KEY ISSUES AND CHALLENGES IN THE DEEPENING PENETRATION OF DEMAND RESPONSE RESOURCES

presentation by

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OVERVIEW

- We focus on the key developments in the implementation of demand response resources or *DRR*s, with special attention to their economic and policy aspects
- We highlight recent demand response challenges in the integration of deepening levels of *DRR* penetration and success stories

OUTLINE

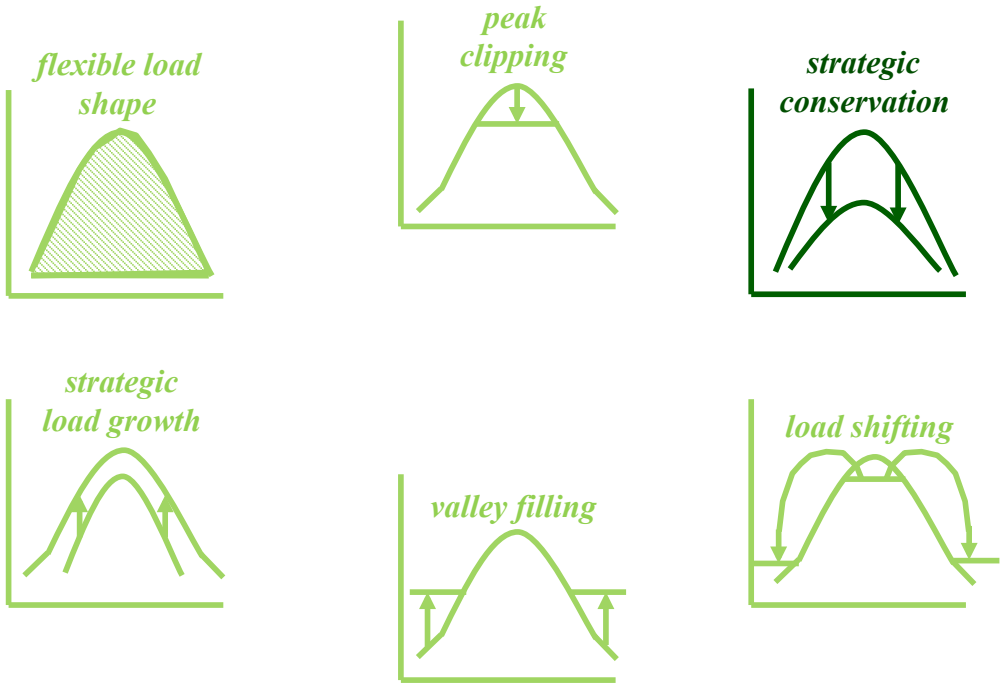
- *DSM*: the predecessor to today's *DRR*s
- Demand response: motivation and capabilities
- Key demand response drivers
- *DRR* challenges and limitations
- *DRR* contributions
- Concluding remarks

FROM DEMAND-SIDE MANAGEMENT TO *DRR*s

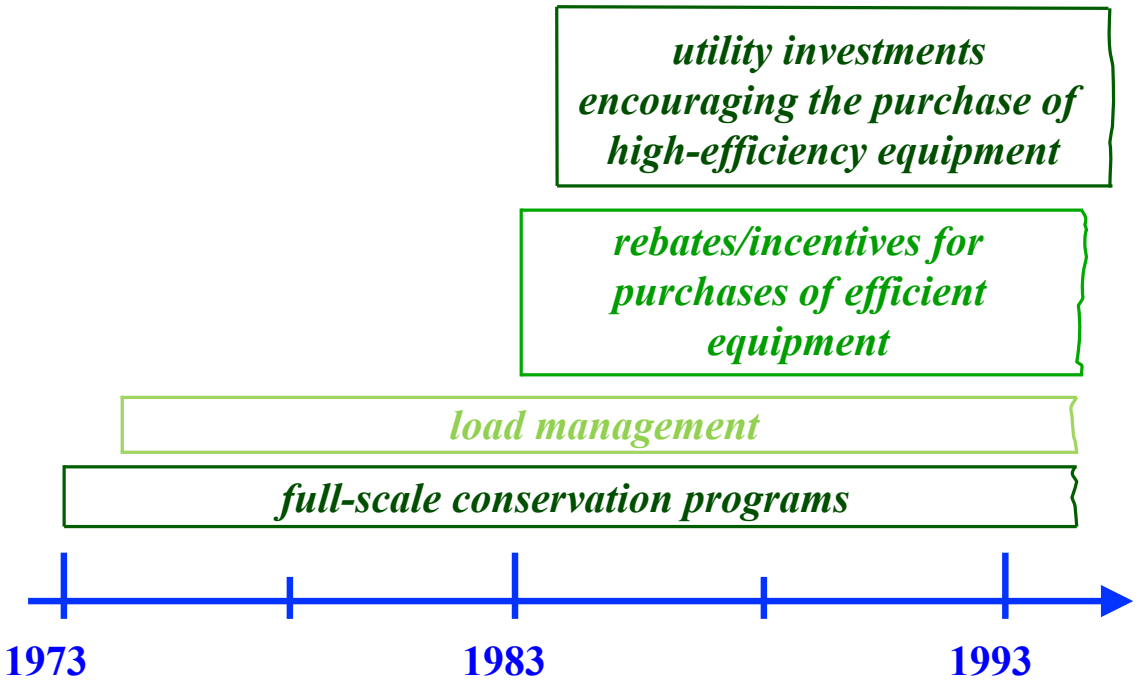
DEMAND-SIDE MANAGEMENT

- In the regulated environment, the term demand-side management (*DSM*) was used to refer to the implementation of programs that modify the demand of the system
- In practical terms, a *DSM* program is any measure that influences load on the *customer side* of the meter
- In analogy to supply-side resources, demand-side resources can be targeted for base, intermediate and peaking applications

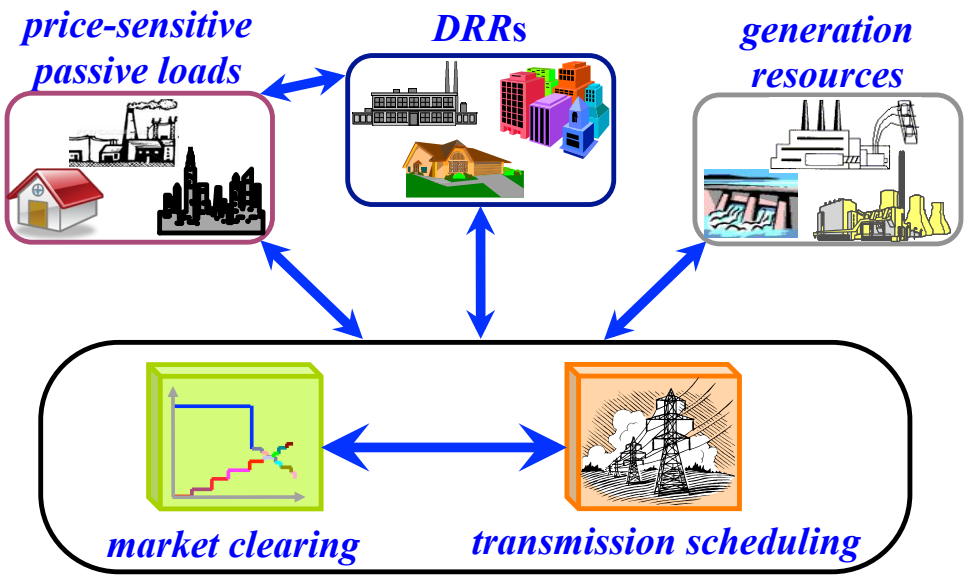
DSM PROGRAMS' LOAD SHAPE OBJECTIVES



EVOLUTION OF *DSM*



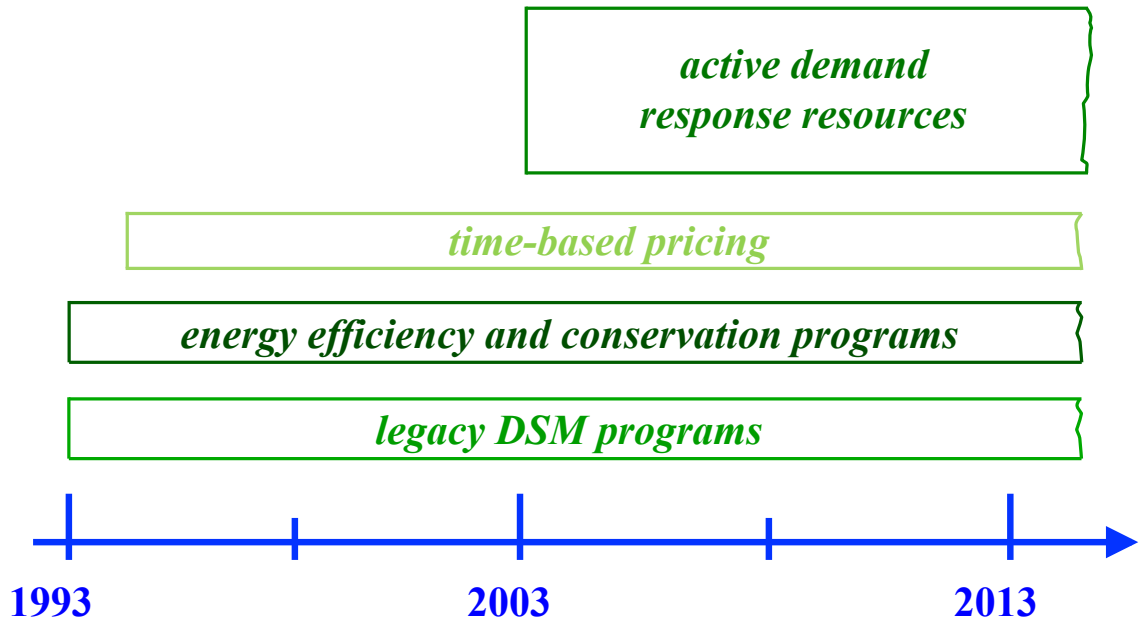
DEMAND RESPONSE RESOURCES (*DRRs*)



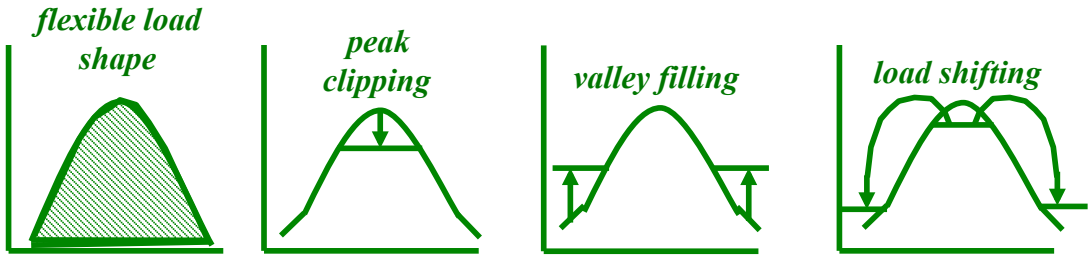
NATURE OF *DRR*

- The objective of *demand response* is to make the load an active participant in balancing electricity supply and demand around the clock via side-by-side competition with supply-side resources
- *DRR*s curtail their loads in response to incentive payments to induce lower electricity consumption at specified times
- *DRR*s are attractive alternatives to supply-side resources to meet the supply-demand balance

