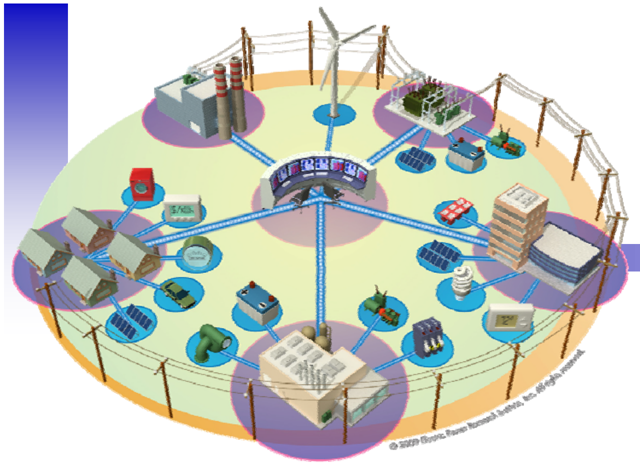

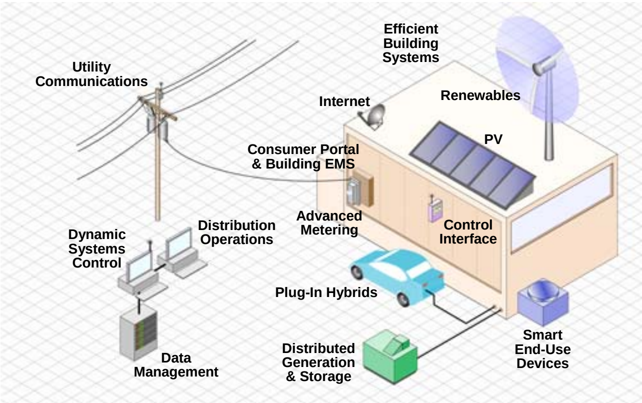

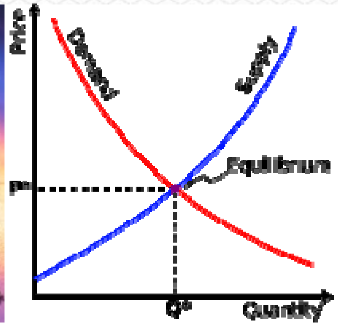

Smart Grid Demonstrations Integrating Large Scale Distributed Energy Resources

Matt Wakefield, EPRI

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3/11/2009

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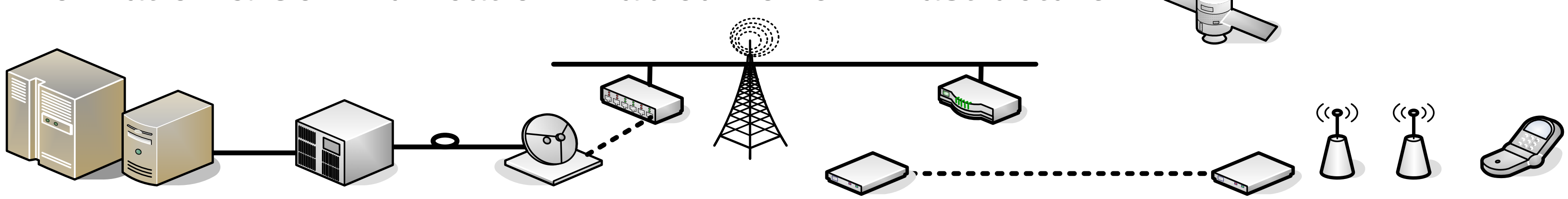
Smart Grid

Sensors….Two Way Communications….Intelligence

Markets	Transmission	Substation	Distribution	Consumer
				

Information & Communication Enabled Power Infrastructure



Acting on this Information Will:

Enable active participation by consumers	
Anticipate & respond to system disturbances (self-heal)	Accommodate all generation and storage options
Operate resiliently against attack and natural disaster	Enable new products, services and markets
Optimize asset utilization and operate efficiently	Provide power quality for the digital economy

