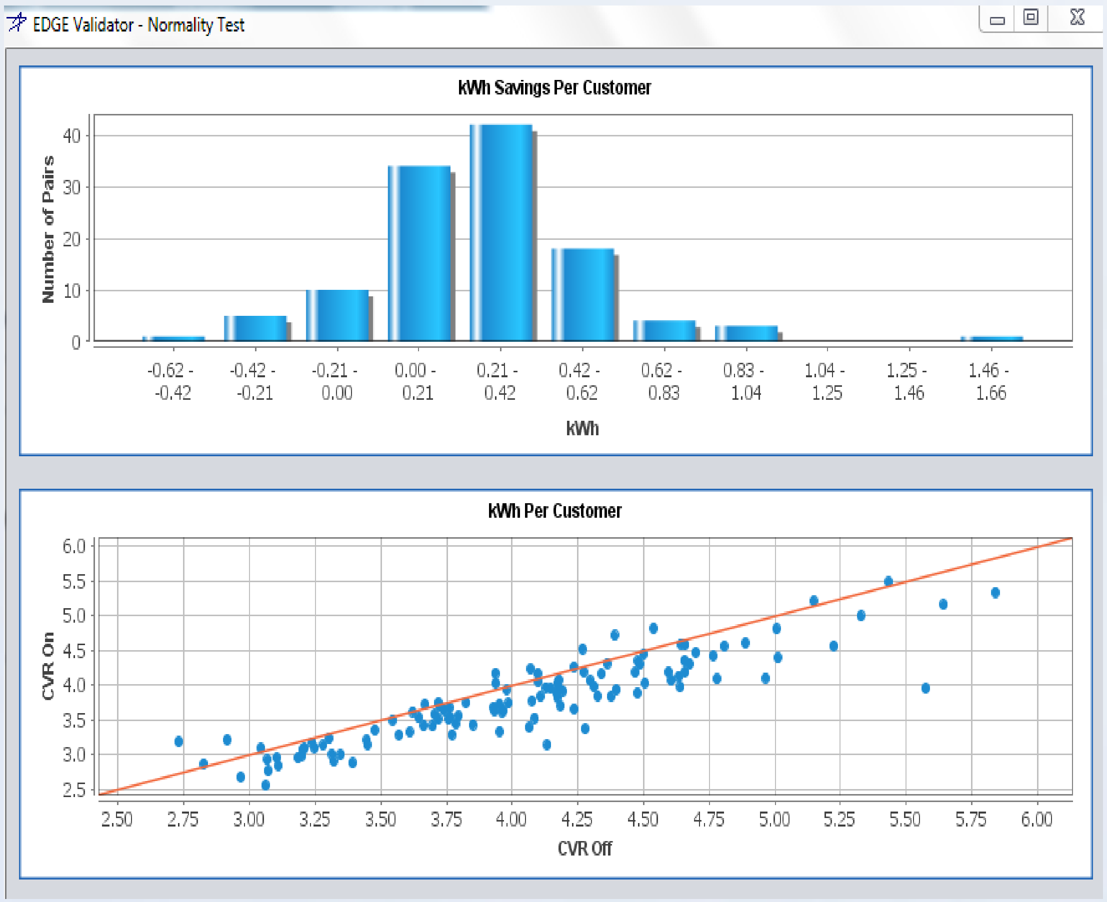
CVR/VAR OFF | **CVR/VAR ON**

Record 1		Record 2
TX #1	=	TX #1
Status	<>	Status
Day Type	=	Day Type
CDD	± 1	CDD
HDD	± 1	HDD
Humidity	± 5%	Humidity
Volts	Δ Volts	Volts
kW/Customer	Δ kW	kW/Customer

- The objective of the Measurement and Verification phase is to confirm through verifiable statistical analysis that the expected energy savings by circuit was achieved
- The rigorous statistical method incorporates a paired difference test that compares daily/hourly samples of the baseline circuit data (“OFF” condition) to the CVR circuit data (“ON” condition) under matched operating conditions.

Statistically Calculate Energy and Demand Savings

Statistical Savings Analysis



Savings Results

Results

Savings

Lifetime Usage (MWh):	458,312
Lifetime Savings (MWh):	10,356
Lifetime Savings:	2.26%
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30 Day Usage (MWh):	14,585
30 Day Savings (MWh):	501
30 Day Savings:	3.44%

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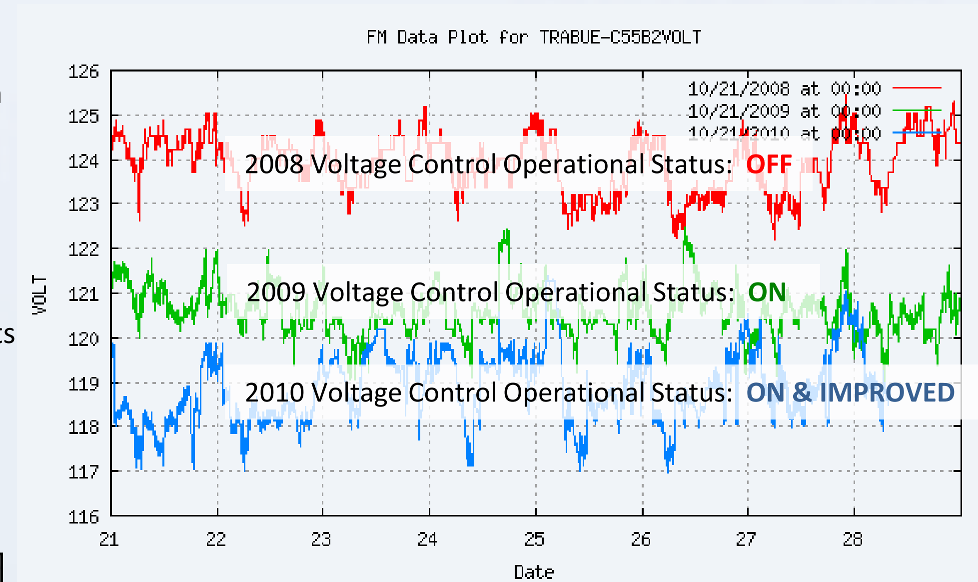
Case Study – Midlothian Virginia

- ✓ Successful precision control of voltage on two circuits in the lower 5% band (114 to 120 volts) since January 28, 2009
- ✓ 6,697 meters deployed
- ✓ Two 34.5 kV Urban Circuits
- ✓ Direct Measurement and Validation of savings on circuits implemented
- ✓ Two Full Years of CVR Operation



