

# Power System Reliability: Promoting Responsive Loads

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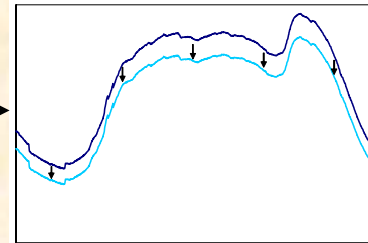
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# Responsive Load Is The Largest Underutilized Reliability Resource In North America

- **Good match between some load's inherent response capability and power system's physical reliability requirements**
  - Preconceptions about what response is easiest are often wrong
  - Advances in communications and control technology make it possible to exploit load response
- ❖ **Market and reliability rules need to be reexamined**
  - Our goal should be to enhance reliability, not to simply embrace existing rules
  - NERC Prohibition lifted, Regional rules need changing

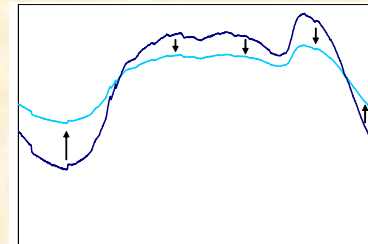
# There Are Five Basic Types of Demand Response

1. **Energy Efficiency** programs reduce electricity consumption and usually reduce peak demand

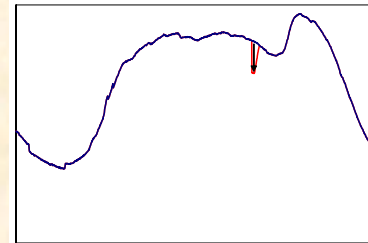


2. **Price Response** programs move consumption from day to night (real time pricing or time of use)

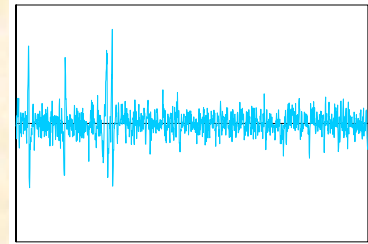
3. **Peak Shaving** programs require more response during peak hours and focus on reducing peaks every high-load day



4. **Reliability Response** (contingency response) requires the fastest, shortest duration response. Response is only required during power system “events” – *this is new and slowly developing*



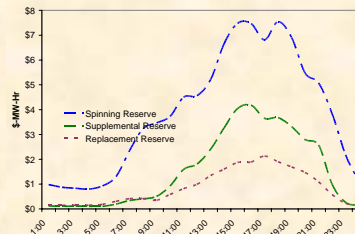
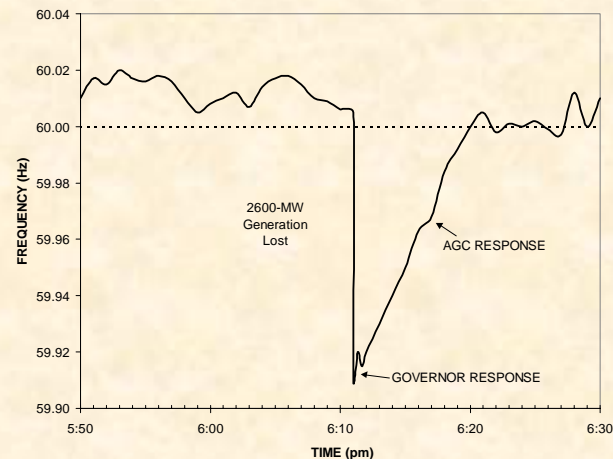
5. **Regulation Response** continuously follows the power system’s minute-to-minute commands to balance the aggregate system – *this is not done anywhere yet and ORNL methodology may have the potential to dramatically change production costs, especially for aluminum*



# Responsive Loads: Better Matched To Spinning Reserves Than Peak Reduction

- **Better for the load:** shorter, less frequent disruption (less storage is required)
- **Better for the power system:** faster response, more reliable, redundancy, distributed, better use of generation
- **Better for other loads:** reduced energy and ancillary service prices – not all loads need respond
- **Better for society:** reduced need for generation and transmission

## Power System Reliability Events Are Fast, Infrequent and Relatively Short



*Highest value when load is most available*

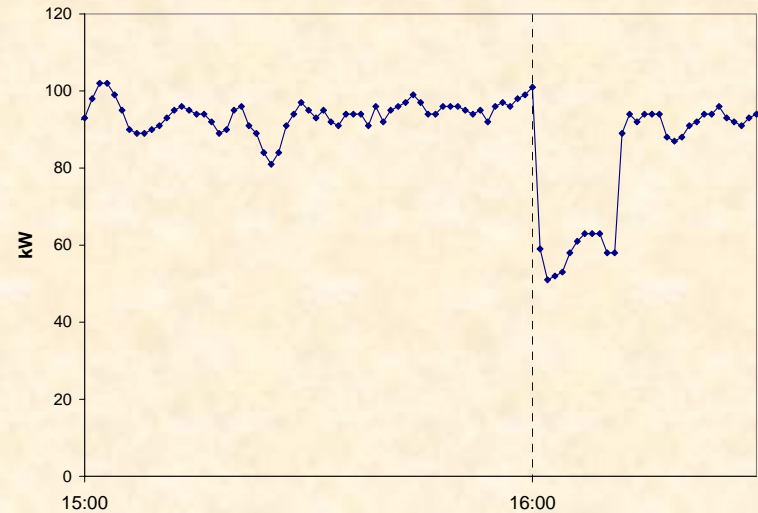
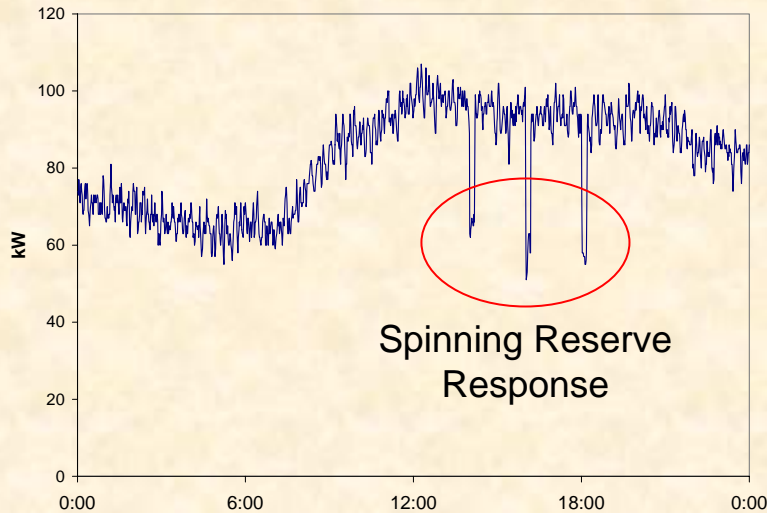
*Not necessarily available in "square" blocks*

