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Spinning Reserve from Hotel Load Response: Initial Progress

October 2008

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SPINNING RESERVE FROM HOTEL LOAD RESPONSE: INITIAL PROGRESS

Prepared for the
Office of Electricity Delivery and Energy Reliability
Transmission Reliability Program
U.S. Department of Energy
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ACRONYMS

CAISO	California Independent System Operator
DSI	Digital Systems Incorporated
ERCOT	Electric Reliability Council of Texas
Hz	Hertz – cycles per second
ISO-NE	Independent System Operator of New England
KW	kilowatt
MW	megawatt
MW-hr	megawatt of ancillary service capacity for 1 hour
NERC	North American Electric Reliability Corporation
NYISO	New York Independent System Operator
PJM	PJM Interconnection, LLC
WECC	Western Electricity Coordinating Council

1. INTRODUCTION AND BACKGROUND

This project was motivated by the fundamental match between hotel space conditioning load response capability and power system contingency response needs. As power system costs rise and capacity is strained, demand response can provide a significant system reliability benefit at a potentially attractive cost.

At ORNL's suggestion, Digital Solutions Inc., (DSI) adapted its hotel air-conditioning/heating control technology to supply power system spinning reserve. Spinning reserve is any back-up energy production capacity that can be made available to a transmission system immediately, and once online, can operate continuously for a period of time established by the local system operator. Spinning traditionally is derived from spinning turbines. Reserve generator turbines can literally be kept spinning without producing any energy as a way to reduce the length of time required to bring them online when needed. DSI's energy-saving technology was primarily designed to provide the hotel operator with the ability to control individual room temperature set-points based on occupancy (25% to 50% energy savings based on Kirby and Ally 2002). DSI added instantaneous local load shedding capability in response to power system frequency and centrally dispatched load shedding capability in response to power system operator command.

The 162-room Music Road Hotel in Pigeon Forge, Tennessee, agreed to host the spinning reserve test. The Tennessee Valley Authority (TVA) supplied real-time metering equipment in the form of an Internet-connected Dranetz-BMI power quality meter and monitoring expertise to record total hotel load during both normal operations and testing. The Sevier County Electric System installed the metering.

Preliminary testing showed that hotel load can be curtailed by 22% to 37% depending on the outdoor temperature and the time of day even before implementing control over the common area air conditioning loads, which would further increase the curtailment. Although testing was not performed during highest system or hotel loading (September rather than July and August), and it is anticipated that curtailment would increase during those times. Full response occurred in 12 to 60 seconds from when the system operator's command to shed load was issued. The load drop was very rapid, essentially as fast as the 2 second metering could detect, with all units responding essentially simultaneously. Load restoration was ramped back up in several minutes. The restoration ramp can be adjusted to the power system needs.

Frequency response testing was not completed. Although initial testing showed that the units respond essentially instantaneously, problems with local power quality generated false low-frequency signals, which required testing to be stopped. This should not be a problem in actual operation because the frequency trip points will be staggered to generate a droop curve that mimics generator governor response. The actual trip frequencies will be low enough to avoid power quality problems. Frequency response testing will resume once the local power quality problem is fully understood and reasonable test frequency settings can be determined.

Overall, the preliminary testing was extremely successful. The hotel’s response capability matches the power system’s reliability need, being faster than generation response and inherently available when the power system is under the most stress (times of high system and hotel load). Periodic testing is scheduled throughout the winter and spring to characterize hotel response capability under a full range of conditions. More extensive testing will resume when summer outdoor temperatures are again high enough to fully test hotel response.

The next four chapters are organized as follows: Chapter 2 discusses hotel air conditioning response capability as a supplier of spinning reserve in general; Chapter 3 describes the preliminary testing and the results obtained; and Chapter 4 discusses frequency response testing. Finally, Chapter 5 provides conclusions and recommendations.

2. HOTEL RESPONSE CAPABILITY AND POWER SYSTEM RELIABILITY NEEDS

This project was motivated by the fundamental match between hotel space conditioning load response capability and power system contingency response needs.[1] As power system costs rise and capacity is strained, demand response can provide a significant power system reliability benefit at a potentially attractive cost. This chapter discusses the power system's fundamental reliability requirements and how responsive load capability matches those requirements.

