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Key Learnings from the EPRI Smart Grid Demonstration Initiative

EPRI Product ID: 3002004652

http://smartgrid.epri.com/Demo.aspx

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FORCES
November 14, 2014

The Electric Power Research Institute

Independent

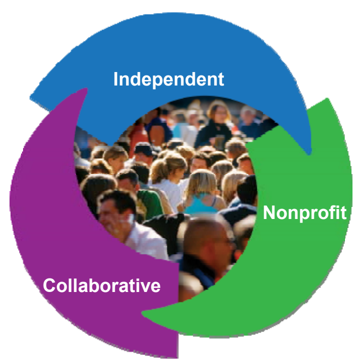
Objective, scientifically based results address reliability, efficiency, affordability, health, safety and the environment

Nonprofit

Chartered to serve the public benefit

Collaborative

Bring together scientists, engineers, academic researchers, industry experts



EPRI's Mission
To conduct research, development and demonstration on key issues facing the electricity sector on behalf of our members, energy stakeholders, and society

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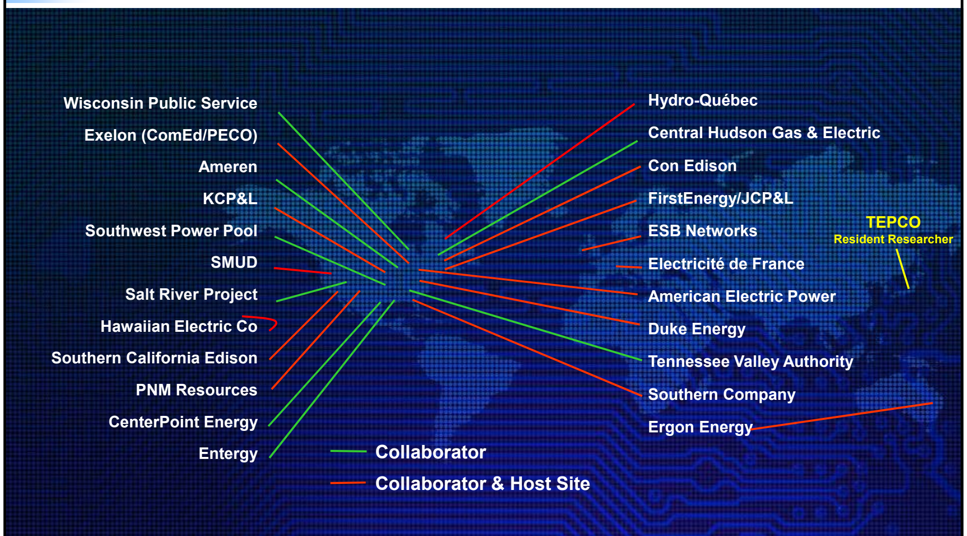
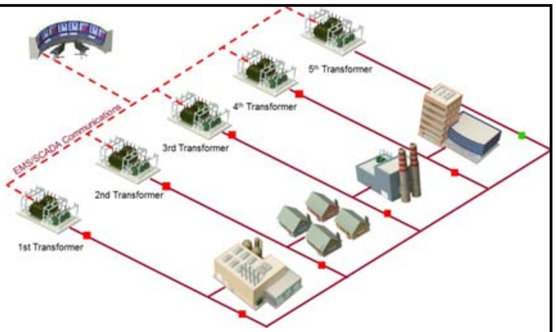
Smart Grid Demonstration –24 Collaborators



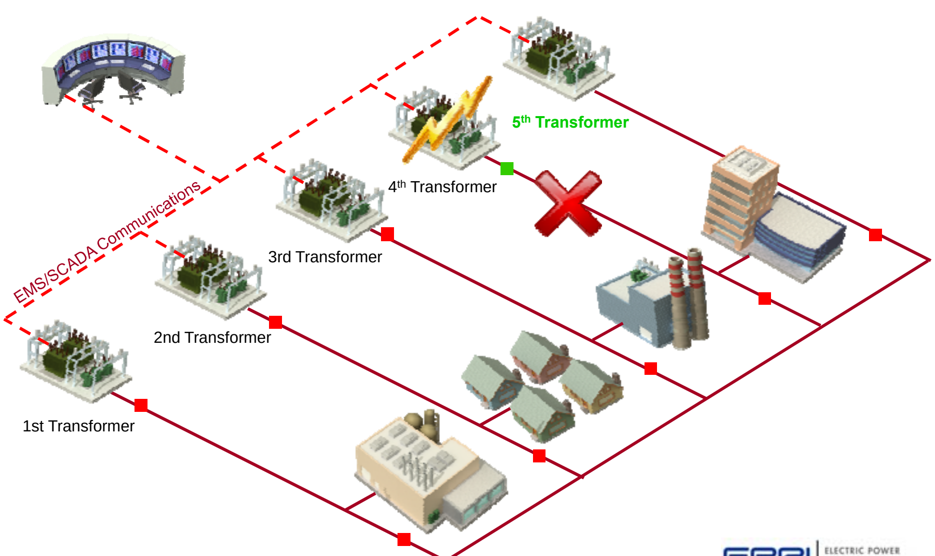
Demonstrations: proving grounds for Research

