Distributor Thoughts on Smart Grid

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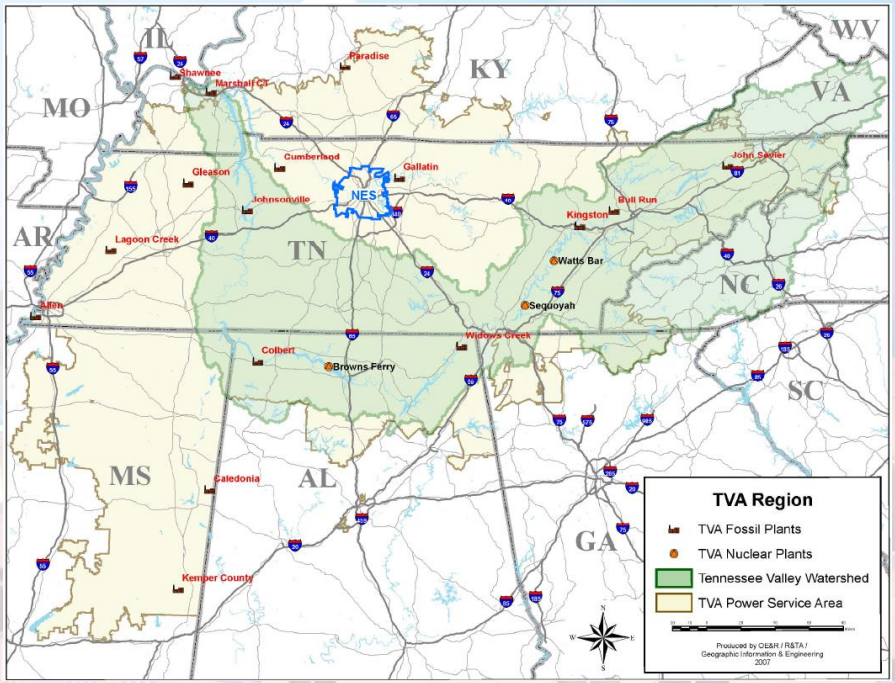
Agenda

- Introduction
- Smart Grid Program Strategy & Technical Aspects
- Financial Considerations
- Progress, Results & Future of NES' Smart Grid

Introduction

About NES

- 12th largest Municipal-owned Power Company
- 360,000 customers
- Over 700 square miles – all of Davidson County and portions of 6 others
- Purchase all power from TVA



NES Fiscal Facts

- Peak demand of 2,700 MW (summer peak)
- 65 substations and about 300 feeders
- 161kV, 69kV, 23.9kV, 13.8kV, & 4kV
- 8 SONET fiber rings and Ethernet to all high-voltage substations
- Over $1 billion in annual revenue

NES' Smart Grid Guiding Principles

- Align with NES corporate vision and strategy.
- Use the NES fiber system for backhaul communications where feasible.
- Implement a system that can readily incorporate new requirements.
- Minimize disruption to operations when implementing AMI.
- Avoid commitments to limited lifetime and proprietary technology.
- Purchase off-the-shelf components, including software, where practical.
- Follow industry standards wherever possible.

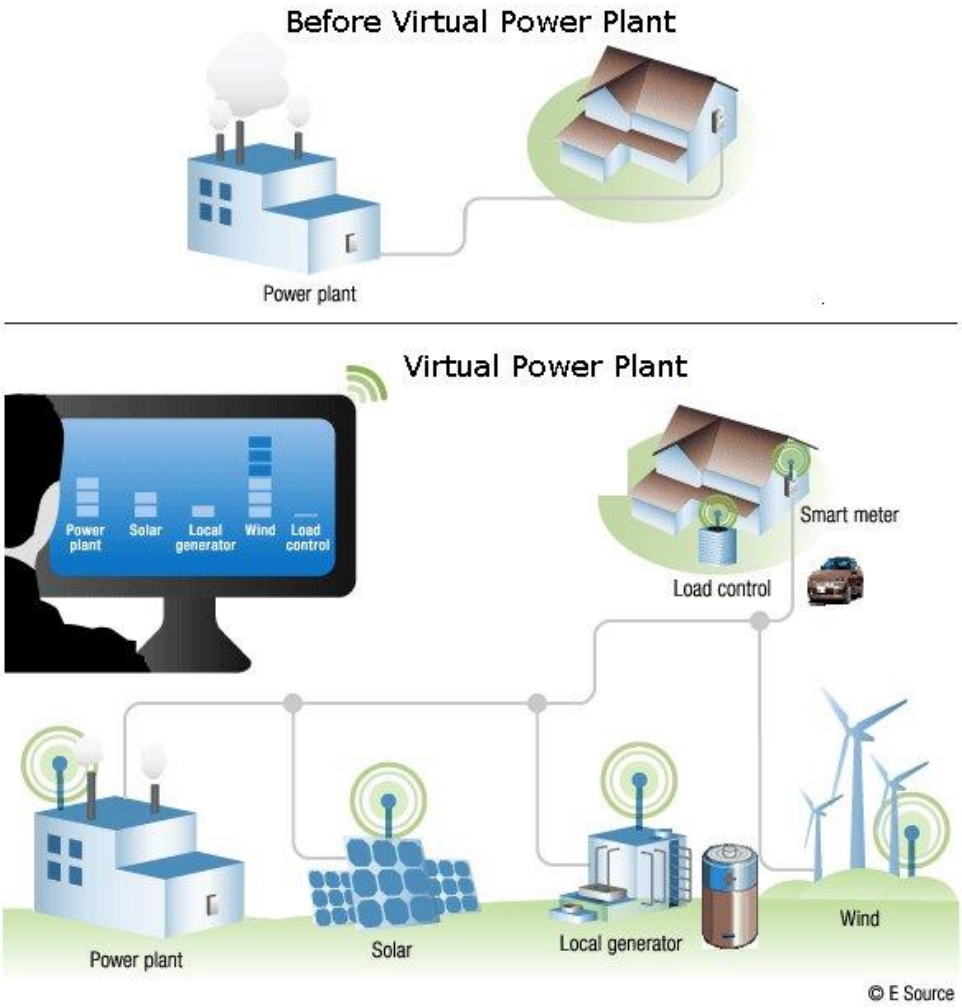
Strategy & Technical

Smart Grid Program Drivers

Why Are We Doing This?

- Tennessee Valley Authority's goal is to avoid/defer building new generating facilities
- TVA time-differentiated rate structure shifted financial risks and impacts to distributors
- NES is recouping some costs through Voltage Regulation by shaving peak demand charges

“Virtual” Power Plant



Smart Grid VPP Projects

- **Advanced Voltage Management**
  - Voltage reduction results in a lower kw demand
  - Approx. 700 meters will monitor system voltage
  - 40 MW
- **Direct Load Control**
  - Commercial HVAC
  - Commercial and Residential Water Heaters
  - 10.25 MW
- **Critical Peak Pricing (future)**
  - Voluntary load reduction
  - 2 MW

Smart Grid Project

- Install system-wide network
- Install 30,000 new meters at key points

- 9,616 commercial meters
- 10,956 residential meters with remote connect/disconnect switch, 9,428 without

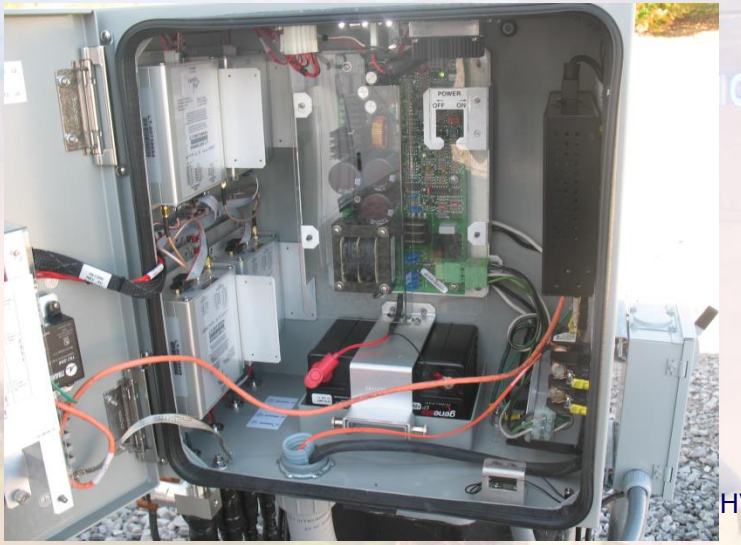
- 700 voltage monitoring meters
- 127 capacitor banks
- 4,000 DLC devices for HVAC/water heaters

