ELECTRIC POWER RESEARCH INSTITUTE

U.S. DEPARTMENT OF ENERGY

Systems Driving the Integrated Grid

Moderators: John Simmins EPRI / Eric Lightner DOE

Speakers:
Ron Melton – Pacific Northwest National Labs
Walter Bartel – CenterPoint Energy
Melanie Miller – Duke Energy
Bruno Prestat – Electricity d’France
Bob Hay – Electric Power Board of Chattanooga
Will O’Dell – Snohomish Public Utility Board
Joe Schatz – Southern Company

The Smart Grid Experience: Applying Results, Reaching Beyond

Tuesday 28-October-2014 10:30am

Session: Systems Driving the Integrated Grid

Applying Results:

Successes

Surprises

Reaching Beyond

Pacific Northwest Smart Grid Demonstration

Presentation for panel on:

Systems Driving the Integrated Grid

Charlotte, NC

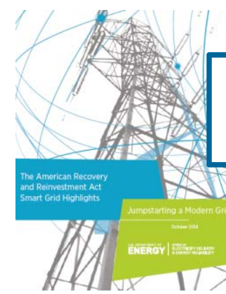
October 28, 2014

PNWD-SA-10423

PNWD-SA-10423

Pacific Northwest Smart Grid Demonstration

- Dr. Ron Melton – Project Director
- Team Lead for Electricity Infrastructure Integration, Pacific Northwest National Laboratory
- Administrator, GridWise® Architecture Council
- Over 30 years experience applying computer technology to engineering and scientific problems
- MS and PhD in Engineering Science from the California Institute of Technology
- BSEE from University of Washington
- Senior Member of IEEE and ACM
- ron.melton@pnnl.gov - 509-372-6777
- www.pnwsmartgrid.org & www.gridwiseac.org



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Pacific Northwest Smart Grid Demonstration Project

What:

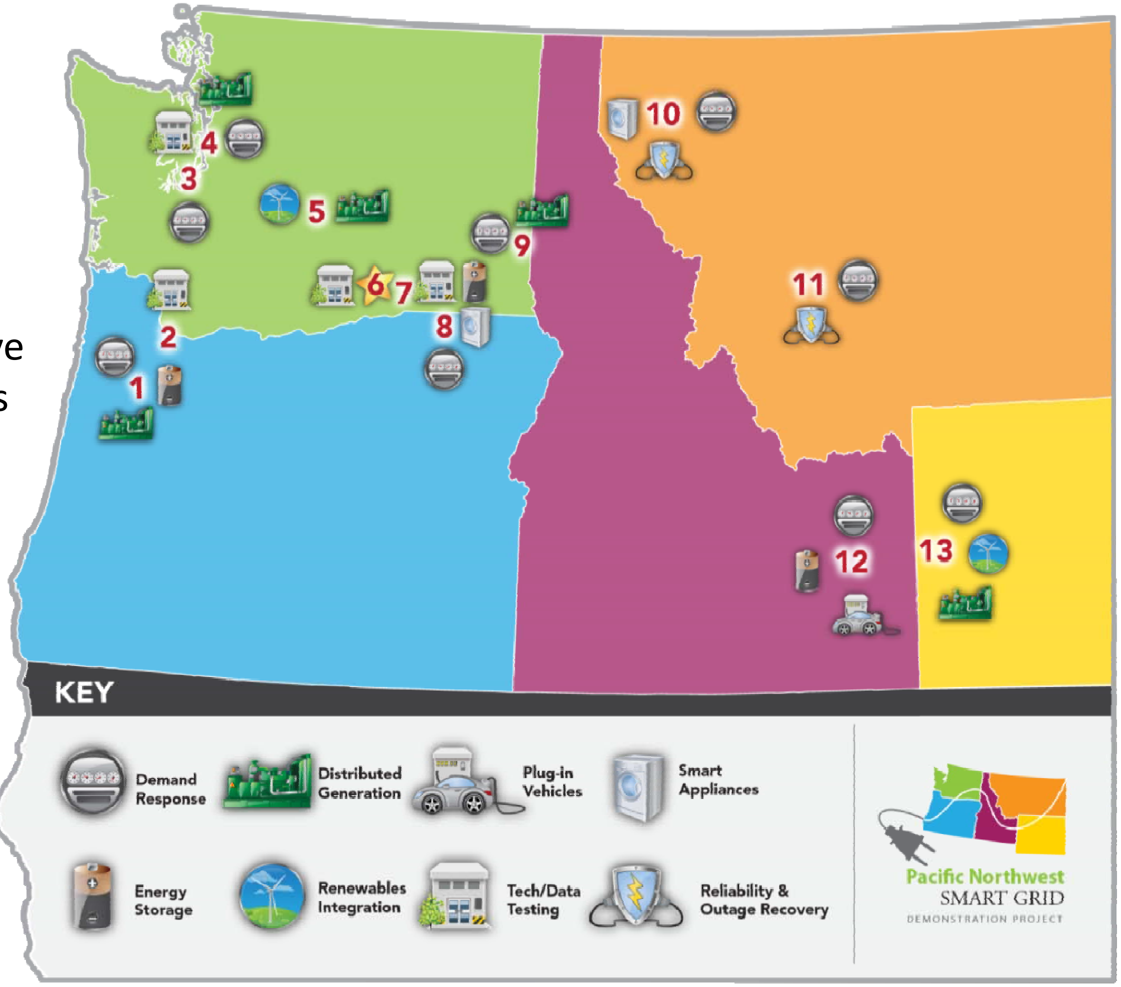
- $178M, ARRA-funded, 5-year demonstration
- 60,000 metered customers in 5 states

Why:

- Develop communications and control infrastructure using incentive signals to engage responsive assets
- Quantify costs and benefits
- Contribute to standards development
- Facilitate integration of wind and other renewables

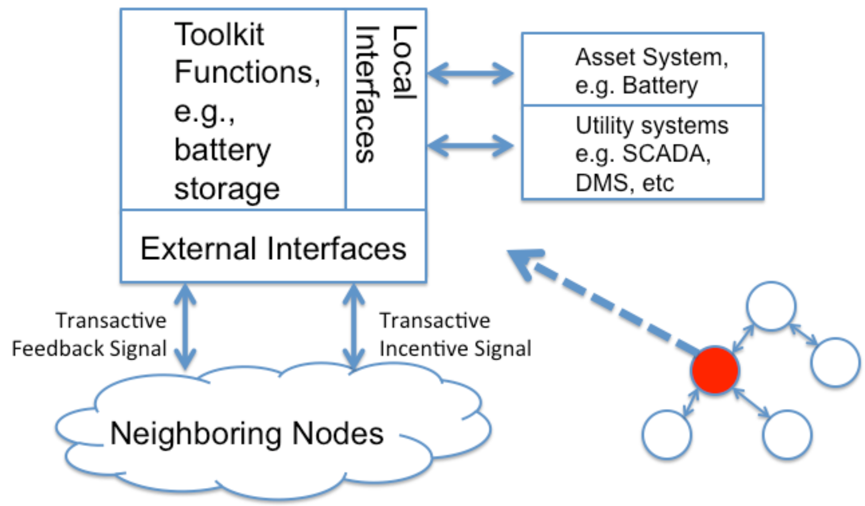
Who:

Led by Battelle and partners including BPA, 11 utilities, 2 universities, and 5 vendors



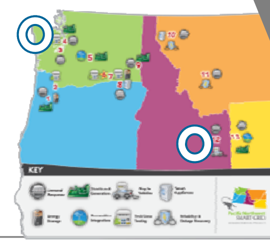
Project Successes

- Developed and demonstrated ability to coordinate incentive signal response across 11 utilities in five states using transactive control technology
- At the end of the demo project:
  - ~ 80 Megawatts of distributed responsive assets engaged
  - ~ $80M Base of smart grid equipment installed at 11 utilities

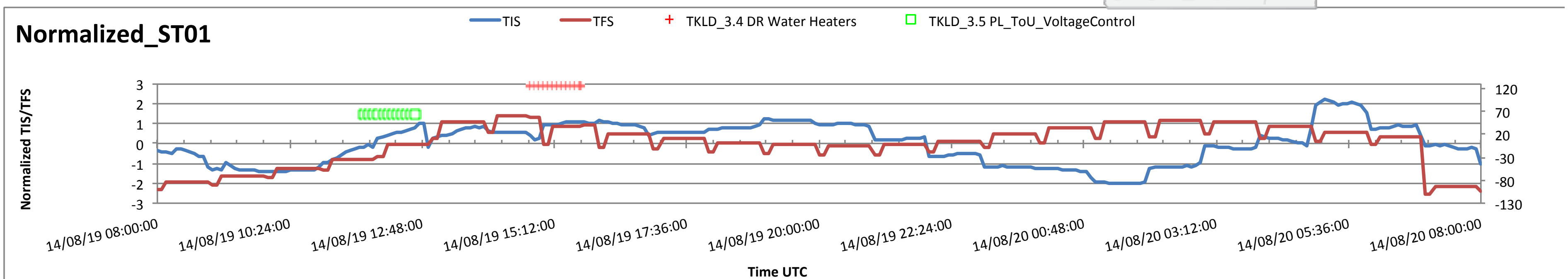


- Transactive control system design and reference implementation suitable for standardization

