The Smart Grid

From Vertical Integration to Enabling Price Responsive Demand

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Connecticut Light & Power
The Northeast Utilities System

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Presentation Topic

- History of the U.S. Electric Power Industry
- Restructuring (Deregulation)
- Independent System Operators
- Integration of Demand Resources
- Order 745 and the State Energy Strategy
- Demand Response Enabling Technologies
- The Smart Grid and its applications
- Load Monitoring and Automation Control

History of the U.S. Electric Power Industry

http://www.eia.gov/cneaf/electricity/page/electric_kid/append_a.html#N_2_

- The modern electric utility industry began in the 1880s
- Thomas Edison's NYC electricity generating station, opened September 4, 1882 with four key elements:
  - reliable central generation,
  - efficient distribution,
  - a successful end use (in 1882, the light bulb)
  - a competitive price.

History of the U.S. Electric Power Industry

http://www.eia.gov/cneaf/electricity/page/electric_kid/append_a.html#N_2_

- In the late 1880s
  - Electric motors raised electricity demand
    - transportation and industry needs
  - Small DC central stations dotted many U.S. cities;
    - Limited by transmission inefficiencies of direct current (100's of feet)
- AC Power and High Voltage Transmission
  - George Westinghouse in 1896 inaugurated the
    - AC allowed generating stations to be placed far from consumption centers (10's of miles)

History of the U.S. Electric Power Industry

http://www.eia.gov/cneaf/electricity/page/electric_kid/append_a.html#N_2_

- Economies of Scale, Growth, Consolidation
  - Growth and consolidation of the electric utility industry
    - 1932 State and Federal regulation begins
  - Consolidated organizations brought the financial strength, expertise and competencies
    - Vertical integration of generation, transmission and distribution becomes a practical business model

Restructuring (Deregulation)

- Policy Acts that called for the restructuring of electric utility companies (late 1980's and early 1990's)
- Utilities retaining their ownership of distribution and transmission – divest generation
  - Envisioned communications systems and networks to provide services to distribution system end-users

Independent System Operators (ISOs)

- ISO set up to operate energy and capacity markets for the generators.
  - ISOs responsible for system reliability, dispatch of generation and energy/capacity markets

Integration of Demand Resources (DR)

http://www.elp.com/index/display/article-display/344761/articles/utility-automation-engineering-td/volume-13/issue-11/features/growing-role-for-demand-response-in-iso-operations.html

- Following the 2005 Energy Act, DR has become embedded in national energy policy.
  - Demand response and energy efficiency to reduction of greenhouse gases and reliance on fossil fuels.
  -
- ISOs begin a long journey toward integration of DR resources into their supply side operations.

Demand Response Disruption
Federal Energy Regulatory Commission's (FERC's) Order 745 Overturned

Order 745 defined the final details of fully integrating Demand Response into ISO markets

DC Circuit Courts rules that FERC does not have Jurisdiction over Demand Resources (May 2014)

December 16, 2014 is deadline for submitting appeal

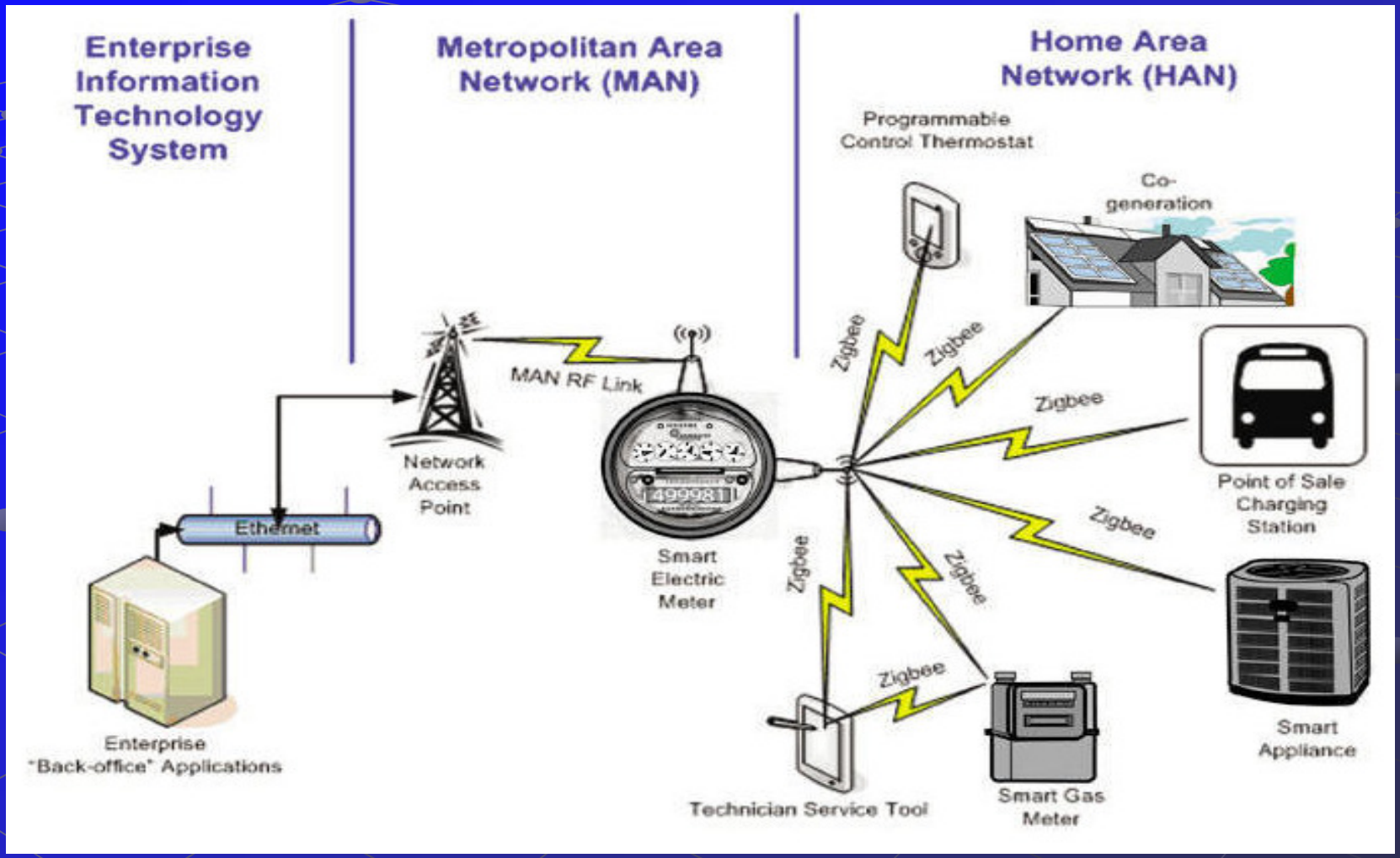
Preparing For The Future:
CT's Comprehensive Energy Strategy Plan Encourages Peak Demand Management Technologies and Energy Efficiency

