

Representative Status of DSM, USA

Presentation to
IEA-DSM / Workshop on "Using DSM to Support Electricity Grids"

Mumbai, India
March 25-26

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Representative Status and Progress in the United States

- **Background**
- **Representative Sample**
 - **Spinning/Contingency Reserve**
 - **Aggregate Small Commercial/Residential**
 - **Large Industrial**
 - **Regional Market/Program**
 - **Regulation Reserve**

The North American Electric Grid is Managed by 8 (NERC) Reliability Councils

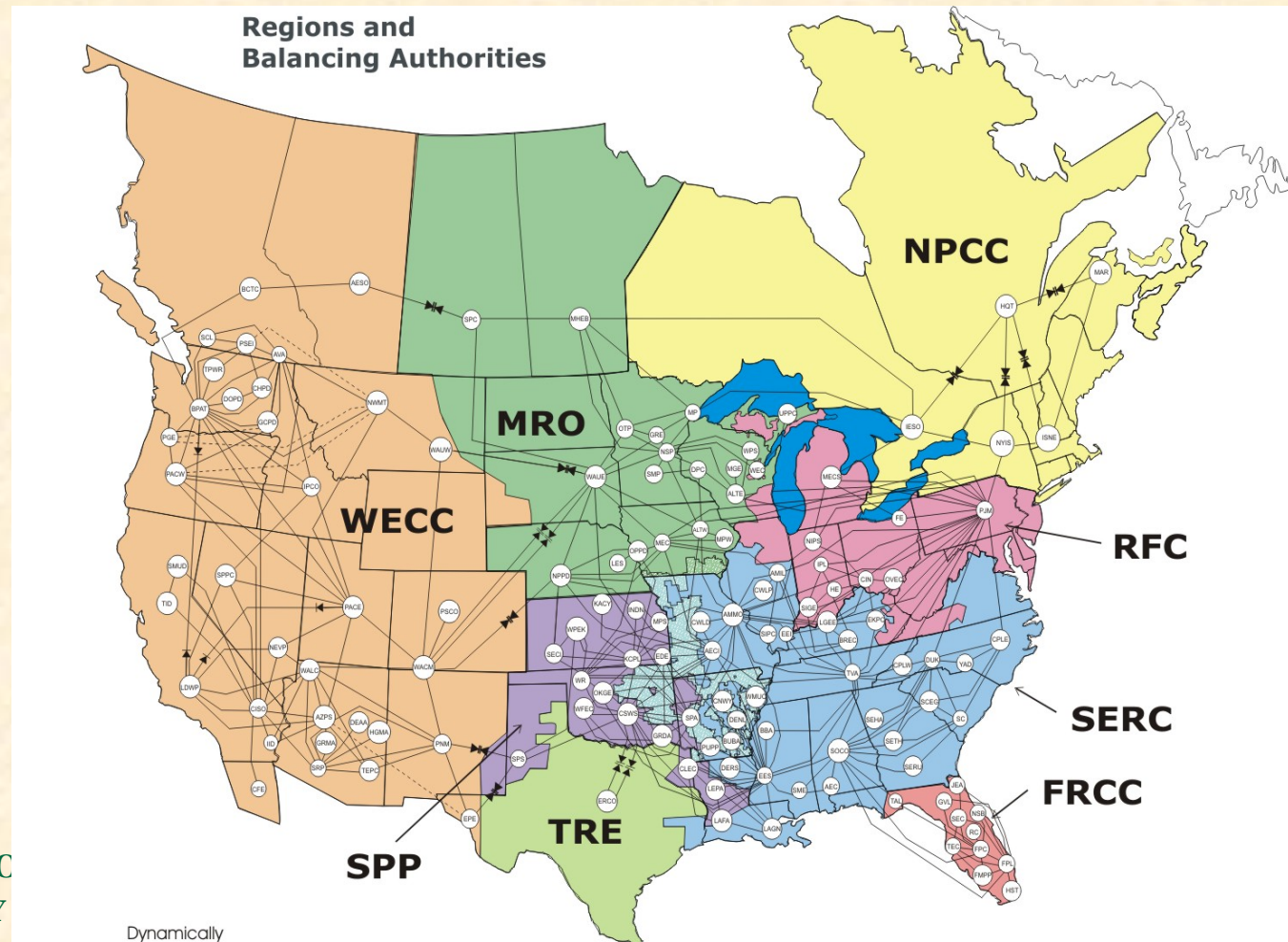
Coordinated by NERC and Regulated by FERC