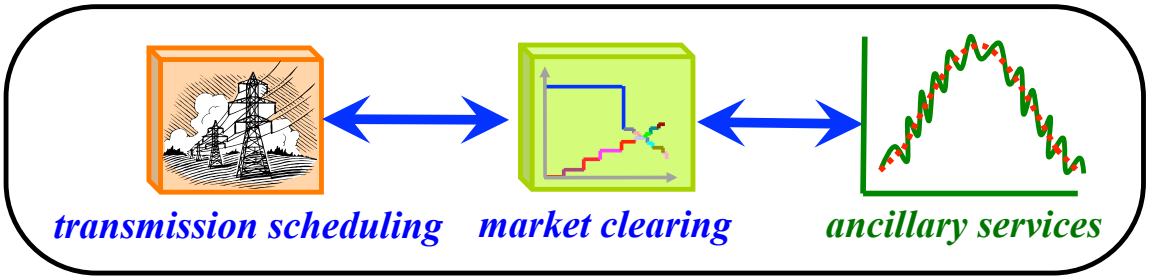
THE TRANSITION TO *DRRs*



DRR ACTIVITIES

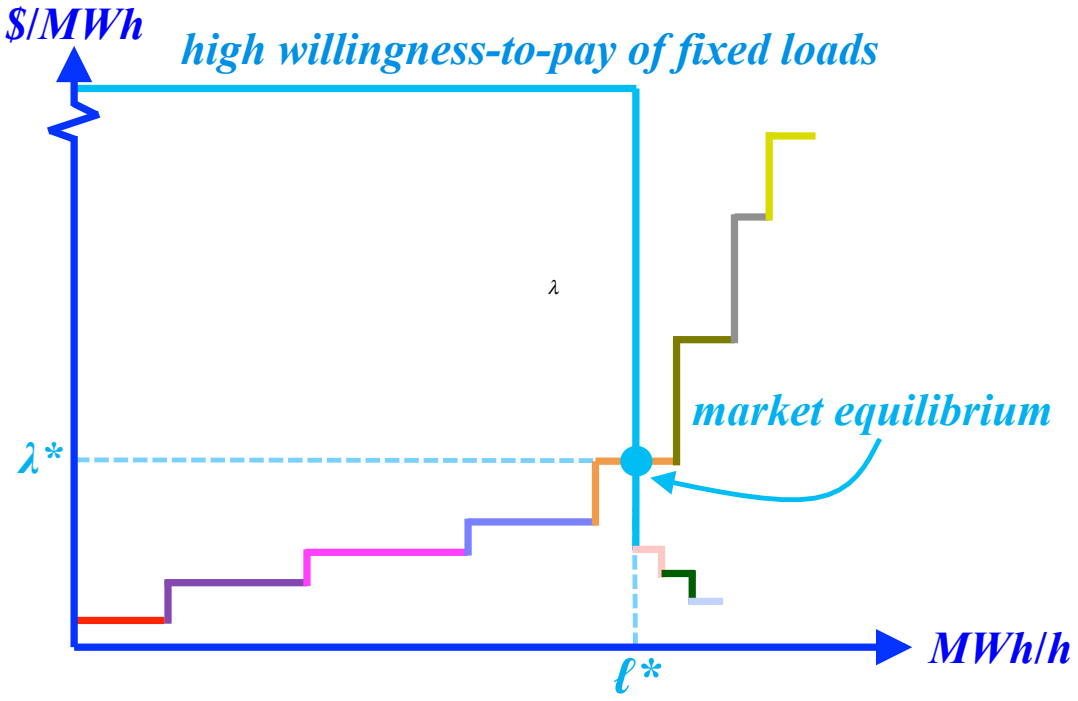


***DRR*s help to balance the supply and demand around the clock and in ancillary service provision**

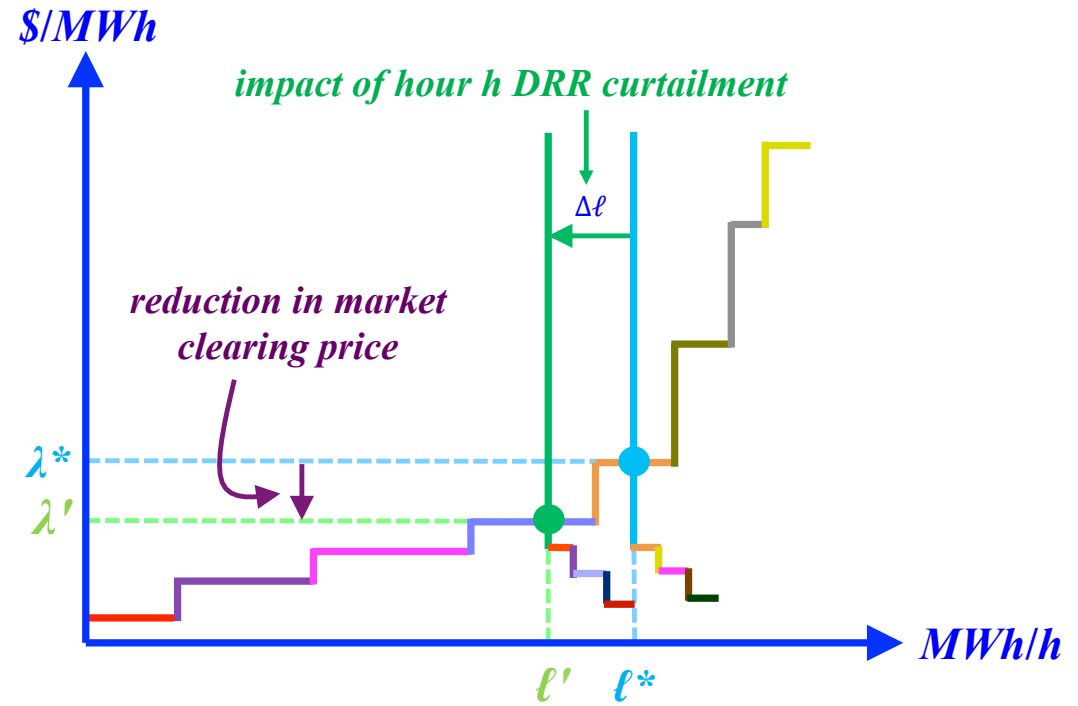


DRR ECONOMICS

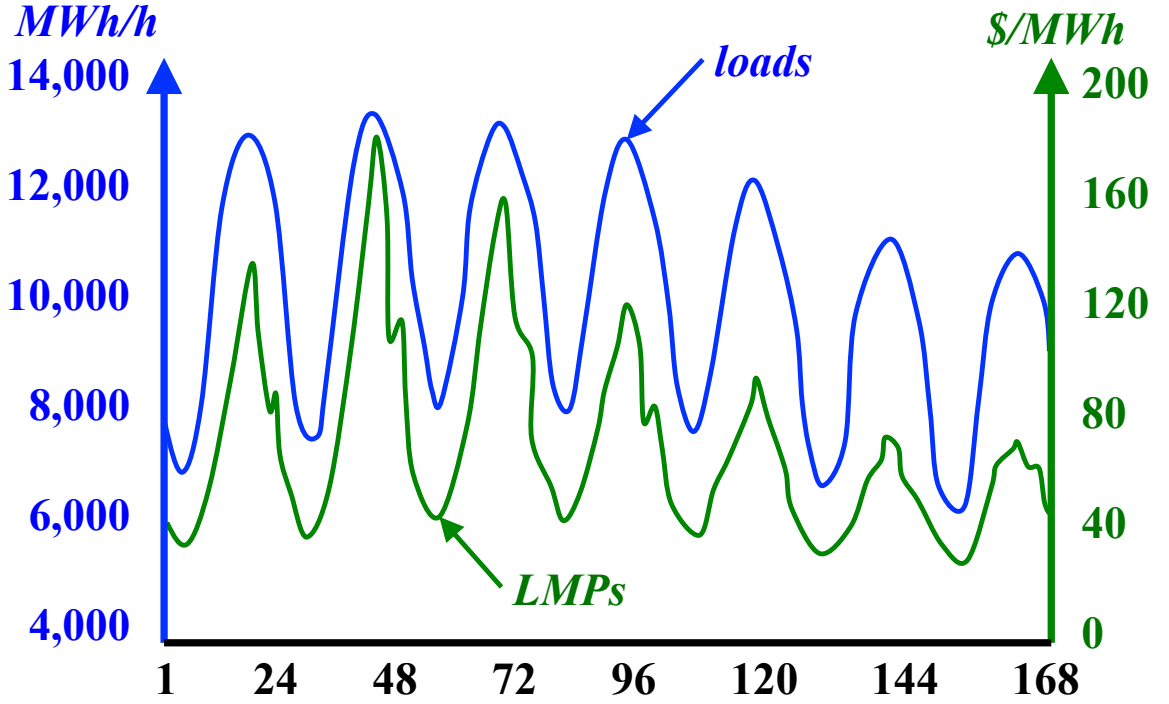
ELECTRICITY MARKET CLEARING



HOUR *h* *DRR* CURTAILMENT MARKET IMPACTS



PJM NODE LOADS AND *LMP*s IN THE WEEK OF AUGUST 9, 2010

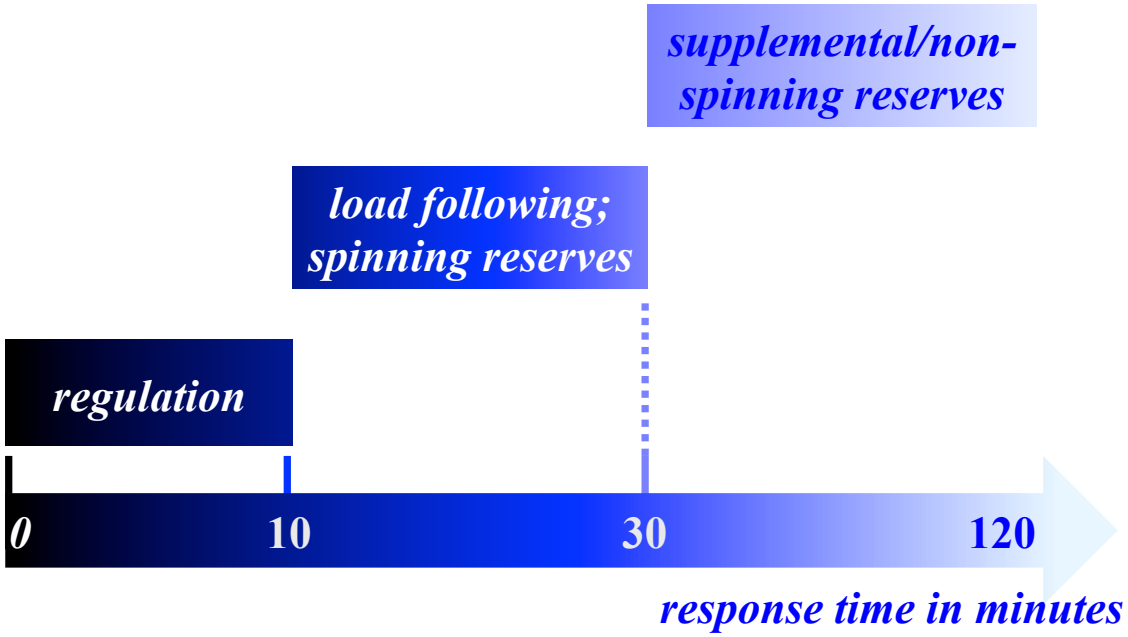


*DRR*s ARE ATTRACTIVE

- *Jon Wellinghoff, Chairman, FERC*: "There are tremendous benefits from demand response at very low costs, costs much lower than we can put any supply in place. This is the first fuel."
- *Jim Rogers, CEO, Duke Energy*: "The most environmentally responsible plant you build is the one that you don't build."