- "Connecticut must find ways to expand its peak demand reduction efforts".

- Advanced meters can display real-time energy
  - Making dynamic pricing workable from a technical perspective
  - Facilitate the transmit of information to online Internet portals, where consumers check their usage in real time.

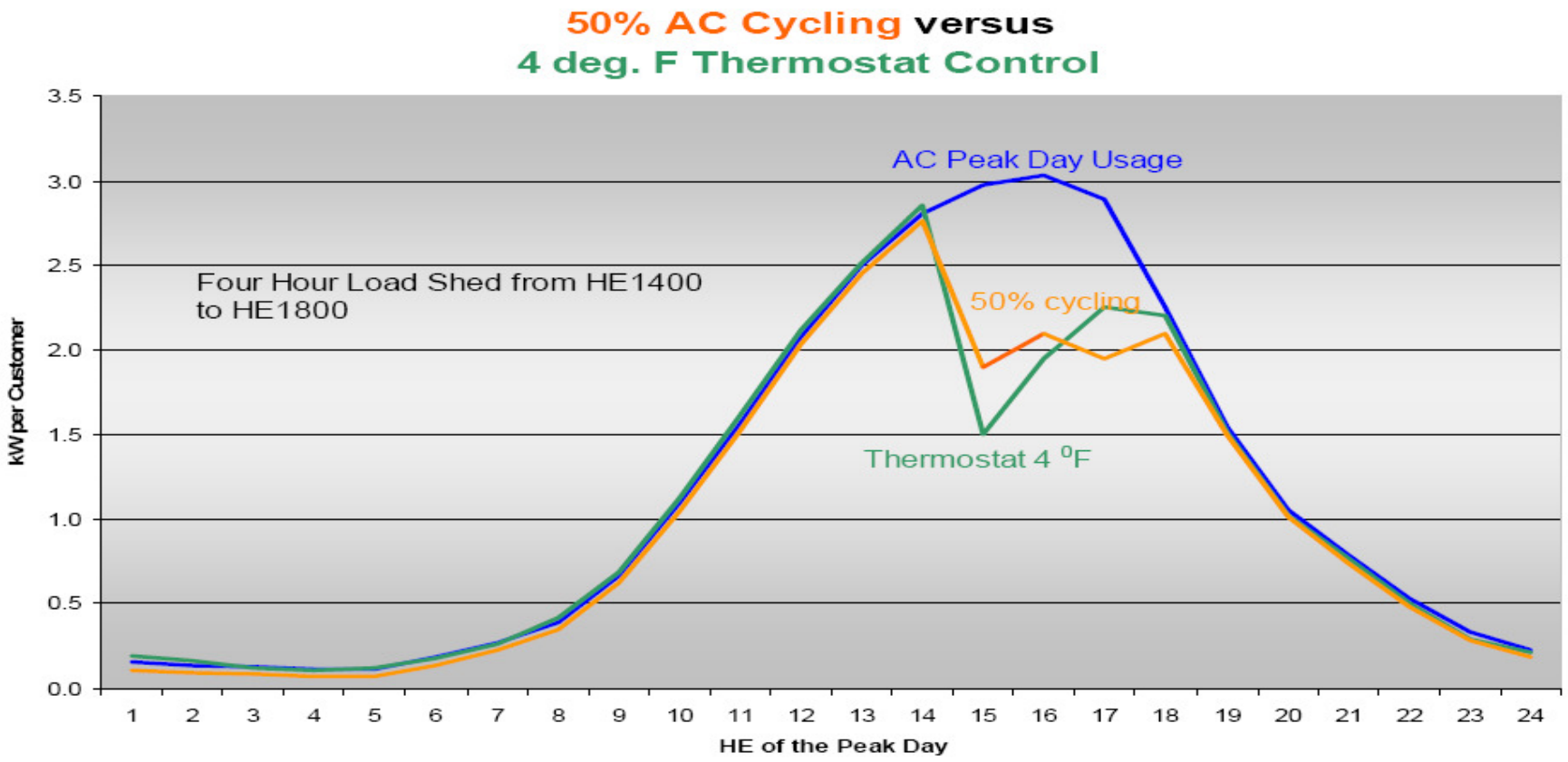
- This Strategy recommends invest in the technologies necessary to allow customers to lower their costs by managing peak demand."