Within Reliability Councils (RC) there are Balancing Areas (BA)

Independent System Operators (ISOs) are grouped as the RCs

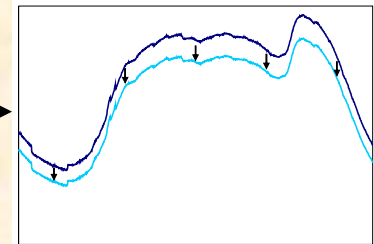
ISOs and utilities work with utilities to ensure load and generation are balanced with BAs

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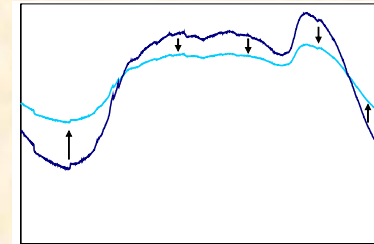
There Are Five Basic Types of Demand Response

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

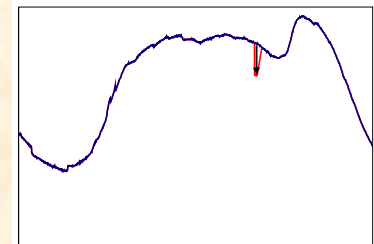


2. **Price Response** programs move consumption from day to night (real time pricing or time of use)

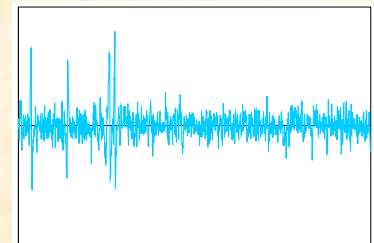
3. **Peak Shaving** programs require more response during peak hours and focus on reducing peaks every high-load day



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*



Demand Side Management is Demand/Load Response which can be (Ancillary) Services

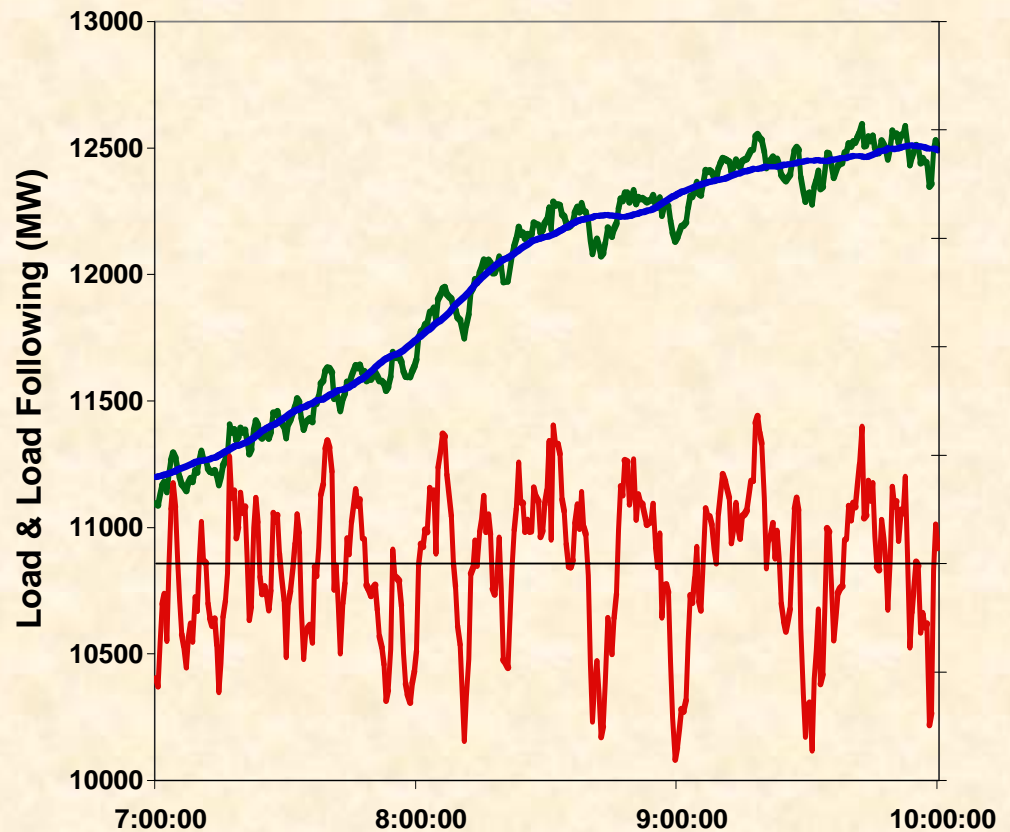
- **Demand side management can also be stated as Demand or Load Response**
- **The electric power industry can be described as set of services provided to Load**
- **Some services are ancillary to just MW/MVAR, especially as related to reliability. E.g., Spinning Reserve and Regulation**
- **These services can be supplied by generator or through Demand Response with appropriately responsive load**
 - sometimes more effectively and cheaper