# Spinning Reserves From Many Small Loads Commercial and Residential Loads

- Supervisory controllers in hospitality industry can:
  - Save energy and can reduce electric demand
  - Reduce space heating/cooling in rooms that are unoccupied
  - Shift electric loads during peak periods for short time intervals
  - Provide the capability for utilities to satisfy spinning reserve(?)
- **Easy retrofit – Fast deployment**
  - Developed by Digital Solutions; tested for energy savings by ORNL
- **Spinning reserve is an easy add-on**
  - Modified to operate by pager signal from utility
- **Will work with many technologies**



# Digital Solutions Motel Energy Management System Provides Spinning Reserve – System Reliability Feature at Low Additional Cost

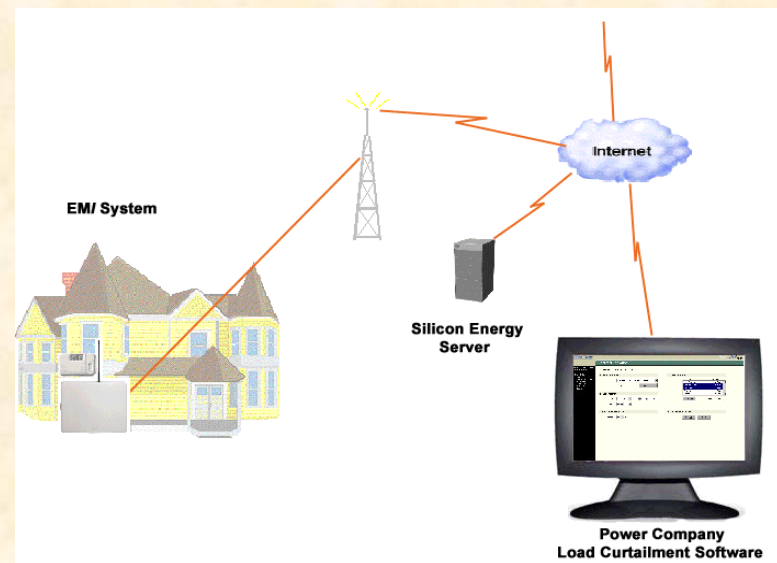
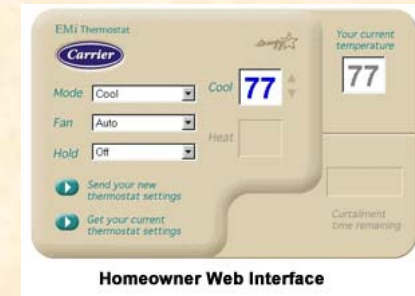


- 80 room Howard Johnson motel
- 1 minute revenue metering
- Pager deployed spinning reserve
- 34kW, 36% load drop in 1 minute