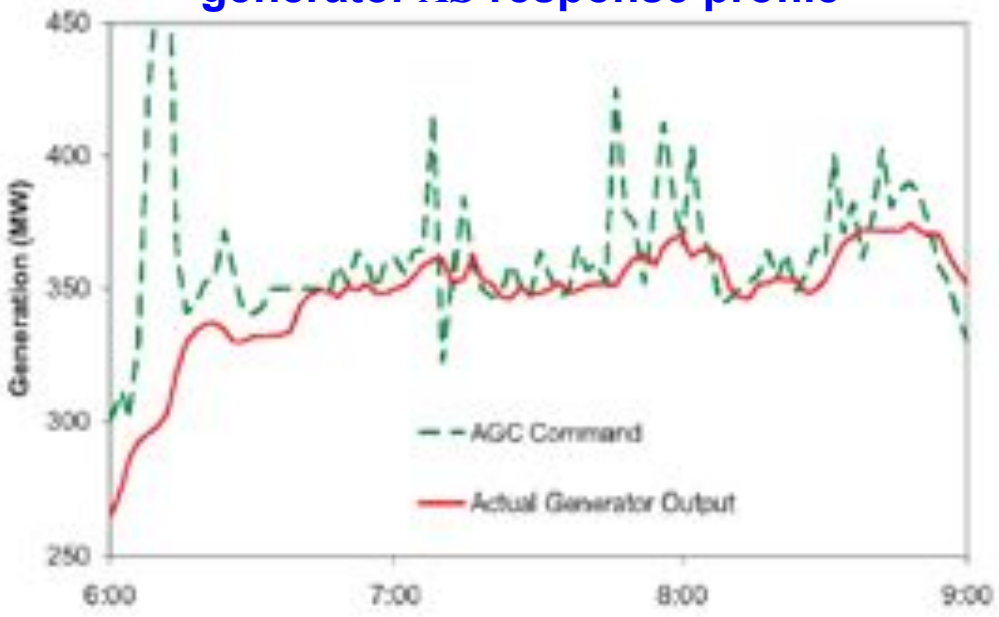
ADDITIONAL *DRR* CAPABILITIES

DRR PROVISION OF CAPACITY-BASED ANCILLARY SERVICES



CONVENTIONAL GENERATION REGULATION ANCILLARY SERVICE

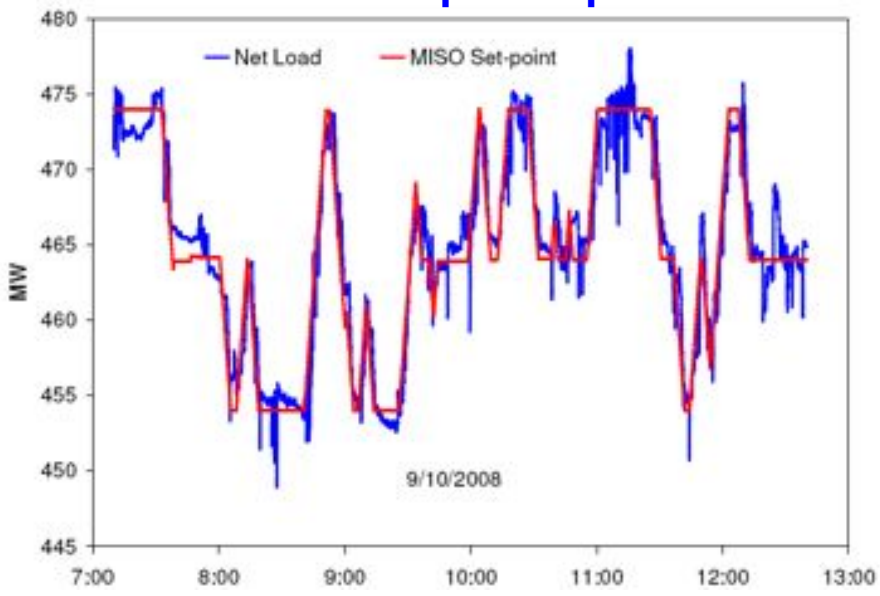
generator *AS* response profile



Source: EnerNOC, "The Potential for Demand Response to Aid in the Integration of Renewable Resources", April 2011

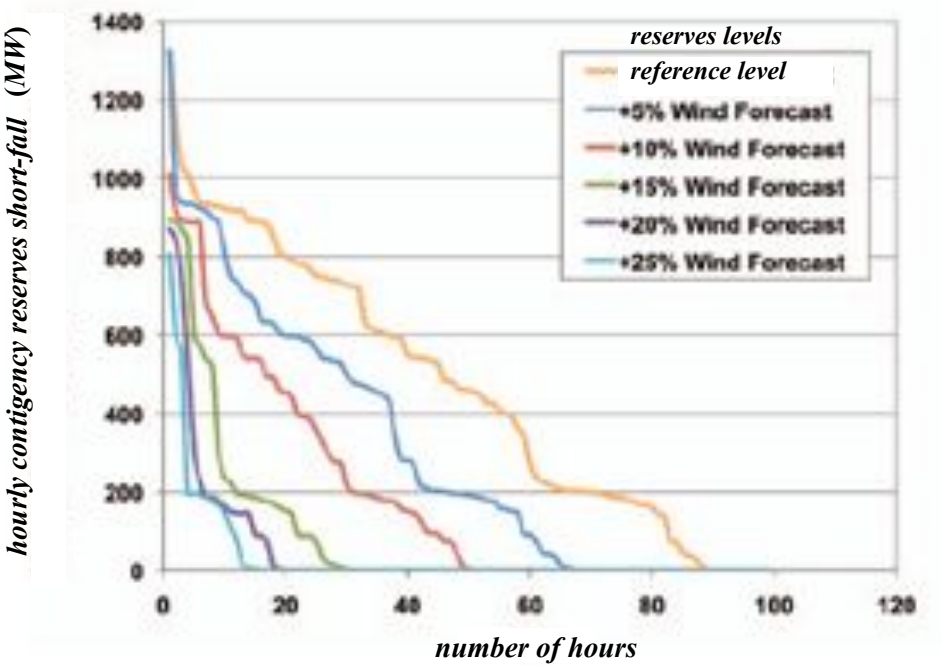
DRR PROVIDED REGULATION SERVICE

DRR AS response profile



Source: EnerNOC, "The Potential for Demand Response to Aid in the Integration of Renewable Resources", April 2011

RESERVES – SHORTFALL DURATION CURVES

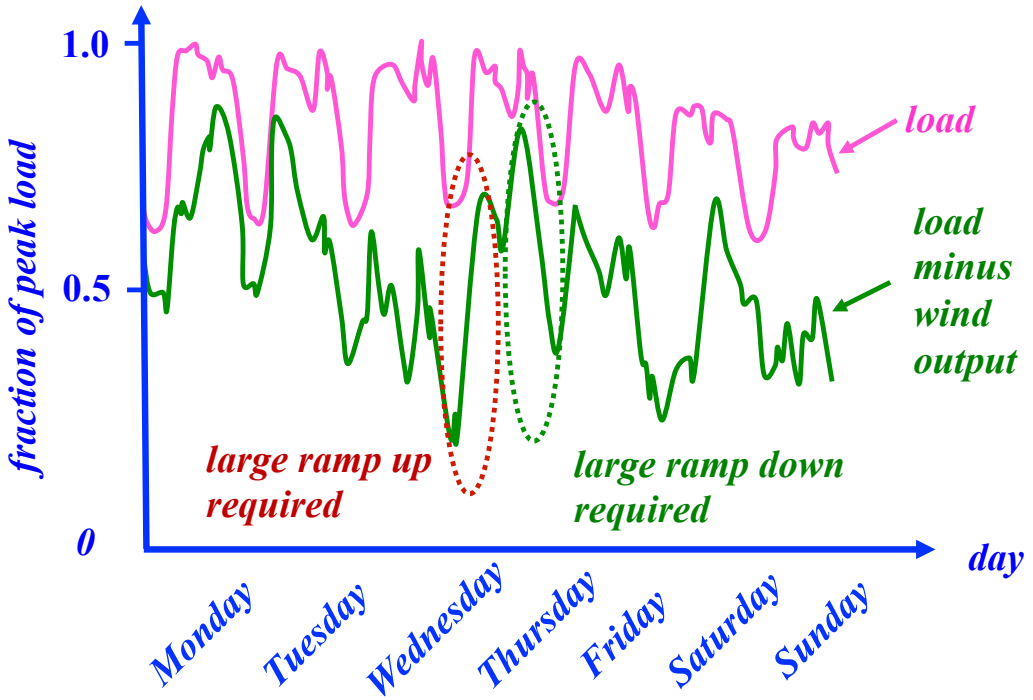


Source: National Renewable Energy Laboratory (NREL) "Western Wind and Solar Integration Study", May 2010

ECONOMIC LOAD PARTICIPATION

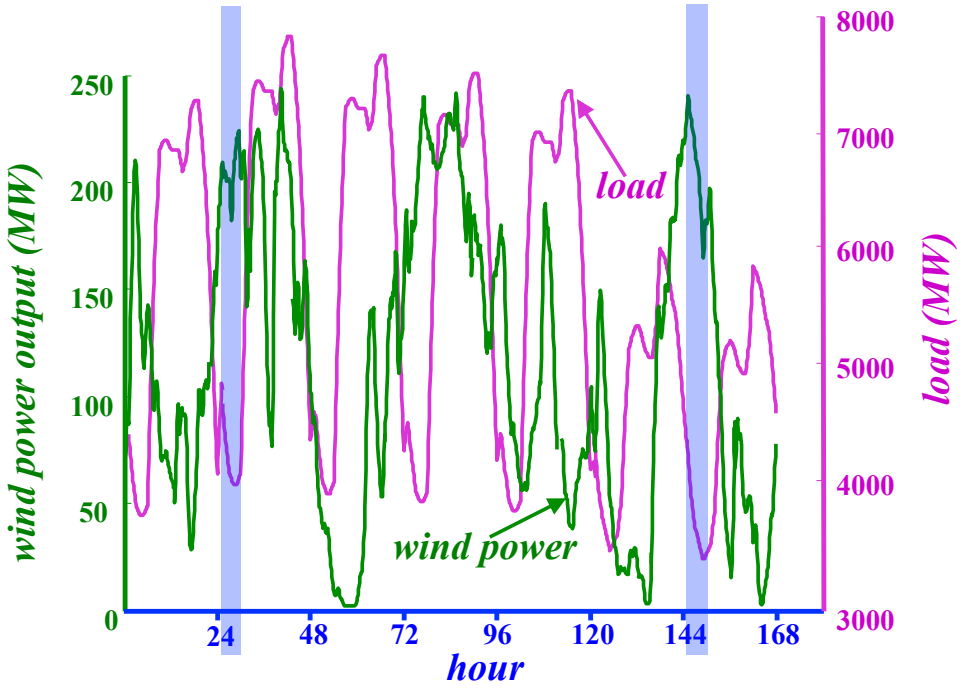
- The *NREL* study investigated the costs of providing additional spinning reserves
  - each additional 5 % increment of committed spinning reserve is increasingly expensive
  - additional spinning reserves can reduce but not eliminate contingency shortfalls
- Demand response is considerably more economic than spinning reserves and can result in major savings as it is more cost-effective to have *DRR*s address the hours of contingency reserves short-falls rather than increase reserves for 8,760 hours

*DRR*s FOR DEEP WIND PENETRATION INTEGRATED INTO THE GRID



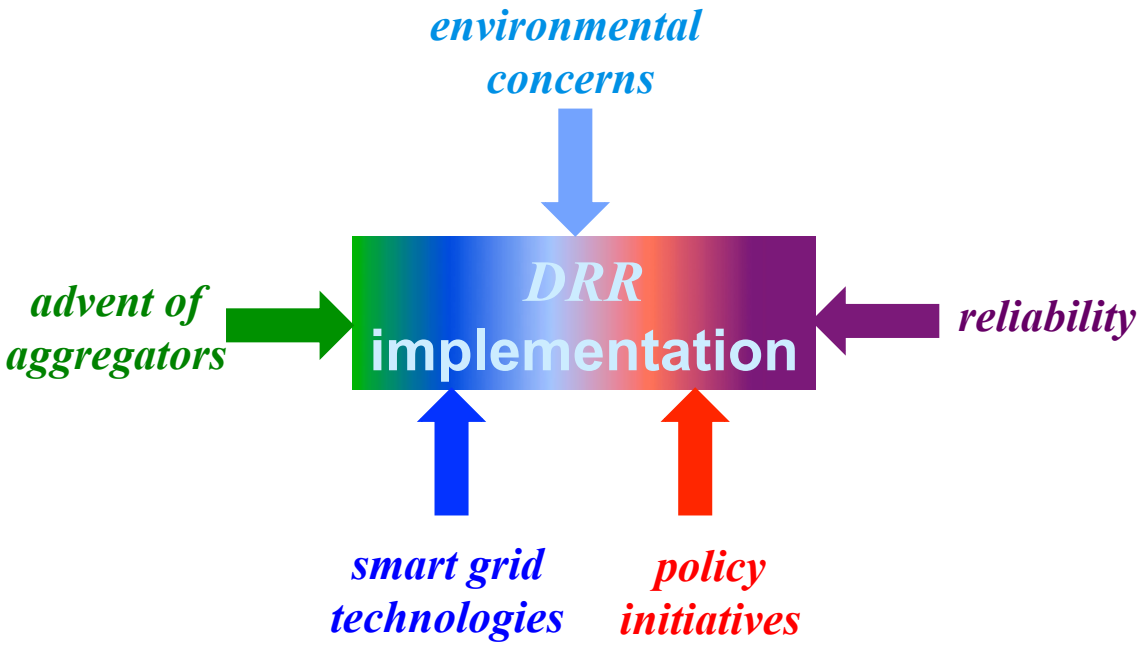
Adapted from: M. Lange & U. Focken, "Physical Approach to Short-Term Wind Power Prediction", Springer, 2006