The power system must be continually ready to respond to the sudden failure of a major generator or transmission line. Extra generating capacity is kept available to provide a series of reserves that can restore the generation/load balance as shown in Fig. 1. The reserves are sequenced with spinning reserve responding immediately followed by non-spinning and replacement reserves.[2] Finally, the energy market responds and conditions return to normal. When responsive loads provide contingency reserves, generation is freed up to generate and supply load rather than having to stand by to supply reserves.

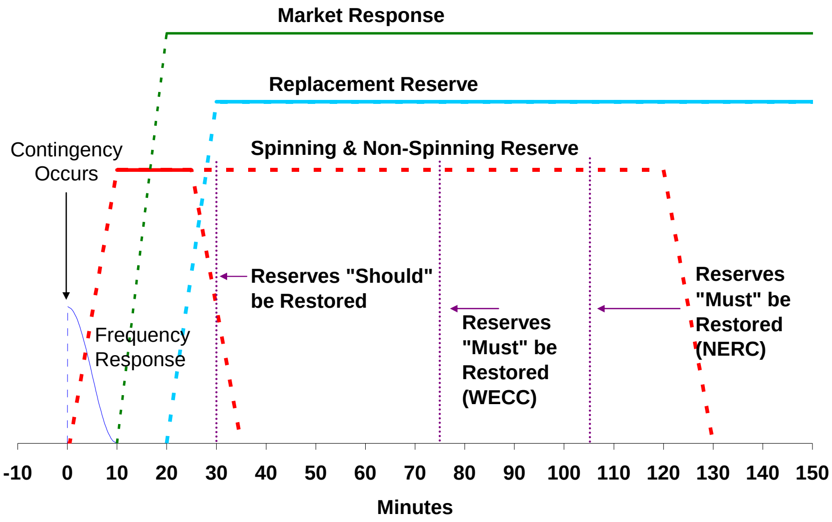

Fig. 1. A series of contingency reserves are kept available to maintain power system reliability in case a major generator suddenly fails.

It is desirable to restore the contingency reserves as quickly as possible so that they are available to respond to another generation failure. North American Electric Reliability Corporation (NERC) rules require reserves in the east to be restored within 105 min. Western Electric Coordinating Council (WECC) rules require reserves to be restored

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[1] Other loads are also potentially excellent suppliers of spinning reserve for essentially the same reasons discussed here. Residential air conditioning, hot water heaters, pool pumps, agricultural water pumping, many industrial processes, commercial freezers, and numerous other loads are potentially in this category.

[2] A frequency responsive reserve is being discussed that will replace the frequency responsive component of spinning reserve.

within 75 min in the west. In actual practice, reserves are typically restored much faster, as shown in Fig. 2 for three independent system operators (ISOs): New York (NYISO), New England (ISO-NE), and California (CAISO). Both California and New England deploy contingency reserves about twice per month. New York uses contingency reserves about ten times more frequently. Fig. 2 also shows that in all three balancing areas, the contingency reserve deployment is typically short, only occasionally longer than the average of about 11 min .

