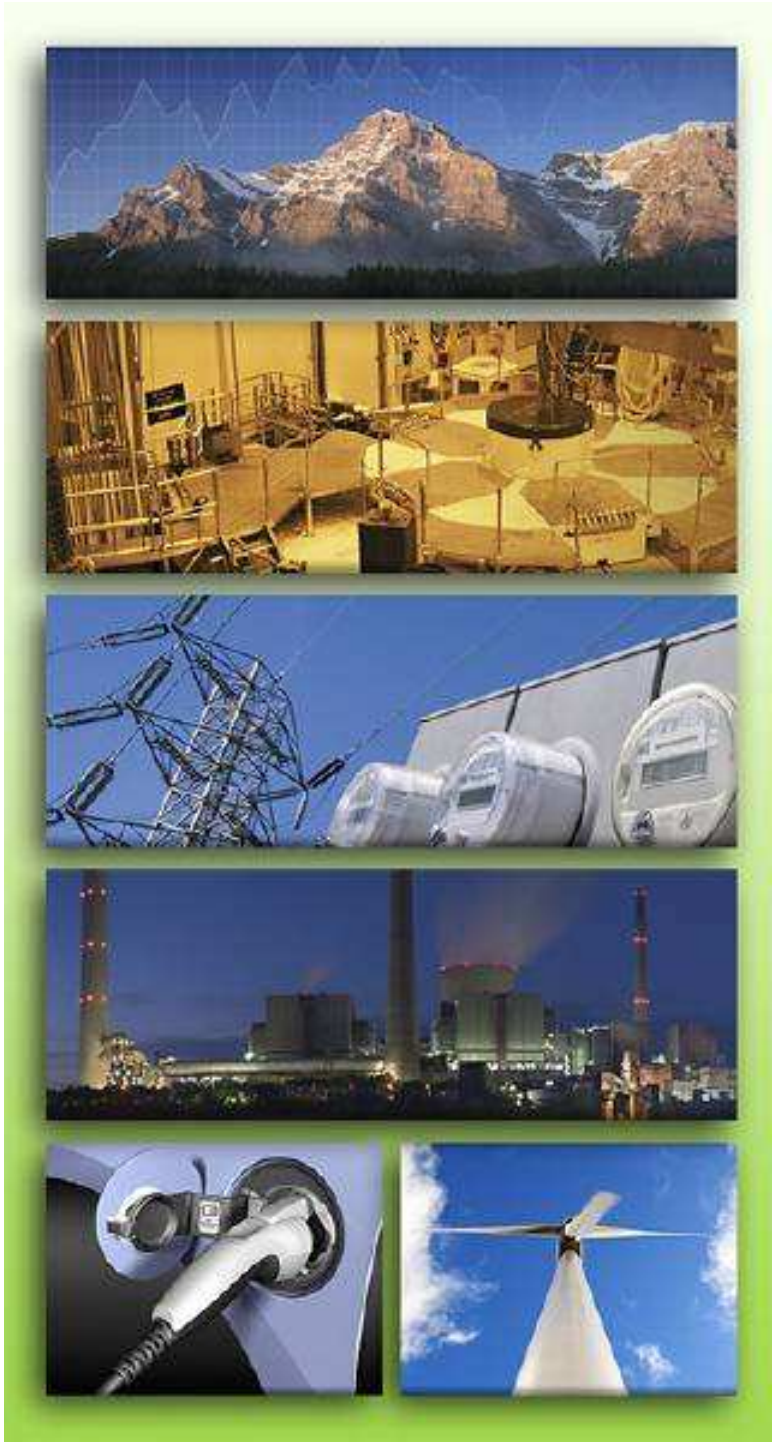


ELECTRIC POWER RESEARCH INSTITUTE

Our Low Carbon Future:

Getting There and Empowering Consumers to Participate

Ellen Petrill
Director, State & Regional Relations

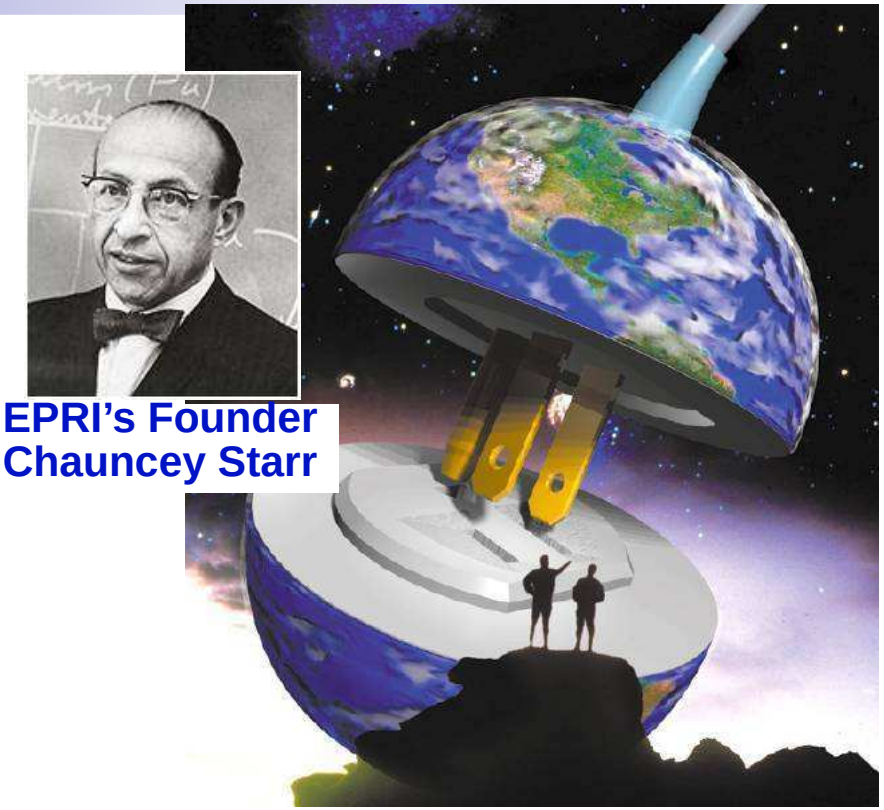
Institute for Regulatory Policy Studies: An Assessment of Energy Markets in the Midwest
April 29, 2010

Outline

- Getting to a low-carbon future
- Smart grid: what is it and what will it enable?
- Feedback and consumer behavior
- Industry/EPRI smart grid demonstration projects

EPRI brings together expert *people* with new and exciting *ideas* to help *energize the world*!

- Founded by and for the electricity industry in 1973
- Independent, non-profit center for public interest energy and environmental research
- Collaborative approach
- Over $355M annual funding
- 450+ participants in more than 40 countries



EPRI's Founder Chauncey Starr

Focus: Reliable, affordable, and environmentally-sustainable electricity

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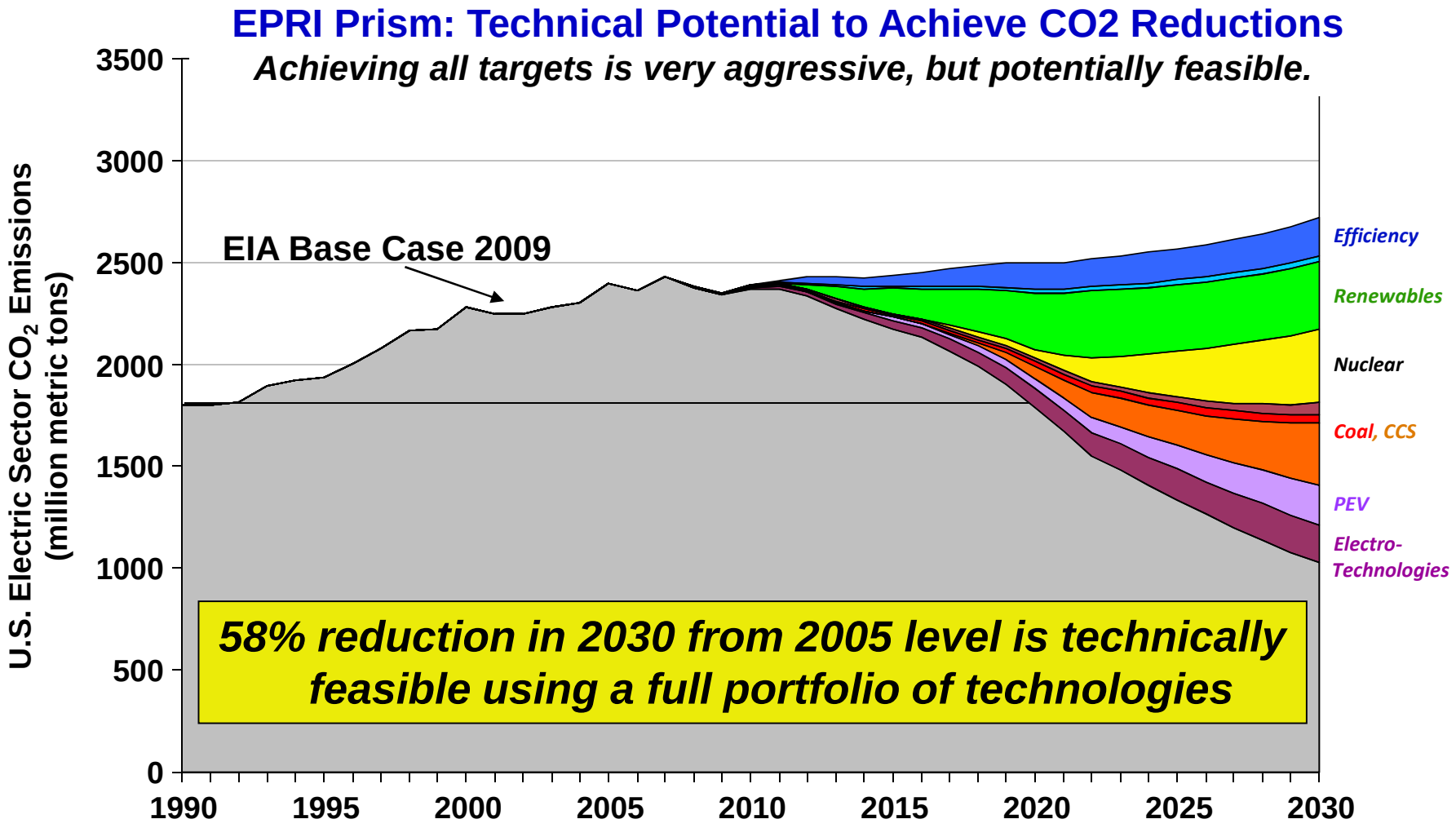
Getting to a Low Carbon Future

A Low Carbon Future Needs A Full Portfolio of Technologies



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2009 Prism Technology Targets