Project Successes: TIS / TFS / Asset System Response Examples

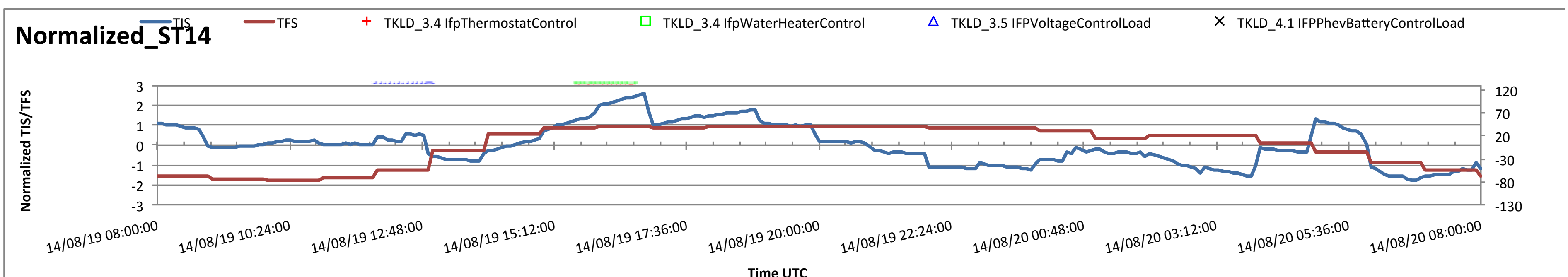


Peninsula Light – Fox Island



Daylight Hours – Fox Island

Idaho Falls Power



Daylight Hours – Idaho Falls

Surprises

- Significant amount of time was required to test and validate transactive control – more than we expected
- Utilities are challenged to deal with the diversity and volume of data – the devil is in the details
- Need INCs and DECs – generally only get INCs
- Several examples of early stage adoption challenges
  - Vendor bankruptcies
  - Actual equipment performance not matching advertised equipment performance
- Safety problems with small-scale wind turbines led to removal of the equipment
- Some examples of unexpected or greater than expected benefits from smart grid technology

Reaching Beyond

- Scale up to engage additional responsive assets
- Transition from R&D to operations
- Operationalize for balancing authorities (regional value)
- Further deployment with energy service providers to enhance value to their operations (local value)
- Market interfaces / market mechanisms
- Integration with existing energy management and market management system approaches (unit commitment, economic dispatch and load forecasting)
- Theoretical underpinnings – in particular as they relate to stability
- Modeling and simulation capability
- Refinement of transactive control functions
- Extend to include reactive power

The Smart Grid Experience: Applying Results, Reaching Beyond

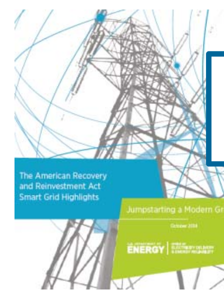
CenterPoint Energy's Intelligent Grid

Walter R. Bartel, P.E.
CenterPoint Energy

October 27-29, 2014
Charlotte, NC

Walter R. Bartel, P.E.

- Director of Grid Performance & Reliability
- Responsible for Intelligent Grid & Technology initiatives
- 22 Years at CenterPoint Energy & predecessor companies
- Worked extensively in the areas of distribution automation, system reliability, construction, operations and engineering
- Served as CNP’s primary representative with local governments, political subdivisions, chambers of commerce, and other public and private entities
- Bachelor of Science in Electrical Engineering from the University of Houston
- Licensed Professional Engineer in the State of Texas



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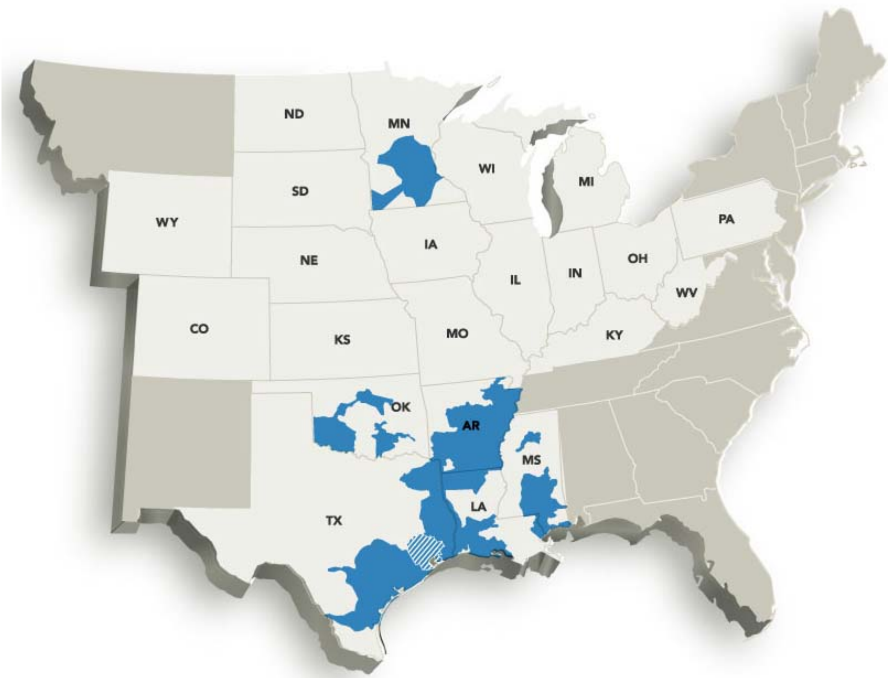
Who Is CenterPoint Energy?



Electric Transmission & Distribution

Natural Gas Distribution

Competitive Natural Gas Sales & Services

Headquartered in Houston, Texas

- 5.5M Electric & Gas Customers
- $21.8B in Assets
- $8.1B in Revenue
- 8,500+ Employees
- 140+ Years Service to our Community

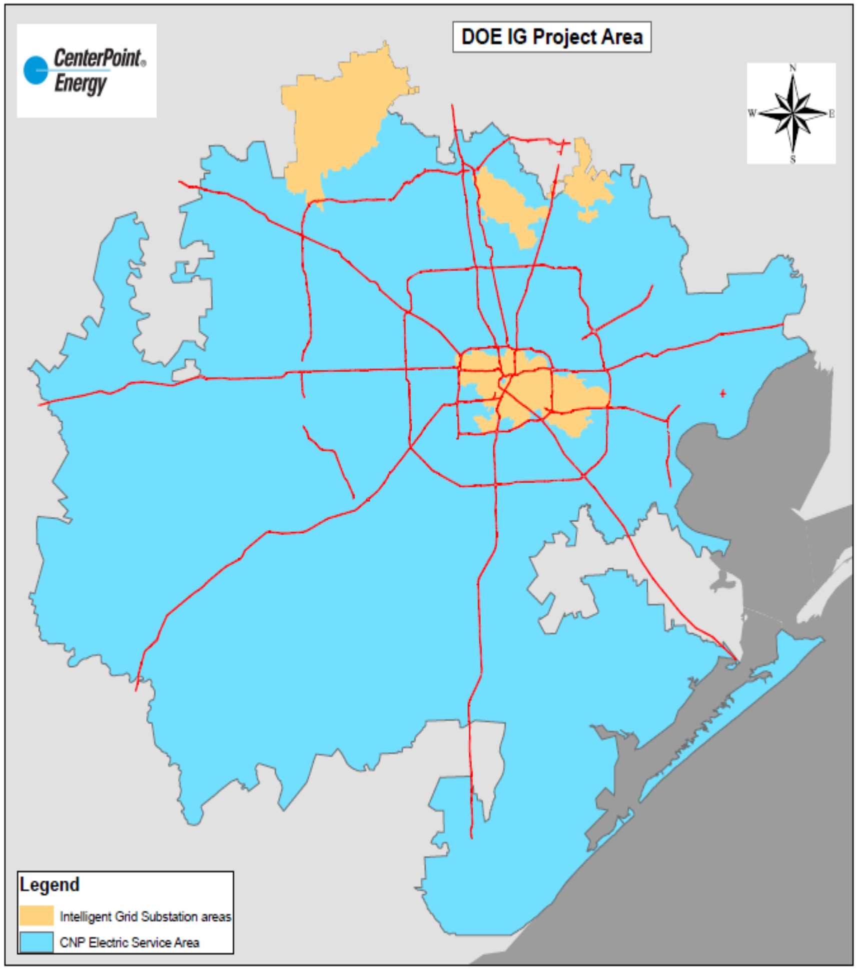
Electric T&D Business

- 2.2M+ Customers in Houston area
- 17.0 GW Peak Demand
- 79.5 GWH Delivered Annually
- 234 Substations
- ≈ 4K Miles of Transmission
- ≈ 50K Miles of Distribution

Intelligent Grid Description

SG Investment Grant

- Project $640M $540M AMS **$100M IG** CNP1
- **Grant $200M** $150M AMS **$ 50M IG**



Objectives

- Improve distribution grid visibility
- Improve system reliability, resiliency & operational performance
- Implement a fully integrated system, working seamlessly with enterprise applications to provide a foundational platform to support Advanced Grid Management Applications (ADMS)

Infrastructure (≈ 13% of Dist. Grid)