Advanced Metering Infrastructure

AMI Network Components

- 51,000 meters
- 27 collectors on poles at substations, a radio tower and one on Verizon backhaul
- 621 routers on poles and street light arms

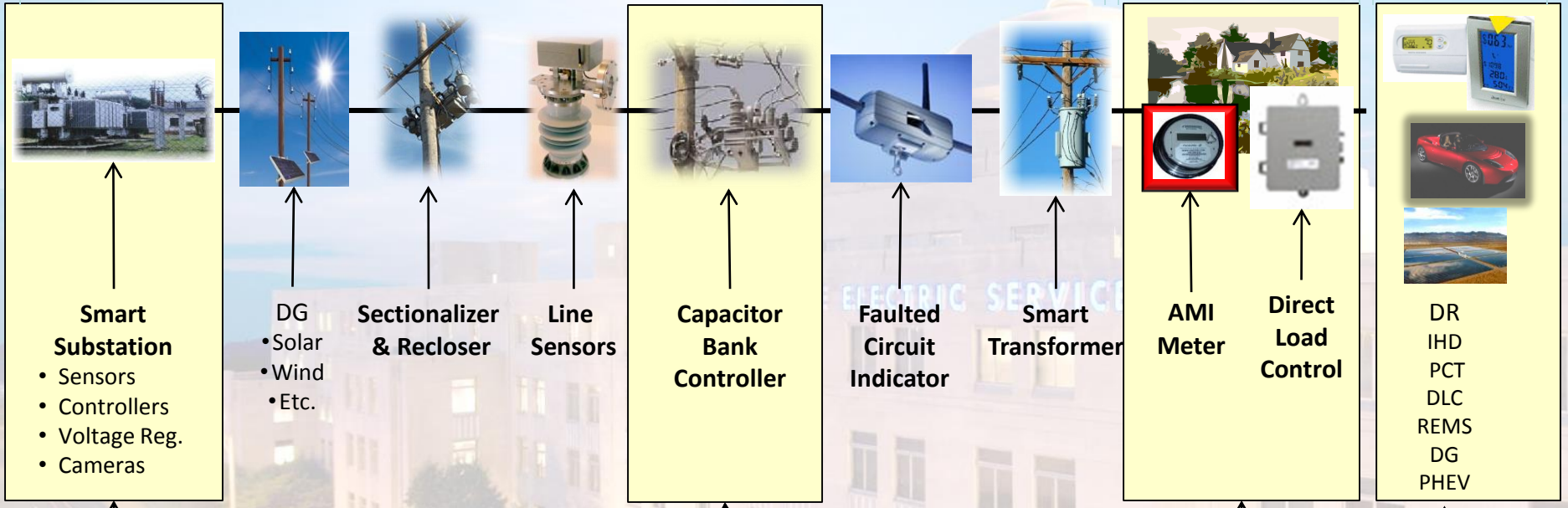
Inside of Collector



HVI

NES's Smart Grid will support AMI, DA and DR applications in order to address NES needs.

Distribution Automation (DA) | **AMI** | **Demand Response (DR)**



NES Virtual Power Plant Focus

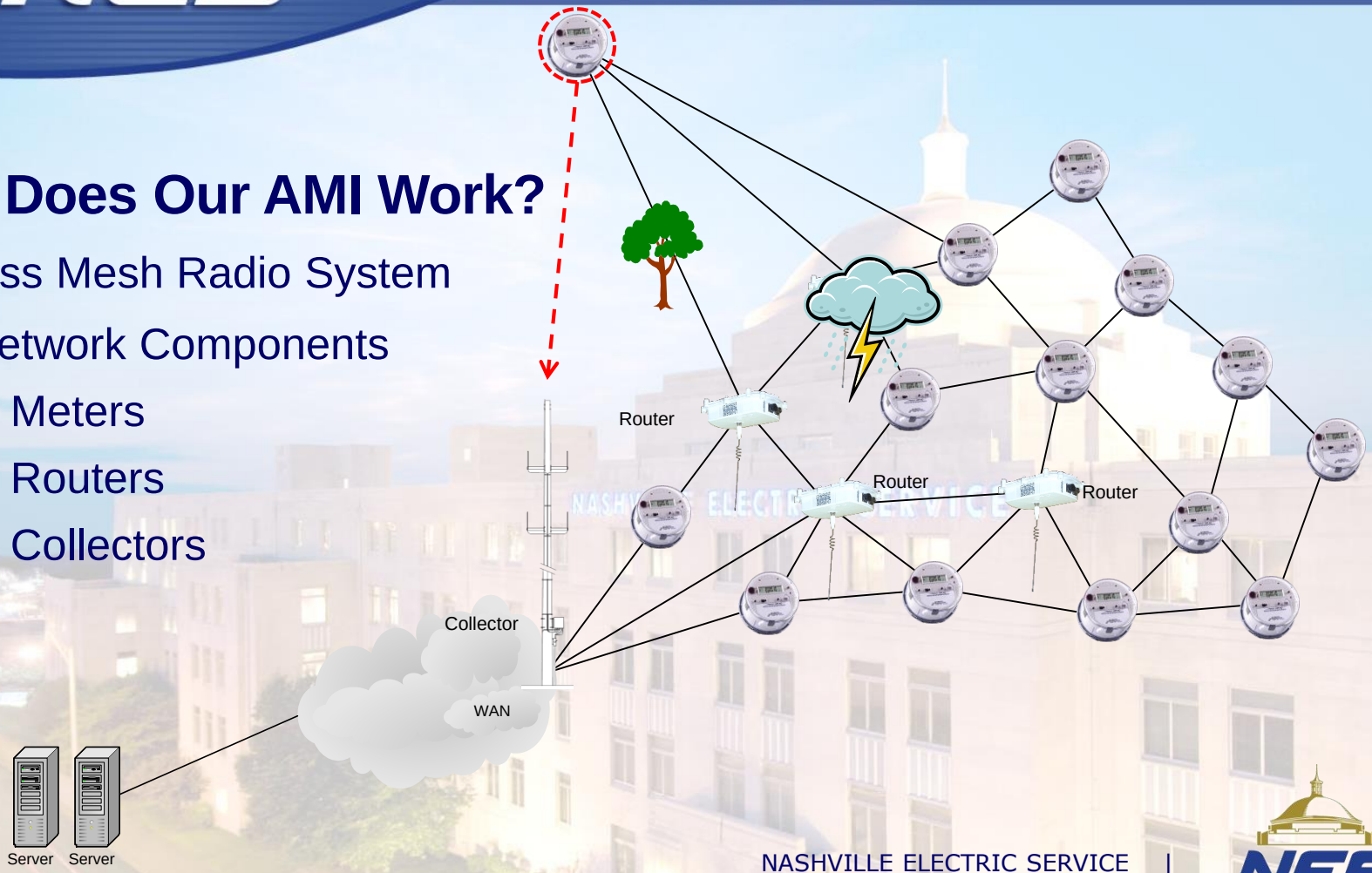
Advanced Metering Infrastructure (AMI)

How Does Our AMI Work?