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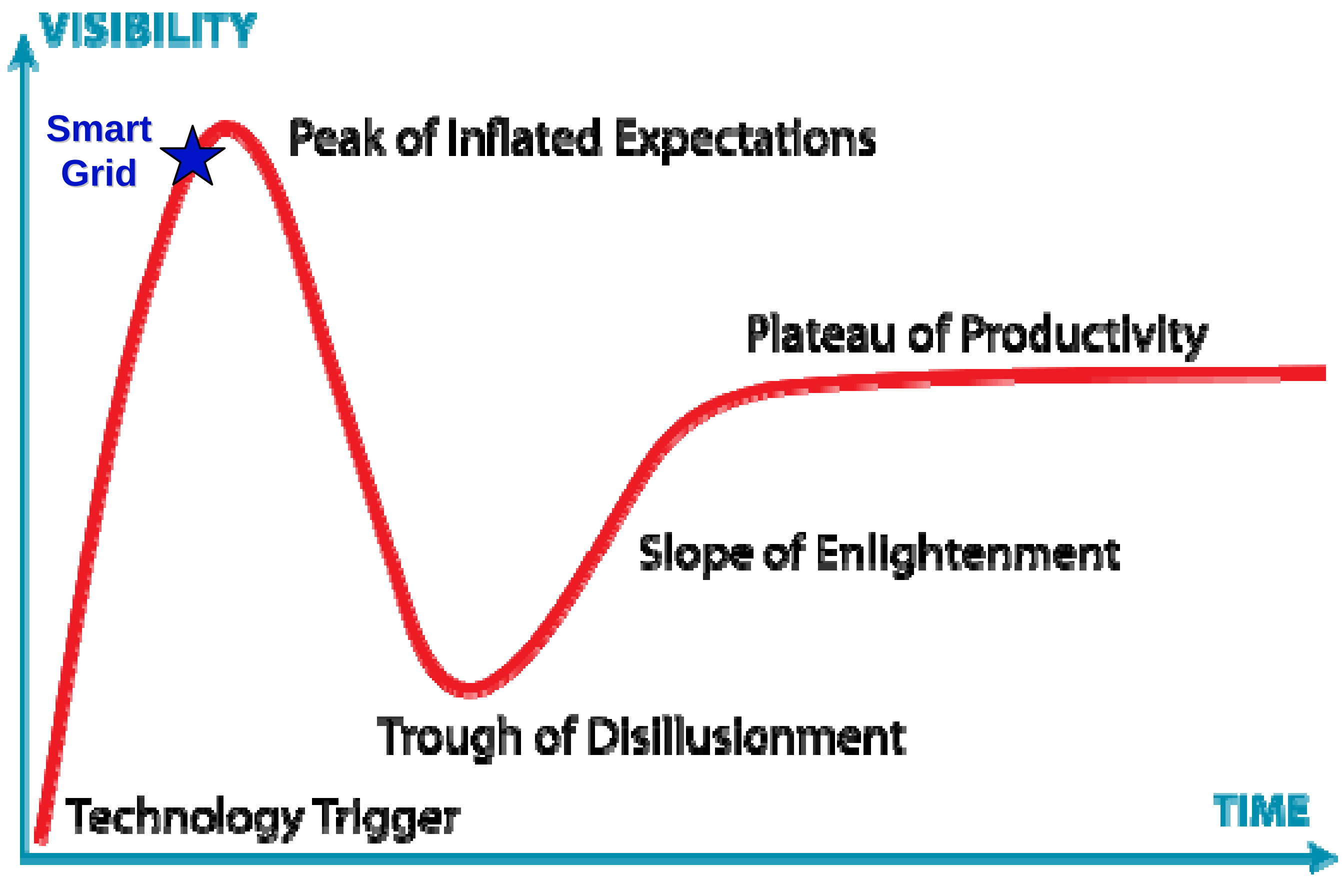
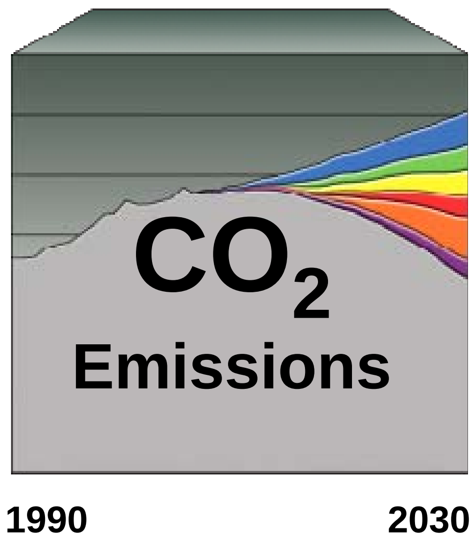
Hype Cycle