Contingency
N-0, N-1 & N-2



- Contingency
  - The loss of a substation transformer or its supply feeder.
- N-0
  - The state where all dispatched resources are available.
- N-1
  - The state where the occurrence of a single contingency event has resulted in <u>one</u> transformer becoming unavailable.
- N-2
  - The state where the occurrence of a single contingency event followed by another contingency event has left two substation transformers out of service.

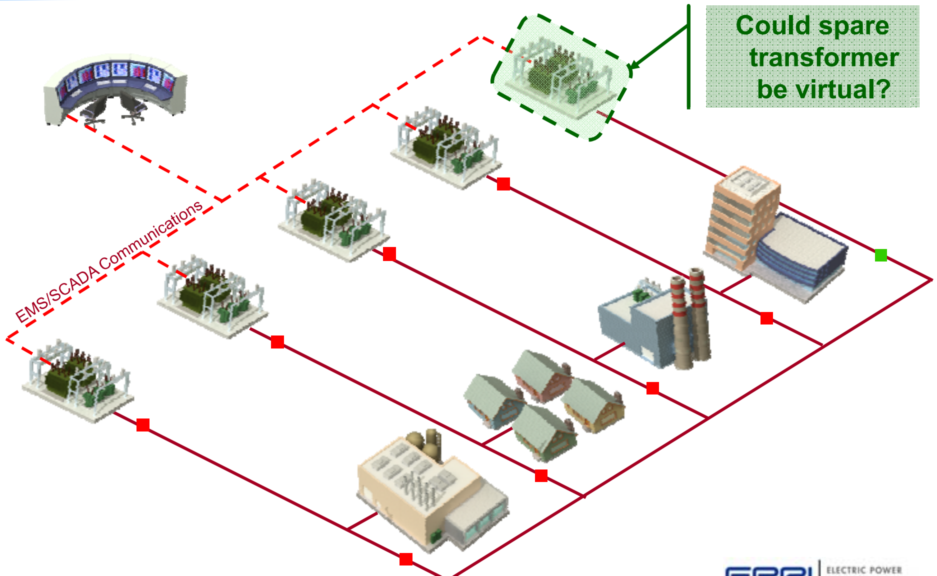
Contingency Design with Single Event



Case Study

VPP to Achieve Contingency Goals

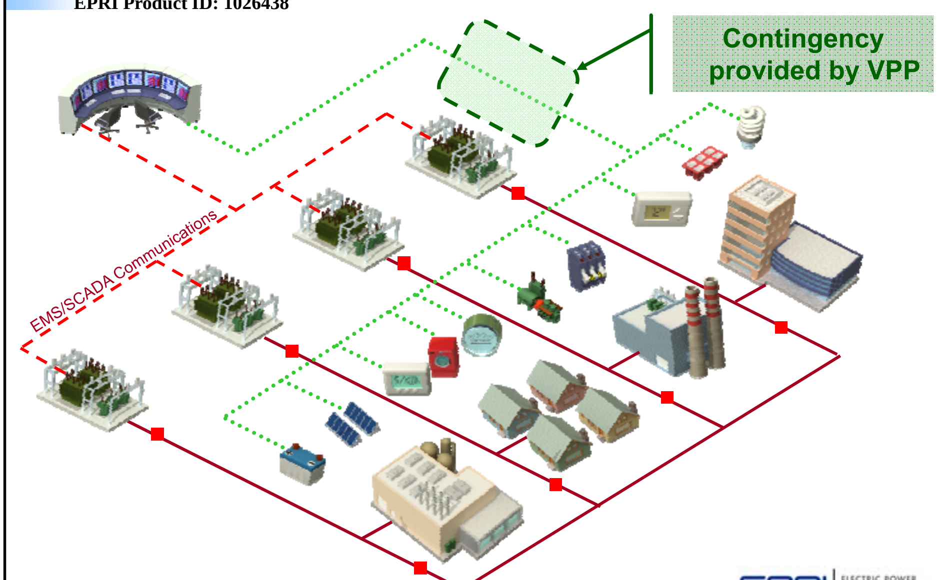
EPRI Product ID: 1026438



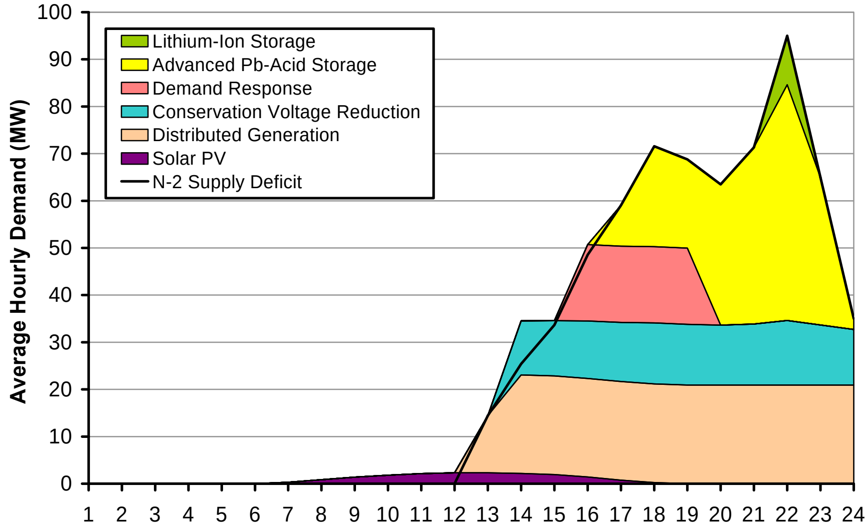
DER Providing Contingency Support

VPP for Achieving N-2 Contingency