- ≈ 570 IGSDs
- 31 Substation Upgrades
- Dual Path Communications

Advanced DMS

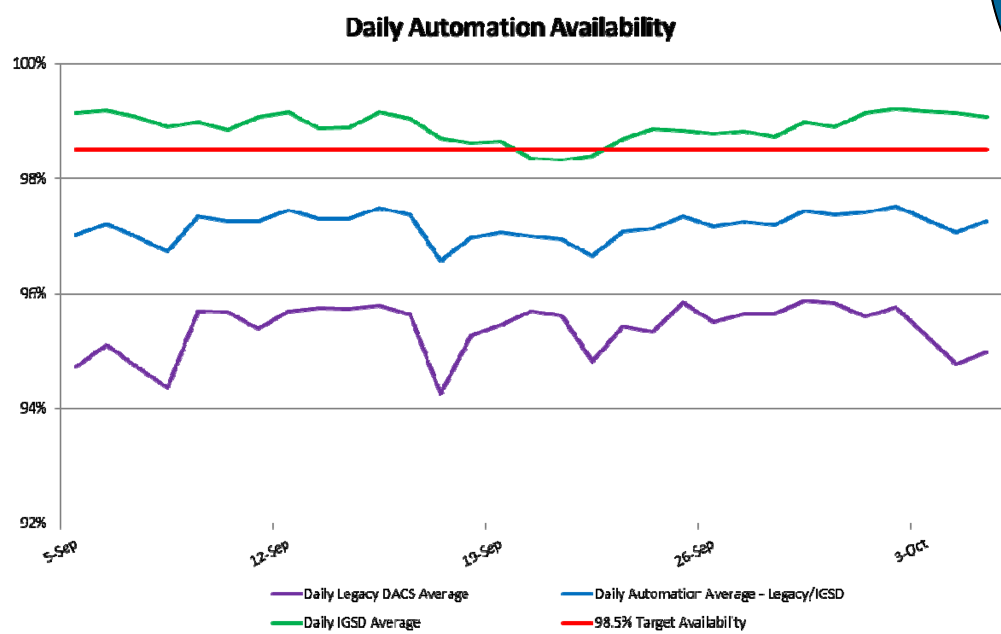
- Phased Deployment Through Q2 2015

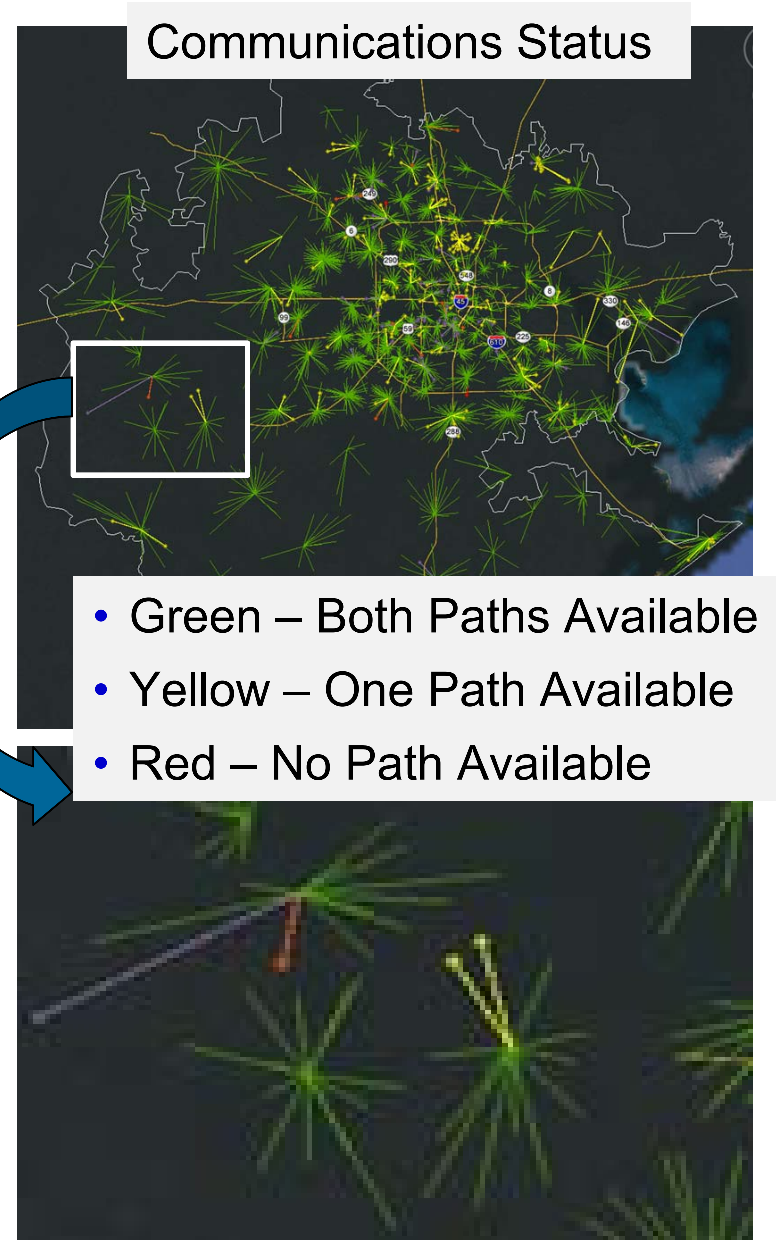
Slide 13

CNP1 Check what needs to be in bold
Atkins, Karen, 10/15/2014

Successes - DSCADA

- Securely operating ≈ 1,350 Units
  - ≈ 50/50 IGSDs & Legacy Devices
- Manages dual communications (IGSDs)
- Develop & enhance E2E Monitoring
- Measure DA Availability





Successes – Reliability Improvements

IG Project Area	2011	2012	2013	2014 (Sept)
Events	13	20	81	57
Avoided CMI	193K	612K	7.3M	7.6M
Avg Improvement	9.4%	21.9%	25.3%	33.0%

System Wide	2011	2012	2013	2014 (Sept)
Events	247	320	305	200
Avoided CMI	15.45M	27.11M	32.81M	21.42M
Avg Improvement	12.2%	21.3%	26.4%	30.0%

Avoided CMI: Comparison w/Historical Manual Restoration Model

Avg. Improvement: Improvement in Outage Response where Automation was Available

Results Achieved Using Manual Processes for Fault Locating & Switching Analysis and Remote (not automatic) Switch Operation

Surprises

- Quality Control is Critical – Internal & Vendor
- You May Not Speak the “Same Language” as your Vendor
  - Enhanced System Requirements; Re-Planned Project
- Difficult to Demonstrate Reliability Improvements when the “Project” Encompasses only High Reliability Performing Areas
- Prepare for the Onslaught of New Data
- Communications Infrastructure is as Important as the Power Delivery Infrastructure
- The “Fully” Integrated System is Not Always Initially the Reality

Reaching Beyond – Next Steps

- ADMS Operational Go Live I – Q1 2015, Go Live II – Q2 2015
- System Wide IG Infrastructure 2016 – 2025
- Continue Working with ADMS Partner & Others to Develop & Implement Advanced DMS and Equipment Applications
  - Enhanced Fault Location & Characterization
  - Automated Fault Isolation & Restoration
  - Self-Diagnostics
  - Volt/VAR Optimization
  - Distributed Energy Resource Management
  - Integrated Damage Prediction & Restoration Planning

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U.S. DEPARTMENT OF ENERGY

Melanie Miller

The Smart Grid Experience: Applying Results, Reaching Beyond

October 27-29, 2014
Charlotte, NC

Melanie Miller
Duke Energy

- Over 14 years with Duke Energy
- Responsible for testing new technologies
- Currently focusing on integration of distributed energy resources into the distribution and transmission grid and integrating new technology into the Distribution Management System (DMS) to provide energy efficiencies, reliability improvements and improve customer service

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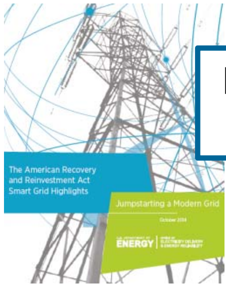

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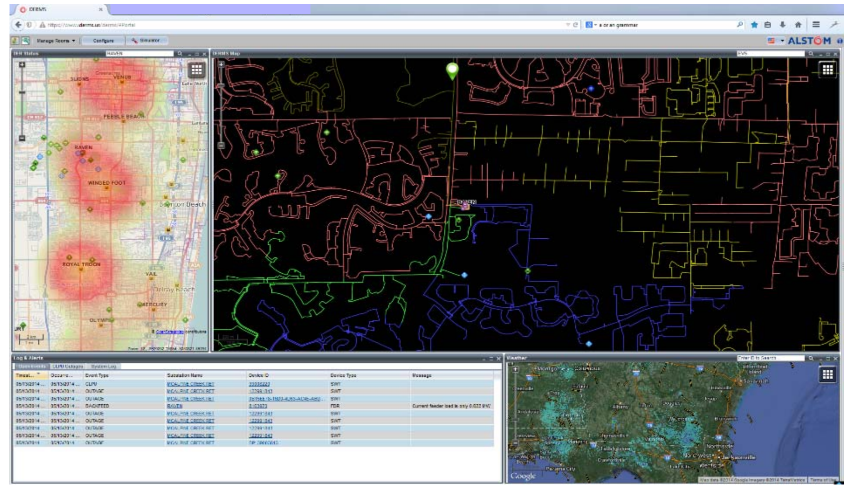
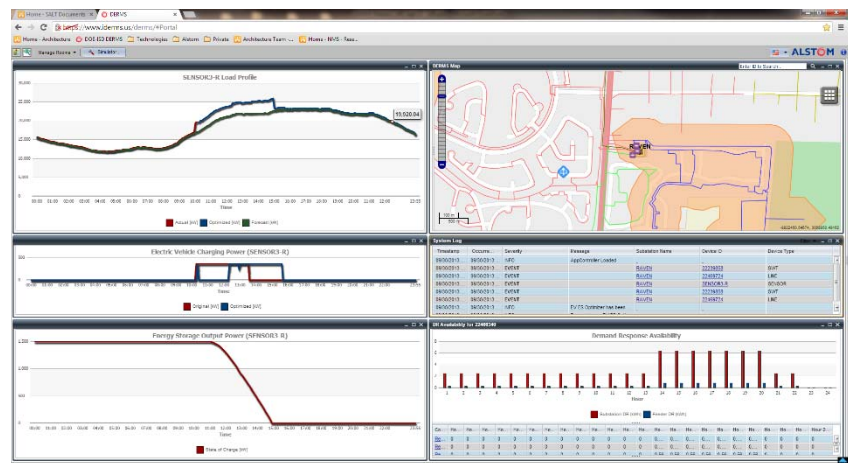
Duke Energy's Distributed Energy Resource Management System (DERMS)