Meter Control Portal



http://motorcycle.swri.org/4org/d10/comm/smartgrid/Images/schematic.jpg

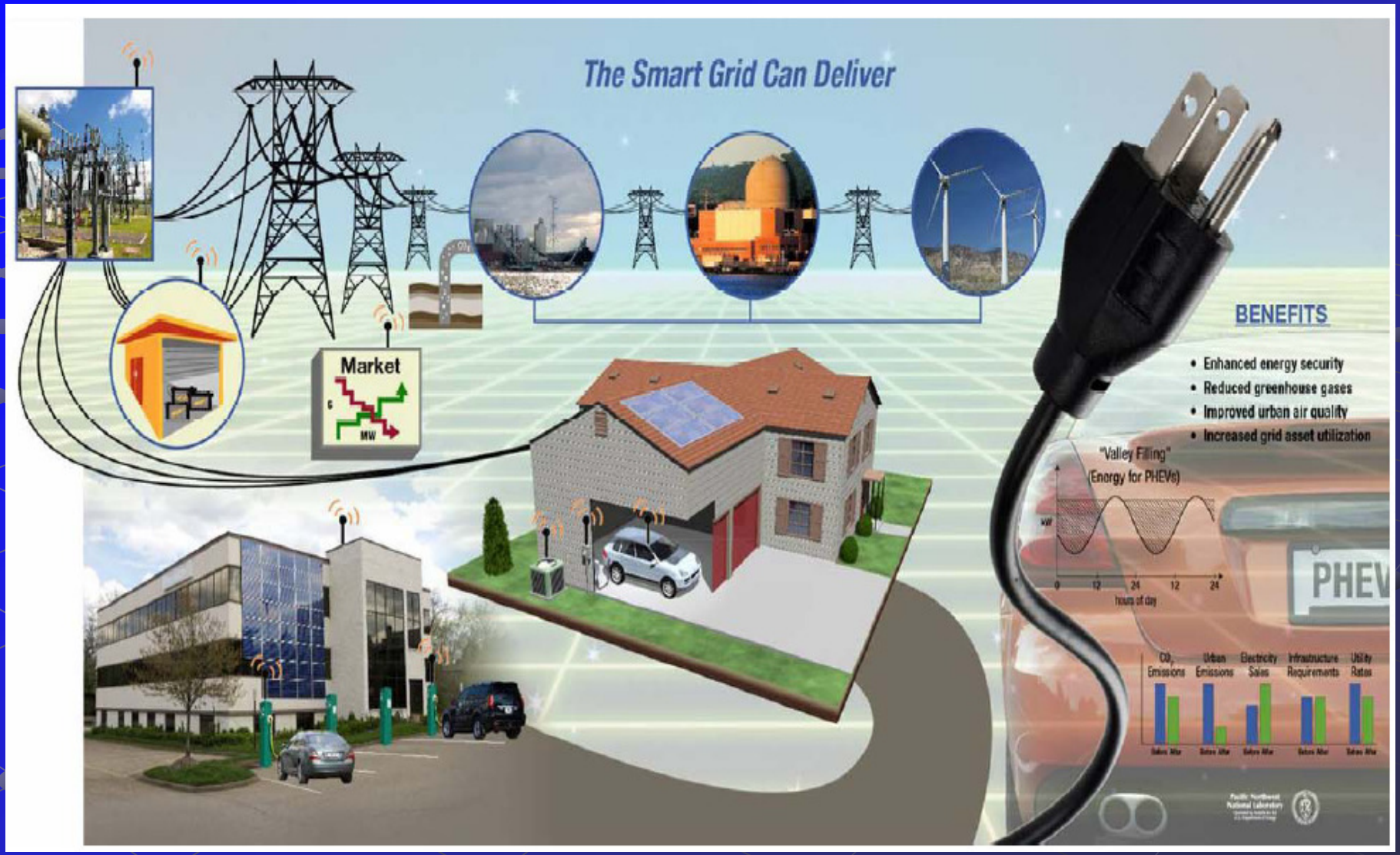
Impact of Demand Response



Source: Presentation by M. Martinez (SCE) at the Peak Load Management Association Conference, September 2004.