EPRI Product ID: 1026438



Worst Day Dispatch



A Case Study on
Demand Side Uses of Thermal Storage Plant

conEdison

EPRI Product ID: 3002003870

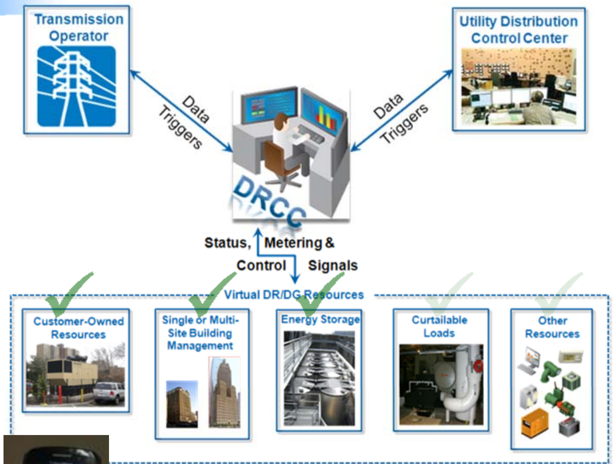
- ***1,000 cooling ton ice chiller***
- ***63 storage tanks***
- ***stores 10,000 ton-hours***

Total annual benefit estimated at $695,000.
This will offset the cost of the TSP in 3.3 years.

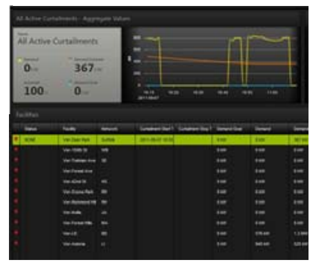
Remote Dispatch of Customer-Owned Resources

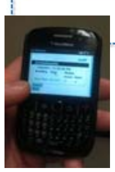
conEdison

EPRI Product ID: 1026437



System Operator or Distribution Operator can remotely activate resources.





Remote dispatch occurred within 3 minutes during testing. Faster response is anticipated when customer acknowledgement is fully automated.