MISALIGNMENT OF WIND OUTPUT AND LOAD: *DRR* OPPORTUNITIES



DEEPENING *DRR* PENETRATION

DRR IMPLEMENTATION DRIVERS



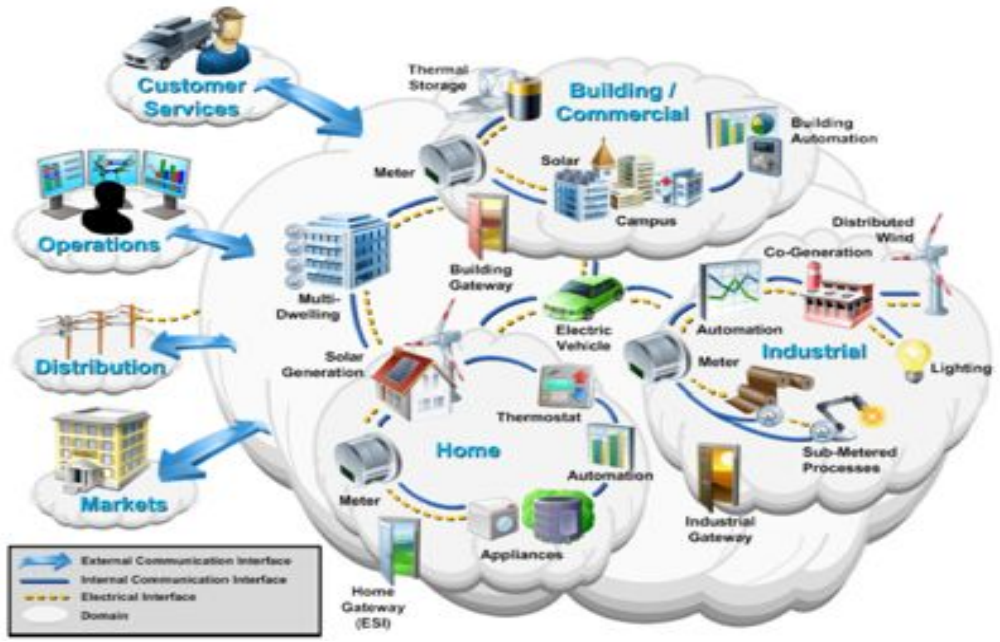
THE SMART GRID

The smart grid represents a modernized electricity delivery system that monitors, protects and automatically optimizes the operation of all its interconnected elements – from the central and distributed generator, through the high-voltage transmission grid and the distribution network to industrial users and building automation systems, to energy storage devices and to end-use consumers and their thermostats, electric vehicles, appliances and other devices.

THREE SALIENT ASPECTS

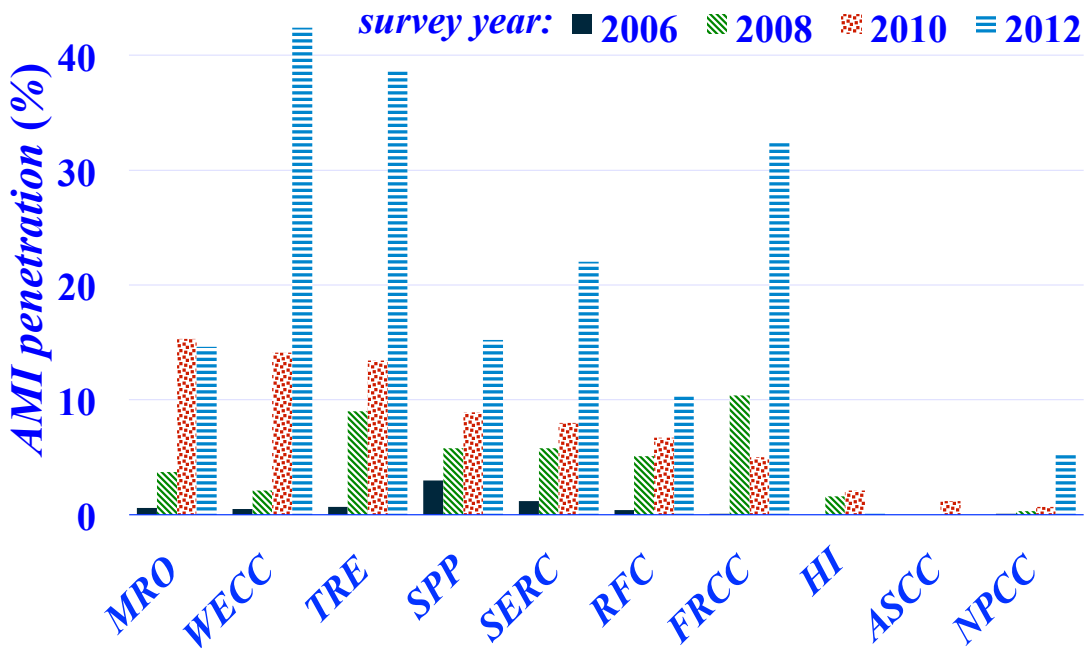
- Combined digital intelligence and real-time communications: to improve the operations/control of the transmission and distribution grids
- Advanced metering solutions: to replace the legacy metering infrastructure
- Deployment of appropriate technologies, devices, and services: to access and leverage energy usage information in smart appliances and in the integration of renewable energy

CUSTOMERS AND THE SMART GRID



Source: NIST Framework and Roadmap for Smart Grid Interoperability , http://www.sae.org/smartgrid/nist_smartgrid_interoperability.pdf

ADVANCED METERING INFRASTRUCTURE (*AMI*) EVOLUTION

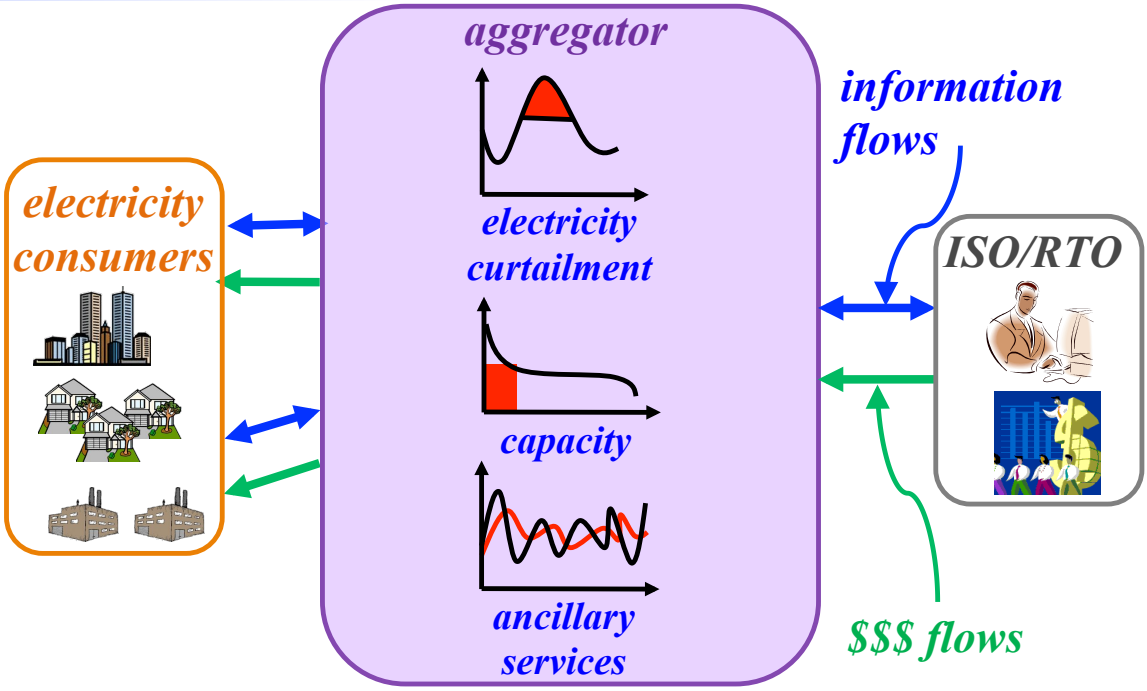


Source: Assessment of Demand Response and Advanced Metering, FERC 2012, http://www.ferc.gov/legal/staff-reports/12-20-12-demand-response.pdf

ROLE OF AGGREGATION

- An aggregator is officially called a *curtailment service provider*
- Such an entity is authorized to act as an intermediary between the *ISO/RTO* and electricity consumers to deliver demand response capabilities to meet *ISO/RTO* needs in its markets

AGGREGATOR SERVICES

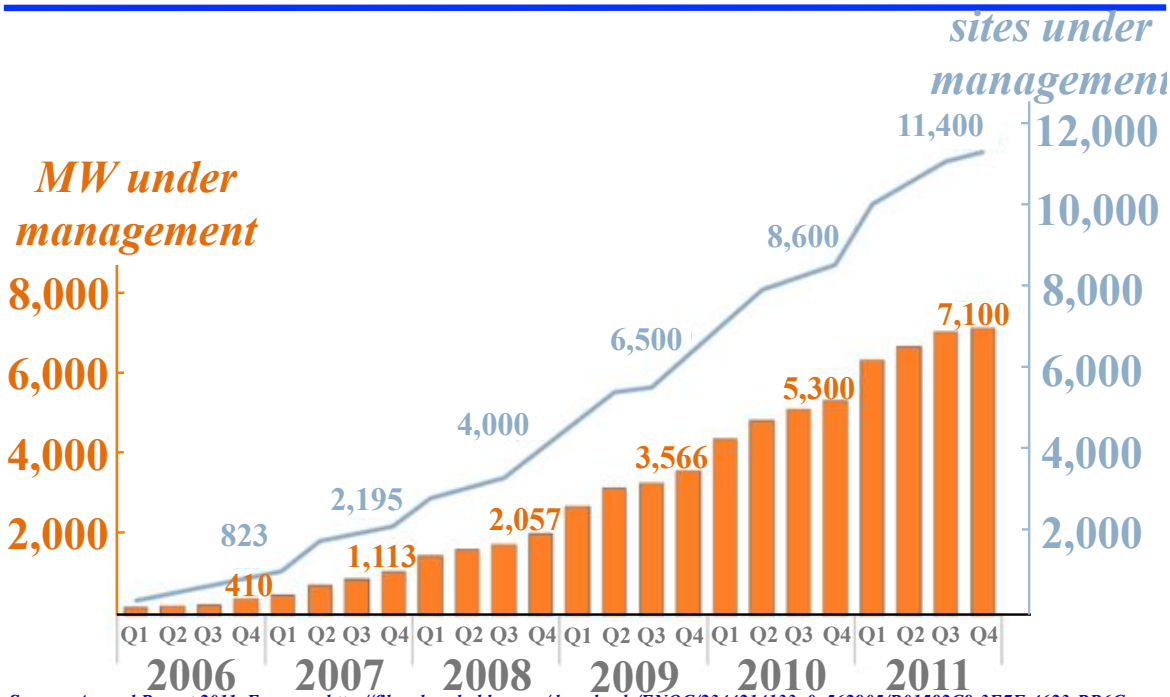


2011 STATS FOR THE TWO LARGEST AGGREGATORS

aggregator	*Comverge*	*EnerNOC*
demand portfolio size (MW)	4,564	7,100
annual portfolio growth (%)	22	34
revenues (million $)	136.4	286.6
annual revenue growth (%)	14	2.1