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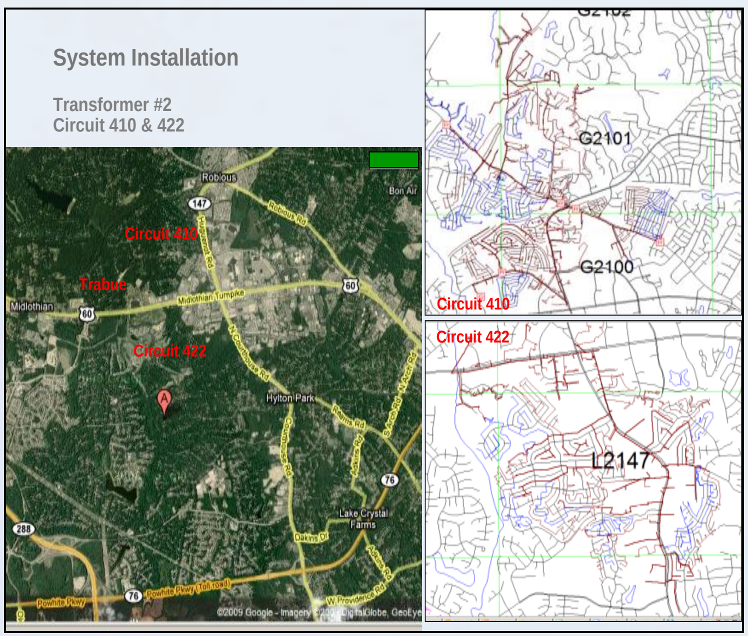

- ✓ **$267,000** in energy savings yielded for 8,760 hours of CVR operations at the single Trabue Tx2
- ✓ Demonstrated real-time feedback from premise level readings enabled Dominion to continuously execute voltage control to keep all customers in lower 5% band
- ✓ Trailing 180 day performance yields **$292,000 (5,144 MWh)** in annualized energy savings

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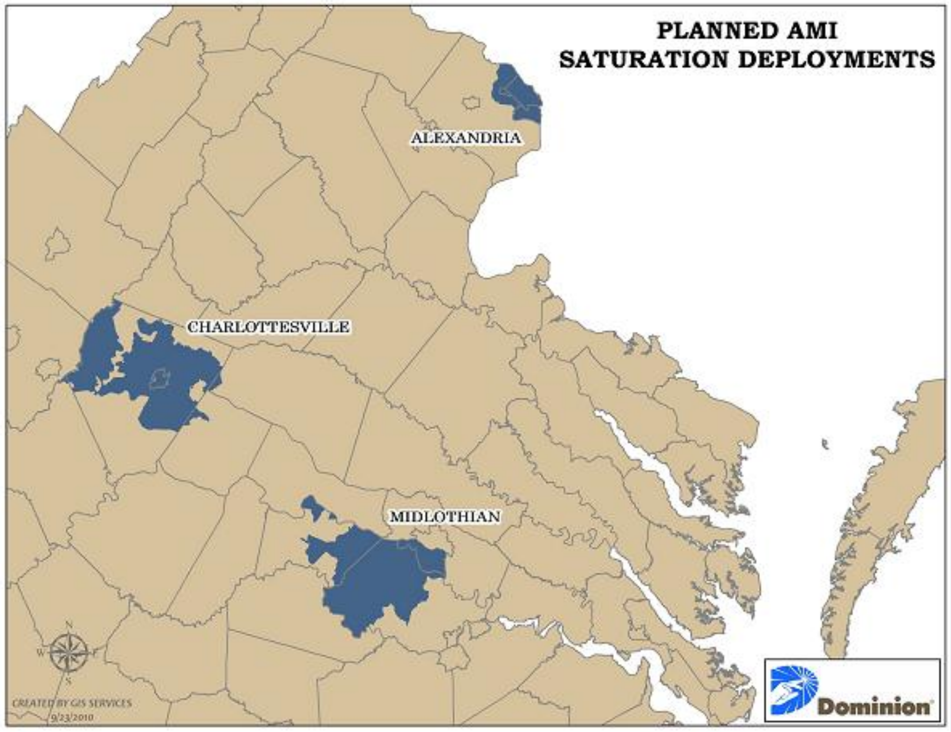
Voltage Conservation Activity in Virginia
Current Deployments

Saturation Deployments

- **Midlothian**
  - Voltage Conservation M&V
  - Two representative circuits
- **Charlottesville**
  - Diverse elevations
  - Rural
  - Communications challenges
  - Circuit Lengths
  - Higher Voltage Drops
- **Northern Virginia**
  - Urban
  - Short Circuit Lengths
  - Lower Voltage Drops



	Midlothian	Charlottesville	Northern Virginia
Meters	6,697	50,135	34,011
CVR Status	M&V Q1 09	M&V Q2 10	M&V Q3 11

CVR technology is currently deployed in Midlothian, Charlottesville and Northern Virginia for approximately 80,000 customers.

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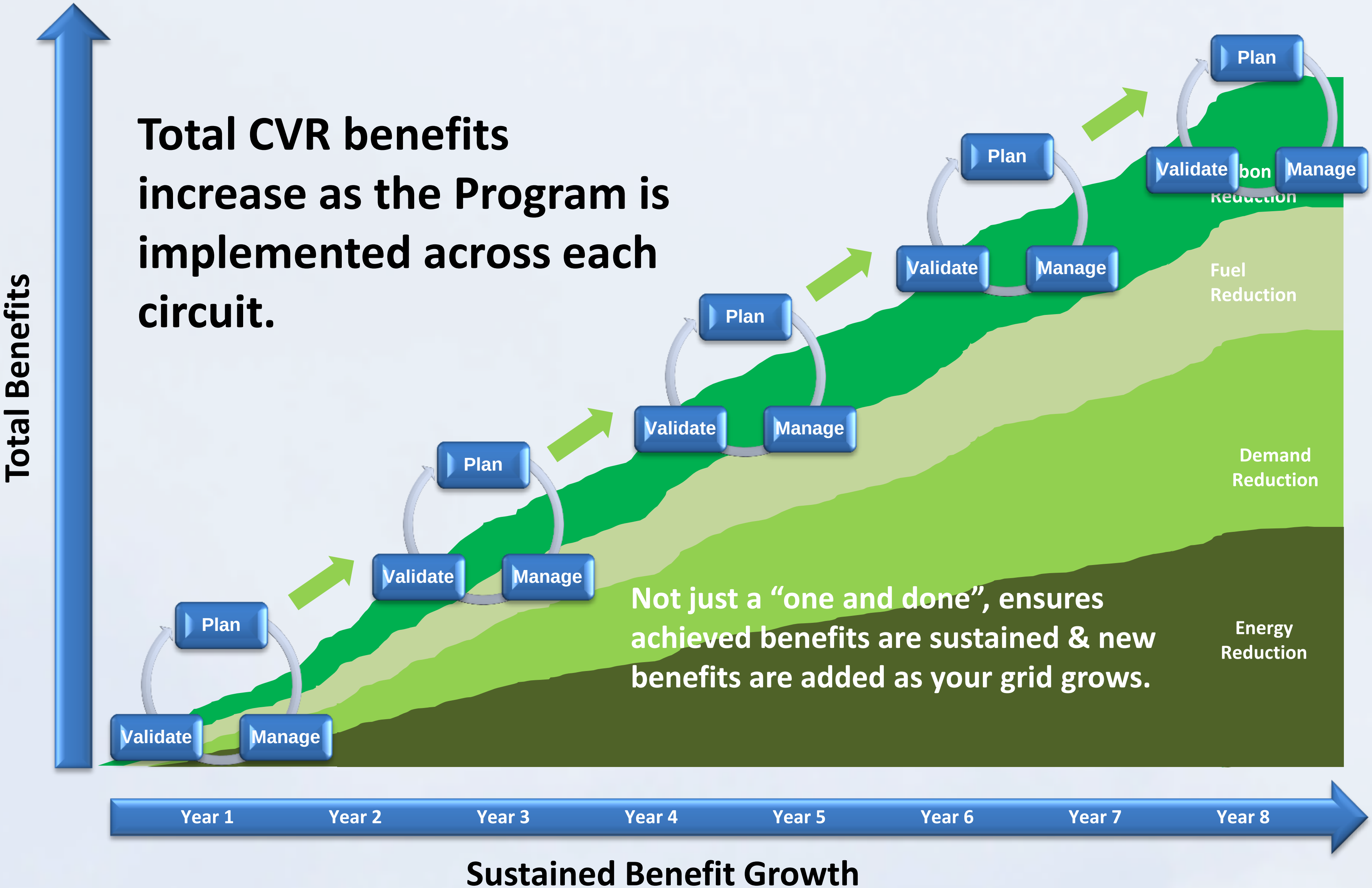
Distribution Efficiency Program Benefits