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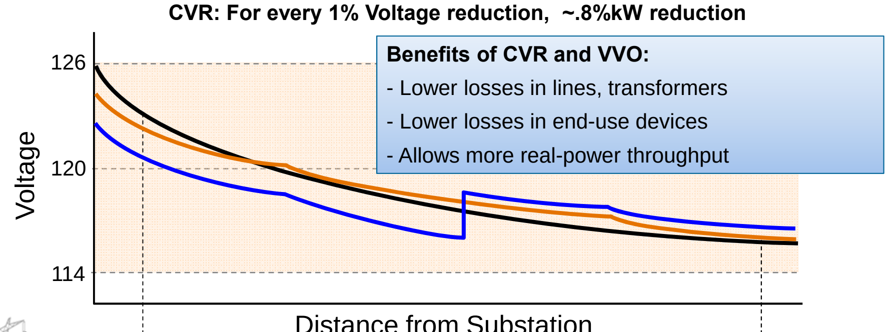
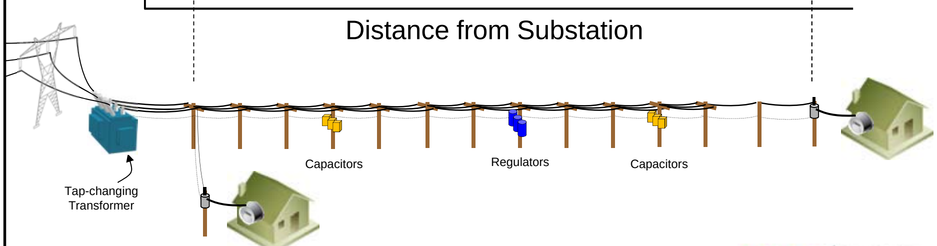
CVR and VVO Overview

CVR: For every 1% Voltage reduction, ~.8%kW reduction



Benefits of CVR and VVO:
- Lower losses in lines, transformers
- Lower losses in end-use devices
- Allows more real-power throughput



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A Case Study on

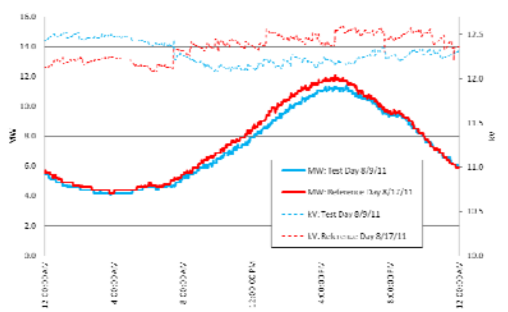
Conservation Voltage Reduction and Volt-VAR Optimization

SMUD

Substation	Approximate Avg. Percentage Demand Reduction (2% V reduction)
Substation A	2.5%
Substation B	1.0%

Additional testing of a larger pool of substations to be done to determine predictability of the CVR control strategy