Smart Grid Demonstrations will Manage Expectations to enable Realistic Business Evaluation and take us Quickly to the Plateau of Productivity

Smart Grid – CO_2 Impact from Integrating DER



Technology Challenges

1. **Smart Grids and Communication Infrastructure**
2. **Transmission Grids and Associated Energy Storage Infrastructures**
3. **Advanced Light Water Reactors**
4. **Coal-Based Generation Units with CO_2 Capture and Storage**

Avoided CO_2 Emissions from Smart Grid, 2030 (Tg CO_2)*	***Low***	***High***
Direct Feedback PHEV Integration Renewable Integration EE & Demand Response Peak Load Mgmt Reduced Line Losses Cont. Comm. Large Commercial Buildings	60	211
% of Total U.S. CO_2 Emissions	~3%	~10%

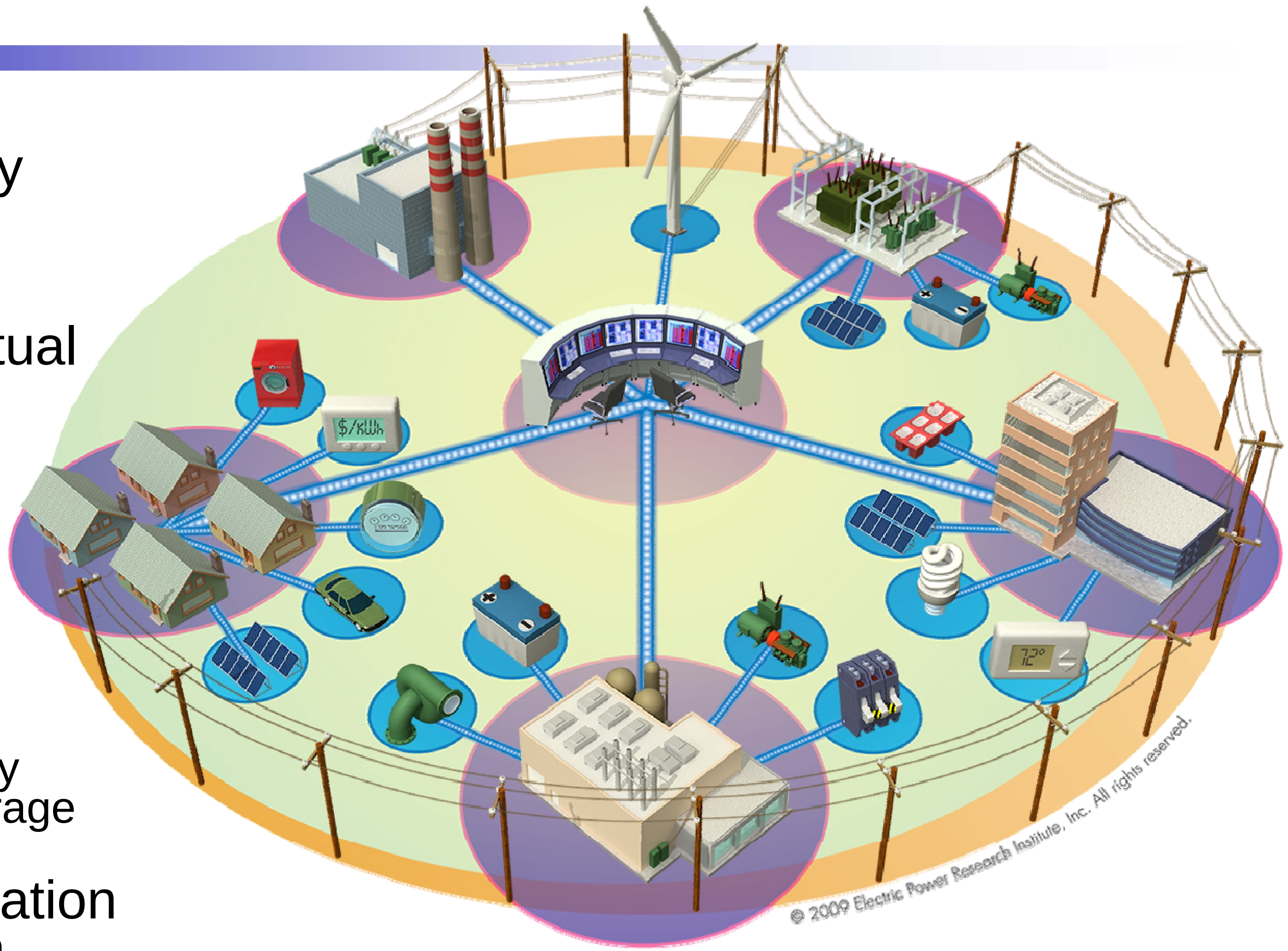
~80% of Avoided CO2 Emissions from Smart Grid are from