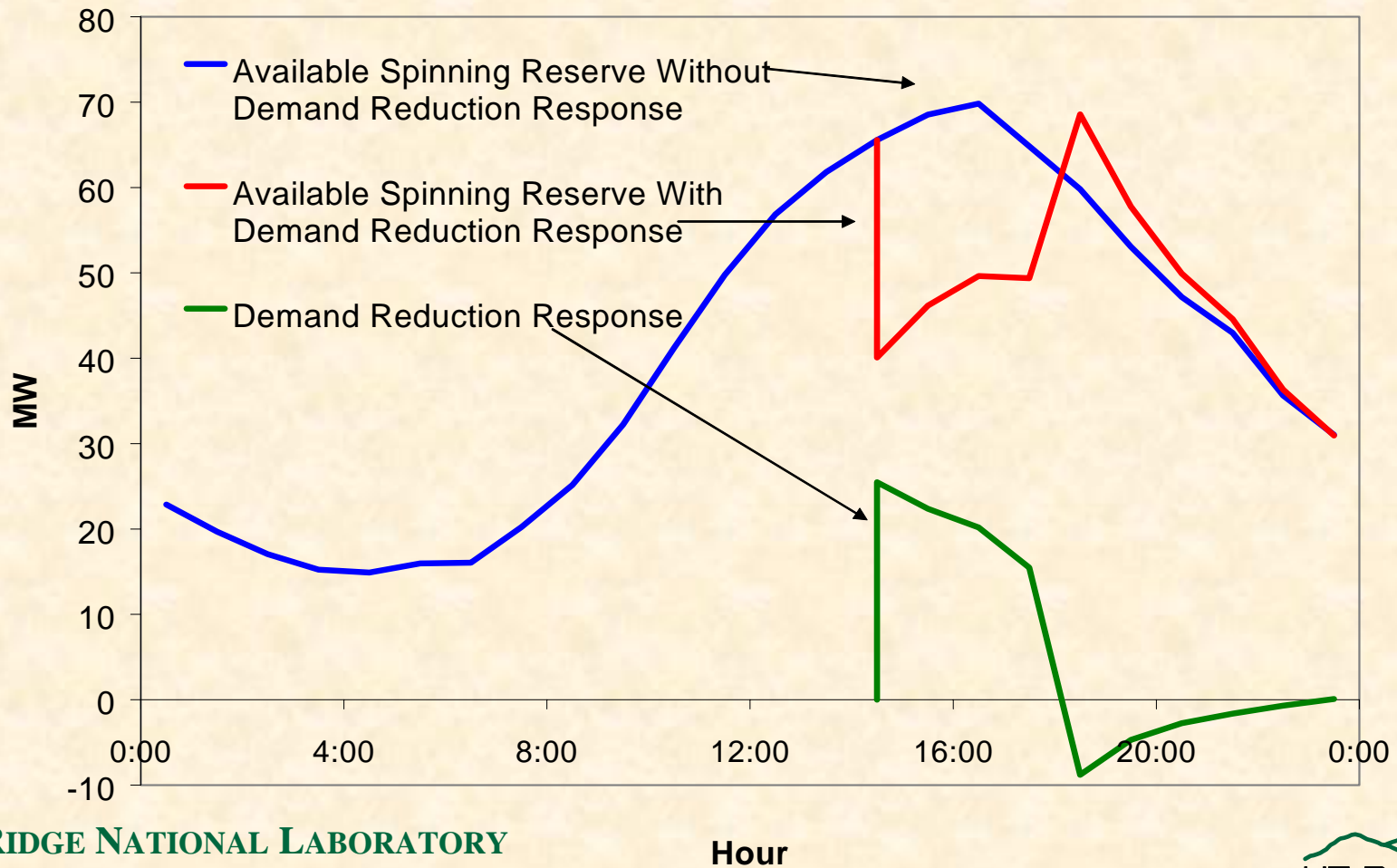


# Spinning Reserve From Residential and Small Commercial Thermostats

- Existing Carrier ComfortChoice technology for peak reduction
- Faster than generation for spinning reserve
- Spinning reserve capability ~3x peak reduction
- Significant monitoring in place



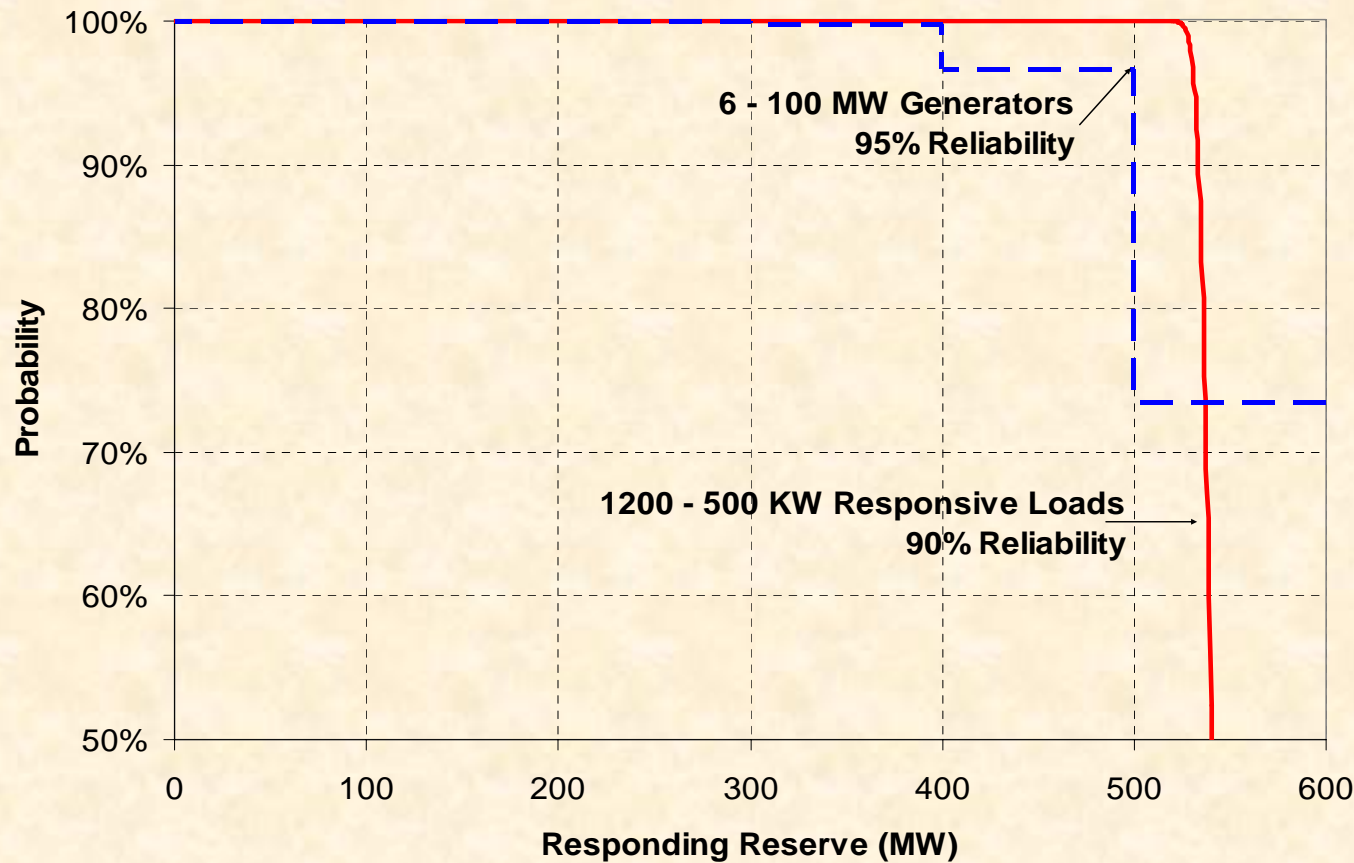
# Can Provide 3X Spinning Reserve While Providing Peak Reduction