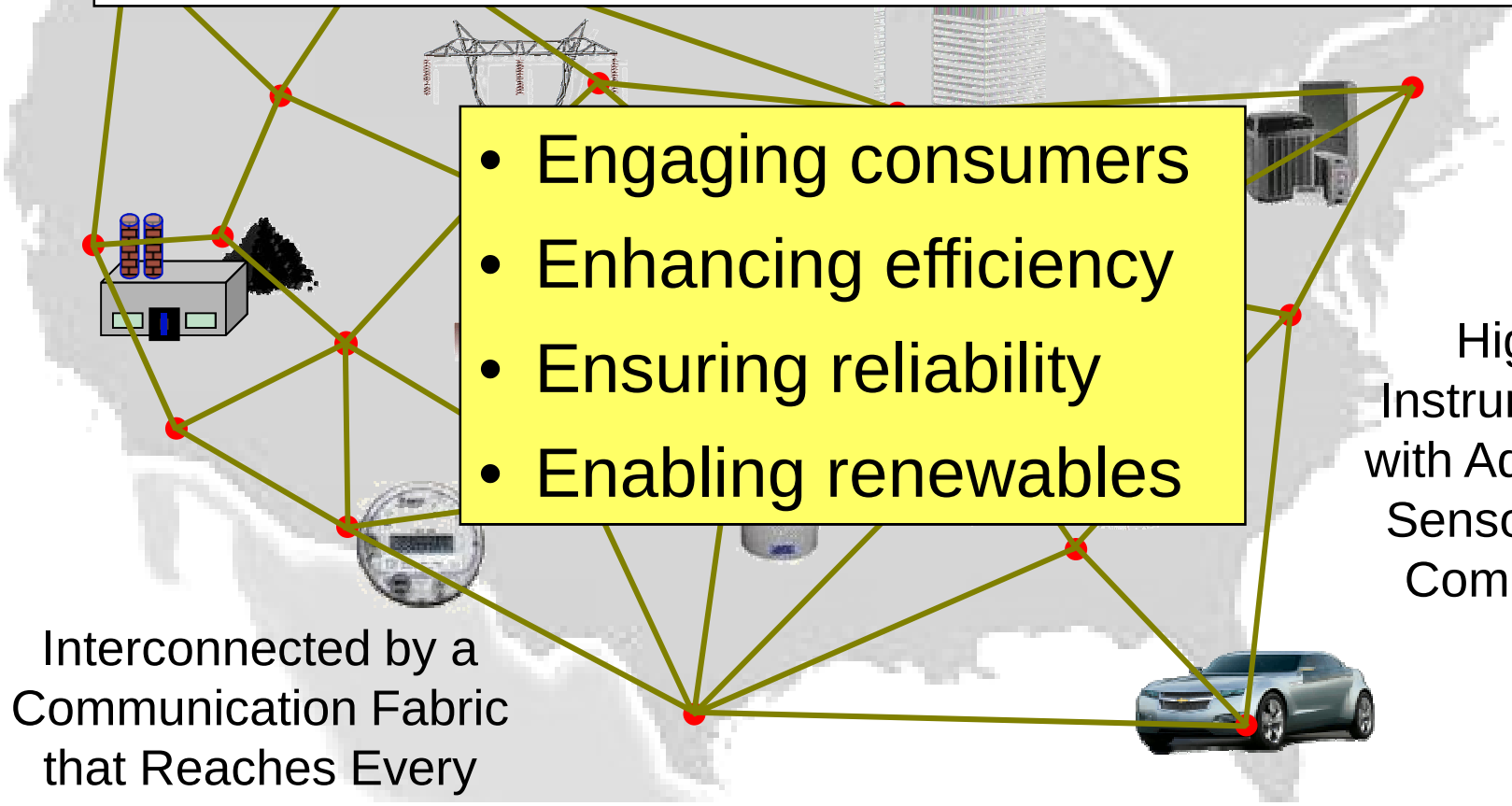
Technology	EIA AEO Base Case	EPRI Prism Target
Efficiency	Load Growth ~ +0.95%/yr	Load Growth ~ +0.47%/yr
T&D Efficiency	None	20% Reduction in T&D Losses by 2030
Renewables	60 GWe by 2030	135 GWe by 2030
Nuclear	12.5 GWe New Build by 2030	No Retirements; 64 GWe New Build by 2030
Fossil Efficiency	40% N…	…5 Efficiency for 75 GWe Existing Fleet 49% New Coal; 70% New NGCCs by 2030
C…	None	90% Capture for All New Coal + NGCC After 2020 Retrofits for 60 GWe Existing Fleet
Electric Transportation	None	PEVs by 2010; 40% New Vehicle Share by 2025 3x Current Non-Road Use by 2030
Electro-technologies	None	Replace ~4.5% Direct Fossil Use by 2030

Enabled by Smart Grid

Smart Grid: What is it and what will it enable?

What is Smart Grid?

Two-way flow of electricity and information in an automated electricity delivery network



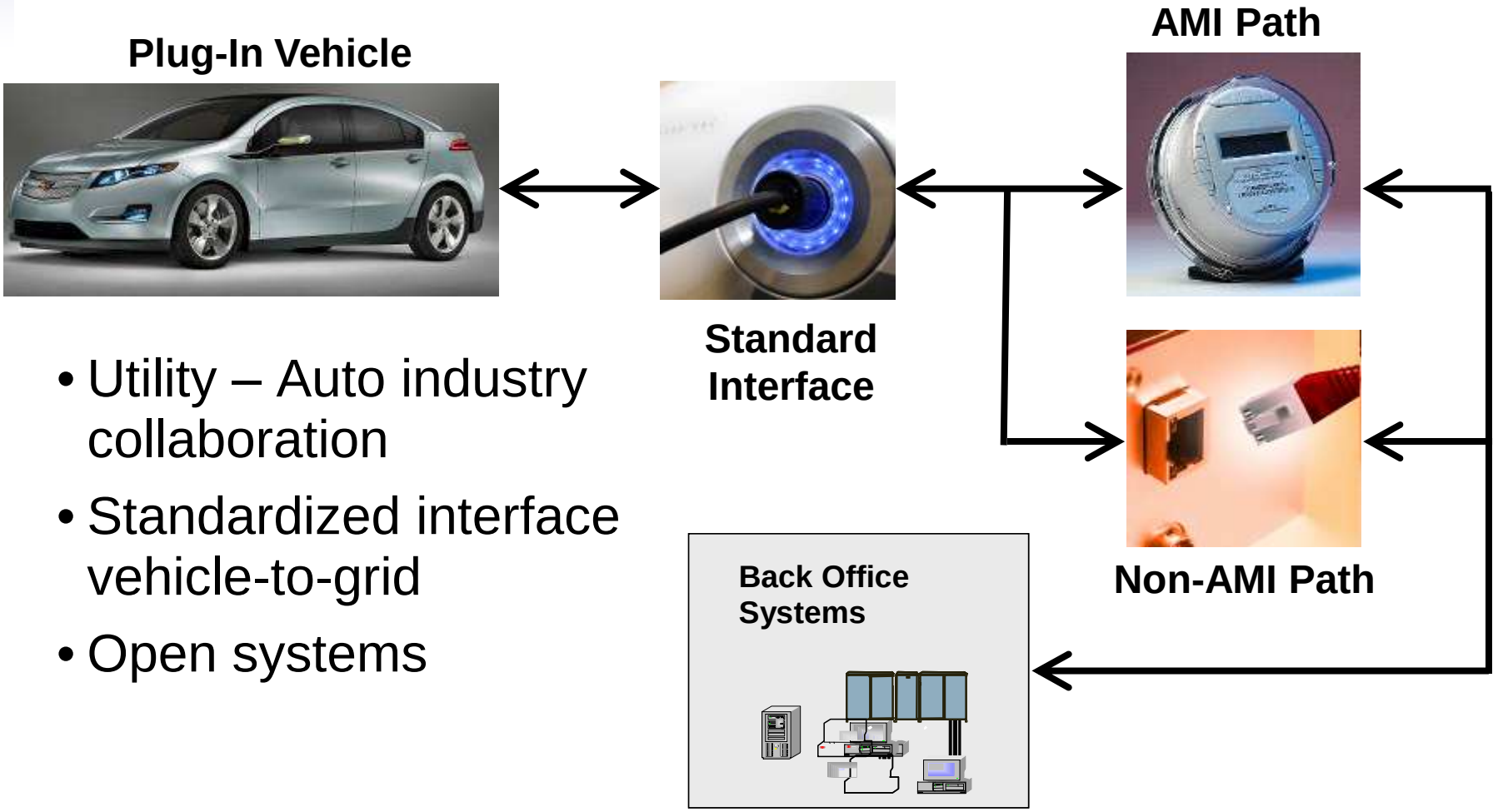
- Engaging consumers
- Enhancing efficiency
- Ensuring reliability
- Enabling renewables

Highly Instrumented with Advanced Sensors and Computing

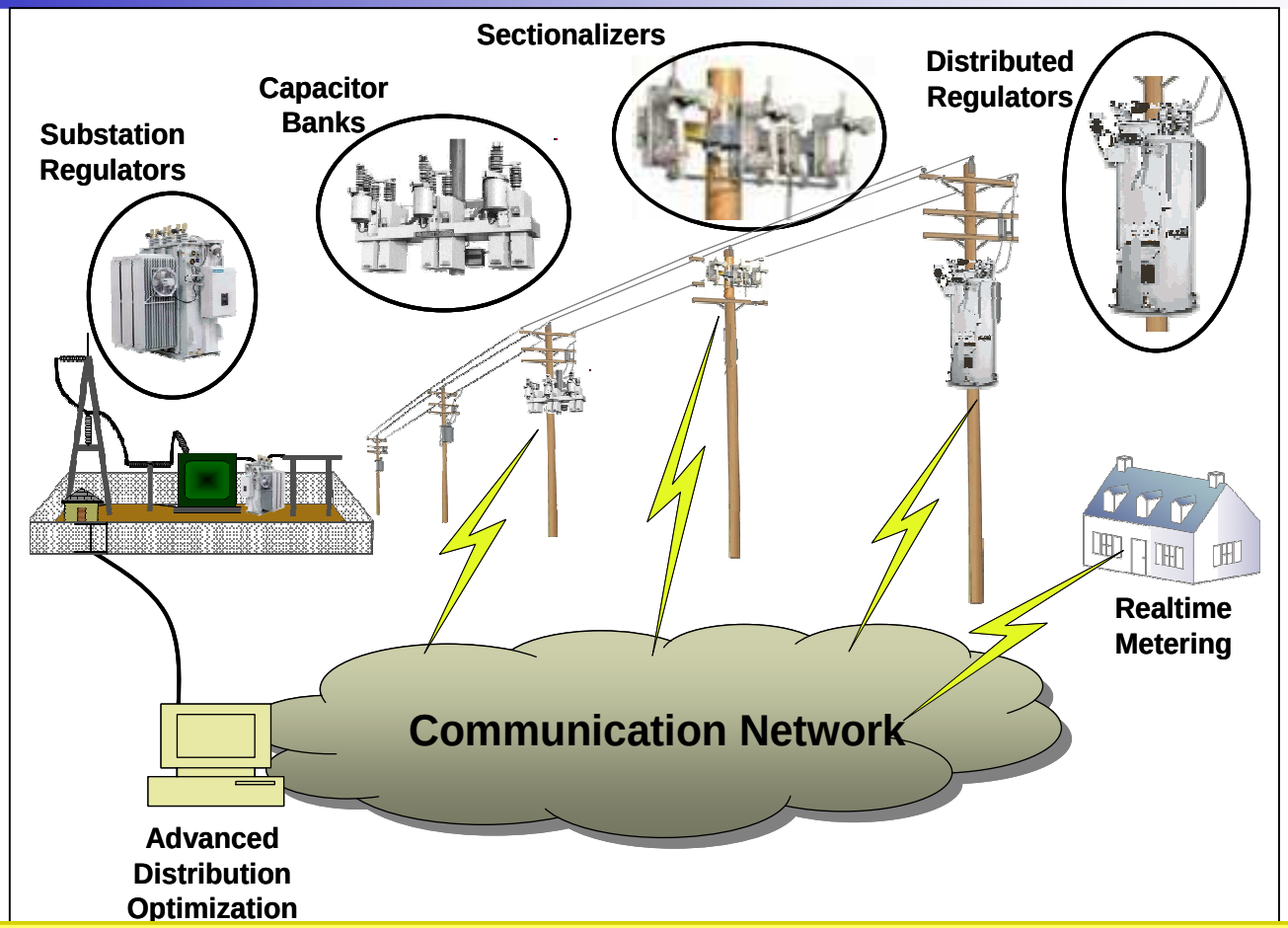
Interconnected by a Communication Fabric that Reaches Every Device