Project Description

- Management and forecasting of DER (Distributed Generation, Storage, Demand Response)
- Accurate representation of the distribution system in real- or near real-time (capture real-time topology)
- Simulation of distribution systems based on real-time operational planning to analyze the benefits of smart grid assets

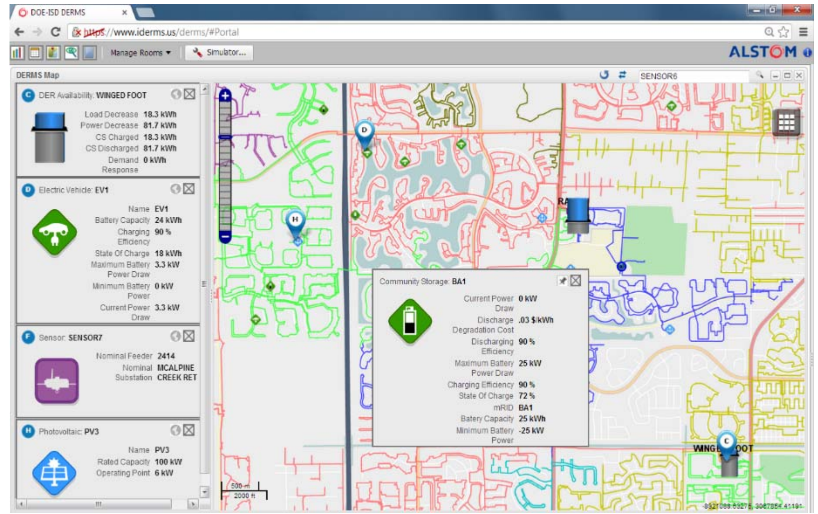


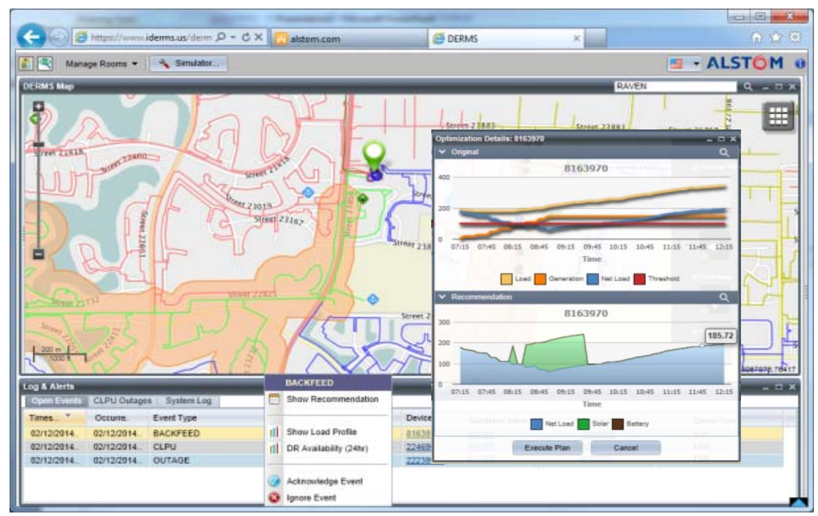


Duke Energy Distributed Energy Resource Management System (DERMS)

Project Successes

- DER visualization
- Solar back feed mitigation
- Performed modeling and verification using actual data
- Cold Load pick up mitigation

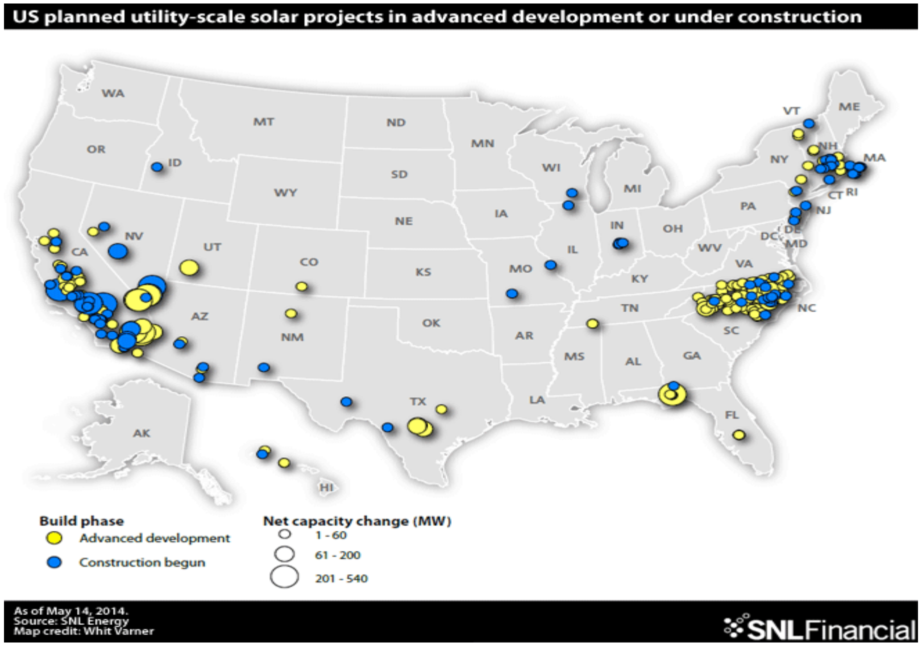




Duke Energy Distributed Energy Resource Management System (DERMS)

Surprises Related to the Project

- DERs are still maturing so the amount of change continues to significantly impact the development
- Number of early hardware companies that we planned on leveraging for this project have gone bankrupt or exited the market



- Electric Vehicles (EVs) have not penetrated the market as expected
- Solar Photovoltaic installations in the Carolina's have continued to grow

Duke Energy Distributed Energy Resource Management System (DERMS)

Reaching Beyond

- Forecasting of DERs, specifically Solar Photovoltaic
- Develop data requirements for Solar Photovoltaic model
- Regulatory change for managing DERs for grid benefits
- Developing standards for distribution and transmission lines to accommodate bidirectional power flow with the least cost design

PREMIO VPP

Final Results and Lessons Learned from the R&D Field Trial

V. Briat, M. Cassat EDF R&D/EIFER, B. Prestat, EDF R&D - EPRI

October 27-29, 2014
Charlotte, NC

Bruno Prestat

- EDF R&D, Intl. Smart Grid Program Manager
- Resident Researcher at EPRI / Palo Alto, CA
- 25+ years with EDF (15+ with EDF R&D)
- M.S. degree in Electrical Engineering from Institut National Polytechnique de Grenoble, France
- Major focus areas:
  – Power system dynamics, modeling, generators' performance
  – Electricity markets, economics and regulations
  – Smart grid, microgrids (technology integration, costs/benefits, regulations…)
  – Energy storage (EASE, EU Platform Smart Grids, EPRI ESIC…)

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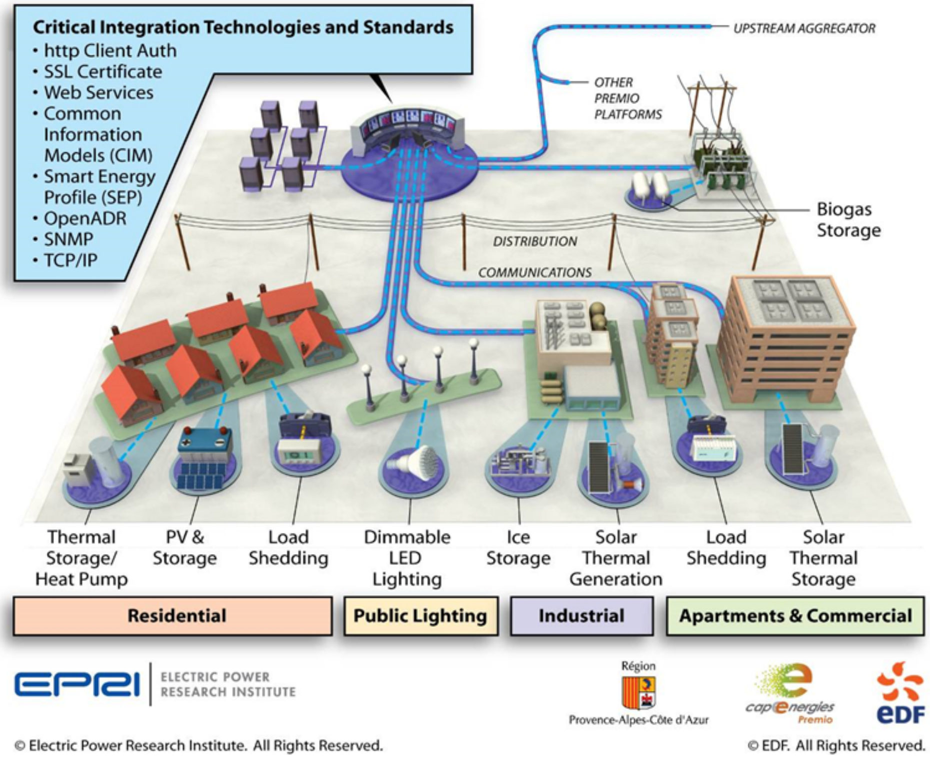
Project Description



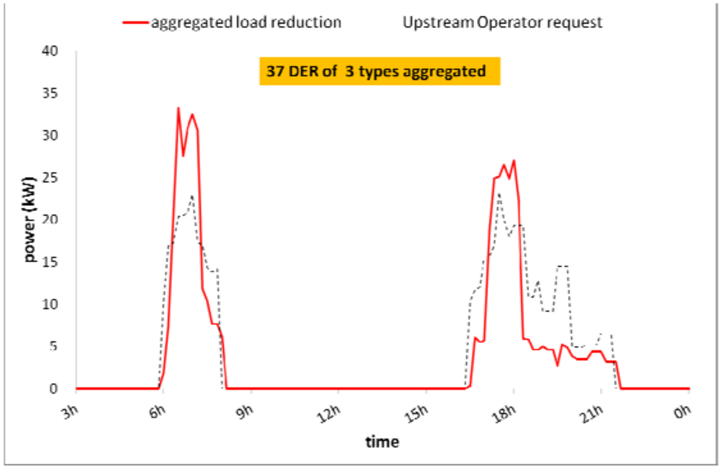
- **Why?**
  - To relieve stress on local electric grid while reducing CO2 emissions at local scale