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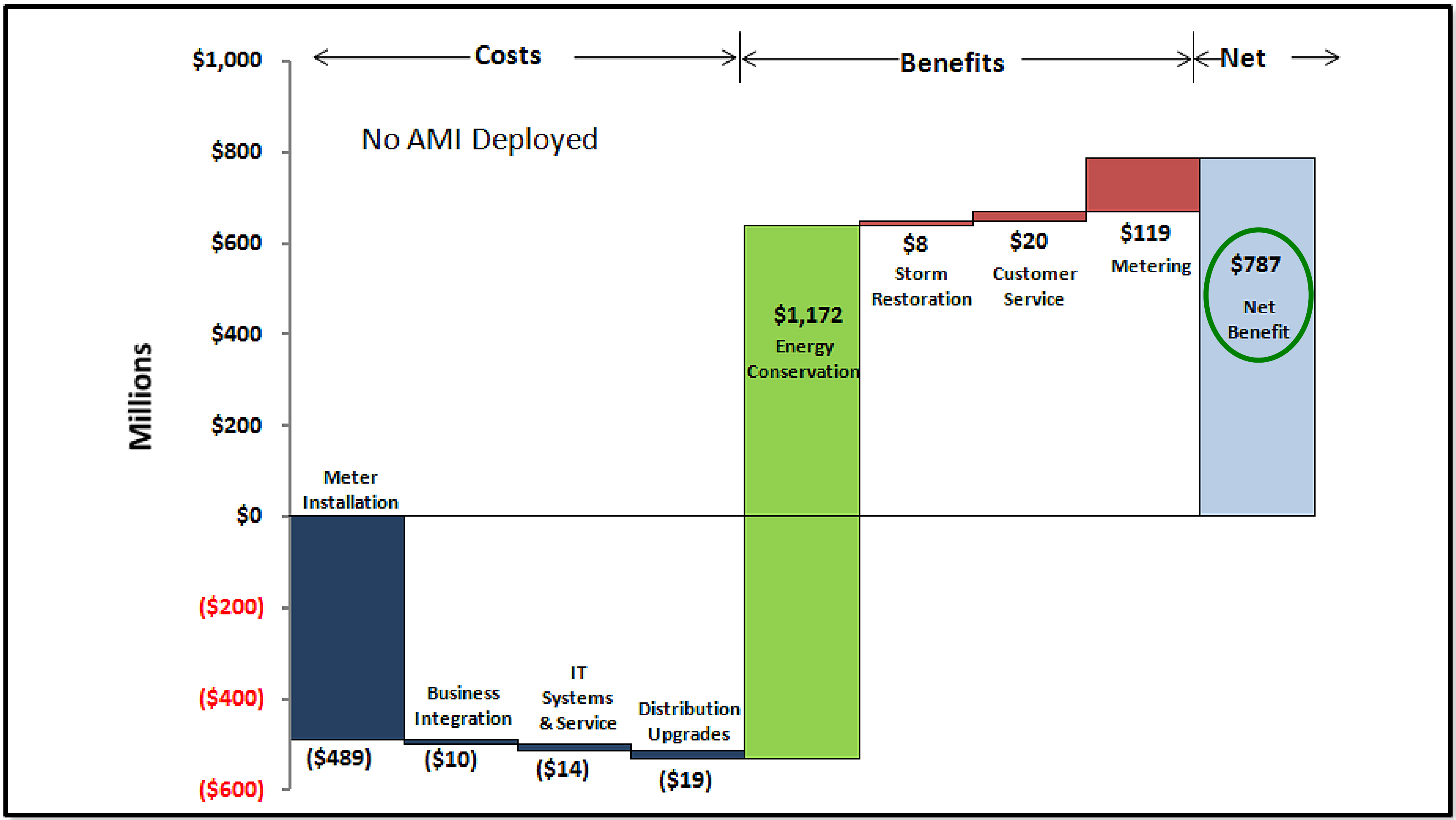
Cumulative Costs & Benefits over 10 Years



In August 2008, Dominion Virginia Power had developed a business case for its AMI solution for its 2.4 million Virginia jurisdictional customers.

Projections based on data filed in Dominion Virginia Power rate case PUE – 2009-00019.

Based on 2008 PJM Southern Region nodal forward price curves.

