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Conference & Exposition

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Evaluating the Opportunity for Demand Response

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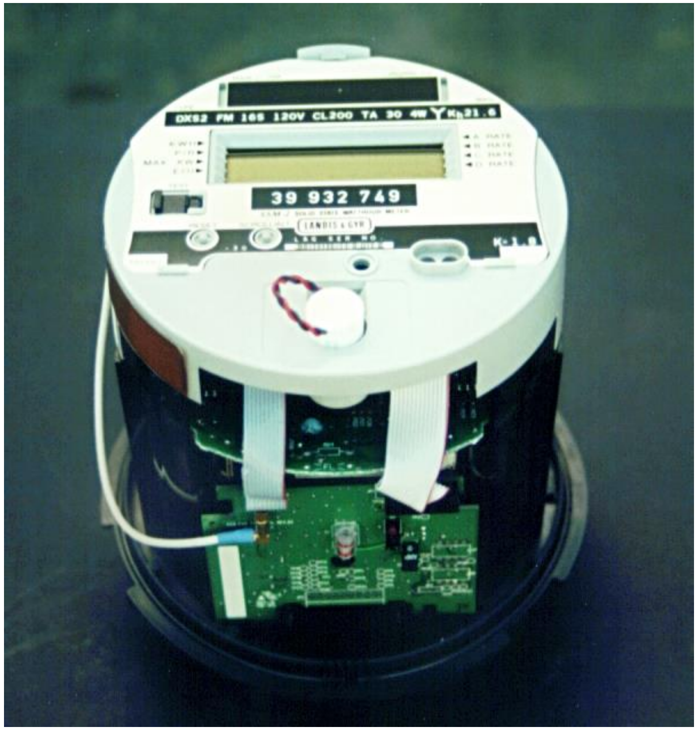
Agenda

1:00 - 1:20 pm	❶	Introductions
1:20 - 1:40 pm	❷	Definitions and Problems
2:00 - 2:40 pm	❸	Systems & Technologies
2:40 - 3:00 pm	❹	Rates & Tariffs
		Break
3:20 - 4:40 pm	❺	Opportunities & Customers
4:40 - 5:00 pm		Questions

Introductions

- Company/Utilities Represented
- Background
- Exposure to Demand Response
  - Positive?
  - Negative?
- Plans to Implement?
  - Pilot Projects
  - Large Program



Definitions and Overview

What is Demand Response?

- Varieties of demand response:
  - complete premises outages (brownouts)
  - involuntary complete curtailments of certain end uses (e.g., air conditioning cycling)
  - voluntary or partial curtailments of certain end uses (e.g., dimming lighting)
  - usage shifting
  - paying a premium price for usage (e.g., peak rates)
  - avoiding usage

Definitions of Demand Response Differ

- Traditional reliability
  - Direct load control, partial or curtailable load reductions
  - Complete load interruptions
- Traditional economic
  - Price response by end-use customers, including
  - Dynamic pricing: real-time pricing (RTP), critical peak pricing (CPP), time-of-use (TOU) rates
  - Demand bidding or buyback programs
- Contemporary
  - A substitute for supply emphasizing the role of demand response as a customer cost management resource

Direct Demand Response

- RTO/ISO contracts
  - Contractual Curtailment (reliability based)
  - Economic (pricing and demand bidding)
- Utility programs
  - direct control of devices on customer premises
  - without customer involvement (e.g., switches, brownouts)
  - with customer overrides of control signals (on-premises or remote)
- Customers are obligated

Indirect Demand Response

- Government policies and advertising
  - California: Flex Your Power
- Utility rates and marketing
  - time-of-use rates (fixed or varying in real-time)
  - other economic incentives
  - providing information about customers’ actual and potential energy use (e.g., costs, system congestion, system emergencies)
- Customers are influenced

Federal Energy Regulatory Commission

"Changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized."

U.S. Department of Energy, Benefits of Demand Response in Electricity Markets and Recommendations for Achieving Them: A Report to the United States Congress Pursuant to Section 1252 of the Energy Policy Act of 2005, February 2006 (February 2006 DOE EPAct Report)

Typical Utility Definition of Demand Response

Dispatchable and predictable load reduction, which provides reliability, reduces infrastructure requirements, and helps limit rate increases

Our Definition of Demand Response

- Demand response achieves transient peak load reduction by modifying customer energy use
- Customers modify energy use by:
  - participation in utility programs
  - changing usage as a result of utility influence
- Demand-responsive metering is:
  - any form of automated metering enabling any form of demand response

Demand Response Vs. Energy Efficiency

- Energy efficiency delivers long term and long duration results
  - Retail energy efficiency measures aim to reduce demand across the load forecast period
  - Retail energy efficiency measures need to be verified as sustainable over time
- Demand response delivers long term but short duration results
  - demand response measures aim to postpone demand, or pause demand, during events
  - wholesale and retail demand response measures need only be verified for as little as one hour

The Problem

Supply = Demand

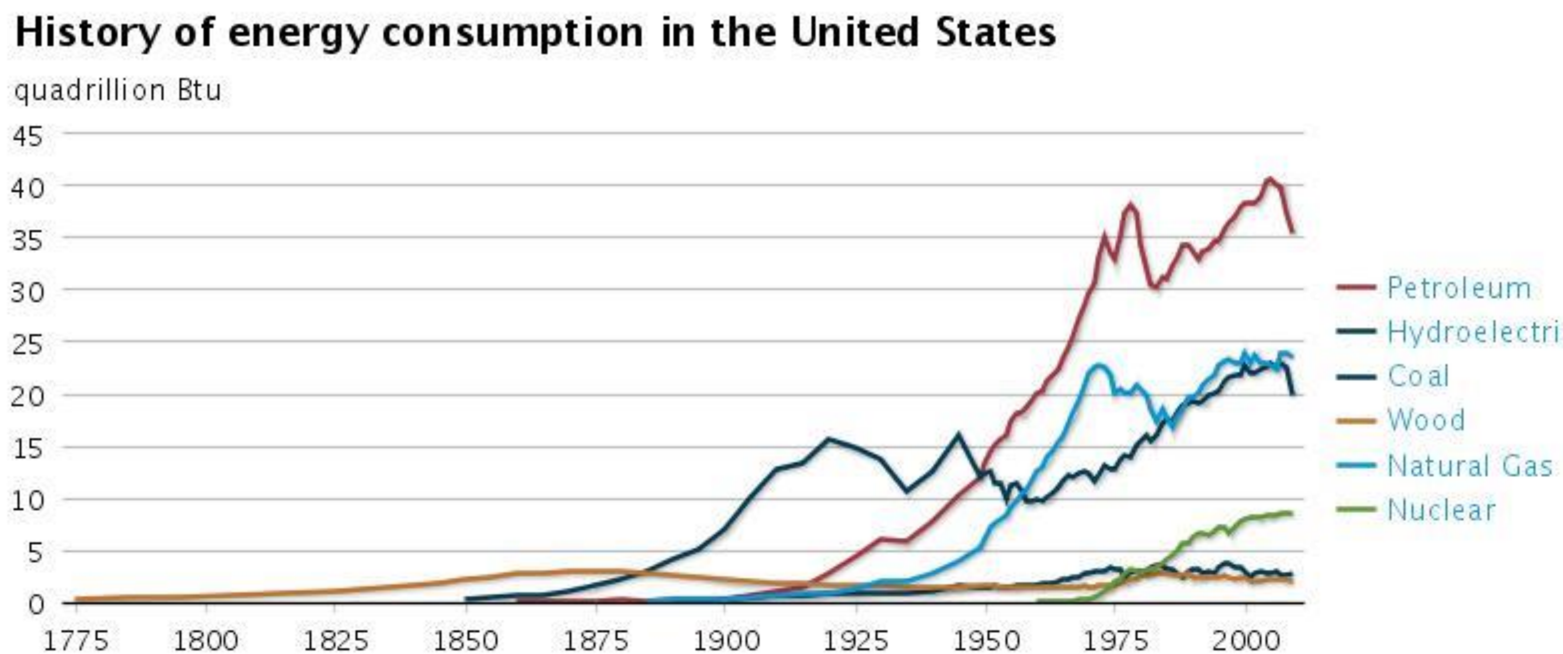
Customers Set Demand

Utilities respond with supply

Challenges

- Increasing demand
- Reliability Expectations
- Reducing greenhouse gases
- Legacy plant retirement
- Large scale integration
- New transmission requirements
- Transportation transition
- Changing business environment