# Substantial Installed Capacity That Could Be Tested Today

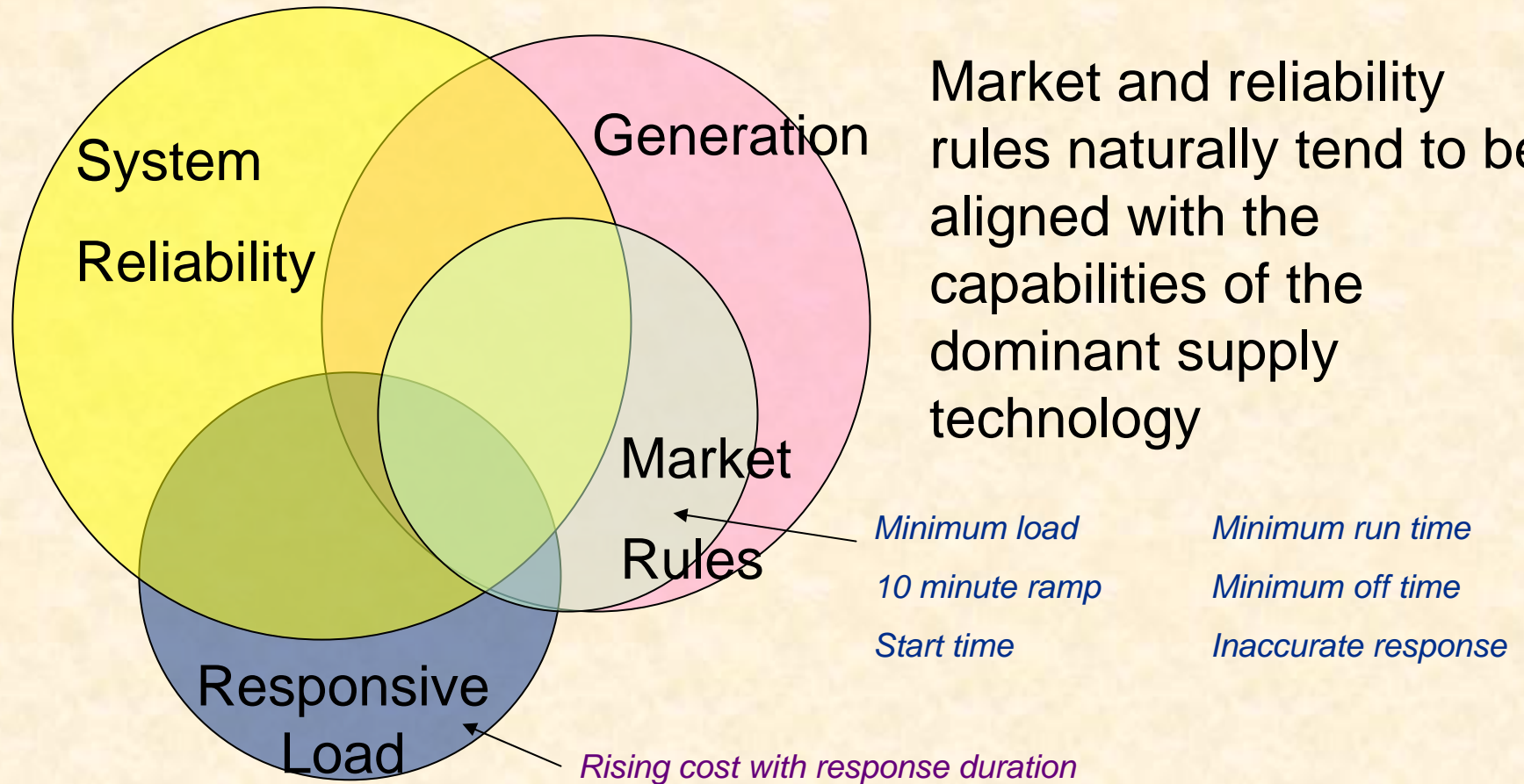
	Units	Demand Reduction	Spinning Reserve
LIPA	<b>23,400</b>	<b>25 MW</b>	<b>75 MW</b>
Con Ed	<b>10,000 (25K)</b>	<b>10 (25)W</b>	<b>30 (75) MW</b>
SCE	<b>5,000</b>	<b>5 MW</b>	<b>15 MW</b>
SDG&E	<b>5,000</b>	<b>5 MW</b>	<b>15 MW</b>