Integration of DER

* Source: EPRI Publication 1016905, The Green Grid Savings and GHG reduction Enabled by a Smart Grid

EPRI Smart Grid Demonstrations

- Integration of Distributed Energy Resources (DER)
- Deploying the Virtual Power Plant
- Several regional demonstrations
  - Multiple Levels of Integration
  - Multiple Types of Distributed Energy Resources & Storage
- Leverages Information & Communication Technologies



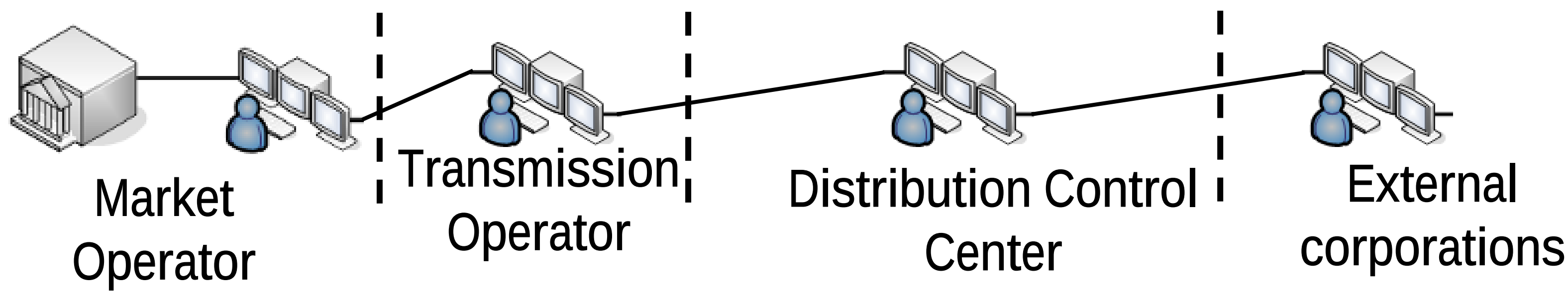
EPRI Smart Grid Demonstration Goals

- 5 Year Initiative
- Leverage Utility Investments
  - Application of Technologies & Standards Available Today
  - Research Beyond Scope of Typical Utility Deployment
    - Advance/Further Technology, Standards, Interoperability
- Leverage the Collaboration Benefits
  - The Whole is Greater than the Sum of its Parts

- Understand the "State of the Smart Grid"
  - Cost Benefit Analysis (CBA)
  - Gaps in Technology, Standards, CBA

Smart Grid Demonstration Approach

- **Integration of DER with Utility Operations**

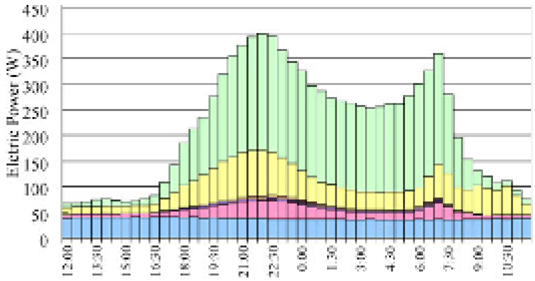


- **Ensure Interoperability of DER**
  - Demonstrating use of common language to exchange information with distributed resources from various manufacturers
  - Multiple use of communication and metering infrastructure for control, measurement & verification of the dispatchable resource

Shared Learning from Multiple Demonstrations and Use of EPRI's IntelliGrid Architecture will Lend to Expandability, Scalability, and Repeatability