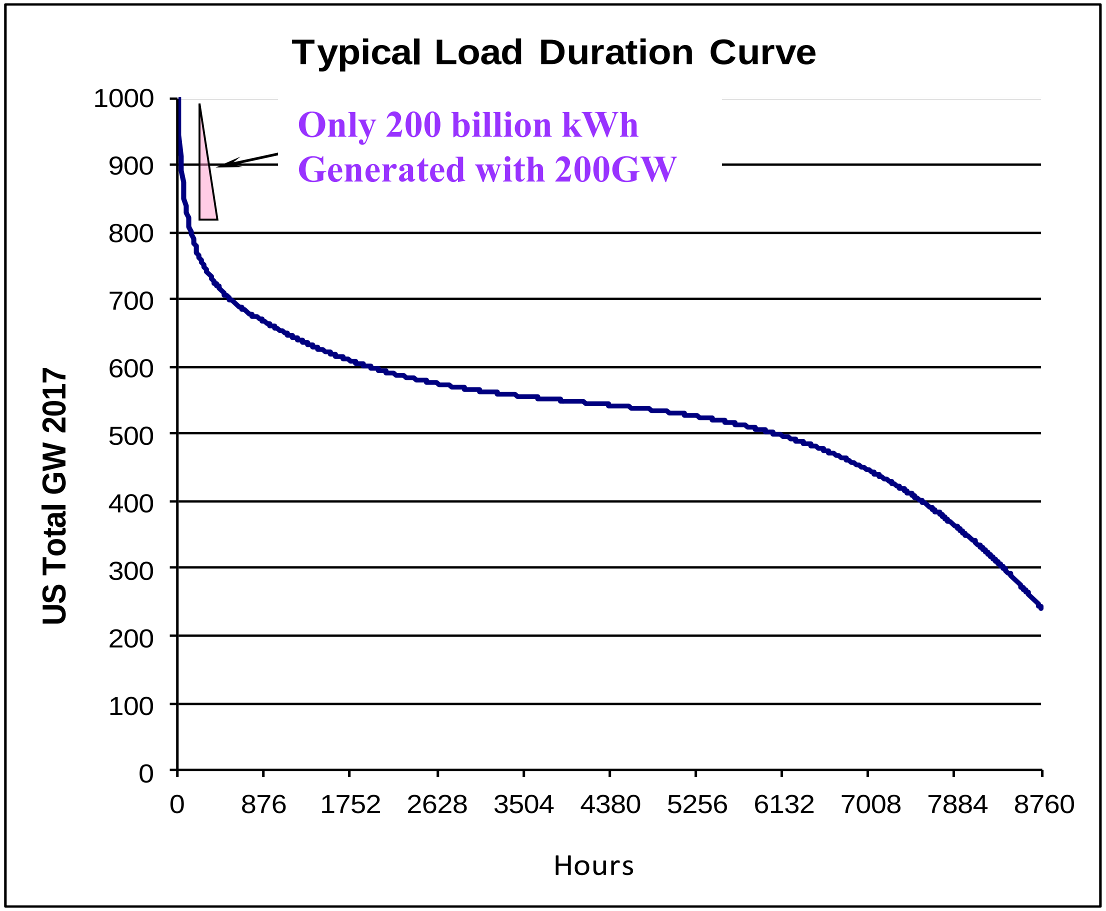
Electric Energy Usage



Source: US Energy Information Administration

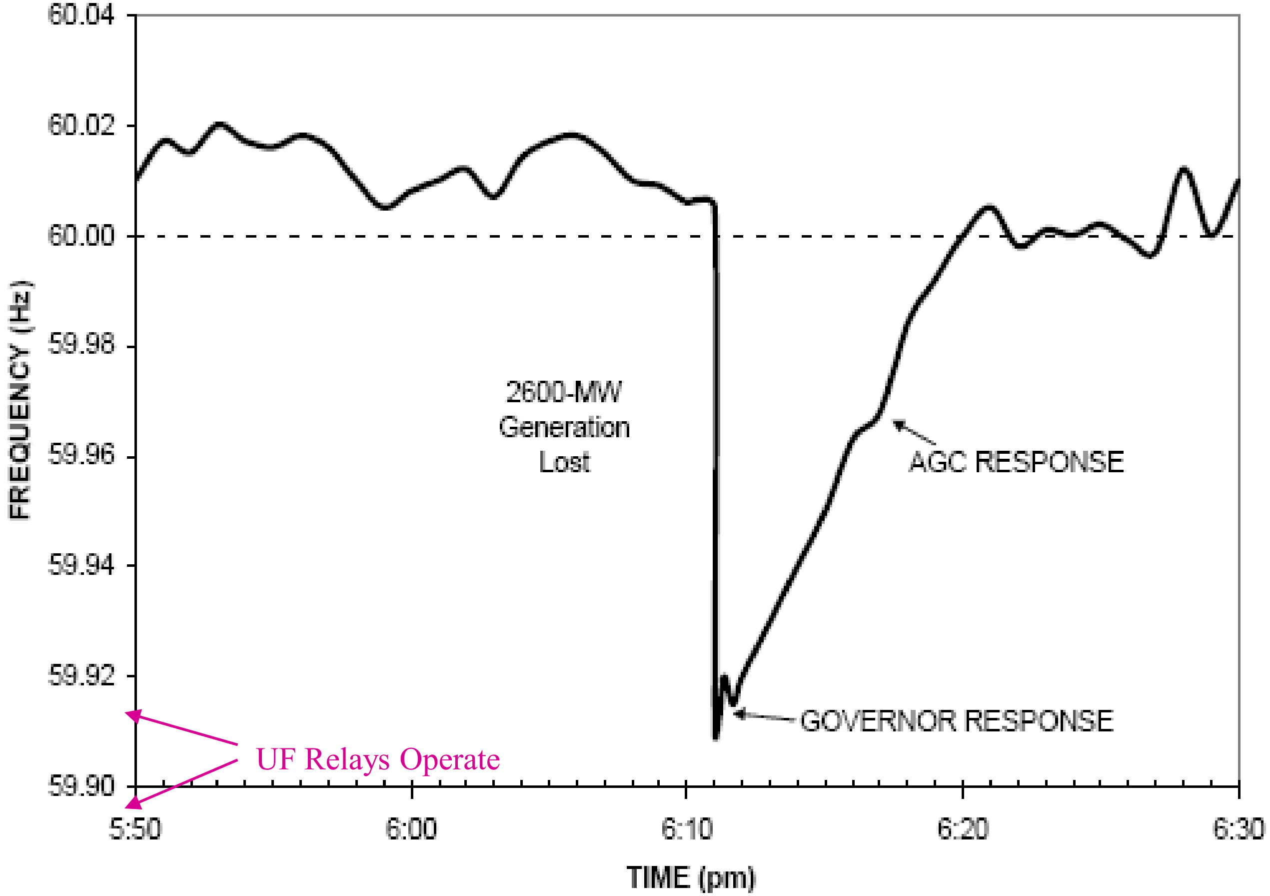
Demand vs. Capacity

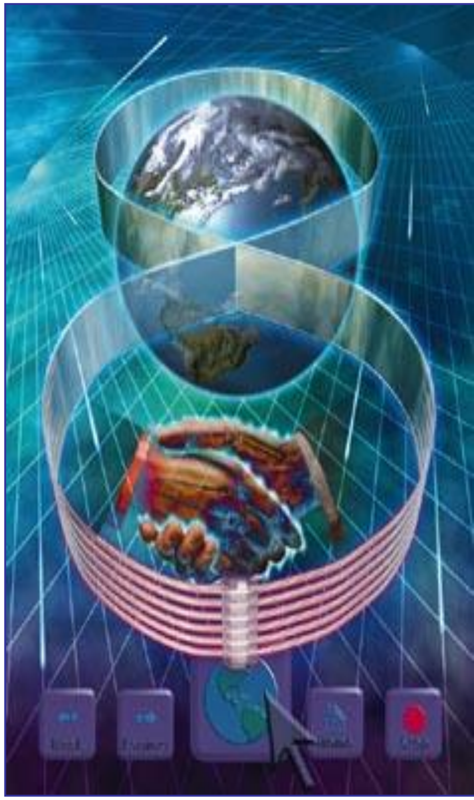
Top 20% of Capacity Rarely Used



Meeting Reliability Expectations

Spinning Reserves

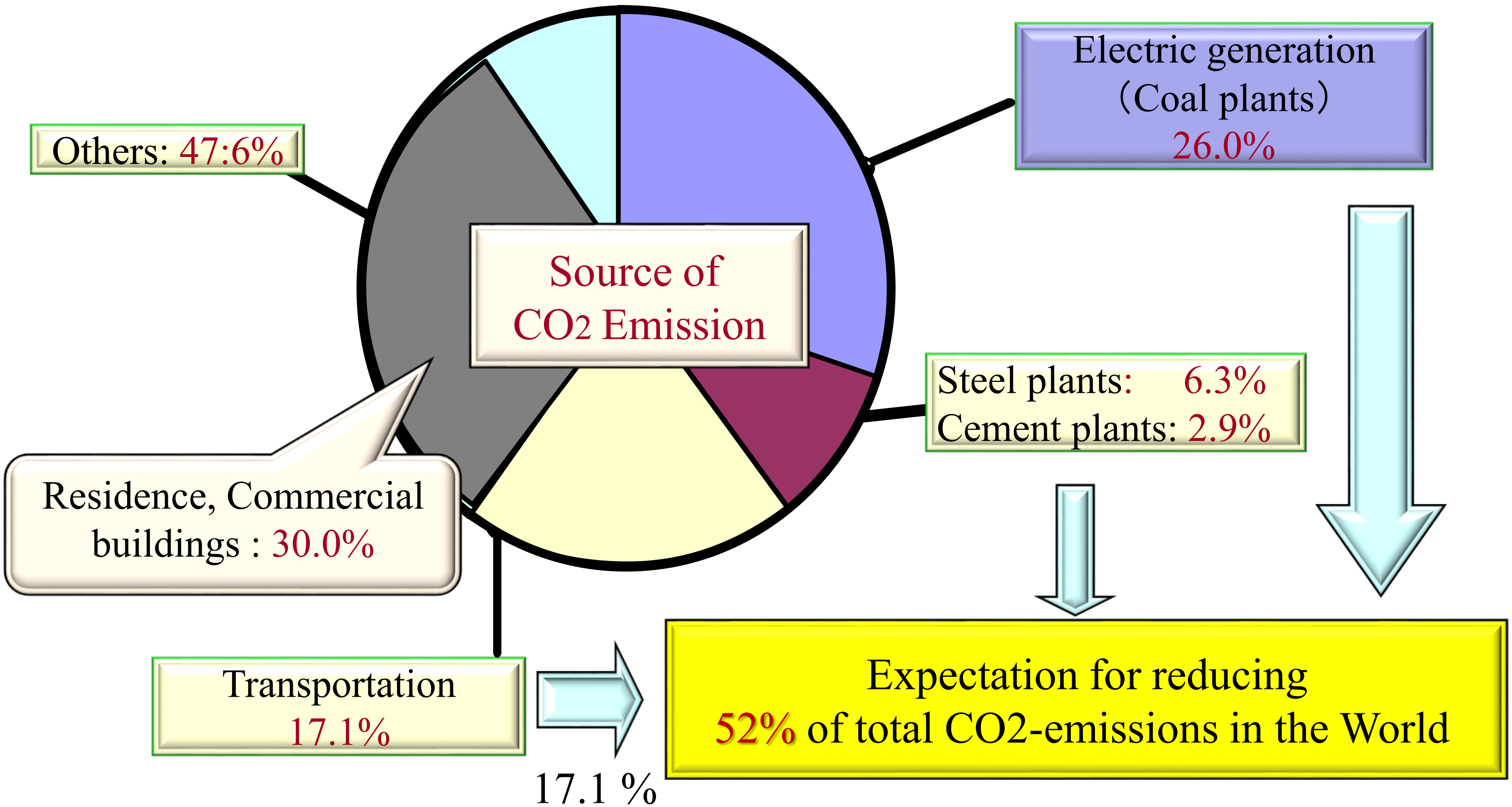




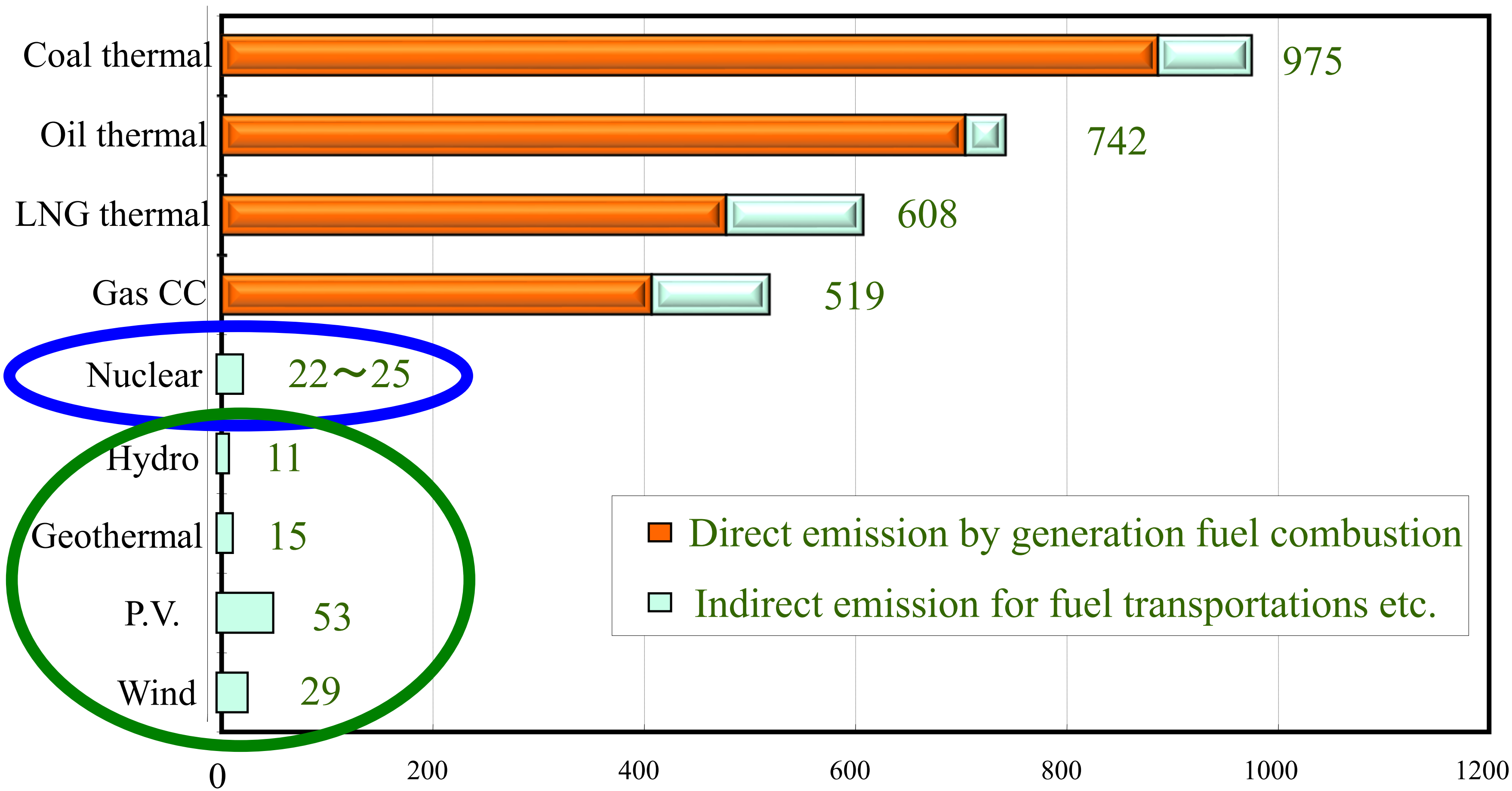
Source: ERCOT

Sources of CO2 Emissions in the World

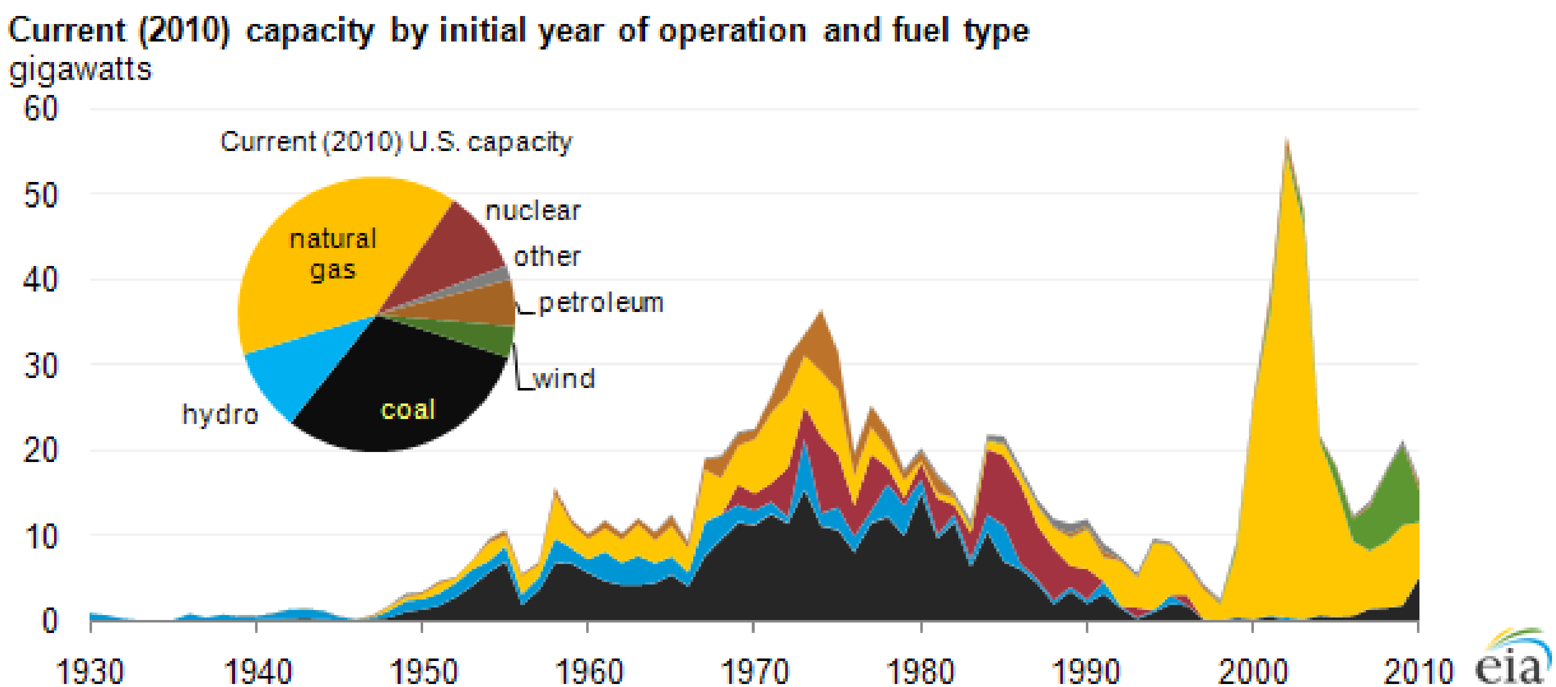
(based on 1971-2007 Data)



CO2-Emission by Generation Resources
(Methane included)

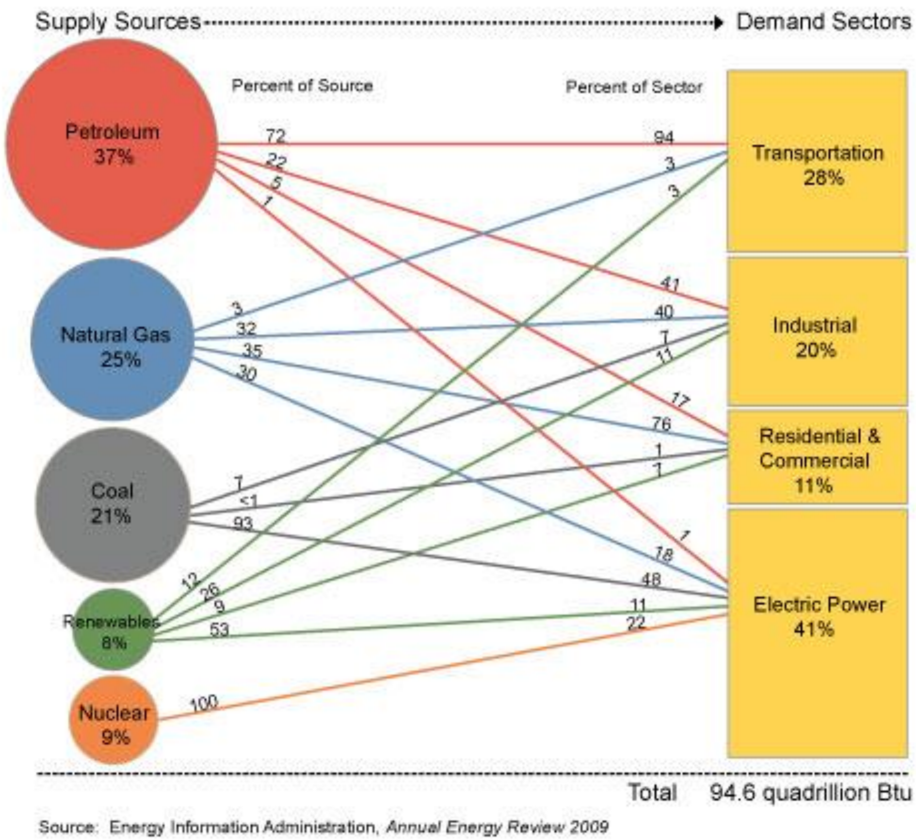


US Electric Plant Installation



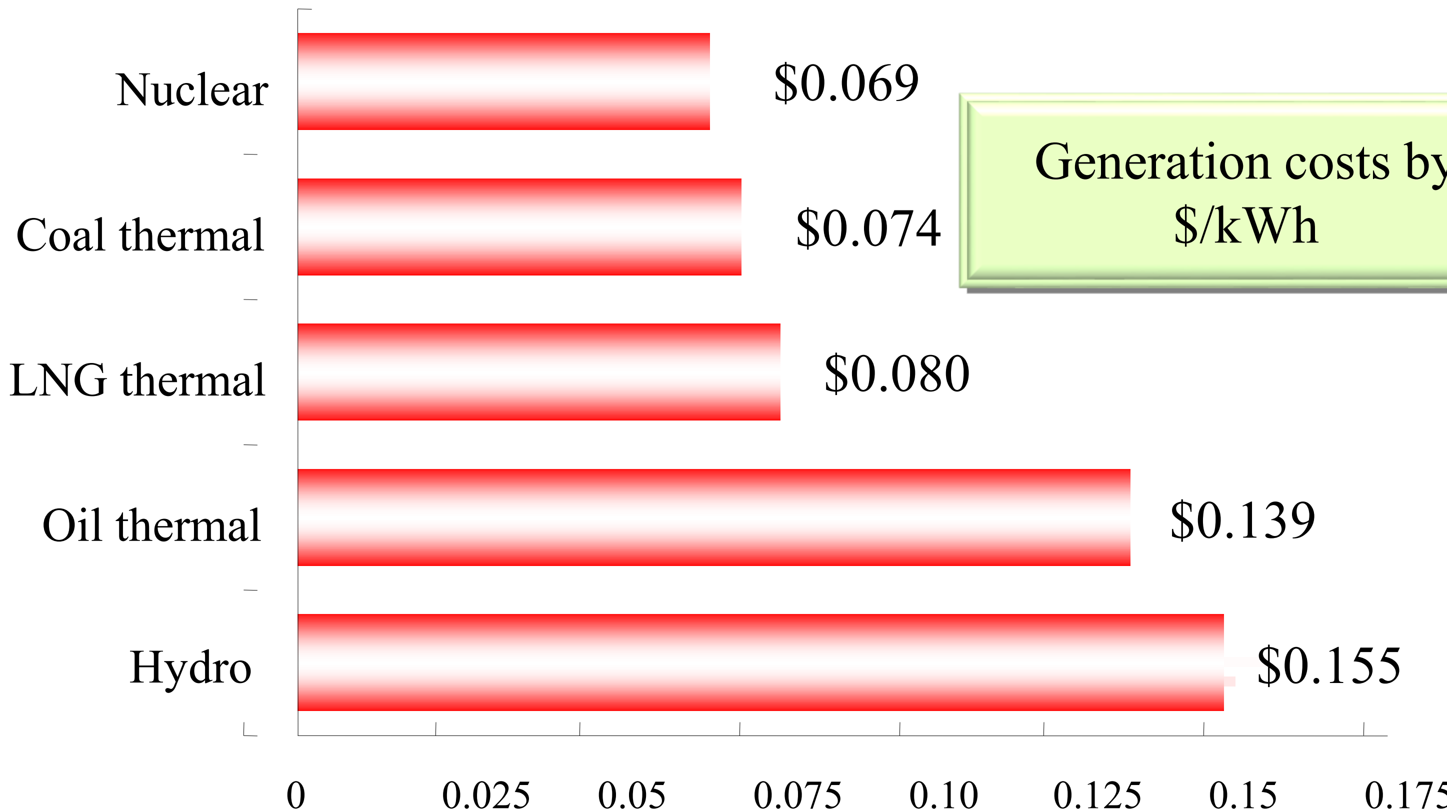
Source: US Energy Information Administration

U.S. Primary Energy Flow by Source



Comparisons of Generation Costs of Various Generation Resources

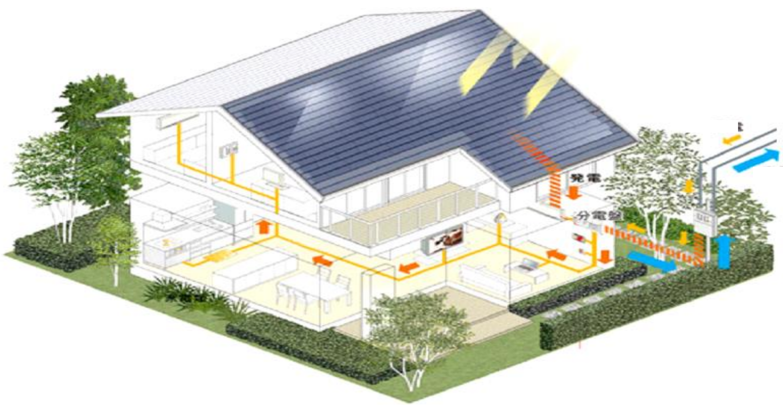
- Nuclear , Coal, and LNG plants have low generation costs including fixed costs
- Oil thermal plants show high generation cost due to high ratio of fuel cost in the total cost, and generation costs are very sensitive to fuel costs



Reference: METI Electric Industry Council, 2004 January,
Assumption: Life time;40 years, The rate of operation;80%, Discount ratio;3%

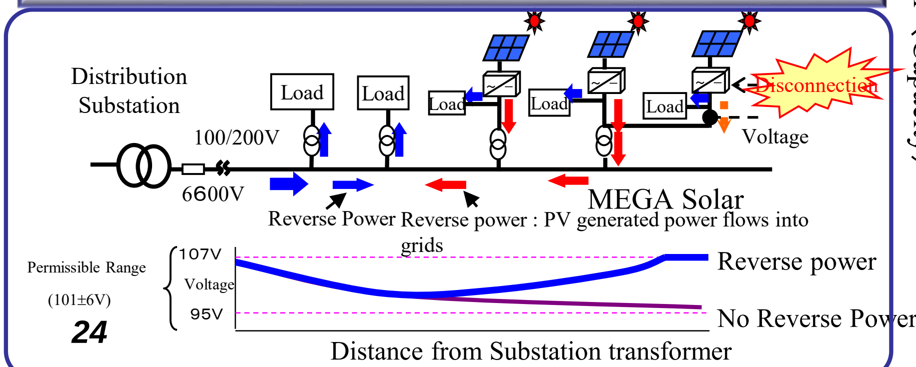
Issues in Power System Operation by Large Scale Installation of Sustainable Energy

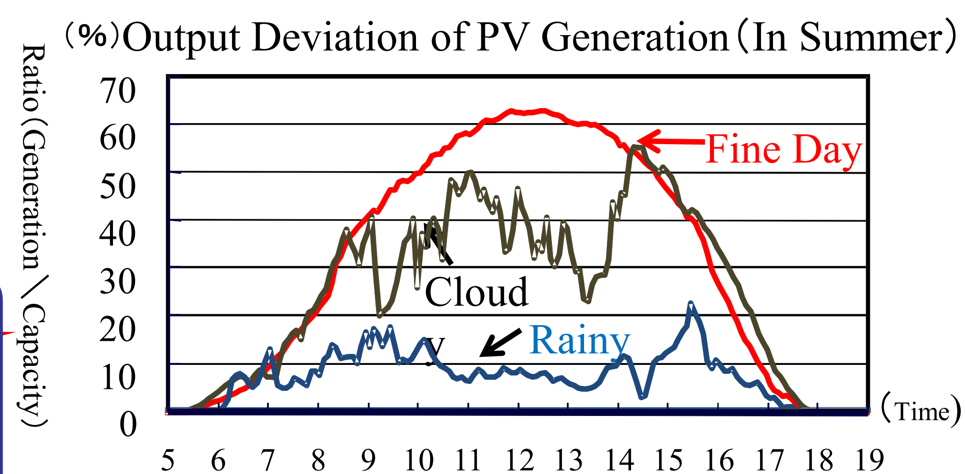
- By large scale installation of sustainable energy such as PV generation, new problems in power grids ; Excess energy, Voltage increase and Shortage of frequency control capacity occur.
- Necessity of power stabilization control to keep their own functionality of power networks



Technical Issue in PV Generation Installation

Voltage Increase and Reverse Power in Distribution Networks

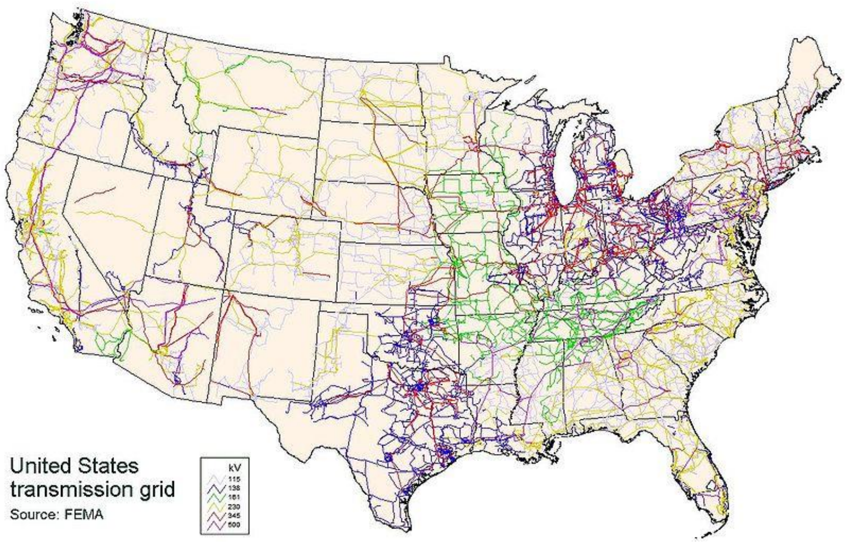


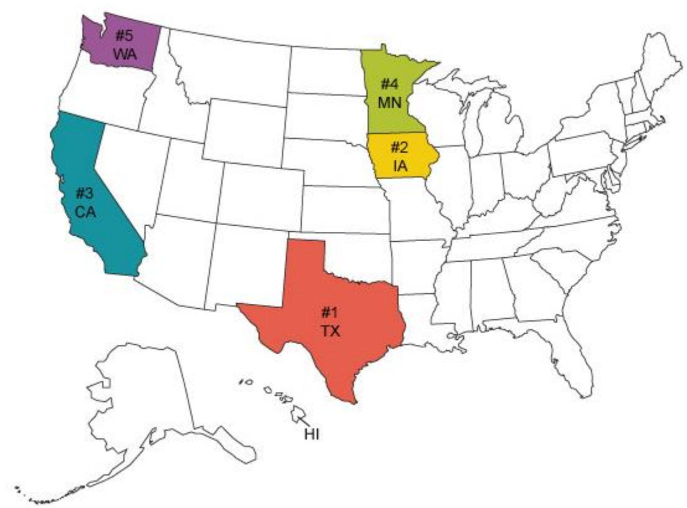


PV Power Generation Systems

Number of PV-equipped houses: 553
Total PV capacity: 2,129 kW
Average capacity per house: 3.85 kW

U.S. Transmission System





Source: U.S. Energy Information Administration, *Electric Power Monthly,* Table 1.17.B (March 2011), preliminary 2010 data.