Enabling PHEV Through Smart Charging

- Utility – Auto industry collaboration
- Standardized interface vehicle-to-grid
- Open systems



Reducing Energy Usage and Peak Demand by Optimizing Distribution System Operation



Devices, Sensors, and Communications and Controls Will Enable Voltage Optimization

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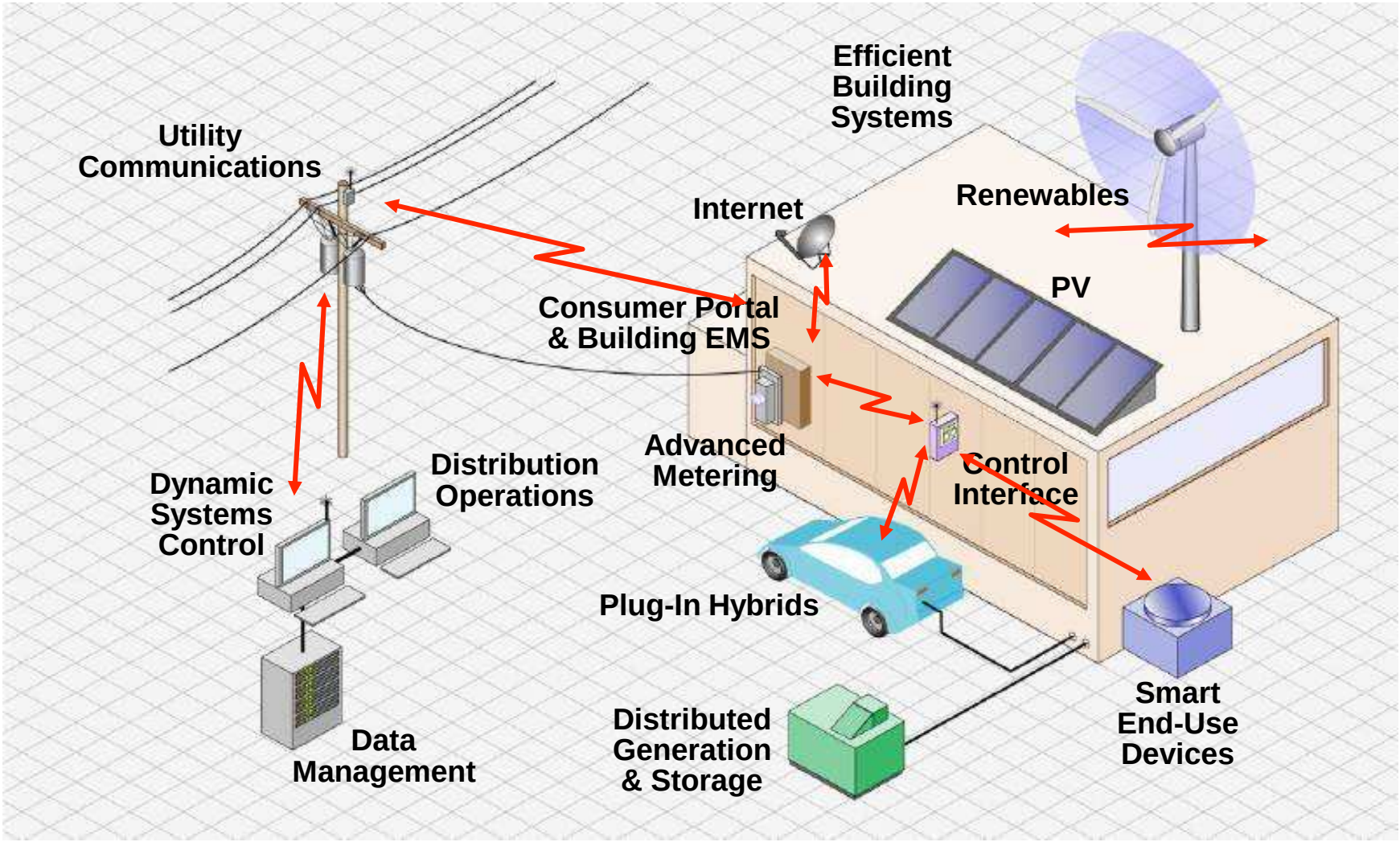
The Smart Grid: Empowering Consumers through Dynamic Energy Management



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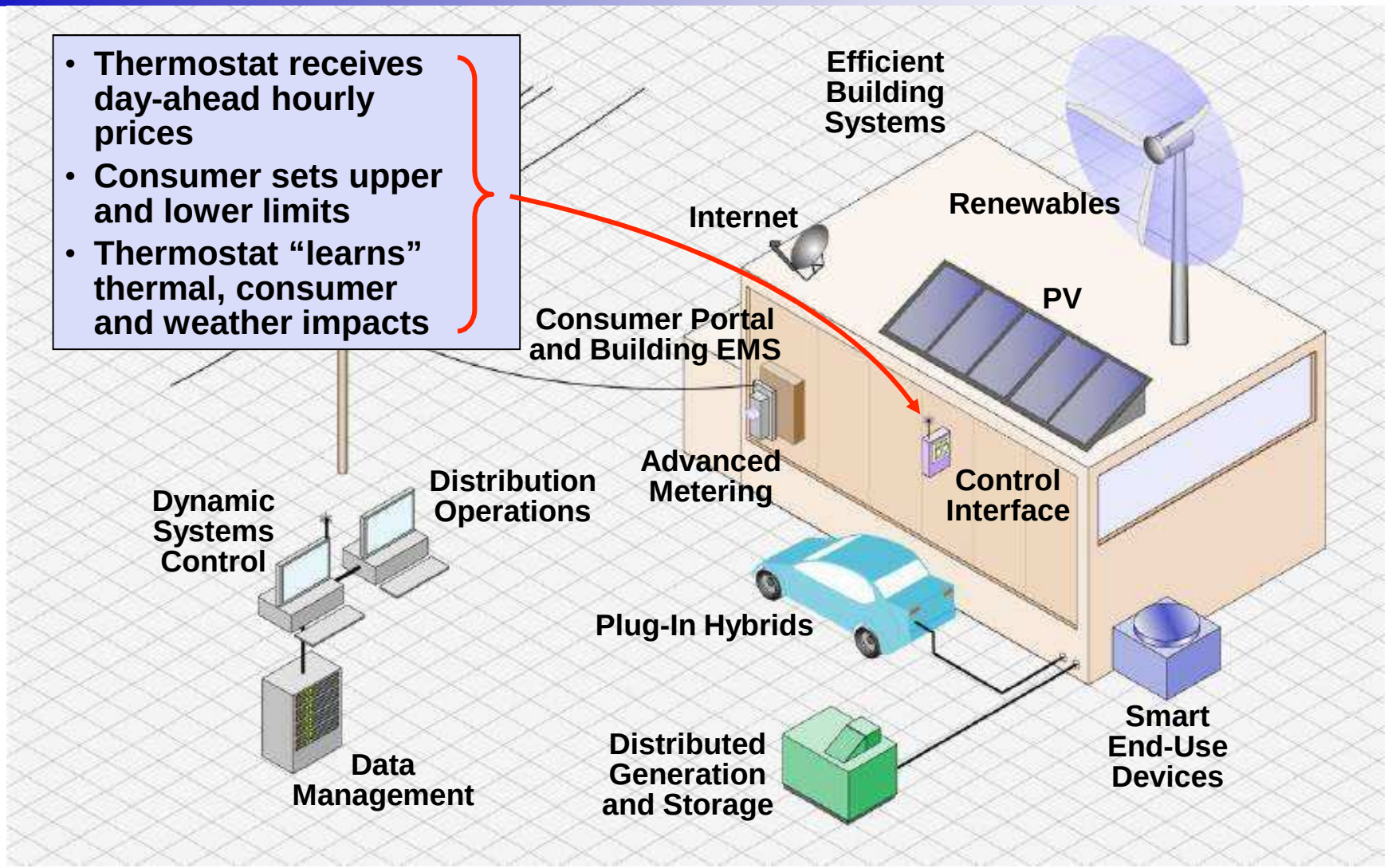
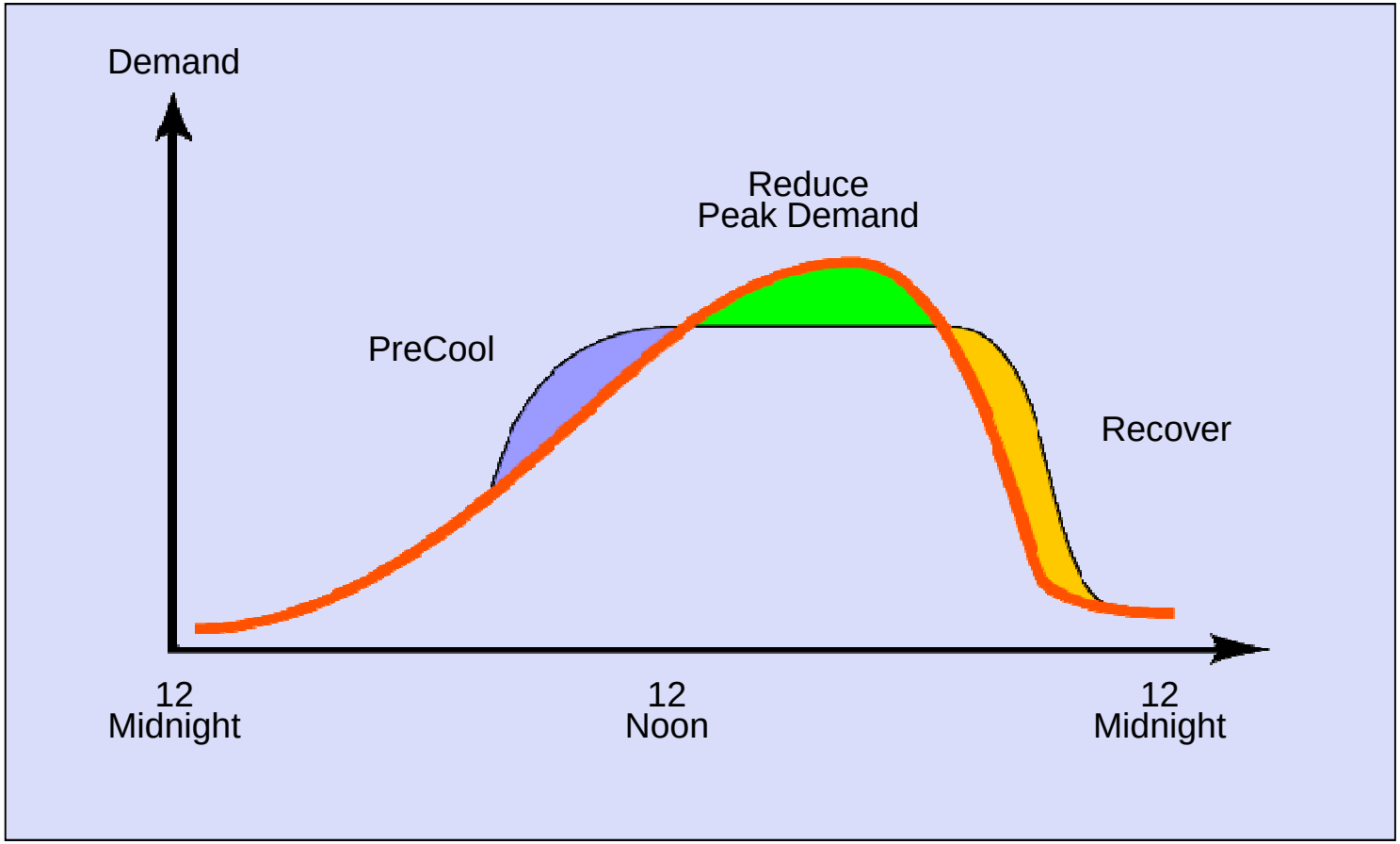
Prices to Devices: Tomorrow's Smart Pricing

