EPRI ELECTRIC POWER RESEARCH INSTITUTE

U.S. DEPARTMENT OF ENERGY

Transforming the Grid Through Integration

Moderators

Matt Wakefield, EPRI

Merrill Smith, US DOE

Speakers

Andre Wellington, Consolidated Edison

Tom Bonner, Exelon

Eva Gardow, FirstEnergy

Brian Arellano, PNM Resources

Ed Hedges, Kansas City Power & Light

The Smart Grid Experience: Applying Results, Reaching Beyond

October 27-29, 2014

Session 1:
Transforming the Grid Through Integration

Applying Results:

Successes

Surprises

Reaching Beyond

Andre Wellington

conEdison

- Smart Grid Project Manager, Con Edison
- Responsible for managing deployment of DRMS and DERMS platforms and associated demonstration technologies. Technologies include energy storage, building controls, distributed generation and residential DR.
- Ten years of experience in the utility industry covering various areas including smart grid, residential and commercial demand side management, substations and distribution systems.
- Certified PMP, MBA from NYU, BSME from GA Tech

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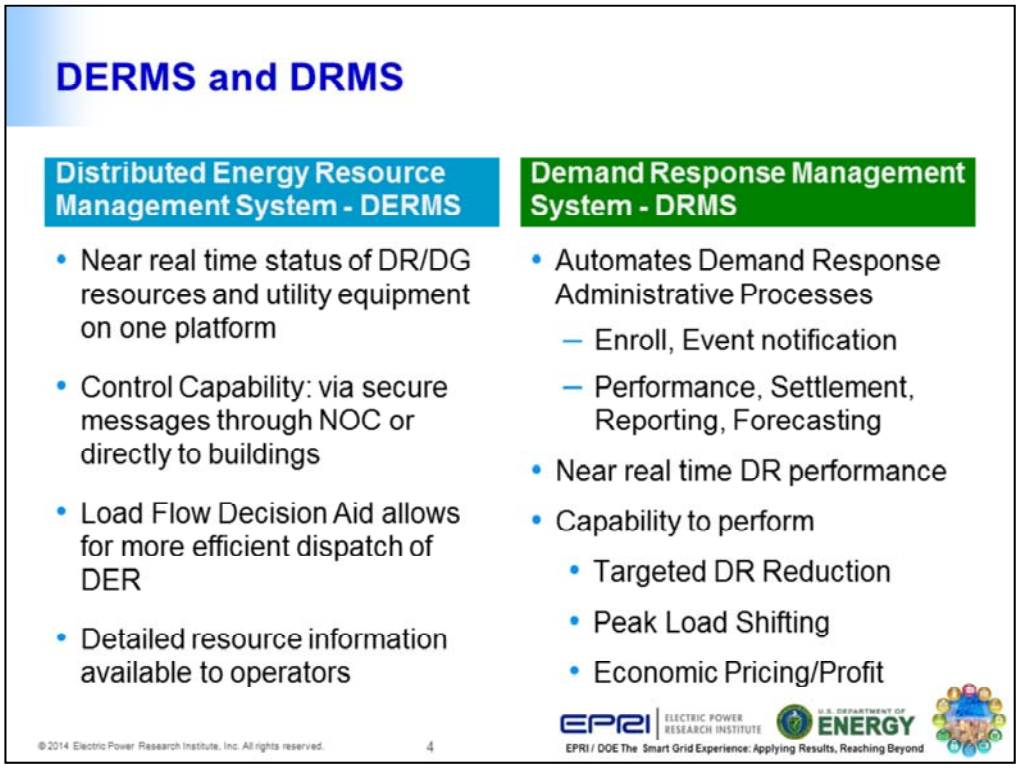


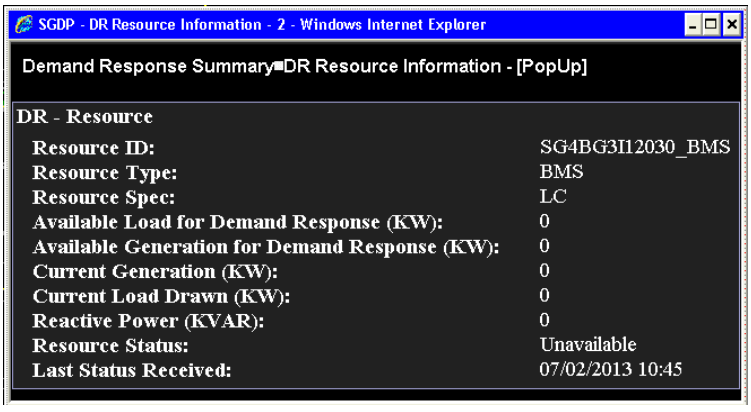
Distributed Energy Resource Management System - DERMS

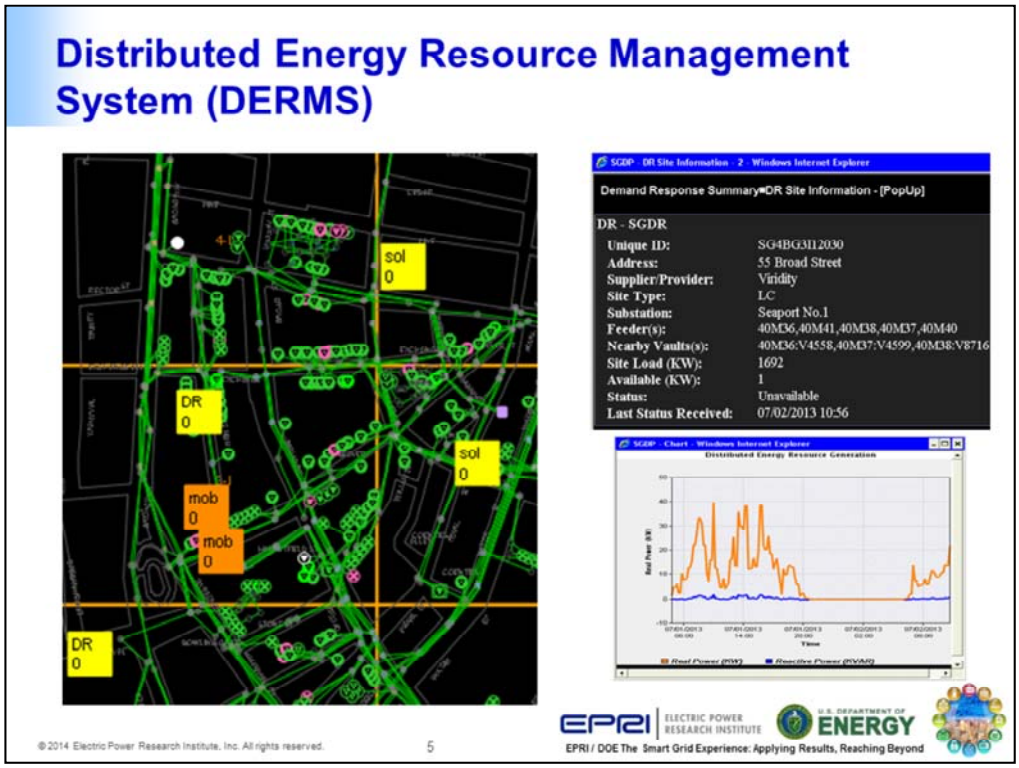
- Distributed Energy Resource Management System – Siemens/TIBCO
- Demand Response & Distributed Generation resources integrated with distributed system
- Near real time status of DR and DG resources
- Control Capability: Demonstrated control of DR Resources via secure messages through NOC or directly to buildings (proof of concept)
- Load Flow Decision Aid allows for more efficient dispatch of DER (proof of concept)
- User Group – Distribution Engineering

Demand Response Management System - DRMS

- Demand Response Management System
  - Alstom Grid
- Demand Response Program Management
  - Enrollment, Event notification, Performance/Settlement, Reporting
- Near real time DR performance – Aggregating
- User Group – Energy Efficiency