# Statistical Response May Be Better Than Monitored Response

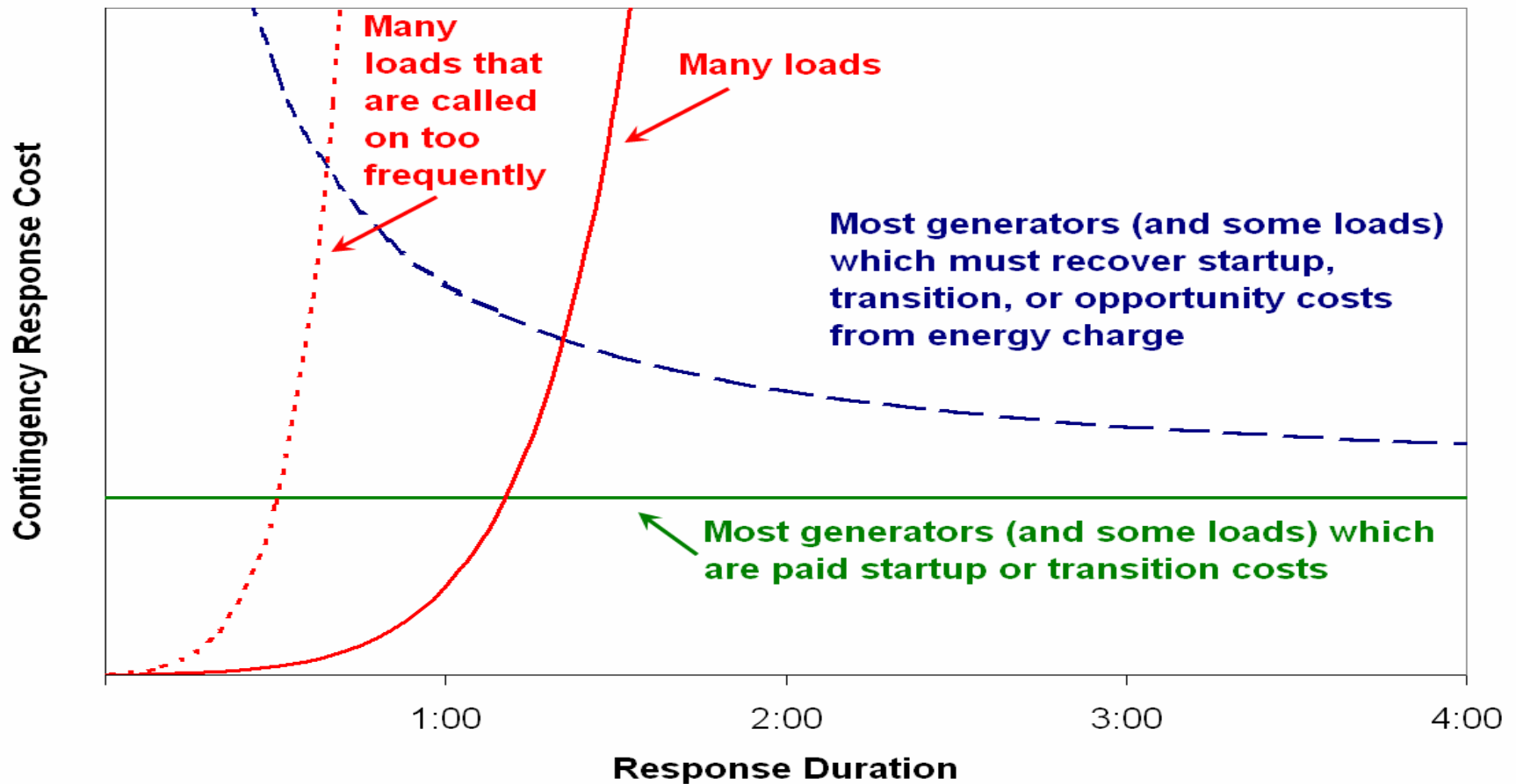


Aggregation of many (smaller) individually lower reliability resources still provides higher guaranteed response than fewer (larger) individually higher reliability resources

# Market Rules Do Not Align Perfectly With Reliability Needs



# The Rising Response Cost of Responsive Loads Is Different Than Generation: It Should Be Accommodated

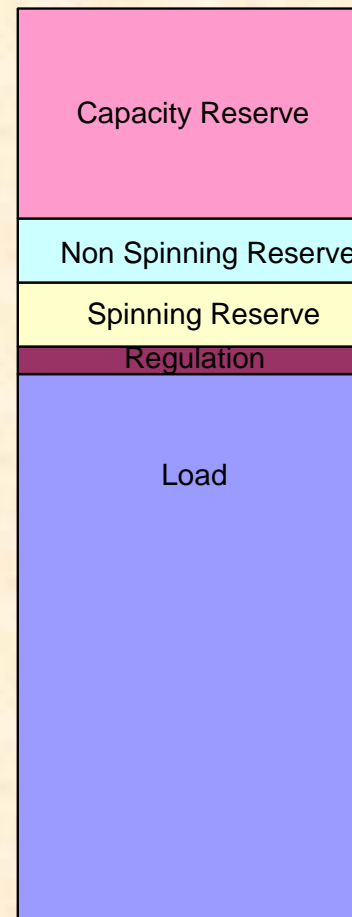


# Spinning Reserve As Capacity

Spinning reserve is part of the real-time capacity requirement

Supplying spinning reserve frees other generation to serve load

If long-term spinning reserve payments do not cover the capital cost of a CT they are probably flawed or incomplete



\$500/kw –  
Combustion Turbine

\$400/kw (Tot.);  
\$46/kw (Inc.) –  
Responsive load

Needed in Real Time

# Chickens and Eggs

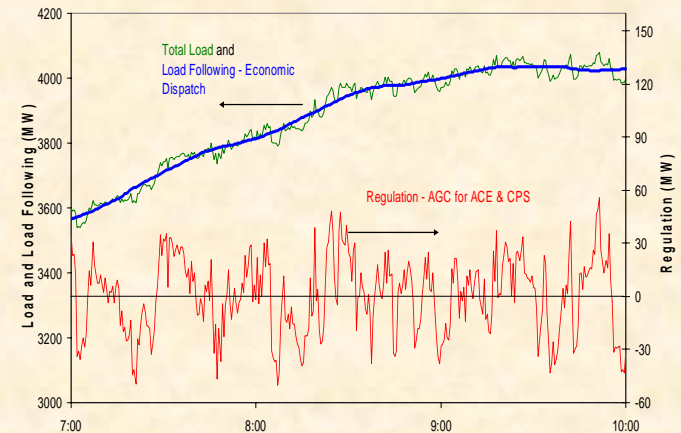
- **Reliability and market rules are structured around the incumbent large generation technology**
- **Reliability councils and ISOs will not consider changing reliability and market rules until there is consensus among all stakeholders in both groups that there is a sufficient responsive load to warrant considering a change**
- **Loads can not consider investing in response capability until they know what response is required and what the compensation will be**
- ❖ **Some ISOs are unable to facilitate tests of new technologies because that might violate their market independence**
  - ❖ **All hypothetical problems must be solved *before* any technology is tested**
- **Utility perspective is generally “Supply the slower/longer/less-critical services first. Once you are successful there then consider the faster/shorter/more-critical services”**
- **Slower services are easier for generators to provide but tougher for many loads. This approach creates a high initial hurdle.**

# Benefits and Complicating Characteristics

- **Full instantaneous response**
- **Never causes congestion**
  - Distributed throughout the network
- **Guaranteed availability when the system is under peak stress**
  - But not available 24x7
- **Power system reliability response is typically an incremental enhancement in capability**
  - Spinning reserve added to peak reduction
- **Communications and control technologies have advanced tremendously**
  - But there are many choices
- **Diversity in resource availability**
  - Increases response robustness but complicates analysis
- **Some loads' rising cost curve with response duration**
  - “Joint optimization” is optimized for generators only