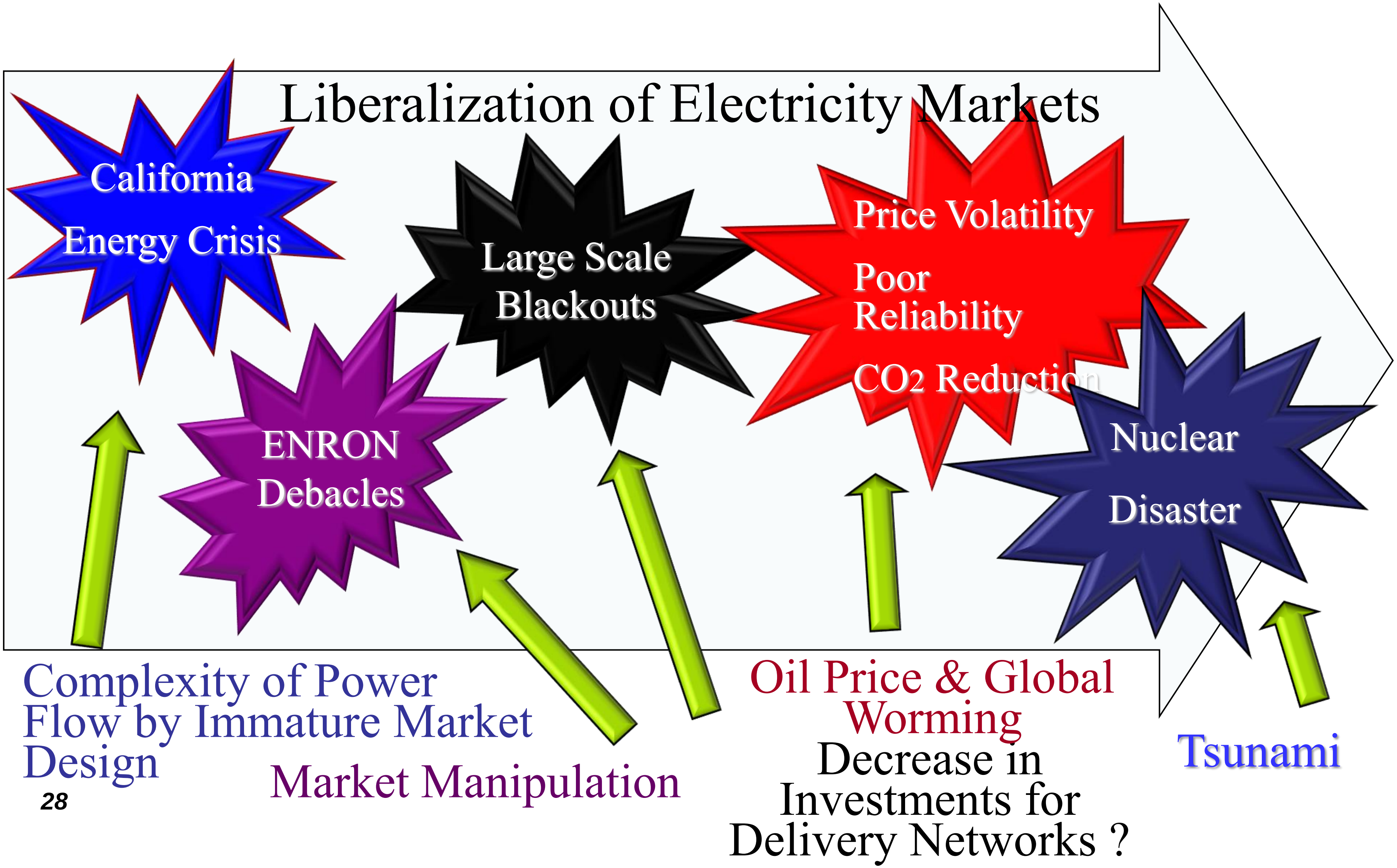
Electric Vehicles-EV

1.4 kW

6.6 kW

62.5 kW

Changing Business Environment



Japan Tsunami

Possible Solutions

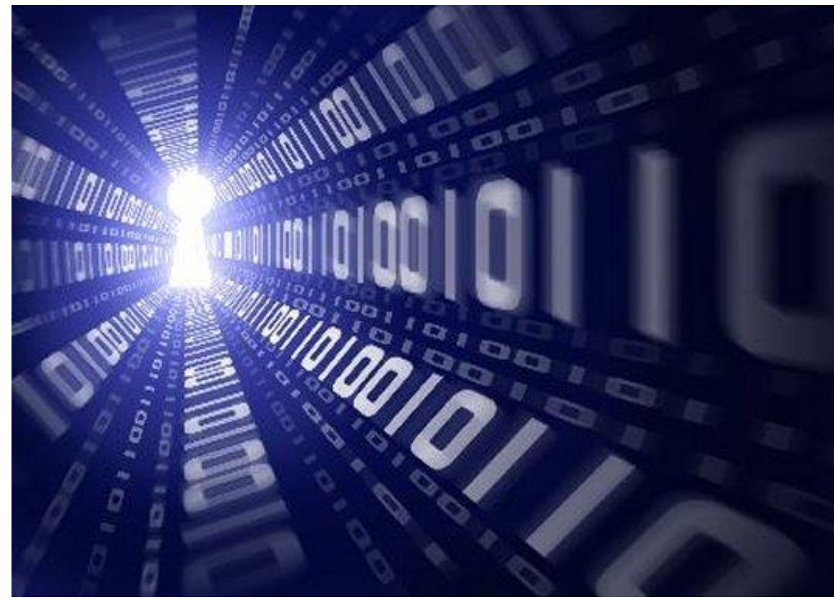
Solution Mix

- Add generation
- Conservation
- Energy storage
- Demand Response

Demand Response Systems & Technology

Demand Response Ingredients

- Demand Responsive Metering
- Communications
- Standards-Future Proofing
- Data Management
  - storage
  - precision
- Controls
  - Direct
  - Smart
  - Customer Impacts



Metrology: AMR/AMI Feature Sets

Complexity, Data Rates and Technology Cost

Manual

- Access problem

- Regular monthly reads
- Off-cycle reads costly

Touchpad Walk-by

- Access problem

- Regular monthly reads
- Off-cycle reads costly
- Complex reads

Off-site Drive-by

- NO access problem
- Improves throughput

- Regular monthly reads
- Off-cycle reads costly
- Complex reads?

NMR/AMI

- NO access problem
- Fast throughput
- Territory wide operation
- Opportunity for outside operation & contract metering

- Regular monthly reads
- Off-cycle reads
- Complex reads
- Flexible Tariffs

- Billing date options
- Summary and coincident billing

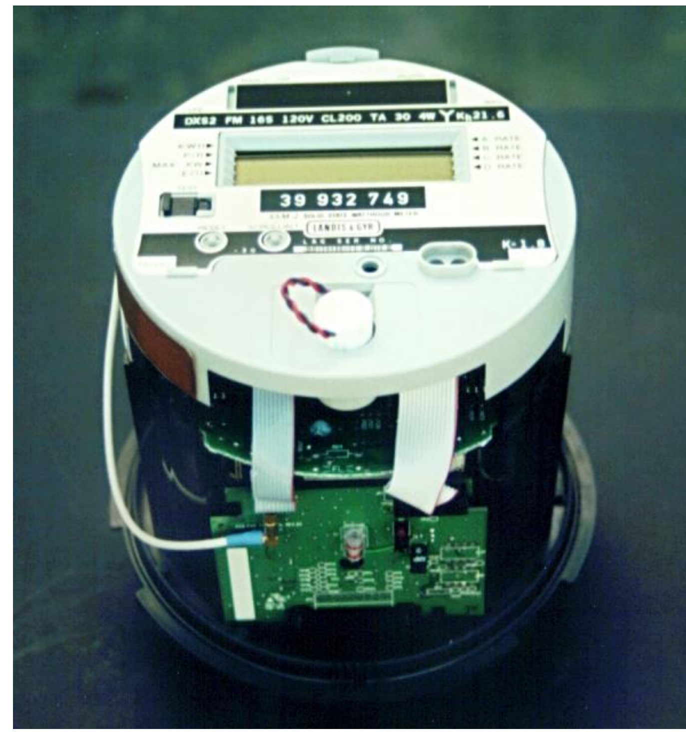
- Outage/Restoration
- Real time tamper
- Remote service on/off

- Value-added services

Increasing DR Support →

Demand Responsive Metering

- Measurement
  - Storage
  - Timing
  - Precision
- Communication
  - Meter
    - One-Way vs. Two-Way
    - Latency
  - HAN Gateway vs. Direct
- Replace vs. Retrofit
  - Second Counter
  - Direct Register Read



Metrology: Legislation

- *EPAct 2005 recognized that the penetration of advanced metering is important for the future development of electric demand responsiveness in the United States*

Communications: Considerations

- Media
- Availability & Reliability
- Bandwidth
- Security
- Gateway

Communications: AMI Alternatives

- Telephone (Inbound and Outbound)
- PLC (Very low frequency to BPL)
- RF Network (Licensed and Unlicensed)
- Cellular (GPRS, 1XRTT, iDen, etc.)
- Cable/Fiber
- Wi-Fi
- WiMAX
- Hybrid Mesh

Communications: Metering Gateways

- Communication Possibilities
  - Short Hop Radio From the Meter
  - PLC
  - Direct Connect
  - AMI LAN
  - Secure Public Network

- HAN-Premise Devices
  - Thermostats and In-home Displays
  - Contactors and Remote Appliance Controllers

- Other Meters
  - gas, water

Standards: Considerations

- Meter
- Communications
- End-point
- Data

Standards: Relevant Organizations

- ANSI
  - **American National Standards Institute**
- IEEE
  - **Institute of Electrical and Electronic Engineers**
- IEC
  - **International Electrotechnical Commission**
- Open Auto-DR
  - **Open Automated Demand Response Communication Standards**

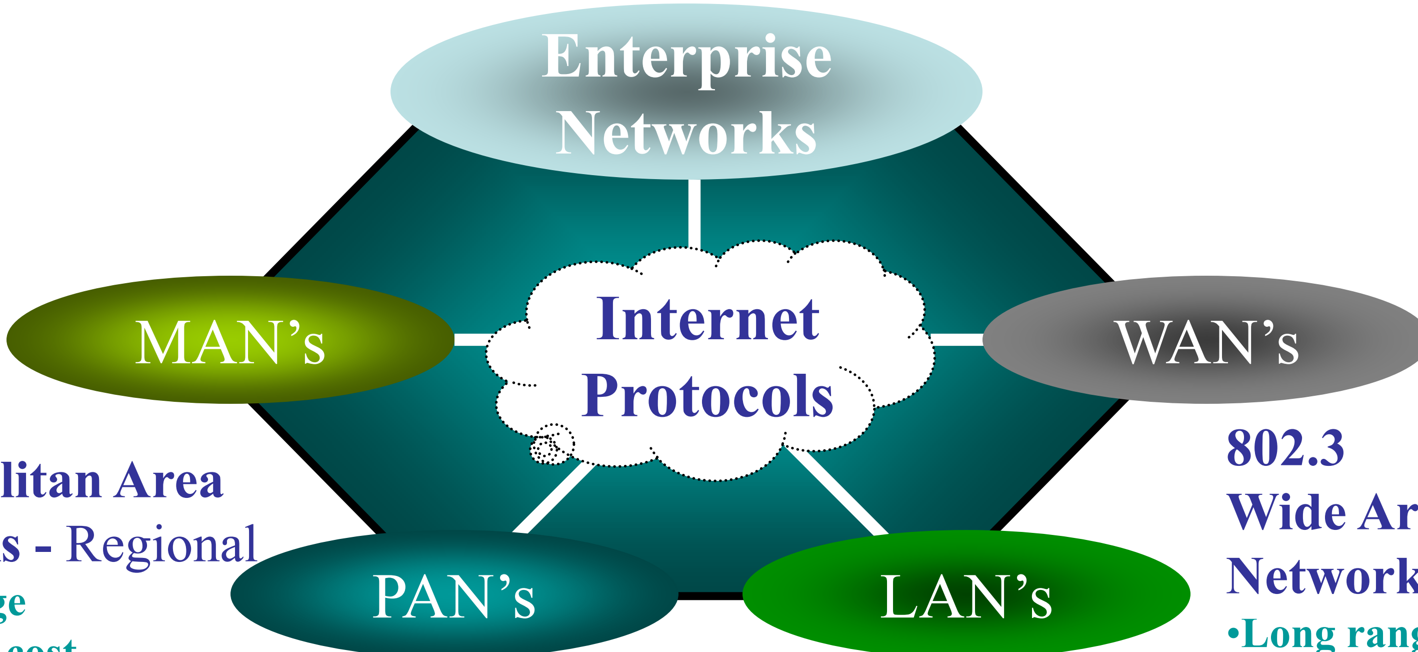
Standards: ANSI C12-19

- Common data structure
  - data transfer to and from utility end devices
  - approved after cooperation among utilities, meter manufacturers, Industry Canada, AMRA et al
  - table sets segmented into decades, each decade a specific feature set and data type (e.g., TOU)
  - data transfer by reading or writing to tables
  - the set of standard tables will grow
    - »
- The Secretariat of the Accredited Standards Committee on Electricity Metering, C12
  - the National Electrical Manufacturers Association
  - the National Institute of Standards and Technology

Standards: ANSI C12-22

- Describes the application layer for network communications
- Transports C.12.19 standard electric metering data tables over any physical medium
- The ANSI C.12.22 standard open protocol functions similarly for networked meter communications

Standards: IEEE Wireless Networks



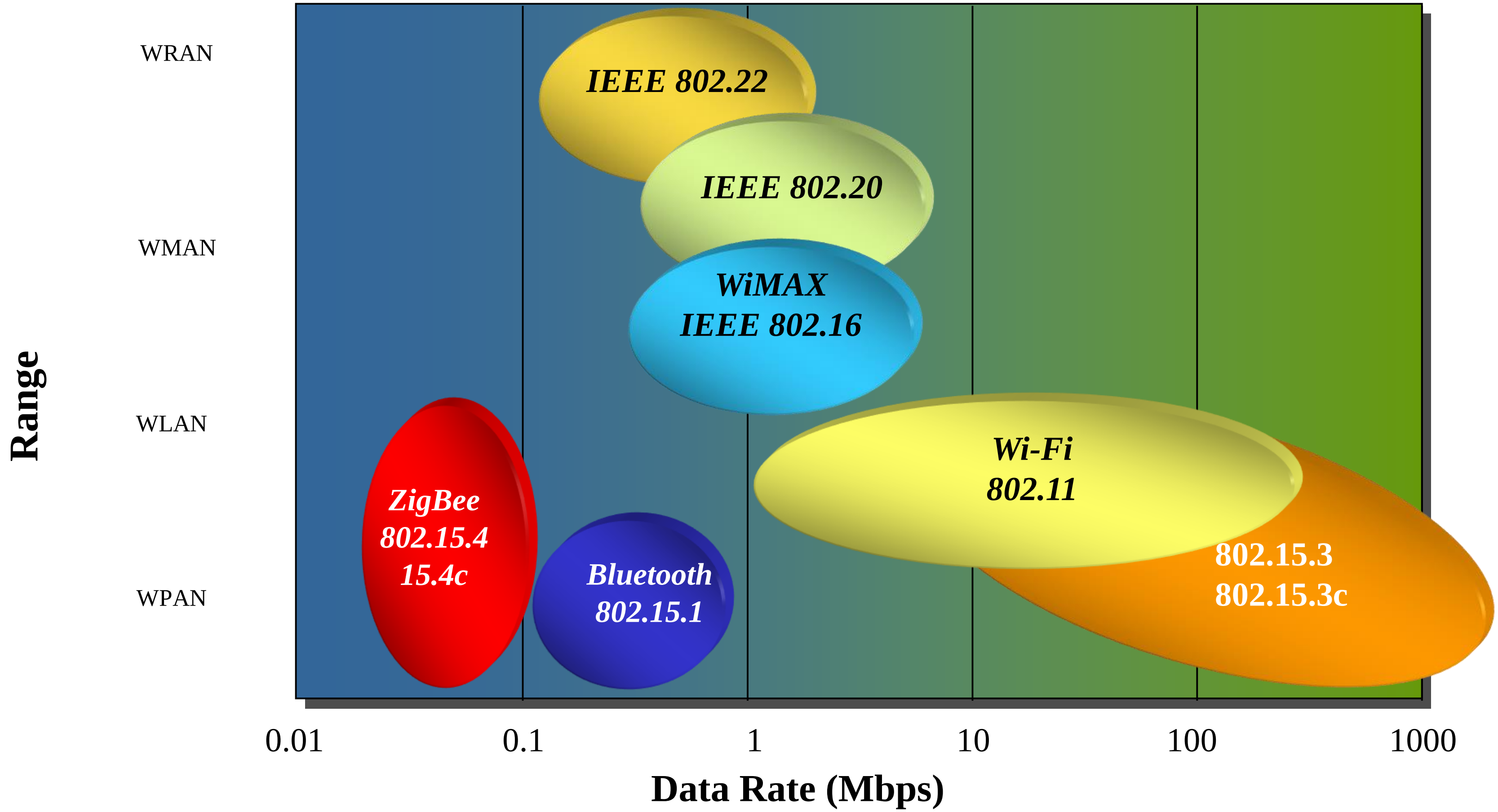
802.16
Metropolitan Area Networks - Regional
- **Long range**
- **Moderate cost**
- **Mixed media**

802.15
Personal Area Networks - Devices
- **Short to medium range**
- **Ultra low cost**
- **Low Power**

802.11
Local Area Networks - Computers
- **Short range**
- **Moderate cost**
  - **Home Networks**
  - **Hot Spots**

802.3
Wide Area Networks - Global
- **Long range**
- **High cost**
  - **Cellular**
  - **Satellite**

Standards: IEEE Wireless Data Rates



Standards: IEEE P1901 - HomePlug

- HomePlug design
  - specifies the home networking technology connecting devices through home power lines
  - the standard specifies the physical layer (PHY) and medium access control (MAC)

- HomePlug operations
  - a powerline network runs Ethernet over the existing electrical system, and connects via AC wall outlets
  - provides a non-wireless alternative to stringing network cables to all the rooms in the house

USNAP

- USNAP (Utility Smart Network Access Port) is a utility industry initiative whose primary objective is to create a low-cost protocol-agnostic, interoperable communications card standard for connecting HAN (Home Area Network) devices to Smart Meters.

- This standard resembles the popular USB standard for attaching hardware devices in a computer. USNAP defines a standard connector, PCB interface and serial interface enabling consumer products to support a variety of communication protocols.

Standards: IEC 61968 and 61970

- A semantic model
  - describes the components of a power system
  - asset tracking, work scheduling and customer billing
- The Common Information Model (CIM) for power systems
  - comprised of two standards (61970-301 and 61968-11)
  - designed to facilitate the exchange of power system network data between companies
  - designed to allow the exchange of data between applications within a company

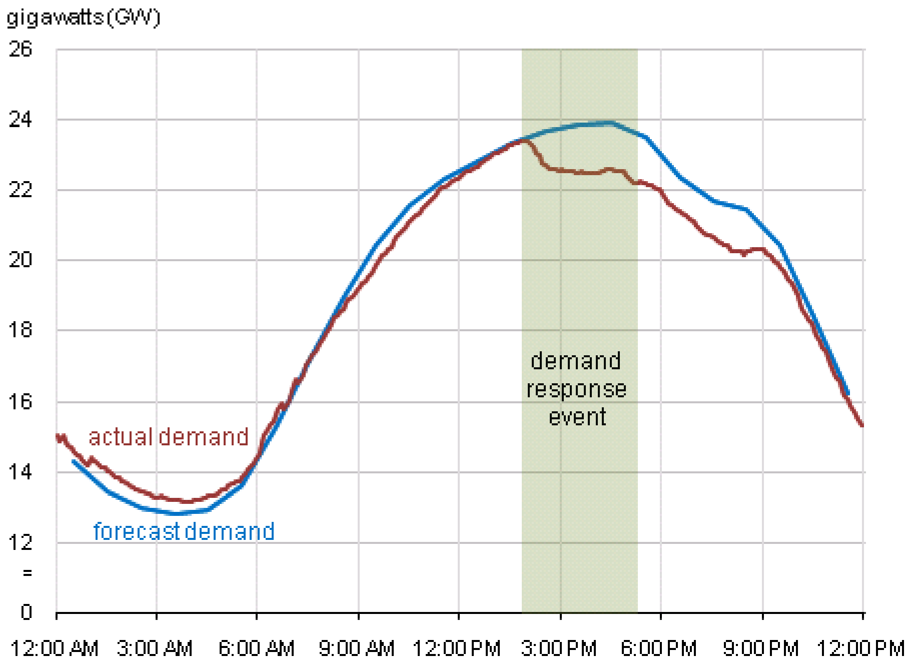
Standards: Automated Demand Response

- Automated Demand Response (Auto-DR)
  - a program managed by the Demand Response Research Center (DRRC)
  - designed to link facility energy management control systems (EMCS) with external utility-generated price or emergency signals

- Auto-DR signals initiate pre-programmed signals
  - customers define strategies to shift, reduce or shed loads
  - customer responses through the facility's EMCS are automated, but both opt-out and override options are available
  - Auto-DR reduces cost and complexity, deliver consistent and reliable demand response