Sample of DER information available in DERMS ->





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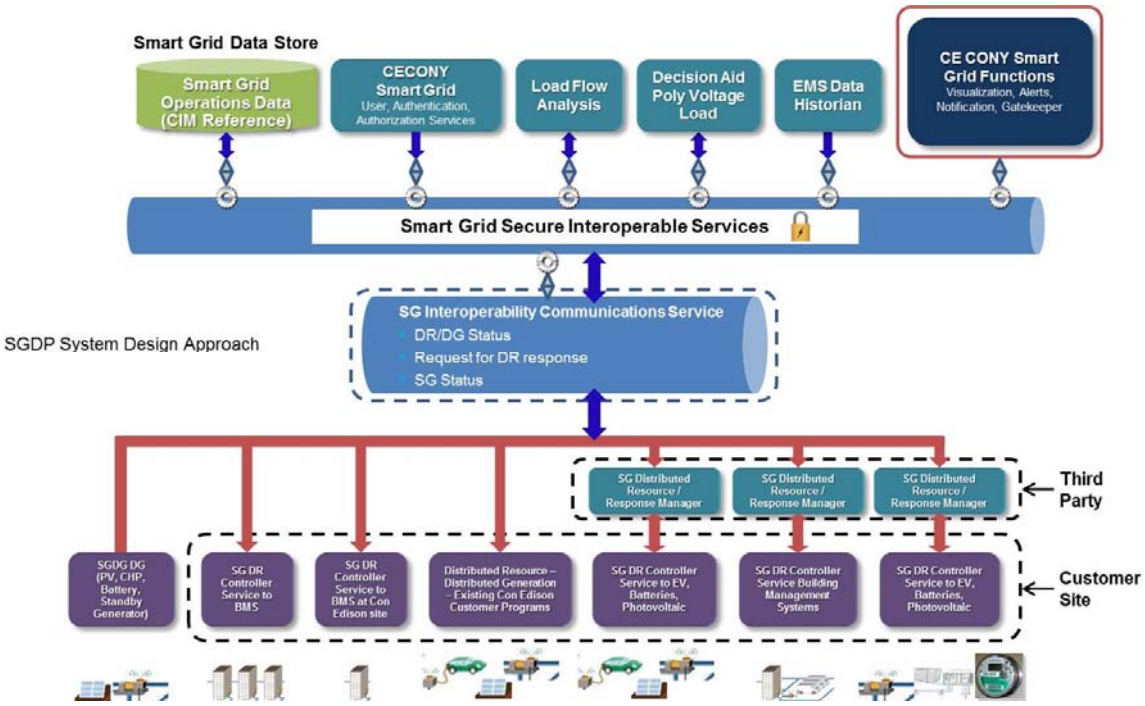

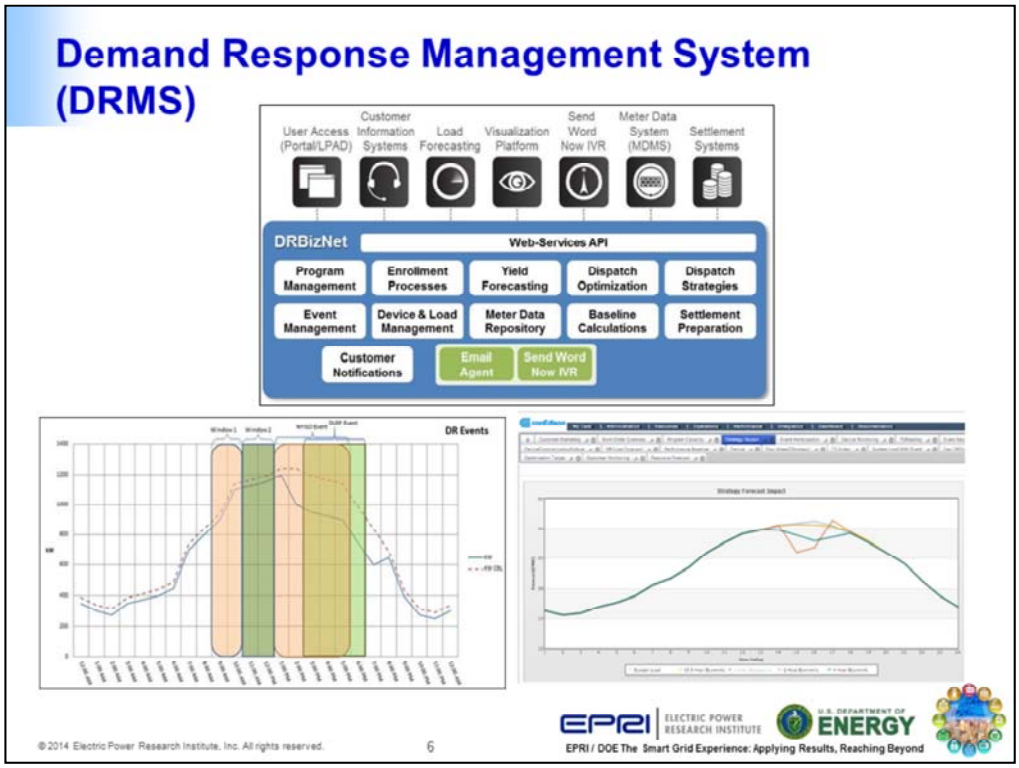

Demand Response Management System - DRMS

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  - Alstom Grid
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- Control Capability: Alstom targeting to implement OpenADR 2.0b by end of 2014 (disabled initially)
- User Group – Energy Efficiency

Program	June 2013 Enrollment		June 2014 Enrollment		% of Change	
	MW	Customers	MW	Customers	MW	Customers
Commercial Contingency	175	677	189	716	8%	6%
Commercial Peak-Shaving	72	278	111	385	54%	38%
Residential Contingency & Peak Shaving	37	26,898	40	30,353	7%	13%
NYISO	408	2,302	381	1,964	-7%	-15%

RESERVATION PAYMENT OPTION INCENTIVES

Reservation payment

$10 per kW per month for 4 or fewer events in a month

$15 per kW per month for 5 or more events in a month

Performance payment: $1.00 per kWh

Unplanned Event Payment: $6.00 per kWh (based on performance)

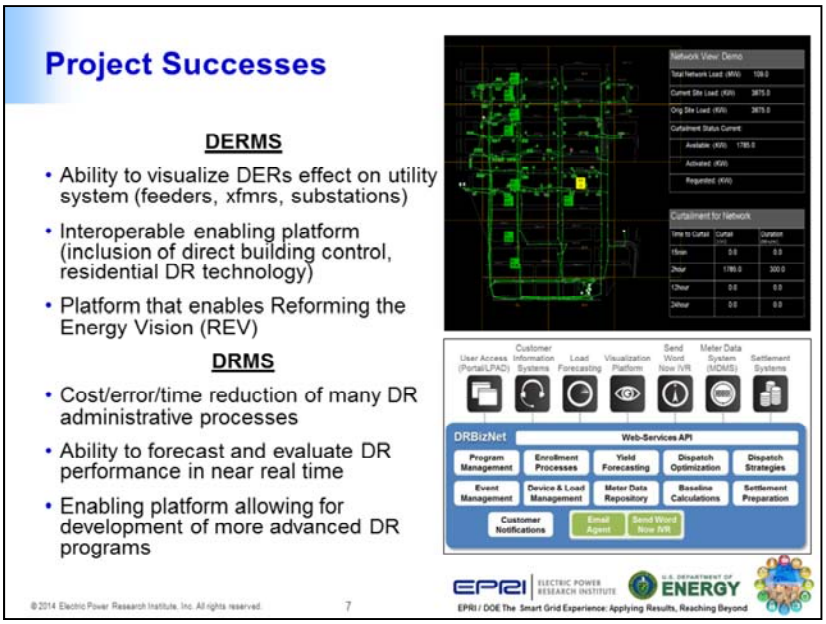
Three Year Incentive payment: $10 per kW per month per season for the three year incentive period for customers who complete three years and perform at 80% or over for Planned and Test events.

Performance penalty based on a 1:1 ratio

VOLUNTARY OPTION INCENTIVES:
Planned Event: $3 per kWh
Unplanned Event: $10 per kWh
No Reservation and No Three Year Incentive payments

Standard event window: 4 hours

Program duration: May 1 – Sept. 30



DR in Con Edison

-MWs and Customer count rising

-Administrative costs for DR portfolio very high.

-Baseline calculation is very complex

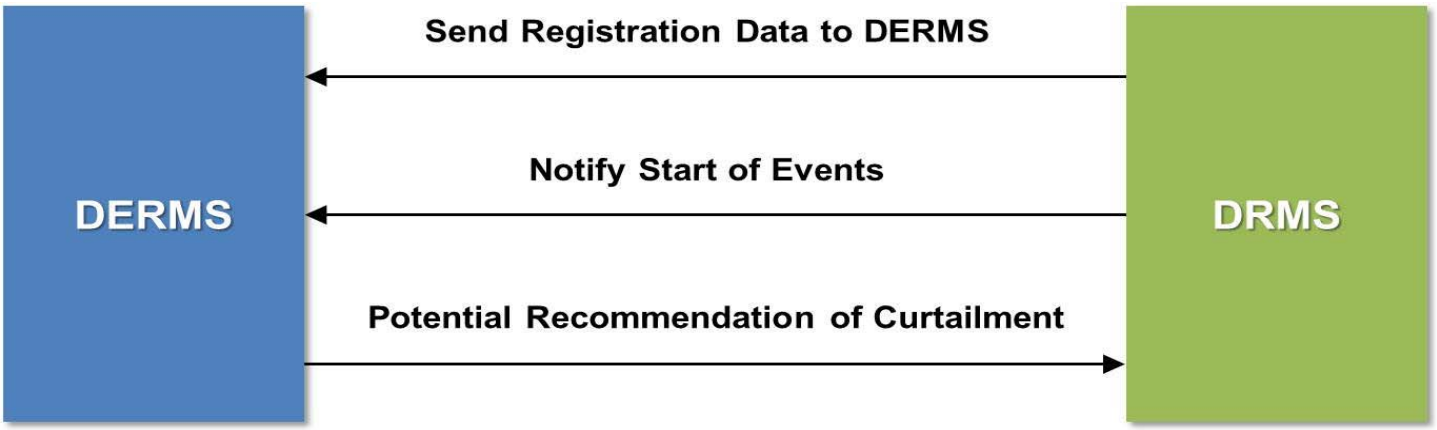
- Lookback window 30 days, 15 min intervals
- Most similar 10 days selected, bottom 5 dropped
- Aggregators evaluated on portfolio performance
- Penalties for non perfomance