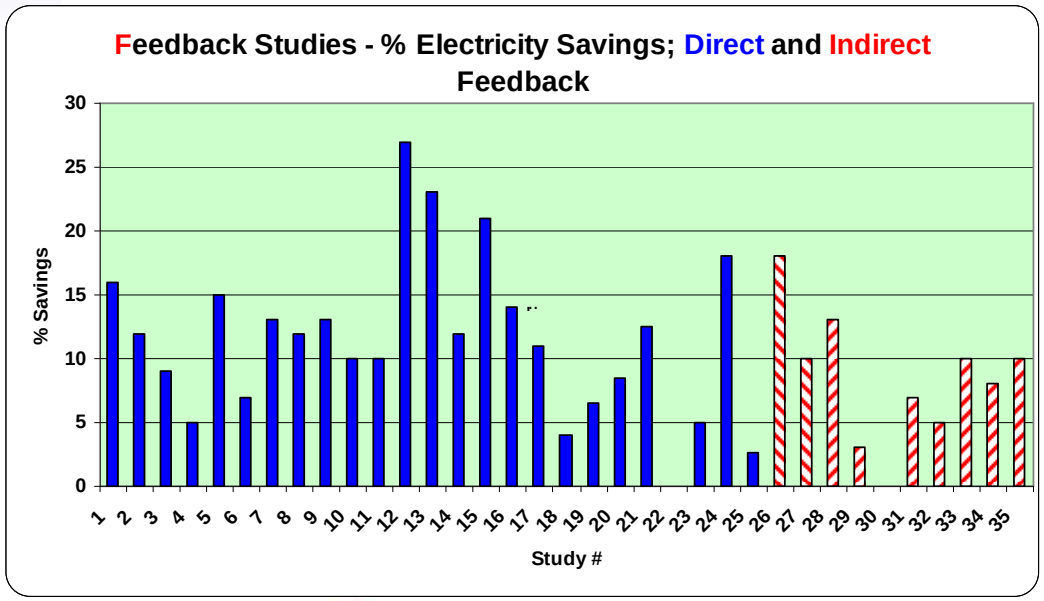


Reducing Peak with Prices to Devices



Reduce peak while maintaining comfort and productivity

Smart Grid Can Provide Feedback Enabling Consumers to be More Efficient



Feedback studies have resulted in a range of results

EPRI research will help quantify feedback benefits

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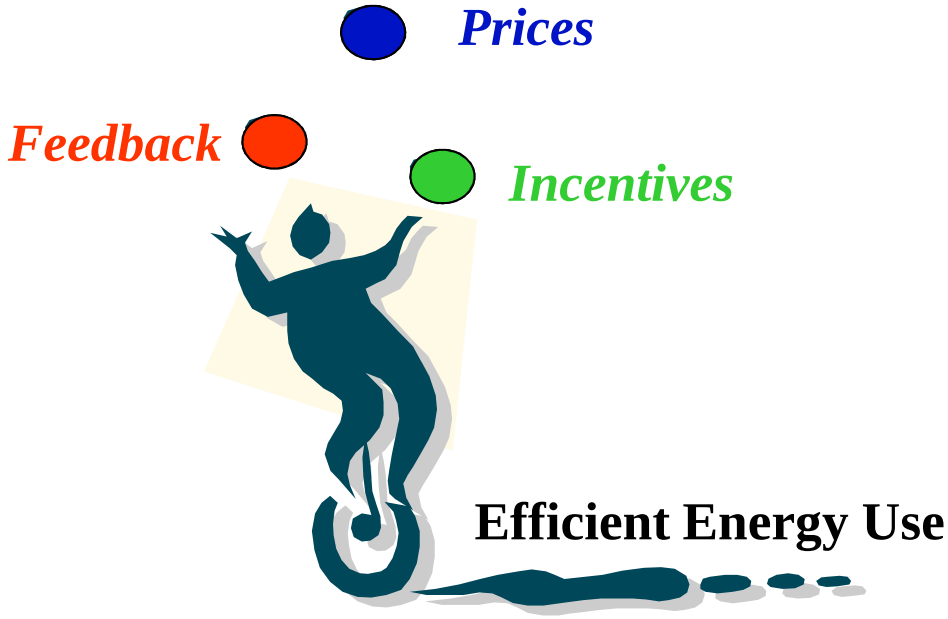
Electricity Related Apps – More Will Come!

Feedback and Consumer Behavior

Feedback Defined and Characterized

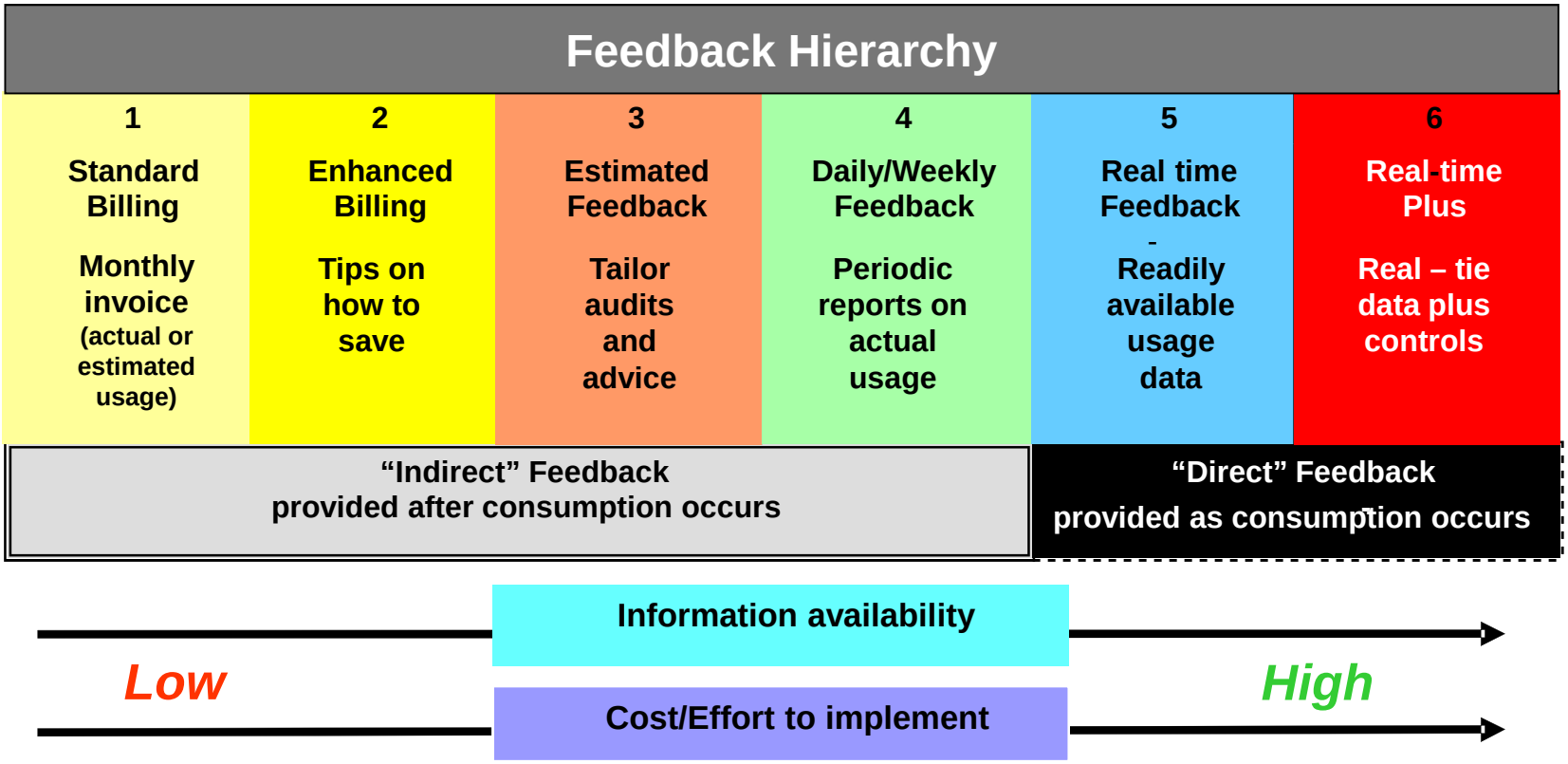
- What is feedback?
  - "A process whereby the results of action serve continually to modify further action."

    -- Webster's Pocket Dictionary, 1997



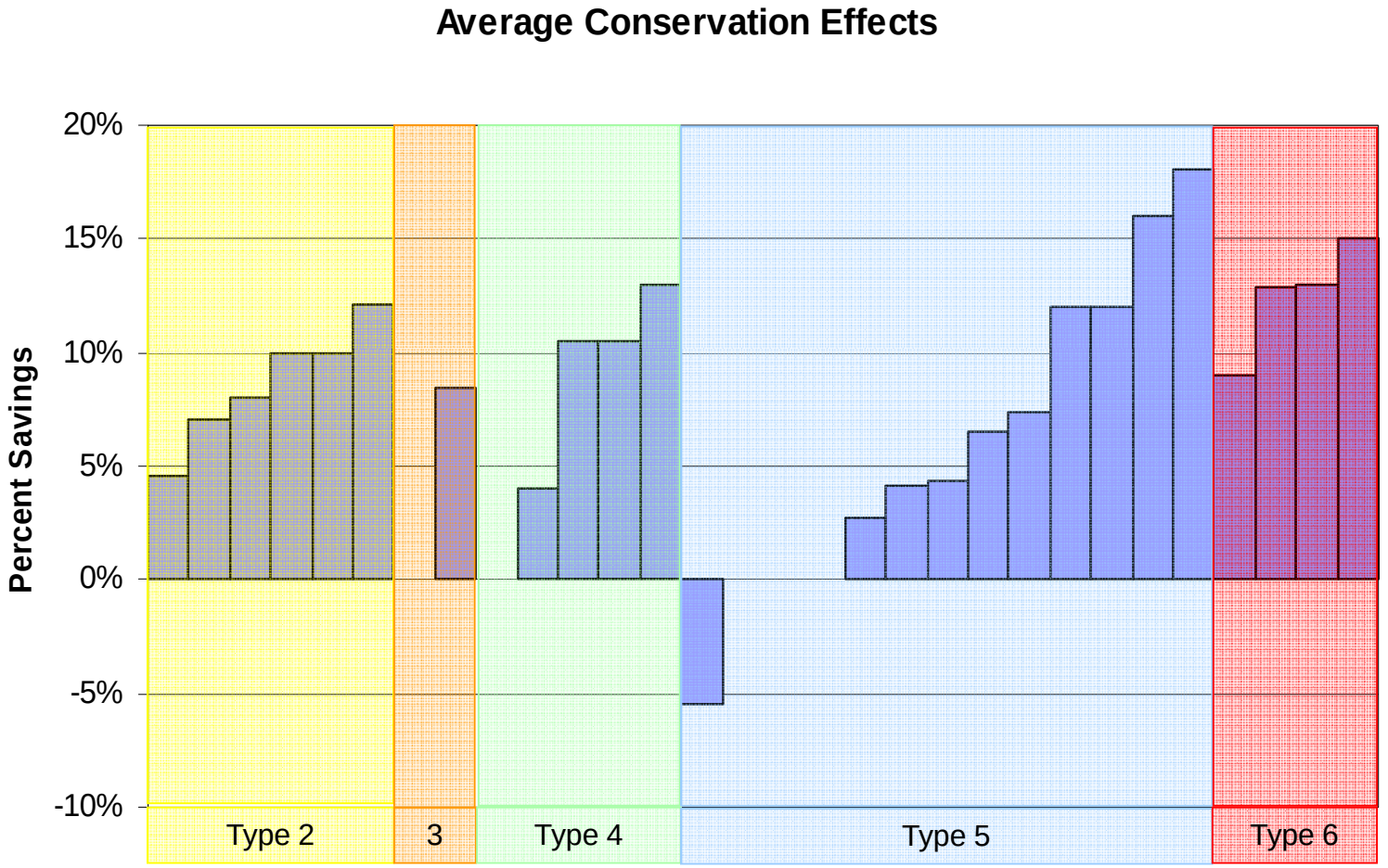
EPRI Synthesized Feedback and Developed Framework in 2009

- Darby provided an important distinction; indirect vs. direct
- EPRI added a functional hierarchy



EPRI Report 1016844: *Residential Electricity Use Feedback: A Research Synthesis and Economic Framework*

Research Revealed A Range of Results



The State of Feedback Research

Our understanding of how feedback influences electricity consumption is incomplete

Extensibility

Can the results be extended to other markets and circumstances reliably?