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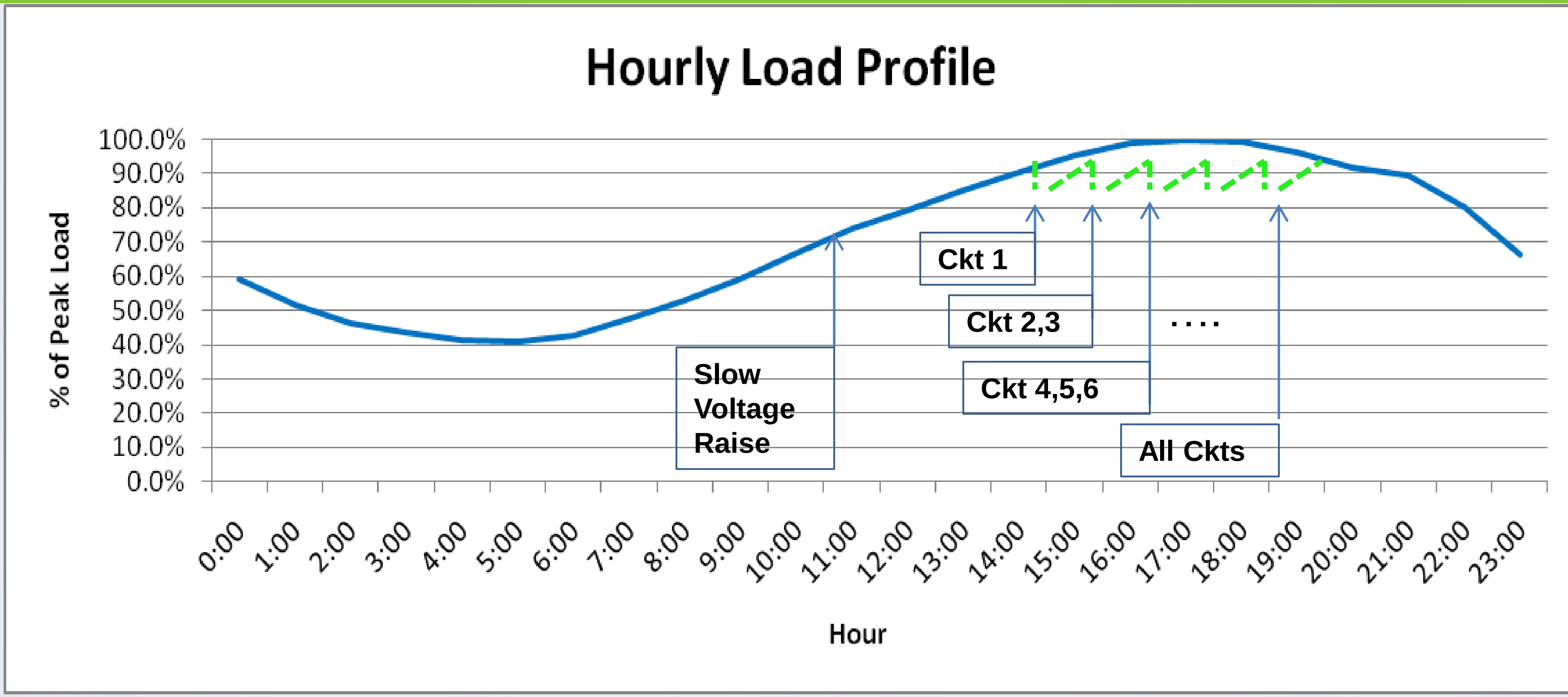
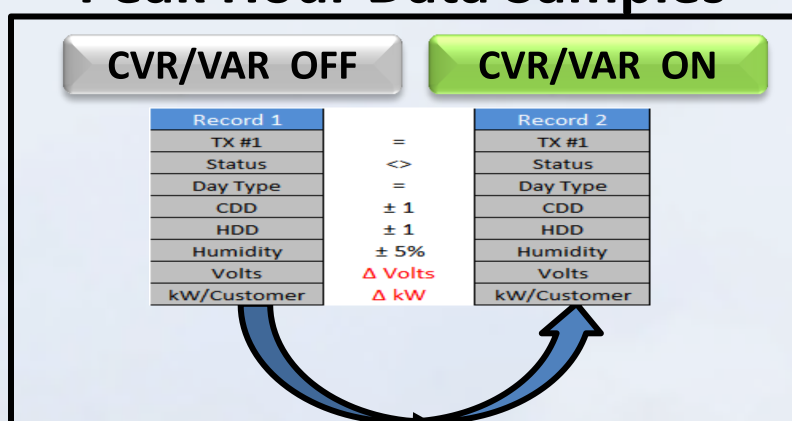
Peak Load Distribution Analysis, Control & Validation



Peak Hour Data Samples



- ✓ Water Heater Energy Storage Affect
- ✓ Sequential Circuit Voltage Switching
- ✓ Return to VVO level with no secondary peaks
- ✓ No Customer impact
- ✓ DSM VVO

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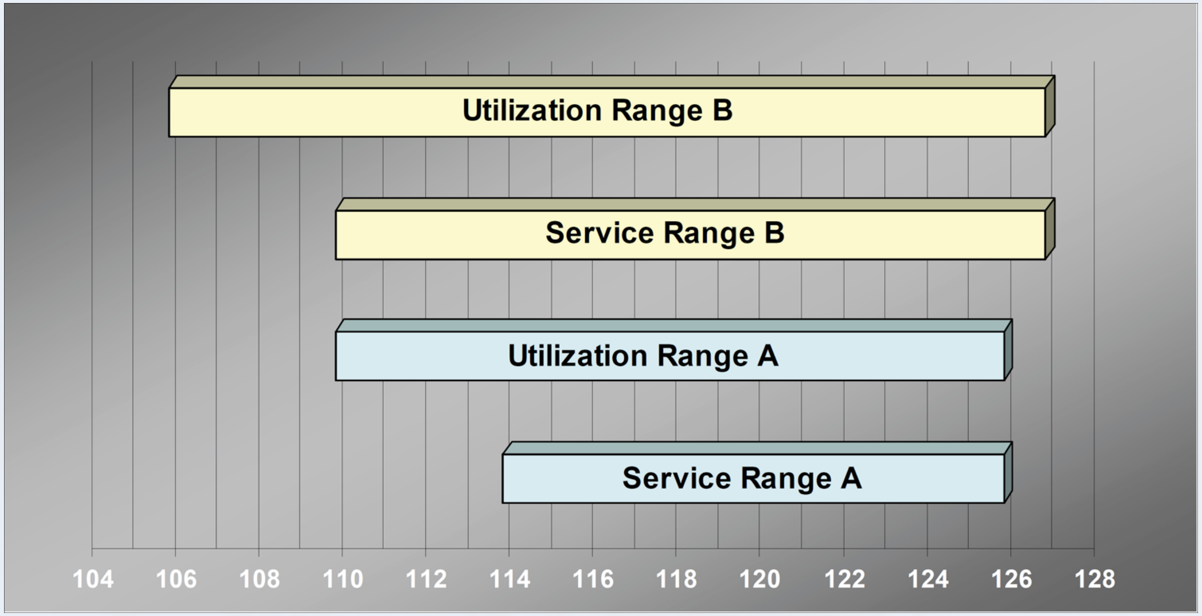
Extending Measurement to the Utilization Level