-Utility DR programs dispatched same time as ISO programs

DERs used to test DERMS

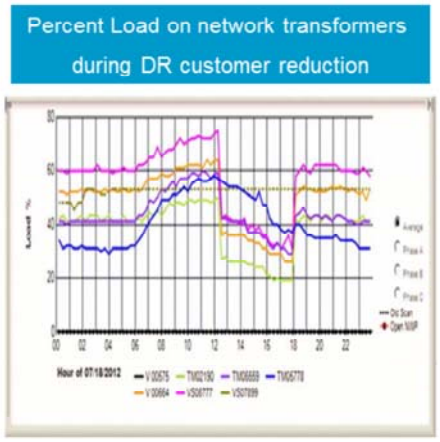
Resources:

Distributed Generation
Energy Storage
Electric Vehicle Charging Stations
Building Management Systems
Home Area Networks - modlets
Demand Response Customers



Surprises Related to the Project

- Shifts in regulatory agency views can greatly change utility priorities and ways in which DERs are dispatched
- DRMS was a bridging platform to enable us to increase magnitude of DR and enable more advanced programs
- Viewing the impact of DERs on company equipment is key to future utility use of DERs



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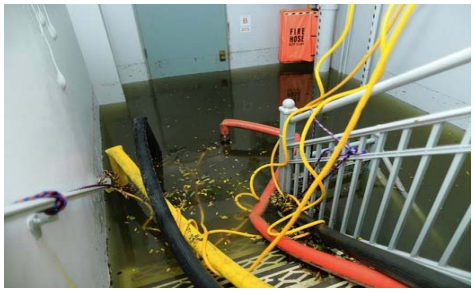
EPRI / DOE The Smart Grid Experience: Applying Results, Reaching Beyond

<u>Company Wide Strategy for Integrating Customer-side Resources</u>
-Identify networks that are experiencing capacity constraints
-Determine availability and reliability of customer-side resources
-Enhance utility operation to integrate and operate reliable, real-time resources
-Include alternative resources and capacity deferrals in system infrastructure plans – <u>need accuracy in doing this.</u>

Other Surprises from our subawardees - partners who delivered DERs to the project

Superstorm Sandy caused redesign and redeployment of some customer resources.

- Thermal Storage Plant in lower Manhattan in basement of this building (see pictures)



The specifications around different DERs have to be further developed to enable wide spread adoption and deployment

- Reverse Power Relays (RPR)
- Tariff changes for battery storage to enable better payback periods

Reaching Beyond

- Deployment and internal training for platforms ongoing
- Strengthening legacy systems crucial
  - Wireless communications systems upgraded
  - Data quality of CIS systems reviewed
- Keeping platforms interoperable – residential technologies next
- Market analysis of technical and achievable potential of DERs necessary
- New program development necessary based on above analysis
  - More capacity vs more advance programs
- Educating regulators/customers on new platforms

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EPRI / DOE The Smart Grid Experience: Applying Results, Reaching Beyond

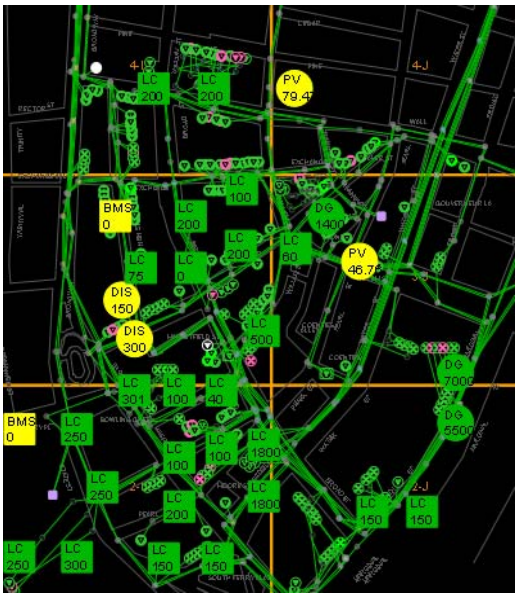
Over Saturation of Demand Response resources needed to simulate PVL decision aid and DRs relieving system Constraints. ->

Raises the question- do we want

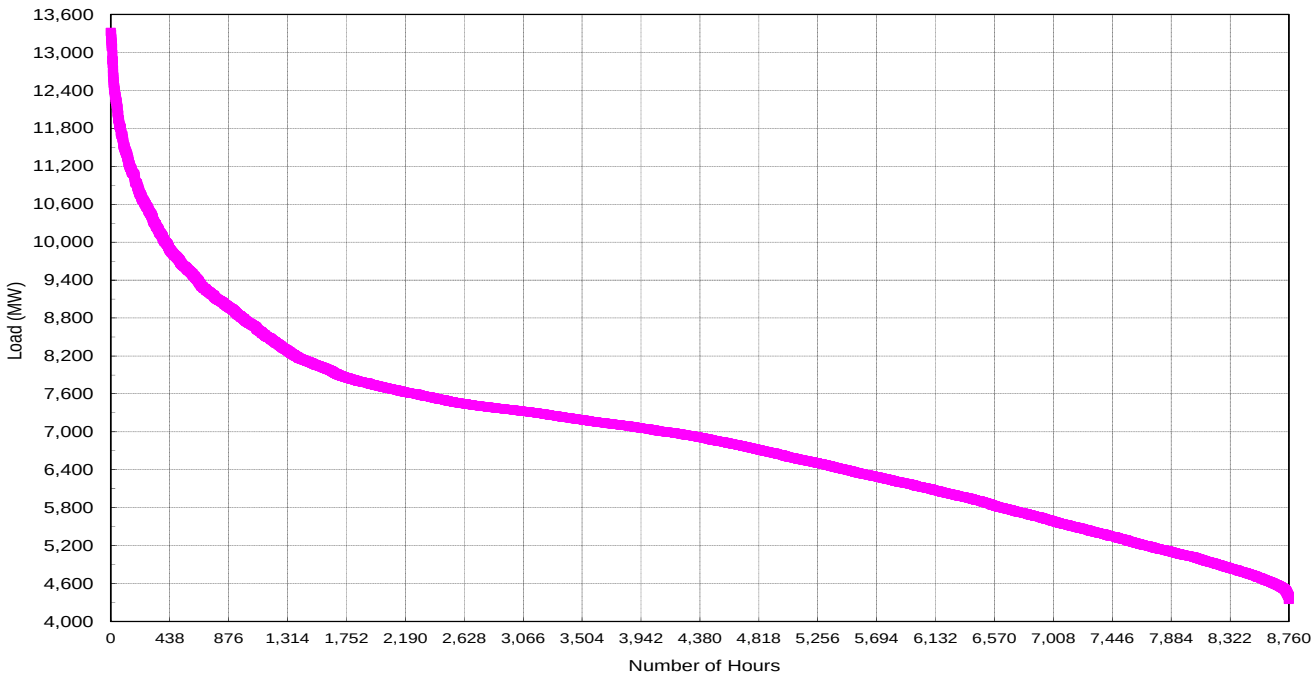
More MWs through simpler/less complex programs

or

faster more advanced programs (i.e. auto DR)



Con Edison Load Duration Curve 2013



1 or 2 Questions?

Tom Bonner, PECO

- Manager, Corporate Policy, PECO
  - At PECO since 2007, was lead author of PECO Smart Grid Investment Grant and Project Manager for Partnership projects
    - Oversaw SGIG Partnership customer-side demonstrations of Drexel University, Univ. of Pennsylvania and Liberty Property Trust
    - Organized 2012 DOE MidAtlantic Smart Grid Collaborative
  - Worked at MidAmerican Energy Holdings Co. as Manager, Congressional Relations, 1997-2007
  - Associate Director, Washington, DC Office of PA Governor 1995-1996
  - Senior Legislative Aide, U.S. House of Representatives, 1991-1995
  - B.A. University of Pennsylvania 1987, M.A. University of Virginia 1996
- .