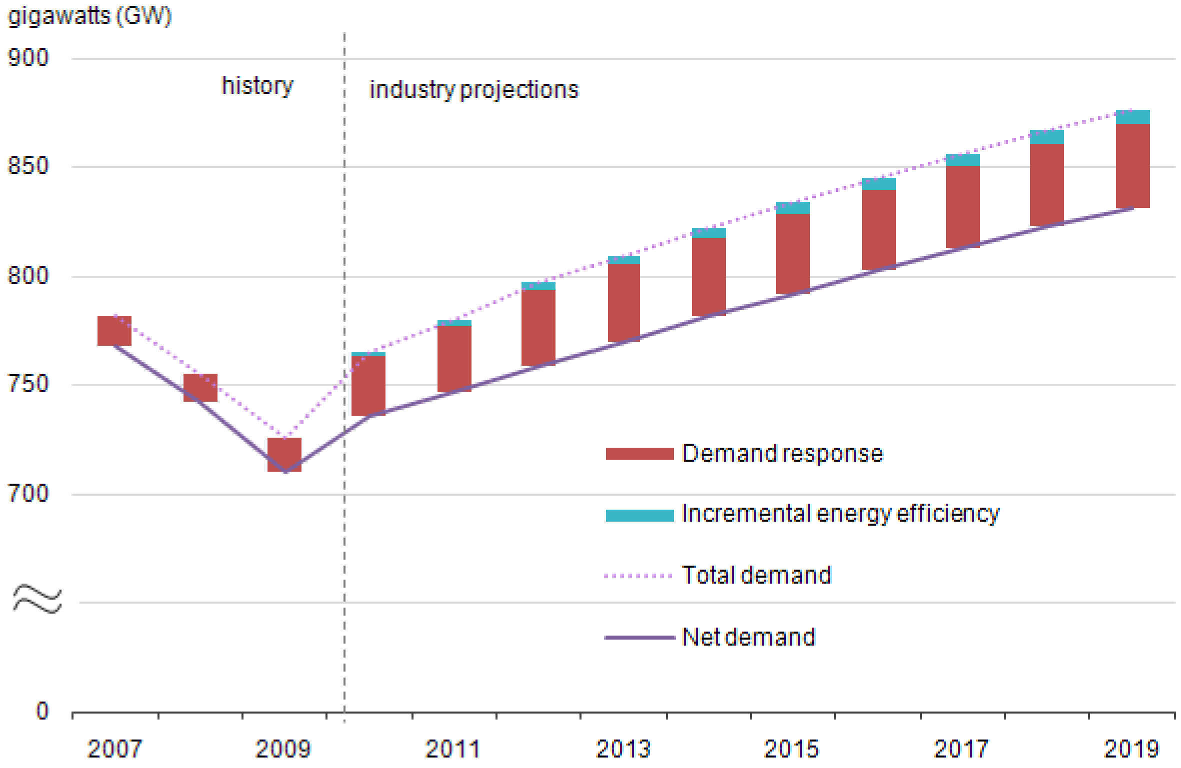
- The Demand Response Research Center is operated by Lawrence Berkeley National Laboratory for the California Energy Commission's Public Interest Energy Research Program (PIER).

an example: ISO-NE electric load, June 24, 2010

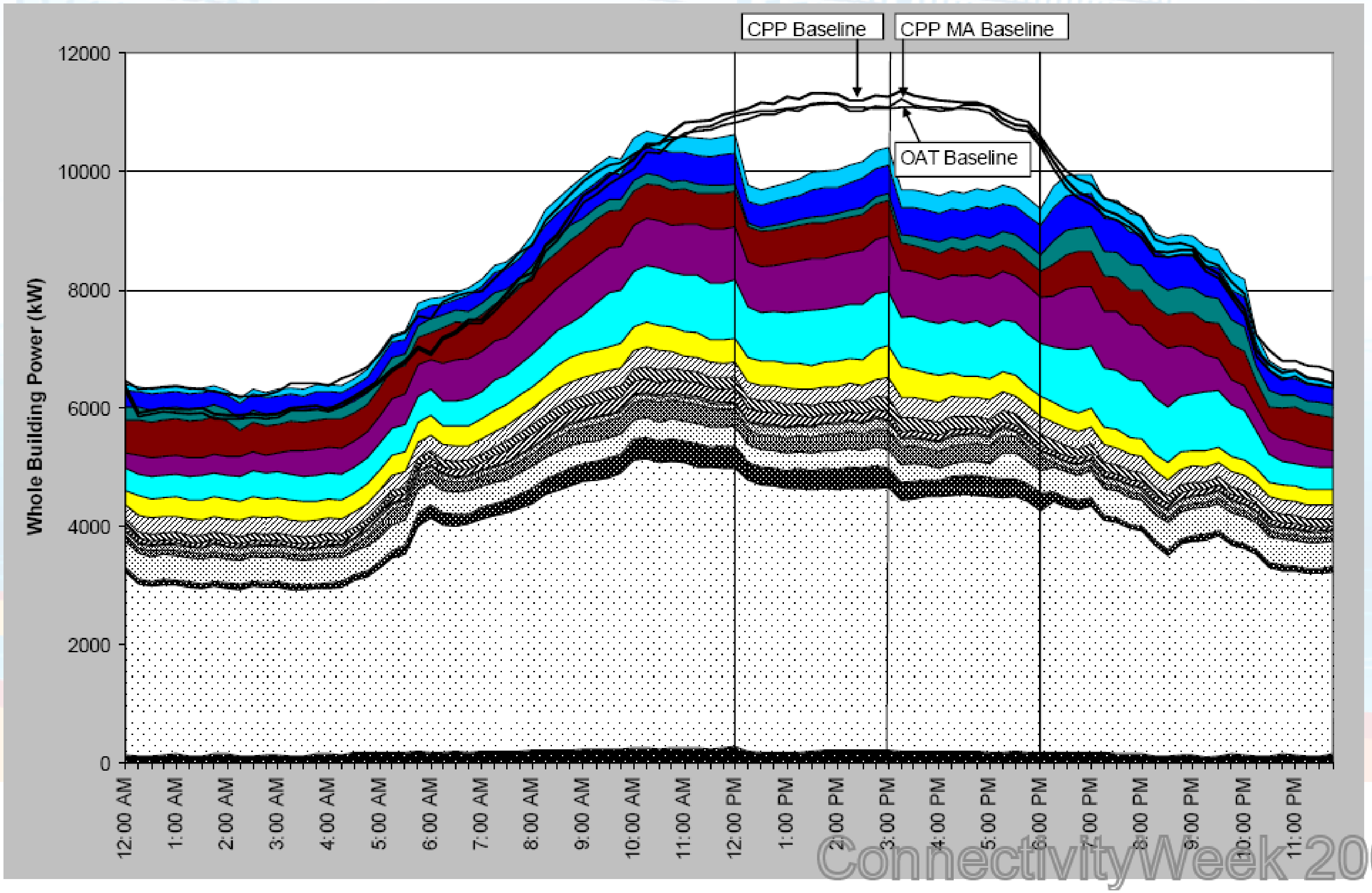


DR Projections

Grid planners report increases in expected peak demand response, energy efficiency



Examples: Auto-DR



Data: Storage and Precision

- Location
  - Meter
  - AMI System
  - MDMS
  - CIS

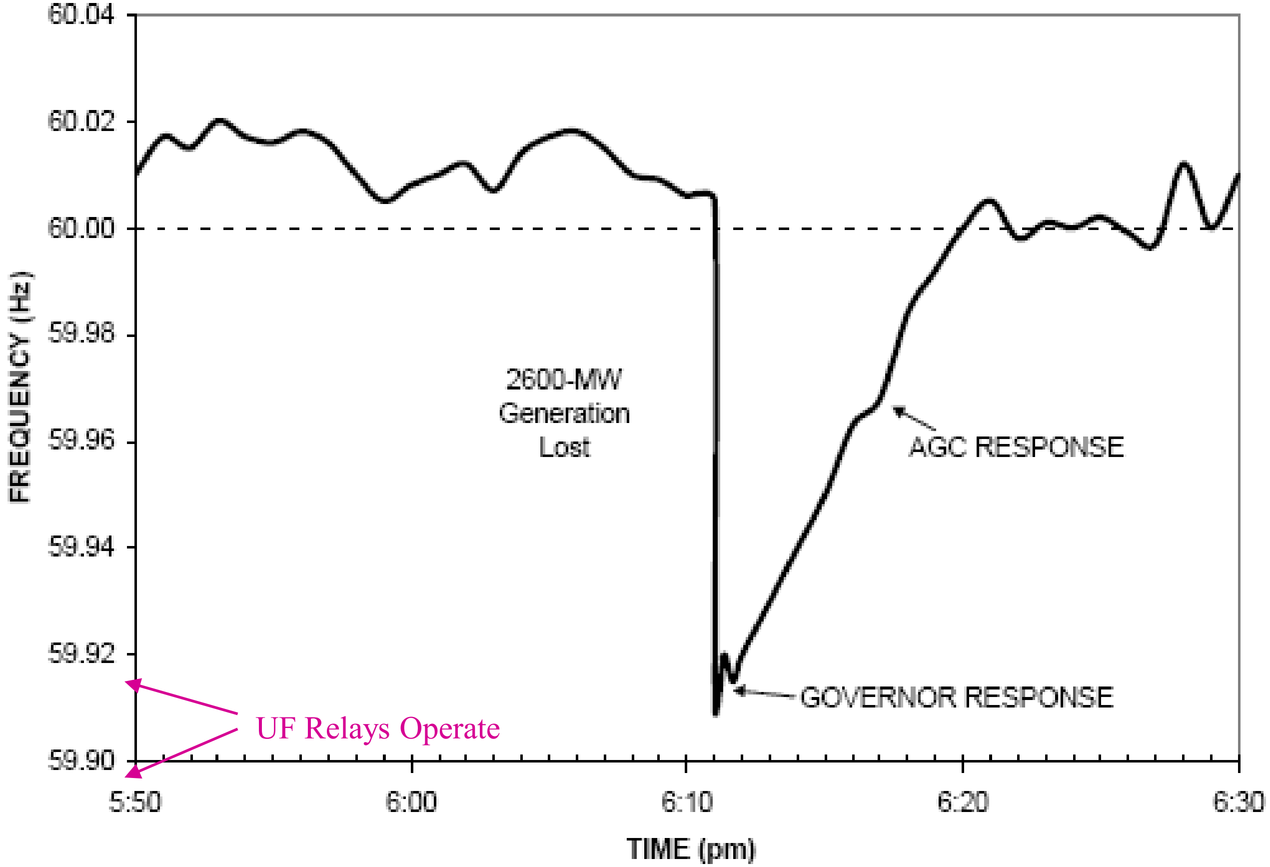
- Duration
  - Meter
    - Loss of communication
  - AMI System
    - System Maintenance
  - MDMS
    - Varied Applications
    - Long Term
  - CIS
    - Customer Dialog
    - Billing

- Precision

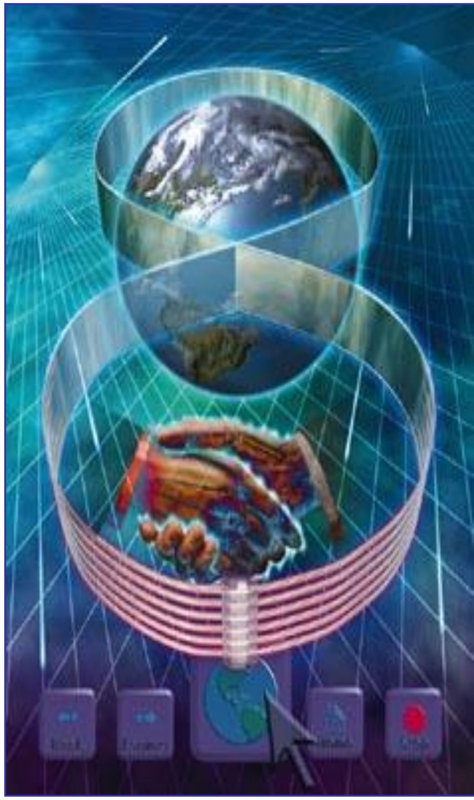
Data: Demand Response Control

- Informational
- Direct vs. Indirect
- Customer Acceptance
- Availability
- Predictability
- Scheduling
- Latency
- Measurement and Validation

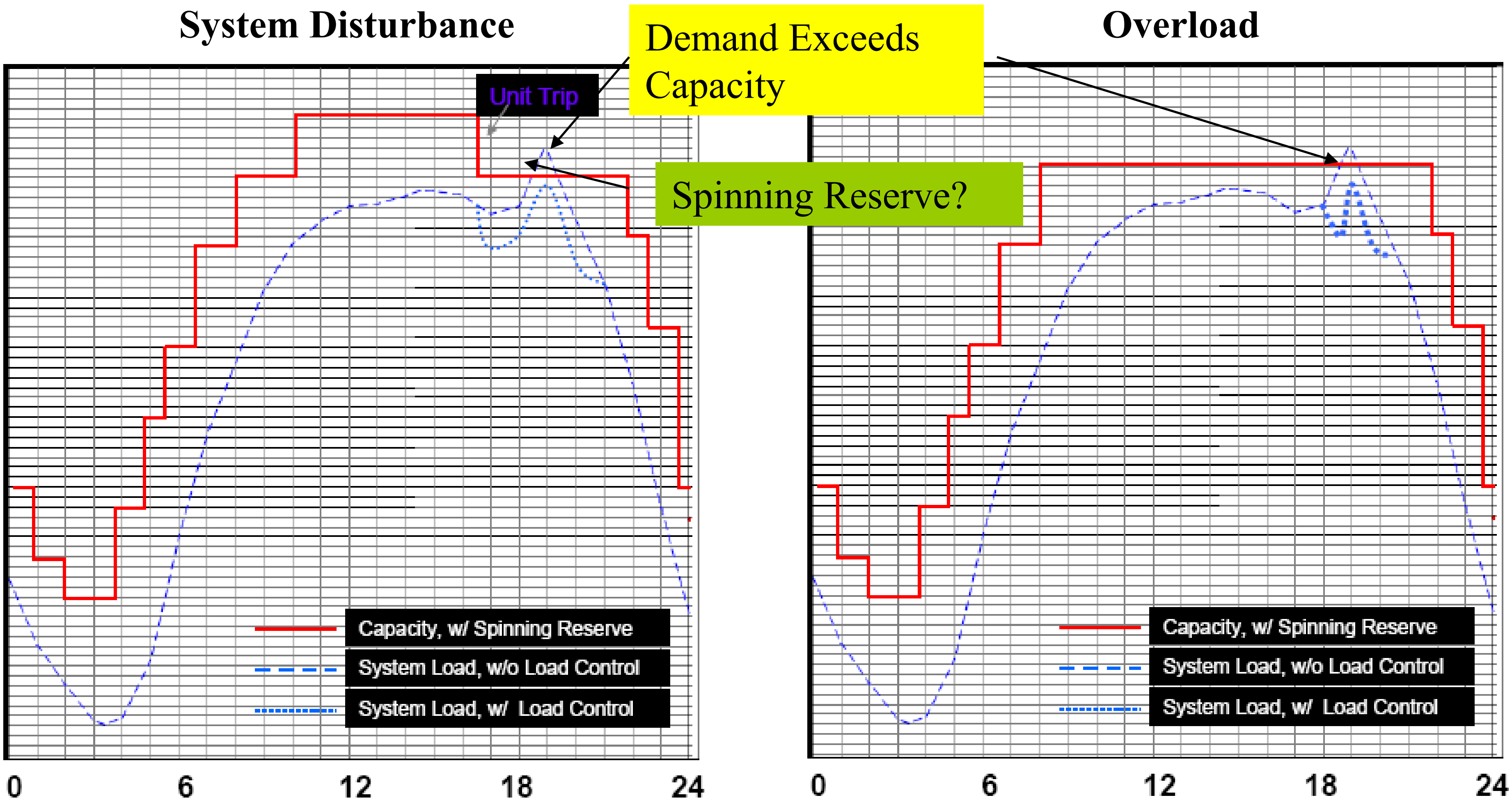
Control: Traditional System Response



Source: ERCOT



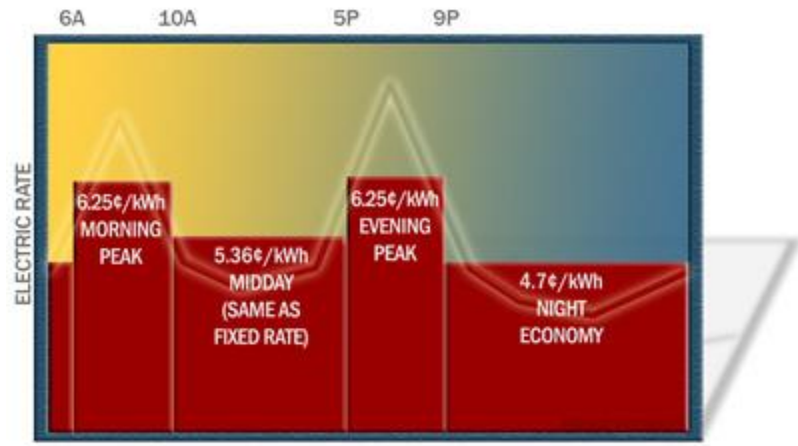
Control: Load Control vs. UF Load Shed

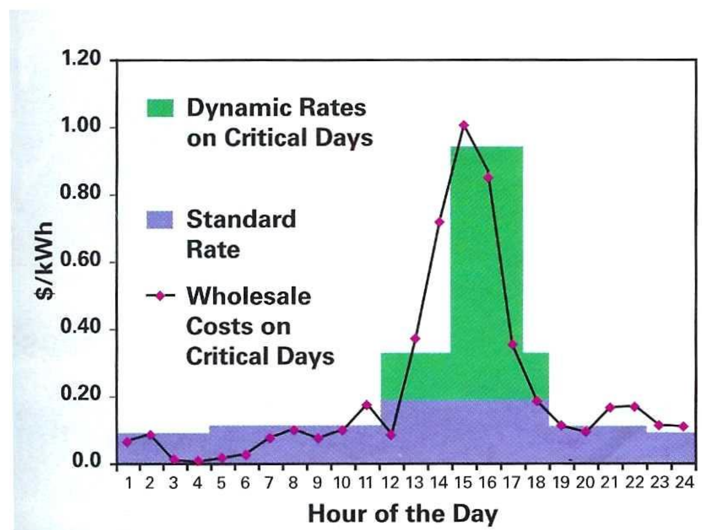


Courtesy of Cannon Technologies

Control: Price Signals

- TOU
  - Defined
  - Predictable
- RTP
  - Unpredictable
  - Continuous
- CPP
  - Short Notification
  - Infrequent





The hourly price of electricity on critical summer weekdays (generic)

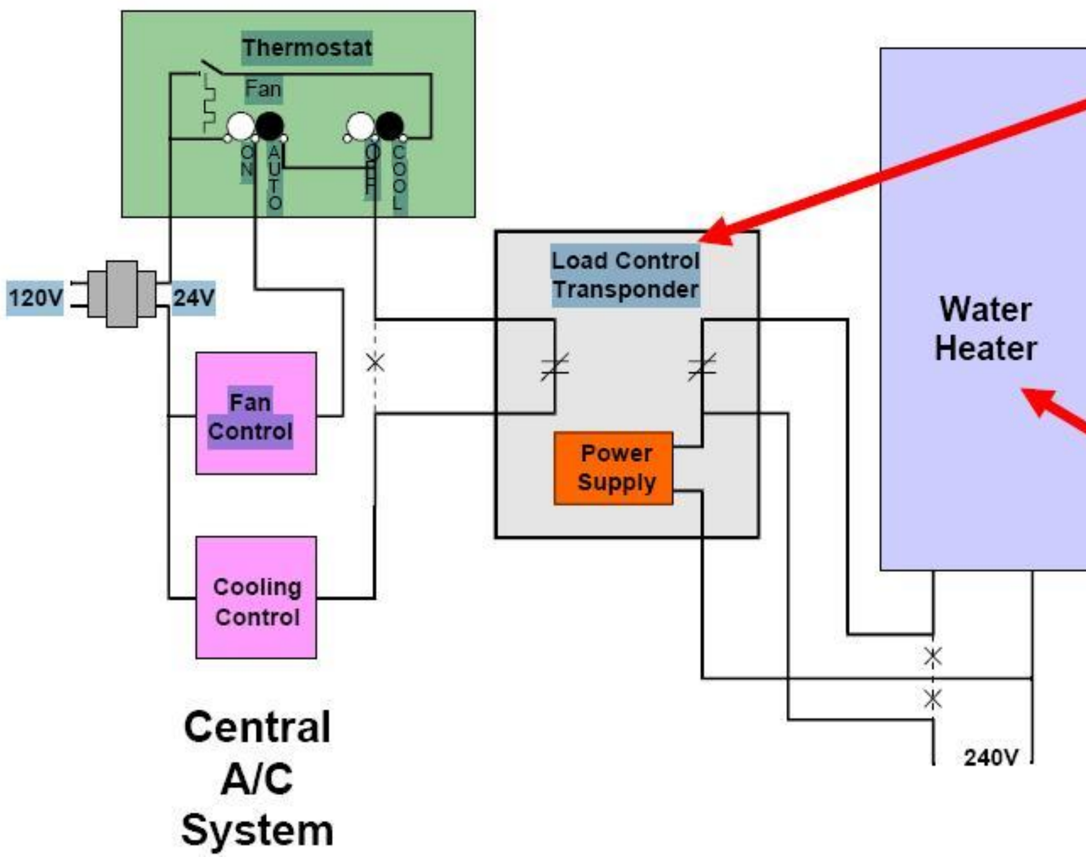
Control: Demand Response Variations

- Traditional
- Price Signals
- Hot Water
- Air Conditioning
- Pool Pumps
- Programmable Thermostats