# Loads May Have The Capability To Provide *Regulation*

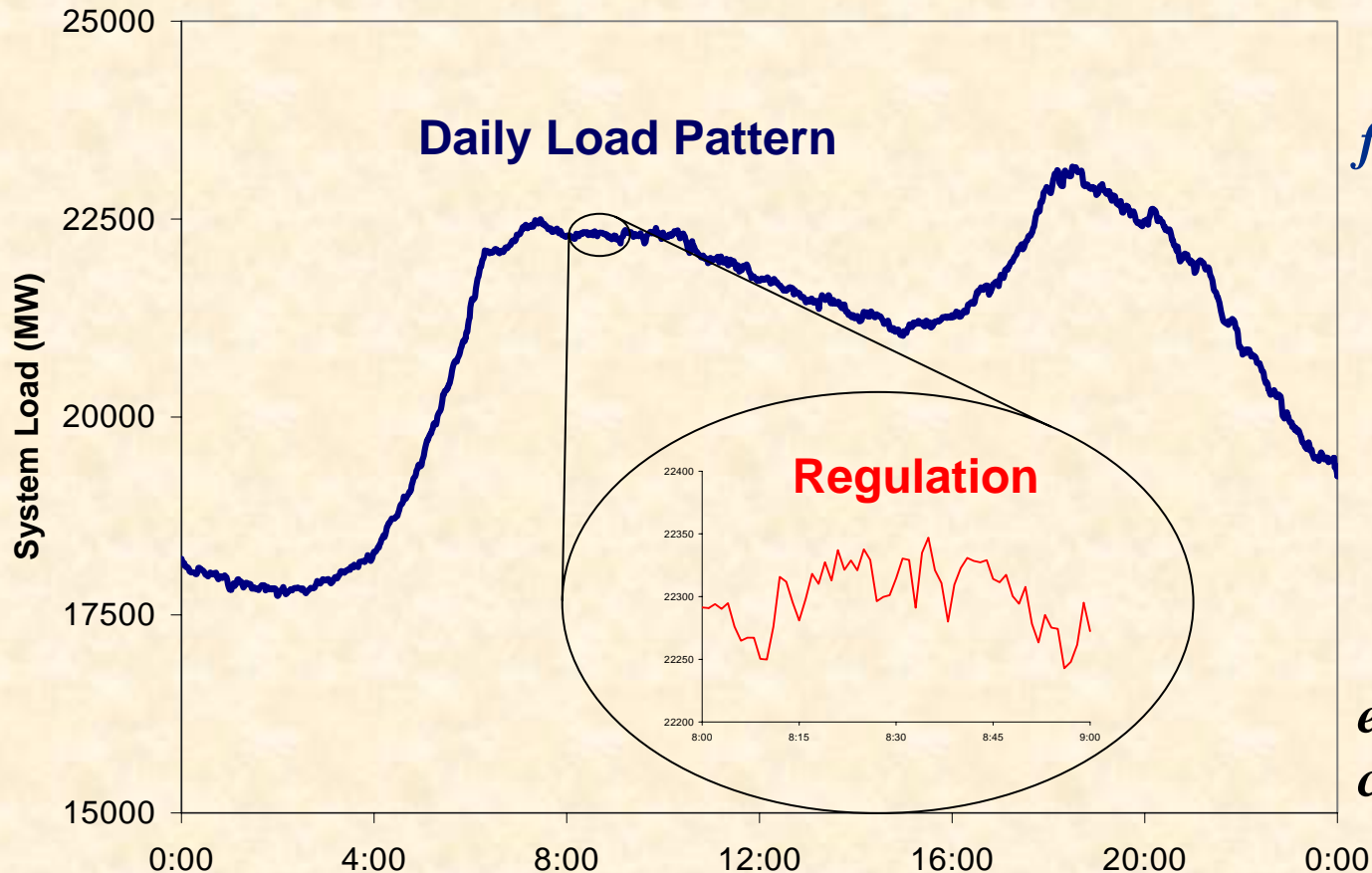
- Air liquefaction 1,000MW
- Induction & ladle metallurgy furnaces 1,000MW
- Gas & water pumping with variable speed motor drives
- **Electrolysis: >14,000MW**
  - Aluminum 6,500MW
  - Chlor-alkali 4,500MW
  - Potassium hydroxide 1,000MW
  - Magnesium, sodium chlorate, copper



CPS 1&2 are the metrics for minute-to-minute control area balancing

Regulation is the most expensive ancillary service

# Regulation Is The Most Expensive Ancillary Service Utilities Consume



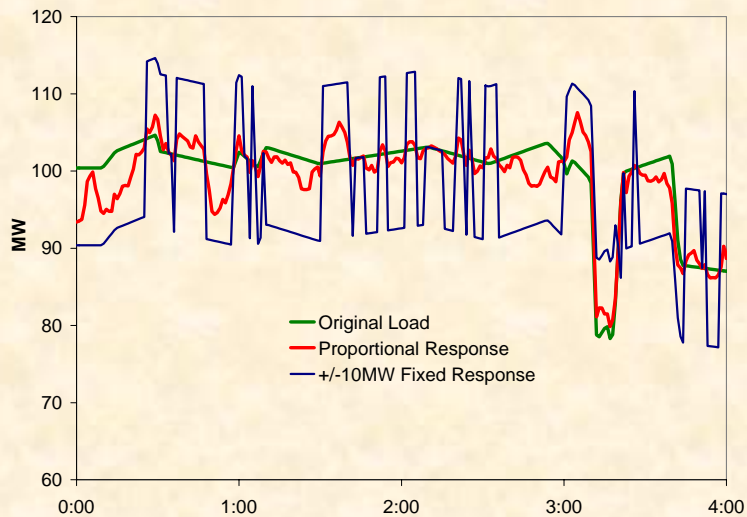
*Aggregate load follows a predictable daily pattern*

*Regulation requirements are more random*

*Regulation is not peak reduction, interruptible load, emergency response, curtailment, time-of-use, etc.*

**Regulation is the minute-to-minute balancing of the power system. It is slower than power quality and flicker. It is faster than energy markets.**

# Initial Testing of Load Supplying Regulation at CCMA



- The same net energy is consumed – the same production is met
- Two response options are shown – blue may be better for both the load and the power system than red

# Ancillary Services From *Regulated* T&D Resources: *A Paradigm Shift*

- **Generation based ancillary services are competitive because generators are primarily in competitive *energy* markets**
  - Generation based ancillary service costs are primarily energy opportunity costs
- **Responsive load that is not actively engaged in energy markets may be more like T&D resources (FACTS devices)**
  - Should not compete in competitive ancillary service markets
  - Should be rate based

# Reactive Power Analogy

- **Markets for dynamic reactive support from generators are starting to develop**
- **Should Static Var Compensators become competitive resources instead of regulated transmission resources?**
- **Should capacitors?**

**No. The regulated T&D resources reduce the system requirements for dynamic reactive power support from competitive generation markets. Regulated resources can coexist with competitive resources for the supply of ancillary services.**