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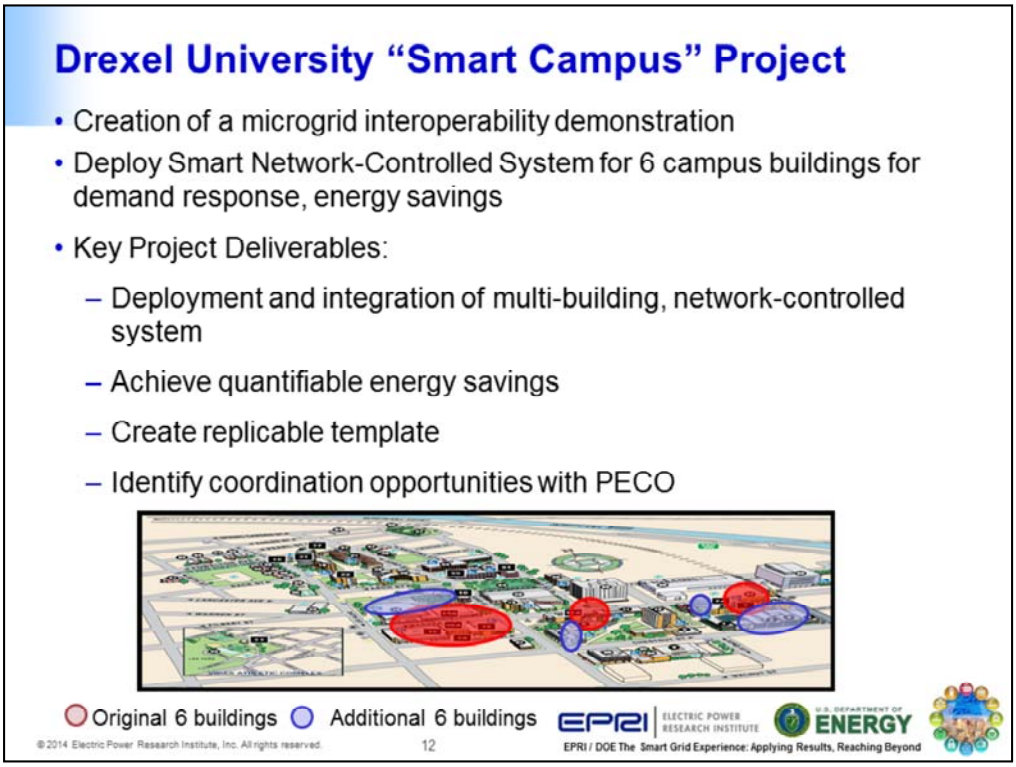

As part of its U.S. DOE Smart Grid Investment Grant project, PECO sub-allocated ~$4 million of SGIG funding to support sub-recipient demonstration projects.

In addition to the Drexel "Smart Campus" project, PECO allocated funding to the University of Pennsylvania to install AMI metering in campus buildings and upgrade two campus substations with smart technologies comparable to PECO and to Liberty Property Trust to pilot energy management technologies and identify shared owner-tenant savings models.

The projects aimed to identify opportunities and challenges in achieving EE and DR opportunities in the institutional and commercial sectors

Project Successes

- All project deliverables completed favorable to budget with expanded scope (12 buildings v. 6 planned)
- Energy Management Simulator completed and operational
  - Hardware, software platform for developing and testing smart grid applications
  - Laboratory components replicate building load behavior and test energy management approaches
- DR events executed and active participation in energy markets (DOE project period)
  - PJM Energy Market – 138 MWh sold for ~ net retail savings $15,140
  - PJM Capacity Market – 15 MWh sold yielding estimated net revenue $58,372
- 13 technical papers published
- Lessons Learned
  - Importance of meter selection and placement in "smart buildings"
  - Importance of close coordination between campus facilities and network operations in design, planning and operation
  - Increased PECO understanding of opportunities and challenges of Demand Response capabilities at campuses and institutional customers

Project Successes

Monthly energy market participation showing load response and corresponding credit

Year	Month	Load Response (MWh)	Load Response Credit ($)
2010	June	2.273	239.300
2010	July	21.066	3556.740
2010	Aug.	23.582	2087.420
2010	Sept.	6.451	711.680
2011	July	4.586	1009.430
2011	Aug.	2.052	108.180
2011	Sept.	0.465	8.880
2012	May	6.817	-22.380
2012	June	19.025	1082.050
2012	July	13.195	1334.700
2012	Aug.	9.574	914.690
2012	Sept.	5.412	497.170
2012	Oct.	-0.877	-39.110
2013	June	0.178	9.406
2013	July	5.996	514.474
2013	Aug.	3.916	-53.893
2013	Sept.	13.847	595.449

Load response results are highly weather and market dependent. 2014 results are being finalized, but mild weather resulted in comparatively low market participation

Surprises Related to the Project

- Economic environment related to wholesale energy prices changed significantly from time of development (2009) to execution (2011-2014)
- Initial project description identified Siemens DEMS as the simulation environment for DR planning model. Cost and flexibility issues led to the decision to develop software in-house
- Original project plan intended to utilize existing metering to support demand response plans at Drexel.
- During the project it was determined installation of sub-metering would be required to achieve project goals
- Additional sub-metering in turn required programming changes to the building management system (BMS)

Reaching Beyond

- SGIG projects provide test cases on how sophisticated customers can apply behind-the-meter technologies for EE/DR
- Continue expansion of Drexel network to determine cost-effective opportunities to expand EE/DR
- Continue to develop innovative methods of demand side management and Smart Grid technologies through Drexel network studies and the Drexel Energy Management Simulator
- Apply lessons learned from these projects to work with other projects/customers (Navy Yard, City of Philadelphia)
- Deploy AMI metering to largest MV-90 class customers

1 or 2 Questions

Eva L. Gardow, FirstEnergy Service Co.

- Senior Project Manager at FirstEnergy Service Company
- EPRI Smart Grid Integrated Distributed Energy Resources Management project manager which is deployed in FirstEnergy's New Jersey distribution company, JCP&L. Technologies include direct load control, distribution line sensors, substation monitoring and energy storage technologies
- Chair of EPRI's Energy Storage Integration Council
- Energy Storage Board of Directors
- Managed JCP&L's renewable energy program for New Jersey
- Holds a BSME from Clarkson University and an MBA from the University of Hartford.