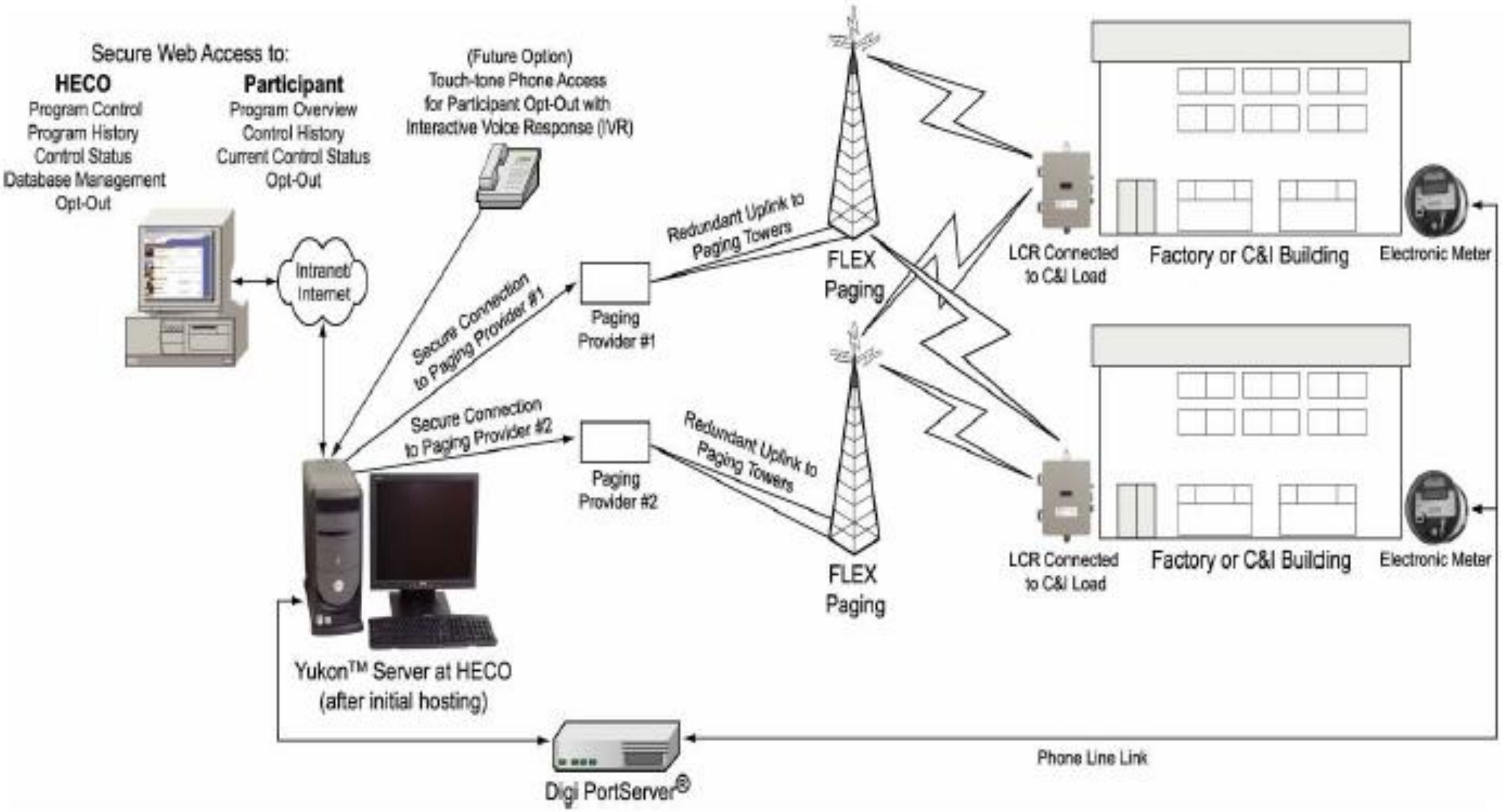
- Pre-cooling
- Thermal Storage
- Lighting
  - Indoor
  - Outdoor
- Appliance
  - Direct
  - Smart

Examples: Hot Water, Swimming Pool and Air Conditioning Cycling

Examples: Residential Hot Water and Heating/Ventilating/Air

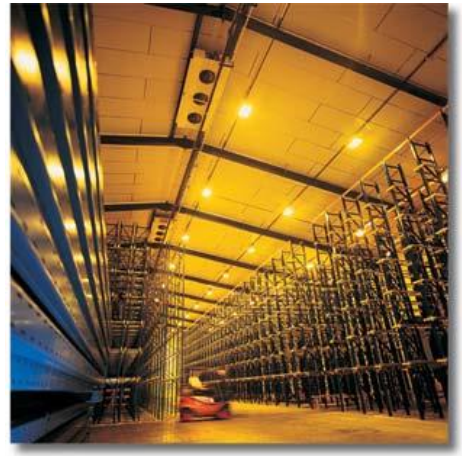


Examples: Direct Load Control at HECO

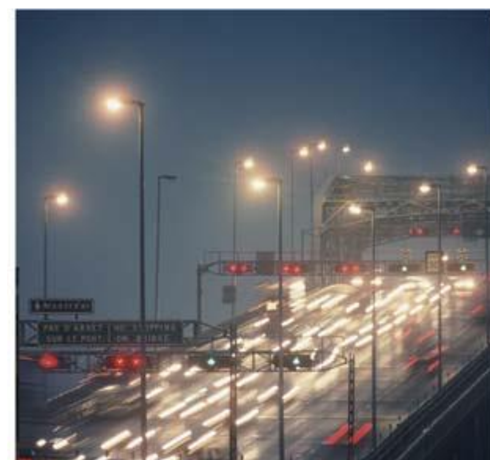


Courtesy of Cannon Technologies

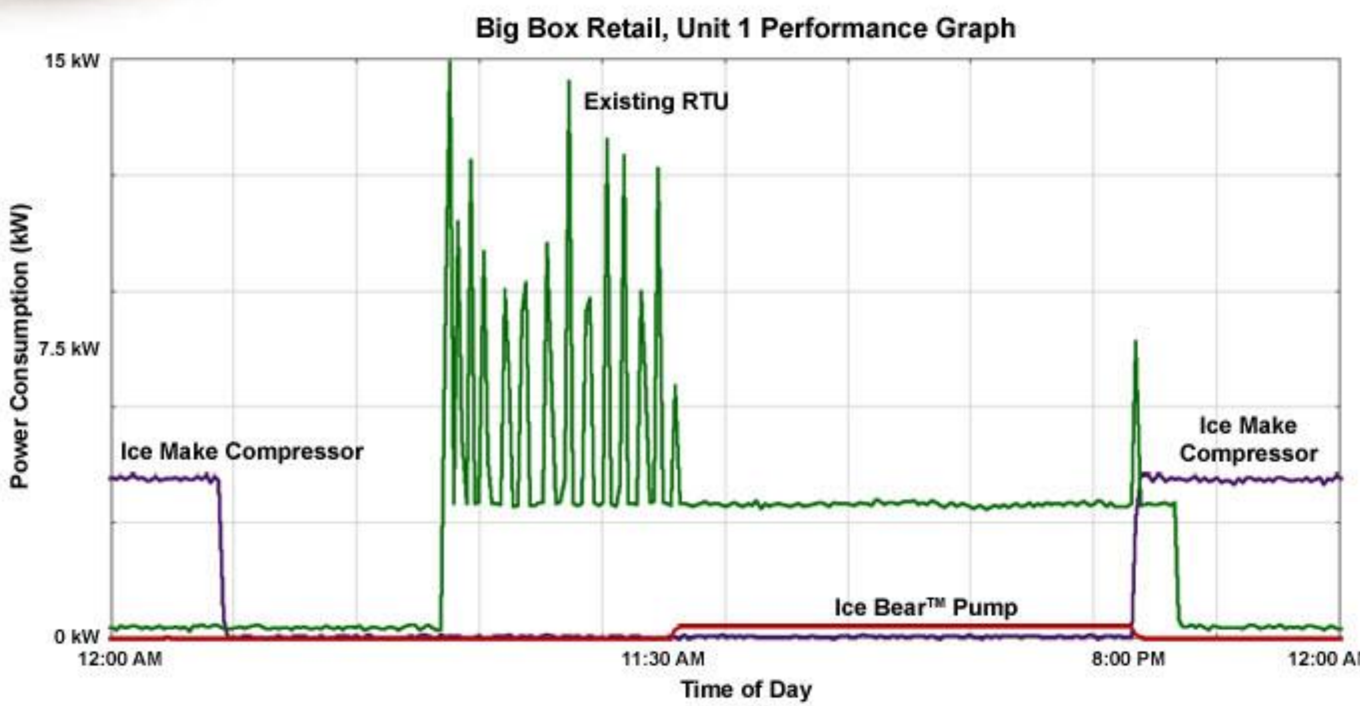
Examples: Lighting



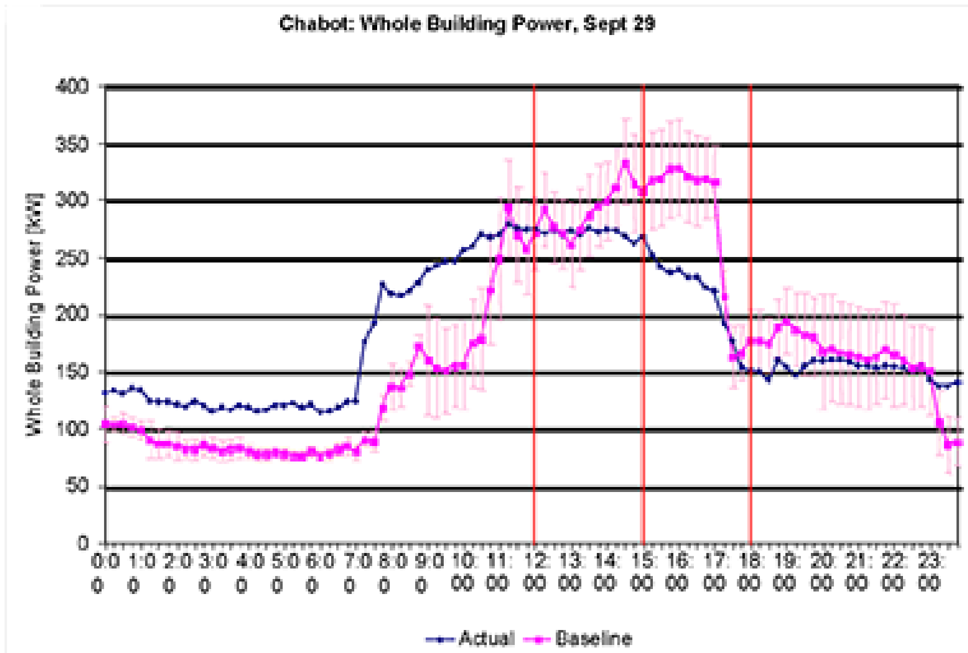
- Outdoor Lighting
  - Demand Response
  - Conservation
- Indoor Lighting
  - Conservation

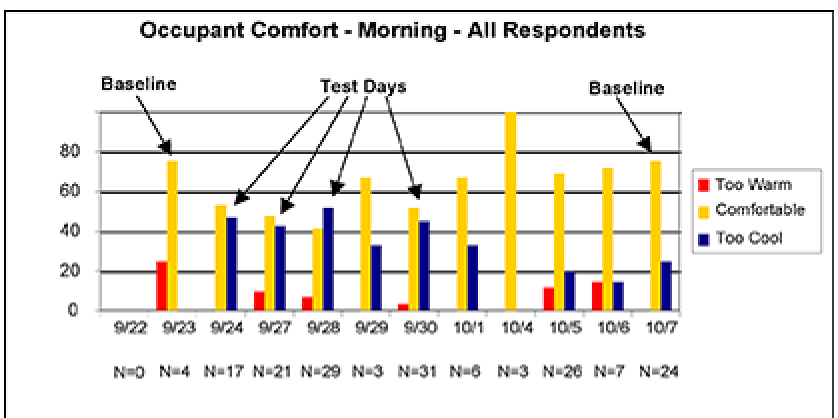


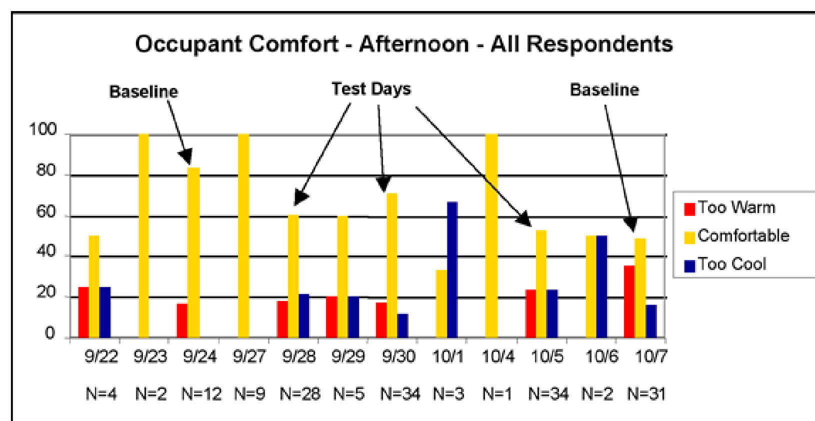
Examples: Thermal Storage



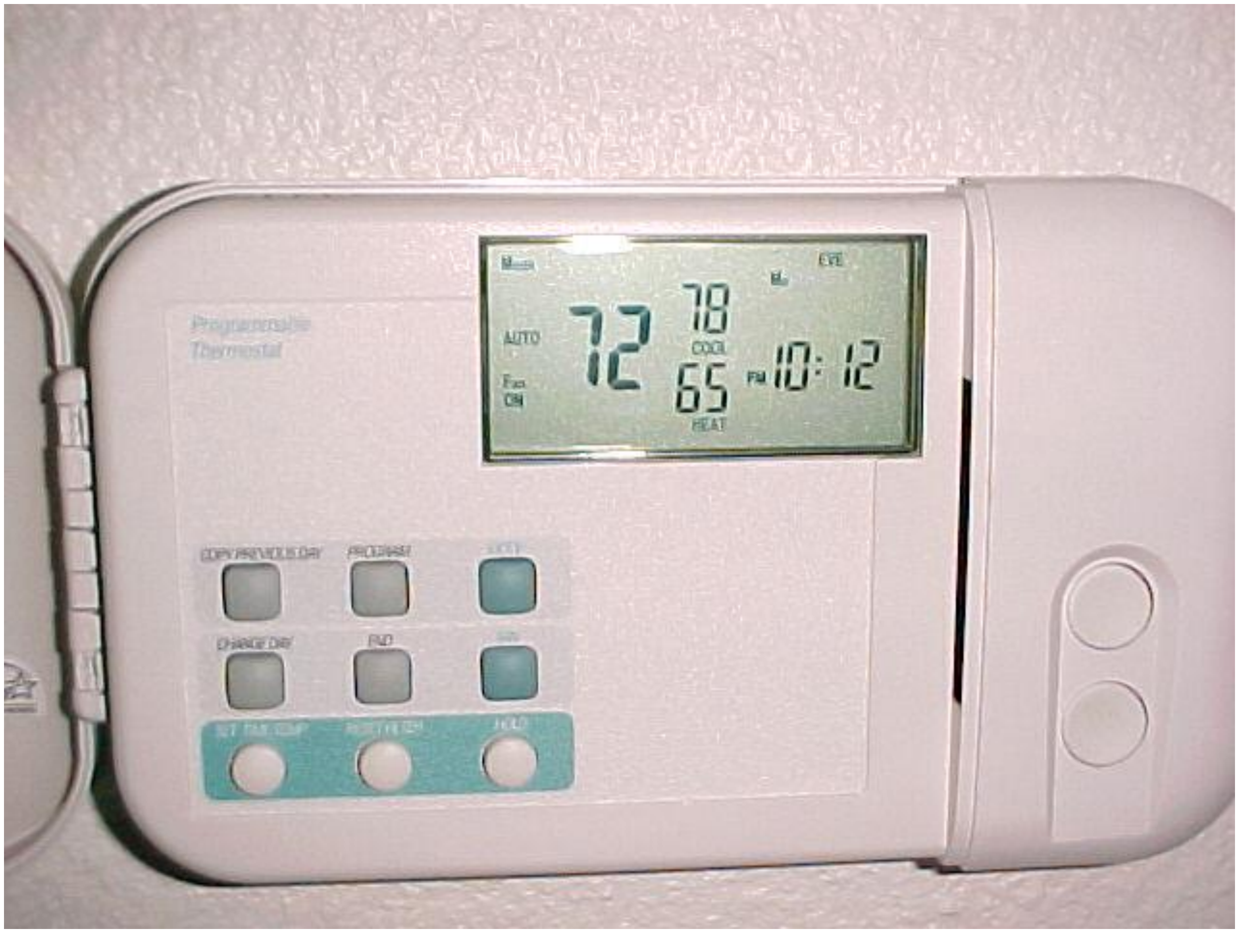
Examples: Pre-Cooling



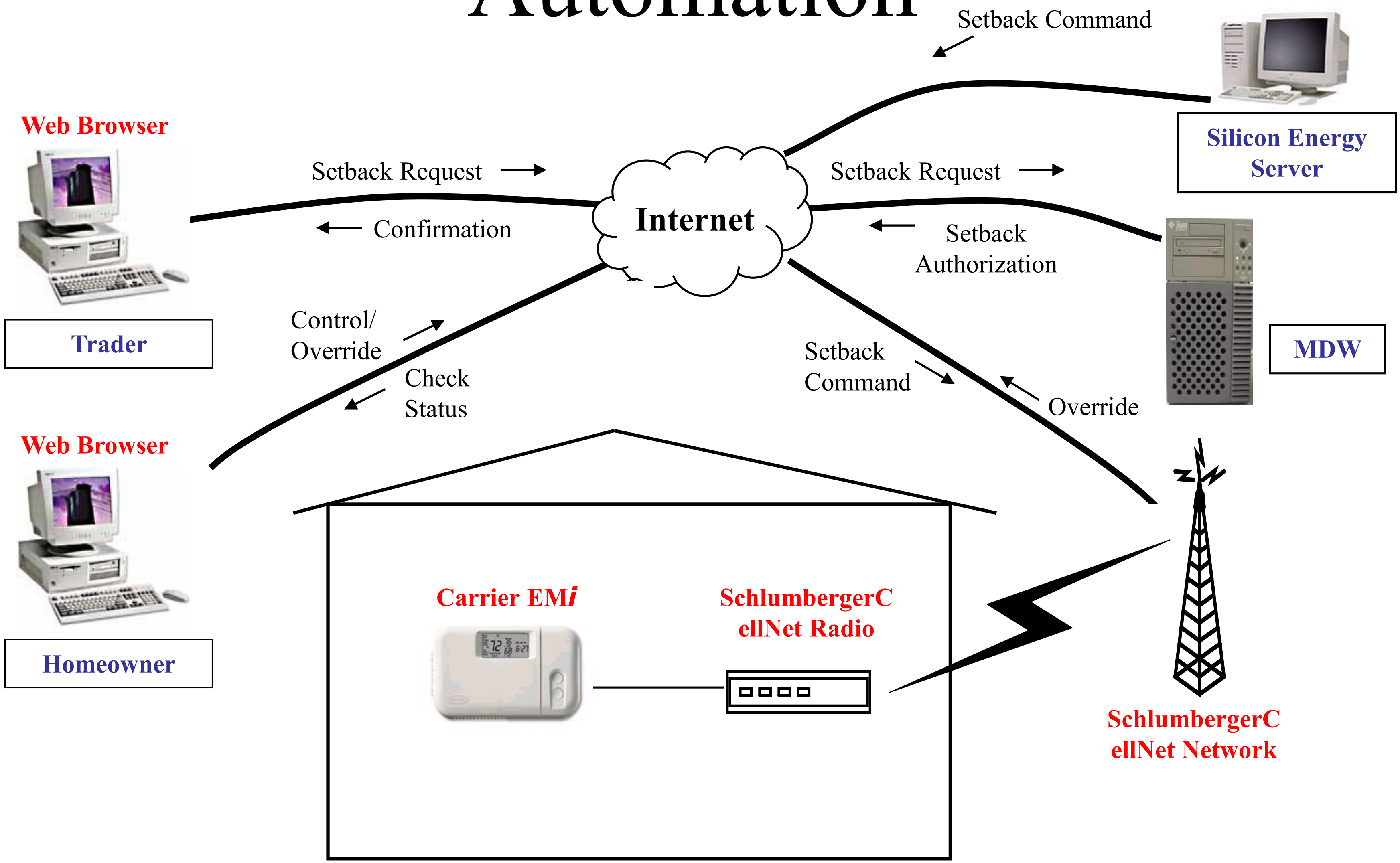




Examples: Programmable Thermostat



Examples: PSE Premise Automation

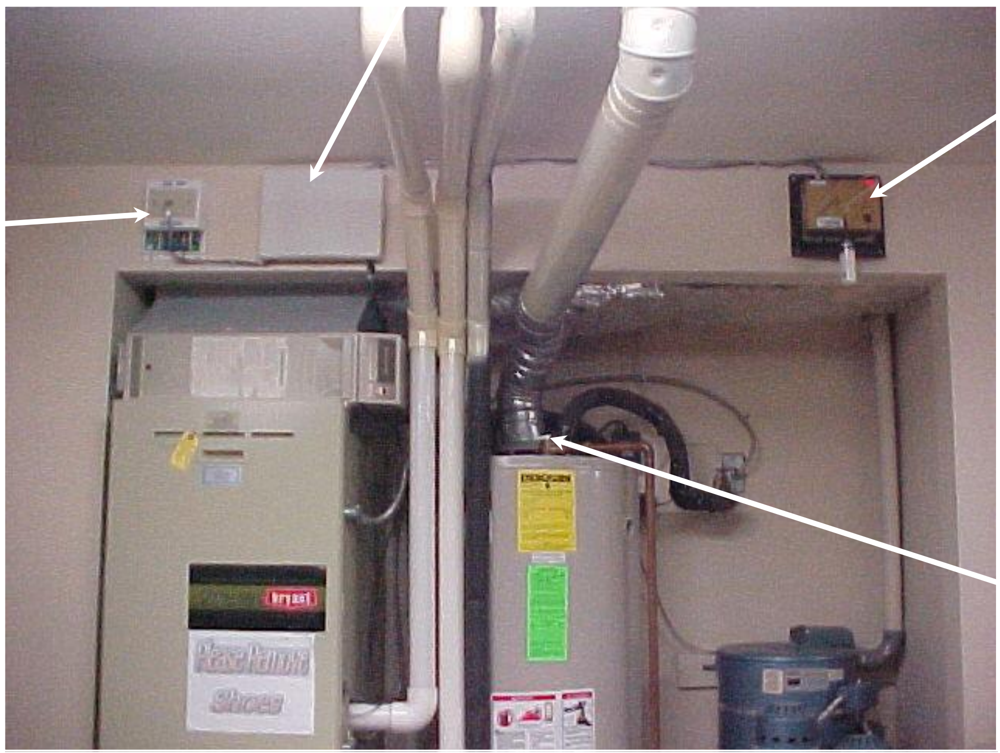


Examples:Premise Wiring

Controller

Two-Way
End Point
Radio

Gateway



Water
Heater
Contactor

Examples: Appliances

Table 1 New Appliances Placed Annually in Occupied US Households

Appliance	Replacement in Existing Homes % Electric	Avg Life	Units Sold in millions	Penetration in New Homes % Electric	Units Sold in millions	Coincident Peak kW contribution per Appliance btwn 4p & 8p (summer) Avg Day	Pk Day	New Appliance Load Contribution in GW Avg Day	Pk Day
Water Heater	38%	15	2.8	40%	0.4	0.60	0.60	1.9	1.9
Window AC	22%	13	1.8	25%	0.2	0.50	0.90	1.0	1.9
Central AC	54%	25	2.4	60%	0.5	1.00	3.00	2.9	8.7
Stove	59%	16	4.0	60%	0.5	0.48	0.46	2.2	2.1
Refrigerator	110%	18	6.7	100%	0.9	0.10	0.11	0.8	0.8
Dryer	57%	15	4.2	60%	0.5	0.15	0.14	0.7	0.7
Freezer	32%	20	1.7	30%	0.3	0.10	0.10	0.2	0.2
Dishwasher	53%	13	4.5	60%	0.5	0.05	0.04	0.2	0.2
			28.0		**3.9**			**9.9**	**16.4**
						Average Benefit per Appliance=>		0.3 KW	0.5 KW