- **How?**
  - Testing a VPP optimizing the integration of distributed generation, energy storage, and dynamic load control
  - Implementing energy efficiency measures

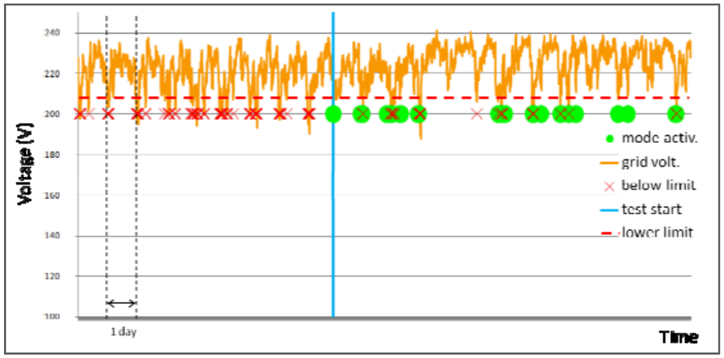
- **When & What?**
  - Winter 2010/2011: 1st test phase
  - Winter 2011/2012: regular operation, 231continuous load reductions (50% > 70 min. and 10% > 4 hours) aggregating ~40 DER

Project Successes

- **VPP: Proven Technical Feasibility**
  - VPP responded to every request
  - Load reductions up to 75% of controlled devices consumption (80 kW) at peak
  - Response velocity up to 60 kW/hour
- **Energy Reduction**
  - 600 kWh (avg.) of reduced energy (not necessarily saved) per load shedding*
- **. Consumers' Comfort and Benefits**
  - No loss of comfort for demo participants
  - Some customers could actually lower their contractual power subscription (kVA)
- **Good Performance of Tested Technologies**



Source EDF, PREMIO



Source EDF, PREMIO

*does neither consider monitoring and controlling devices consumption nor rebound effects

Surprises Related to the Project

- **Virtual Power Plant**
  - Limited response precision (small scale VPP)
- **Energy reduction**
  - Consumption of monitoring and control devices was not negligible
- **Consumers' behavior**
  - Financial savings were not the first expectation: "Pioneer Users" spirit
  - Variety of customers' reactions
- **Information & Communication Technologies**
  - Several difficulties encountered with gateways and interconnection of equipment (lack of standardization and interoperability)
  - Data Lifecycle Management: specific issue all along the project

Reaching Beyond

- PREMIO was only intended to provide qualitative results (small scale demo)
  → **Larger scale pilot projects lead by EDF or ERDF**

- An enhanced platform could be used for reserve margins calls within 15 min.
  → **Intraday use cases tested in new projects**

- Flexibility should not be limited to load reduction
  → **Load increase tested in new projects**

- French 'Linky' **Smart Meter** (ERDF to deploy 35M smart meters by 2020) at the core of new projects

Linky smart meter. Source: ERDF

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Smart Grid Experience - Distribution Automation

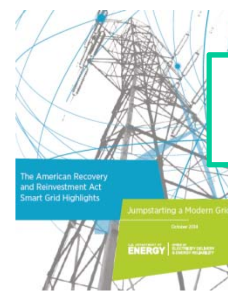
Bob Hay, Smart Grid Operations Manager, Power Delivery

October 27-29, 2014
Charlotte, NC

EPB – Electric Power Board of Chattanooga, TN – Gig City

Robert (Bob) Hay – P.E.

- BSEE Lafayette College Easton, PA
- Distribution Engineer (PP&L)
- Telecommunications Engineer (AT&T)
- Advanced Train Control (CSX)
- Information Technology (TVA)
- CLEC / Fiber Optic build out (EPB – 11 yrs.)
- Smart Grid Development (EPB – 5 yrs.)
- hayrw@epb.net



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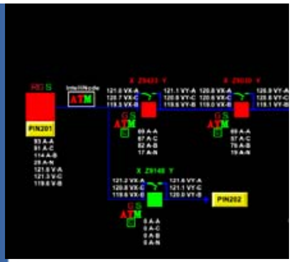
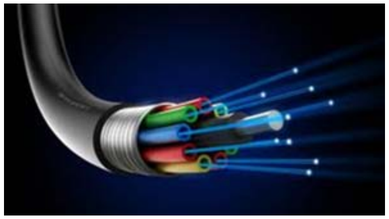


Chattanooga's Self-healing Electric Grid

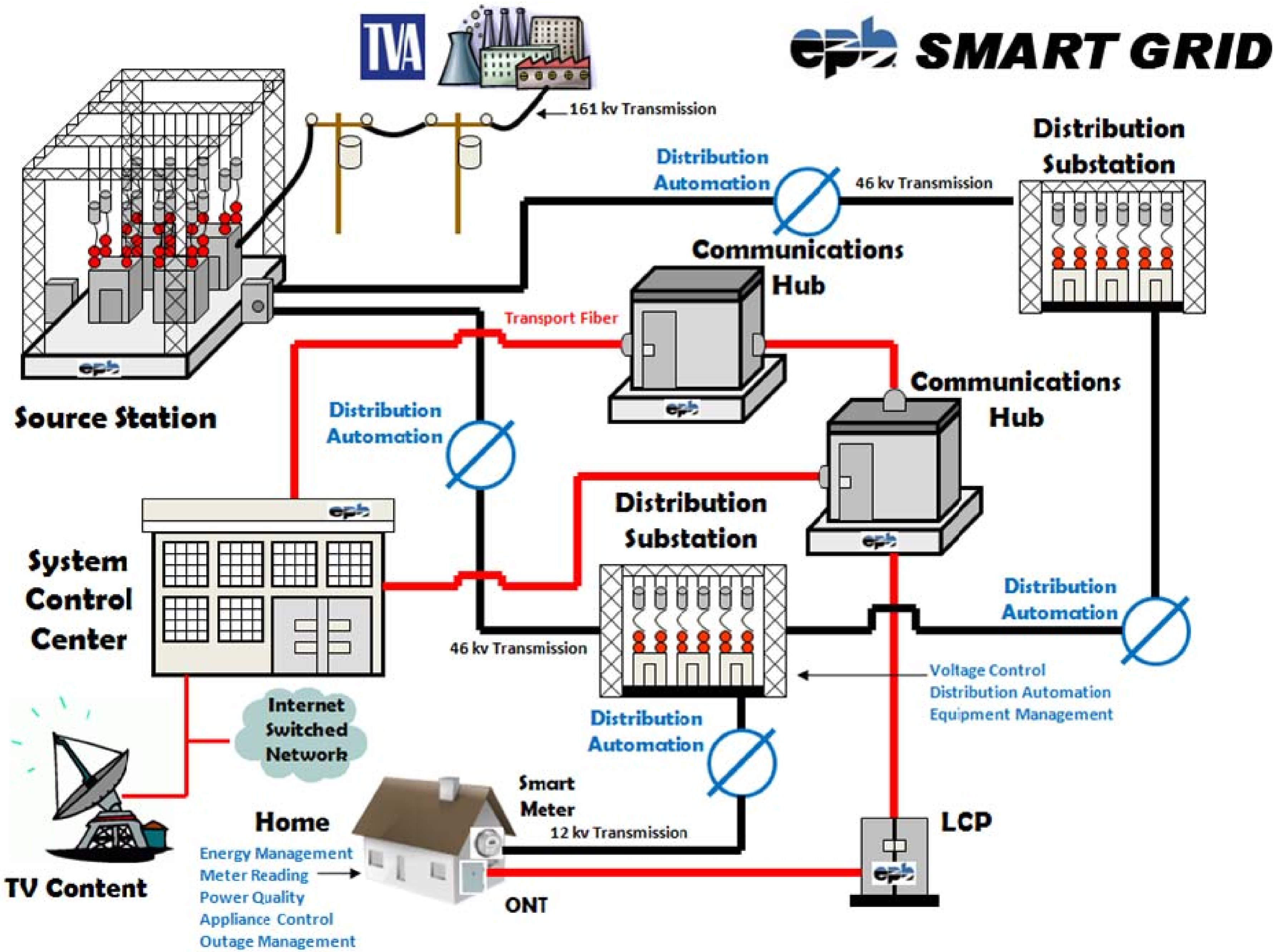


The Smart Grid Experience

EPRI – DOE: Charlotte, NC

October 28, 2014

EPB Smart Grid Development: Bob Hay - PE



SMART GRID
TVA
161 kv Transmission
Distribution Automation
46 kv Transmission
Distribution Substation
Communications Hub
Source Station
Transport Fiber
Distribution Automation
Communications Hub
System Control Center
Distribution Substation
Distribution Automation
46 kv Transmission
Voltage Control
Distribution Automation
Equipment Management
Internet Switched Network
Distribution Automation
TV Content
Home
Energy Management
Meter Reading
Power Quality
Appliance Control
Outage Management
Smart Meter
12 kv Transmission
ONT
LCP

DA Automation
Goal: Improve SAIDI 40%

Description

- **12 kV Automation**
  - $43.6 M – 1,194 IntelliRupters
  - 18 month deployment
  - Approx. 150 customers between switches
  - S&C IntelliTeam SG
- **46 kV Automation**
  - $4.7M – 214 motor operated switches
  - Every substation has automatic restoration capability for 46kv line faults
  - Schweitzer automation

SUCCESS – Yes!!!