FirstEnergy

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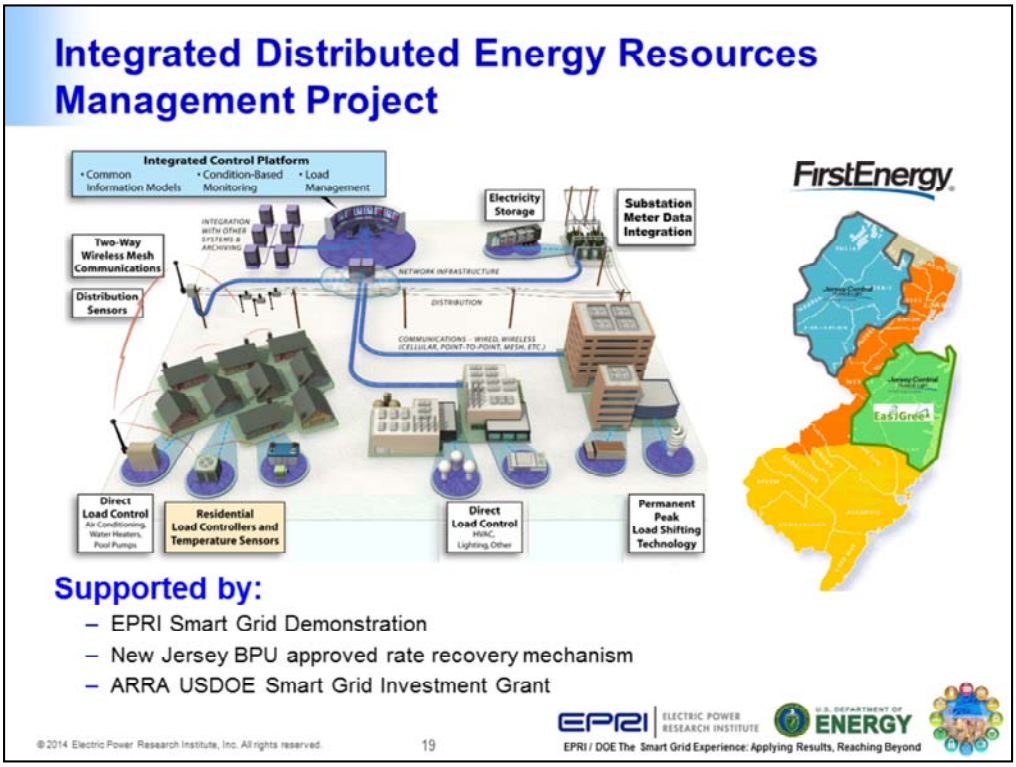
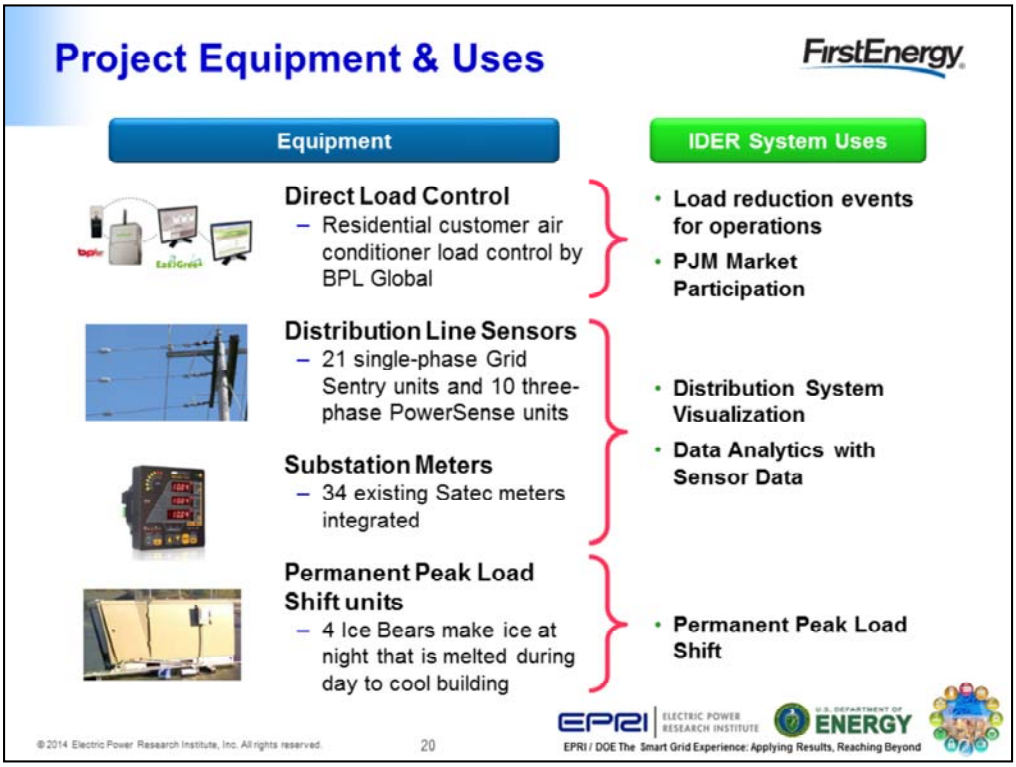
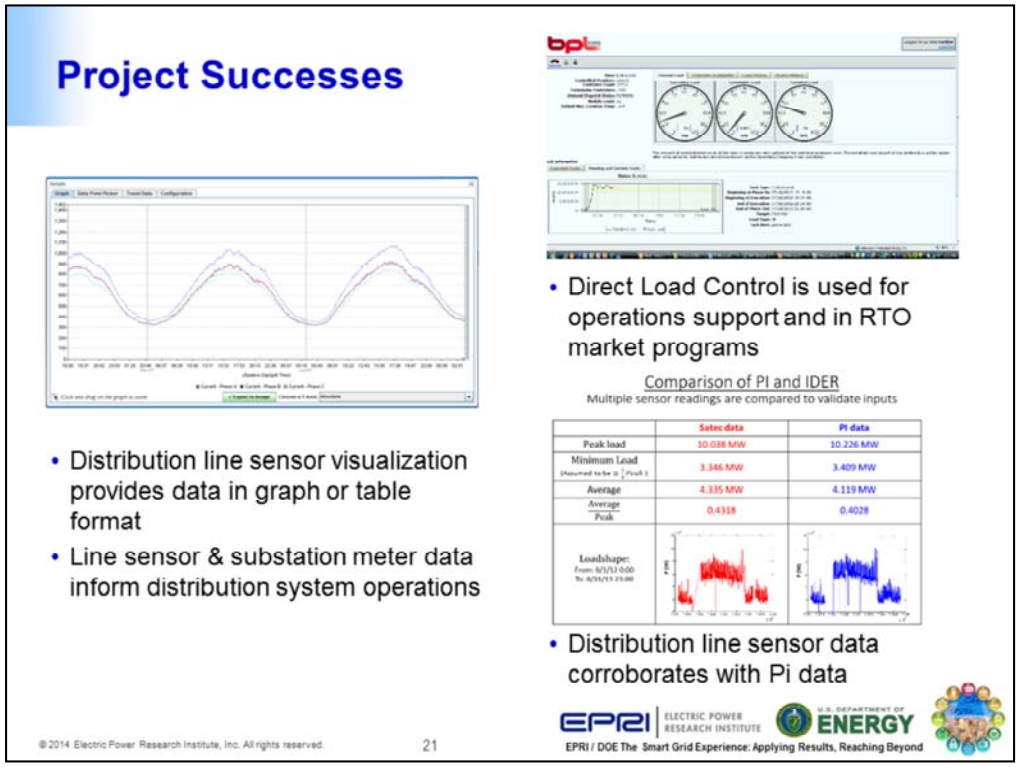


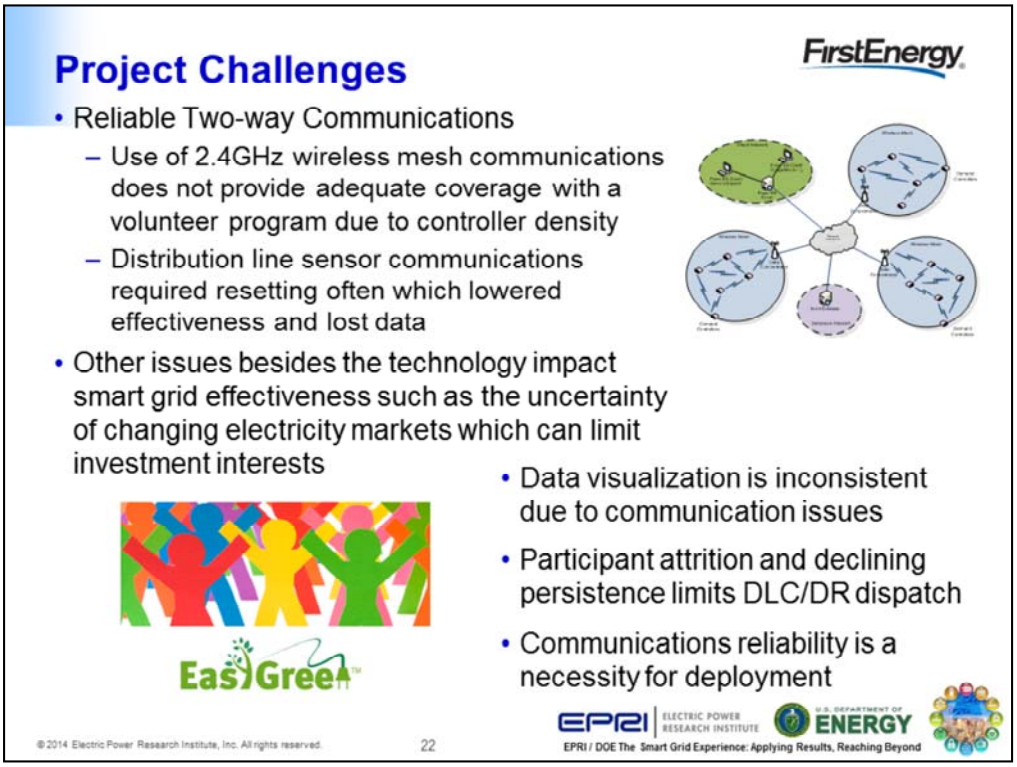
- Integrated Distributed Energy Resources (IDER) Management to support Distribution Operations and participate in PJM market programs
- Demonstrate value and viability of an integrated targeted real-time system monitoring, visualization and peak load management from an Integrated Control Platform (ICP) using two-way communication



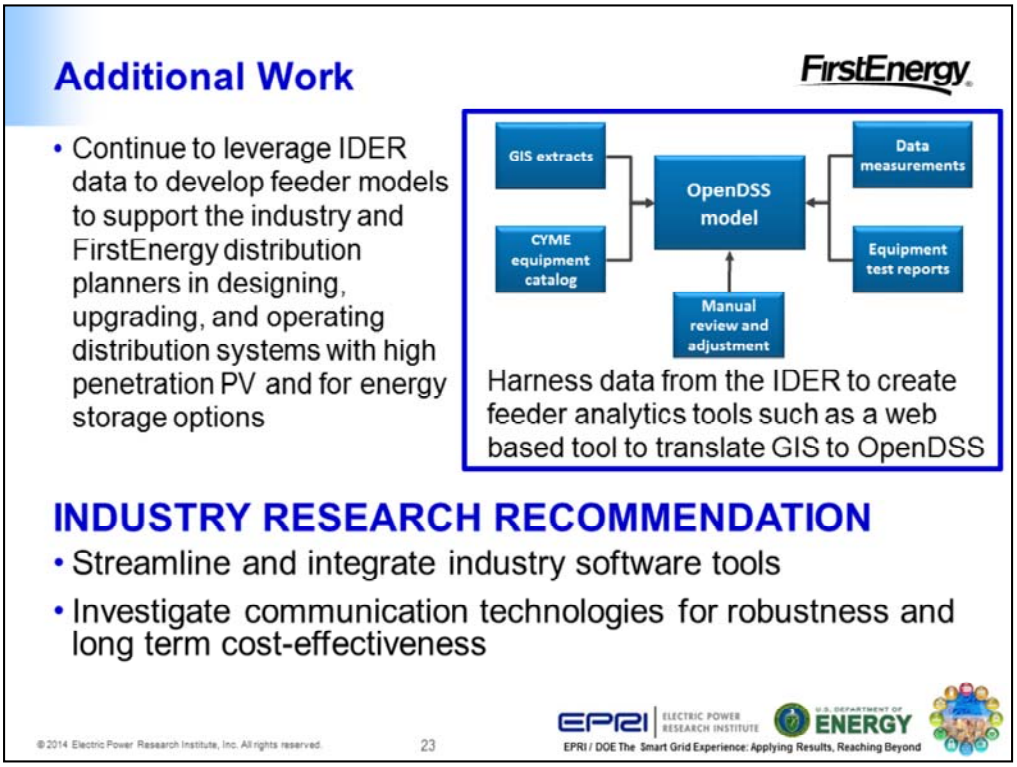
- Installation of all technologies went well
  - Customer response to DLC marketing program was higher than average through the use of door-to-door solicitation
  - JCP&L line crews installed DLS and provided feedback to vendor that improved installation techniques
  - JCP&L Techs installed substation meter communications so that full data sets could be accessed by operators and engineers
  - Ice Bears were installed on a Staples roof by contractor and were well accepted by customer.