http://sites.energetics.com/madri/pdfs/LMADRT_060506.pdf

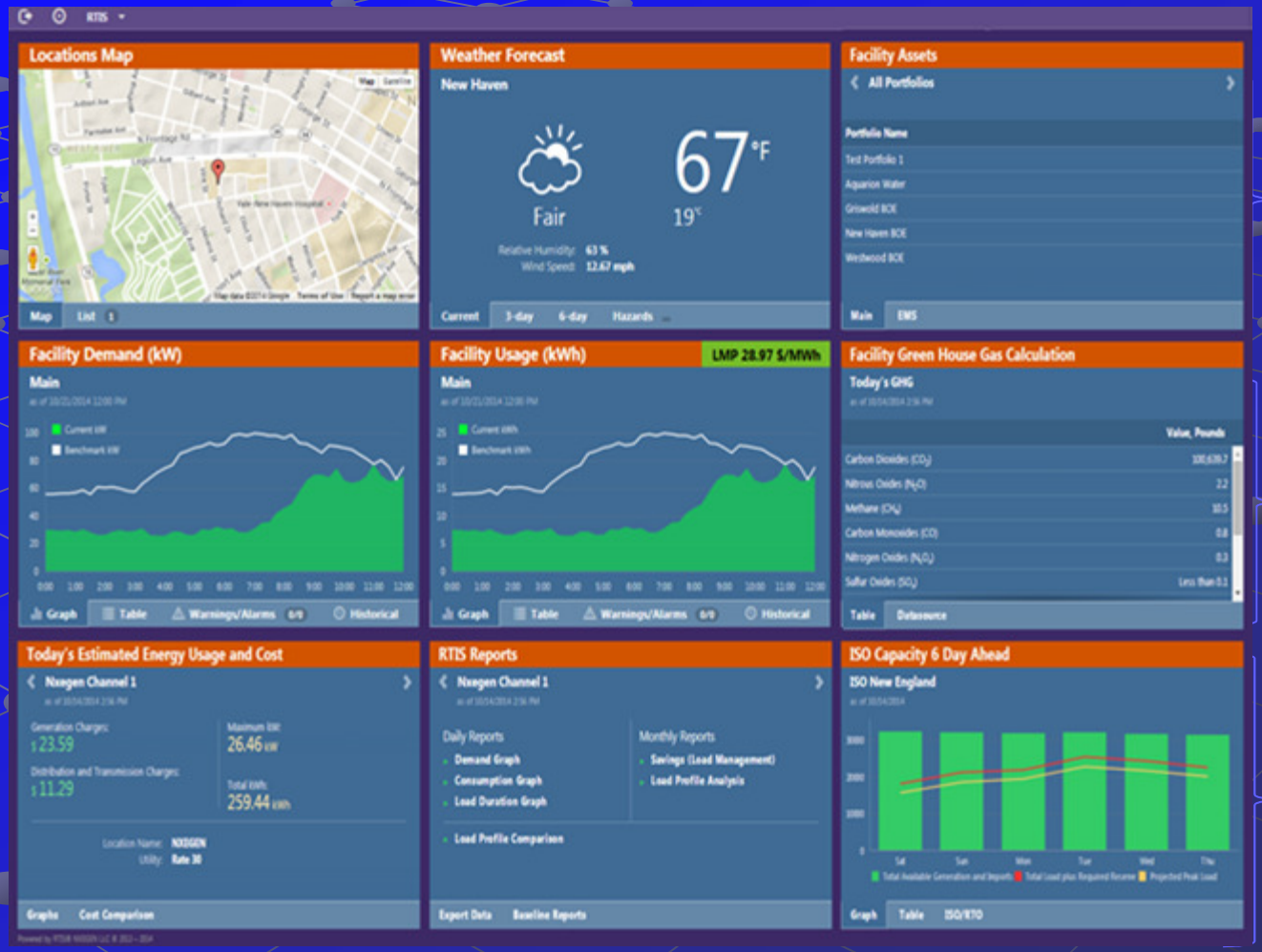
The Smart Grid and Its Applications



http://www.oe.energy.gov/smartgrid.htm

Commercial Facilities
Energy Efficiency Systems And Load Control Portals

➔ Data Collections, Logging and Analysis = Forecasting of Load Reduction Availability



Facility Views

Weather Alerts

Integrated Energy Efficiency Systems

Facility kW

Facility kWh

LMP*

GHGs

RT kW/kWh Cost**

Historian of Usage/Cost/Weather

Supply Capacity Forecasts

* Locational Marginal Price – Whole sale market price for kWh, **Real-time cost of kW and kWh at the customer level (retail)

Demand Control Business Case

Premise for Business Case Dynamics

Maturing Role of Demand Control

- Overturning of Order 745 is upheld
- State Mandates for Grid Modernization/efficient use of infrastructure, compliance with EPA section 111(d)
- Implications at the State level for regulating Demand Response; Rate Tariffs, Demand Markets (PJM whitepaper), Direct Load Control integration
- Advances in computing power, intelligent control and communications networks (data)
  - Enabling the Maturing Role of Demand Response

Demand Control Business Case

Basic Steps of the Value Creation Chain

Value Creation Chain ➔	Demand Response Enabled Equipment	Control and operational awareness at customer facilities	Aggregation of data and communications at LSE Level	Efficient use of demand