Wireless Mesh Radio System

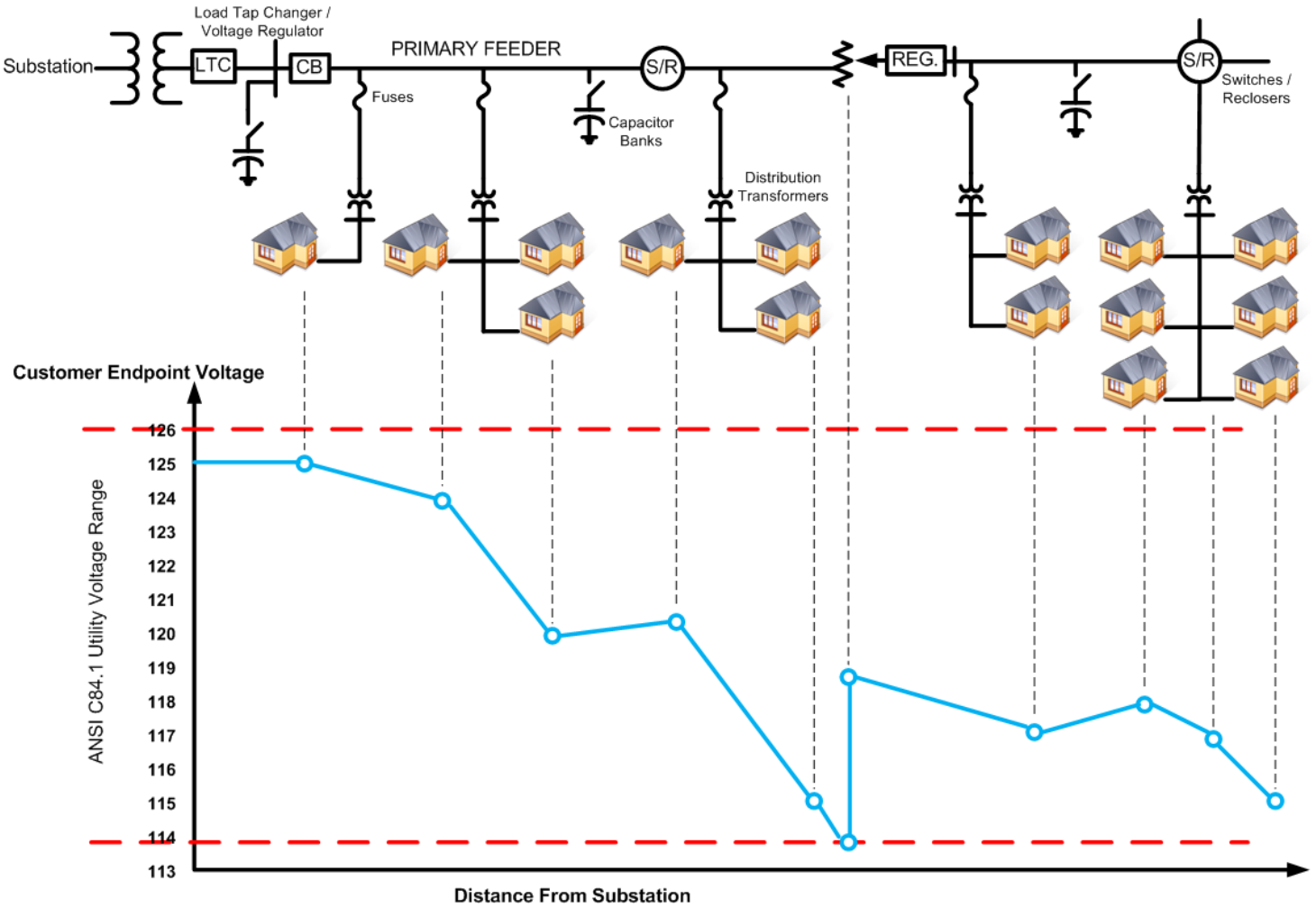
AMI Network Components

- Meters
- Routers
- Collectors



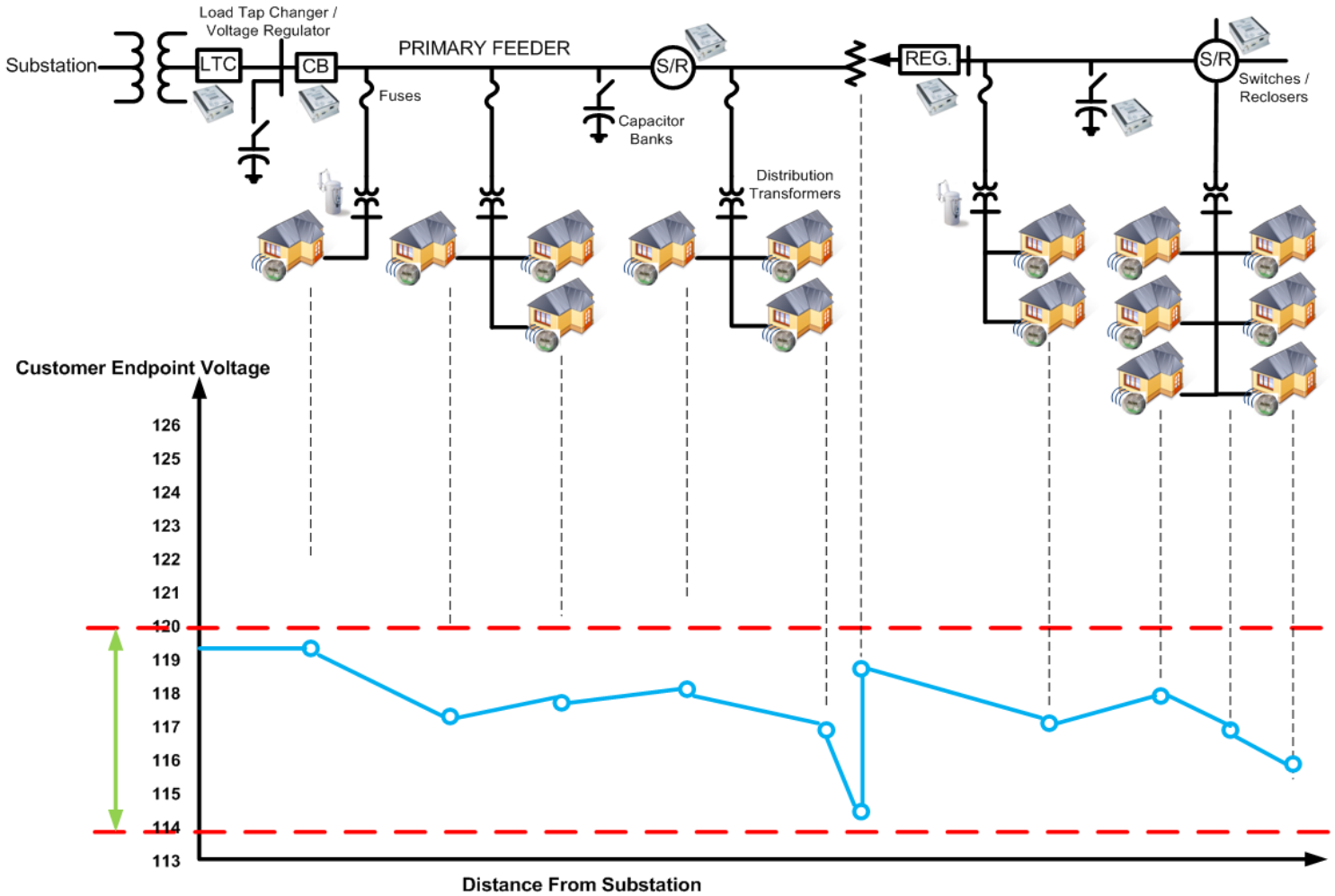
Normal Voltage Profile

Source: Landis+Gyr



AMI Enhanced Volt Management

Source: Landis+Gyr



SCADA Center – Controls
LTC
Capacitors
Regulators

Command Center – Controls
AMI - Functions

DMS Alston Areva Load Volt Var Management Software

Direct Load Control

- Program – 10.25 MW – June 1, 2014
- Pilot – 600 units – June 1, 2013
- Load Control Switches
- RTUs to be used on Building Management Systems
- Potential for 4k to 10k switches
- Deployed across service territory
- TVA Saturation Survey