- Direct Load Control managed centrally using 2-way communications is used in RTO market programs
- Line sensor & substation meter data inform distribution system operations
  - Optimizing maintenance schedules
  - Verifying accuracy and timing of emergency load transfers
  - Assisting in solving customer complaints
- Distribution line sensor data visualization gives planning engineers easy access to load profiles, load balancing info and other distribution line anomalies
- Pi data was corroborated with Satec meter data. Prior to the integration of the Satec meters with the IDER system, they were read manually for instantaneous data monthly. The Satecs do not save data.
- Operators are trained annually on the IDER system and understand the technology



- FirstEnergy is communication technology neutral
- Direct Load Control uses 2.4GHz Wireless Mesh Network and Cellular Backhaul
- Distribution Line Sensor And Substation Data uses Cellular
- A site visit for manual resetting of some of the Distribution Line Sensor communications has been needed regularly. Data is lost between loss of communication and resets
- Communications; equipment deployment density is important with two-way wireless mesh networks
- Attrition ~8% per year
  - Custom retention is challenging without an annual customer incentive payment
- Electrical Energy storage was planned for, however it was not technologically ready



- IDER data was used to develop, test and demonstrate feeder models with the purpose to create a user friendly interface to make the tools more integrated so they would be routinely and quickly usable.
- FE has initiated work to advance modeling tools, which can be leveraged, as an industry recommendation, to streamline and integrate industry software tools

1 or 2 Questions?

Brian Arellano PNM Resources

- Brian Arellano has been with PNM for 17 years holding positions as a GIS Manager, Distribution Engineer, Transmission & Distribution Project Manager, and Advanced Technology & Strategy Department.
- Recent responsibilities cover emerging technologies and implementing strategic objectives as well as critical infrastructure compliance.
  - *GIS innovations*
  - *Process improvements (Six Sigma Methodologies)*
  - *Energy Storage*
  - *Advanced Modeling and Analysis in correlation with EPRI's Integration of Distributed renewables*
  - *Critical Station Security and Cyber Security architecture.*
- Brian holds a BSEE from the University of New Mexico and currently pursuing an MS in Electrical Engineering.

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PNM Prosperity Energy Storage

Project Description

- First of 16 DOE Smart Grid Storage Demonstration Projects to go on line – Sept 2011
- Designed to both smooth PV intermittency and shift PV energy for on-peak delivery
- Successfully demonstrating true Storage/PV integration to Utility operations

Equipment

- 500 kW PV (fixed C-Si panels) – not DOE funded
- Ecoult/East Penn - Advanced Lead Acid Battery system for "shifting" – 1MWh
- Ecoult/East Penn - "Ultra" Battery system for "smoothing - 500kW

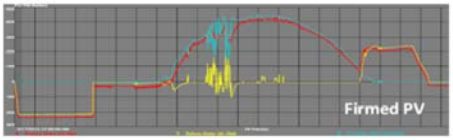
THE UNIVERSITY of NEW MEXICO

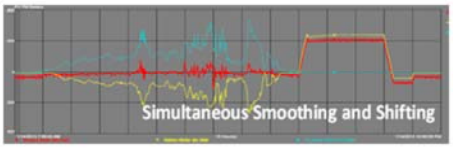
Sandia National Laboratories

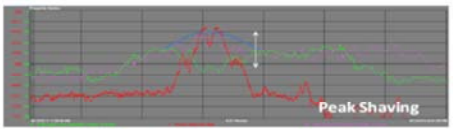
Create a dispatchable renewable resource

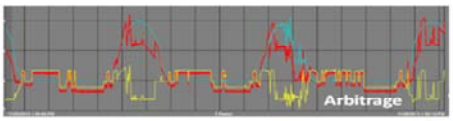
Energy Storage – Stacking Benefits

- Developed flexible control in algorithms
  - Smoothing parameters
  - Shifting parameters
- Flexibility allows for prioritization and optimization
- Minimal or Zero Latency in control signals



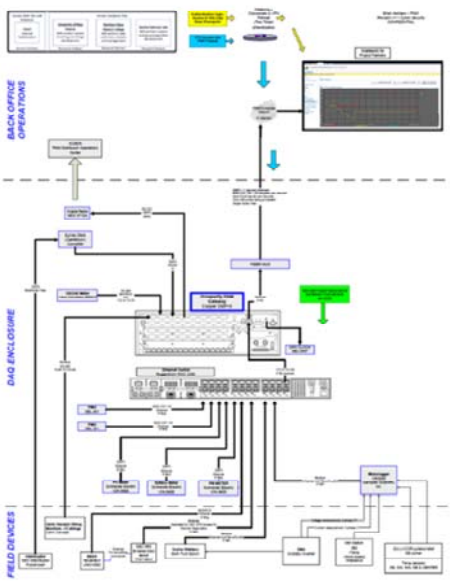






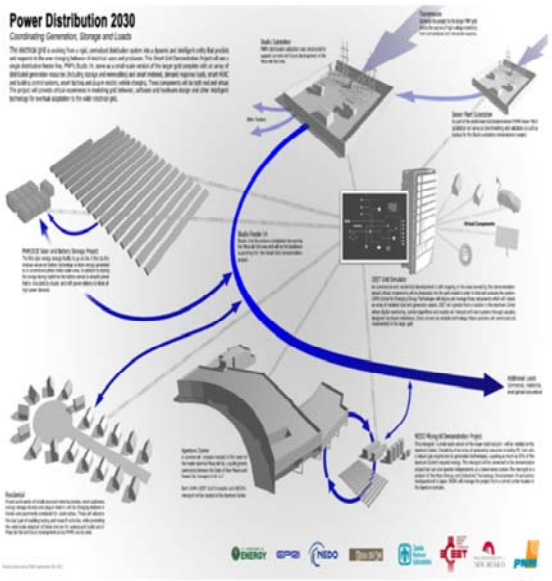
Lessons Learned

- Lack of battery control system
- Integration of data acquisition system
  - Protocol translation
  - Latency requirements for system are needed
  - Architecture to support cyber security for critical assets



Reaching Beyond

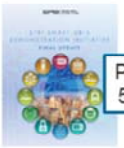
- Coordinated Control with other DR and target overall system balancing
  - Micro grid coordinated control to understand customer owned distributed resources
- Target other test cases such as:
  - Volt/VAR
  - Fast frequency response (FFR)
- Implement concepts to optimize how much storage is needed.
- Analysis and development:
  - Back office coordination of distributed resources
  - Distributed Energy Resource Management System (DERMS)
  - Advanced OpenDSS models
  - OpenDSS and ESVT



1 or 2 Questions?

Ed Hedges, Kansas City Power & Light

- Edward T. Hedges, P.E.
- Manager SmartGrid Technology Planning
- Kansas City Power & Light Co.
- Responsible for development of near- and long-term technology plans to guide the development of KCP&L's vision for the future electric distribution network or SmartGrid
- Technology Architect and Principal Investigator for KCP&L's SmartGrid Demonstration Project which is both a DOE Regional Smart Grid Demonstration Project and an EPRI Smart Grid Demonstration Project.
- BS in Electrical Engineering from University of Illinois
- Registered Professional Engineer in Wisconsin.