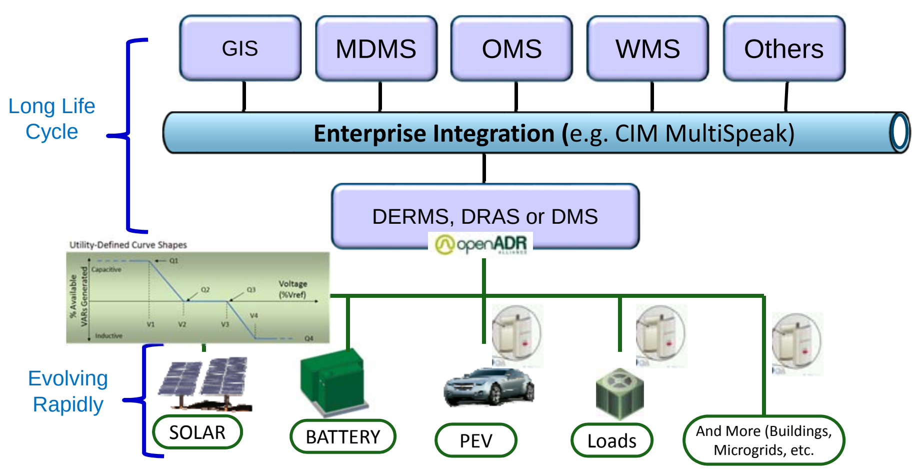
Substation A 2% CVR Analysis



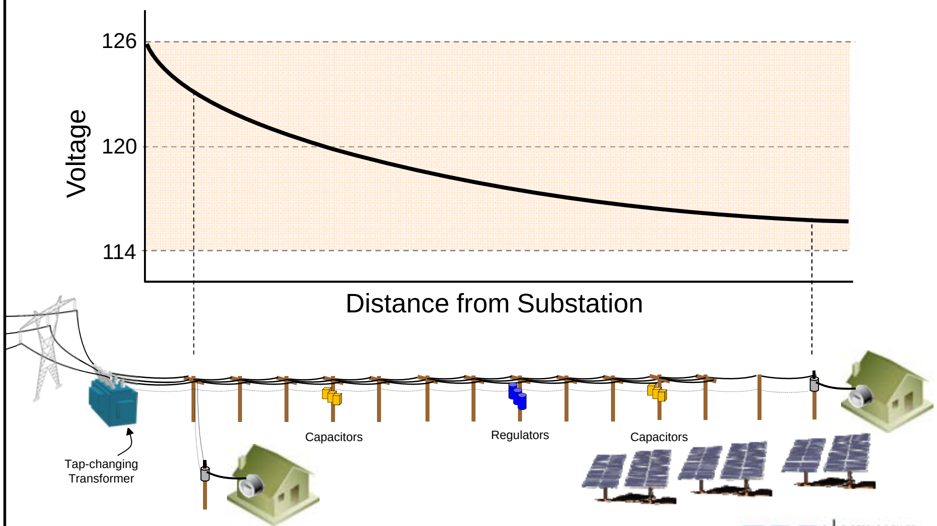
Volt-VAR optimization enabled efficient operation of the distribution system while conservation voltage reduction reduced peak demand by an average of 1.7%.

DR/DER Integration & Standards

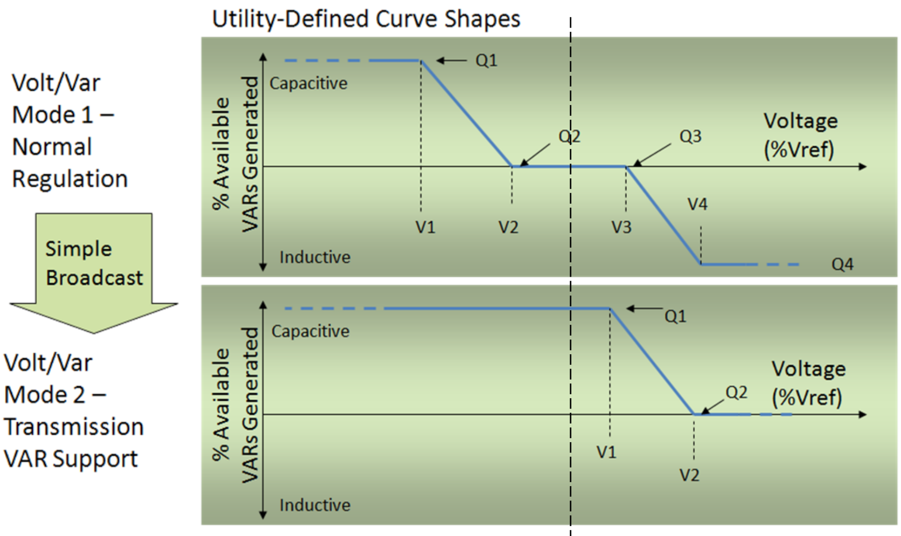
Distributed Energy Resource Management System (DERMS)
Demand Response Automation System (DRAS)
Distribution Management System (DMS)



Injected Power Influences Voltage & Power Quality on the Grid



Emergence of "Smart" Solar



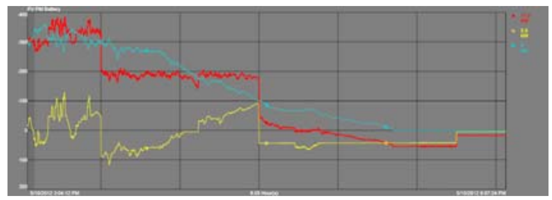
A Case Study on

Use of Storage for Simultaneous Voltage Smoothing and Peak Shifting

500kW PV and Advanced Carbon Battery for Shifting (1 MWh) and UltraBattery for Smoothing (500kW)

1 of 8 Containers Consisting of 160 Battery Cells Each

Data Acquisition System



Concept of Simultaneous Smoothing and Shifting Proven

A 1-second data capture rate of PV output proved essential to use storage for smoothing functions.

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A Case Study on

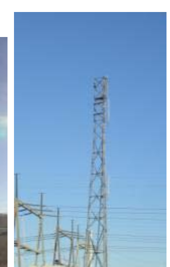
A Field Area (communications) Network Pilot

Multiple Communication Systems for Different Applications

Two-way capacitor bank monitors and controllers, for Volt/VAR Monitoring & Control

Additional Applications

Distribution Automation
Transformer Monitors
SCADA, AMI
Workforce, Video



3.65GHz equipment tested

WiMAX

A wireless broadband network can be integrated across a utility to serve as the unifying infrastructure.

