OE Visualization and Controls Peer Review

Technical Assistance to ISO's and Grid Operators For Loads Providing Ancillary Services To Enhance Grid Reliability

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Programmatic Goal

- *Load As a Resource* : One of four program areas within the Office of Electricity's Transmission Reliability Program:
  - "This activity evaluates the capability of load to respond to price signals to improve grid reliability and market efficiency."
- This work includes the "Potential of load to provide ancillary services."
- Project demonstrates and promotes the use of responsive load to provide ancillary services; helps ISOs and grid operators understand the resource and how best to apply it.

Overall Program Approach

- Research
  - Power system reliability needs
  - Responsive load capabilities and costs
  - Ancillary service quantification
    - Total system
    - Individual loads and generators
  - Monitoring, metering, control capabilities
- Outreach
  - ISOs
  - Reliability councils
  - Vertically integrated utilities
  - Loads
- Demonstrations
  - Large loads
  - Aggregations of small loads

Program Effort and Benefits

Responsive load is the most underutilized reliability resource in North America

- Using load response to provide ancillary services is often better for the power system and better for the loads
  - Faster, more reliable response
  - Frees generation to supply energy
  - Shorter, less frequent interruptions
- Misconceptions concerning load response capabilities and limitations are the largest obstacles to greater use
  - Inadvertent discrimination is built into reliability and market rules that were designed to accommodate the incumbent generation technology
  - Rule changes will not be considered until there is a demonstrated, large-scale load resource
  - Resources can not develop without rule changes and access to markets
- Large demonstrations would be useful
  - Demonstrations tend to piggyback onto other deployed technologies
  - Much can be done with continued research and education

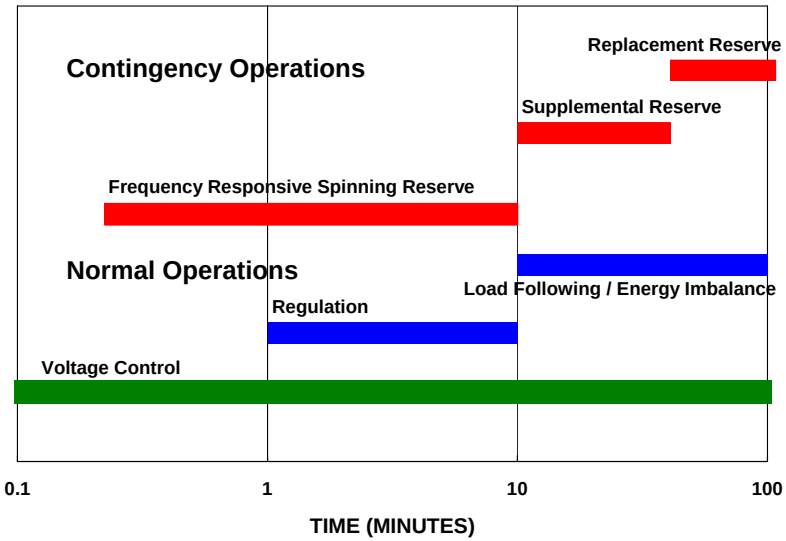
Much progress has been made; there is much that still needs to be done. It is a slow process

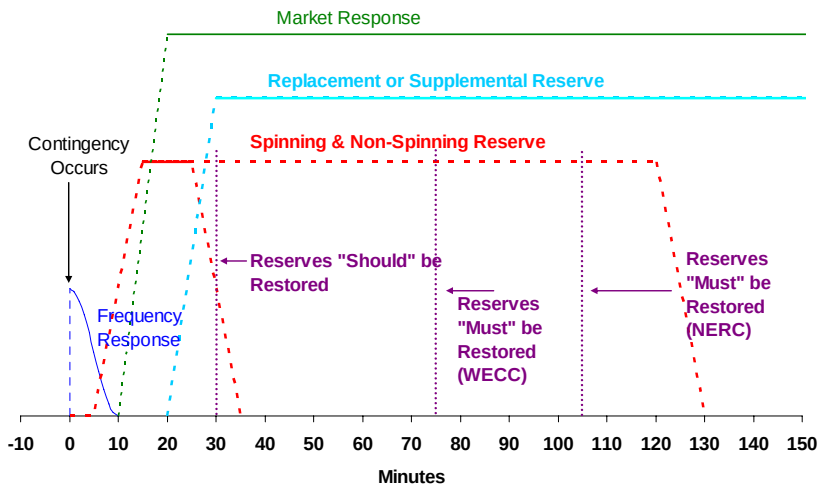
Demand Response For Power System Reliability: FAQ