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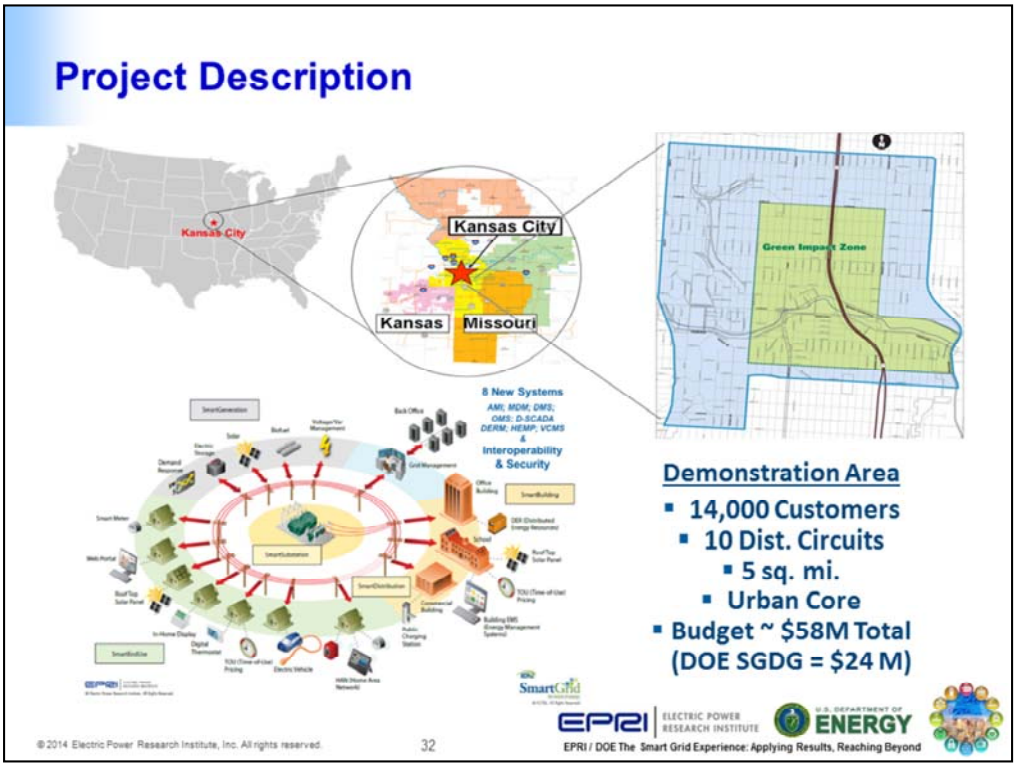


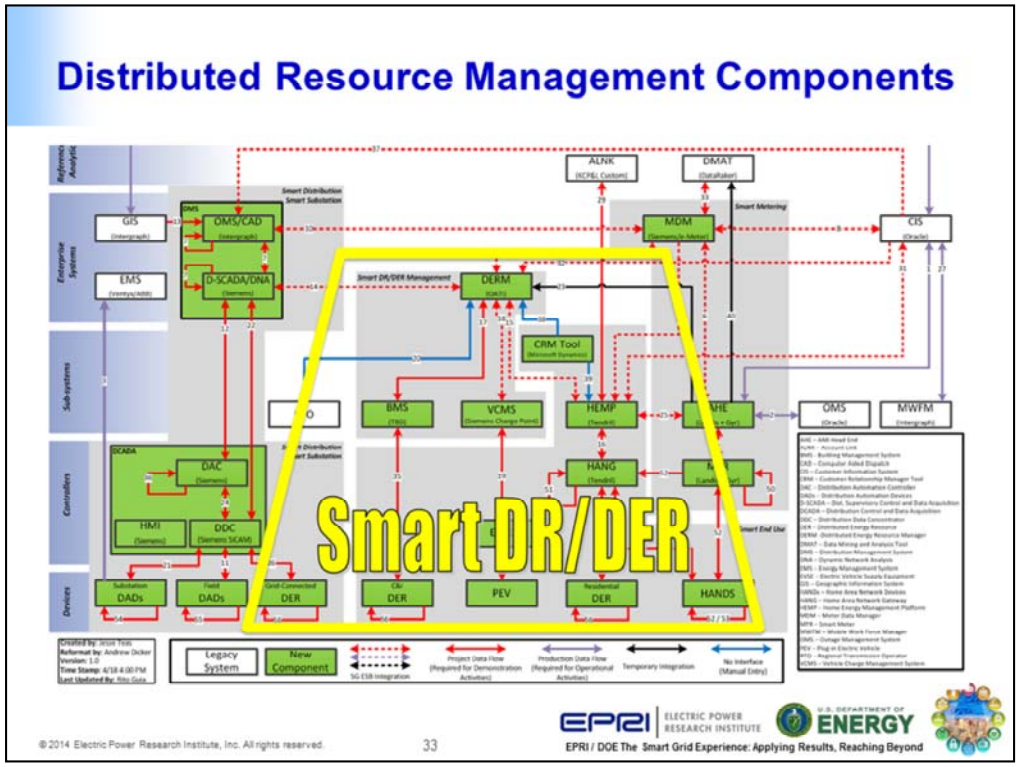
Complies with the Department of Energy's (DOE's) funding guidelines and combines commercial innovation with a unique smart grid approach:

First**, it creates a complete, end-to-end smart grid** — from smart generation to smart end-use — that will deliver improved performance focused on a major substation in an urban location.

Second**, it introduces new technologies, applications, protocols**, communications and business models that will be evaluated, demonstrated and refined to achieve improved operations, increase energy efficiency, reduce energy delivery costs and improve environmental performance.

Third, **it incorporates a best-in-class approach to technology integration**, application development and partnership collaboration, allowing KCP&L to advance the progression of complete smart grid solutions — with interoperability standards — rather than singular, packaged applications.

Finally, KCP&L's demonstration project will provide the critical energy infrastructure required to **support a targeted urban revitalization effort** in Kansas City's Green Impact Zone.



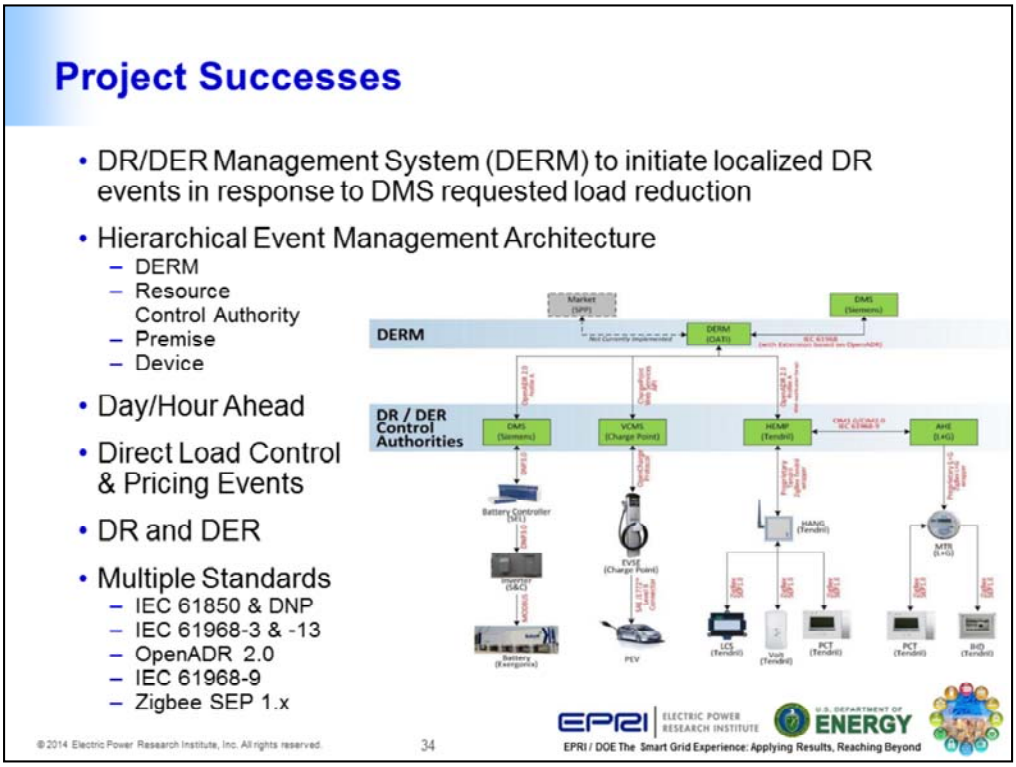
SmartSubstation - IEC 61850 Automation and Protection Network
GOOSE Protection Schemes
Local DCADA (substation controller) & Operator HMI

SmartDistribution - Consolidated UI for OMS, D-SCADA, DMS
IP WIFI Mesh Network, Reclosers, Capacitors, & Fault Indicators
Distributed Substation based '1st Responder ' application servers

SmartMetering - SmartMeters, AMI, & MDM integrated to legacy CIS & OMS

SmartEnd Use - mySmart Portal - home energy management portal (HEMP)
mySmart Display - in-home usage, pricing, and daily bill true up
mySmart Thermostat - PCT without Home Area Network (HAN) mySmart Network - Gateway, PCT, 120v & 240v switches
mySmart Rate - TOU rate with 4 hour peak period (3-7p.m.) with 6x price differential
EV Public Charge Stations with Vehicle Charge Mgmt. System (VCMS)

SmartGeneration - 1 MW/1 MWHR Grid Battery Energy Storage System (BESS)
170 kW Roof-Top Solar Generation
DR/DER Management System (DERM)
Implemented Direct Load Control and Designed Price Based DR Events