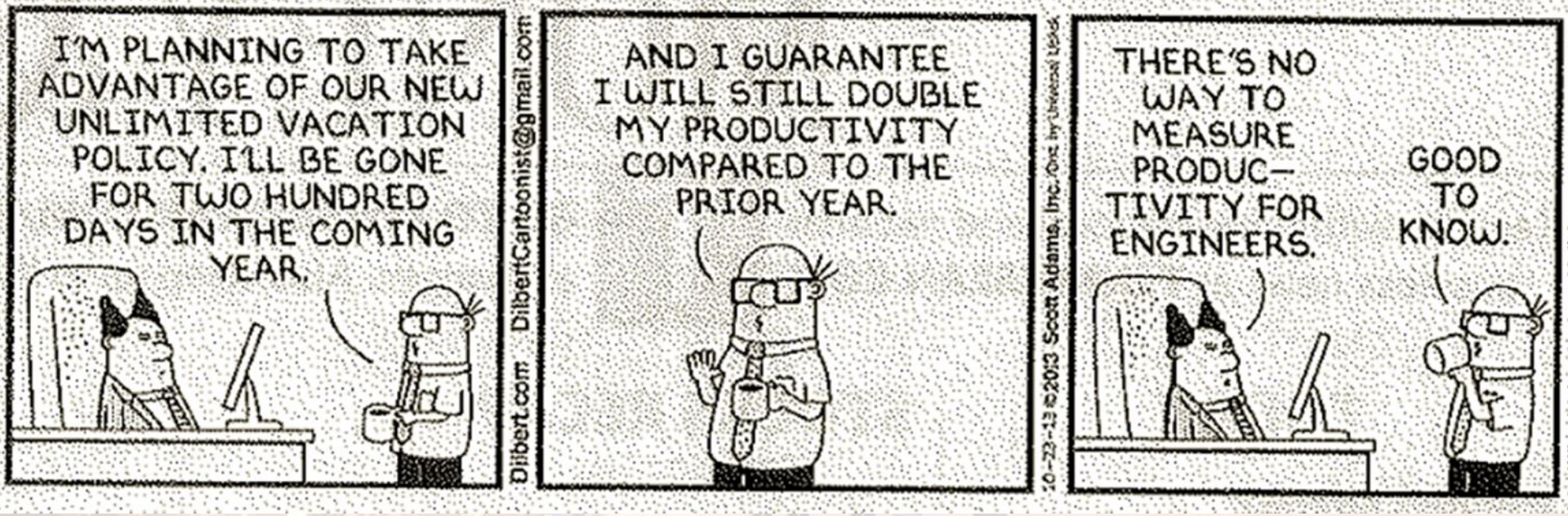
Gridstream Load Control Receiver

- CSE Load Control Receiver (LCR) –Ideal for controlling residential and small commercial and industrial appliances such as air conditioners, strip heat, pool pumps and water heaters.
- L+G Network Interface Card (NIC)
- On-board logic to execute cycling profiles with configurable shed times and duty cycles.
- Interruptible control events or return to normal operation without additional commands.
- Configured to stagger the ramp-in and ramp-out of control events.