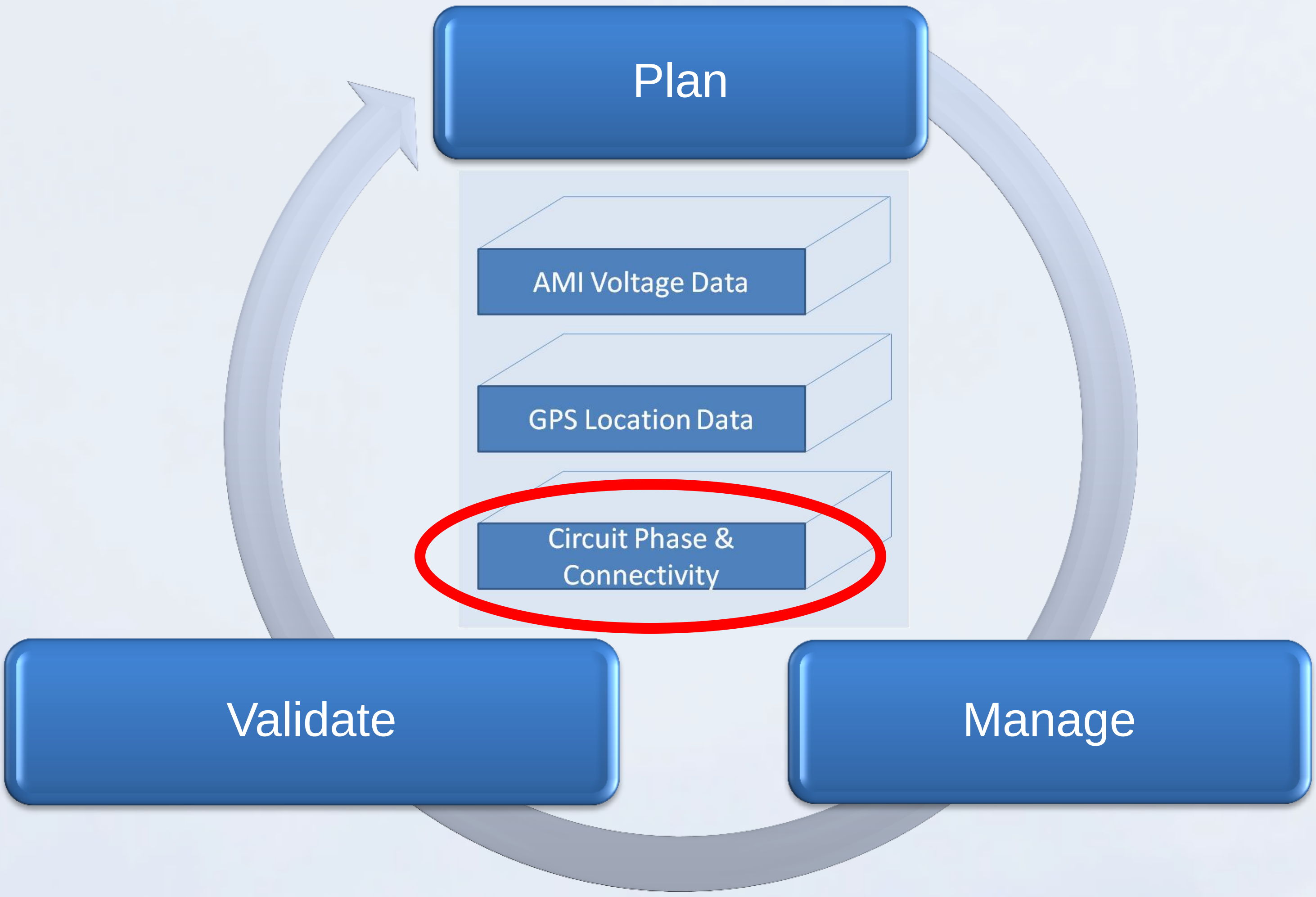


ANSI C84.1 Standard System Voltages

- ❑Service Voltage: The voltage at the point where the electrical system of the supplier and the electrical system of the user are connected.
- ❑Utilization Voltage: The voltage at the line terminals of utilization equipment.

- ❑Range A: Normal operational voltage range. Occurrence of voltage outside this range should be infrequent.
- ❑Range B: Excursions of voltage above and below the Range A limits. While a part of practical operations, these excursions shall be limited in extent, frequency, and duration. Corrective action shall be taken to restore to Range A.

Geospatial Distribution Analysis, Control & Validation



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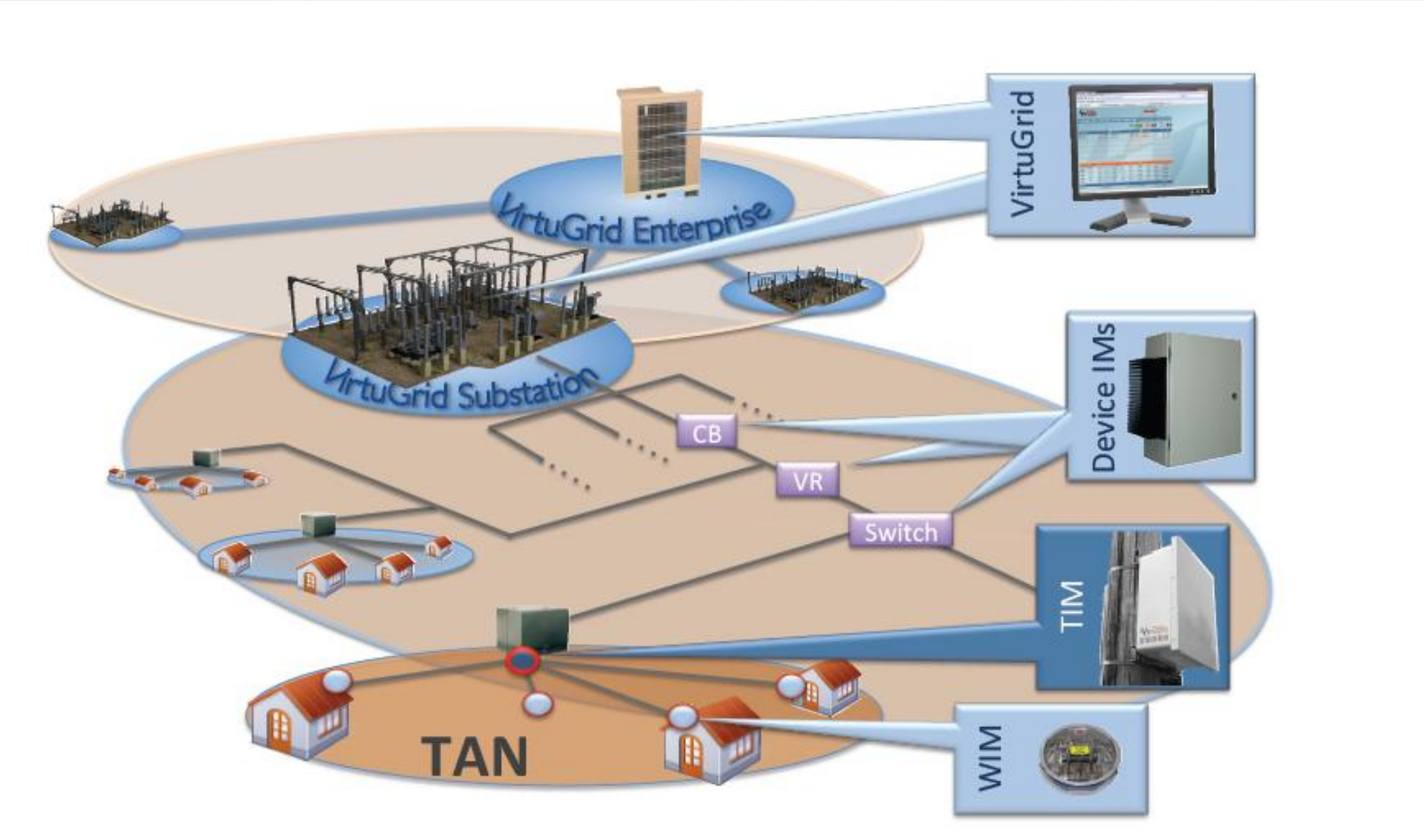
Power Tagging Technologies