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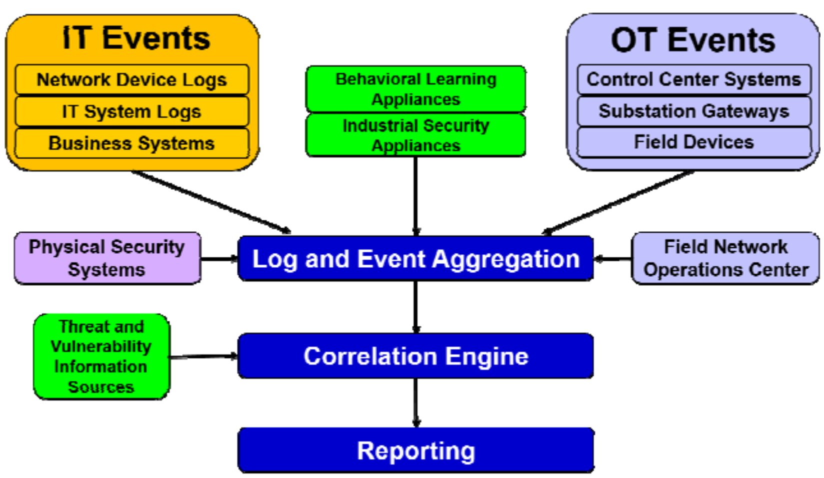
Cyber Security for Smart Grid…

- Address **interconnected systems** – both IT and control systems
  - Addressed in all systems, not just critical assets

- Consider the **lifecycle** of IT/telecomm systems versus control systems
  - Patch management/update cycles
  - Product life cycle
- Continuously **assess** the security status
  - Technical Information Publicly available

- Acknowledge there will be some security breaches
  - Focus on response and recovery
    - For example, isolate/quarantine infected devices
  - *Fail secure*
    - Address both safety and security
- Apply IT/telecomm security lessons-learned from the past 40 years
- Train and educate

Integrated Security Operations Center



ESB Networks – Ireland
Customer Behaviour Trial

Objective: "**Assess impact of Smart meters on peak demand & overall energy use**"

- 6,400 customers
  - 4800 Domestic
  - 1600 Business

	Residential Tariffs- Charges		
Tariff	Night	Day	Peak
Tariff A	12.0	14.0	20.0
Tariff B	11.0	13.5	26.0
Tariff C	10.0	13.0	22.0
Tariff D	9.0	12.5	38.0
Weekend	10.0	14.0	

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ESB Network Results

- Overall Energy Reduction% 2 ½%
- Behavior – was it Sustained? Yes
- Peak Shift for Customers with IHD 11%
- Peak Load Shift without IHD 8.8%
- Minimal added Benefit (2.2%) of IHD doesn't justify Cost
- No TOU "Tipping Point"

Generalized Custom Behavior Results for Demo's

Customer's Engaged	5% 10%
Customer Performance (During an Event)	10% 15%
Adoption of Technology	<2%

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Opt-Out Results

Hypothesis – Opt-Out Program will result in more participation

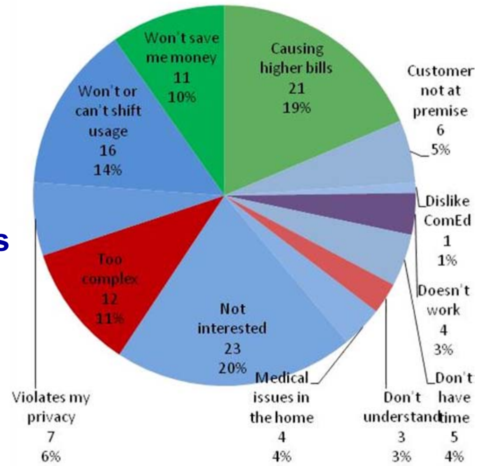
About 8500 Customers

- Assigned a new electric rate
- Provided enabling technologies
- Given option to "Opt-Out"