Two Services Are of Prime Interest: Spinning Reserve and Regulation

- **Spinning Reserve** is paid 3x to 4x what non-spinning reserve is paid
 - \$6-\$8/MW-hr of *capacity* (no energy)
- Spinning Reserve is the fast, infrequent response to a power system failure
- Regulation is the fast, continuous response to power system balancing commands
- **Regulation** is paid 2x to 9x what spinning reserve is paid
 - \$30-\$60/MW-hr of *capacity* (no energy)
- Both are energy neutral
 - No* impact on aluminum production volume
 - ❖ *This needs discussion and work*

Load Can Be Decomposed Into Three Components

- Control area load & generation can be decomposed into three parts:
 - Base Energy
 - supplied by unit commitment selection and economic dispatch
 - Regulation
 - supplied by dedicated generation on AGC (~1.5%)
 - Load Following
 - supplied by moving units on economic dispatch



Contingency / Spinning Reserves through Responsive Load

- **Background**
- **Coordinated Small Commercial Load**
- **Coordinated Large Industrial Load**

current and previous work

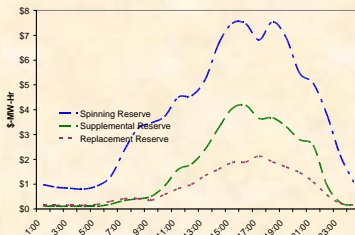
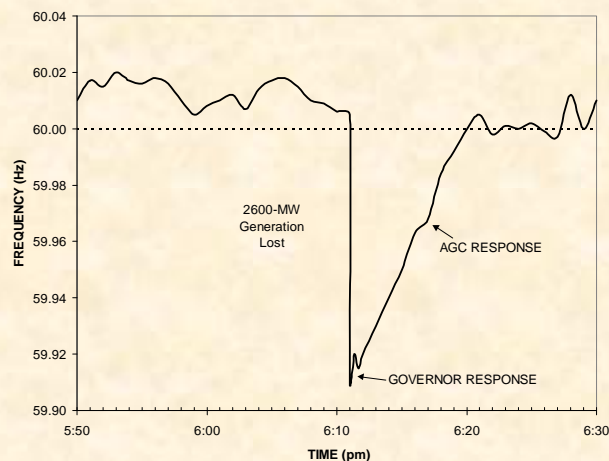
Kirby, BJ