Demand Control Business Case

Market Climate Assessment

	More Active Control Participation on the Demand Side			
Scenarios	Ⓐ Utility directly manages demand	Ⓑ Utility passively meeting demand	Ⓒ ISO manages grid with supply- side and demand- side mechanisms	Ⓓ ISO manages grid with supply-side mechanisms
Economics	Recoverable Asset Based	Rate Tariff Based	Avoided Capacity Charges Based	Wholesale Market Based
Examples	Direct load control of DHW heaters	Rates like kVa billing	PJM White paper	CURRENT STATE
Customers' demand management role	Hybrid: Active/Passive	Active	Active	Passive
LSEs' demand management role	Active	Passive	Active	Passive
ISO/RTO demand management role	Passive	Passive	Active	Active

*Under scenario "D" Utilities are Representatives of aggregate demand at the nodal level and Natural Managers of substation and circuit infrastructure .

Demand Control Business Case

Market Entities - Role

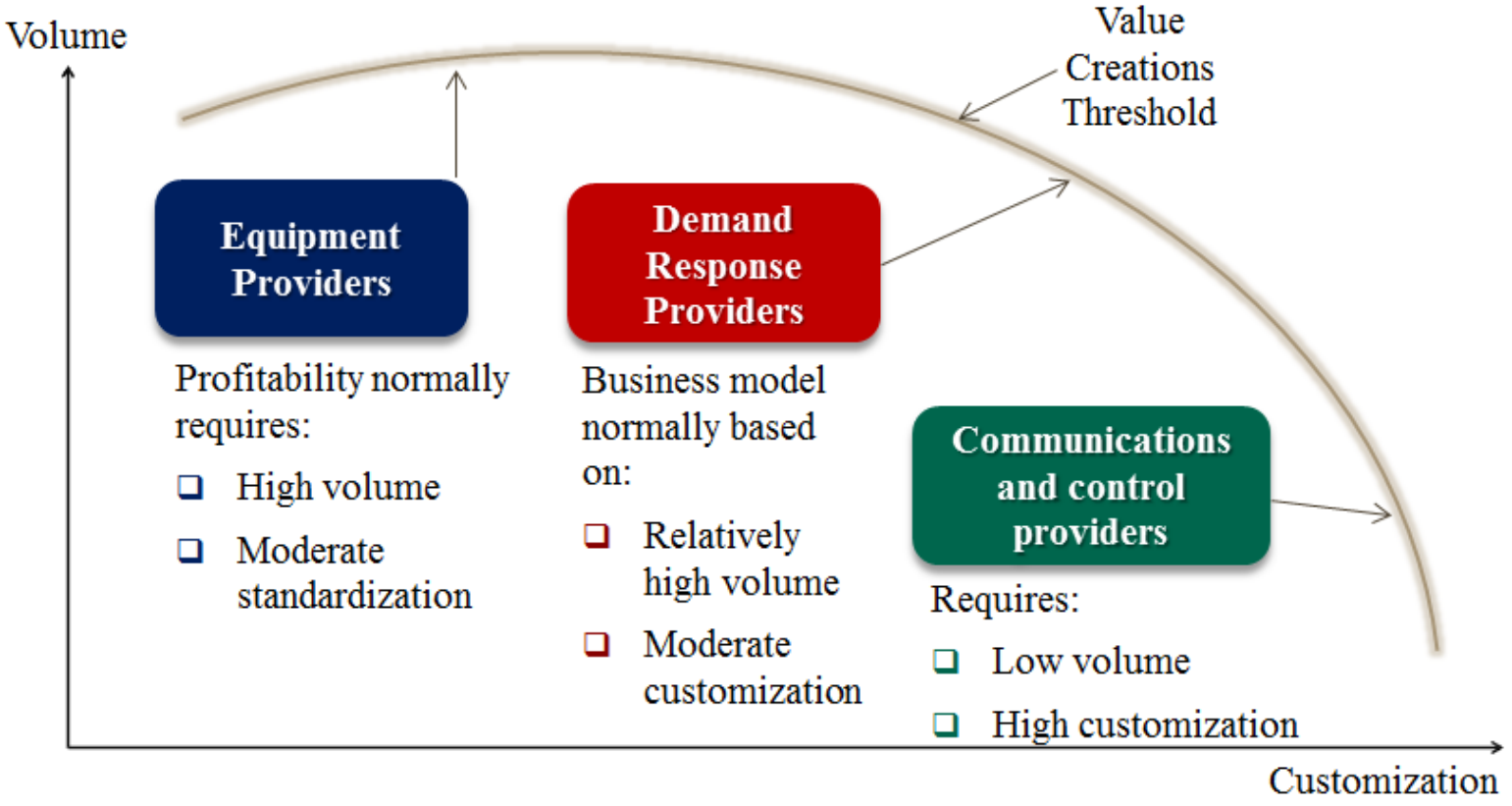
Value Creation Chain →	Demand Response Enabled Equipment	Control and operational awareness at customer facilities	Aggregation of data and communications at LSE Level	Efficient use of demand
Feature	Digital signal control	Load control and end-user facility awareness	Data transfer and information management	Reduced costs
Market Entity	Equipment provider	Demand Response provider	Communications and control providers	End users and LSE
Action	Sales, installation and compatibility	Provides load reduction availability and executes reduction commands	Facilitate data communications and situational awareness	Efficient use of demand
Customer interface or LSE interface	Customer	Customer	LSE	Customer and LSE