- **Pilot scale**
- **Sampling frame**
- **Feedback Mechanism**
- **Technology scope**

Veracity

Have feedback impacts been characterized fully and separately?

- **Persistence**
- **Characterization**
- **Verification**
- **Price effects**

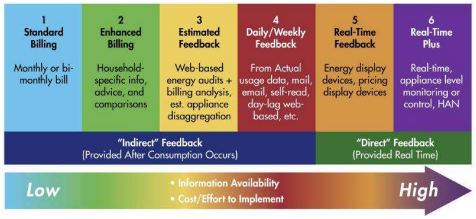
Cost-Effectiveness

Are the results robust and comprehensive enough to support tests of program efficacy?

- **Awareness**
- **Willingness to pay**
- **System and societal value**

Feedback Body of Research Looks Promising, But Questions Remain

- Results promising, but wide ranging: -6% to 18%
  - Includes older studies, smaller sample sizes…
- Characterization is incomplete
- EPRI literature review revealed research gaps:
  - Sample sizes
  - Persistence
  - Feedback types (relative impact)
  - Pricing interactions
  - Demographic distributions



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Considering In-Home Devices Studies (Category 5)

- Review of 7 studies
  - Connecticut Power & Light, Dominion Virginia Power, Energy Trust of Oregon, Hydro One (4 studies), Massachusetts
- Of 5 with known numbers:
  - 0 to 6.5% overall energy savings (kWh)
  - Average: 3.8%
  - All the same device (Blue Line PowerCost Monitor)
  - Pilot sizes:
    - 350 to 30,000
  - Analysis sample sizes:
    - 153 to ~1,000

2009 Highlights: Pilot Numbers Growing, Guidance Of Value

- Identified 36 utilities with pilots (detailed overview of nine)

2 Enhanced Billing	3 Estimated Feedback	4 Daily/Weekly Feedback	5 Real-Time Feedback	6 Real-Time Plus
11	0	14	32	12

  - Many more…
  - SG stimulus funding recipients
  - EPRI efforts: SG demos, feedback collaborative

- How are they addressing the research gaps?
  - Size and rigor
  - Persistence
  - Relative value of different feedback types
  - Dynamic pricing interactions
  - Demographic variations

New EPRI Report: Feedback Research Design Protocols

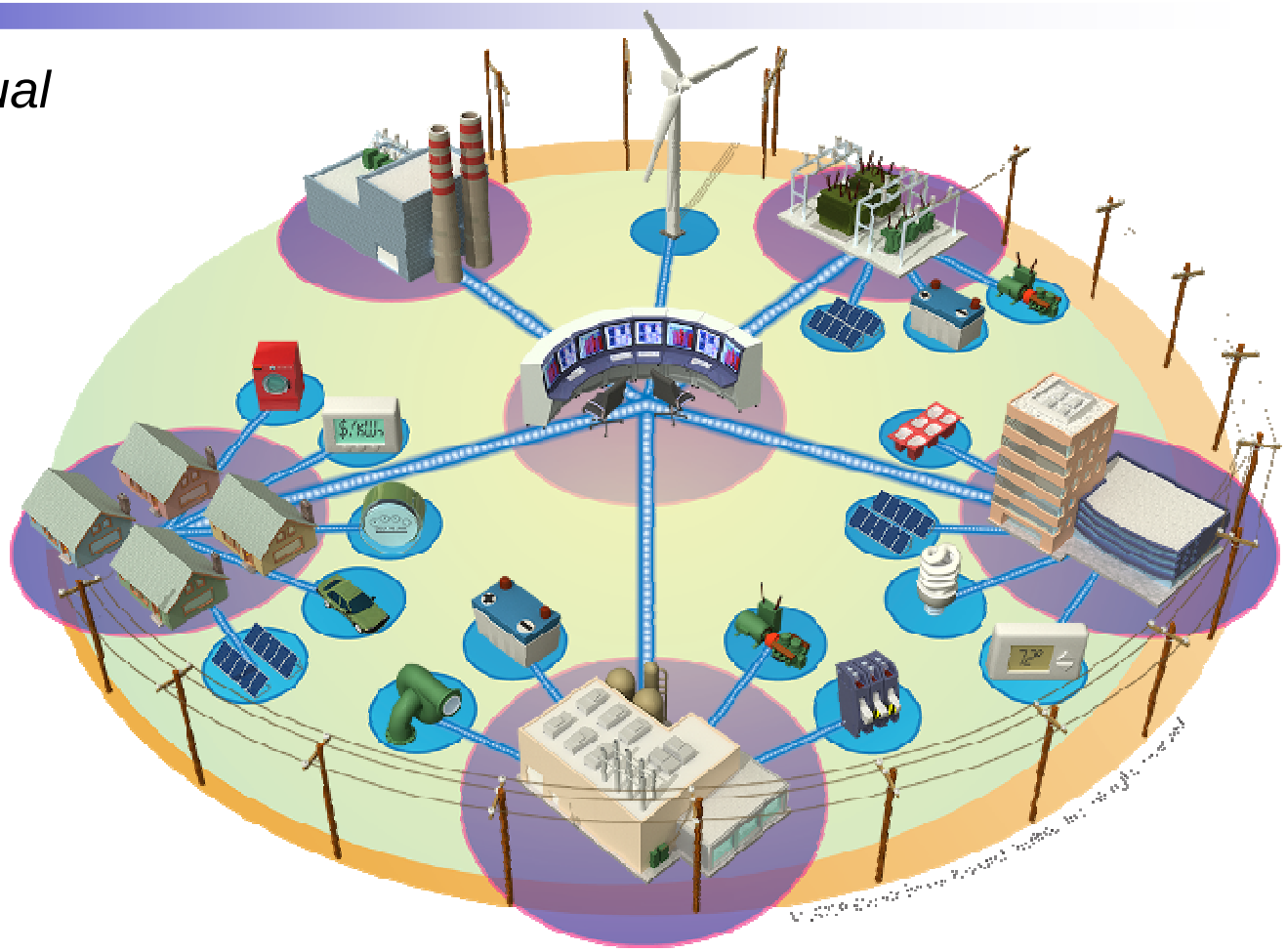
Objectives

- Facilitate design and implementation of feedback research
- Develop three protocols
  - Research design
  - Analysis
  - Documentation
- Protocols will:
  - Be based on accepted principles of sound experimental design
  - Allow for the pooling of results
    - Address key research gaps collaboratively, not “one-off”
  - Provide approaches for understanding what and how behavior change occurs
- Represents 1st phase of EPRI’s effort to develop a feedback research collaborative

Industry/EPRI Smart Grid Demonstration Projects

Learning from Industry/EPRI Demonstrations

- Deploying the *Virtual Power Plant*
- Demonstrate integration and interoperability
- 8-10 regional demonstrations
  - Multiple levels of integration
  - Multiple types of distributed energy resources and storage

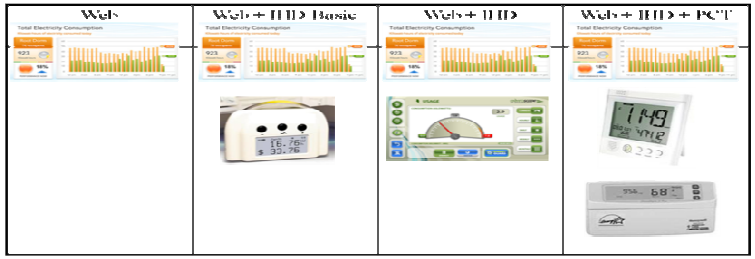


Exelon (ComEd/PECO) Smart Grid Demo Project

Exelon Smart Grid Strategy

ComEd – Customer Application Pilot

Arguably most comprehensive customer behavior study ever, includes “opt-out” signup

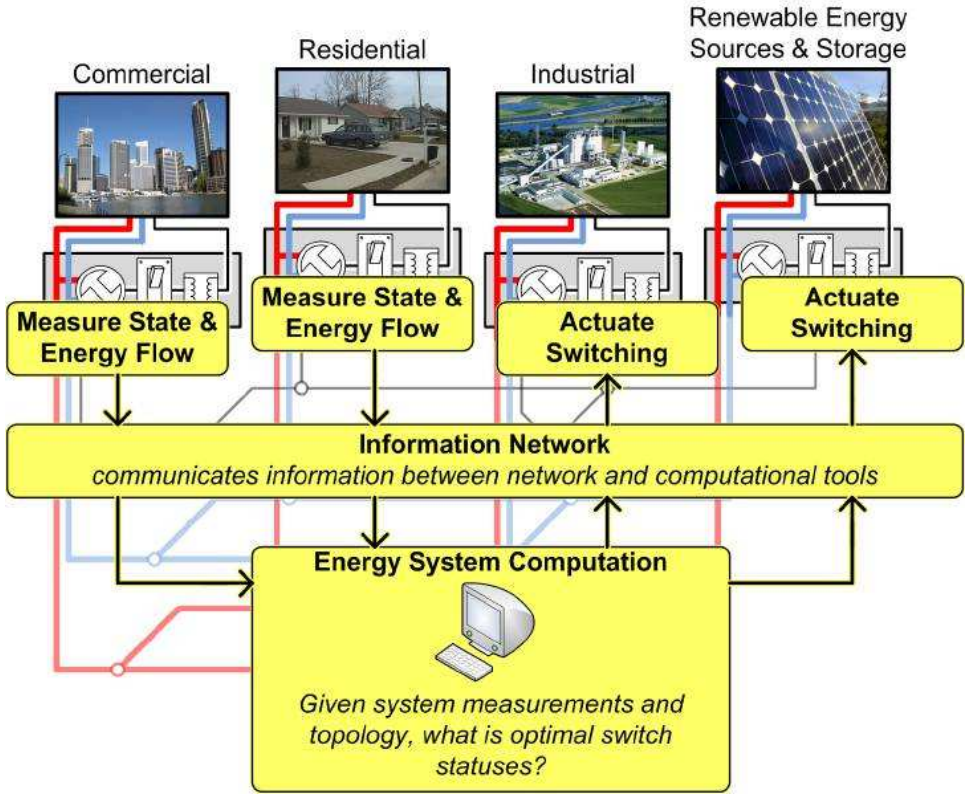


	In-Home Technologies			
RATES	Simple → Sophisticated			
Flat ↓ Dynamic	X	X	X	X
	X	X	X	X
	X	X	X	X
	X	X	X	X