Sensors to measure grid device connectivity, voltage and load



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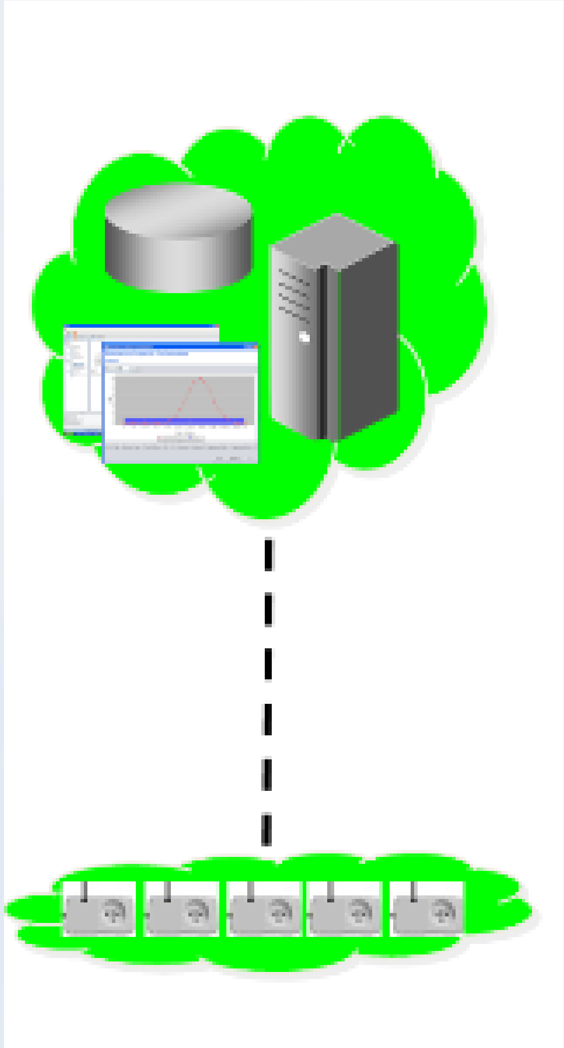
Greenlet Technologies

Sensors to measure and control utilization level voltage and Load



Centralized Application for Energy Service Companies and Utilities: Manages usage of millions of appliances in order to reduce peak power consumption. The software application monitors power, predicts power consumption and power reduction potential, sends notifications to customers prior to peak events, controls power reduction via Greenlet units and Internet communications, verifies actual power reduction and provides the required information for billing to help calculate payback to consumers for "Peak Shaving".

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Viridity Energy

viridityenergy

Microgrid Management

- Viridity offers a unique controller to optimize microgrids.
- The microgrids created by Viridity are planned to minimize importation of electricity while simultaneously maximizing the opportunity to export electricity out of the microgrid.
- At Viridity Energy, we take every resource into account in the formation of the microgrid, including load, generation and distribution infrastructure
- Often, reliability is the sole factor that is considered in the creation of a microgrid. As the industry has evolved, economics and security have been added as important factors. Our unique VPower engine brings all of these aspects together, allowing for economic, security and reliability to be symbiotic elements of the microgrid.
- Our Microgrid Solutions are designed to allow for evolution. It is our hope and anticipation that our clients will continue to introduce new technologies into their microgrids, and our technology and unique approach factors in that integration.

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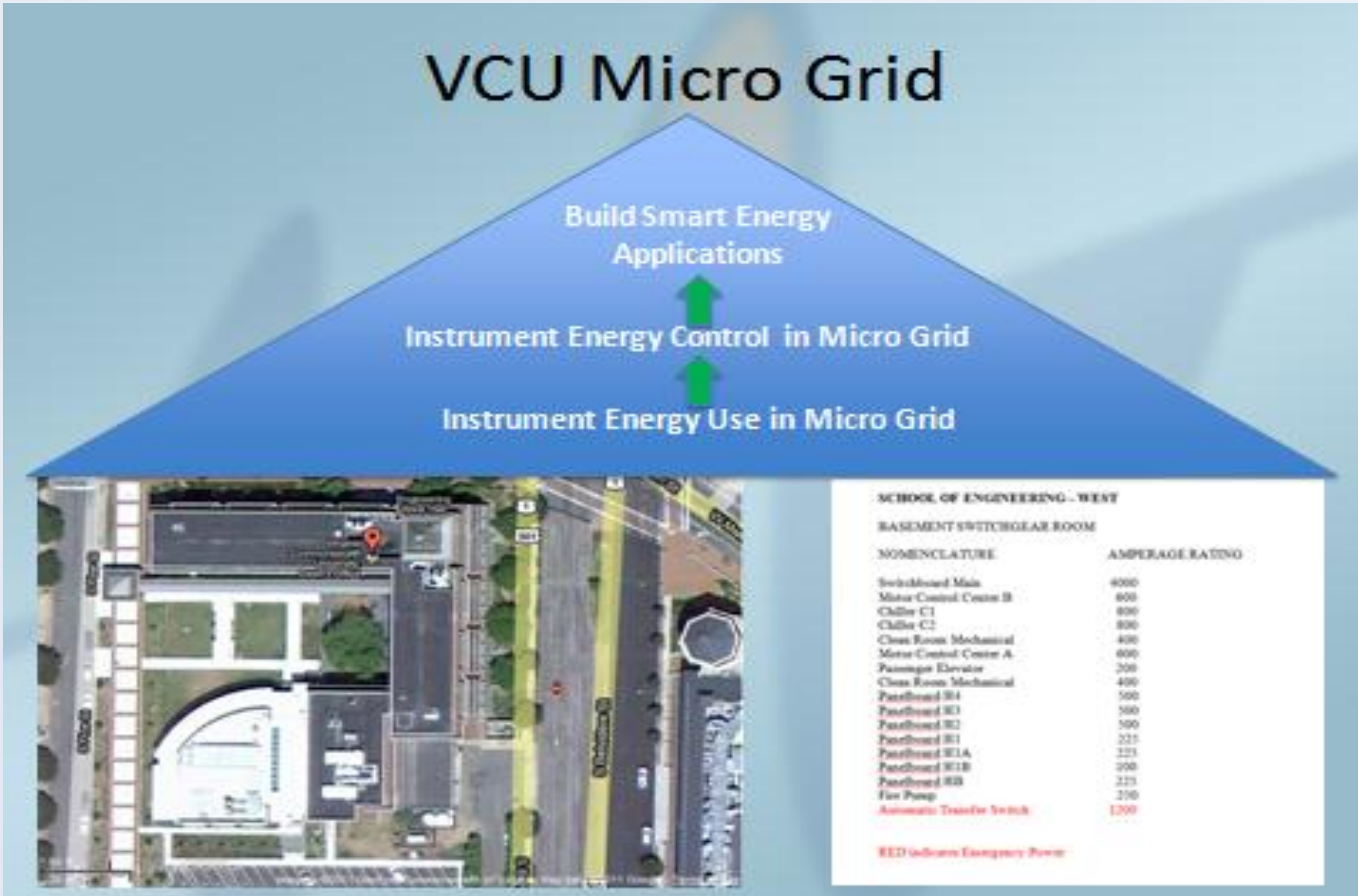
Extending Measurement to the Utilization Level