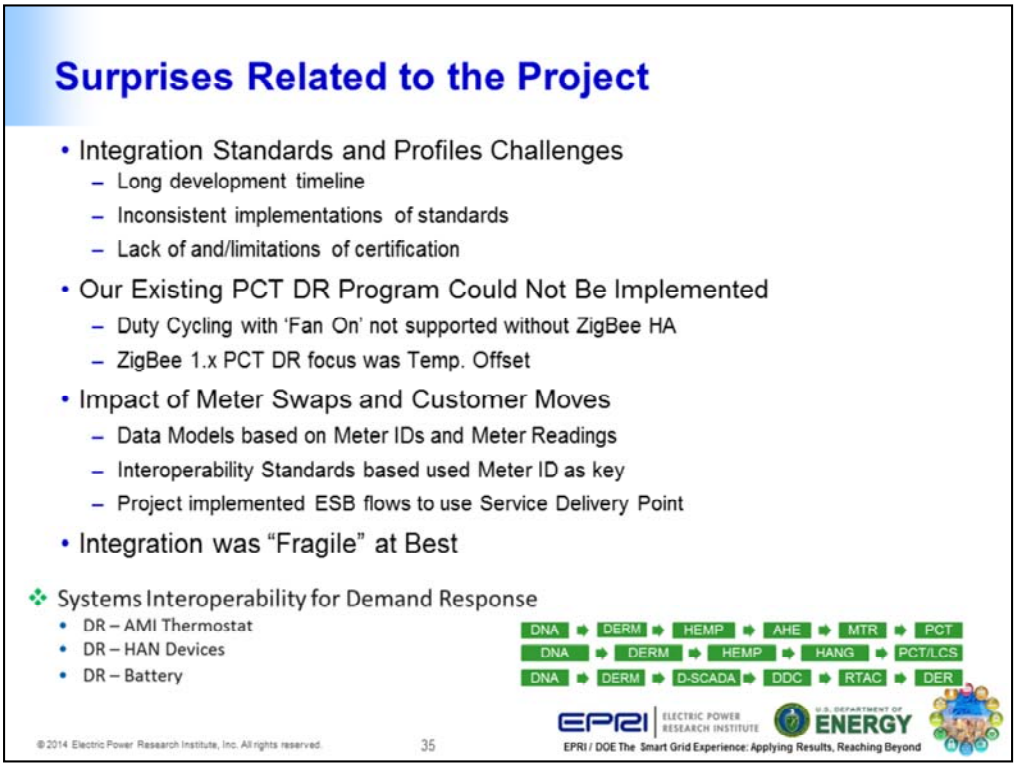


Implemented Demand Response Architecture

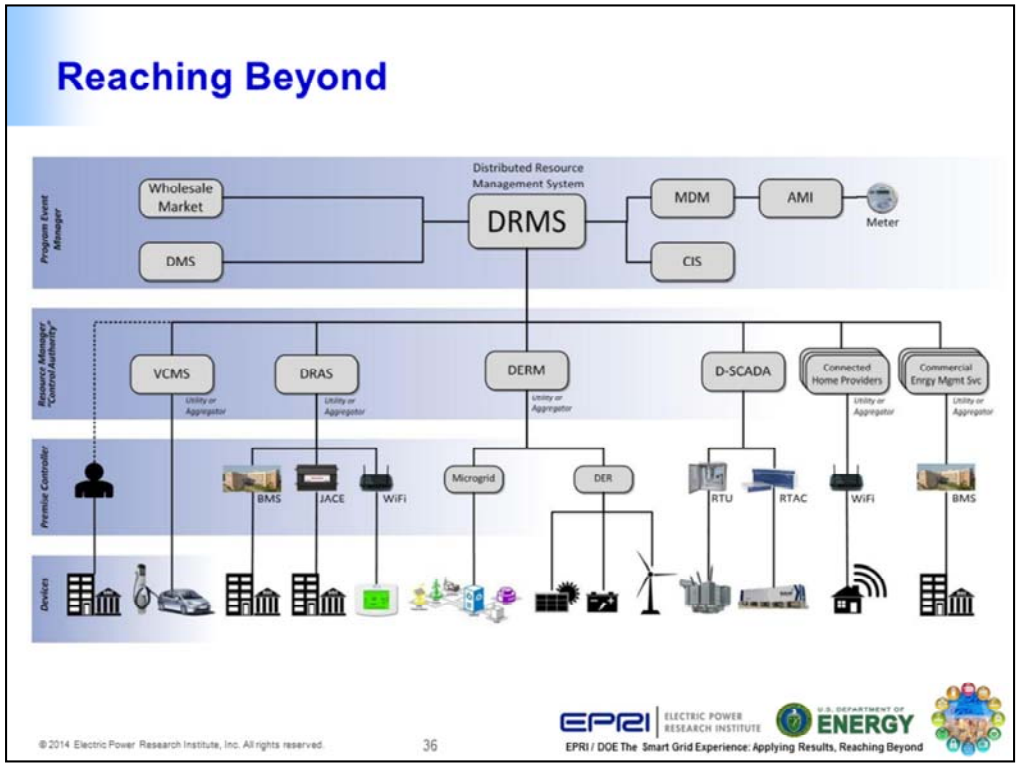
- **Centralized, System-Wide DR Event Planning (DERM)**
  - Knowledge of all DR/DR Resources & Programs
  - Analyzes Requests for Demand Response
  - Schedules and Communicates DR/DER Events to Control Authorities
- **Distributed DR Management**
  - Multiple DR Control Authorities (HEMP, DMS, Commercial BMS, and VCMS)
  - Direct Load Control & Pay For Performance Models
- **Local Event Execution**
  - Device acts on scheduled events and pricing signals

Integrations Implemented

- SUB >< DMS IEC 61850 new use standard 'outside Substation'
- DMS >< DERM IEC 61968 significant extensions were required
  - manage load reduction requests
    - grid element and localized load reductions
    - model exchanges (DMS based on CIMv10)
- DERM >< HEMP OpenADR2 Profile A pre-release
- HEMP >< HAN ZigBee SEP 1.x HAN includes Gateway, PCT & Load Switches
- HEMP >< AMI IEC 61968-9 ESB managed SDPID to MeterID transformations
- AMI >< PCT ZigBee SEP 1.x
- DERM >< DMS OpenADR2 Profile A pre-release for Grid Battery
- DERM >< VCMS vendor API Used existing ChargePoint API



- **Integration Standards Continued to Evolve During Project**
  - ZigBee SEP 2.0 originally estimated to be adopted in 2010
  - OpenADR 2.0 and ZigBee SEP only recently finalized
  - Implemented with SEP 1.x and a prelease of OpenADR 2.0 Profile A
- **Benefits of KCP&L's Existing PCT DR Program**
  - 4 Hr. duration, 30% (or 50%) duty cycle , with fan "ON"
  - Provides a consistent level of load reduction during entire event
  - Customer comfort is maintained by air circulation provided by fan
- **ZigBee SEP PCT DR Program Implemented**
  - Temp. Offset only provides load reduction during the first hour (or so) of the DR event.
  - Fan could not be turned on during the event. ZigBee HA function not supported by SEP
- **Issues with Meter Exchanges**
  - HAN devices needed to be re-joined to the new meter which is a manual process that required Customer participation.
  - Meter exchanges caused HEMP problems with historical usage displays because it could not handle the read discontinuity
- **30% of Premises Experienced Customer Move In/Out**
  - Proactively contacted new residents to establish them in programs
  - Many new residents did not join the PCT/HAN programs
  - Sometimes Devices were 'lost' when resident moved out



Need Continued Focus on 'plug and play' Interoperability and Device Interchangeability

- **Need Industry "Application Profiles" and Application Profile Certification**
  - SEP 2.0 and OpenADR 2.0 have made good progress especially at device level
  - Application Profiles need to prescribe message formats and expected behaviors
  - Continue EPRI's work to develop DERM integration requirements

As Illustrated KCP&L is Exploring an Distributed Resource Mgmt. Architecture that incorporates a DRMS, DERM & DRAS

- **Most in industry now uses the DERM to refer to a system that provides DER Manager/Aggregator functionality.** So what is a DRMS?
- **DRMS - Distributed Resource (Program/Event) Management System**
  - Configure DR/DER Program Definition and Parameters
  - Track Resource Location, Capacity, and Availability
  - Optimize resource selection to meet MKT/DMS requests
  - Schedules events, assigns resources and communicates pending events
  - Tracks event participation, contribution, and settlement
- **DRAS, DERM, VCMS, and many types of 'Aggregators'**
  - Responsible for managing communications with local DR/DER resources
  - Responsible for registering and reporting the availability of its DR/DER resources
- **We believe the DR/DER architecture needs missing 'system' to support the many DR/DER programs and program delivery channels that will evolve.**

Questions & Discussion

- Common Themes?
- Successes?
- Surprises?
- Reaching Beyond – What's Needed Next?

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