Study Groups

PECO Smart Campus – Drexel University

Microgrid



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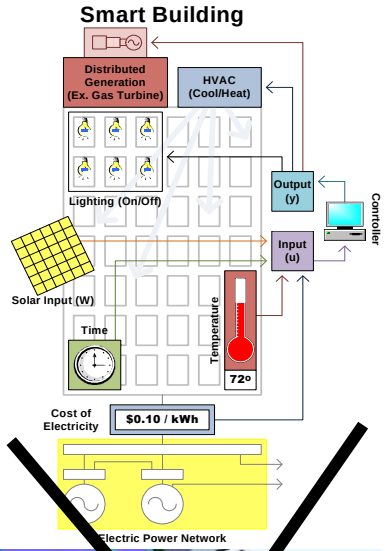
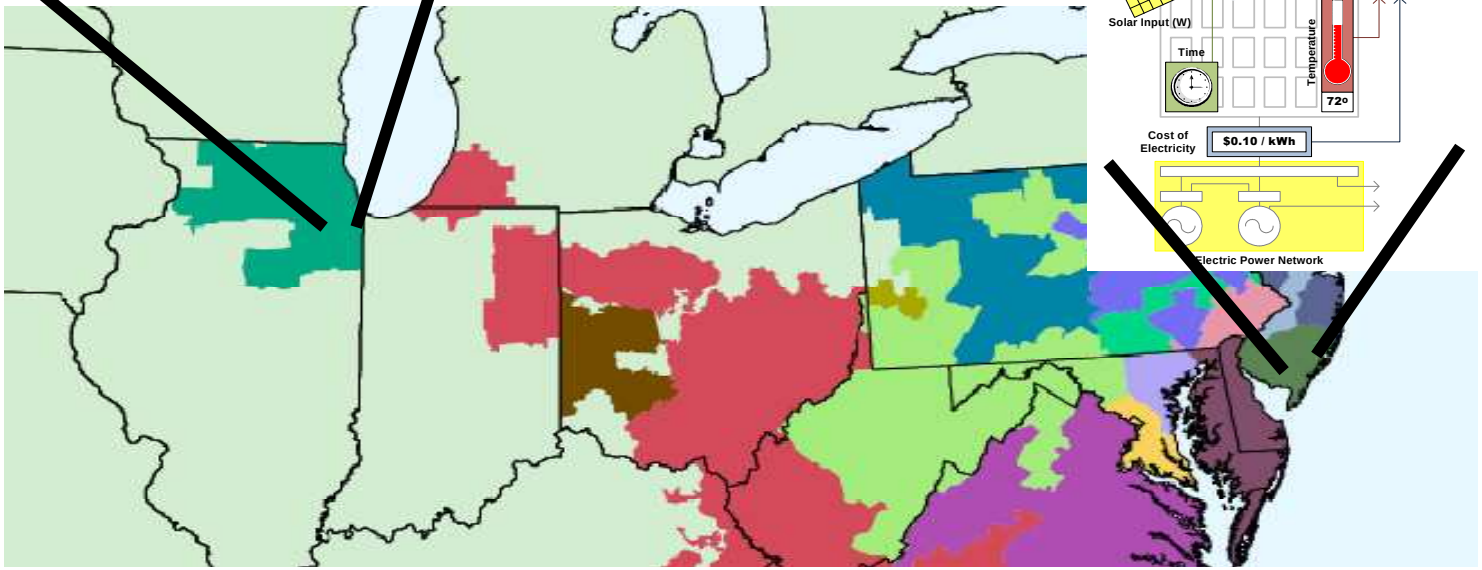
Exelon (ComEd/PECO) Project Locations

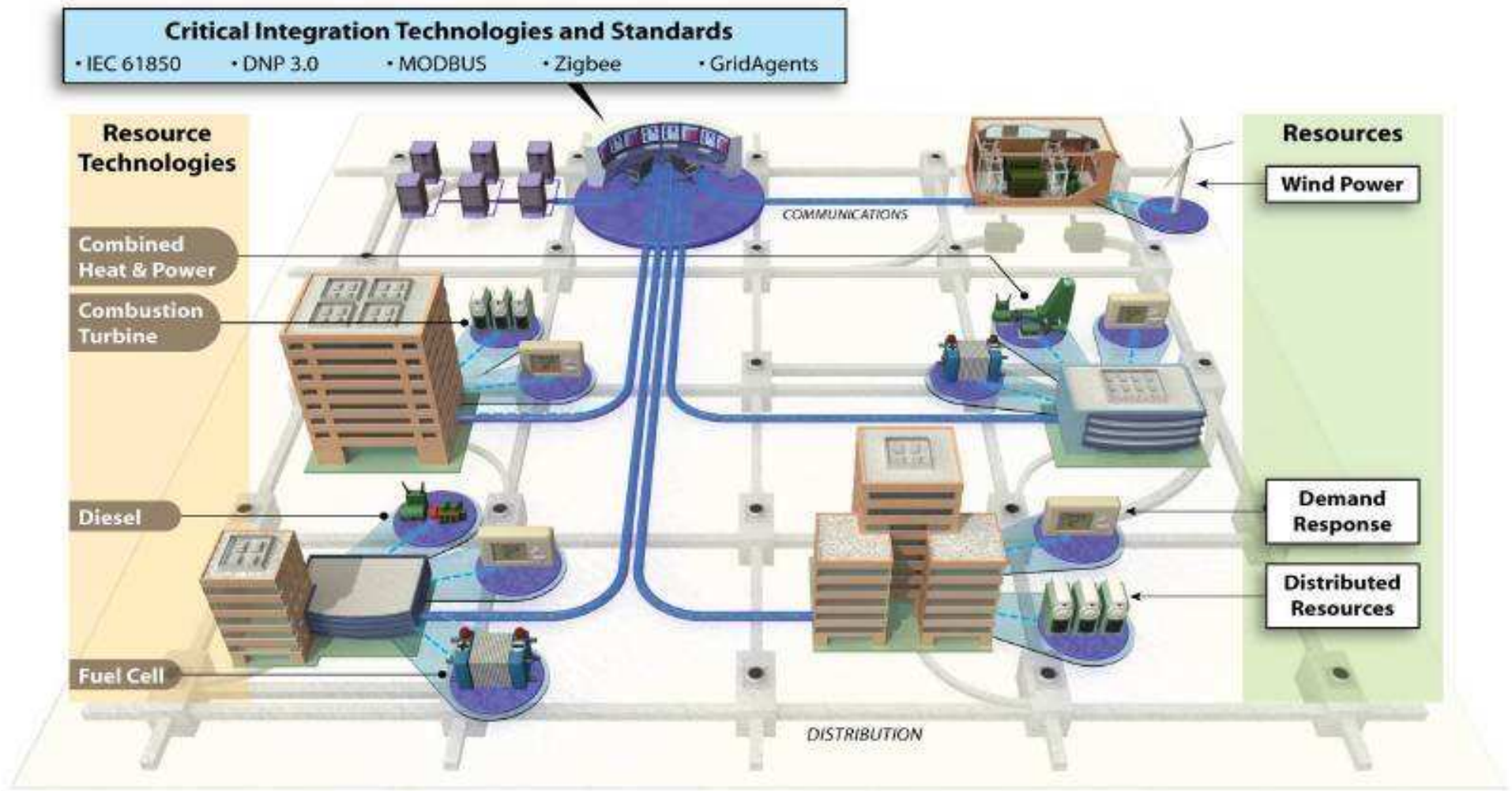
ComEd Customer Application Pilot

PECO – Drexel Smart Campus Project





Con Edison
Interoperability of Demand Response Resources



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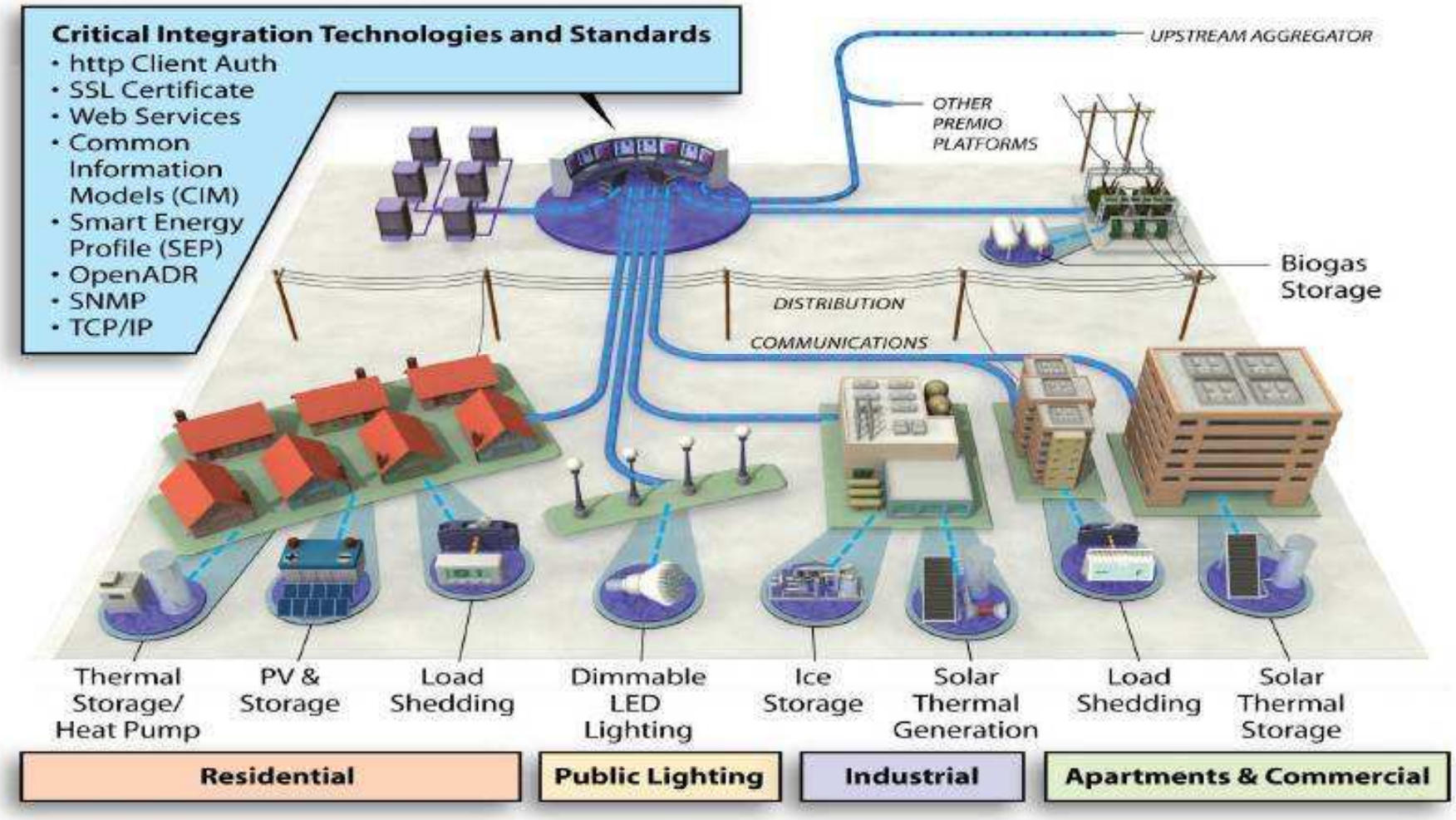
ConEdison

Electricité de France (EDF)