- SAIDI / SAIFI cut in half
- Dispatcher acceptance

SUCCESS – Yes x2

- Isolate faults quickly
- Self-healing quickly
- Dispatchers can move load easily
- Reduce storm restoration time
- Additional data points and waveforms improve analysis
- LOV – thousands back in seconds

DA Surprises & Reach

Surprises

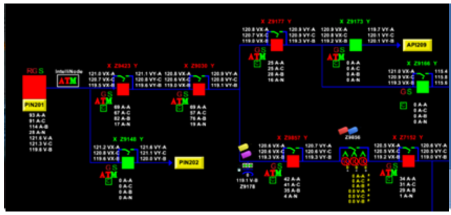
- 46 kV sensors
- 12 kV Marching faults
  - Conductor slap
- Needed taller poles
  - 40% > planned
- Processing Big Data
  - 9,800 commtrade files
- Tools to deploy software upgrades

Positive Surprises

- Dispatch ‘quiet’ at storm peak
- Storm Savings
  - 2 major storms: $2.8 M

Reaching beyond

- DA is a ‘future’ enabler
  - Distributed Generation
  - Energy Storage
  - Micro-grid development
- Conductor slap detection
  - Auto-detect & DMS fault locate
- Layering Intelligence
  - “3 mouse clicks” to visualization
  - SOE automation
    - What just happened?
    - To dispatcher in 30 seconds!
- System to deploy software



← SCADA →

Goal: Add capacity to support DA

Description

- Replace SCADA system to support 500% expansion of points
- Convert serial to Ethernet/IP
- Eliminate radio network

Surprises

- Processing big data
- Single point of fail is less urgent
- SG fault indicators clear too fast

Successes

- Poll every 2 seconds
- Process 164,000 points
  - 744 substation devices
  - 1685 line devices
- Fiber very reliable

Reaching Beyond

- Improve dispatcher experience
  - Optimize information
- Fault location predictions
  - Conductor slap & transients

AMI / SG Meter System
Goal: Basics + SG of the future

Description

- $4 M – 174,000 Tantalus Meters
- Three (3) year deployment
- One (1) Terabyte / month
- $4 M SGMS / MDM System Integration

Successes

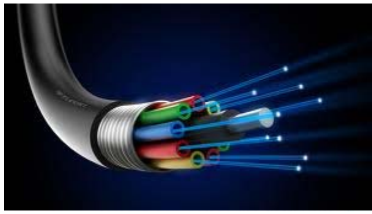
- Identify theft (150 / month)
- Remote disconnect /re-connect
- Harvest capabilities of AMI network
- Customer web portal – (usage)
- Confirm power at location
- Physical meter abstraction
- OMS Integration

Surprises

- Processing big data
- Can only generate ½ of the reports we want
- Firmware upgrade across fiber
- Data replication
- 80 operational states

Reaching Beyond

- Historical theft analysis
- Anomaly notification
- Energy management
- HAN integration



Questions & Comments

Smart Grid Experience

“Awesome” on steroids

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U.S. DEPARTMENT OF ENERGY

Implementation of a DMS at Snohomish County PUD

Will Odell

Smart Grid Program Manager

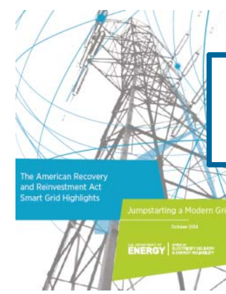
October 28, 2014
Charlotte, NC

SNOHOMISH COUNTY PUD PUBLIC UTILITY DISTRICT NO. 1

Will Odell

- Will Odell is the Smart Grid Program Manager for Snohomish County PUD.
- Responsible for research, evaluation and selection of new technologies that will be integrated into the PUD’s grid.
- Manages DOE directed ARRA Smart Grid Investment Grant
- Manages Clean Energy Fund grant from the State of Washington to install and optimize grid level energy storage and to develop the MESA standards.
- 25+ years of experience in the energy industry working in both public and investor owned organizations.
- Degrees from North Carolina State University and the University of Washington.

Speaker Photo



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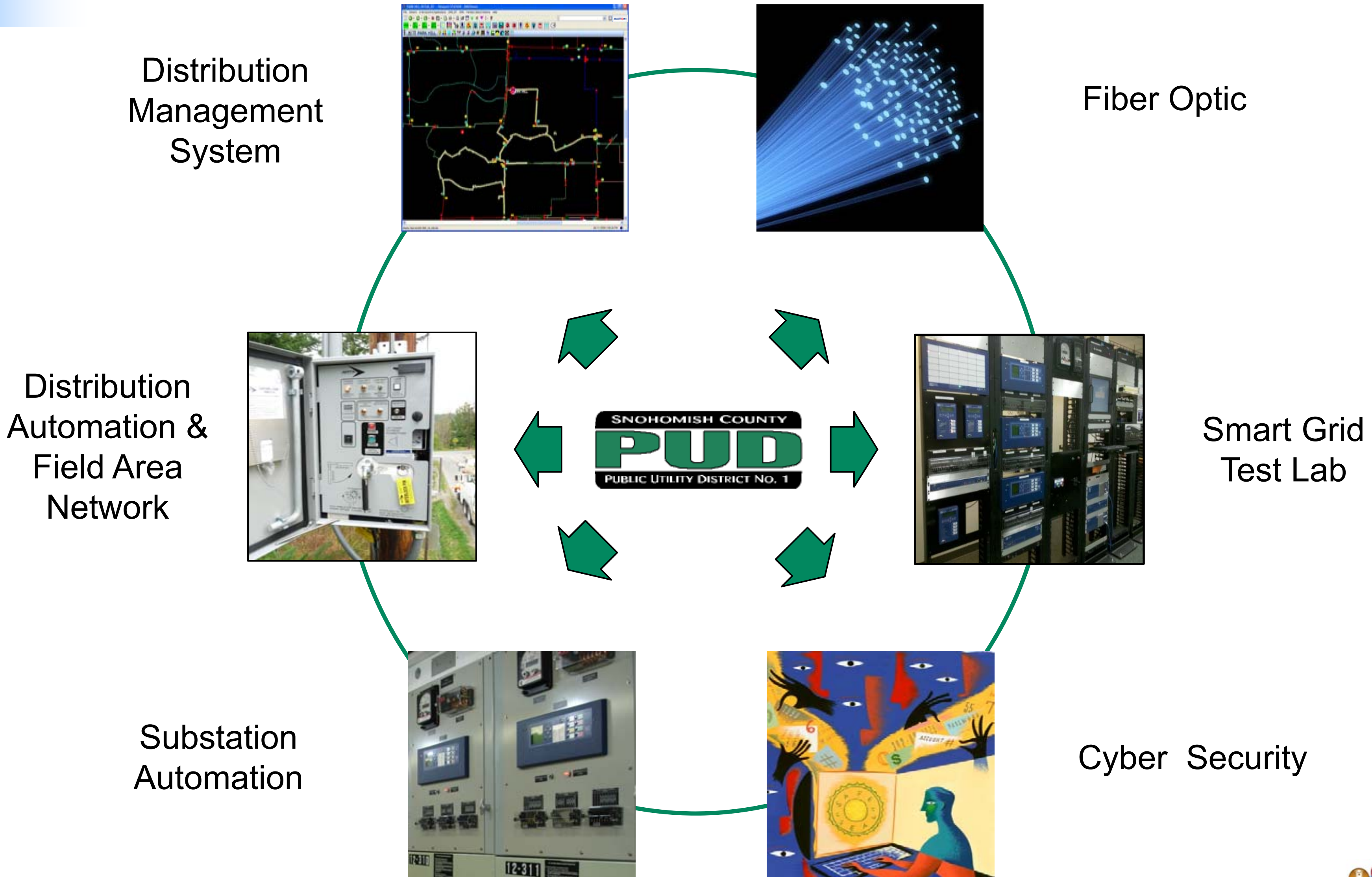
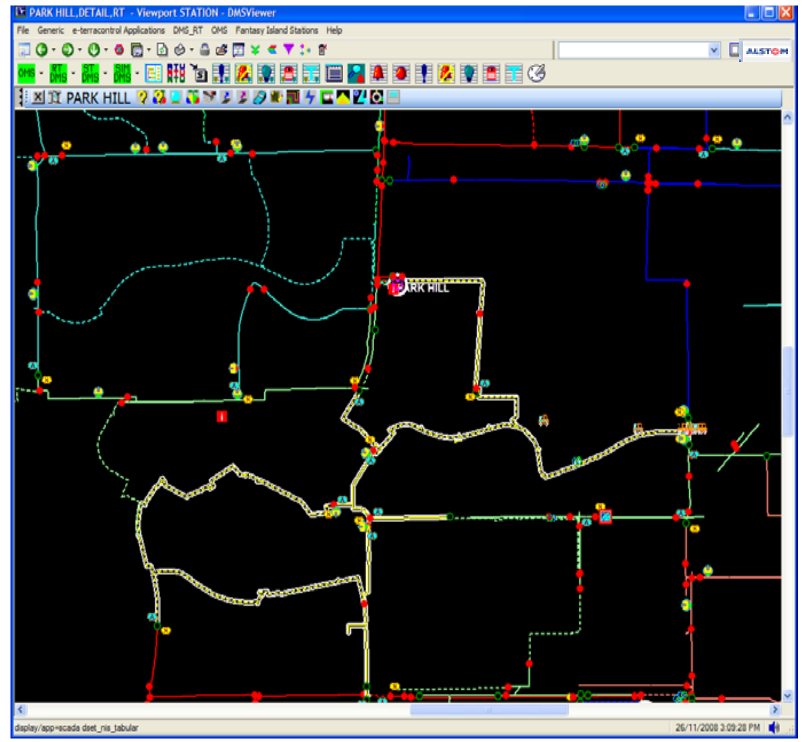
Smart Grid Investment Grant