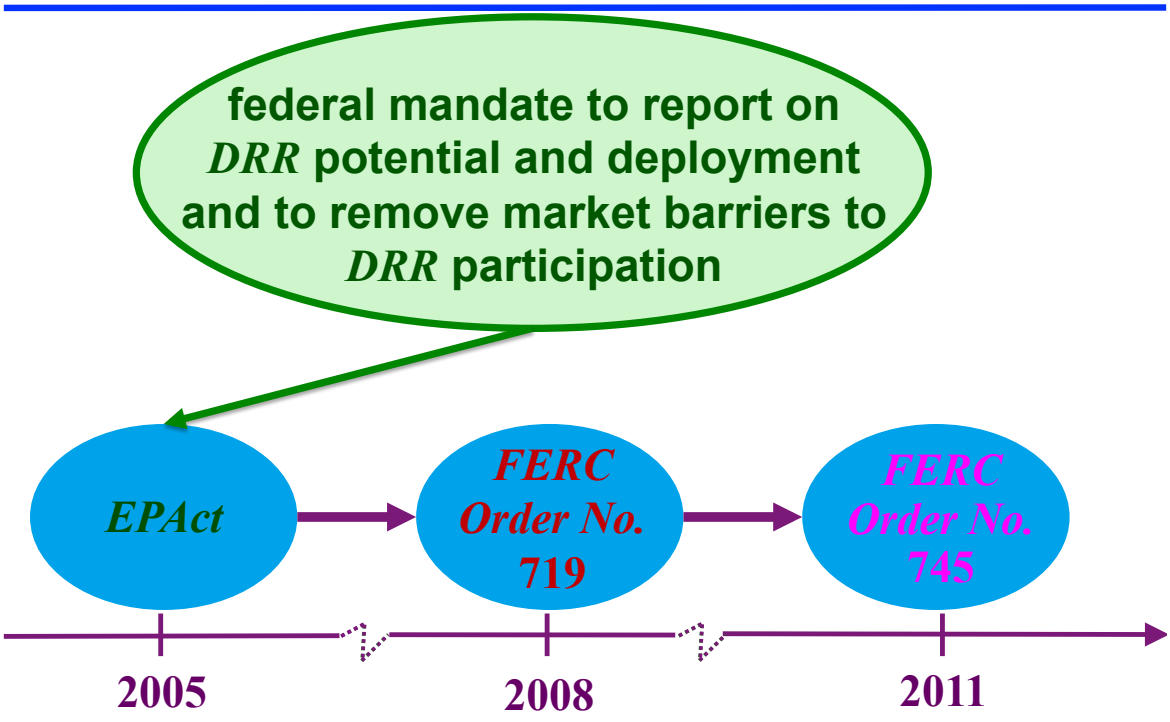
Source: Global revenues from demand response services $1.3 billion in 2011, http://www.pikeresearch.com/newsroom/large-global-vendors-will-account-for-a-growing-share-of-the-demand-response-market-over-the-next-five-years

ENERNOC DEMAND PORTFOLIO GROWTH

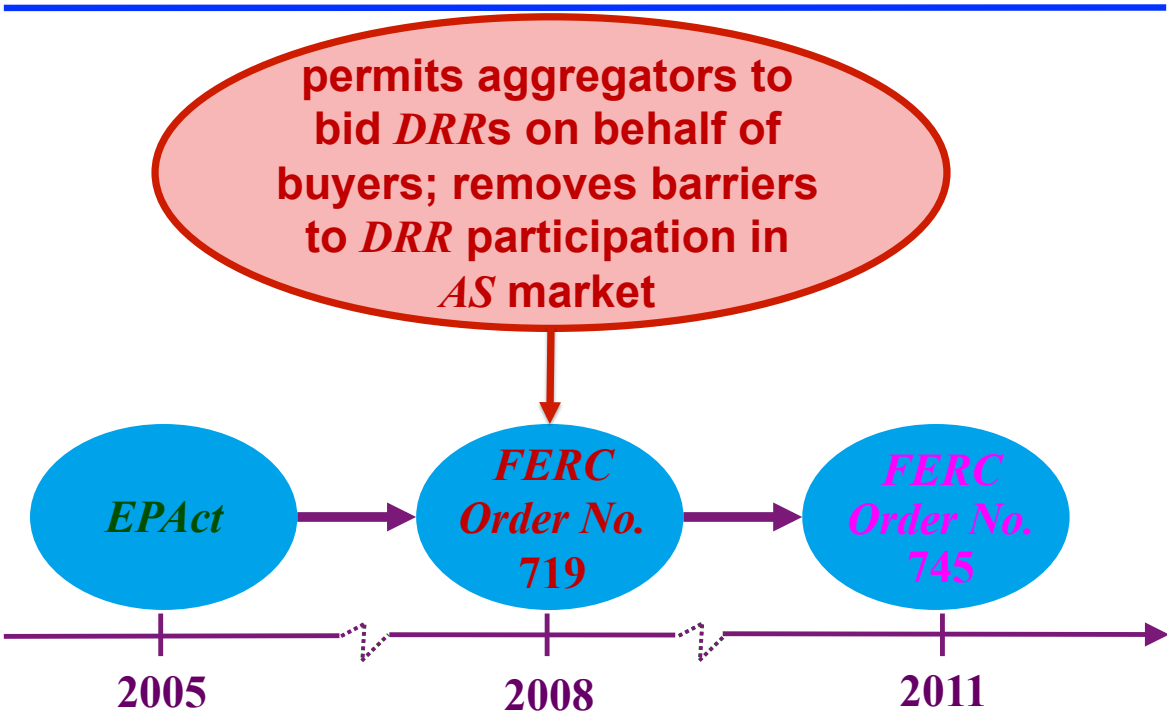


Source: Annual Report 2011, Enernoc, http://files.shareholder.com/downloads/ENOC/2344214133x0x562905/B01582C9-3E7F-4623-BB6C-D43E92ACF0F9/Enernoc_2011_Annual.pdf

FEDERAL REGULATORY INITIATIVES ON *DRR*

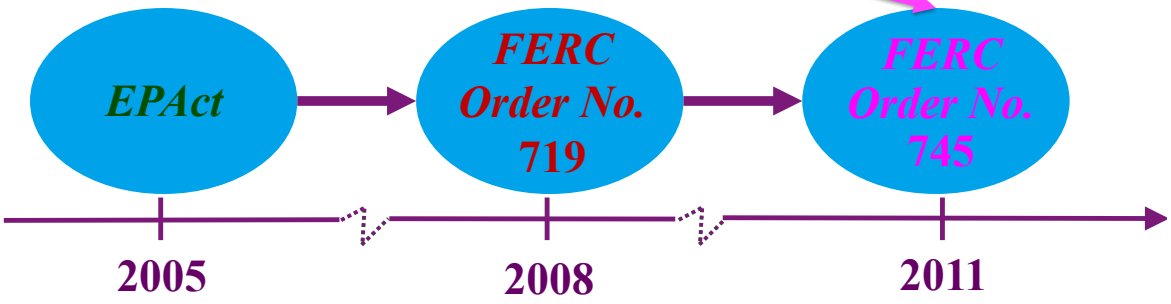


FEDERAL REGULATORY INITIATIVES ON *DRR*



FEDERAL REGULATORY INITIATIVES ON *DRR*

requires determination of the threshold price by the net benefits test (*NBT*) and the payment to each *DRR*, that satisfies the *NBT*, at the post-curtailment *LMP* for its accepted curtailment



FERC REGULATORY DEVELOPMENTS

key objectives	*FERC Order No.*
remove market barriers	**719, 745**
allow aggregation	719
provide AS by DRRs	719
incentivize for DRR participation in DAMs/RTMs	745

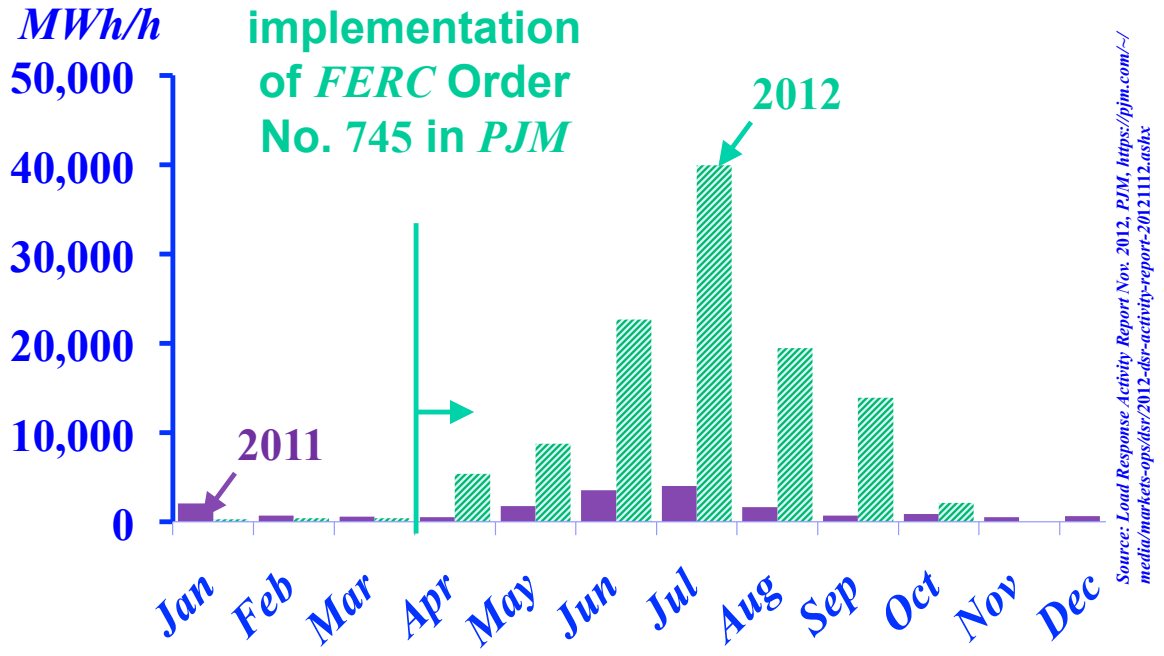
FERC ORDER NO. 745

- *FERC* Order No. 745 specified the incentives to the *DRR*s for load curtailments in the *DAM*s
- The Order mandated each *ISO/RTO* to perform a monthly net benefits test (*NBT*) to determine its monthly *threshold price criterion*, to serve as the trigger for the compensation to each *DRR* at its nodal *LMP*

FERC ORDER NO. 745

- The Order represents a significant increase in *DRR* incentives over past practices
- These incentives provide major stimulus for *DRR* participation in electricity markets
- The Order represents a major push in the encou-ragement of the implementation of additional *DRR*

2011 – 2012 *PJM DRR* CURTAILMENTS



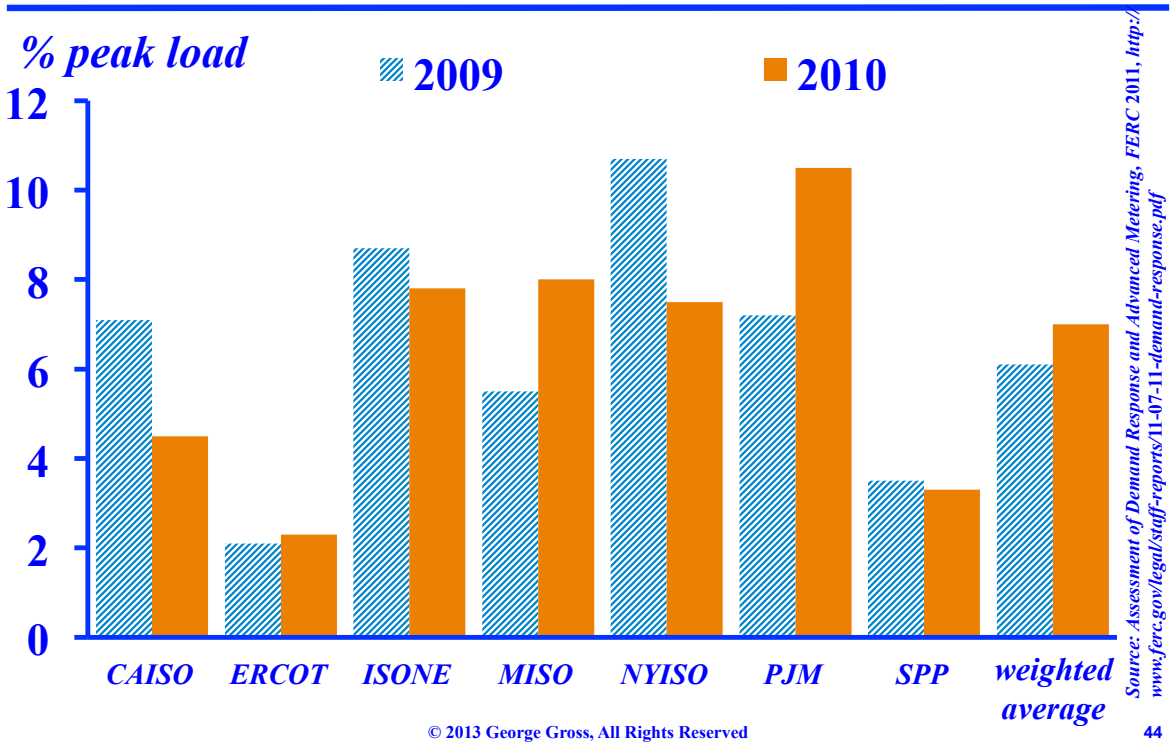
REPRESENTATIVE STATE – LEVEL *TOU* PRICING TARIFFS