# There May Be An Alternative: Regulated Resources to Manage Risk

- **The regulator could evaluate a technology, determine if it offers advantages for rate payers, approve the project (limited risk) deployment, and authorize payment through the T&D tariff**
  - It might reduce the need for an ancillary service and save rate payers money while increasing reliability
- **The ancillary service could be offered to the system operator at no cost, reducing the amount of ancillary service that must be procured in the unchanged ancillary service market**
- **Rules for service delivery can be legitimately different because the system operator is in control of how and when the resource is used**
  - Physical rules remain important but market rules can differ
  - Physical rules can be technology specific
- **If the project goes well the regulator can decide to expand the program**
  - There is no danger of unexpected market resource shifts or reliability degradation
- **The new technology may move into the competitive arena with market rules adjusted based upon knowledge rather than perception, OR the new technology may remain as a regulated T&D asset**

# Conclusions

- **Responsive load is the most underutilized reliability resource on the North American power system**
- **Power system reliability response is a *better* match to the response capabilities of some loads than peak reduction**
- **Advances in communications and control technologies now make using load response for power system reliability possible**
- ❖ ***Institutional challenges can be as great or greater than technical challenges***
  - ***New technologies need to be tested & demonstrated***

# Example: Spinning Reserves From Large Pumping Loads

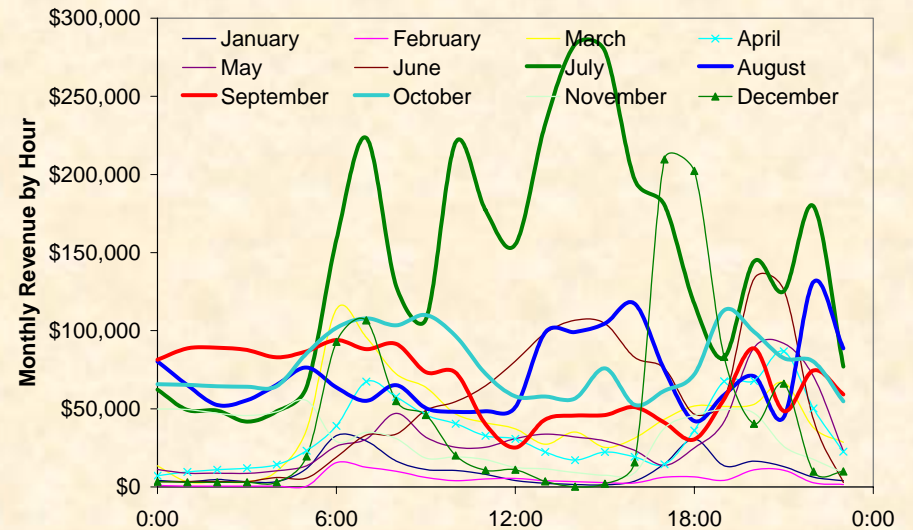
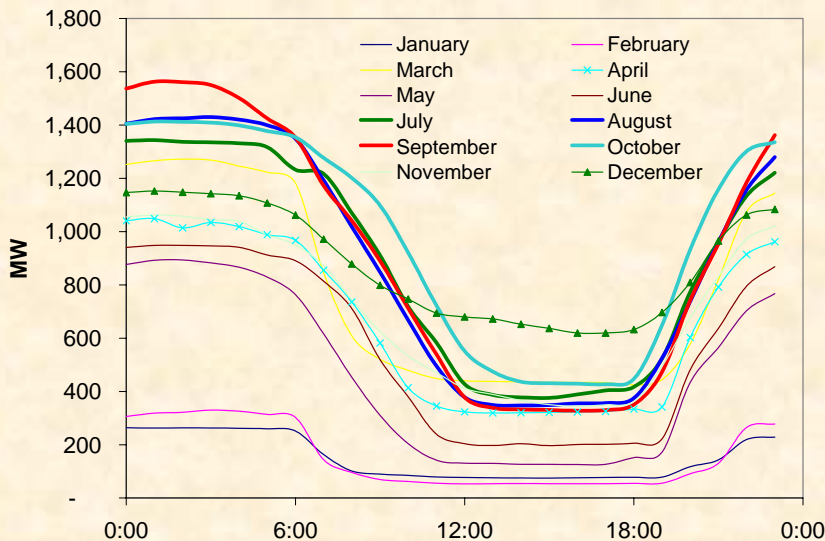
- This demonstration with the CA Department of Water Resources consist of controlling water utility pumps so that they respond to frequency deviations and system operator commands for contingency events
- Variable speed drives may help increase operational flexibility and motor lifetimes



4% of Total US Load Is Domestic Water Pumping and Irrigation. Most Have *Some* Storage. CDWR Interested In Expanding Opportunities.

- **Modeling hourly pump power consumption and power system spinning reserve price data to determine the potential benefit – consider inter-pump operating constraints and storage**
- **Evaluating soft-start capabilities**
- **Demonstrating response**

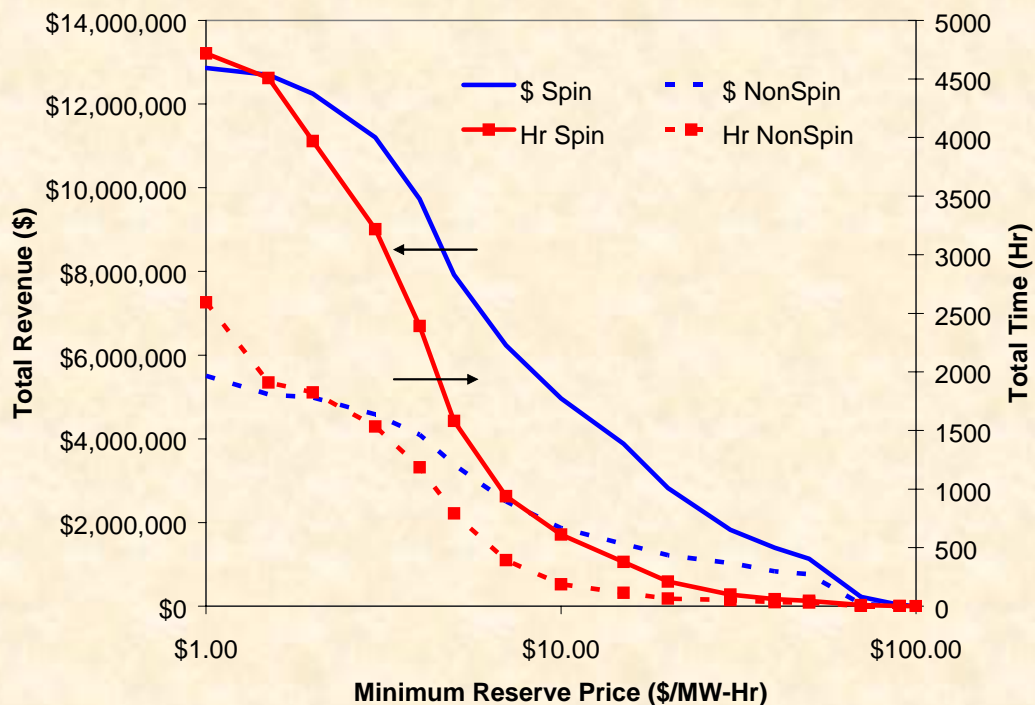
# CDWR Manages Pumping Loads To Reduce Energy Costs