LSE ~ Load Serving Entity = Electric Utility

Demand Control Business Case

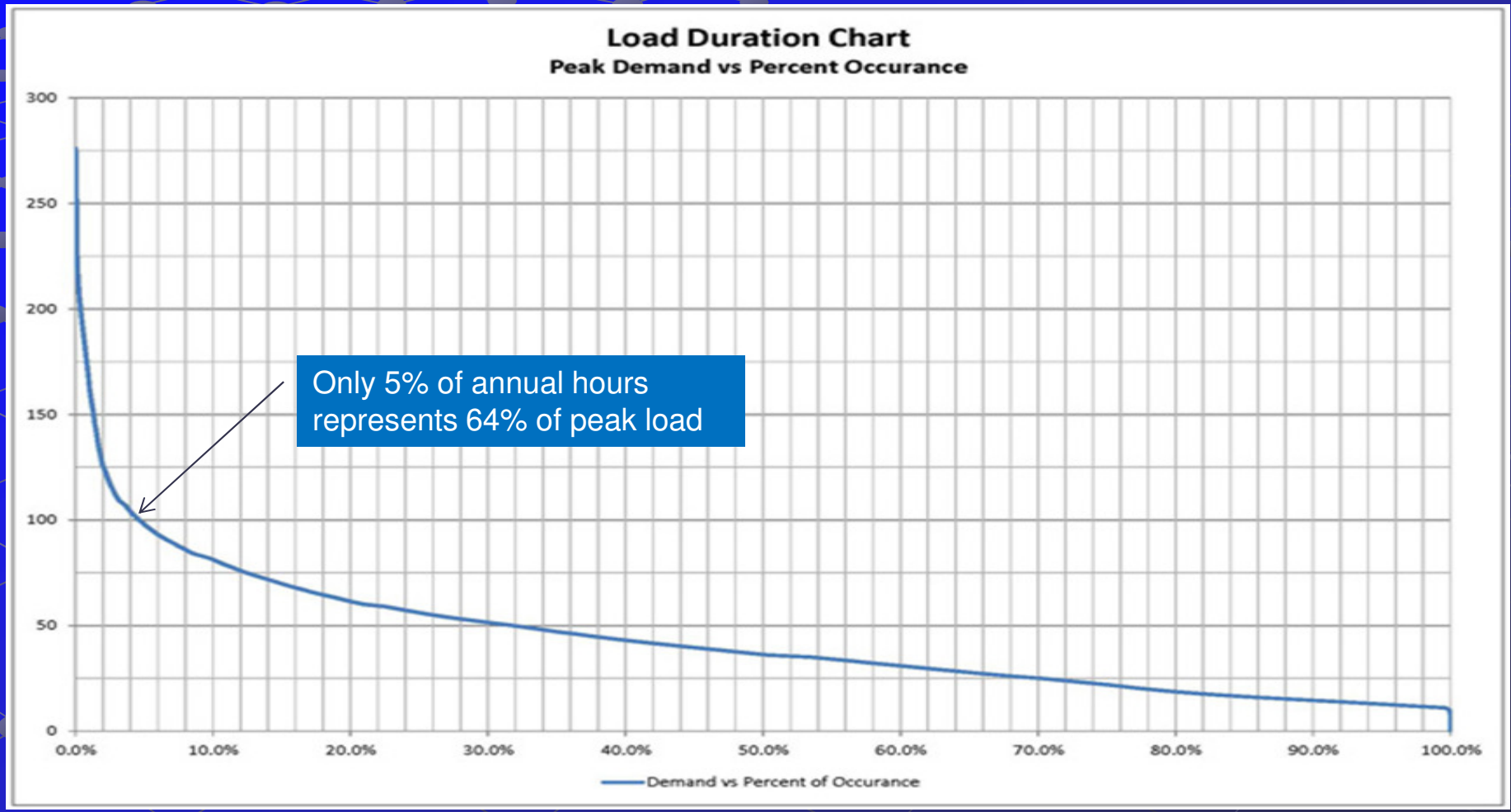
Market Entities – Strategic Direction (arrows)

Strategic direction and existing position help understanding of Market Role



Demand Control Business Case

Technologies: ➔ Load Duration Monitoring



Equipment is running coincidently, cycling controls can harvest this available load through cycling controls

Demand Control Business Case

Technologies

Monitoring Intelligence

Data Collections, Logging and Analysis = Forecasting of Load Reduction Availability

- **Equipment Status –** Relative to real time position on Load Duration Curve
- **Climatic conditions, time of day, occupancy –** Relative internal condition change rate (temperature gain, CO2 gain)
- **Daylighting sensing, time of day** – Relative to fixture dimming/daylight harvesting
- **Process monitoring** – Relative to fluid flow rates, batch process temperature dead-band set points, refrigeration dead-band set points

Demand Control Business Case

Technologies

Enabled Equipment

Energy Management System (EMS) interface with microprocessor controlled equipment