PREMIO: Distributed Energy Resources Aggregation & Management



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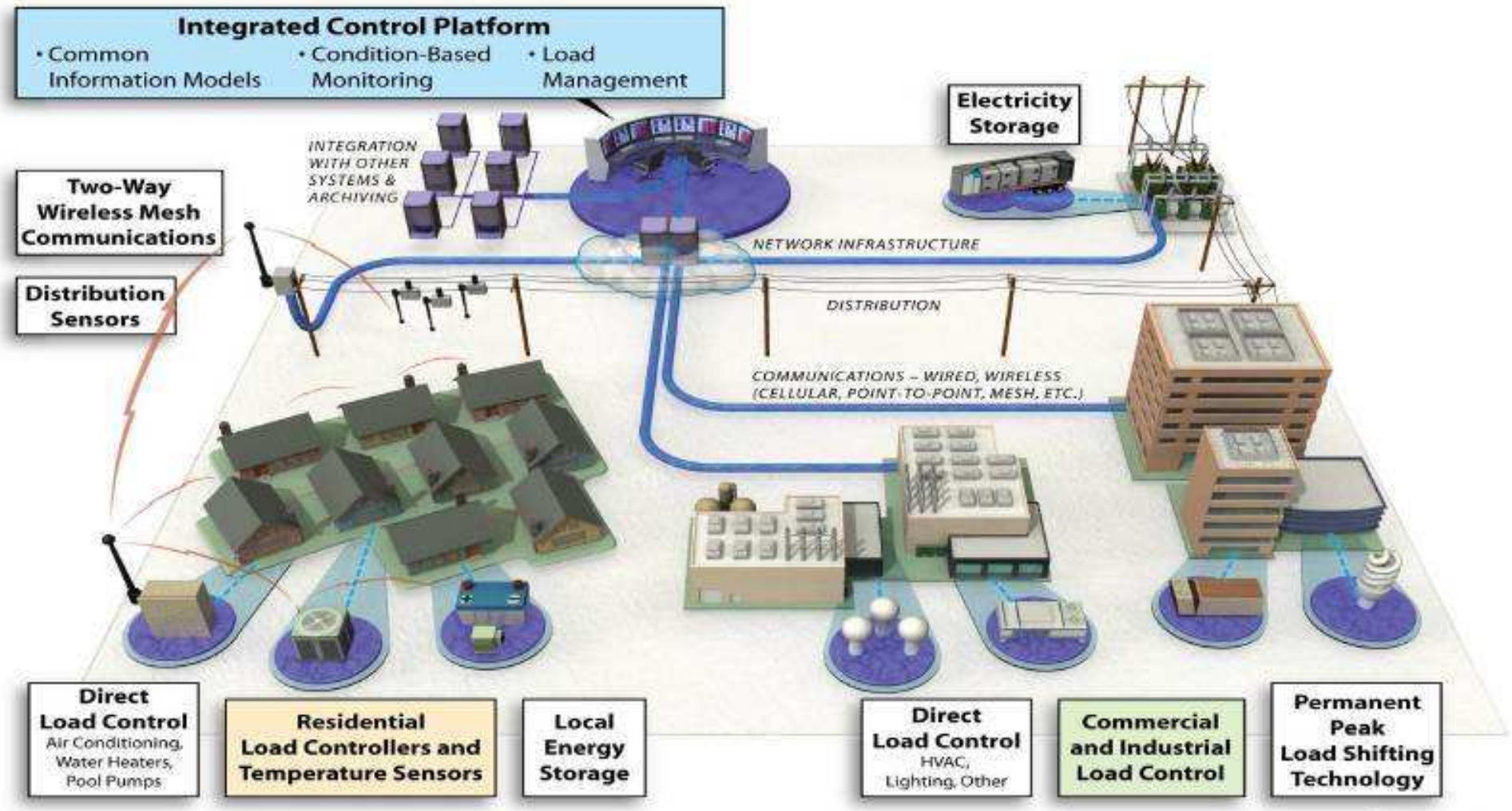
Région Provence-Alpes-Côte d'Azur

capenergies Premio

EDF

FirstEnergy / Jersey Central Power & Light
Integrated Distributed Energy Resources



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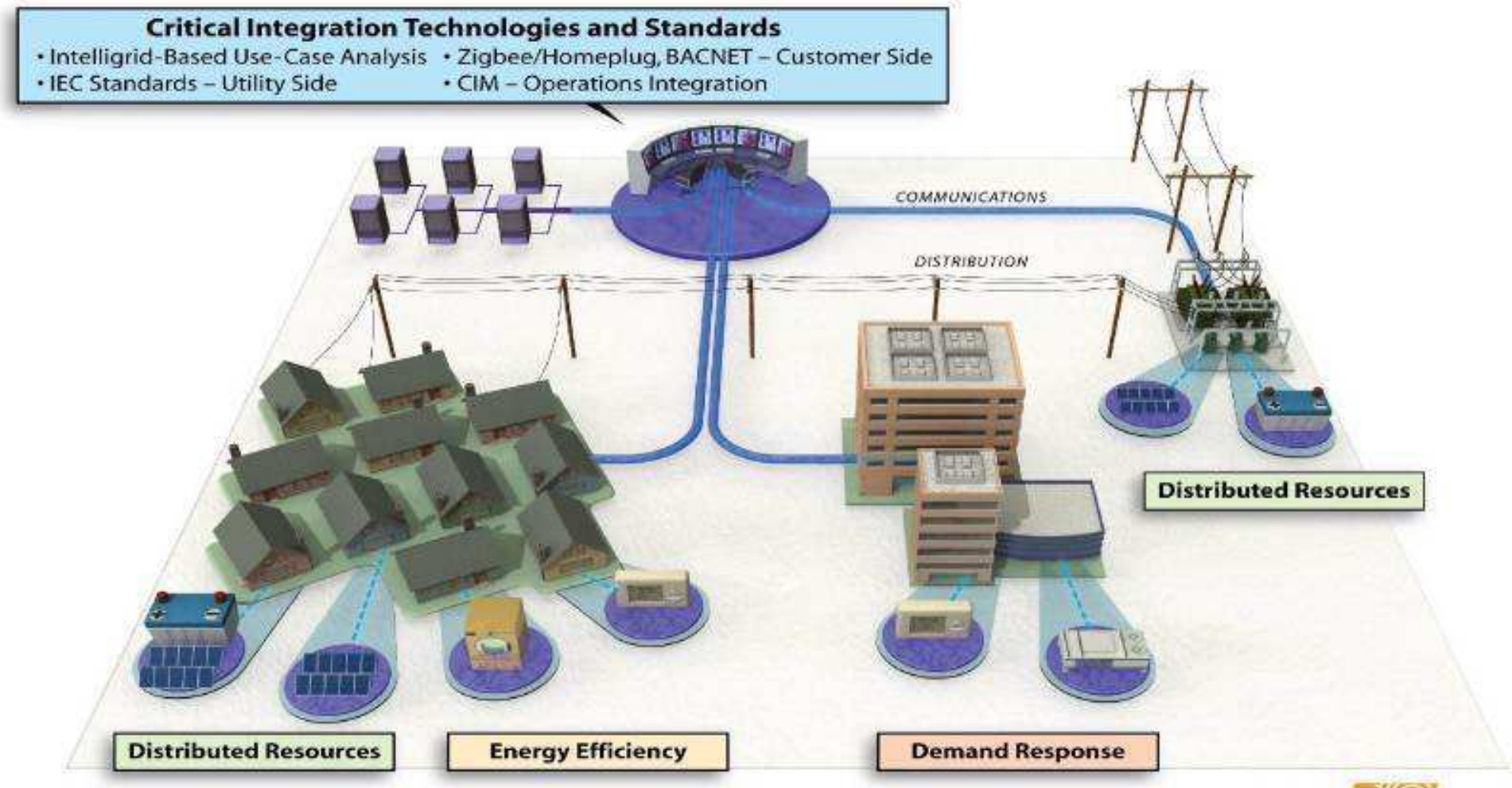
FirstEnergy

Jersey Central Power & Light
A FirstEnergy Company

Public Service Co. of New Mexico

High-Penetration PV thru Grid Automation and Demand Response



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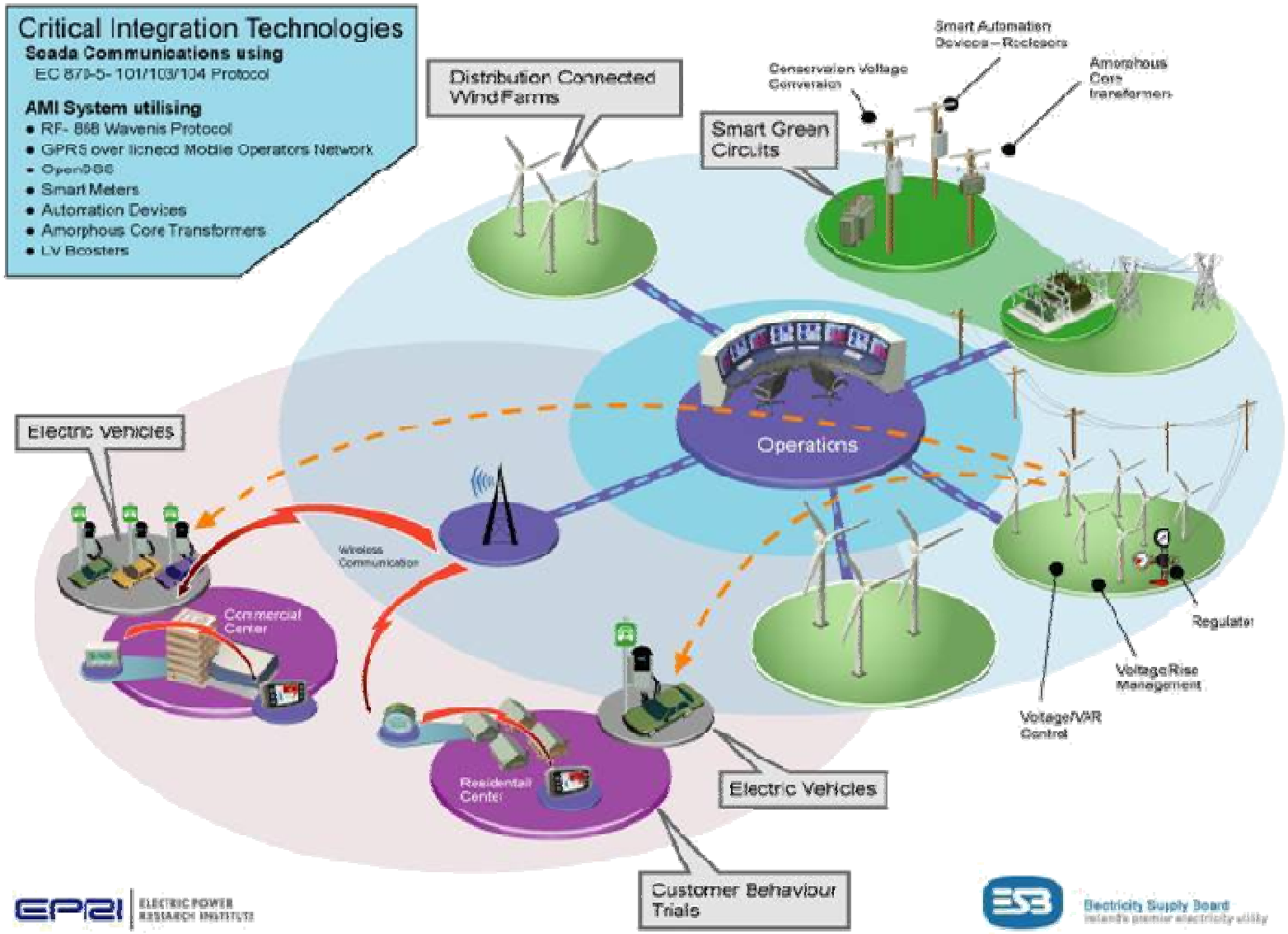
PNM