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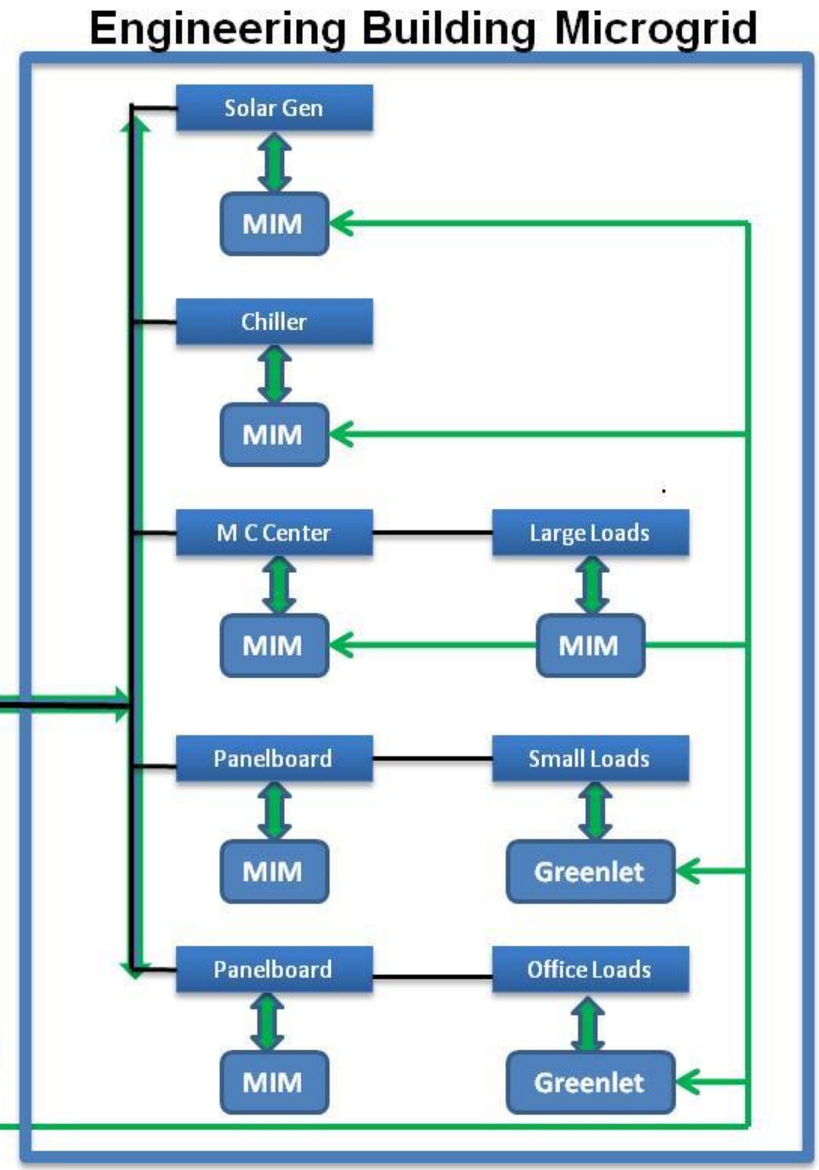
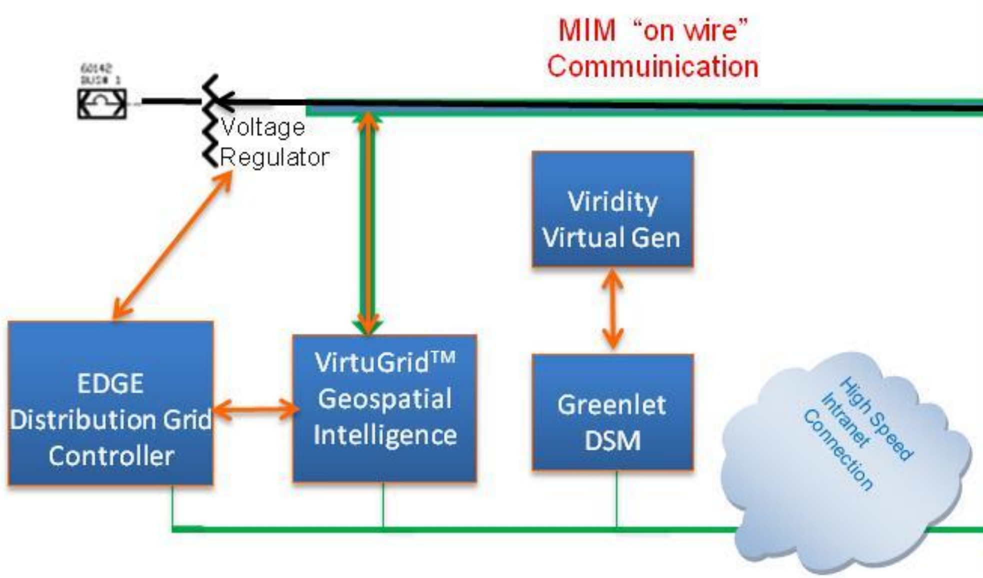
Case Study & Demonstration: VCU MicroGrid

Microgrid Demonstration
Engineering Building Distribution Grid:

1. 30 Power Tagging MIMs for Monitoring
2. Controllable Building Voltage Regulators
3. PTT Virtugrid Application System
4. 200 Greenlet DSM Controllers
5. EDGE Distribution Grid Control
6. Viridity Virtual Generation Aggregation