Assumptions

Market Saturation from Table 963 Statistical Abstracts 2006			For reference in 2007
Number of US Households 2007	109.3	million	US Peak Summer Load
Number of New Households	0.9	per yr.	Forecast is 790 GW

Customer Sign-up

❹ Rates & Tariffs

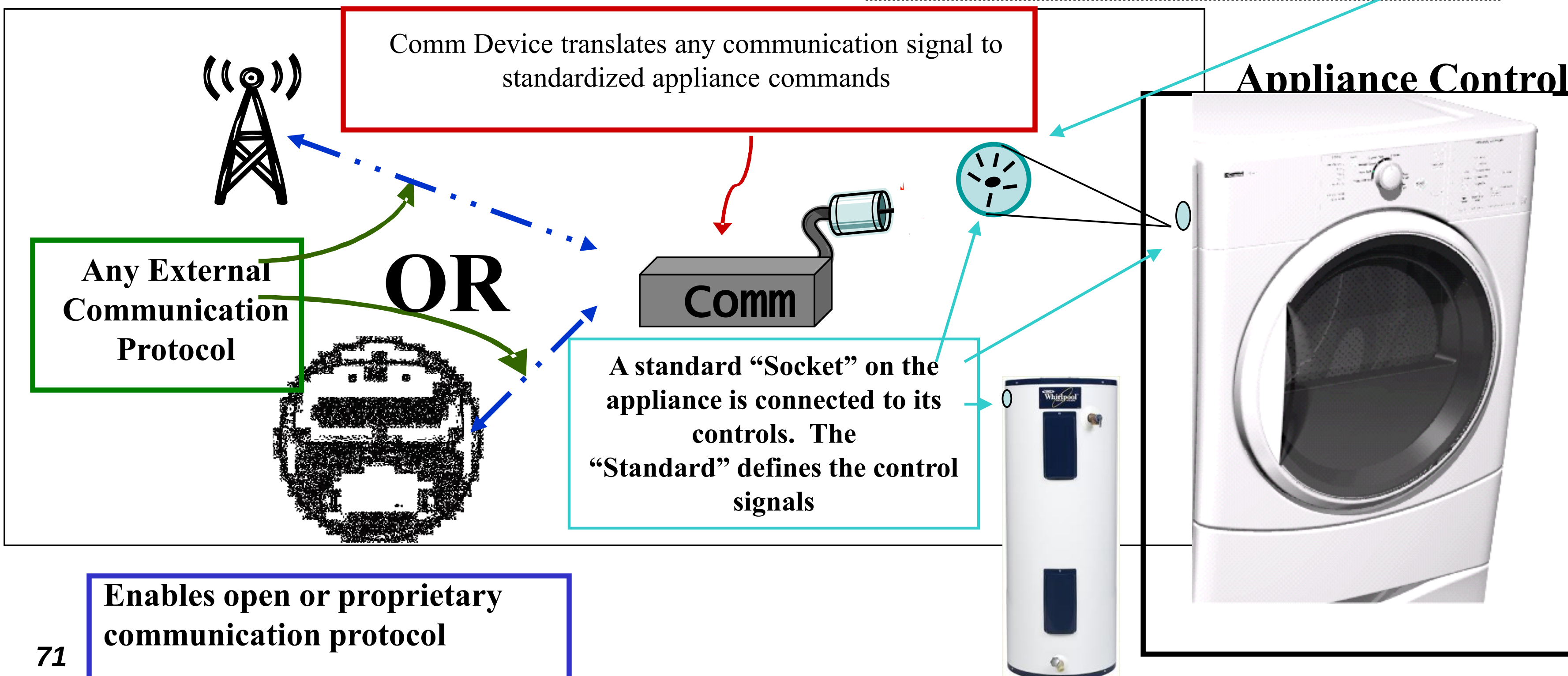
Rates & Tariffs: Changing Economics

Principles of Design

- All major appliances designed w std. "Socket"
- Pins define simple commands that even non-digital appliances can interpret
- Supports simple communication packets
- UL is Customer Installable
- UL Inexpensive- low risk

Pin 1 for High Price
Pin 2 for Direct Load Control
Pin 3 for Grid Instability
Pin 4 supplies low voltage
Pin 5 digital signals (optional)
Pin 6 Ground

Example of simple protocol



Rates & Tariffs: The Invisible Hand Comes to Electricity

- Price changes to balance supply & demand
  - True for most commodities, but not regulated commodities
- Electricity prices vary by hour
  - but if the meters are only read monthly, billing is monthly
  - AMI enables time-sensitive billing
- Customers expect monthly, volume-based bills

Rates & Tariffs: High-Level Approaches

- Direct Load Control
  - – tariff gives customer a monthly payment
  - – utility gets direct control by installing switch
  - – usually no override by customer
- Pure Price Incentives
  - – tariff for TOU, RTP, CPP, CPC
  - – customer must manage load
- Combinations
  - – customer signs up for rate & enabling technology

Rates & Tariffs: FPL Direct Load Control

- 20 year program, HVAC cycling
- $5 to $20 monthly credit on bill (depends on appliance)
- Easy for customer to understand, but invasive
- Predictable response for power operations
- Varying success when new owners

Rates & Tariffs: Price Designs

- TOU
  - specific prices (usually two or three) at specific times
  - price spread
  - around for 25 years
  - typically low response (<2%), but loyal customers
  - non participants give credit for choice
- Critical Peak Pricing (CPP)
  - California Statewide Pricing Pilot led to many

Rates & Tariffs: Real-Time Pricing (RTP)

- Real-Time Pricing
  - prices known only day before, volatility can be serious
  - requires expertise, time investment for customers to benefit
  - has worked best for large commercial customers with energy management systems
- The future of RTP
  - works with residential space heating/cooling, water heating

Rates & Tariffs: Buyback

- Buyback design
  - establish baseline use through recent history
  - contract with customer
  - customer receives 4-16 hour notice to cut back per contract
  - mandatory with penalty
  - Customer shares in spot market power cost

Rates & Tariffs: AmerenUE TOU Rates

Summer: Three-Tier TOU Only Rate		
Off Peak	**Weekday 10PM–10AM, Weekends, Holidays**	**4.80 cents/kWh**
Mid Peak	**Weekdays 10AM–3PM and 7PM-10PM**	**7.50 cents/kWh**
Peak	**Weekday 3PM–7PM**	**18.31 cents/kWh**
Summer: Three-Tier TOU with CPP Rate		
Off Peak	**Weekday 10PM–10AM, Weekends, Holidays**	**4.80 cents/kWh**
Mid Peak	**Weekdays 10AM–3PM and 7PM-10PM**	**7.50 cents/kWh**
Peak	**Weekday 3PM–7PM**	**16.75 cents/kWh**
CPP	**Weekday 3PM –7PM, 10 times per summer**	**30.00 cents/kWh**

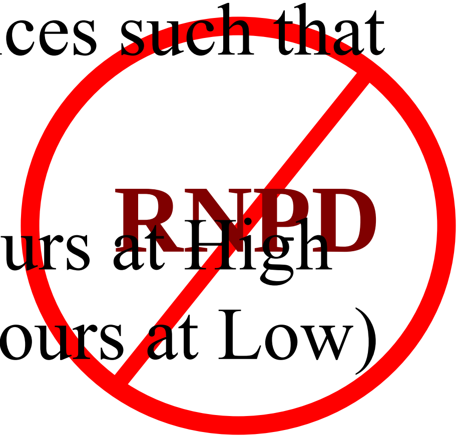
Rates & Tariffs: AmerenUE TOU Design

- TOU with three rate levels
- TOU with three rate levels
  - and, a critical peak pricing component
- TOU with three rate levels
  - and, a critical peak pricing component
  - and, enabling technology (a “smar

Rates & Tariffs: Revenue-Neutral Pricing

- Most utilities prefer revenue-neutral designs
- Statistical concept
  - start with 8760 statistical load profile of a specific customer group. Choose hours and prices such that
  - flat price * kWh avg/hr * 8760 =

    (High price * kWh avg/hr (in high hrs) * Hours at High
    + Low price * kWh avg/hr (in low hrs) * Hours at Low)



- Customer acceptance
  - time-sensitive rate 2 to 5% <u>less</u> than flat design

❺ Customers

Customer Roles

- Customer decisions fuel demand response
- The quality and nature of customer decisions varies greatly
  - commercial, institutional, residential
  - experimentation, trial, adoption
  - emergency, economics
- The customer relationship is the utility pipeline

Customer Themes

- Customers are involved in AMI, but committed to demand response
- Customers require a simple, clear deal to be recruited and retained
- Opt-in, opt-out, or mandate
- Motivations: savings, citizenship, control
- Methods of participation: spectators,

Demand Response: Customer Impacts

- A more complex and less reliable relationship with the utility
- Compromised or damaged work or personal routines
- Loss of control over daily schedules and premises operations
- The expense and inconvenience of adapting to time-of-use rates

Customers and Demand Response: The First Key

- Communications with <u>customers</u> about:
  - their energy usage
  - electricity rates
  - electricity pricing
  - energy usage alternatives
  - electricity generation and distribution
  - utility operations and management
  - utility regulation
  - and…the specific demand response

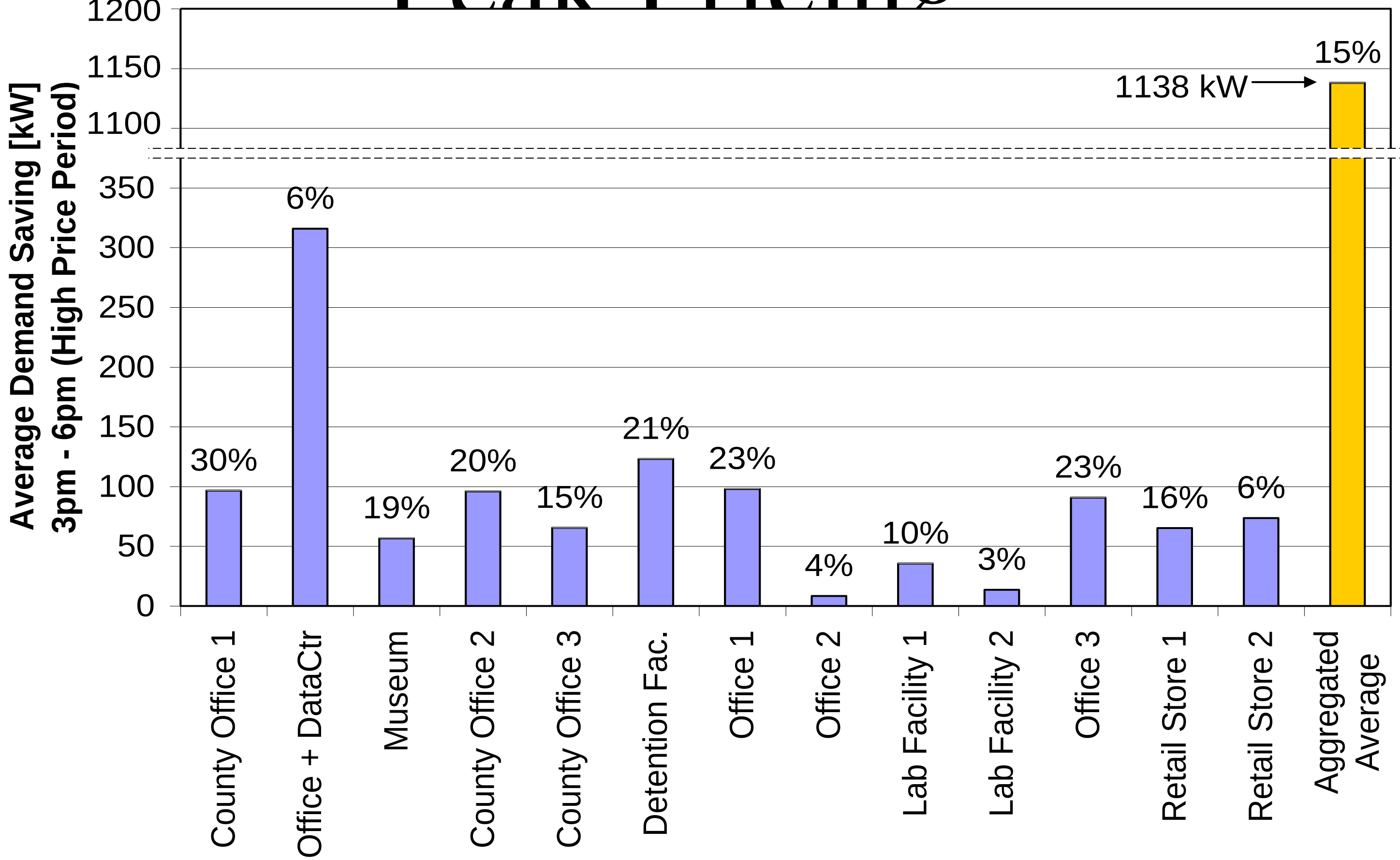
Customers and Demand Response: The Second Key

- Communications with customers' <u>devices</u>:
  - meters
  - Thermostats
  - Home energy displays
  - HVAC systems
  - energy management systems
  - swimming pool pumps
  - appliances
  - lighting

Customer Privacy: a System Feature

- Federal laws govern:
  - computer fraud - intentional, unauthorized access to “a computer” which “obtains … information”
  - wiretapping - laws apply to interception of “electronic communications”
- Courts have determined:
  - consumers do have a reasonable expectation of privacy in PERSONAL information under some circumstances
- What counts as:
  - a “computer”?
  - adequate access control?

California Auto-DR Pilot: Peak Savings in Response to Critical Peak Pricing



- **Average reduction was 14% during 3 hour peak period**
- **Technology performed well: continued use during heat wave**
- **Average costs (set-up; labor/hardware) was $60/kW**

❻ Regulators

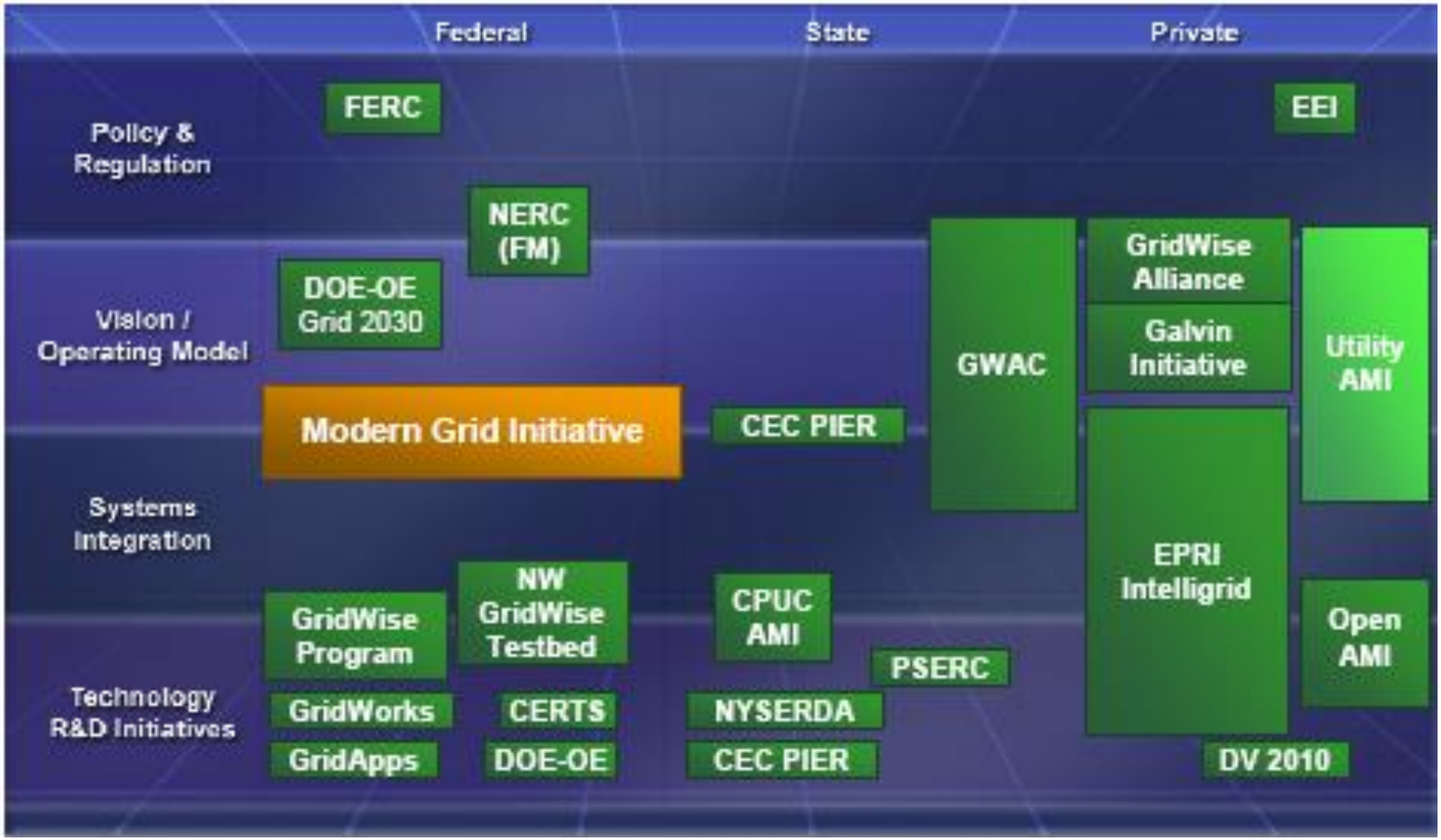
Federal Energy Regulatory Commission

- FERC identified demand-response trends
  - Increased participation in programs
  - Increased role for demand resources in RTO/ISO markets
  - More attention to the development of a smart grid
  - More interest in multistate and state-federal working groups
  - More reliance in state plans and utility strategic plans
  - Increased activity by third-party aggregators

The U.S. Department of Energy (DOE)

- DOE has sought more planning and funding for demand response
- Funding Advances
  - Energy Independence and Security Act of 2007
  - major funding authorized; no appropriations yet
- Planning advances
  - EPACT surveys and state analyses
  - The Modern Grid Initiative
  - coordinating government agencies