Kueck, JD

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



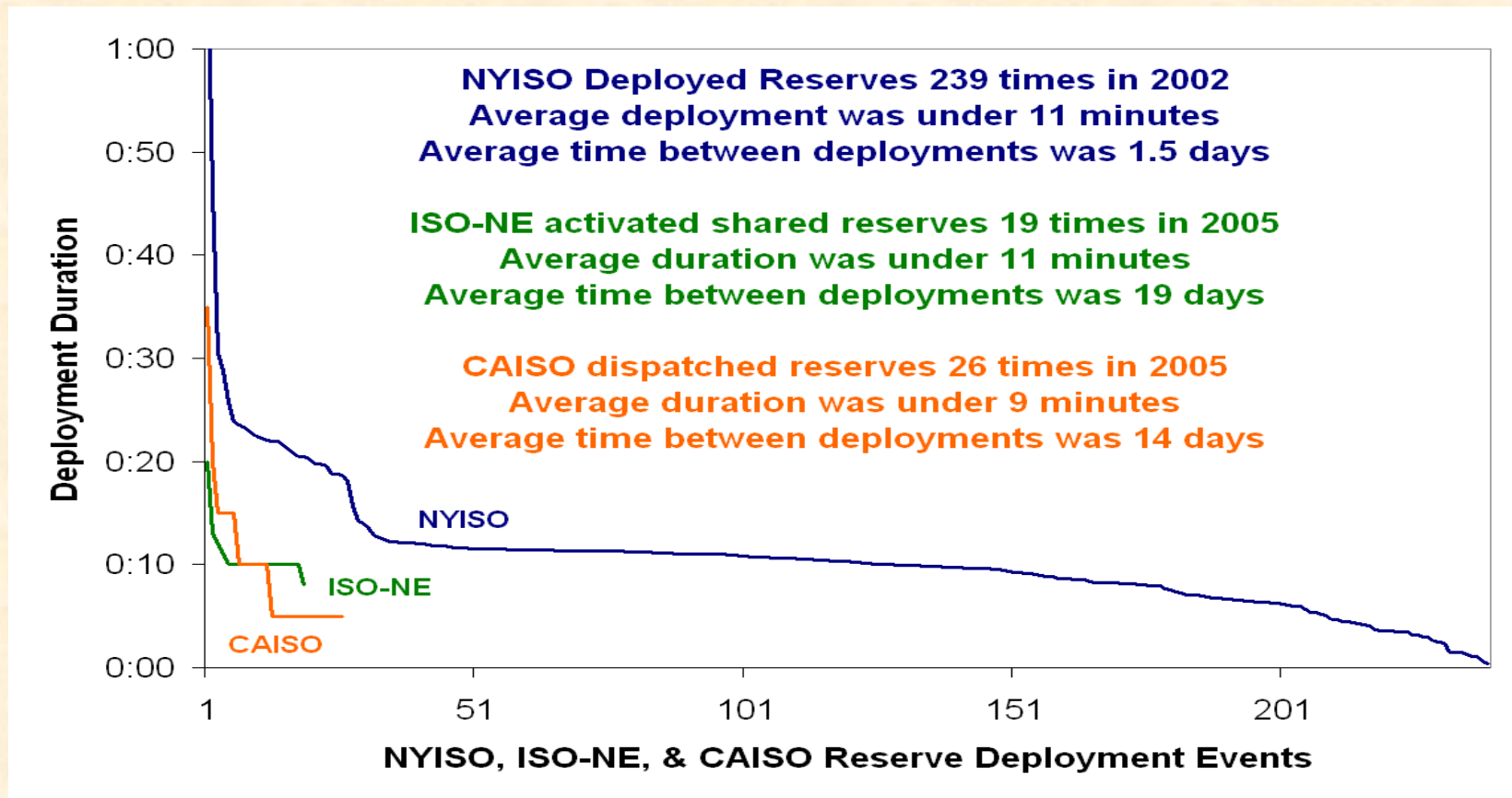
Highest value when load is most available