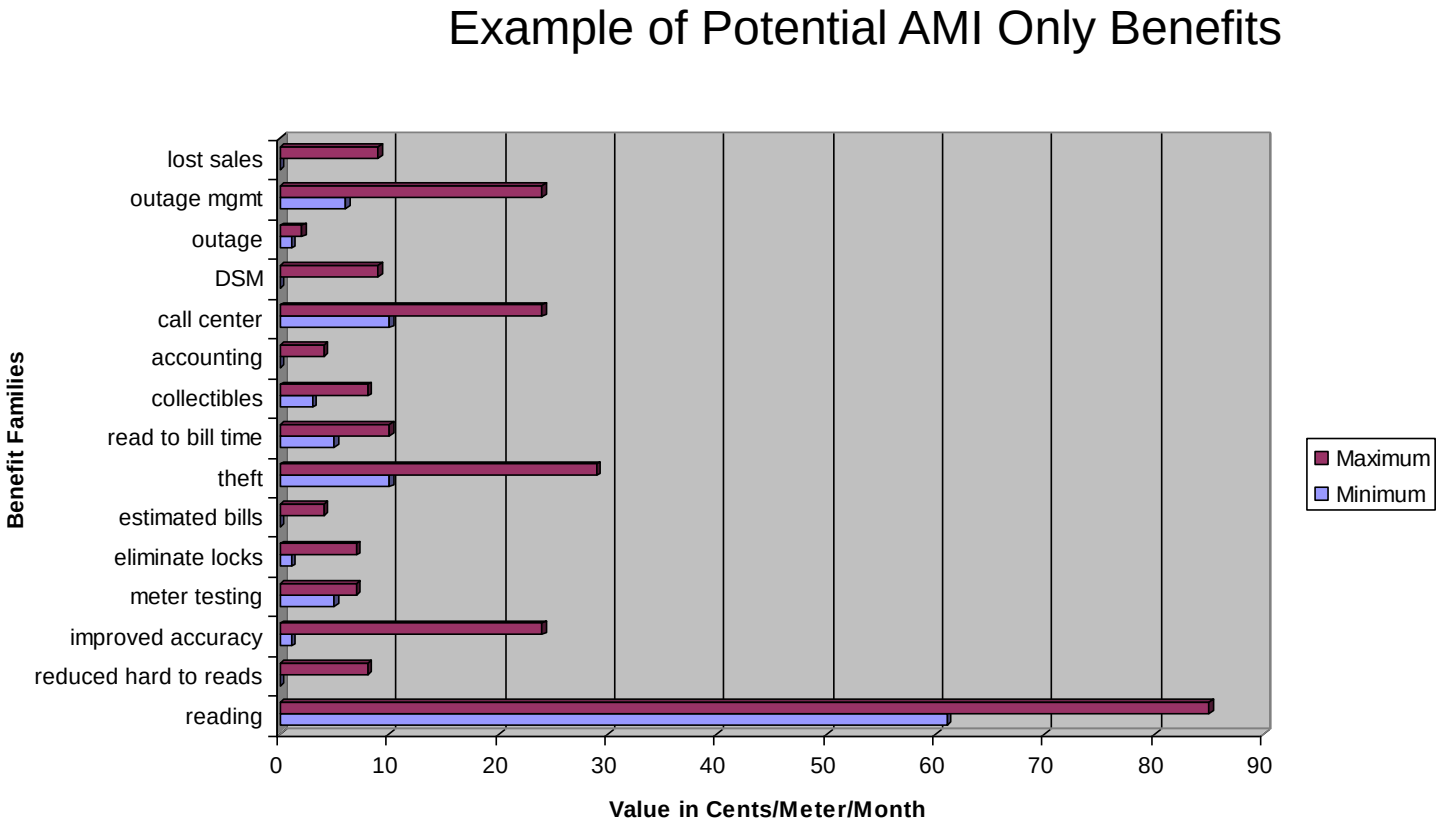
Gridstream Load Control Receiver

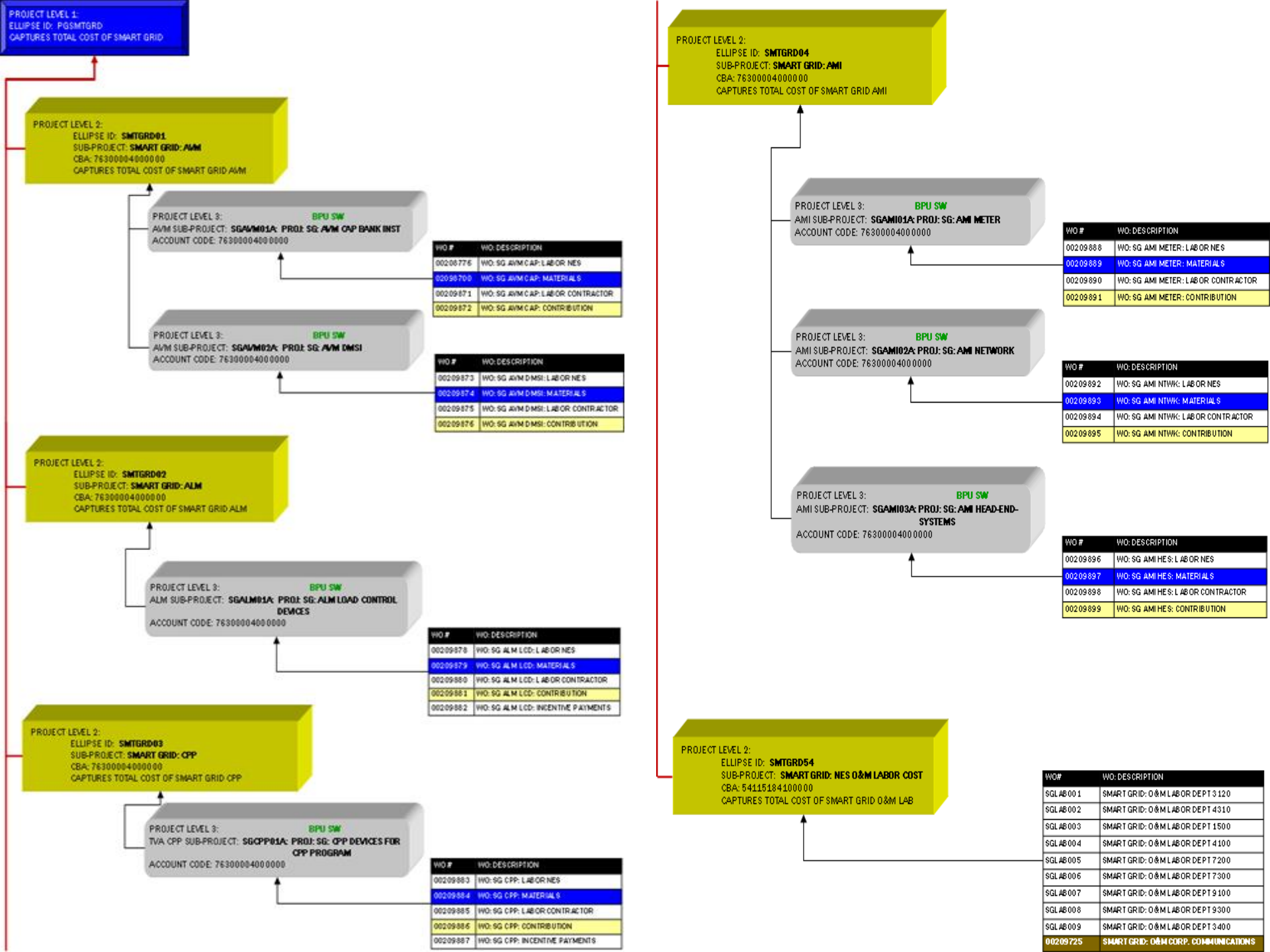
Financial Considerations

DILBERT *Dilbert* appears Monday through Saturday in the Business section.



NES Smart Grid Business Case




PROJECT LEVEL 1:
ELLIPSE ID: PGSMTGRD
CAPTURES TOTAL COST OF SMART GRID
PROJECT LEVEL 2:
ELLIPSE ID: SMTGRD01
SUB-PROJECT: SMART GRID: AVM
CBA: 76300004000000
CAPTURES TOTAL COST OF SMART GRID AVM
PROJECT LEVEL 3: BPU SW
AVM SUB-PROJECT: SGAVM01A: PROJ: SG: AVM CAP BANK INST
ACCOUNT CODE: 76300004000000
WO # | WO: DESCRIPTION
00208776 | WO: SG AVM CAP: LABOR NES
00208700 | WO: SG AVM CAP: MATERIALS
00209871 | WO: SG AVM CAP: LABOR CONTRACTOR
00209872 | WO: SG AVM CAP: CONTRIBUTION
PROJECT LEVEL 3: BPU SW
AVM SUB-PROJECT: SGAVM02A: PROJ: SG: AVM DMSI
ACCOUNT CODE: 76300004000000
WO # | WO: DESCRIPTION
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00209874 | WO: SG AVM DMSI: MATERIALS
00209875 | WO: SG AVM DMSI: LABOR CONTRACTOR
00209876 | WO: SG AVM DMSI: CONTRIBUTION
PROJECT LEVEL 2:
ELLIPSE ID: SMTGRD02
SUB-PROJECT: SMART GRID: ALM
CBA: 76300004000000
CAPTURES TOTAL COST OF SMART GRID ALM
PROJECT LEVEL 3: BPU SW
ALM SUB-PROJECT: SGALM01A: PROJ: SG: ALM LOAD CONTROL DEVICES
ACCOUNT CODE: 76300004000000
WO # | WO: DESCRIPTION
00209878 | WO: SG ALM LCD: LABOR NES
00209879 | WO: SG ALM LCD: MATERIALS
00209880 | WO: SG ALM LCD: LABOR CONTRACTOR
00209881 | WO: SG ALM LCD: CONTRIBUTION
00209882 | WO: SG ALM LCD: INCENTIVE PAYMENTS
PROJECT LEVEL 2:
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SUB-PROJECT: SMART GRID: CPP
CBA: 76300004000000
CAPTURES TOTAL COST OF SMART GRID CPP
PROJECT LEVEL 3: BPU SW
TVA CPP SUB-PROJECT: SGCPP01A: PROJ: SG: CPP DEVICES FOR CPP PROGRAM
ACCOUNT CODE: 76300004000000
WO # | WO: DESCRIPTION
00209883 | WO: SG CPP: LABOR NES
00209884 | WO: SG CPP: MATERIALS
00209885 | WO: SG CPP: LABOR CONTRACTOR
00209886 | WO: SG CPP: CONTRIBUTION
00209887 | WO: SG CPP: INCENTIVE PAYMENTS
PROJECT LEVEL 2:
ELLIPSE ID: SMTGRD04
SUB-PROJECT: SMART GRID: AMI
CBA: 76300004000000
CAPTURES TOTAL COST OF SMART GRID AMI
PROJECT LEVEL 3: BPU SW
AMI SUB-PROJECT: SGAMI01A: PROJ: SG: AMI METER
ACCOUNT CODE: 76300004000000
WO # | WO: DESCRIPTION
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00209889 | WO: SG AMI METER: MATERIALS
00209890 | WO: SG AMI METER: LABOR CONTRACTOR
00209891 | WO: SG AMI METER: CONTRIBUTION
PROJECT LEVEL 3: BPU SW
AMI SUB-PROJECT: SGAMI02A: PROJ: SG: AMI NETWORK
ACCOUNT CODE: 76300004000000
WO # | WO: DESCRIPTION
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00209893 | WO: SG AMI NTWK: MATERIALS
00209894 | WO: SG AMI NTWK: LABOR CONTRACTOR
00209895 | WO: SG AMI NTWK: CONTRIBUTION
PROJECT LEVEL 3: BPU SW
AMI SUB-PROJECT: SGAMI03A: PROJ: SG: AMI HEAD-END-SYSTEMS
ACCOUNT CODE: 76300004000000
WO # | WO: DESCRIPTION
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00209897 | WO: SG AMI HES: MATERIALS
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00209899 | WO: SG AMI HES: CONTRIBUTION
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SUB-PROJECT: SMART GRID: NES O&M LABOR COST
CBA: 54115184100000
CAPTURES TOTAL COST OF SMART GRID O&M LAB
WO# | WO: DESCRIPTION
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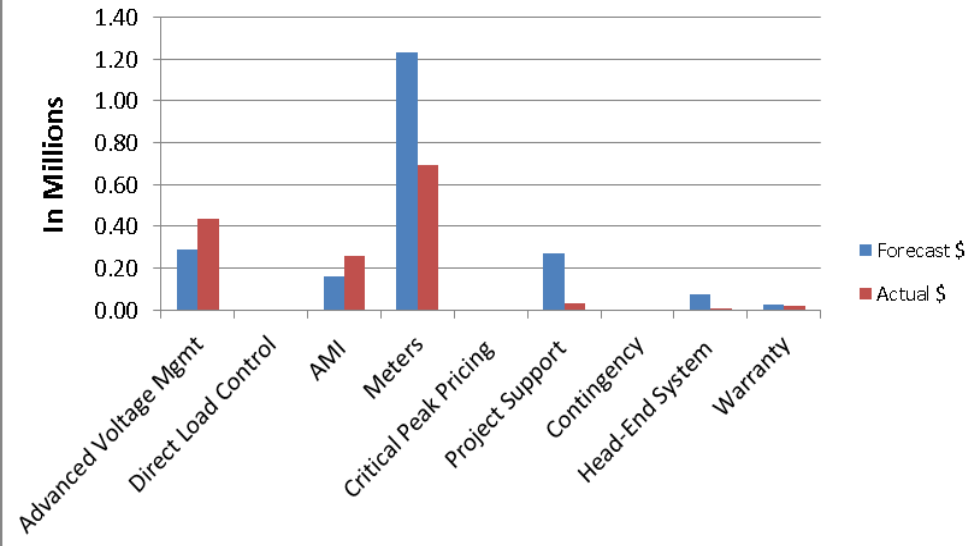
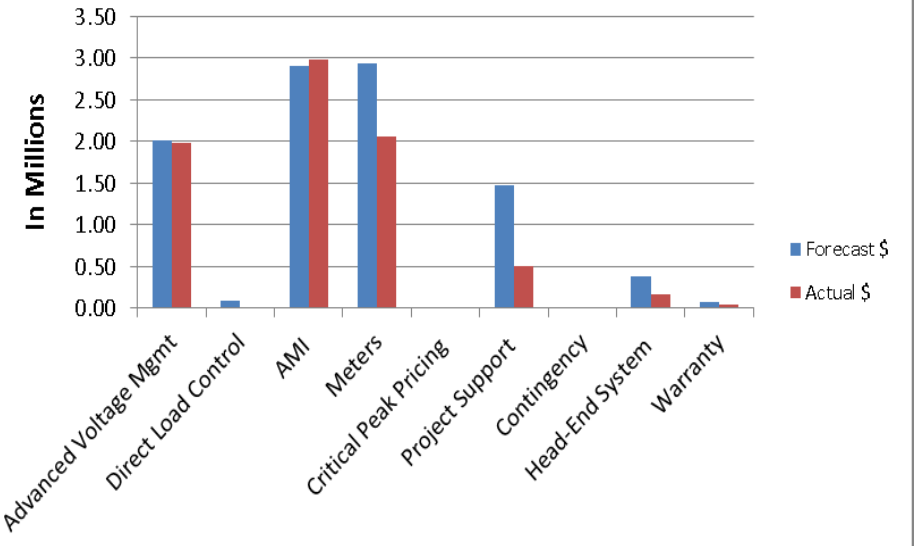
SGLAB002 | SMART GRID: O&M LABOR DEPT 4310
SGLAB003 | SMART GRID: O&M LABOR DEPT 1500
SGLAB004 | SMART GRID: O&M LABOR DEPT 4100
SGLAB005 | SMART GRID: O&M LABOR DEPT 7200
SGLAB006 | SMART GRID: O&M LABOR DEPT 7300
SGLAB007 | SMART GRID: O&M LABOR DEPT 9100
SGLAB008 | SMART GRID: O&M LABOR DEPT 9300
SGLAB009 | SMART GRID: O&M LABOR DEPT 3400
00209725 | SMART GRID: O&M CORP. COMMUNICATIONS