Developers of The Modern Grid



Source: Steve Pullins, 2006

Modern Grid: Communications & Components

- Integrated communications
  - high-speed, fully integrated, two-way communication technologies for real-time information and power exchange
  - an open architecture enabling a plug-and-play environment
  - secure networks, grid components and operators
- Advanced components
  - power system devices applying the latest research in materials, superconductivity, energy storage, power electronics, and microelectronics

Modern Grid: Control, Sensing, and Interfaces

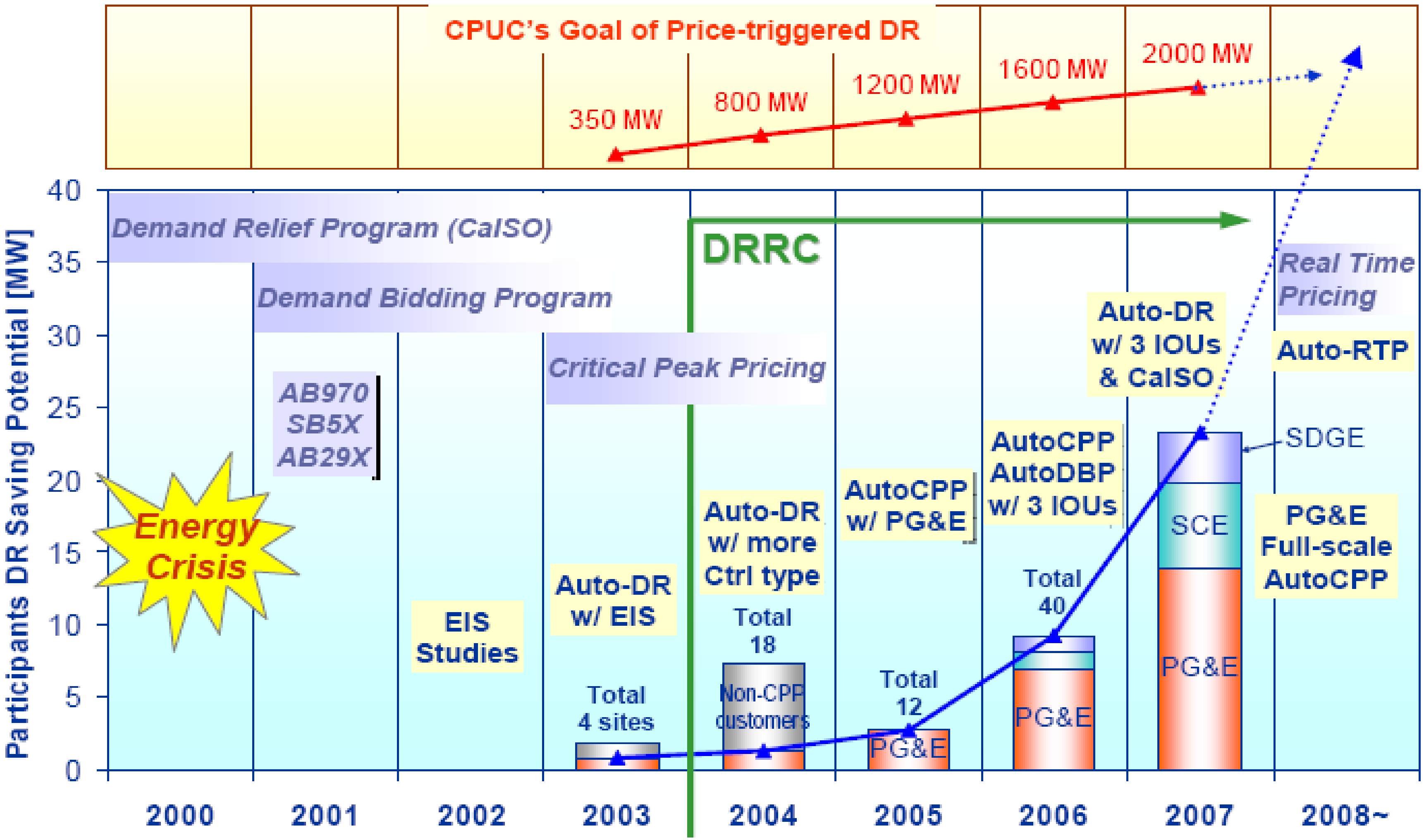
- Advanced Control Methods
  - new power system monitoring methods and algorithms
  - rapid diagnosis and timely, appropriate event response
  - market pricing and enhanced asset management
- Sensing & Measurement
  - improved power system and data management
  - diagnostics for grid integrity and advanced protective relaying, enabling demand response, and congestion relief

State Regulators

- Great variation in enthusiasm
  - – California wants all the demand response money can buy
  - – Oregon wants the demand response money should buy
  - – Other states range from ignorance to advocacy

- Shared recognition of potential
  - – economic efficiency (e.g., of industry) can be improved
  - – the 500 GW of non-baseload power plants have an

Automated DR Experiment in CA



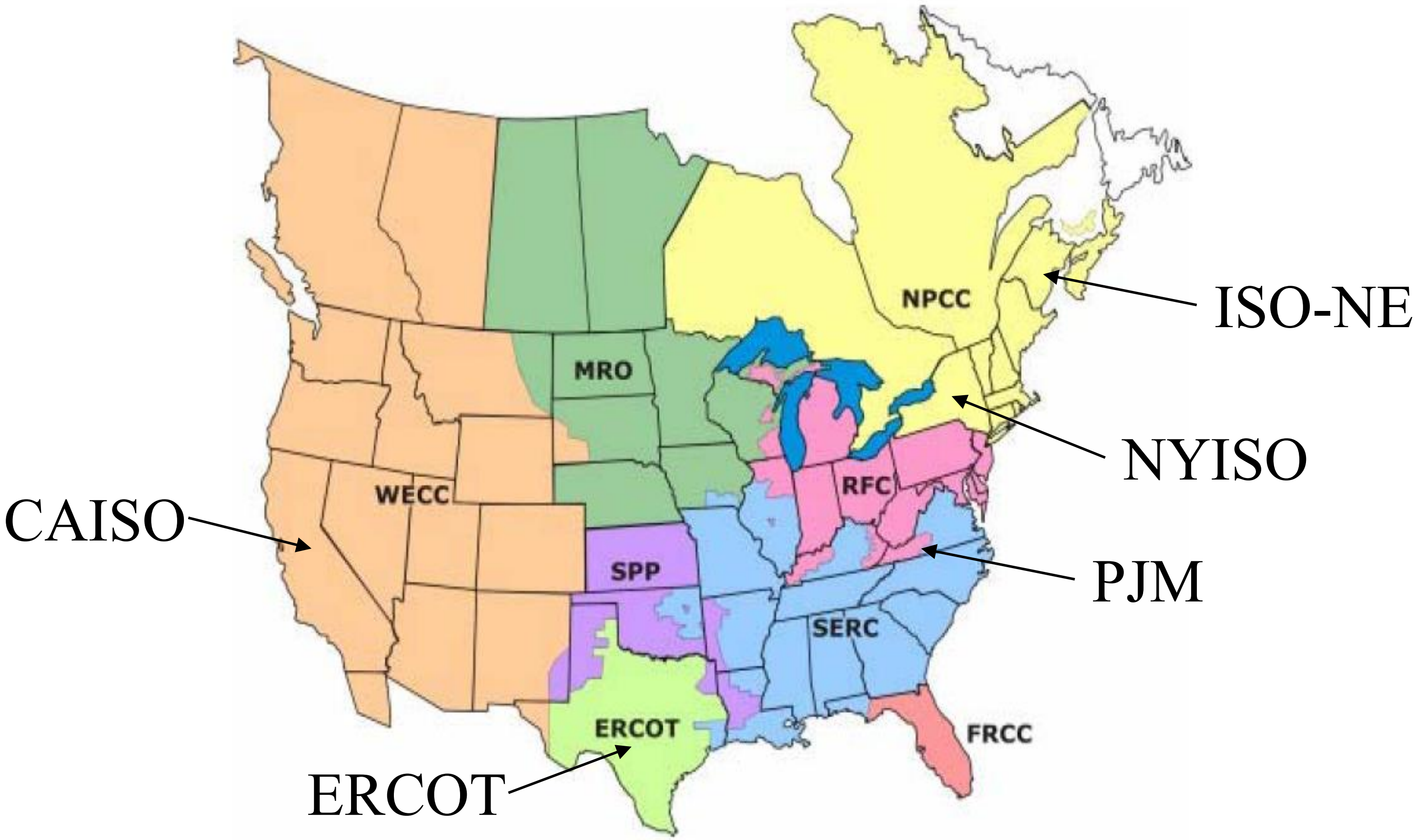
Source: Statewide Auto-DR Planning Meeting, November 13, 2006 presentation by Demand Response Research Center

Regulators and ISOs

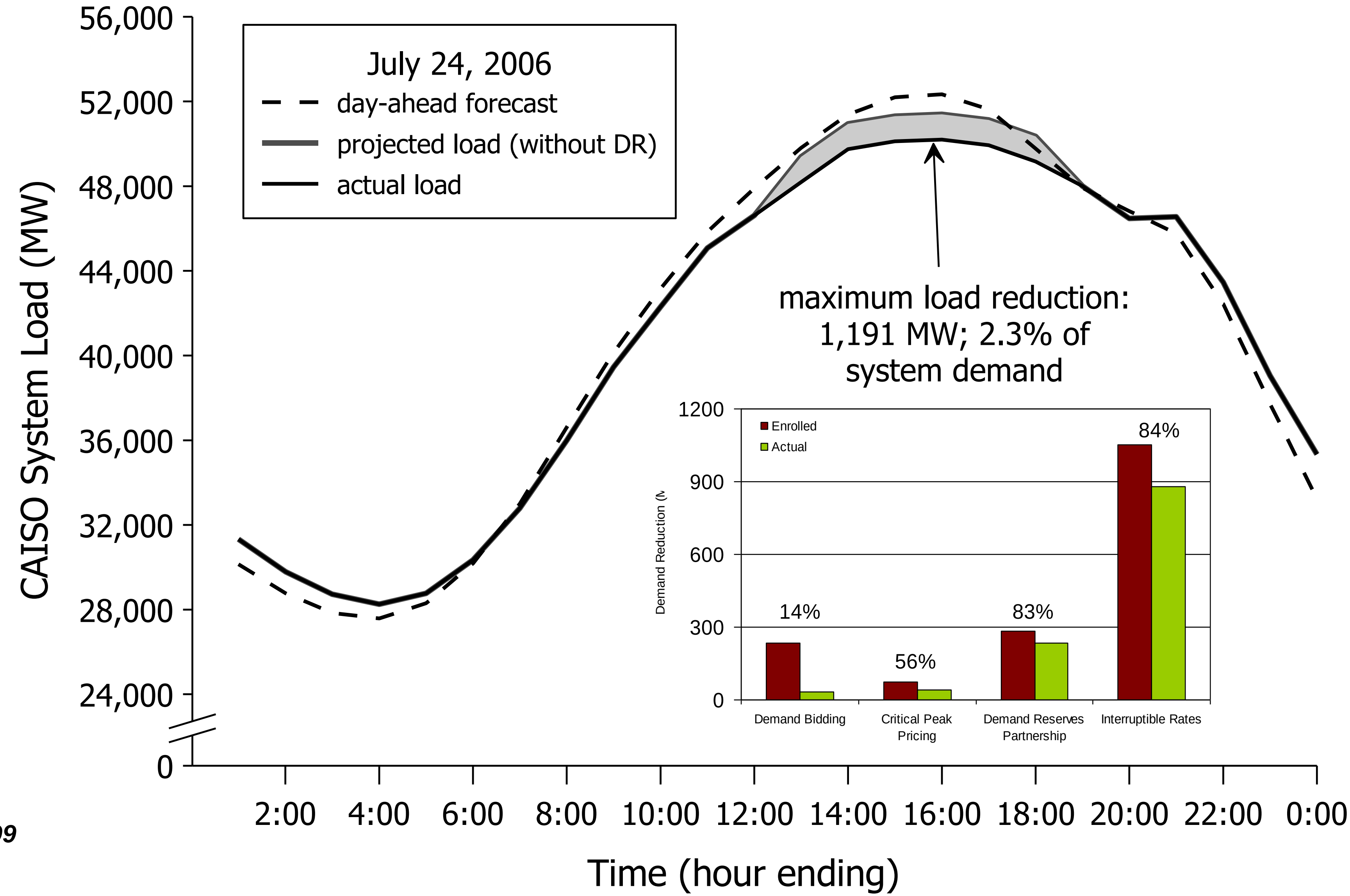
- From a utility resource perspective, ISOs function as regulators and rivals
- ISOs and utilities say demand response has "matured" substantially as a resource since 2001
  - Demand response offsetting "planning reserve" requirements
  - More utility resource plans including demand response (e.g. West)
  - ISO/RTOs allowing demand response resources to participate in capacity and/or reserves markets
- Customers may be migrating from voluntary to capacity-based demand response programs

Source: ***The Summer of 2006: A Milestone in the Ongoing Maturation of Demand Response*** ***The Electricity Journal, Vol. 20, Issue 5, June 2007, Pages 62-75. LBNL-62754. May 2007***

North America Electric Control Regions



Impact of Reliability and Economic DR Programs on CAISO System Load



Performance of Reliability-Based Demand Response Programs

- Reliability-based programs performed well
  - Load response as high as 80% of enrolled resources
- Despite back-to-back events, few customer complaints
- Execution of load reductions was smooth
- Several ISOs/RTOs could confirm DR impacts in real-time
  - Performance varied by zone

“Reliability-based” demand-response programs refer to programs that are activated during system emergencies or to maintain local or system reliability. Reliability-based demand-response programs typically include emergency demand-response programs, capacity market programs, direct load control, interruptible/curtailable rates, and ancillary-services market programs.

Snapshot of 2006

- Summer 2006 was a long-tail season
  - heat storms set new temperature and electrical peak demand records across the country
  - ISOs/RTOs and utilities used demand response resources to maintain electric system reliability and mitigate high prices
- Demand response helped RTO/ISO regions
  - those regions with organized wholesale markets lowered peak-day system peaks between <u>1.4 and 4.1</u> percent

Major Demand Response Events: 2006

Region	ISO/RTO	ISO/RTO Emergency Events	Utility Program Events
Northwest	——	——	•Several utilities[1] activated their DR programs on July 24
California	CAISO	•Stage 2 Alert: July 24	•PG&E: 20 days in June, July & Aug •SCE: 24 days in June, July & Aug •SDG&E: 12 days in June, July & Aug
Midwest	MISO	•Energy Emergency Alert 2: Aug 2 •Energy Emergency Alert 1: 3 days	•ComEd: July 31; Aug 1, 2 •Duke: 4-6 events in different states •EON: 11 events •KCP&L: July 17, 19, 20, 31; August 1, 2, 9, 10
Texas	ERCOT	•No events in mid-summer •DR events called due to generation outage (Apr 17) and frequency aberration (Oct 3)	——
New England	ISO-NE	•Region-wide event: Aug 1, 2 •Local event: June 19	——
New York	NYISO	•Zonal events: July 18, 19; Aug 1, 2, 3	•ConEd: July 17
Mid-Atlantic	PJM	•Zonal events: Aug 2, 3	•PSE&G: 5 events
Southeast	——	——	•Duke: 1 event in the Carolinas •Gulf Power: 2-3 CPP events

Utility Demand Response Programs: 2006

Region	Direct Load Control	Large Customer Reliability Programs	Large Customer Economic Programs	Dynamic Pricing
Northwest	✓	✓	✓	
California	✓	✓	✓	✓
Midwest	✓	✓	✓	✓
Texas[1]				
New England	✓			✓
New York	✓			✓
Mid-Atlantic	✓			✓
Southeast	✓	✓		✓

[1] Texas did not participate in the survey

ISO/RTO DR Programs in 2006

ISO/RTO	Economic Programs	Reliability Programs
CAISO	——	•Voluntary Load Reduction Program
ERCOT	•Balancing Up Load (BUL)	•Load Acting as a Resource (LaaR)— non-spin & responsive reserves*
ISO-NE	•Real-Time Price Response (RTPR) •Day-Ahead Load Response (DALR)	•Real-Time 30-minute Demand Response •Real-Time 2-hour Demand Response •Real-Time Profiled Response •Demand Response Reserves Pilot*
NYISO	•Day-Ahead Demand Response Program (DADRP)	•Emergency Demand Response Program (EDRP) •Installed Capacity/Special Case Resources (ICAP/SCR)
PJM	•Economic Load Response Program: Real-Time (RT) •Economic Load Response Program: Day-Ahead (DA)	•Emergency Load Response Program: (Energy-only) •Full Emergency Load Response Program •Synchronized Reserve and Regulation Markets*

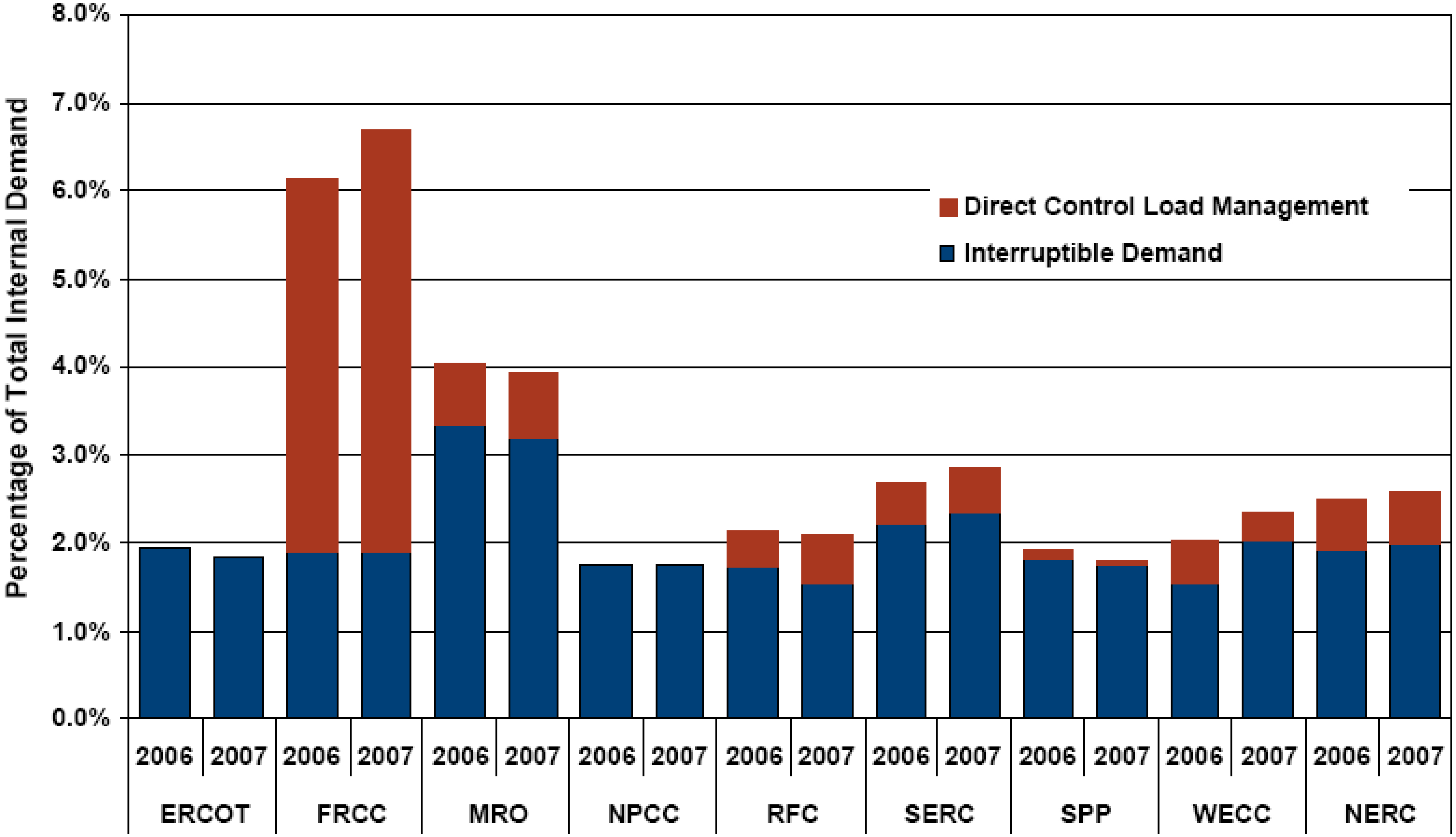
Economic DR Program Activity-2006

Program	Enrollment		Energy Impacts (Jan–Aug)		Maximum Capacity Impacts	
	Assets/ Resources[1]	Load (MW)	Load Reductions (MWHr)	Energy Payments ($1,000)	Load Reduction (MW)	Date/Time
ISO-NE Real-Time Price Response	572	168	19,952	2,863	116	Aug 2/5-6pm
NYISO Day-Ahead Demand Response	19	389	3,479	120	——	——
PJM Economic Load Response Program: Day-Ahead	276	1,195	13,353	905	50	Aug 1/ 8-9pm
PJM Economic Load Response Program: Real-Time	——	——	79,460	8,344	463	Aug 1/ 5-6pm
CA Utilities' Demand Bidding	2048[2]	274[2]	4,684[3]	880	52	July 25