Projects partially funded through the American Recovery and Reinvestment Act of 2009

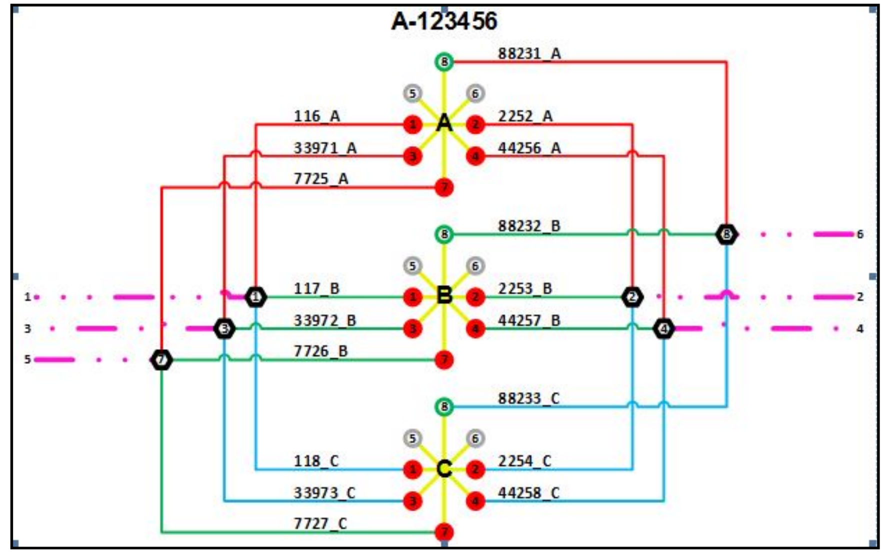
Project Description
Distribution Management System (DMS)

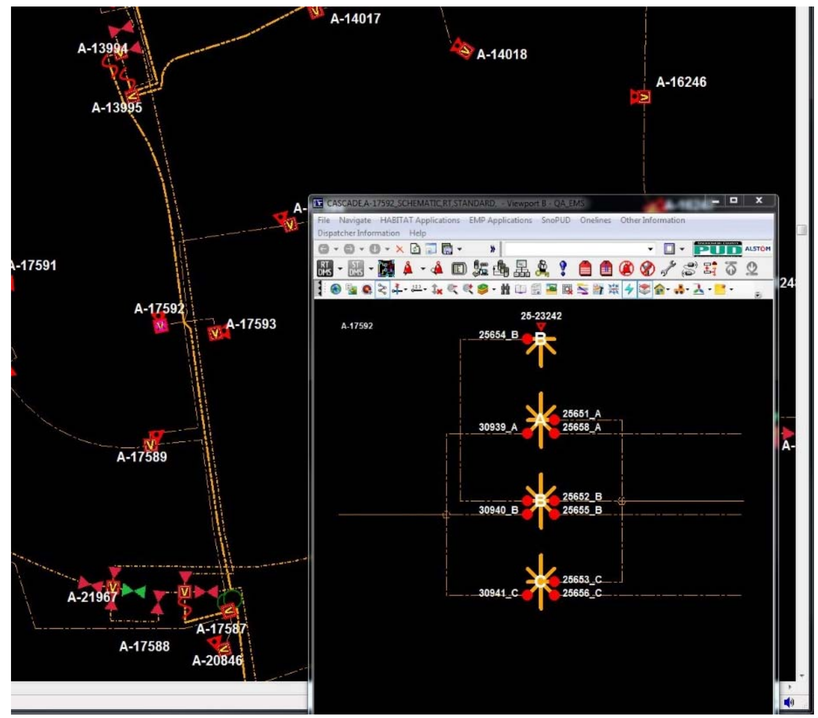
- Implement DMS
- Project Duration - 4 ½ Years
- Project Budget - $6M
- Single Platform EMS/DMS/OMS with interface with other operations applications such as GIS, CIS and Data Historian
- Operational Improvements
  - Reliability and Load Reduction
- Functionality
  - Visualization of real time model
  - Switching and clearance
  - FISR and Volt / VAR Optimization



Project Successes

- Visibility into Distribution System
- Real Time Operating Model
  - Converged Model
  - Daily Model Build
  - Vault / Elbow visualization
- Powerflow
- Training Simulator
- Switch Plans and Safety Documents
- Key Metrics:
  - 20% Reduction in SAIDI in DA Pilot area - TBD
  - 1% Load reduction through Volt / VAR Optimization - TBD





Project Surprises

- OT/IT convergence
- System Architecture - system of record
- Cyber Security - policies & procedures
- Level of effort required to map underground vaults
- Difficulty acquiring dedicated internal resources (i.e. Dispatcher, Engineering Support, etc.)
- Continual testing of DMS software releases

Process Impacts

- DMS model represents “as operated system.”
  - Wall board will get updated as resources allow.
  - Enhanced reporting and tracking of outages for SAIFI, SAIDI and CAIDI
  - Closed Loop Switching Operations (future)
- Processes that are be New or Changed
  - Near real time updating of GIS - GIS, Crews, Engineers (New)
  - Daily GIS updates to DMS including QC check (New)
  - Real Time Distribution Optimization (New)
  - Planning and Protection Processes (Changed)
  - Switch Operation Processes (Changed)

Project Challenges

- Model creation / updating
- Dispatcher acceptance
- Business process changes
- OT/IT Convergence
- Report creation & data analytics
- Nascent software – development cycle
- Vendor restrictions on use of 3rd party integrators

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Looking Forward

- Incorporating grid level Energy Storage
- DERMS
- Elimination of manual processes (i.e. wall board, paper logs, etc.)
- Advanced training simulations / scenarios
- Common platform for streamlined incorporation of OMS and AMI

Required Disclaimer for DOE Projects

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EPRI ELECTRIC POWER RESEARCH INSTITUTE

U.S. DEPARTMENT OF ENERGY

Integrated Distribution Management Systems

Southern Company
Research & Technology Management
Joe E. Schatz

October 28, 2014

Joe Schatz:
Southern Company

- Manager of Transmission and Distribution Research
  - Includes activities in:
    - Power Flow Control
    - Visualization
    - Analytics
    - Unmanned Aircraft Systems
- MSEE and BEE from Auburn University.

Joe Schatz

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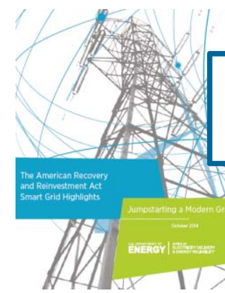

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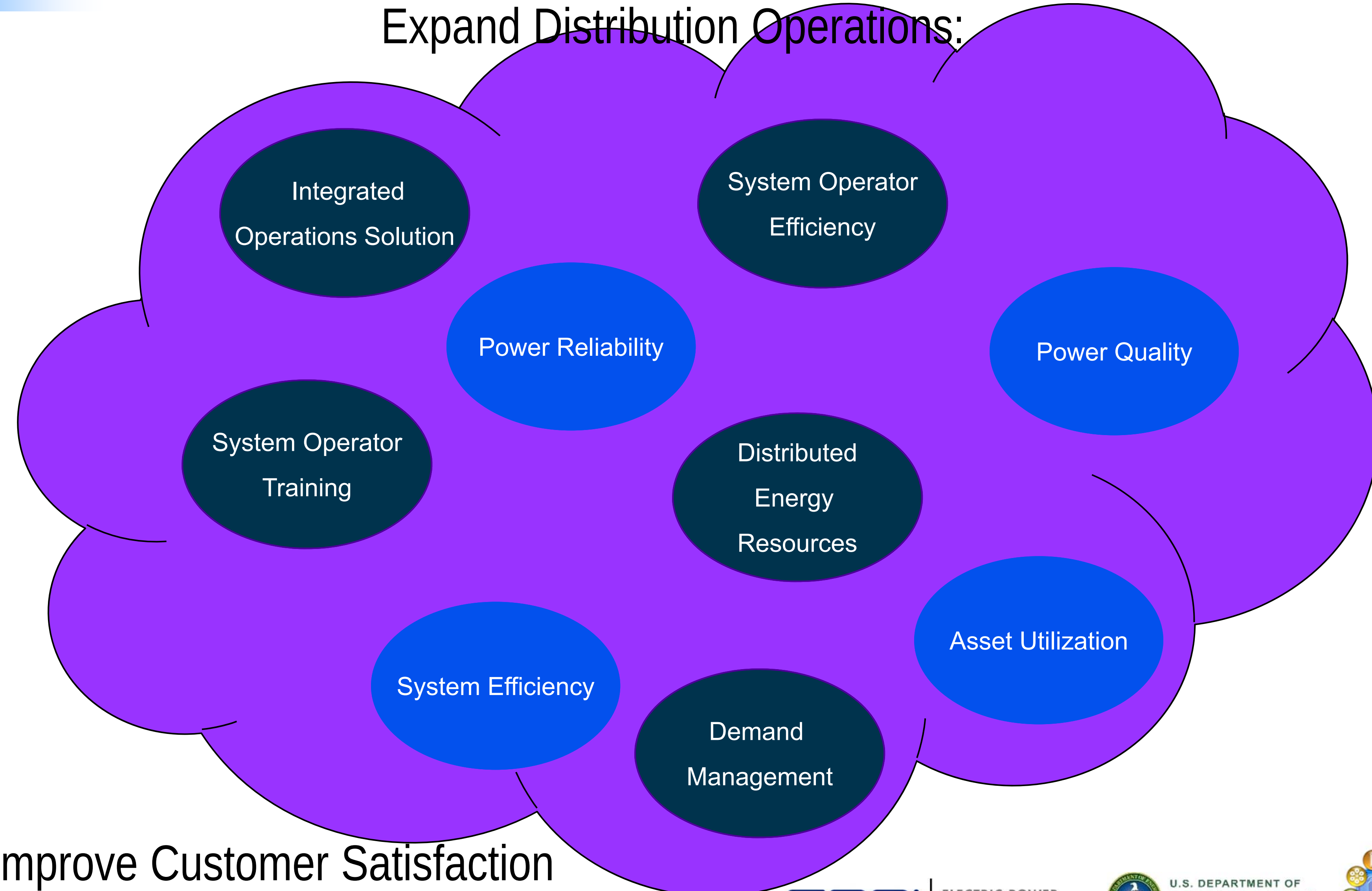
Key Business Drivers