Diverse Characteristics Lead to Multiple Demonstration Sites

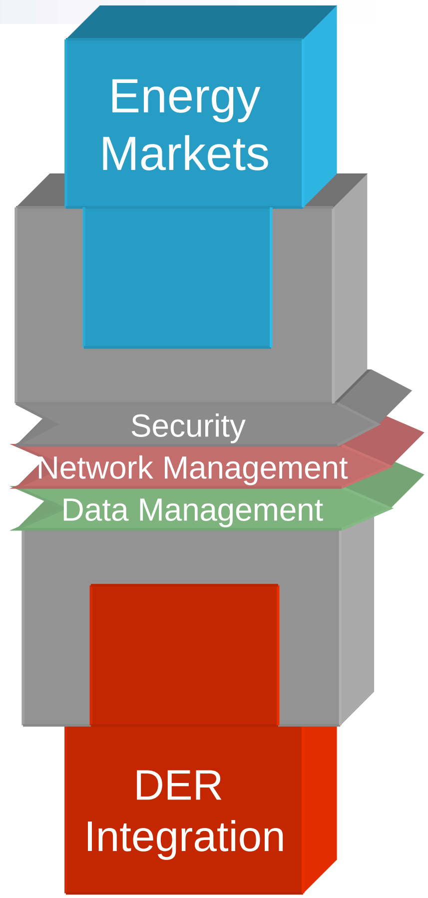
- Regional characteristics
  - Weather
  - Regulatory / Market
  - Availability of Renewable Generation & Storage



- Customer / Load characteristics
  - Residential, Commercial, Industrial
- Distribution system characteristics
  - Rural, suburban, urban overhead and underground systems
- Communication Infrastructure available
  - Public (internet, cellular)
  - Private (AMI, licensed)

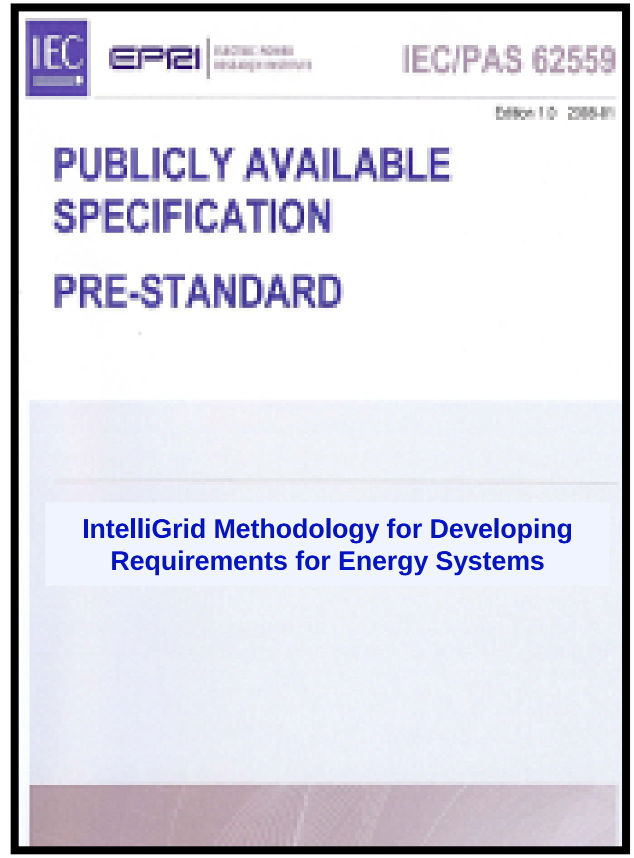
Objectives of the Demonstration Initiative

- Define information models and communications interfaces
  - All Levels of distributed resource integration (home, enterprise, market)
- Develop application guidelines, integration requirements and standards for distributed resource integration.
- Field Assessments to:
  - Understand required systems and technologies for distributed resource integration
- Verify Smart Grid business case assumptions
  - Describe costs and benefits associated DER Integration



Using IntelliGrid Methodology to Develop the Smart Grid Architecture

- **Business Case/Cost Benefit Analysis**
- **Define Requirements of Each Smart Grid Application using the Use Case Process**
- **Design an Architecture for Security, Data Management and Network Management**
- **Select Technologies, Finalize Cost Benefit Assessment**



EPRI's IntelliGrid Methodology is Accepted as an International Recommended Specification and an Industry Best Practice to Architect a Smart Grid

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Collaboration with DOE Distribution Integration Awards