## Spinning Reserve Opportunities and Revenues Are Still Substantial

# CDWR Pumps Could Supply Significant Spinning Reserve

- **62% of total California spinning reserve requirements**
- **100% of California spinning reserve requirements for 3292 hours in 2002**



# Example: Xcel Energy Demonstration

## Cabin Creek – 2x124MW Pumps

At night, when XCEL is pumping up the pond, and they already have their efficient combined cycle plants running at full load, they must run low efficiency peakers as spin. Turning off the pumps would be more reliable, and would save natural gas.

**An immediate opportunity**

OAK RIDGE NATIONAL LABORATORY  
U. S. DEPARTMENT OF ENERGY

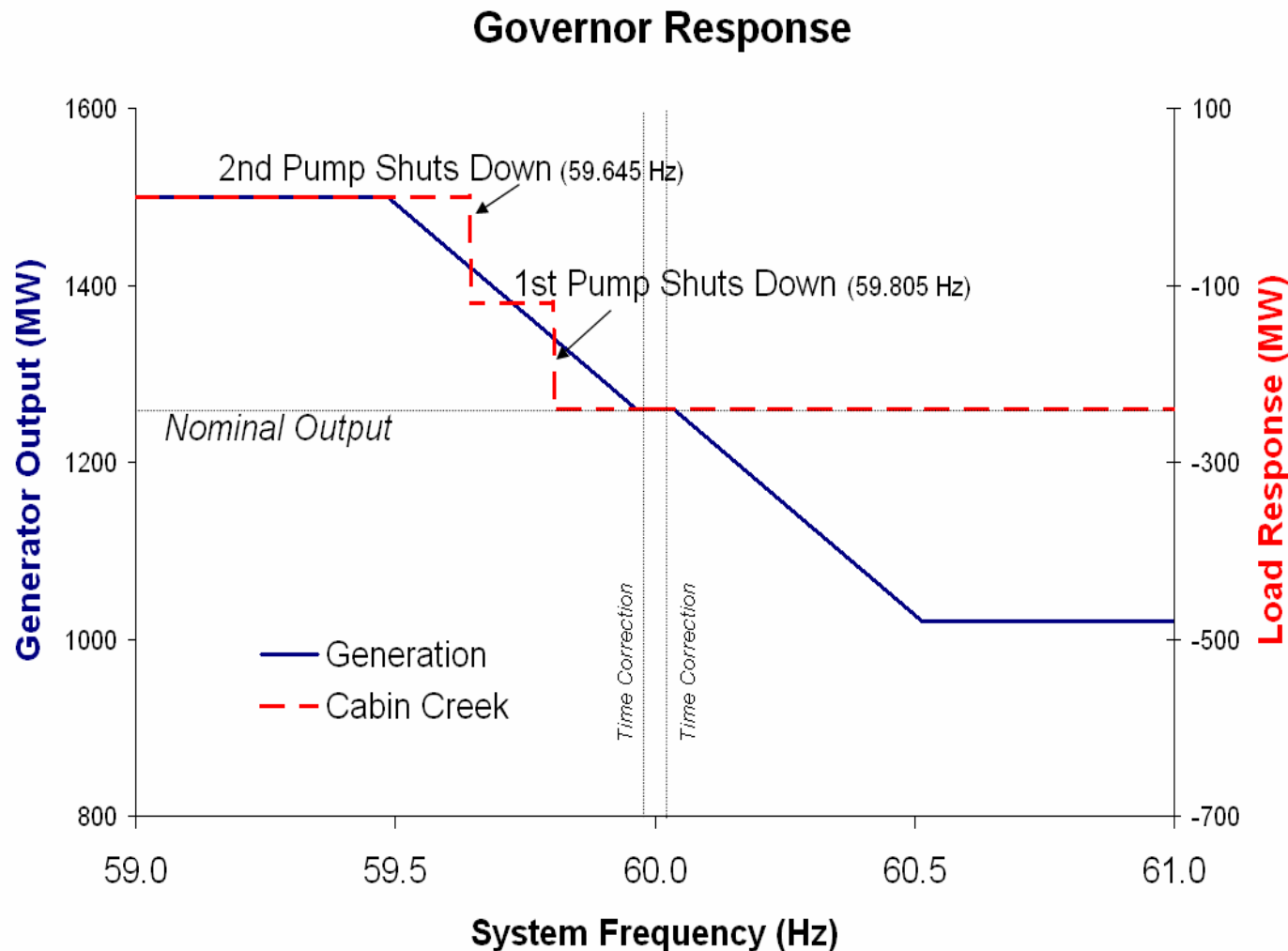


- Pumps currently supply operating reserves
- Xcel wants to supply spin from pump load
- Load removed in <1 minute

**Could be frequency responsive**

❖Must they have a droop curve?

# Cabin Creek Spinning Response Frequency Might Be Matched To The Generator Fleet Response



## Generators

- 3 x 500 MW
- 80 MW spin each
- 240 MW spin total
- 5% droop
- $\pm 0.035$  Hz deadband

## Pumps

- 2 x 120 MW
- 120 MW spin each
- 240 MW spin total
- Staggered response