Expand Distribution Operations:



Improve Customer Satisfaction

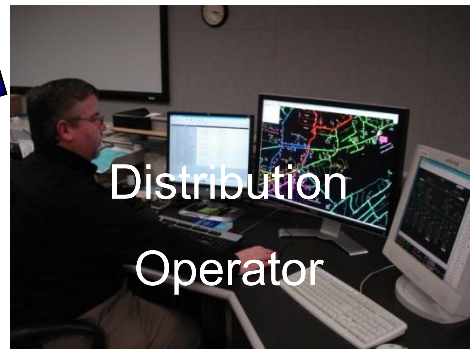
Typical Distribution Operations

SCADA

Alstom

Outage Management

DOES / TCMS

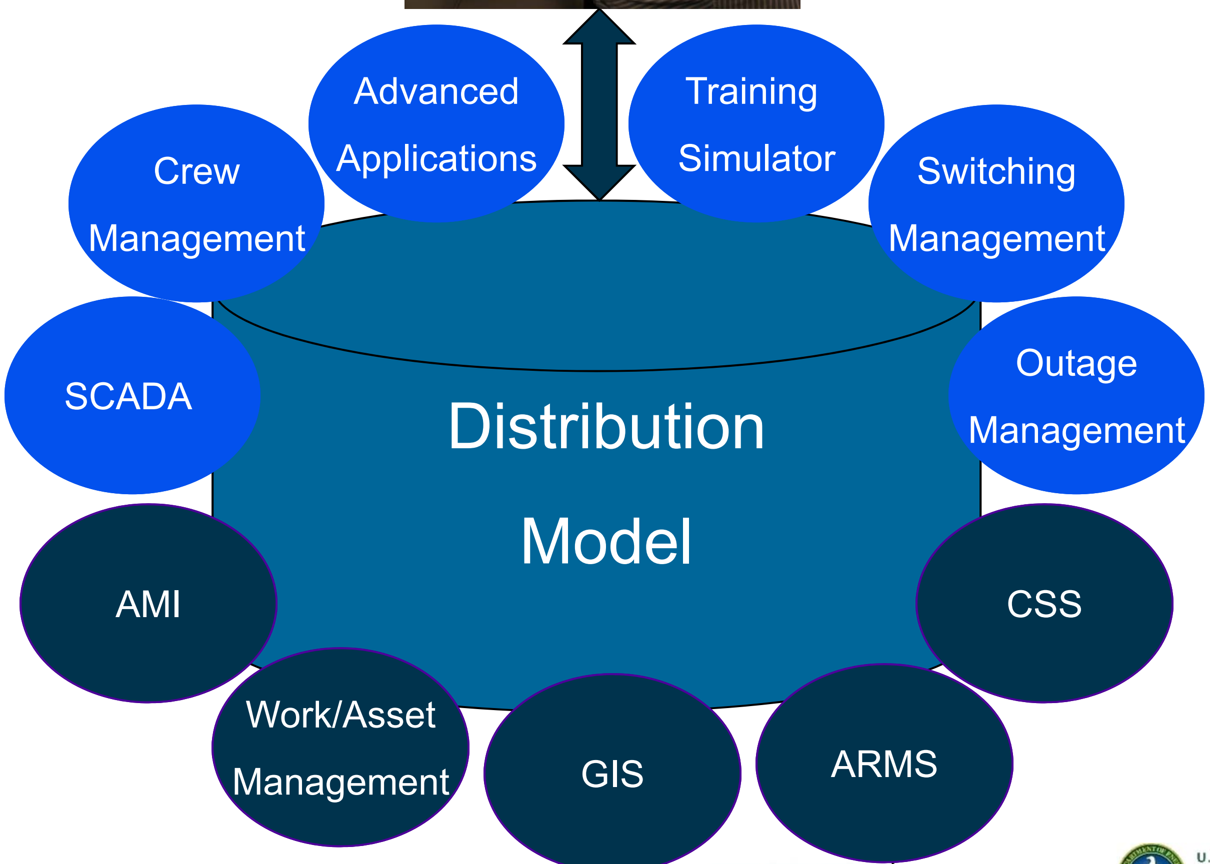


- The Operator is the "Integrator" for the disparate applications and decisions today

EMB ,TCMS,
Wall Maps, CYME
RMS, ARCO

- Southern Company utilizes numerous applications to manage the distribution system
- Real time network analysis and grid

Distribution Operations ~~in the Future~~ NOW!



Integrated Distribution Management System

Single User Interface

- Tightly integrate mission critical operations of SCADA, Outage Mgt, DMS functions into a single user interface

Intelligent Electrical Model

- Networked topological model from substation to circuits extremities facilitates the use of advanced network analysis applications to improve operational decisions

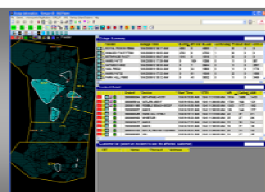
Advanced Network Applications

- Smart Grid functions for improved:
  - Distribution Asset Utilization
  - Distribution Reliability
  - Grid Efficiency
  - Demand Management

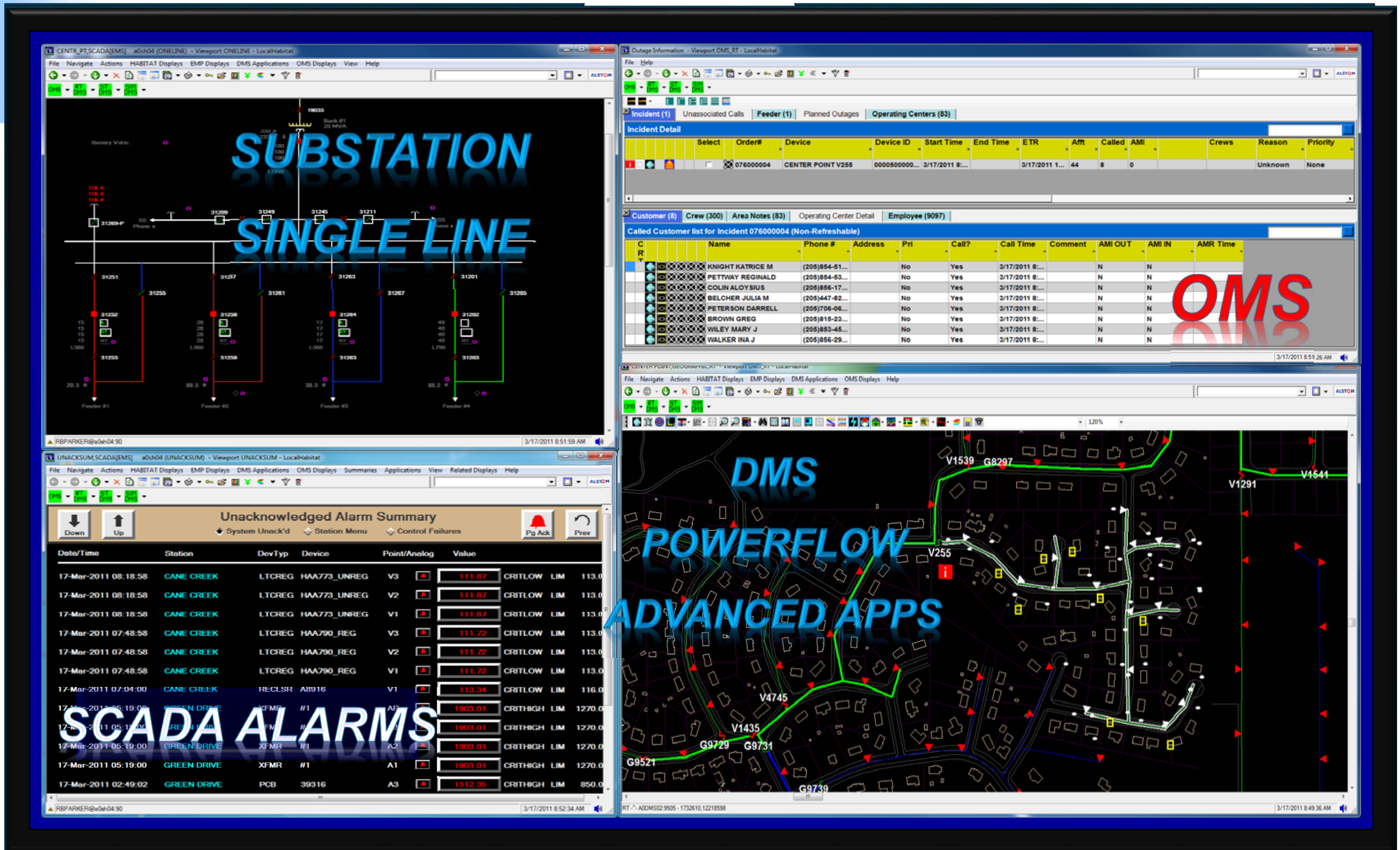
Support of Distributed Generation

- Adding local generation to supplement/offset centralized power supply
- Manage the distributed generation from IDMS

Distribution Training Simulator



- Industry first for Distribution Utilities
- Training Simulator to provide initial and on-going training of personnel
- Platform for system performance testing



SCADA Integrated Distribution Mgt System OMS

Questions / Discussion

Together…Shaping the Future of Electricity