- Allegheny Power, WVU, NC State, Research & Development Solutions, Augusta Systems, Tollgrade – **West Virginia Super Circuit**
- ATK Launch Systems, Rocky Mountain Power, P&E Automation – **integration of renewables, DG, and storage (compressed air).**
- Chevron Energy Solutions, Alameda County, PG&E, VRN Power Systems, SatCon, Univ of Wisc., NREL, LBNL, E3 – **Solar, fuel cell and storage microgrid**.
- City of Fort Collins, Colorado State Univ, InteGrid Lab, Comm Found of Northern Col, Governor's Energy Office, Advanced Energy, Woodward Spirae, Eaton – **3.5 MW mixed distributed resources for peak load reduction**.
- IIT, Exelon/ComEd, Galvin Electricity, S&C – **"perfect Power" demonstration**
- Con Edison, Verizon, Innovative power, Infotility, Enernex – **Interoperability between utility and end use customers for DG aggregation.**
- SDG&E, Horizon Energy Group, Advanced Control Systems, PNNL, Univ of San Diego, Motorola, Lockheed Martin – **Integrating multiple distributed resources with advanced controls.**
- Univ of Hawaii, GE, HECO, MECO, Columbus Electric Coop, NM Inst of Mining and Tech, Sentech, UPC Wind – **Mgt of distributed resources for improved quality and reliability, grid support, and transmission relief**.
- Univ of Nevada, Pulte Homes, Nevada Power, GE Ecomagination – **Integrated PV, battery storage, and consumer products with advanced metering**.

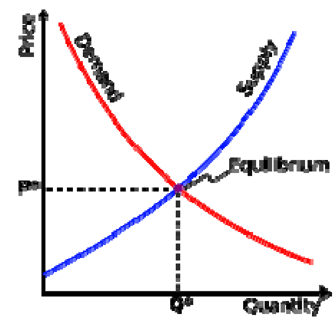
Project Participants and Collaboration

EPRI BoD Initiative & IntelliGrid Program	**EPRI/Utility Team**	**Standard Development Organizations (SDO)**
Department of Energy (Office of Energy Efficiency & Renewable Energy & Office of Electricity Delivery and Energy Reliability)	**UCA International User's Group** OPEN HAN OPEN SEC OPEN AMI OPEN Enterprise Utility AMI	**IEC**
California Energy Commission	**GridWise Alliance**	**IEEE**
NYSERDA	**European Smart Grid Initiatives**	**AHAM**
Others	**Manufacturers**	**NIST**
		NEMA
		SAE J2836 (Communication between utility and Plug-in-vehicles)
		ANSI

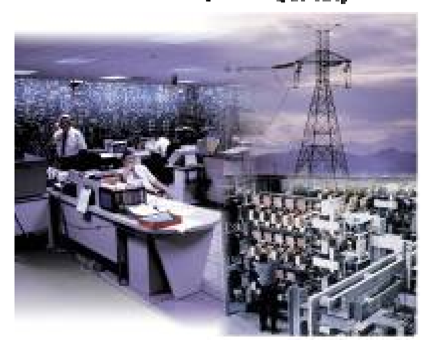
Smart Grid Demonstration Critical Elements

1. Integration of Multiple Distributed Resource Types
   – Demand Response, Distributed Generation, Storage, Renewable Generation

2. Connect retail customers to wholesale conditions
   – Dynamic Rates, Ancillary Services



3. Integration with System Planning & Operations
   – Level of integration, Tools & Techniques, Visibility



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Smart Grid Demonstration Critical Elements

4. Critical Integration Technologies and Standards
   – Use of standards, common object models, Comm interfaces

5. Compatibility with EPRI's Initiative and Approach
   – Use cases, business case development, enables wide spread integration

6. Funding requirements and leverage of other funding resources
   – Government, Research Orgs, Vendors, Universities
   – Capitol costs born by utility

Host Sites Overview (3 sites selected, expecting 8-10 total over 5 years)

	Consolidated Edison	FirstEnergy	PNM Resources
Resources	Distributed Generation Demand Response Wind Plant	HVAC (Res., C&I) DR Electric Storage Thermal Storage	Solar PV (residential & System) Storage & DR
Integration	End-to-end (Customer owned DG, DR provider, Con Edison, NYISO)	Real Time T&D Ops & Planning PJM	HAN, SCADA, System Ops & Planning
Diversity	Dense Urban Environment Customer Owned Resources	Smart Grid w/Out use of AMI system Master Controller Concept	Large deployment of Residential PV. Optimization Incl. Volt & Freq control
Business Case	Increase Reliability Reduce Peak Demand	Grid efficiency and reliability at local level	15% peak load reduction at feeder
Furthers Industry	Interoperability of Distributed Energy Resources (DER)	Local delivery system Integration of DER	Technologies & Standards for Renewable Integration