Not necessarily available in "square" blocks

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 are changing

Reserve Deployments Typically Short But Occasionally Long



Example: 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**



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

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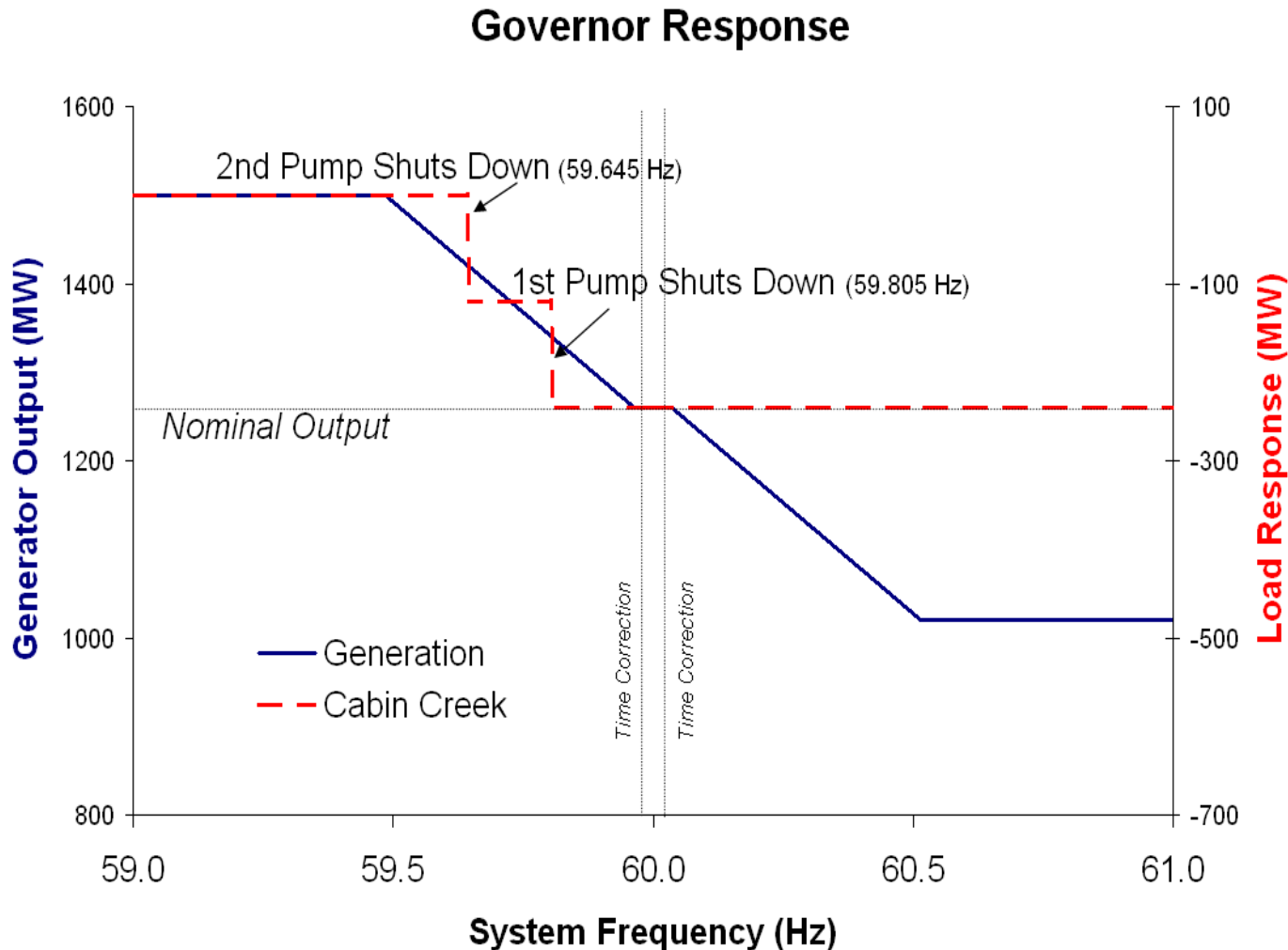


- Pumps currently supply operating reserves
- Xcel wants to supply spin from pump load
- Load removed in <1 minute

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
- ± 0.035 Hz deadband

Pumps

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

ERCOT

Electric Reliability Council of Texas

Responsive Load Market

ERCOT Allows Loads To Provide Spinning Reserve

- **Loads allowed to supply $\frac{1}{2}$ of the 2300 MW spin requirement**
 - Working very well for both the system operators and the loads
 - Restriction will likely be lifted as operators gain experience and confidence
- **More loads want to supply spin than can be accommodated**
 - 1600 MW often bid in
 - **Each is allocated $1150/1600 * \text{their-bid-MW}$**
 - Does result in oversupply when they deliver the full reserve bid