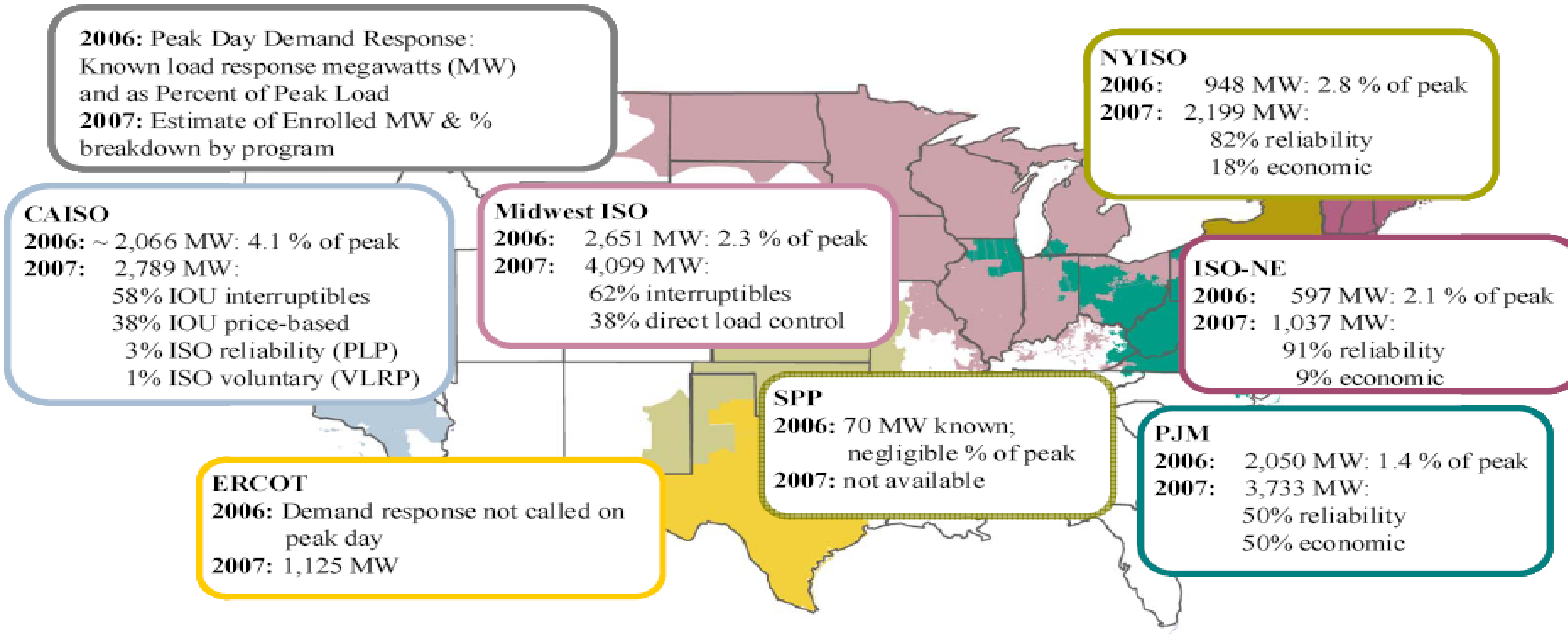
Source:

The Summer of 2006: A Milestone in the Ongoing Maturation of Demand Response The Electricity Journal, Vol. 20, Issue 5, June 2007, Pages 62-75. LBNL-62754. May 2007

Demand Response Availability by Region



2006 DR Contributions, 2007 Enrollments



The Gap Between Potential and Reality

- Less than half of demand response's potential is realized
- 2004: 20,500 MW of peak load reduction was available
- 2004: 8,976 MW of actual peak load reduction delivered

❼ The Business Case

Commitment: the Role of a Business Case

- Will Power Operations believe you're ready?
- Does Customer Service believe they're ready?
- Does Rates & Regulatory Affairs believe it's necessary?

- Does Resource Planning believe it's

Power Operations Concerns

- Q: Will demand response show up?
  - A one-day mistake in peak-load resource planning or execution can cost more than $1 million
  - Demand response is unproven, and statistics don't prove it
  - Customers are uncontrollable
  - Demand response is unpredictable and unsustainable
- A: Yes, demand response is reliable
  - demand response potential can be forecast reliably for different hours, days, seasons, and weather

Customer Service Concerns

- Q: Will demand response be overwhelming?
  - program inquiries, enrollment tracking, fulfillment status
  - CIS Modifications to support bill impacts
  - education to support calls during events
  - billing changes
  - broken appliances… but not
  - Dis-enroll requests

- A: No, but it will be a big job
  - infrastructure modifications before start up

Rates and Regulatory Affairs

- Q: Do we have to?
  - nature abhors a vacuum; this department abhors change
  - new rate designed and documented
  - Prudence demonstrated
  - interveners and regulatory staff convinced
  - lost revenue from reduced energy use, shifting prices, uncertain customer acceptance

- A: Yes, the alternative is familiar but worse

Resource Planning Concerns

- Q: Is demand response a prudent resource?
  - business case and resource plans need to match
  - unfamiliar technology with unusual development and operating requirements
  - long-standing assumptions and plans change
  - demand response models distinctively (e.g., risk, capacity value)

»

- A: Yes, once mastered, demand response is prudent and flexible

  - real-time spot resource reduces pressure elsewhere in

Public Affairs Concerns

- Q: Can we sell it?
  - demand response is mostly economic value
  - involvement in electricity as a product has been rising as rates increase and global warming becomes a concern
  - some customers value social good, green, control values
  - interveners often have different values
  - understanding the tradeoffs with peaker plant alternatives is a challenge

Finance Concerns

- Q: is demand response valuable and safe?
  - estimating the value of demand response involves new technology, vendors, operations, and maintenance
  - estimates vary for customer support, event strategies, education, customer turnover
  - estimating risks and learning curves (especially of timing) is difficult
  - benefits and costs are diffuse across the organization

- Yes, but it takes some proving

Learning Objectives for th
Business Case

- Design decisions
  - utility objectives
  - regulatory objectives
- System modeling
  - operations
  - financial
- Approval process
  - utility
  - regulators

A Typical Approach

- Create the business proposition
  - understand the loads that need to be shifted (resources)
  - target customers, and understand their load shift potential
  - examine similar programs in other utilities
  - estimate costs and benefits with vendors and consultants
  - discuss the value of capacity with regulators

- Establish the business case

A Typical Utility Timeline of What's Next

- Internal Business Case approval: months 1-6
  - Risk Mitigation, Implementation, Communication Plans
- RFP process: months 4-10
  - drafting, vendor briefing and responses, evaluation
- Vendor negotiations: months 10-16
  - exploration of alternatives, Business Case revisions
- Regulatory approval: months 12-18
  - Coordination with other filings (e.g., rate cases)
- Program development and testing: months 14-24
  - customer research, preparation of marketing materials
  - vendor and internal IT development and integration
  - system acceptance testing

Business Case:
Key Elements

- Market: attractive and available
- Offering: feasible and beneficial
- Organization: rapid and reliable
- Strategy: practical and successful
- Economics: worth the effort and risks

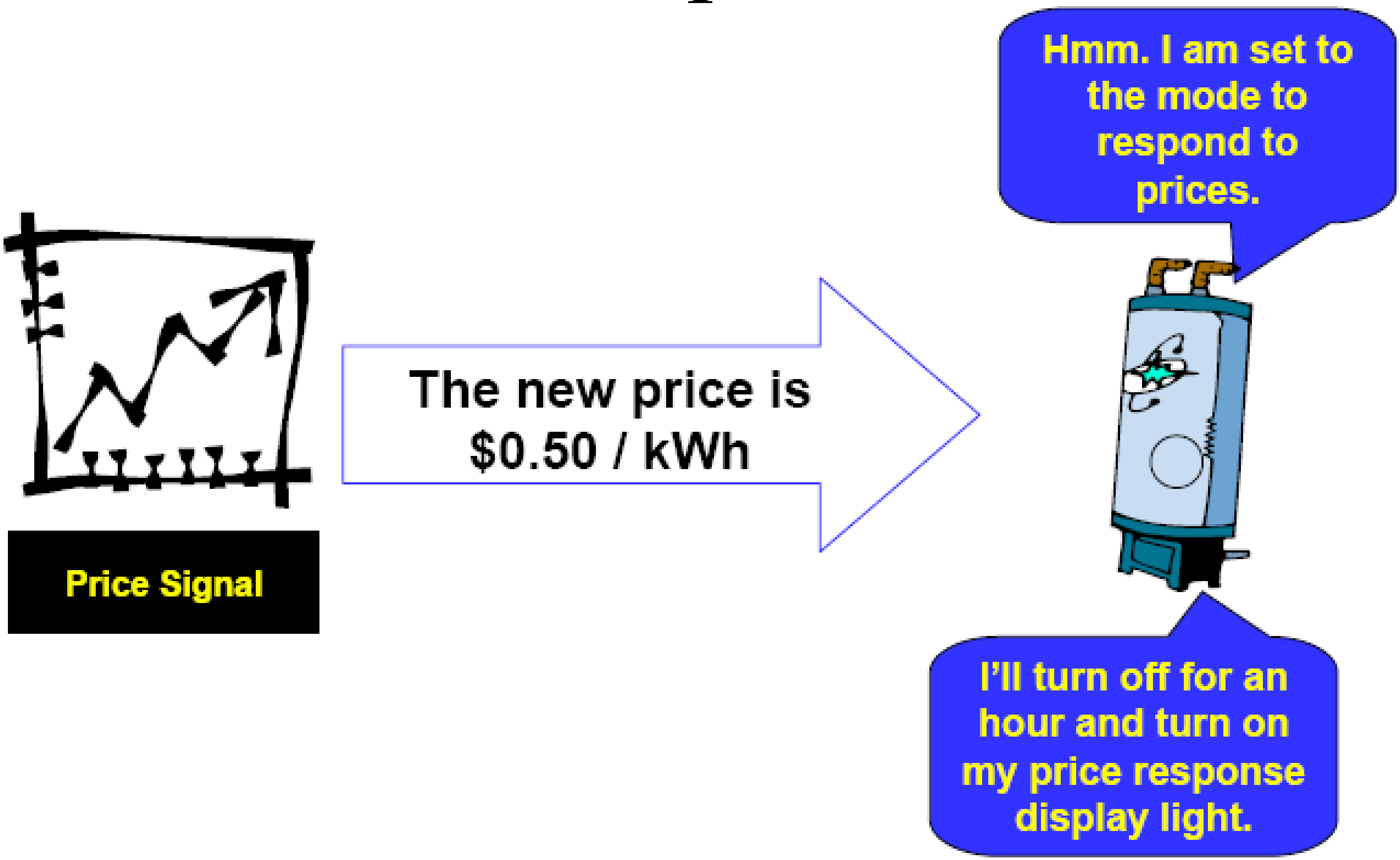
Business Case: Key Elements

- Market: the customer model
- Offering: build or buy
- Organization: allocating work, risk, and benefits
- Strategy: events
- Economics: the financial model

Market: Specifying Demand Response

- Individual loads provided
  - size
  - ease of control
  - importance of the load to the business
  - devices/systems subject to curtailment
- Total load reduction
  - total load available for curtailment
  - target load to be reduced

Market: The Customer's Perspective



Market: Modeling the Customers

- Hours of potential curtailment
- Hours of likely curtailment
- Loads controlled per premise
- Energy curtailed
- Energy shifted
- Customer acceptance rate

- Customer turnover rate

Offering: Design Elements

- Baseline requirements from billing, generation, and regulators
- AMI device choice for Measurement and Verification (handheld, drive-by, wired, wireless)
- DR device choice (appliance switches, thermostats, equipment controls, energy displays)

- Information Systems: communications, rates

Offering: Build or Buy

- Buy approach assigns responsibilities for:
  - customer install hassles
  - maintenance and turnover management
  - scheduling install contractor
  - building a fulfillment application
  - types include Pay for Performance, Third-Party Turnkey

- Build approach:
  - retains greater value for utility/customers
  - offers investment opportunity

Offering: Experience With Buying

- Growing roles for vendors
  - aggregators and Curtailment Service Providers (CSPs)
  - direct participation in ISO/RTO markets (focused on programs with capacity/reservation payments)
  - CSPs account for ~90% of the enrolled customers (~75% of the load) in NYISO's ICAP/SCR market
  - contractor providing demand response resources to utilities (outsourcing)

- Vendors as high-fliers

Offering: Experience With Buying

- Aggregators
  - development of operational capabilities
  - deployment of resources in multiple locations
  - innovative program models
  - partnerships with utilities
  - growing pains

- Retailers
  - see demand response as a way to manage price and volume risk
  - concerned about regulatory future

Offering: Pricing

- Utilities have the scale and scope to diversify and hedge load and risk
- Money doesn't substitute for electricity
- Peak demand can be limited by peak pricing (rush hour rates)
- Predictable limits require customer learning, especially of routines

Offering: Customers and Pricing

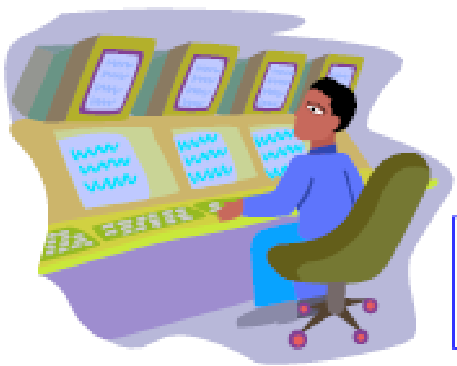
- Customers want the freedom to set routines, few ask for marginal pricing
- Information drives customer load shifting -- demand is price-inelastic
- Variability does not involve risk (e.g., quality, availability, price, timing); volatility does
- Learning and decision-making are risky activities absorbing time and

Offering: Approval and Testing

- Black boxes are usually empty
- Neither a pilot nor a trial is a system acceptance test
- It’s always different in the field
- Demonstration isn’t reliability,
  - which isn’t scalability
  - which isn’t affordability

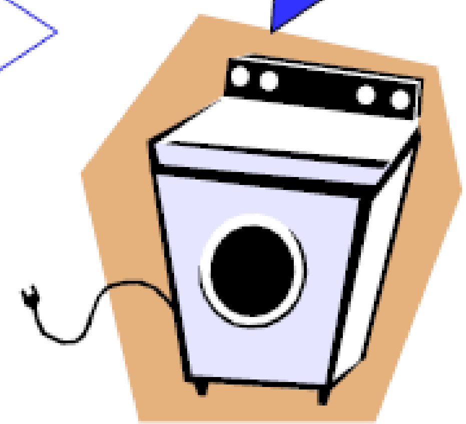
- Customer routines will differ

Organization: the Real-Time Perspective



Can you shed load now?

Sure thing.
I can help by shedding 4.5 kW!



Utility System Operator

But Coincident Peak is What Matters: Dryer 0.2 kW
Got Load Research?

Organization: Primary Benefits

- Improved system reliability
  - enabled by transient, on-call reduction in peak demand
  - reduced electricity costs from reduced production and purchasing during peak periods
  - avoided capacity purchases up to $60 per kW-yr
- Increased customer energy awareness
  - energy efficiency steps
  - energy load-shifting
  - conservation behavior

Organization: Secondary Benefits

- Improved customer/utility relationships
- Improved asset utilization and risk management
  - postponing infrastructure investments
  - avoiding outages
  - optimizing plant utilization
- Reduced environmental impact
  - more efficient electricity generation

Strategy: Events are Individual

- What is the “typical” facilities demand profile during demand response events?

- What is the practical level that facility demand might fall to during an event?

- How would events affect business operations and customer comfort?

Strategy: How Ambitious Are We?

- What are the program's objectives?
- How is demand reduction to be measured?
- Are auxiliary generators an alternative?
- What technologies are we willing to depend upon?

Strategy: The Auto-DR Example

- Can automate ANY demand response program
- Facility managers are notified, but not required for automated sheds to occur
- Defines standard interfaces for many parties to use:
  - Individual sites, multi-site energy managers, aggregators, EMCS companies

Economics: Model Inputs

- Negotiated costs
  - installed cost for control hardware
  - vendor's control applications and computer infrastructure
- Discovered costs
  - customer enrollment model
  - systems acceptance testing
- Rediscovered costs
  - Internal discussions with individual departments

Economics: Model Inputs

- Benefit estimates are acceptable, cost estimates need to be "future facts"

- Recurring cost estimates may be challenging for:
  - communication to control devices to send price signals
  - verification of turnkey provider
  - customer marketing and enrollment
  - program manager and incremental FTEs
  - ongoing Customer Education and Feedback
  - value of capacity
  - avoided energy purchases
  - shifted energy purchases
  - and others…

Economics: Cost of Residential Control

• Communicating Switch or Thermostat	$100 to $150
• Installation Labor	$50 to $125
• Permits	$20
• Marketing $ Per Response	$50
• False Starts (10 to 20%)	$25
– At the door: “I’m sorry we changed our mind.”	
– After discussion with my spouse…. Well, No	
– Appliance Doesn’t Meet Code	
– Buyer Remorse After Install	
• Total per Control Point	$250 to $400

Economics: Historical Value

- 0.7 kW per residential switching event (no device feedback)
- 2.0 kW per residential switching (device feedback)
- $350/MWHr (California 2006)

Economics: Cost/Benefit

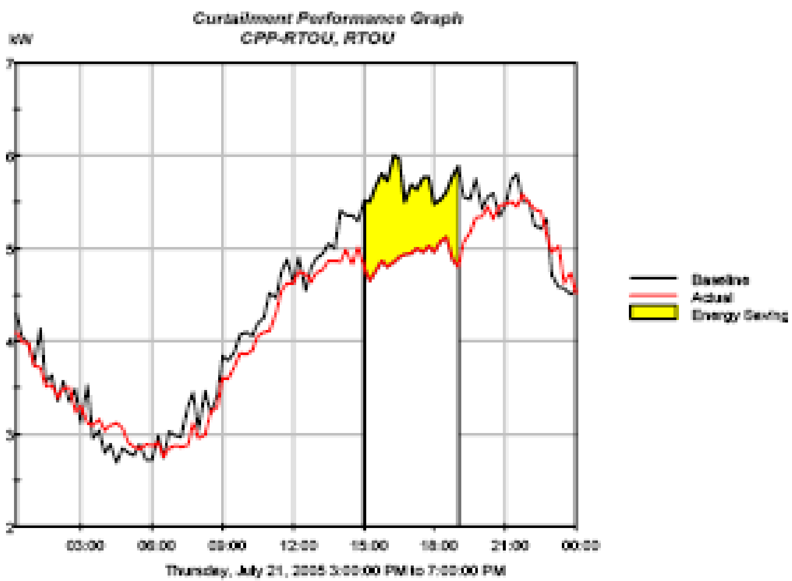
– Traditional approach
  - Standard Practice Model
  - Avoided costs vs. gas-fired peaker plant

– Challenges
  - dispatchable, but not characterized properly
  - controversies regarding capacity, reliability, dispatchability, risk management, consumer surplus
  - No Standard Practices
  - Difficult to measure control and influence

– Allocation of costs and benefits

Economics: an Event at Ameren UE

CPP Event Day
July 21, 2005



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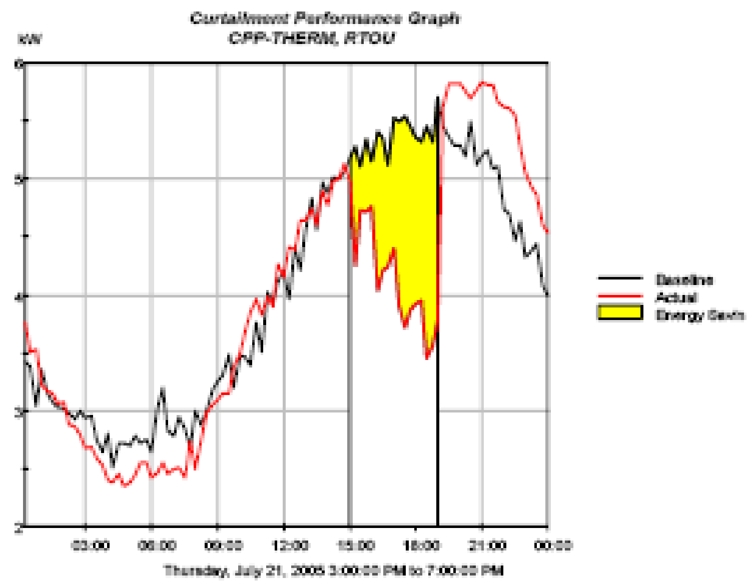

The "CPP Only" group reduced demand by 0.63 kW per participant.
The "CPP W/Smart Thermostat" group reduced demand by 1.36 kW.

Courtesy of Ameren

Questions

Demand Response Challenges

- Resource valuation (ISOs and IRPs)
  - more consistent, standardized methods to verify demand response load impacts
  - Coordination of utilities, ISOs, and the North American Energy Standards Board (NAESB) process
- Facilitating price-responsive demand
  - dynamic pricing tariffs at retail
  - ISO/Utility programs that allow direct bidding of load curtailments into wholesale energy markets
- Technology commercialization and standardization

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