Major Cost Categories for Smart Grid Project	Explanation
AMI Meter & NIC Capital Cost	Integrated residential meter and NIC for 23,000 endpoints; 7,000 commercial meters with removable NIC.
AMI Meter Installation	NES commercial installation for 7K meters and 3k residential meters with vendor installation for 20K residential meters.
IT Hardware & Software	Production and test Head End Systems, including servers, data storage, database and other software
AMI Network Equipment	Includes Advanced Security Package.
AMI Network Deployment Support	Includes project management, system testing support, pre-deployment planning, design and engineering of the AMI Network, field deployment support, hardware site survey and system configuration and integration services.
AMI Network Install	Contractor 2-man crew and bucket at $84/hr. Also includes 10-15% of installations requiring a new pole, transformer & secondary.
IT Integration	IT labor to construct system interfaces.
Field Work Management	Program Management of field work force.
Pre-deployment Planning	Contract legal expenses and planning
Change Management & Training	Changes in internal business processes
Customer Communications	Bill stuffers, door hangers, Corporate Communications
Advanced Voltage Mgmt	Includes purchase and installation of 163 capacitor banks and Volt-Var Optimization software and integration.
Direct Load Control	Includes customer enrollment incentives for 10 years, 4,000 load control switches and Head End System hardware and software.
Critical Peak Pricing/Peak Time	Includes customer enrollment incentives for 10 years.
SLA/System Acceptance Test	Internal labor for System Acceptance Test
WAN/DA Communications	Option #3-Initially, DA using NES 900 MHz system with radios installed at the end point capacitor controllers. In 2012, DA using NES fiber @ sub and $200k for SCADA Center software and 163 routers.
Internal Implementation Support	Cost for design eng., customer eng., test section
Cyber Security	Intrusion and penetration testing after installation.
Contingency	6.0% contingency based on final bid process and funding for additional hardware to meet required SLAs.
Warranty	Includes five year warranty on collectors, routers, NICs, meters and load control switches.

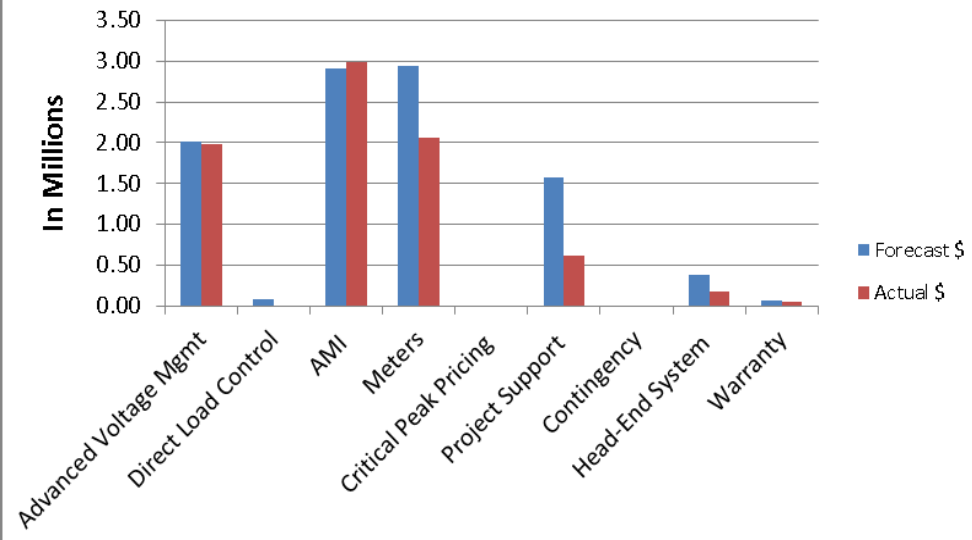
Smart Grid Project Budget vs. Actual (Monthly - Feb 29, 2012)



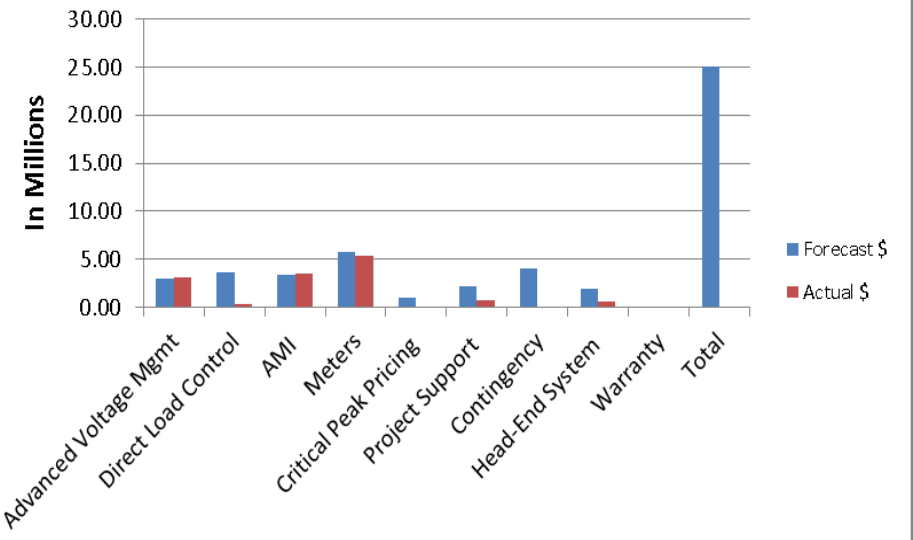
Smart Grid Project FYTD Budget vs. Actual (as of Feb 29, 2012)



Smart Grid Project Total Budget vs. Actual to Date (as of Feb 29, 2012)



Smart Grid Projected Budget vs. Actual (as of Feb 29, 2012)