Concise, comprehensive overview of the potential beneficial use of load response to enhance power system reliability

- Presents issues and findings in a Q/A format; draws material from numerous reports and presentations
- Addresses concerns about impact of responsive load on power system reliability; obstacles to load response as well as opportunities
- Designed for power system operators, planners, regulators, and load owners/operators.
  - Not specifically aimed at ancillary service experts
- Easily portable to an interactive web application
- Modular set of sections on various issues; deliberately short and self-contained
- Publication is expected in October 2006

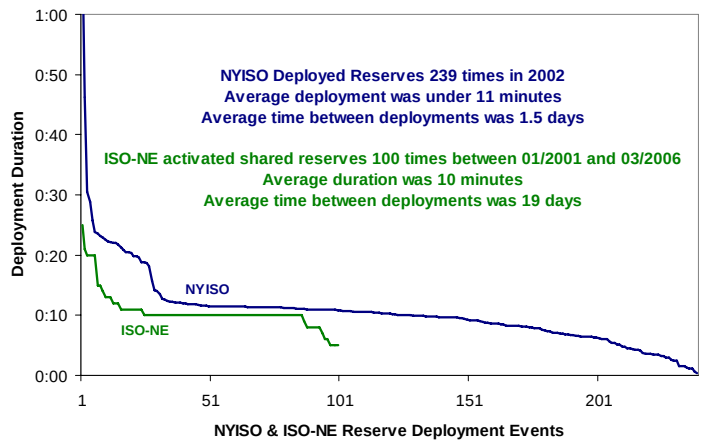
Response Time Is A Dominant Ancillary Service Characteristic





Reserve Deployments:

- *Coordinated response to contingency events*
- *Typically short but occasionally long*
- *Good match to some loads' capabilities*



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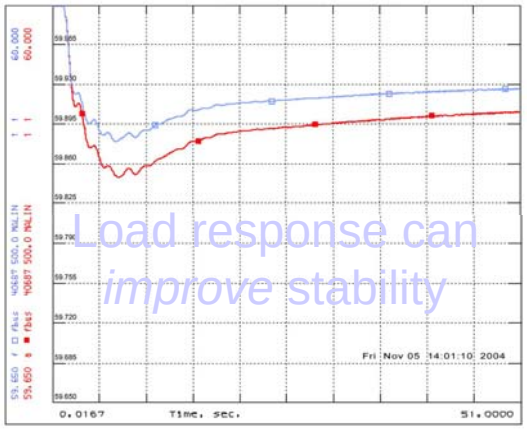
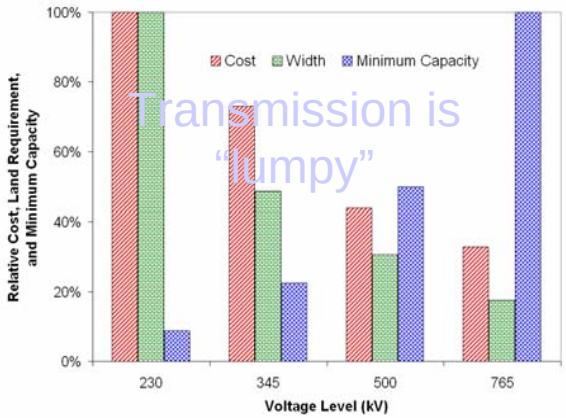
- Fast, short response has more reliability value than slow, long response
- Fast, short response is easier for many loads to provide with modern communications and controls
- Conventional wisdom advocates for slow, long response first
- Conventional wisdom prefers big loads but small loads offer many advantages