Percentage of Customers Opting Out

1. 2%
2. 17%
3. 41%

Opt Out Reasons

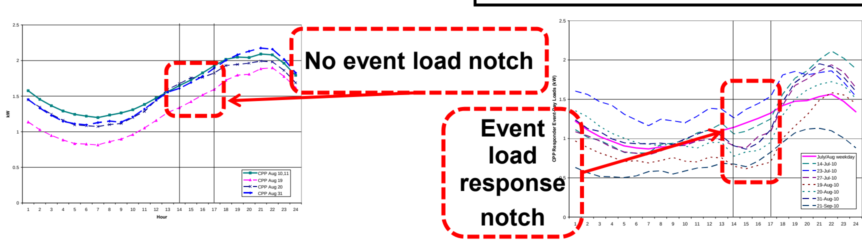


Results

- Up to 20% DR from subset of Critical Peak Price and Peak Time Rebate customers
- Technology treatments added no measurable improvement

Impact of AMI on Demand Response

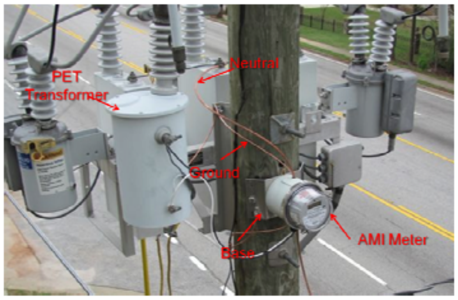
Rate Application	Responder Load as % Application Load	Average % Responder Load Change	Total Responder Load Impact % Application Load
CPP	10.2	-21.8 %	-2.2 %
DA-RTP	8.1	-14.4 %	-1.2 %
PTR	8.1	-14.7 %	-1.2 %
TOU	8.0	-11.3 %	-0.9 %
IBR	5.0	- 5.6 %	-0.3 %
FLR	4.8	- 7.2 %	-0.3 %

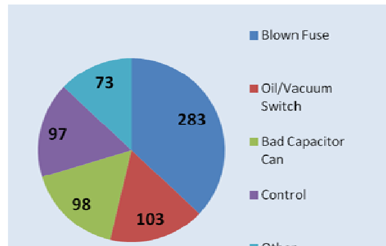


EPRI Case Study 1026447

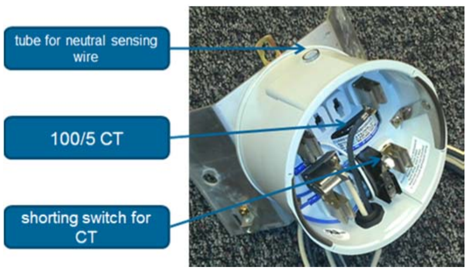
A Capacitor Bank Health Monitor

SOUTHERN COMPANY





Issues Causing Failure of Capacitor Banks



- **Identified over 650 problems in the first 6 months**
- **Changed the inspection schedule from once a year to once a day.**

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What are we Learning in EPRI's Demo's

- Successes
  - Conservation Voltage Reduction / Volt-Var Optimization
  - Confirmation of Consumer Responses to Variable Pricing & Events
  - Innovative Use of Deployed Technology (Use of AMI for Cap Banks)
  - DER can be managed on individual feeders
- Challenges
  - Communication Infrastructure / Cyber Security
  - Consumer Adoption of Technology & Product Availability
  - Energy Storage Business Case
  - "Distribution Data is Just a Mess" (anonymous quote from Utility)
  - Standards Adoption Slower than anticipated, but making progress
  - Virtual Power Plant
    - Not managing significant quantity or variety of resources (yet)

Smart Grid is not a discrete project

It requires a sustained effort and strategy to Integrate the Grid and Communications Infrastructures from an overall Systems Perspective

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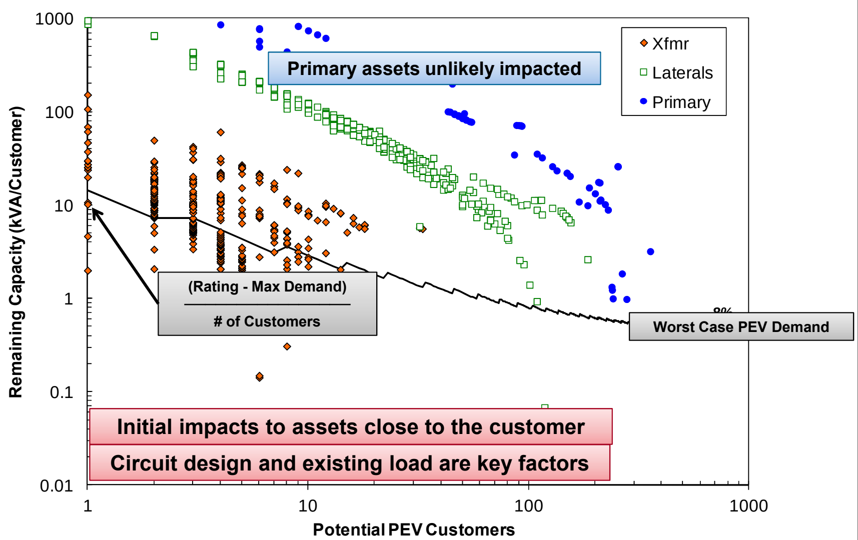
Together…Shaping the Future of Electricity