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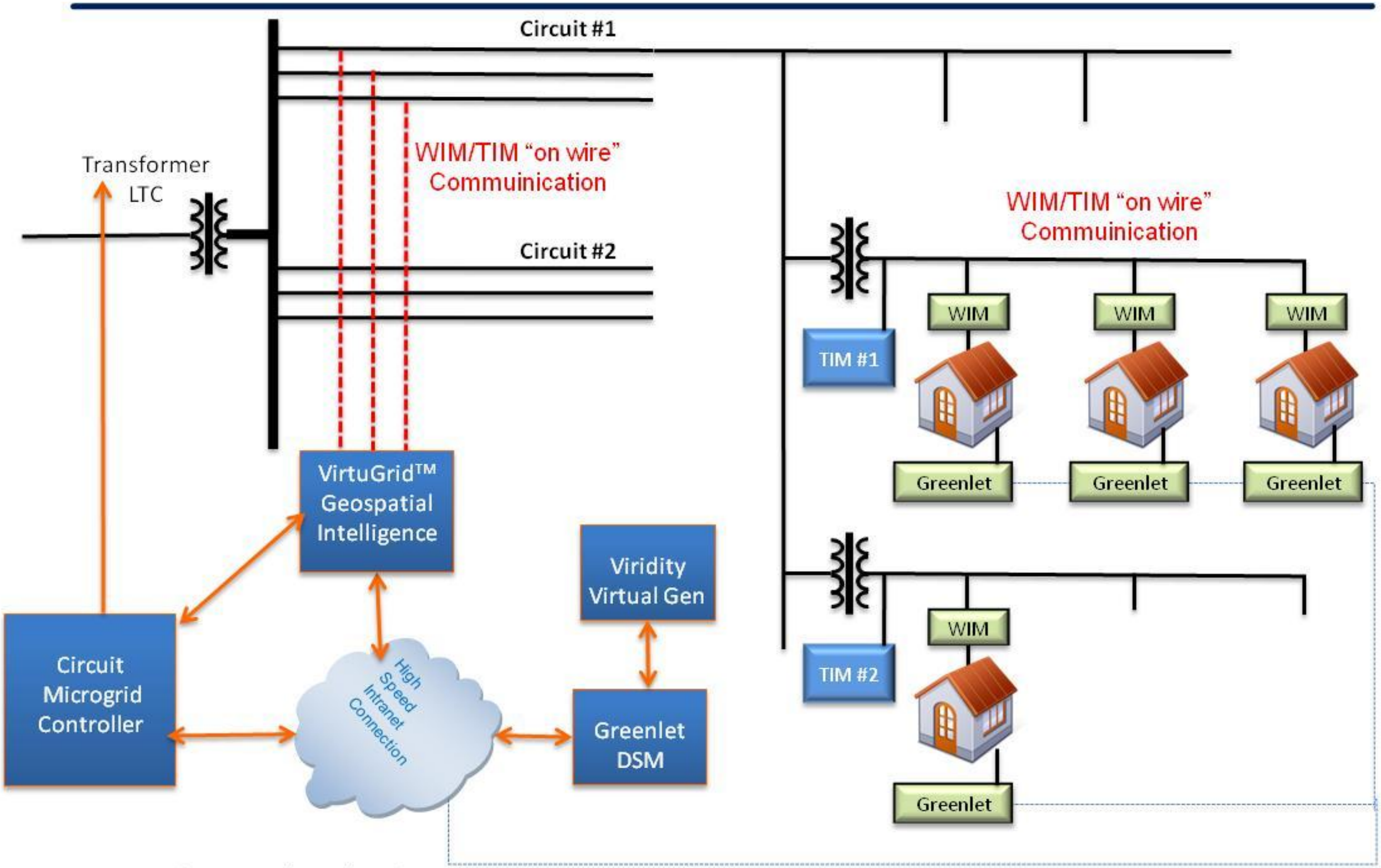
MicroGrid Vision: VCU Results to the Distribution Grid

"Under Construction"

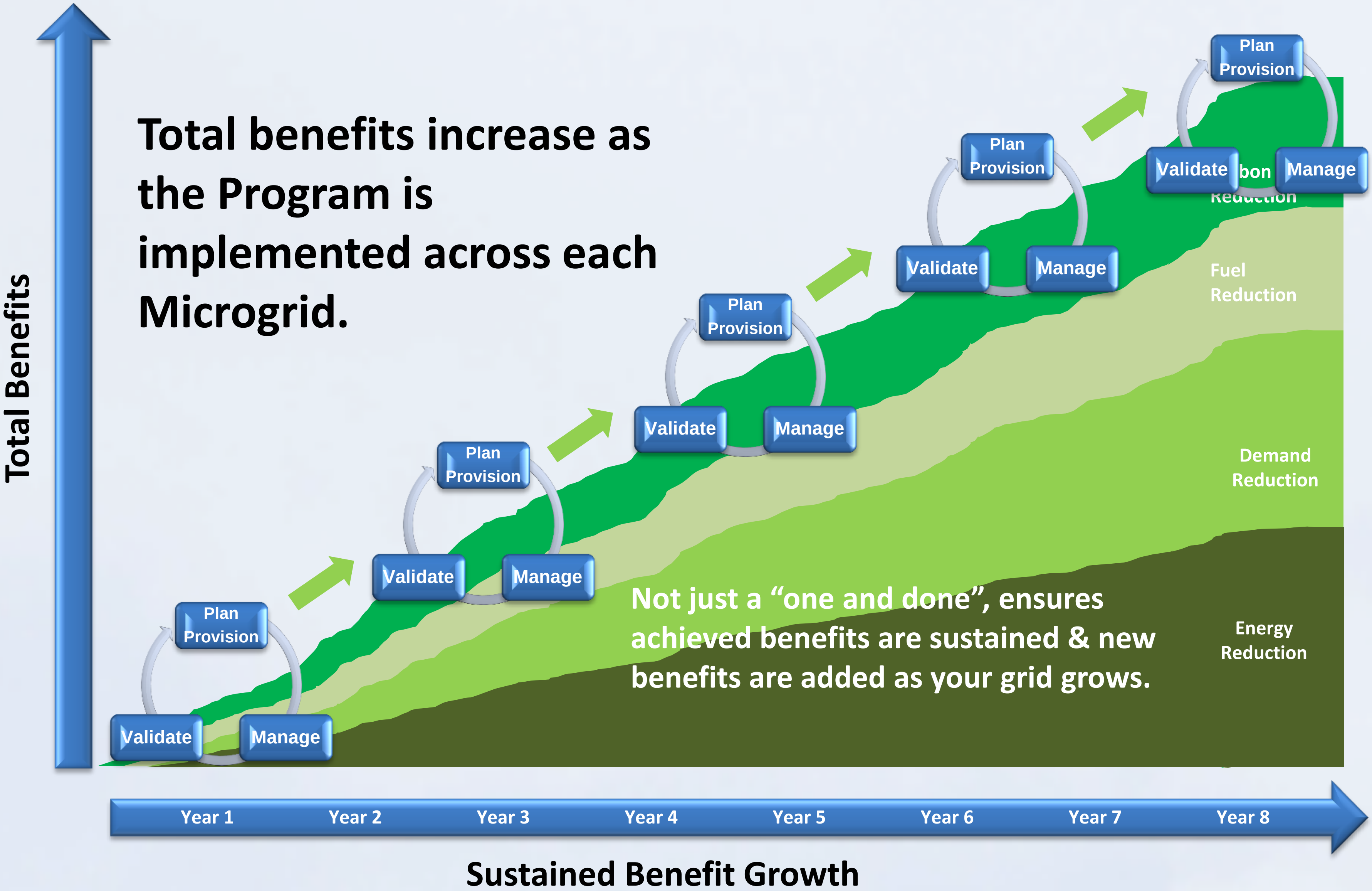


Power Tagging Technologies On Wire Network Operation:

TIM - Distributed MicroGrid Controller - Communicates to VirtuGrid in Substation

WIM - Communication from Distributed Generation/Storage/Load to TIM

Sustainable Provisioning of the Distribution Grid



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Summary

- Using Geospatial Distribution technology Dominion has developed and demonstrated a measurement based voltage control algorithm which enables a *practical execution of conservation voltage reduction with voltage optimization*.
- The Voltage optimization integrates between the existing DMS Software and AMI.
- Independent Measurement and Verification module for Voltage Optimization confirms through verifiable statistical analysis demand and energy savings was achieved
- The results of the demonstration prove that there are *measurable* reductions in energy usage using voltage optimization with customer voltage measurement also improves voltage service.
- *Dominion's demonstration shows an average of 2.8% reduction in annual energy.*
- *Energy savings do not depend on changing customer behavior, additional customer purchases or adoption of in-home technology*
- *AMI technology demonstrates a practical and sustainable method of controlling voltage, providing continuous improvement of circuit performance and clear independent measurement of average circuit savings per customer without the inaccuracies of a non-sustainable circuit model.*

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Questions & Answers

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