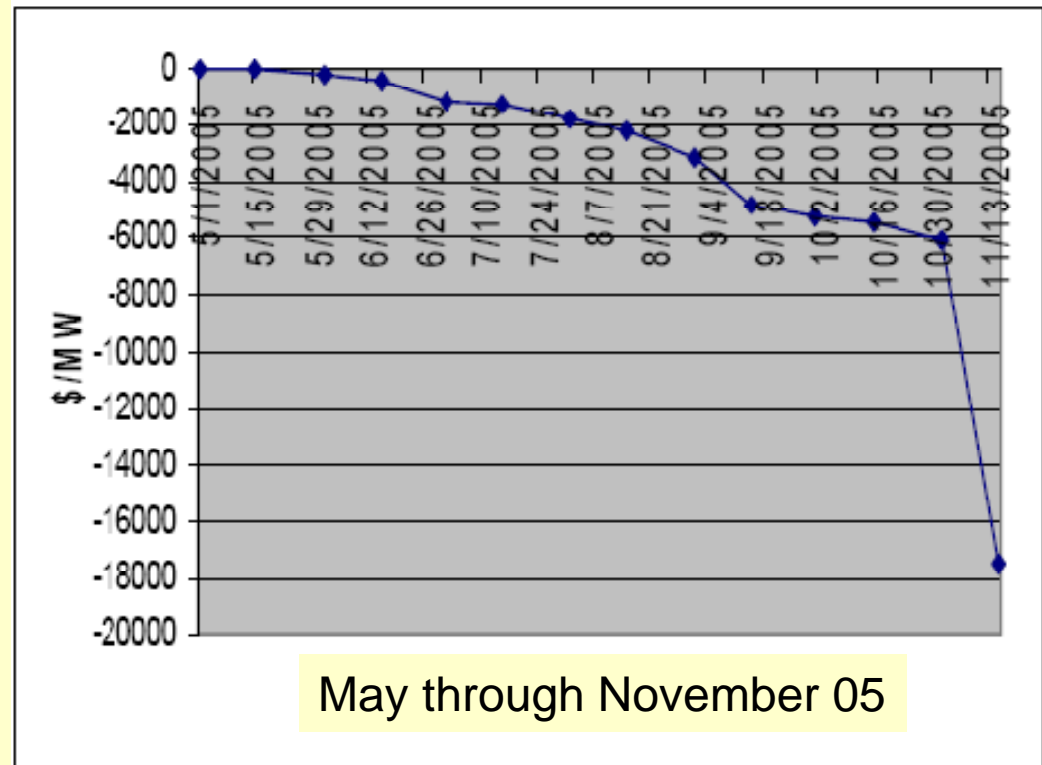
Negative Bid Prices Are A Fixable Anomaly

In 2005, the LaaR portion of the bid stack ranged from \$0 to -\$17,500 per MW, this is so loads can get the Market Clearing price set by generators.

If a current bid stack were used to clear the market under the same type conditions, the cost to LaaRs could easily be \$50MM* for that one day.

ERCOT has taken steps to correct the negative bidding.

Nodal pricing and/or removing the response cap will also solve the problem



ERCOT Responsive Loads

- **No refineries**
- **Air compressors and liquid oxygen plants**
- **Oil well fields**
- **A 15 MW cooperative residential subdivision feeder**
- **Aluminum smelting plant - 350 MW (can rotate lines)**
- **Gas pipeline compressor stations**
- **...**

Mark Patterson runs the LaaR program

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- **512-248-3912**

Regulation From Responsive Load

current and previous work

Kirby, BJ

Balancing Authority (Control Area) Performance Criteria

- **Concerned with impacts on frequency & unscheduled flows**
- **Statistical measures for balancing authorities**
 - **Control Performance Standard (CPS)**
 - **CPS1 limits annual average of 1 minute deviations**
 - **CPS2 limits 10 minute excursions**