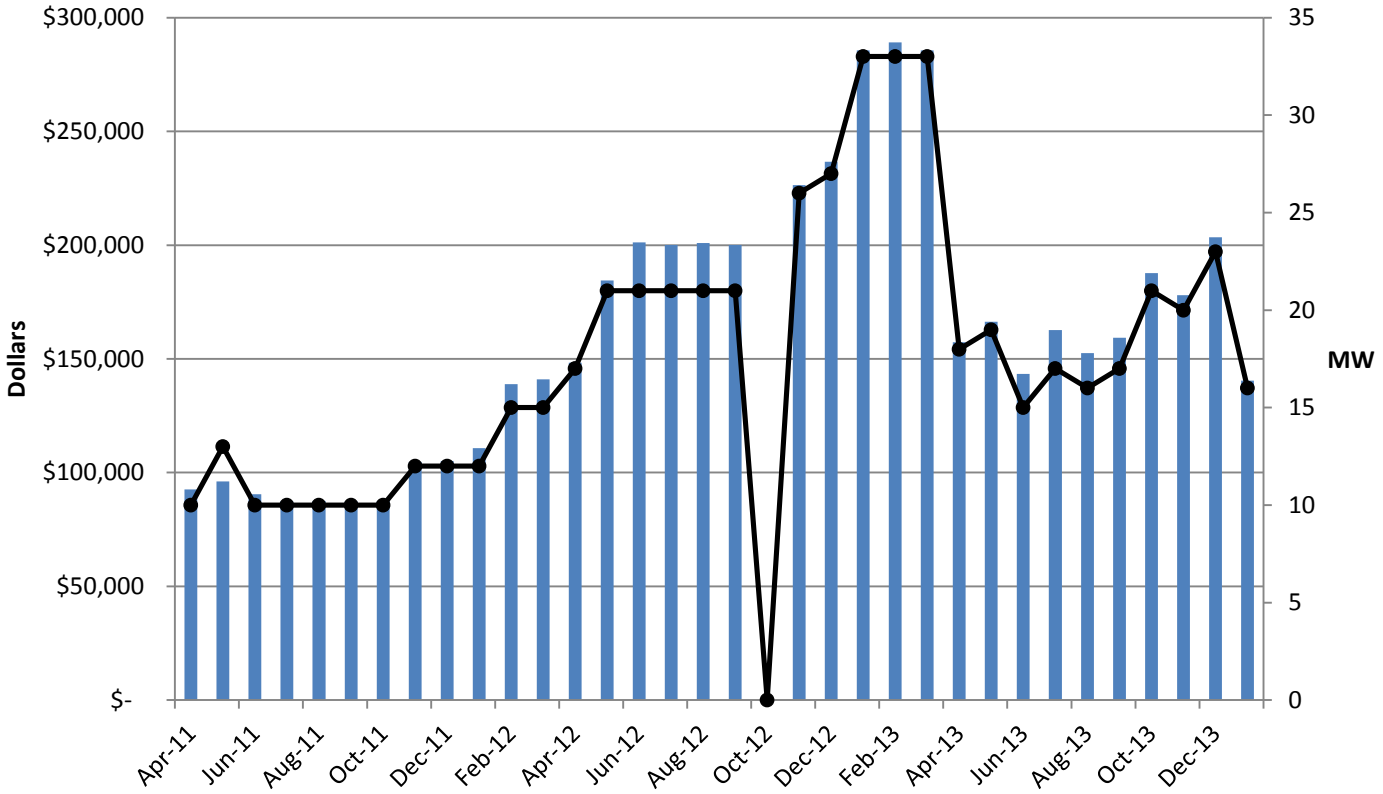
Financial Smart Grid Considerations

- Smart Grid Business Case development
- Employee transitioning
- AMI meter installation costs
- Depreciation strategy for existing meters
- FERC accounts for Smart Grid components
- AMI meter refusal (customer charge)
- Health and privacy considerations

Advanced Voltage Management

- Analytical process to determine when to manage peak demand based on input from Budget & Rates, Engineering, and System Control sections.
- Events initiated through existing SCADA in System Control.
- Dispatchers initiate event to four different groups of load (now switched simultaneously)

$5.3M in Voltage Reduction Savings YTD



Progress,Results and Future

Benefits of Upgraded Meters

Benefits to NES

- Accurate system information
- Improved system reliability and power quality
- Dynamically manage system load

Benefits to the Customer

- Meter readings done remotely
- Better for the environment
- Lights coming on sooner after an outage

AMI Voltage Feedback Loop

Information

Legend:

- Very High: voltage pu between 1.0501 and 1.2000
- High: voltage pu between 1.0300 and 1.0500
- Good: voltage pu between 0.9700 and 1.0299
- Low: voltage pu between 0.9500 and 0.9699
- Very Low: voltage pu between 0.8001 and 0.9499
- Ignore: voltage pu <= .8000 and voltage pu > 1.2000