Sample of Deliverables

- Smart Grid Resource Center & Use Case Repository
  - www.smartgrid.epri.com
- Smart Grid Economic Assessment / Cost Benefit Analysis
  - Co-Developing with DOE & Oak Ridge National Labs
- Smart Grid Architecture Framework
  - How to Minimize Risk of Technology Obsolescence
- Analytical Tools
  - Modeling, CO_2 Impact, Regulatory Impact
- Lab & Field Trials of Technology

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Smart Grid Resource Center

Home | Use Case Repository | Event Calendar | Smart Grid Demo

Smart Grid Resource Center

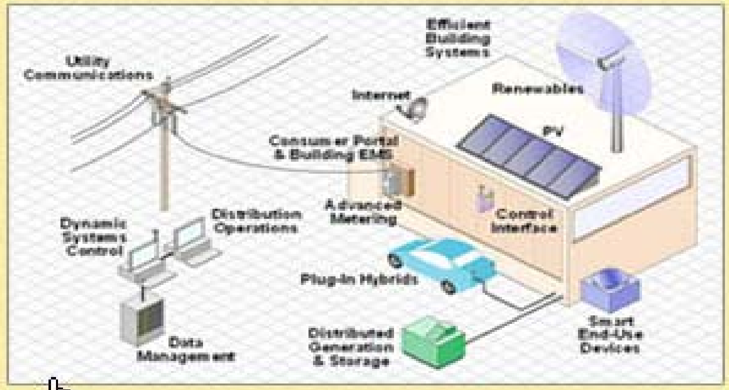
This site serves as a home for information about EPRI Smart Grid research, demonstration projects, and the Smart Grid Use Case Repository.

Smart Grid

A Smart Grid is one that incorporates information and communications technology into every aspect of electricity generation, delivery and consumption in order to:

- minimize environmental impact;
- enhance markets,
- improve reliability and service,
- reduce costs and improve efficiency.

Smart Grid Network



Mouseover Image for larger view

Smart Grid Network

Smart Grid Use Case Repository

The Use Case Repository is a public resource for the electric power industry to house Smart Grid related use cases as well as provide a forum for the industry to contribute to this effort by submitting their own use cases.

- Use Case Repository

Smart Grid News

Current | Archive

Energy Central features an Intelligrid report by EPRI's Don Von Dollen – *Month, Day, 200X*

EPRI's Green Grid report featured on Carbon Offsets Daily – *Month, Day, 200X*

M2M Radio discusses Smart Grid with EPRI's Don Von Dollen – *Month, Day, 200X*

Smart Grid Advisory Update Newsletter

- Decemeber
- Novembe
- Septemb

EPRI Smart Grid Resource Center launched: www. smartgrid.epri.com

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SMART GRID
RESOURCE CENTER

Home | Use Case Repository | Event Calendar | Smart Grid Demo

Use Case Repository

- About the Repository

Smart Grid Use Case Repository

Use Case Categories

- General (18)
- Customer Services (22)
- Distributed Energy Resources (3)
- Distribution Operations (3)
- Market Operations (5)
- Transmission Operations (8)

View all Smart Grid Use Cases (61)

The Use Case Repository is a collection of Smart Grid use cases and requirements developed within the industry as well as through EPRI's smart grid demonstrationinitiative.All Use Cases are delivered as PDFs. All Use Cases are under the Creative Commons license. You may use the NIST Use Case Template to create your own use cases and submit them to mwakefield@epri.com for posting.

Name	Size	Published
Category: General		
Adaptive Transmission Line Protection	254k	1/8/2009
Application Adjusts Load To Meet System	11k	1/8/2009
Capacity Based On Settings From System Operator	11k	1/8/2009
Adaptive Transmission Line Protection	254k	1/8/2009
Application Adjusts Load To Meet System Capacity Based On Settings From System Operator		
Category: Customer Services		
Adaptive Transmission Line Protection	254k	1/8/2009
Application Adjusts Load To Meet System	11k	1/8/2009
Capacity Based On Settings From System Operator	11k	1/8/2009

EPRI to be center of use case repository

Summary

- Maximize the benefits of existing and planned investments
  - Communications and advanced metering infrastructures
  - Identify and further the foundation for demand side resource integration.
- Integration of distributed resources with utility system operations and planning
- Integration of distributed power generation, storage, demand response technology, and renewables into a demand-side virtual power plant.
- Demonstrations should further the industry in regards to integration of distributed resources
- Expect 8-10 EPRI Demonstrations

Questions?