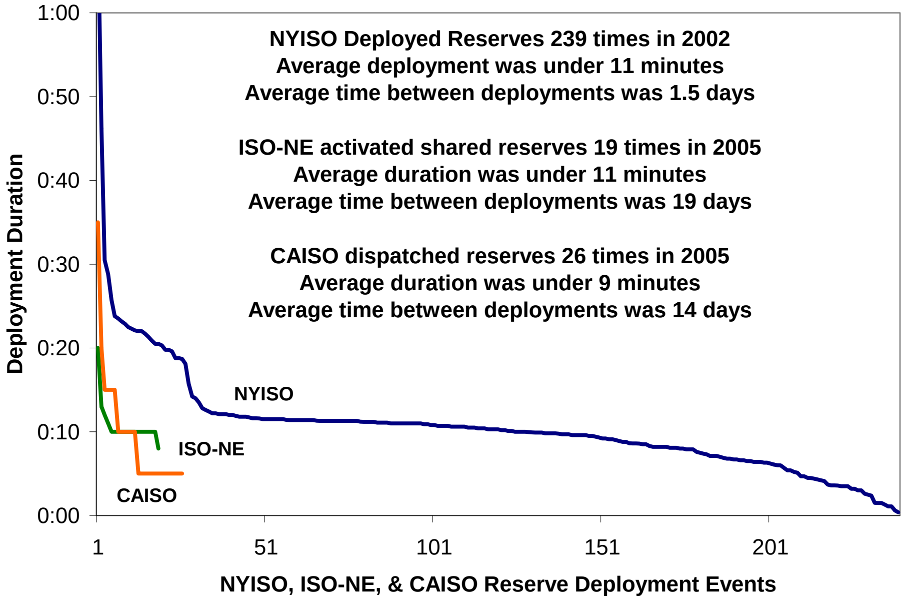

Fig. 2. Although ISOs differ in the frequency of their use of contingency reserves, reserve deployment averages about 11 min.

The power system need for rapid response that typically lasts 10 to 30 min but which can occasionally last longer, shown in Fig. 1 and Fig. 2, matches the response capability of some space conditioning loads quite well. These loads are typically capable of numerous short and infrequent sustained curtailments (Kirby 2003). They can be rapidly restarted and are ready to immediately respond again should another contingency arise. They do not have ramping time, minimum on time, or minimum off time limits that constrain some generators. The only time delay is for the control signal to get from the system operator to the load; much faster than the 10 min allowed for generation to fully respond. When responding to system frequency deviations, the curtailment can be essentially instantaneous. Communications delays are not encountered because frequency is monitored at the load itself.

Supplying contingency reserves is technically more attractive to some loads than providing peak reduction because the response duration and response frequency are shorter. Peak reduction requires actually responding, typically for multiple hours per day, often for multiple days in a row. Peak load reduction is typically required at exactly the time when the air conditioning itself is most needed. In fact, the power system peak is typically created by the air conditioning load. Providing contingency reserves requires that the load be *poised* to respond immediately if a power system emergency occurs but to operate normally otherwise. This imposes a technical communications and control requirement on the load but does not otherwise interfere with the load's normal function.

Supplying faster, shorter, ancillary services is typically more attractive economically as well because spinning reserve is usually worth 2 to 8 times as much as non-spinning reserve and 2 to 20 times as much as replacement reserves on an annual average basis.[3] Ancillary service prices value response speed rather than response duration (Kirby 2006).

The inherent *physical* response capability of some loads is a better match to the fast, short, less frequent *physical* response requirements of spinning reserve than it is to the longer duration, more frequent response requirements of peak reduction or replacement reserves. For some loads, the advanced warning given before response that is required for the slower services has little benefit. Advances in communications and control technologies make the fast response possible. Hotel air conditioning loads, for example, can provide significantly more spinning reserve response than they can provide peak reduction.

One fundamental characteristic that helps determine which service a responsive load can best provide is the amount of storage the load has available. Storage may be in terms of widgets a factory is producing, pressure in a gas pipeline, water in a reservoir, or the thermal mass of a building. There is typically enough thermal storage in a hotel room, for example, to allow the air conditioner to be turned off for 10 to 20 minutes. Longer interruptions may be acceptable if they are infrequent. This matches the power system's requirements for spinning reserves, which are often deployed for ten minutes and infrequently deployed or an hour or more. Peak reduction typically requires response lasting many hours and occurring for at least several days in a row. Providing advanced warning does little to increase the hotel's ability to sustain longer response.

2.1 CO-OPTIMIZATION: EXCELLENT FOR GENERATION, BAD FOR LOAD RESPONSE

Co-optimization (also called joint optimization, simultaneous optimization, or rational buying) minimizes the total cost of energy, regulation, and contingency reserves by allowing the substitution of "higher value" services for "lower value" services. If a generator offers spinning reserve at $8/MW-hr, for example, and other generators are offering non-spinning reserve at $12/MW-hr, the co-optimizer will use the spinning reserve resource for non-spinning reserves (instead of the non-spinning reserves offered) and pay it the spinning reserve clearing price. Co-optimization has many benefits. It encourages generators to bid in with their actual costs for energy and each of the ancillary services. When they do so, the co-optimizer is able to simultaneously minimize overall system costs and maximize individual generator profits.