Regulation Supply Definitions Differ Somewhat Between Regions

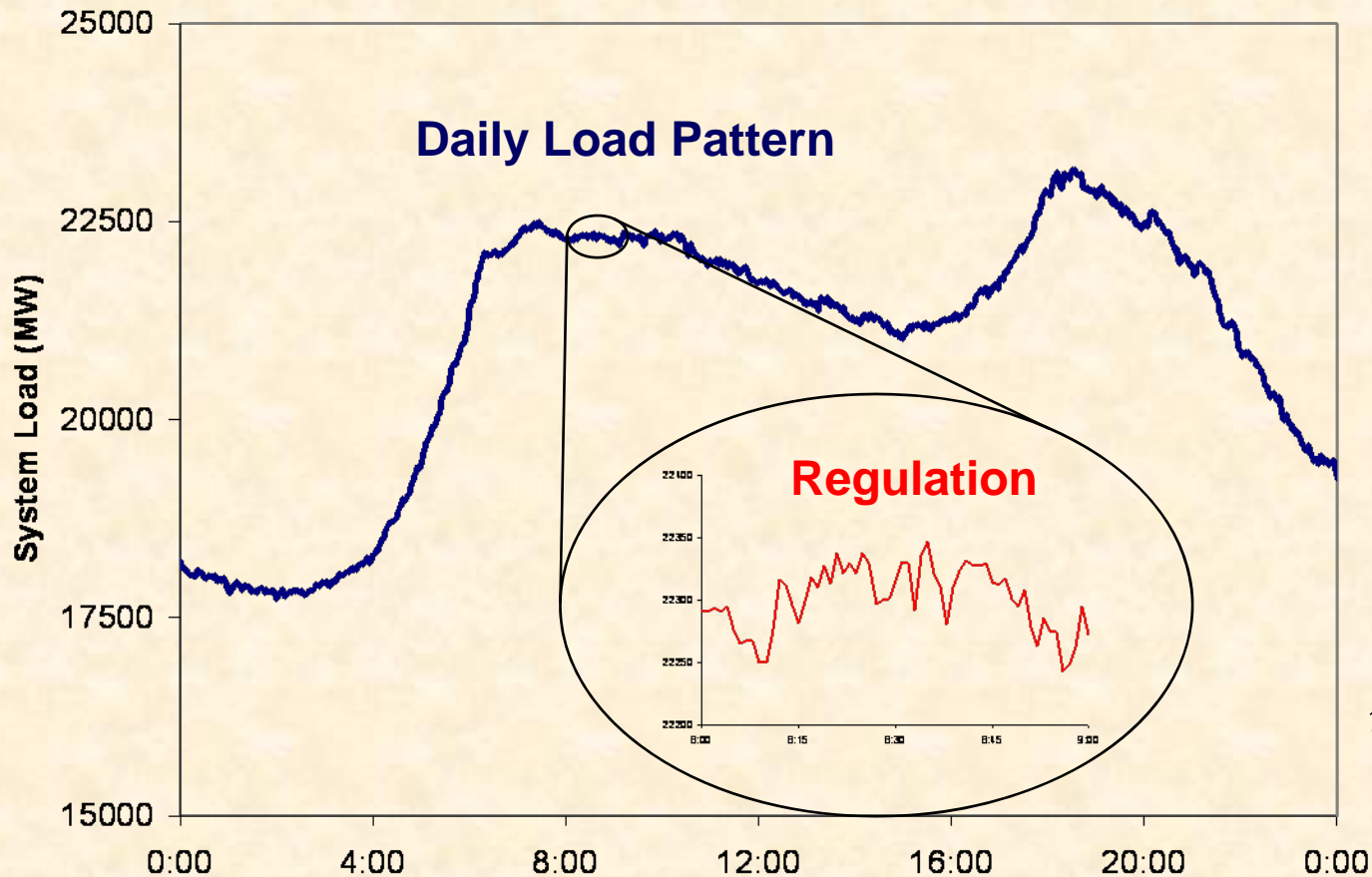
- **5 minute ramp rate**
 - PJM
 - NYISO
 - ISO-NE
 - Ontario
- **10 minute ramp rate**
 - CAIOS
 - Alberta
- **15 minute ramp rate**
 - ERCOT

There are no direct measurements of regulation supply or pay-for-performance metrics yet

Regulation And Load Following Differ

	REGULATION	LOAD FOLLOWING
Patterns	Random, uncorrelated	Largely correlated
Generator control	Requires AGC	Manual
Maximum swing (MW)	Small	10 – 20 times more
Ramp rate (MW/minute)	5 – 10 times more	Slow
Sign changes	20 – 50 times more	Few
Source	Dedicated resource	Economic energy movement

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.