- Demand control strategies leveraging EMS and enabled equipment
  - Microprocessor based VFD, chiller and RTU controls
  - Electronically dimmable lighting controllers (e.g., fluorescent ballasts, LED drivers)
  - Process Equipment

Demand Control Business Case

Market Entities – Real World Examples

Equipment Provider

The *Energy Demand System* is OpenADR4 compliant

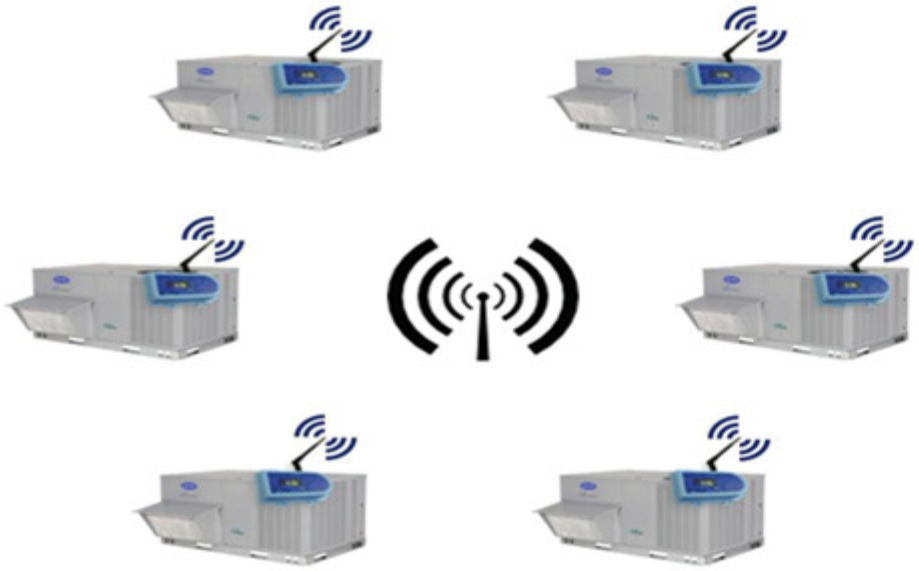


Figure 1 – Energy Demand System Network of Rooftop Units

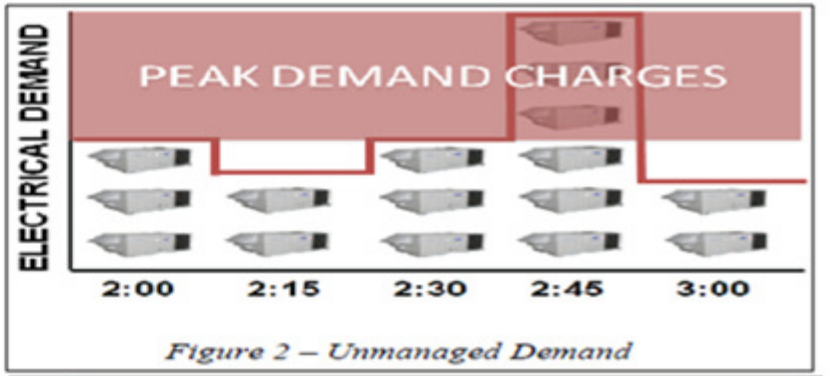


Figure 2 – Unmanaged Demand



Figure 3 – Demand Management with the Energy Demand System



Figure 4 – Demand Response with the Energy Demand System

Facility Energy Efficiency Systems Can Integrate Asset Level Sub Metering and Easy Usage (Cost) Control