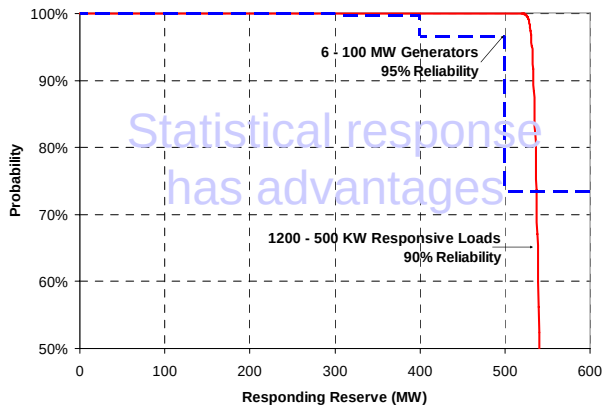
	2002	2003	2004	2005	2006
	Annual **Average** and Maximum $/MW-hr				
			California		
Regulation	**26.9**	**35.5**	**28.7**	**35.2**	**38.5**
	111	164	166	188	399
Spin	**4.3**	**6.4**	**7.9**	**9.9**	**8.4**
	250	92	125	110	225
Non-Spin	**1.8**	**3.6**	**4.7**	**3.2**	**2.5**
	92	92	129	125	110
Replacement	**0.90**	**2.9**	**2.5**	**1.9**	**1.5**
	80	55	90	36	70
			ERCOT		
Regulation		**16.9**	**22.6**	**38.6**	**25.2**
		177	156	1451	351
Responsive		**7.3**	**8.3**	**16.6**	**14.6**
		150	51	731	351
Non-Spin		**3.2**	**1.9**	**6.1**	**4.2**
		249	400	510	125
			New York East		
Regulation	**18.6**	**28.3**	**22.6**	**39.6**	**55.7**
	99	195	99	250	250
Spin	**3.0**	**4.3**	**2.4**	**7.6**	**8.4**
	150	55	44	64	171
Non Spin	**1.5**	**1.0**	**0.3**	**1.5**	**2.3**
	45	3	3	64	171
30 Minute	**1.2**	**1.0**	**0.3**	**0.4**	**0.6**
	45	3	3	4	31
			New York West		
Regulation	**18.6**	**28.3**	**22.6**	**39.6**	**55.7**
	99	195	99	250	250
Spin	**2.8**	**4.2**	**2.4**	**4.9**	**6.0**
	150	55	44	50	45
Non Spin	**1.4**	**1.0**	**0.3**	**0.6**	**0.9**
	45	3	3	13	38
30 Minute	**1.2**	**1.0**	**0.3**	**0.4**	**0.6**
	45	3	3	4	31

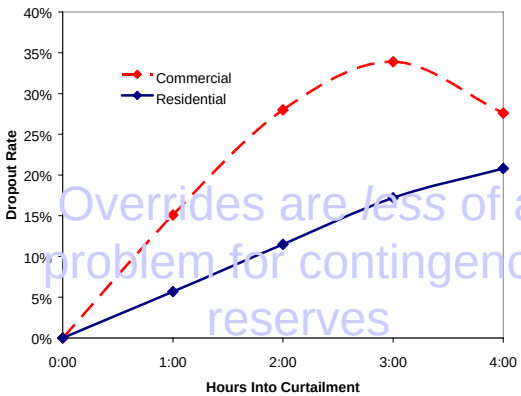
Demand Response Concerns & Obstacles

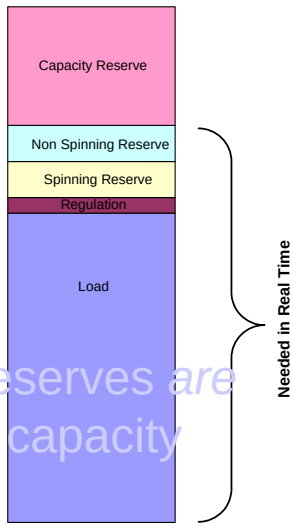
Example Analysis Results

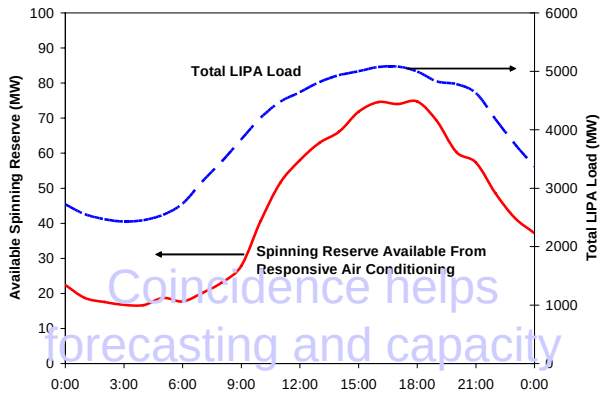












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Load Participation in Ancillary Services in Organized Markets

	Regulation	Contingency Reserves				Co-optimization exemption
		Spinning	Non-spinning Supplemental (10 min)	Long Term Supplemental (30 min)	Replacement (60 min)	
ISO-NE	☑	☑	☑ **L**	☑ **L**		No
NYISO	☑	☑ **L**	☑ **L**	☑ **L**		No
PJM	☑ **L**	☑&C **L**	☑&C **L**			Yes
MISO	C	C	C			Not yet set
ERCOT	☑	☑ **L**		☑ **L**	☑ **L**	Yes
CAISO	☑	☑	☑ **L**			Yes