Arizona	*1/3 of Arizona Public Service and Salt River Project residential customers voluntarily on time-of-use rates*
California	*all three IOUs approved to offer dynamic pricing tariffs in 2013*
Arkansas and Oklahoma	*state commissions approved residential variable peak pricing on a default basis with the option to opt-out*
Illinois	*Ameren Illinois and Commonwealth Edison received ICC approval to establish real-time pricing programs*
Connecticut	*all electric distribution companies must offer critical peak or real-time pricing programs to all customer classes*

CURRENT AND FORECASTED

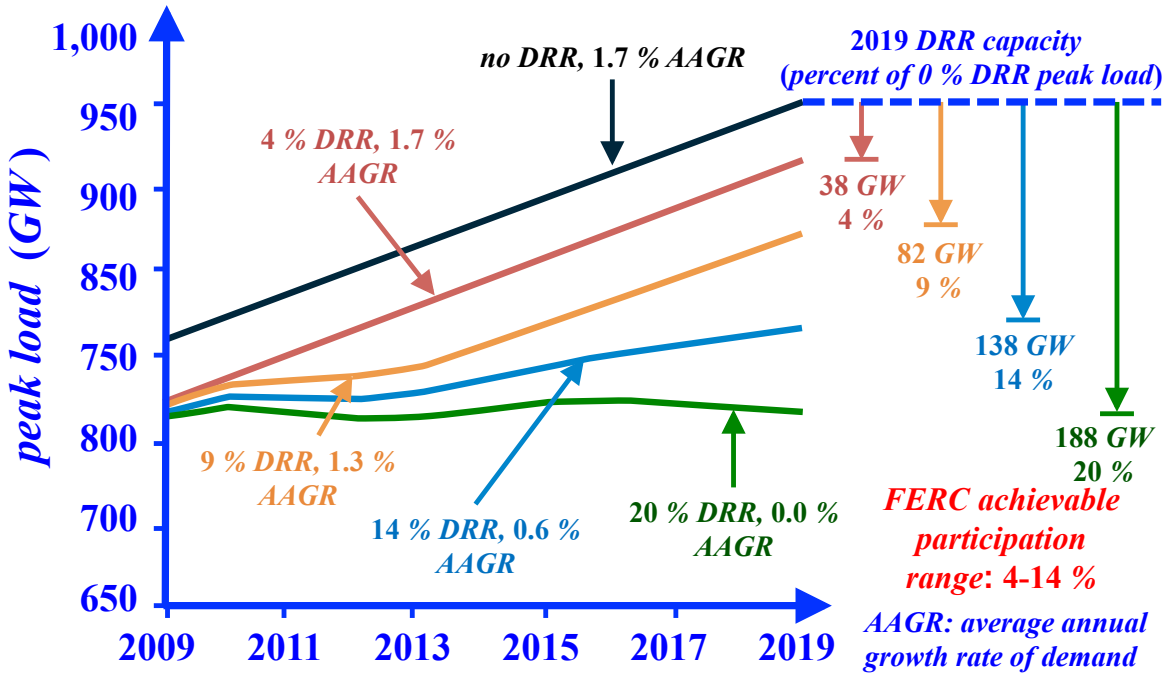
DRR PENETRATION

EXISTING *DRR* CAPACITY



Source: Assessment of Demand Response and Advanced Metering, FERC 2011, http://www.ferc.gov/legal/staff-reports/11-07-11-demand-response.pdf

FERC DRR CAPACITY FORECAST



Source: A National Assessment of Demand Response Potential, FERC 2009,http://www.ferc.gov/legal/staff-reports/06-09-demand-response.pdf

DRR LIMITATIONS AND CHALLENGES

DRR LIMITATIONS AND CHALLENGES

- The potential for *DRR* implementation is limited and challenges arise with deepening *DRR* penetration
- Policies for incentivizing *DRR* participation must be formulated so as to effectively balance the benefits among all the market players

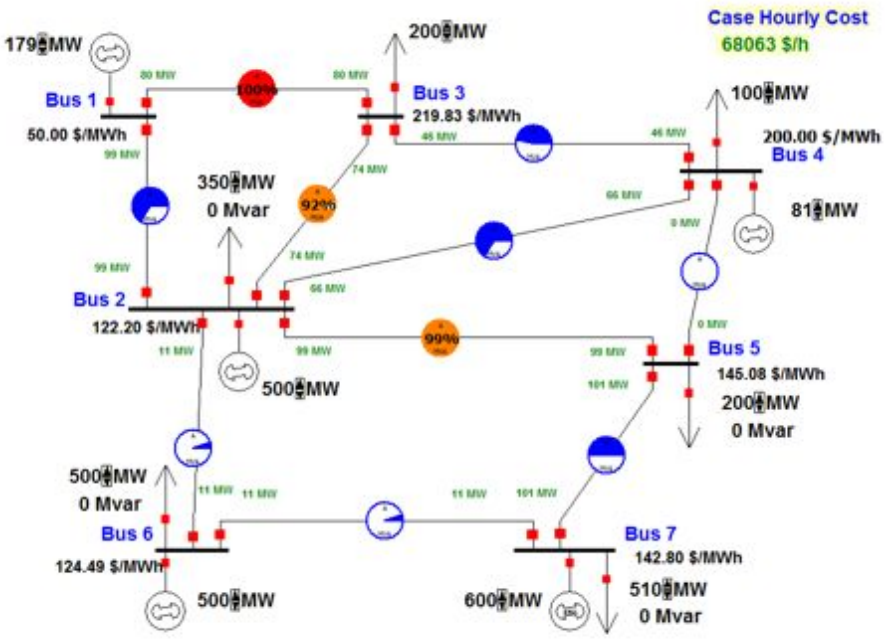
DRR LIMITATIONS AND CHALLENGES

- *DRR* curtailments in high-load hours are likely to be followed by energy recovery in lower-load hours, the so-called *payback effects*, with the associated price impacts
- *DRR*s cannot provide the system dynamic effects that generators do and so there are physical limits to the depths of effective *DRR* penetration

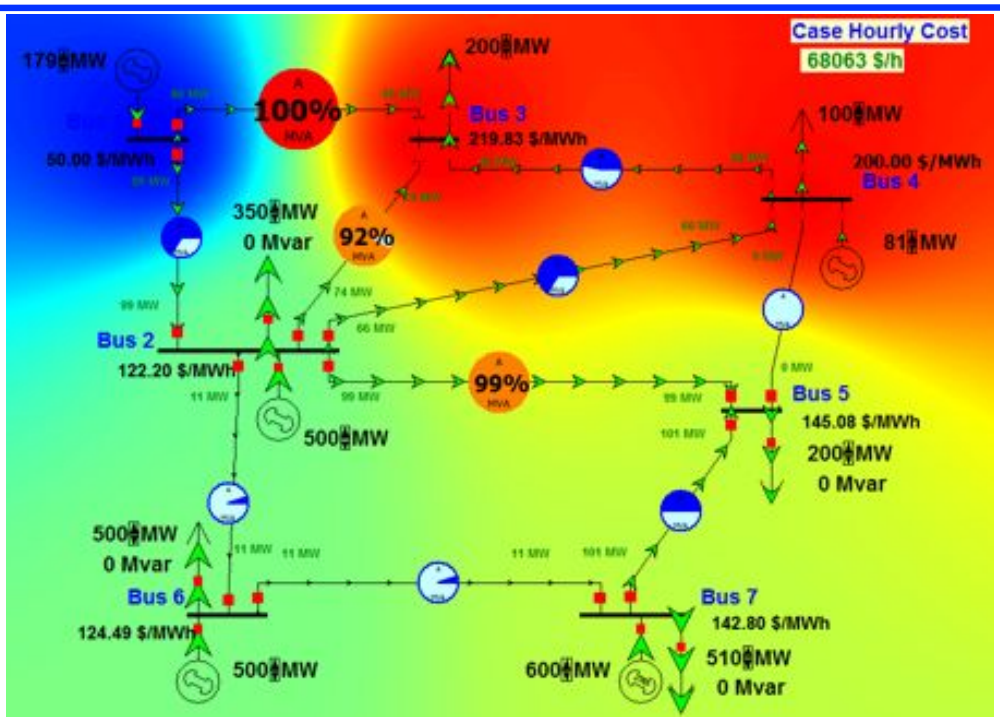
UNINTENDED CONSEQUENCES OF *DRRs*

There are instances when the dispatch of *DRR* curtailments increases the purchase payments of the loads not participating in curtailment provision, rendering those buyers worse off with the *DRR* curtailments than without them