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UT-BATTELLE

Regulation Is The Most Expensive Ancillary Service

	NY East \$/MW-hr	NY West \$/MW-hr	California \$/MW-hr	ERCOT \$/MW-hr
Regulation	\$39.6	\$39.6	\$33.2 ²	\$38.6 ²
Spinning Reserve	\$7.6	\$4.9	\$9.9	\$16.6
Supplemental Reserve	\$1.5	\$0.6	\$3.2	\$6.1
Replacement Reserve	\$0.4	\$0.4	\$1.9	-

1 2005 prices

2 California and ERCOT purchases up and down regulation separately. The combined price is shown here.

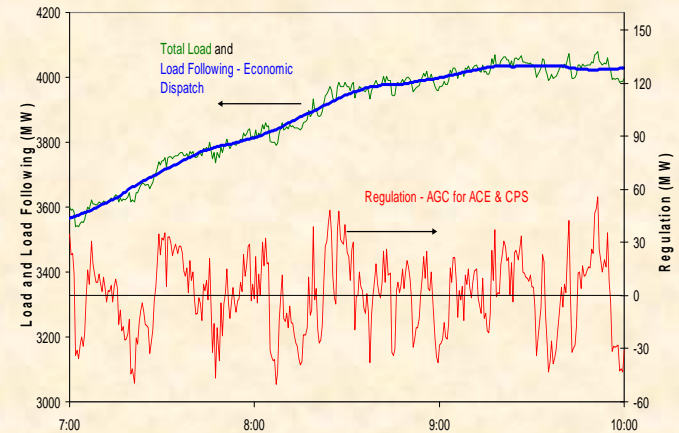
- **Power prices in the Southeast and Northwest are lower than in the Northeast or West**
- **Regulation prices are likely lower as well**

Desirable Load Characteristics

- **High energy requirement**
- **High energy content in product cost**
 - Electricity price sensitive
- **Rate of consumption not tied to product quality**
 - Technology fixes available
- **Ability to control electricity consumption**
 - Flat base consumption
 - Solid state controller
- **Excess production capacity available**

Some Loads May Have The Capability To Provide Regulation (cont.)

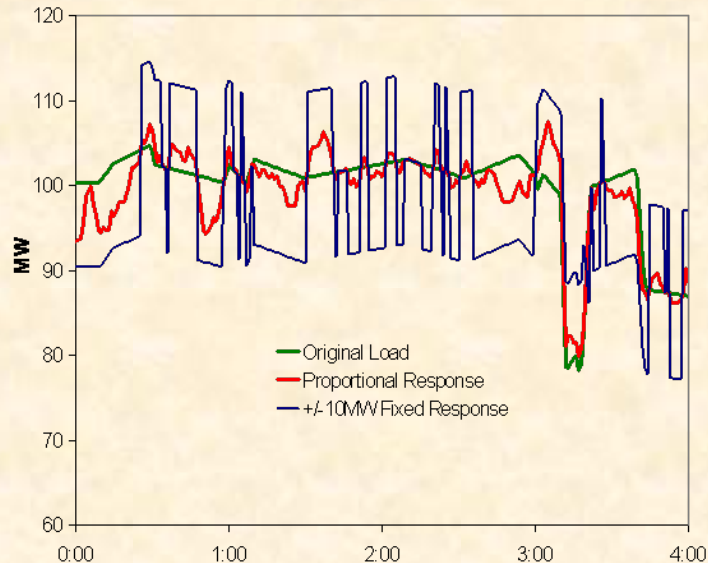
- **Air liquefaction 1,000MW**
- **Induction & ladle metallurgy furnaces 1,000MW**
- **Gas & water pumping with variable speed motor drives**
- **Electrolysis: >14,000MW**
 - **Aluminum 6,500MW**
 - **Chlor-alkali 4,500MW**
 - **Potassium hydroxide 1,000MW**
 - **Magnesium, sodium chlorate, copper**



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

Regulation is the most expensive ancillary service

Example: 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
- Used a tap changing transformer – good (cheap) test but poor solution

Conclusions (1)

- **Responsive loads have the potential to increase reliability, reduce costs, and receive a revenue stream**
- **Advances in communications and control make this practical now**
- **Supplying regulation could greatly benefit both power system reliability and aluminum production**

Conclusions (2)

- **Customer motivation is essential for a significant program. Customer motivation can be ensured by attractive pricing for demand response, or, by supplying a useful technology, such as the radio controlled thermostat.**
- **A market based program which allows customers to respond to real time prices can provide a significant return (8x) on the investment.**
- **Customers are willing to respond to e mail, monitor websites, etc. when they feel they are providing a useful service, and earning money at the same time.**