☑ – Market based

C – Cost based

F – Fixed monthly MVAR payment

L – Responsive load is allowed to participate (or will be shortly)

New England has forward reserves for obtaining supplemental and regulation

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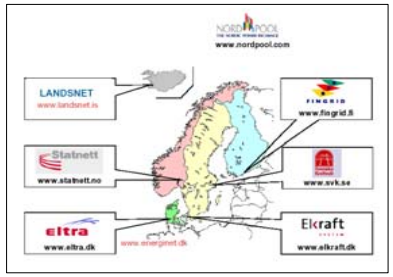
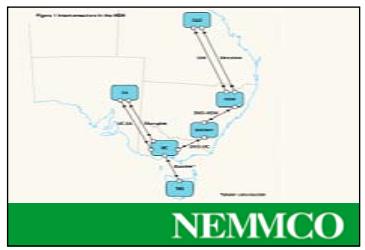
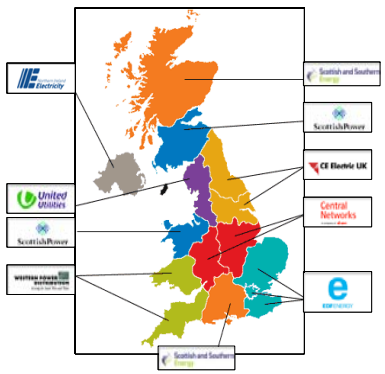
Loads Providing Ancillary Services: Review of International Experience – Report Overview

- Ancillary services functional equivalence structure
- Overview of Selected Electricity Markets
  - Australia, Nordic, U.K., PJM, and ERCOT markets
  - Co-optimization concerns
- Comparative review of ancillary service arrangements
  - Size and technical requirements
  - Procurement arrangements and compensation
  - Load penetration and performance during events
  - Barriers to load participation
- Summary of Key Findings and Recommendations
  - Market design and technical requirements are critical
  - Roles of system operators, regulators, and third party providers
  - Which loads technically match reliability needs and which are motivated?
  - Suggestions for system/grid operators







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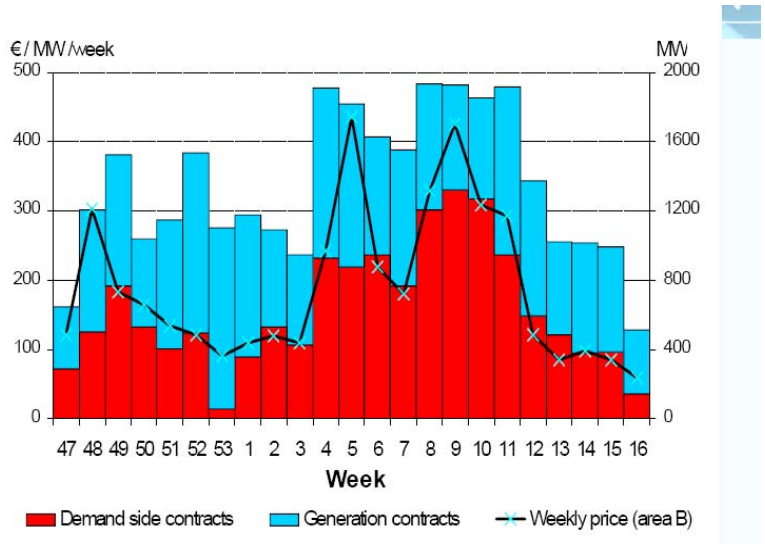
RCOM Volume Evenly Split Between Generators and Load Resources (example finding)

- Hydropower usually provides regulating reserve capacity. However, in wintertime, capacity is short and mostly bid in to the day-ahead market, leaving little capacity available for balancing or regulation. Network constraints further exacerbate this problem.
- The TSO is financially responsible for imbalance management, and they are highly motivated to hedge against spot price volatility.
- Statnett's RCOM mobilizes extra seasonal operating reserves to participate in the imbalance energy and regulating capacity markets.
- **Both generators and loads compete via a weekly bidding process.**
- **During the coldest winter weeks, when demand is high and generation capacity tight, loads make up half or more of the weekly RCOM volume** (Statnett, 2005).