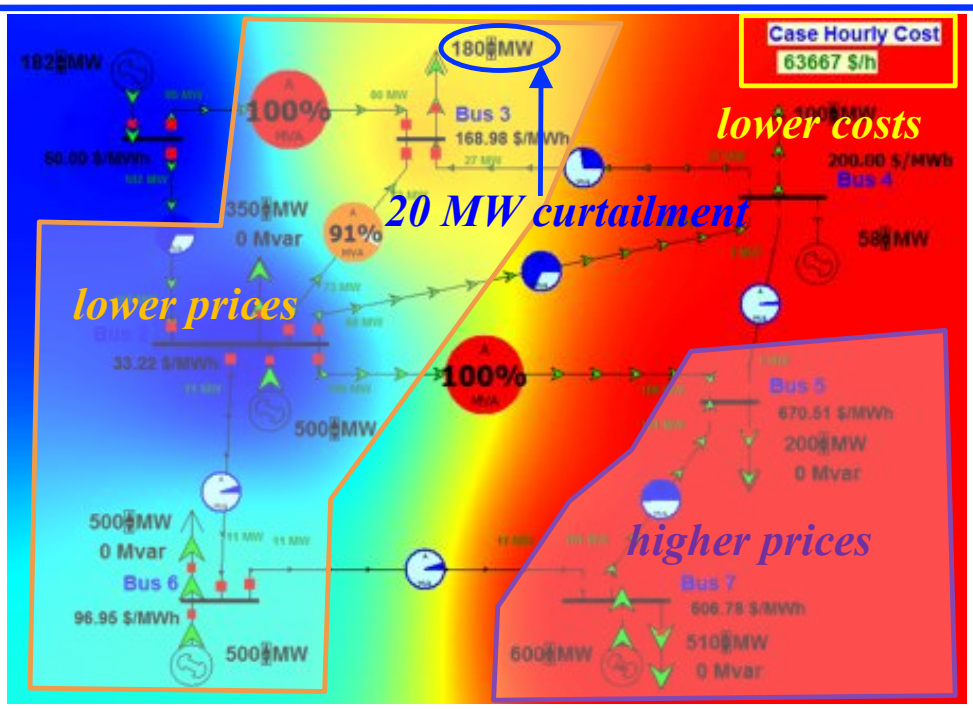
EXAMPLE: 7 – BUS SYSTEM



REFERENCE CASE: NO *DRR* CURTAILMENT



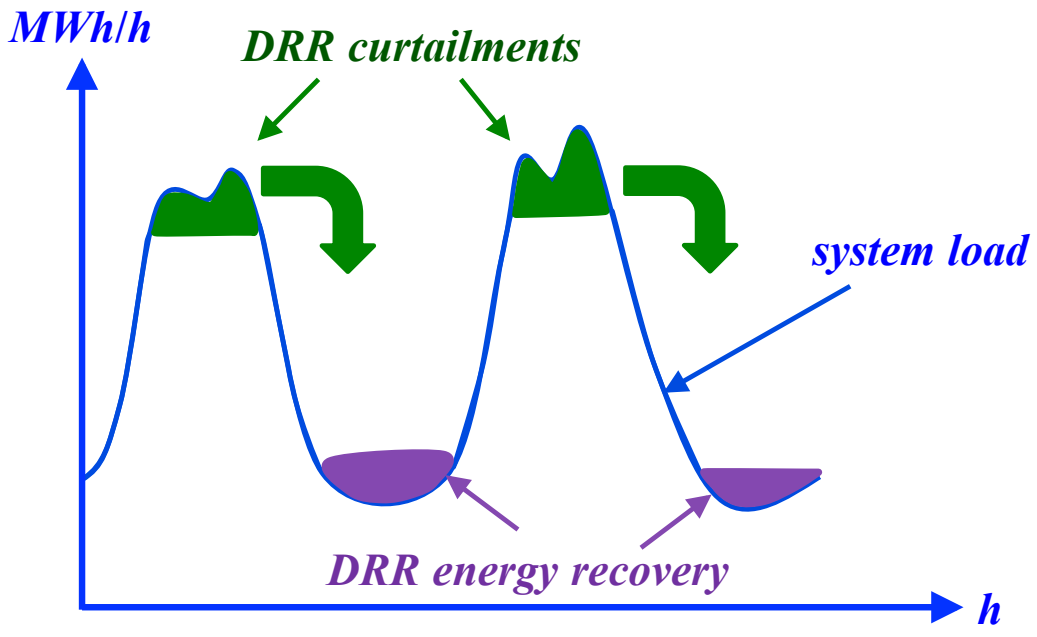
20 – *MW* CURTAILMENT AT BUS 3



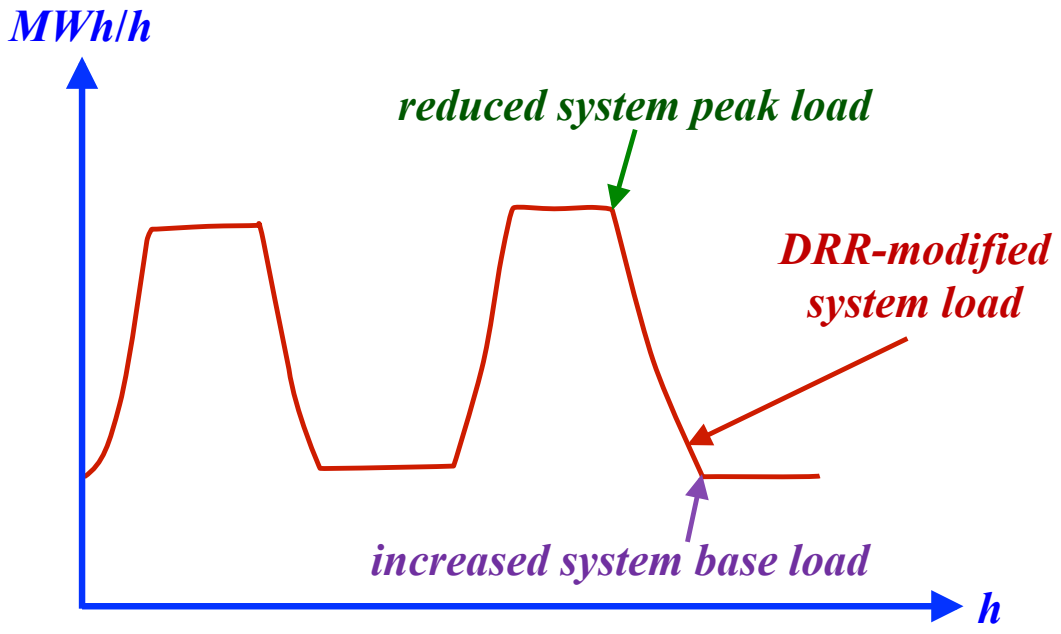
THE IMPACTS OF THE

DRR PAYBACK EFFECTS

DRR WITH ENERGY RECOVERY



DRR WITH ENERGY RECOVERY ACTS



PAST *DRR* STUDIES

- Past *DRR* studies have quantified the economic benefits of *DRR* curtailments without the explicit consideration of their recovery energy impacts
- The reported economic and emission benefits of *DRR*s are not attainable when recovery energy considerations are taken into account

SIMULATION STUDIES

- We discuss *DRR* recovery energy impacts with a series of backcast sensitivity studies for the year 2010 using *MISO* offer, load, and generation mix data
- We simulate the day-ahead market outcomes in 2010 under varying *DRR* penetration levels, utilization intensity and recovery energy values

SIMULATION STUDIES

- We compare *DRR* economic/emission impacts of these cases with respect to the no *DRR* case
- We use the average locational marginal prices (*ALMP*s) and the average per *MWh* CO_2 emissions as the basic metrics of comparison

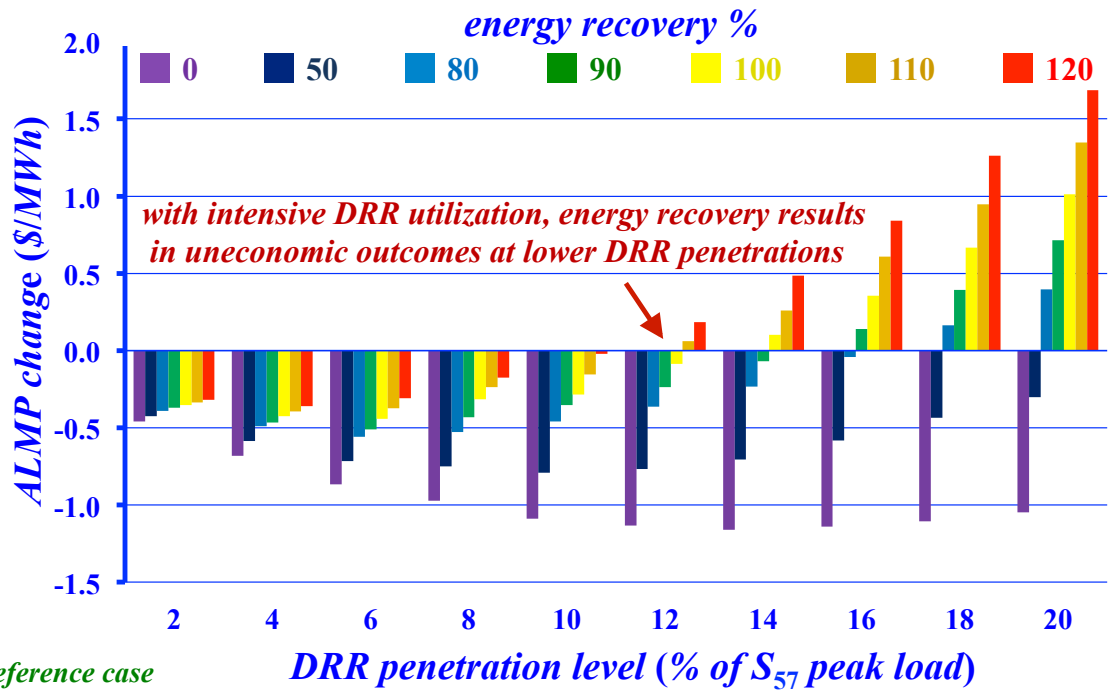
DRR IMPACT CASE STUDY TEST SYSTEMS

study system name	*test system*	*source of offer, load and generation mix data*
S_{57}	*IEEE 57-bus*	*MISO*

DRR IMPACT SENSITIVITY STUDIES

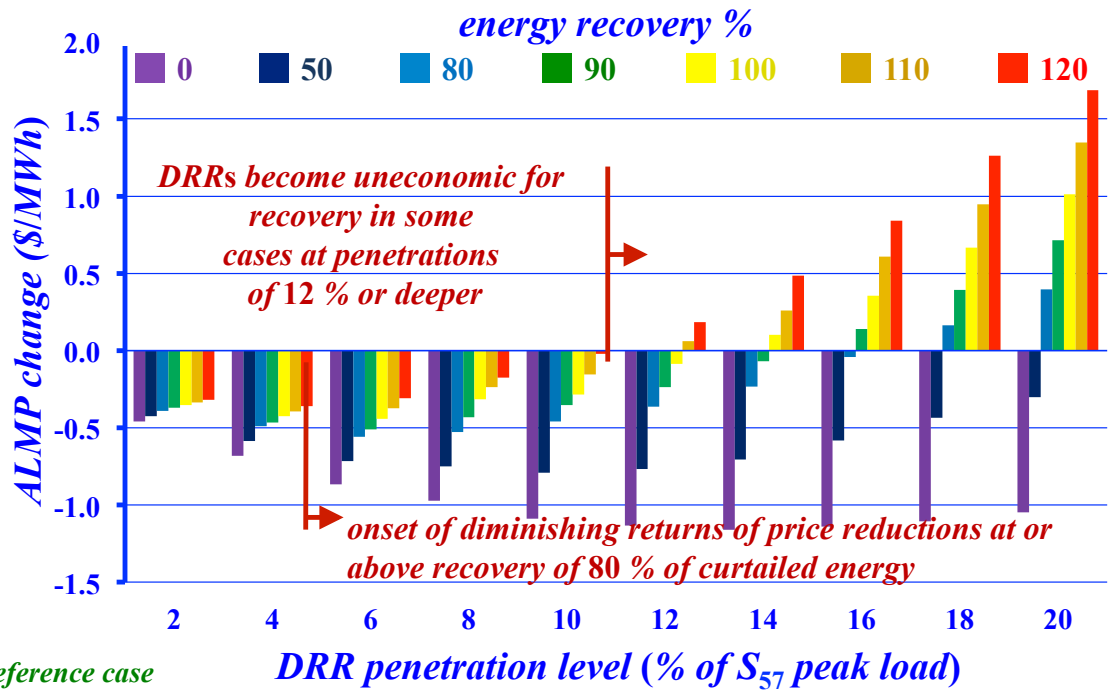
parameter	*range*
DRR capacity	*1 – 20 % of peak load*
DRR recovery energy percentage	*0 – 120 % of curtailed energy*
DRR intensity (low/medium/ high)	*2, 4, 6 out of 8 potential curtailment hours*