ESB Networks (Ireland)

A Roadmap for Smart Grid Networks



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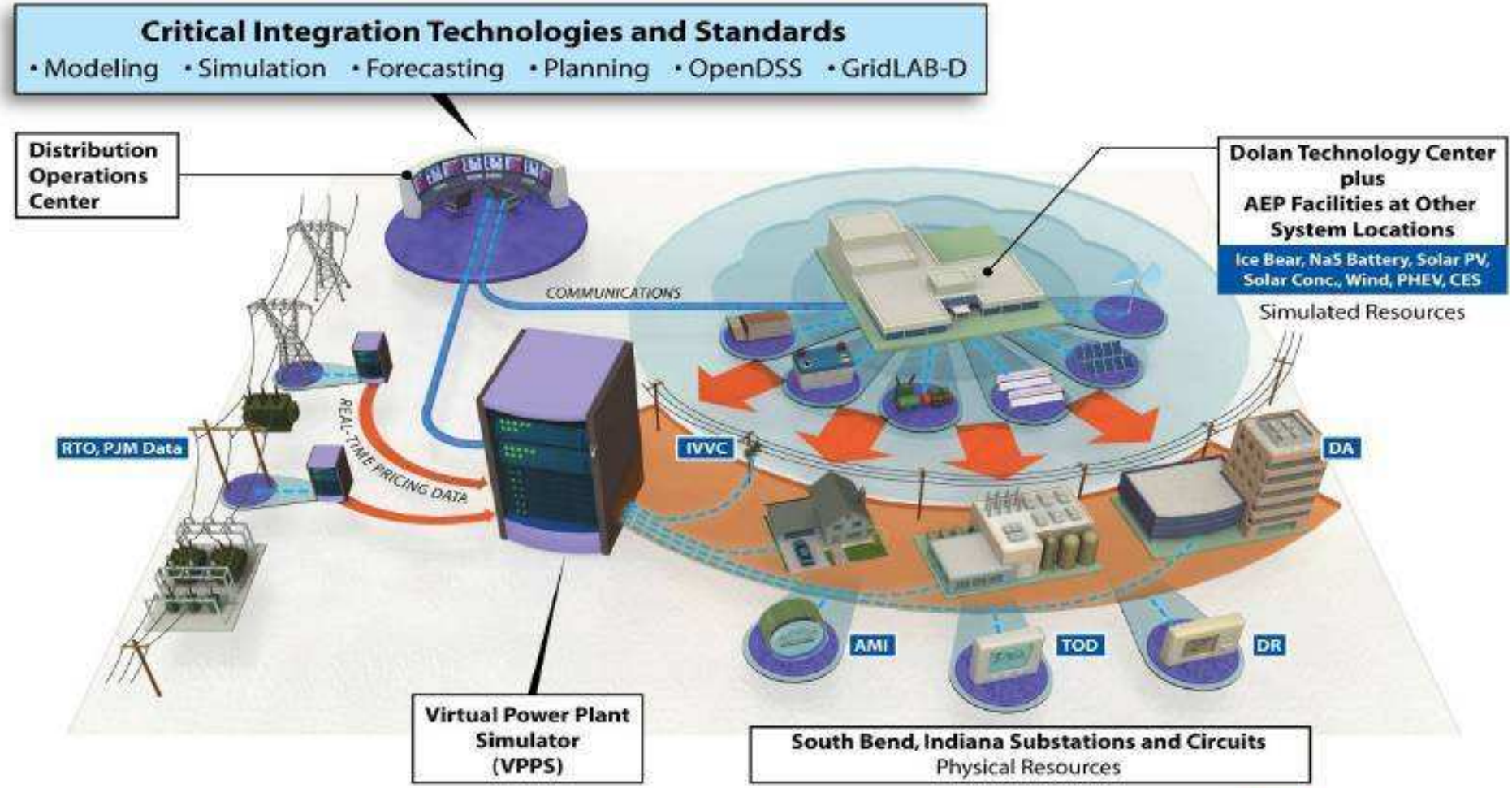
ESB Electricity Supply Board
Ireland's premier electricity utility

American Electric Power
Virtual Power Plant Simulator



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AEP AMERICAN® ELECTRIC POWER

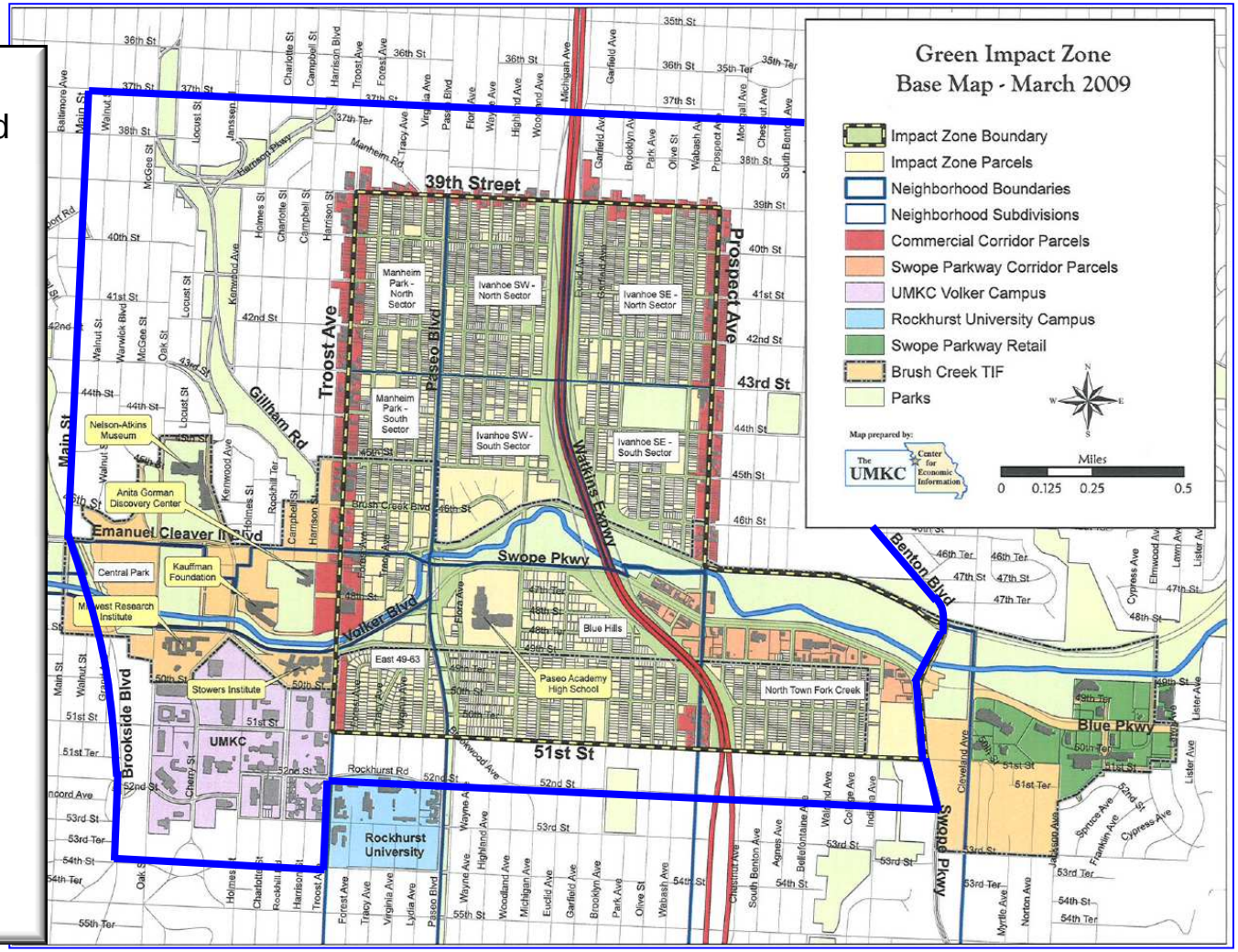
KCP&L Smart Grid Demo Project

The Green Impact Zone

Project Summary

A Concentrated Smart Grid and Energy Efficiency Demonstration Area

- Smart Customer
  - Energy Display
  - Thermostats
  - H-EMS Portal
- Efficiency Programs
  - Residential Rebates
  - C&I Rebates
  - Other
- Distributed Generation
  - Solar Demonstration
- AMI
- Distribution Automation
- Smart Substation
- Distributed Storage
  - Bulk Battery



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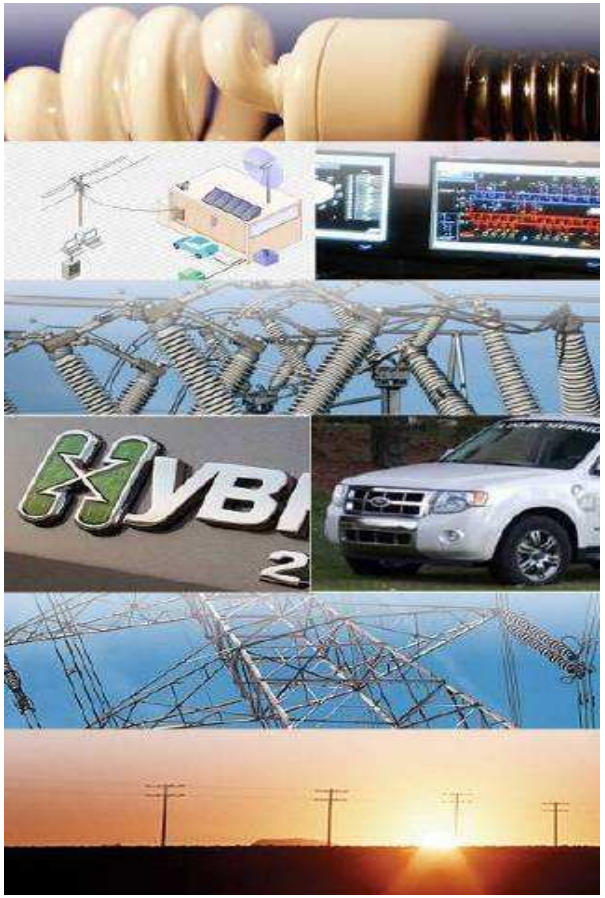
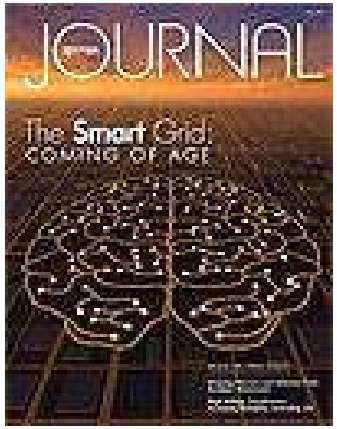
Conclusions

- Electricity technology is key to our low carbon future
- The smart grid is an enabler of innovation
  - Low-carbon options
  - Customer empowerment
- Effects of feedback on consumer behavior appear positive; more work is needed
- R&D and demonstrations are critical to getting to our low carbon future



Resources



The Power to Reduce CO2 Emissions: The Full Portfolio 2009 Technical Report

http://my.epri.com/portal/server.pt?Abstract_id=000000000001020389

Prism/MERGE Analyses: 2009 Update

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Residential Electricity Use Feedback: A Research Synthesis and Economic Framework

http://my.epri.com/portal/server.pt?Abstract_id=000000000001016844

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

Together...Shaping the Future of Electricity

Ellen Petrill
epetrill@epri.com
650-855-8939

www.epri.com

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Image from *NASA Visible Earth*