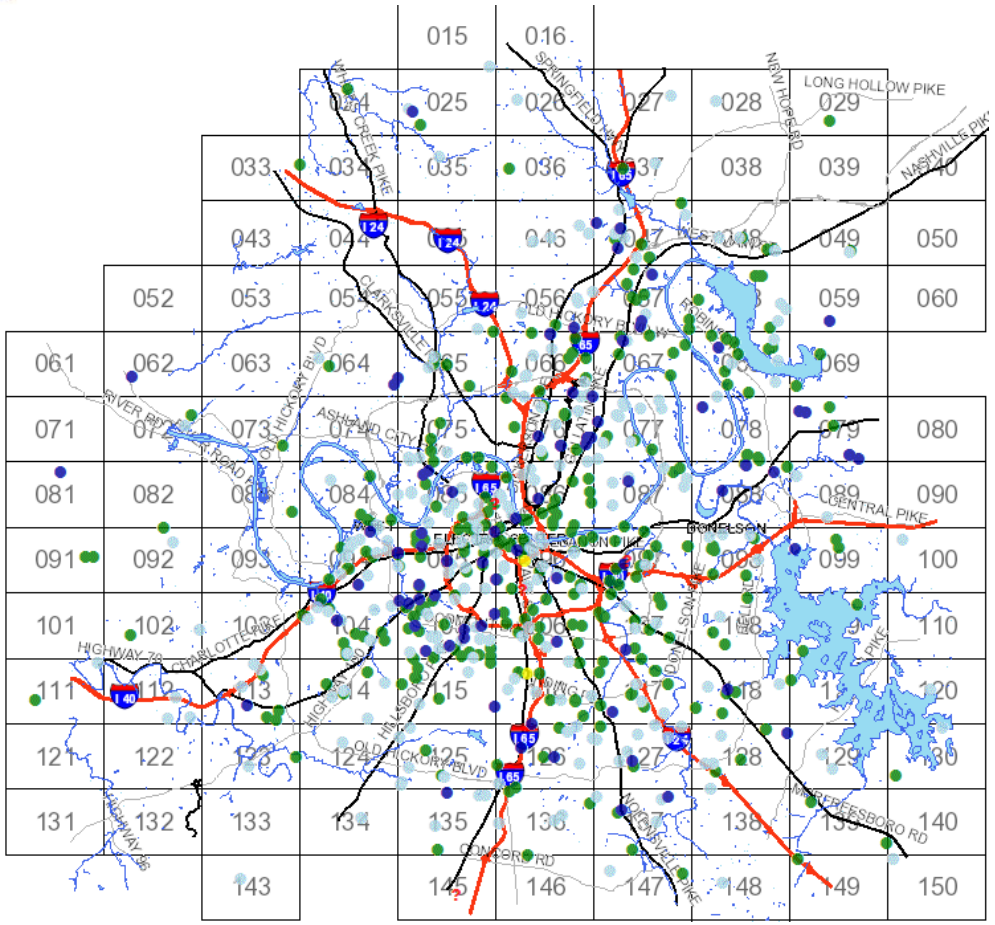
AMI Voltage Ranges

Actions

- Very High
- High
- Good
- Low
- Very Low

Description	Value
Very High	78
High	238
Good	293
Low	2
Ignore	4
	615

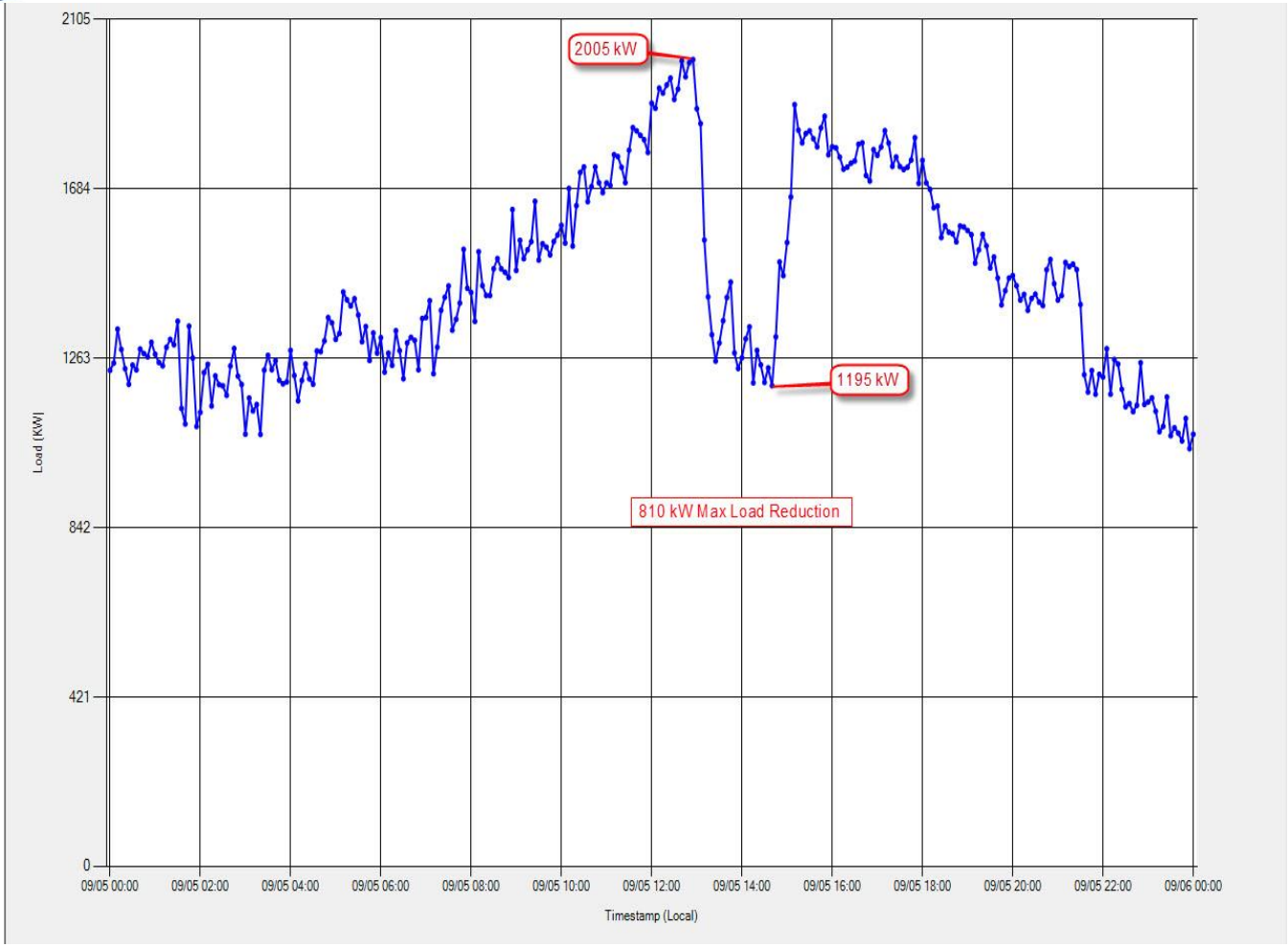
1 - 5



Program combines a 2-way NAN and LCR for load reduction and load voltage/current data

Measurement and Verification with 2-way Communication

- Verified Load Shed
- Spinning Reserve
- Remote Auditing
- Certified Report Auditing
- Tamper Evidence
- Certified Reporting



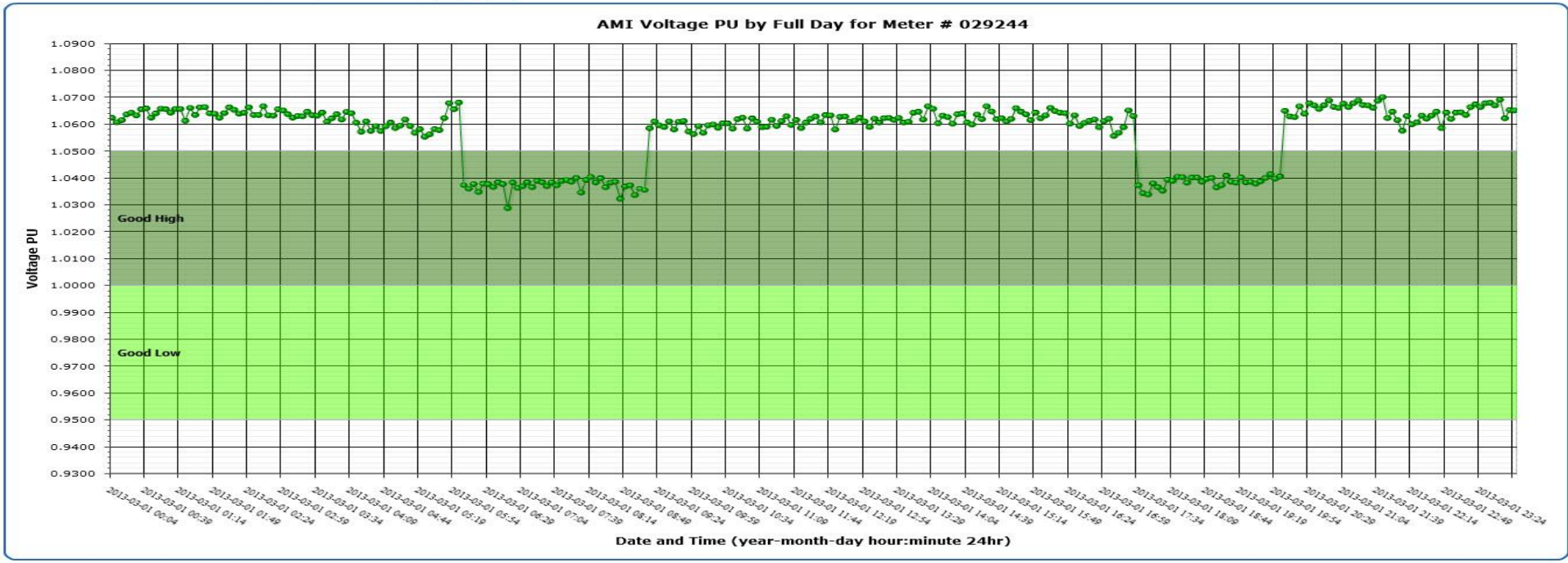
Voltage Fluctuation - Old Hickory F8(PDM)

Event	Date	Started	Ended	No. of Hours	Est. MW	Est. kWh
79	1/22/2013	6:15	9:00	2.75	33	90,750
80	2/1/2013	5:45	8:45	3.00	33	99,000
81	3/1/2013	6:00	8:45	2.75	27	74,250
82	3/1/2013	17:30	20:00	2.50	27	67,500
83	3/2/2013	10:30	13:00	2.50	27	67,500
84	3/2/2013	16:30	19:45	3.25	27	87,750

Information

AMI Voltage PU data is available for Meter # 029244 starting on August 15, 2012.
The highest AMI Voltage PU on record for Meter # 029244 is **1.076** for January 14, 2013
The lowest AMI Voltage PU on record for Meter # 029244 is **.02** for December 13, 2012

Effective Date 2013-03-01 Search < >



As of March 21, 2014

- Phase 1
  - 40 MW of Voltage VPP load reduction
  - 1 MW of Load Control- pilot load reduction
  - 2 MW of CPP pilot (possible future)
- Phase 2: Increase to ~3% or 80MW of peak demand
- Phase 3 (*optional*): Increase capacity >3% of demand

Future SG Initiatives

- Meter Data Management System Implementation
- Integration to NES Outage Management System
- Continued AMI Meter Deployment
- Development of a Smart Grid Maintenance Plan
- Smart Grid Data Analytics Initiative
- Prepayment
- Customer Web Presentment
- Future TOU and/or Coincident Peak Rates

Questions?