S_{57} PRICE IMPACTS UNDER HIGH *DRR* INTENSITY



reference case
ALMP: 57.34 $/MWh

S_{57} PRICE IMPACTS UNDER HIGH *DRR* INTENSITY



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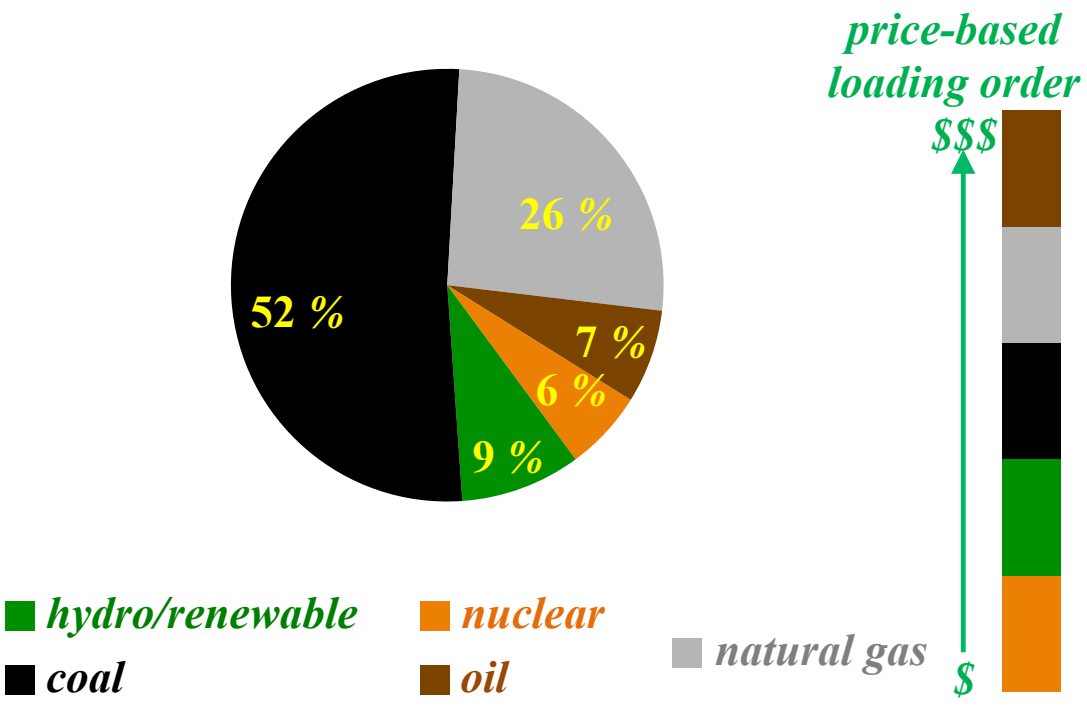
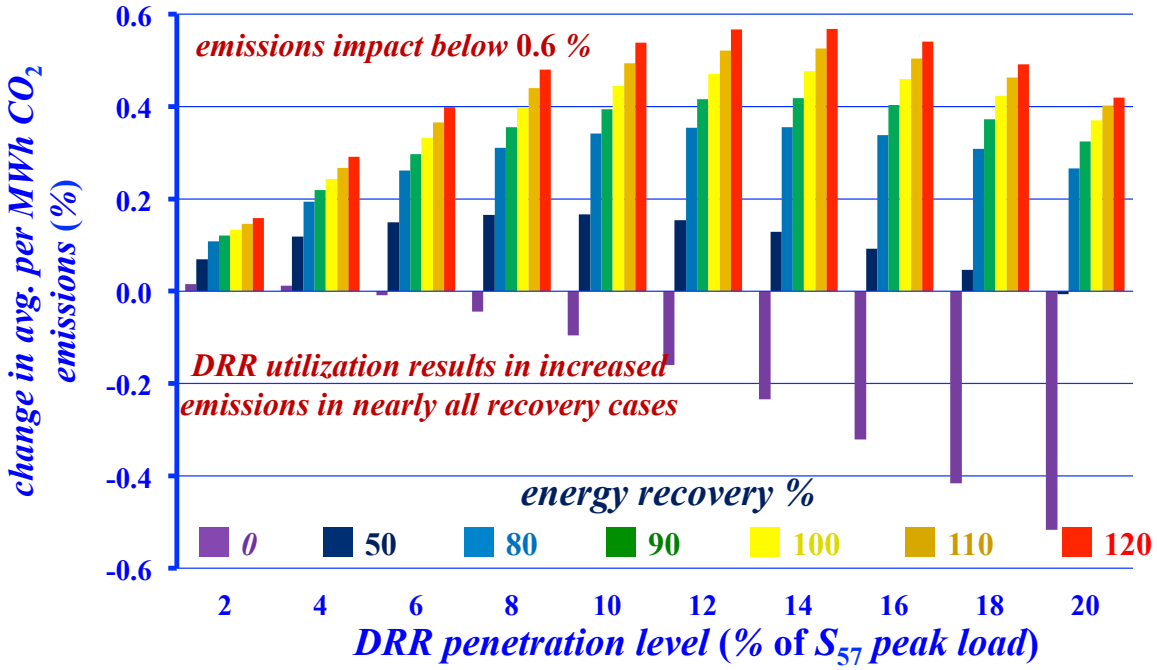
S_{57} RESOURCE MIX



S_{57} EMISSION IMPACTS UNDER HIGH *DRR* INTENSITY



STUDY FINDINGS AND CONCLUSIONS

- The consideration of energy recovery reduces drastically the system-wide economic benefits of *DRR* curtailments and, below certain penetration levels, makes curtailments uneconomic
- *DRR* utilization at *medium to high intensity*, *modest recovery percentages*, and *penetrations within the FERC's achievable participation range* may lead to:

STUDY FINDINGS AND CONCLUSIONS

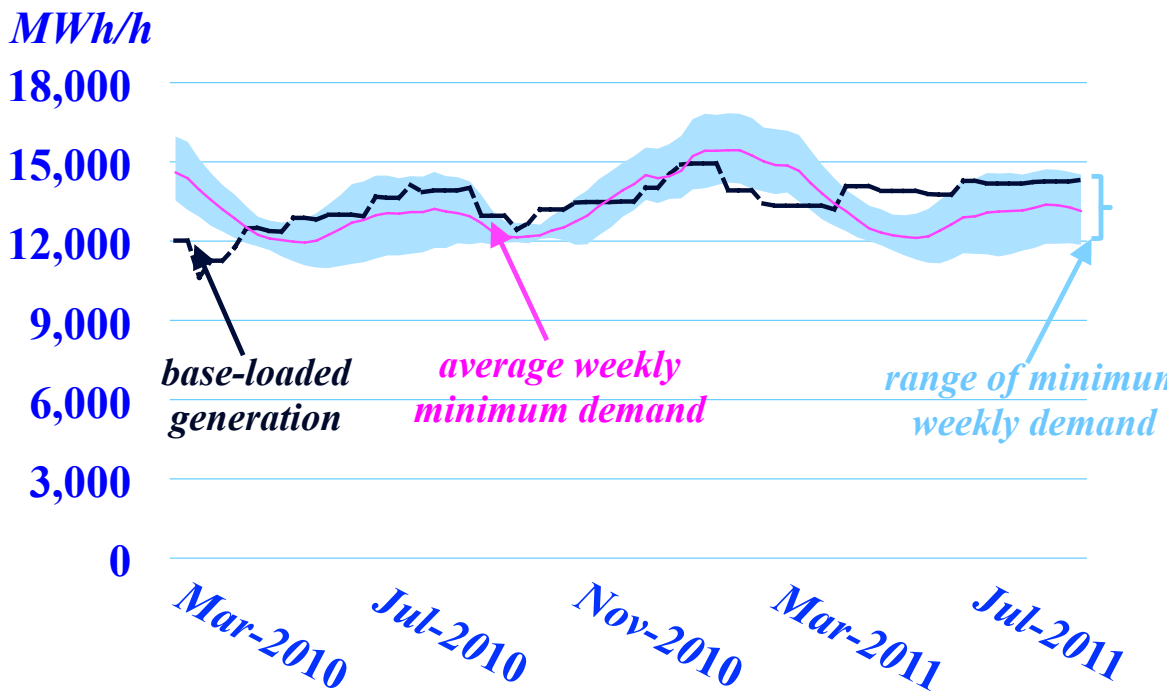
  - uneconomic outcomes or severely diminished *ALMP* reductions
  - emission increases or severely diminished emission reductions
- Deepening penetrations of wind generation may alleviate the severely diminished *ALMP* and CO_2 reductions

DRR CONTRIBUTIONS

VALUE ADDED BY *DRR*s

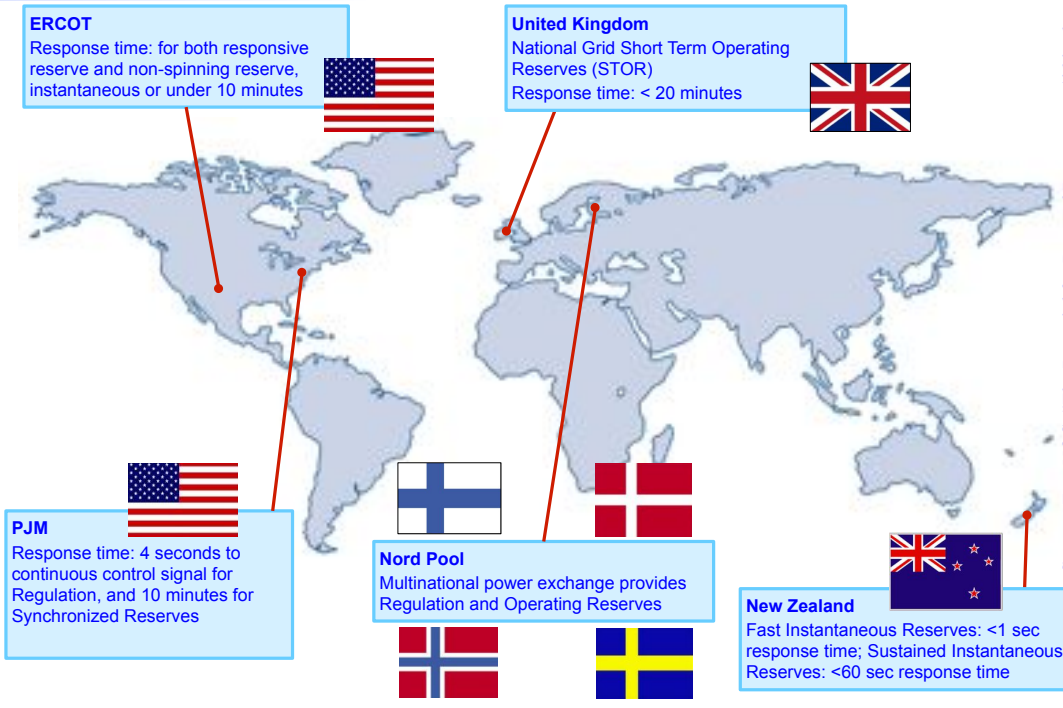
- *DRR*s add value to the electric grid as a cost-effective and clean resource for providing "energy" and ancillary services
- The deployment of *DRR*s presents opportunities to increase the effectiveness of grid utilization and address the operational challenges in the integration of renewable resources

SURPLUS BASE-LOADED GENERATION



source: IESO

DRRs PROVIDE *AS* AROUND THE GLOBE



Source: EnerNOC, "The Potential for Demand Response to Aid in the Integration of Renewable Resources", April 2011

COLD STORAGE LOAD

enterprise	*Four Seasons Produce, Inc.*
location	*Pennsylvania*
program	*EnerNOC DemandSMART™, PJM synchronized reserves and emergency load response*
curtailment source	*chiller reductions*
curtailment range	**0.4 – 1 *MW***
annual rebates	**$ 25,000**

Source: Case Studies, EnerNOC, http://www.enernoc.com/our-resources/case-studies

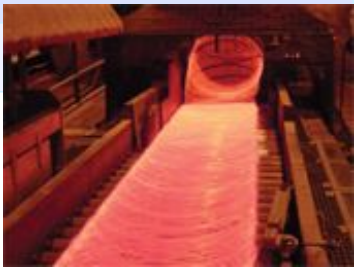
COLD STORAGE LOAD

enterprise	*VersaCold*
location	*Ontario, Canada; Pennsylvania*
program	*EnerNOC DemandSMART™*
curtailment source	*equipment shutdowns, temperature adjustments*
curtailment limit	**3.2 *MW***
annual rebates	**$ 160,000**

Source: Case Studies, EnerNOC, http://www.enernoc.com/our-resources/case-studies

MANUFACTURING LOAD

enterprise	***Leggett & Platt***
location	***Texas and Illinois***
program	***EnerNOC DemandSMART™, emergency response service, PJM emergency load response***
curtailment source	***partial/total operational shutdowns***
curtailment limit	**12 *MW***
annual rebates	**$ 400,000**



Source: Case Studies, EnerNOC, http://www.enernoc.com/our-resources/case-studies

GOVERNMENT FACILITIES

agency	***U.S. DOD***
location	***throughout the United States***
program	***demand response***
curtailment source	***building energy usage adjustments***
curtailment limit	**> 300,000 *buildings***
annual rebates	**$ 14,000,000**

Source: White House highlights demand response activities, opportunities, Platts, http://www.platts.com/RSSFeedDetailedNews/RSSFeed/ElectricPower/6201047

CONCLUDING REMARKS

- *DRR*s currently play a larger role than at any time in maintaining the supply-demand balance and in the provision of capacity-based *AS*
- Smart grid technology, aggregators and policies are key drivers in the deepening *DRR* penetration
- Huge potential exists for *DRR*s to provide grid services, such as regulation and load following, and to play a role in the reliable and effective integration of renewable resources