Market Entities – Real World Examples

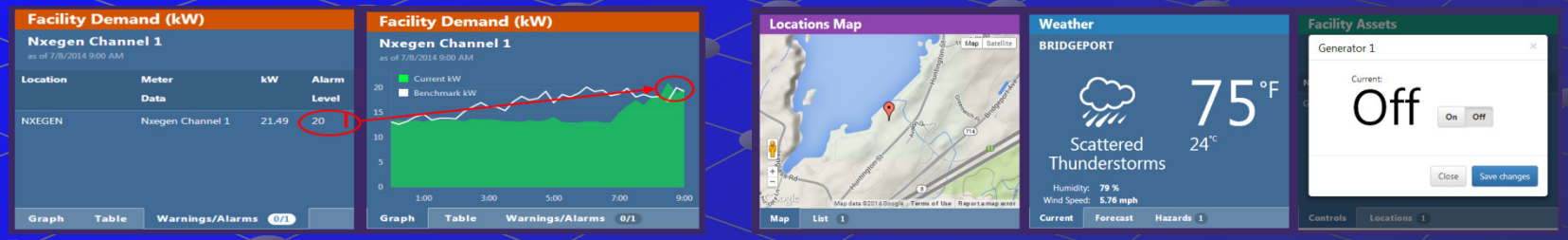
Demand Response Provider - Availability



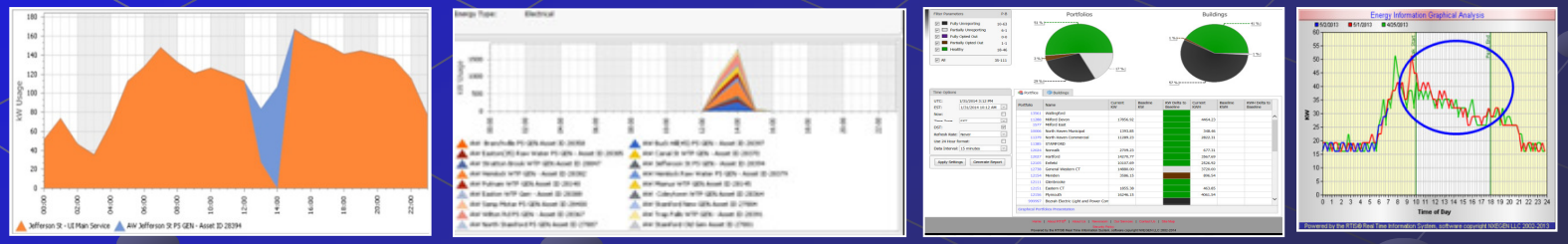
Addressing System Peak via Load Monitoring and Demand Management Triggering

Market Entities – Real World Examples | Demand Response Provider – Automated Control

- Facilities can set triggers to enable demand management and avert their peak demand costs as well as help manage overall utility system peak
  - Auto DR or Semi-Auto DR options
  - Harnessing AutoDR enabling technology incentives
  - Reducing kW/kWh costs; earning payments; and supporting ratebase cost avoidance



- M&V: Aggregate Portfolio managers view facility and portfolio asset status real time; adjust for peak demand, system peak, and dynamic rate management

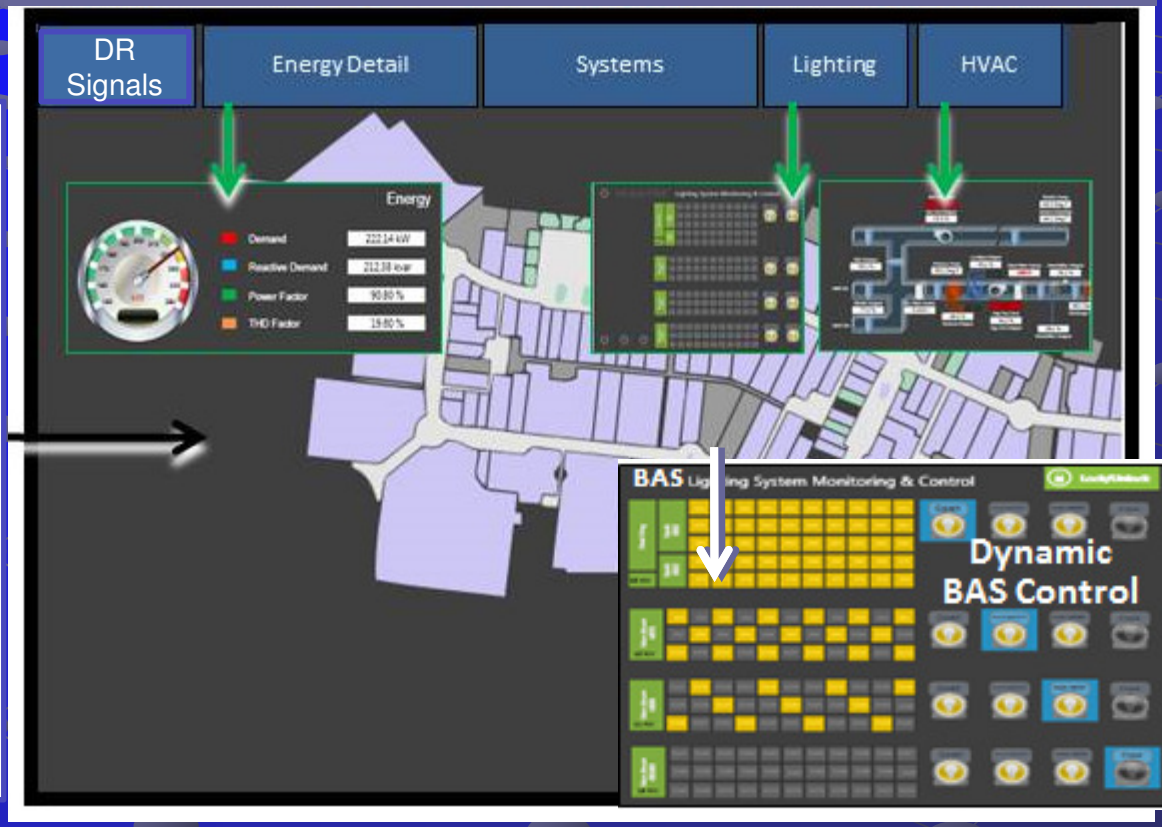


Building Automation Systems Can Be Supervised For Peak Load Management -- Including With Varying Load Control Options

Market Entities – Real World Examples

Communications and Controls Provider

Situational Awareness



Facility/Utility/Grid Economic Dispatch Data Analytics

Potential To Offer Facilities Options For Load Shedding Based On Dynamic, Financial Impacts -- Via AutoDR, Approved Or Manual Dispatches

Conclusions

- The Electric Industry continues to evolve
- Energy Efficiency and Demand Controls is more critical than ever
- Advanced in metering, communications and controls are key enabling technologies
- Policy changes regarding climate change and efficiency use of distribution system infrastructure is currently a key driver of change

Questions?

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