Winter 2004-2005

Source: Statnett

Loads Providing Ancillary Services: Review of International Experience – Findings

- Considerable similarity among basic ancillary services
- Loads can play an important and occasionally dominant role
  - Nordic: half of contingency and replacement reserves and some regulation
  - Nordic: some system operators prefer responsive load to gas turbines
    - Less expensive and less troublesome
  - UK: one third of frequency responsive reserve
  - Australia: all network loading control
  - ERCOT: half of total spinning reserve; maximum currently allowed by rules
- International acceptance of responsive load is also slow
  - Education and confidence building
- Deliberate attention to responsive load is required for success
- Recommendations
  - System operators are pivotal in setting technical and operating rules
  - Transparent and frequent reserve procurement facilitates load participation
  - Capacity/reservation payments should recognize the value of load response
  - Clear ancillary service design allows movement between services

Positive Changes In The Industry

- NERC no longer prohibits load from providing spinning reserve
- ERCOT allows, and load provides, half the spinning reserve – no loads choose to provide balancing energy
- PJM now allows loads to participate in all ancillary service markets
- MISO ancillary service market is expected to allow full load participation
- WECC technical reports now acknowledge that load may soon be allowed to supply spinning reserve
- Co-optimization blocking of load providing contingency reserves is being addressed
  - CAISO allows loads to opt-out of co-optimization
  - ERCOT energy market structure fixes the problem
  - PJM market structure mostly dodges the problem
  - NYISO will allow loads to opt-out of co-optimization in early 2007

Change is slow and takes persistence

2006 Presentations

Ancillary Services 101 (4 hour workshop – twice) – B Kirby, ORNL

Look Again At Load Following: The Value of Response – B Kirby, ORNL

Load Resources for Ancillary Services (4 hour workshop – twice) – B Kirby, ORNL & M Kintner-Meyer, PNNL

Real-Time Balancing Markets as a Supply of Ancillary Services – B Kirby, ORNL

Measuring Consumption of Ancillary Services – B Kirby, ORNL

Power System Reliability: Responsive Loads and Distributed Generation, A Possible Future: NYISO – B Kirby, ORNL

Use of Demand Response to Provide Spinning Reserve: CMOPS, TVA – J Kueck & B Kirby, ORNL

Review of ISO Demand Response Programs: CAISO – J Kueck & B Kirby, ORNL

Load as a Reserve Resource: Selected Case Studies – M Kintner-Meyer, PNNL

Load as Ancillary Services: Technical Potential and Experiences of Load Control for the Mass Market – M Kintner-Meyer, PNNL

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2006 Publications

The Role of Demand Resources In Regional Transmission Expansion Planning and Reliable Operations – B Kirby, ORNL/TM 2006/512, July

Demand Response For Power System Reliability: FAQ – B Kirby, Draft

Loads Providing Ancillary Services: Review of International Experience – G Heffner, C Goldman, B Kirby and M Kintner-Meyer, October 2006, Draft

Related Benefits

Years of DOE programmatic support have developed expertise in understanding how responsive load can support power system reliability, especially by supplying ancillary services. Other programs are able to tap that expertise and help DOE disseminate the knowledge

- FERC Technical Assistance – Staff Report to Congress: ***Assessment of Demand Response and Advanced Metering*** (EPACT Section 1252)
  - LBNL: Analyzed and developed national and regional estimates of the existing demand response resource from programs and time-based tariffs (Goldman)
  - ORNL: Analyzed the role of demand response in regional planning and operations (Kirby)
- International Energy Agency – Task XV: ***Assessment and Development of Network-driven Demand-side Management Measures*** (ORNL: Kueck and Kirby)
- NYISO Environmental Advisory Board
  - LBNL Goldman and ORNL Kirby are on the board and provide advice to NYISO on demand response capabilities and benefits
- CEC Demand Response for Spinning Reserve – ORNL Kueck & Kirby

An Exciting Opportunity: Loads May Have The Capability To Provide Regulation

- Air liquefaction 1,000MW
- Induction & ladle metallurgy furnaces 1,000MW
- Gas & water pumping with variable speed motor drives
- Electrolysis: >14,000MW
  - **Aluminum 6,500MW**
  - Chlor-alkali 4,500MW
  - Potassium hydroxide 1,000MW
  - Magnesium, sodium chlorate, copper
- This could dramatically reduce the cost of producing aluminum in the US while improving power system reliability and reducing power system costs

Without a dramatic change the future for Aluminum looks bleak in the US:

Barron's Oct. 2, 2006: Aluminum Power Struggles – "As of right now, we are doomed," says Jim Southwood, president of the analytical firm Commodity Metals Management

Currently discussing with Alcoa, Century Aluminum, NYISO, and TVA