Electric Vehicles Asset Capacity & Demand

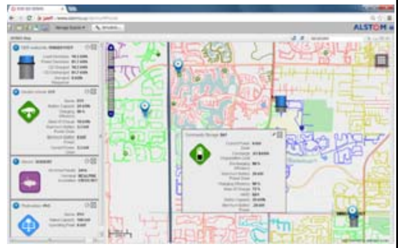


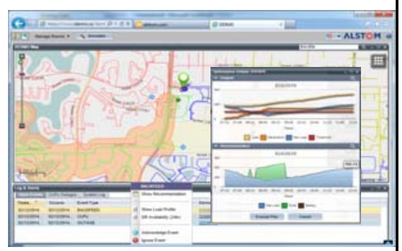
Demo's with EV Research
AEP, Duke, ESB Networks, HECO, SMUD, Southern

Duke Energy Distributed Energy Resource Management System (DERMS) Visualization, Solar Modeling and Management

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





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Duke Energy Distributed Energy Resource Management System (DERMS)

Reaching Beyond – What’s Needed Next?

- 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

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DER Broken Down by Definition

Resource – the ability to impact the operation is beneficial

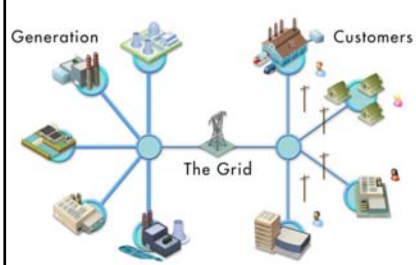
Energy – related, directly or indirectly, to energy consumption or production

Distributed – It is physically located at a variety of locations.

Implications:
- May have a plurality of purposes for dispatch
- Architecture and methods utilized for resource management
- Distributed location implies communication
- Standards are needed for communication
- Need way to measure and verify the impact
- Similar devices but variety of ownership/control/aggregation
- Other variables: type, ownership, command vs. inform, etc.

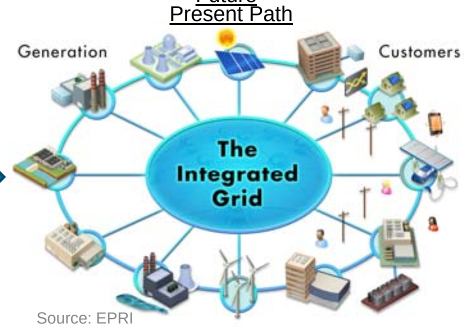
The Electric Grid: Past vs. Present vs. Future

Past



Source: EPRI

Future
Present Path



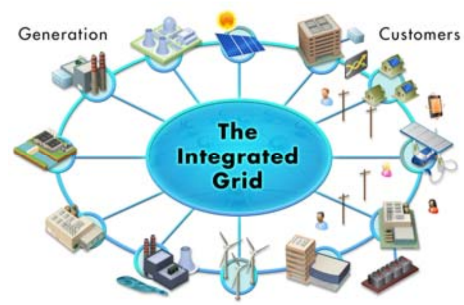
Source: EPRI

Core Mission:
1. Safe
2. Reliable
3. Affordable

Core Mission:
1. Safe
2. Reliable
3. Affordable
4. Environmentally Responsible
5. ~~Connected~~ Integrated

Strategy for the Integrated Grid

Drivers
- Distributed Energy Resources
- Demand Response
- Electric Vehicles
- In-Premise Automation
- Cybersecurity Threats
- Aging Infrastructure
- “Big Data” Complexity
- Stranded Assets



Source: EPRI

New Requirements
- Proactive Operations
- Situational Awareness
- Fast Edge Decisions
- Seamless Interoperability
- Modularity / Scalability
- Hybrid Central/Distributed
- Zero Touch Deployments
- Refined Utility Skillsets

Technology Approach
1. Internet Protocol
2. Translation
3. Common Dictionary
4. Security
5. Analytics

Distributed Intelligence Platform (DIP)