Market rules and system dispatch software in some regions (not TVA) force all resources (generators and loads) that offer ancillary services to be co-optimized across all ancillary services and energy. Unfortunately, co-optimization can effectively bar responsive loads

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[3] Based on analysis of hourly ancillary price data covering 2002 through 2007 for CAISO, ERCOT, and NYISO.

as well as emissions-limited generators and water-limited hydro generators from offering to provide ancillary services. As indicated by the preliminary testing described in this report, a hotel can be an excellent provider of spinning reserve. The hotel can be instantaneously frequency responsive. It can respond to system operator commands much faster than conventional generation. It may have nearly zero response cost (other than the initial capital cost for the communications and control equipment). It might be able to easily sustain response for 15 to 30 min on a regular basis and occasionally for 60 min or longer. In short, it may be a nearly ideal supplier of spinning reserve. But the hotel would be completely unable to provide an 8, 12, or 24 hour response if co-optimized to provide an *energy* response. If there was a risk that the attractive offer to provide spinning reserve could be exercised as an energy source, the hotel would simply not enter the spinning reserve market. The power system would be denied the benefit of this excellent reliability resource.

Many responsive loads differ from most generators in that the cost of response rises with response duration. An air conditioning load, for example, incurs almost no cost when it provides a 10-min interruption but incurs unacceptable costs when it provides a 6-h interruption. Conversely, a generator typically incurs startup and shutdown costs even for short responses but the only costs associated with its response duration are ongoing fuel costs. In fact, many generators have minimum run times and minimum shutdown times. This low-cost-for-short-duration-response (coupled with fast response speed) makes hotel space conditioning (and some other loads) ideal for providing spinning reserve but less well suited for providing energy response or peak reduction.

Unfortunately, current market rules in New York and New England let the ISOs dispatch capacity assigned to reserves for economic reasons as well as reliability purposes. As long as the ISO has enough spinning and non-spinning reserve capacity to cover contingencies, it will dispatch any remaining resources economically regardless of whether that capacity is labeled as contingency reserve. Ancillary service and energy suppliers are automatically co-optimized. This policy works well for most generators but causes severe problems for loads that need to limit the duration or frequency of their response to occasional contingency conditions.[4] Loads can submit very high energy bids in an attempt to be the last resource called but this is still no guarantee that they will not be used as a multi-hour energy resource. Submitting a high cost energy bid also means that the load will be used less frequently for contingency response than is economically optimal. Price caps on energy bids further limit the ability of the loads to control how long they are deployed for.

Fortunately, there is a simple solution. California had this problem with its rational buyer but changed its market rules and now allows resources to flag themselves as available for contingency response only. PJM Interconnection, LLC, a regional transmission organization, allows resources to establish different prices for each service and energy providing a partial solution. The Electric Reliability Council of Texas (ERCOT) does not currently have the problem because most energy is supplied through bilateral arrangements that do not include the ISO. Energy and ancillary service markets are

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[4] Co-optimization often does not work for energy or emissions limited generators either.

separate. Possibly as a consequence, half of ERCOT's contingency response comes from responsive load (the maximum currently allowed) while no loads offer to supply balancing energy.

2.2 CAPACITY VALUE OF LOAD RESPONSE

Responsive load provides the power system with capacity even if the response is limited to spinning reserve and limited to times of high system load. This is because the power system need for capacity includes the contingency reserve requirement. Fig. 3 shows the real-time power system capacity requirements. The power system must have enough capacity to meet load as well as additional capacity to supply regulation, spinning reserve, and non-spinning reserve. Just as a nuclear generator that is incapable of providing regulation is still a capacity resource because it contributes to the on-peak capacity stack, so too is a spinning reserve supplier a capacity resource even if it cannot supply energy. All equally contribute to the total system capacity requirement.

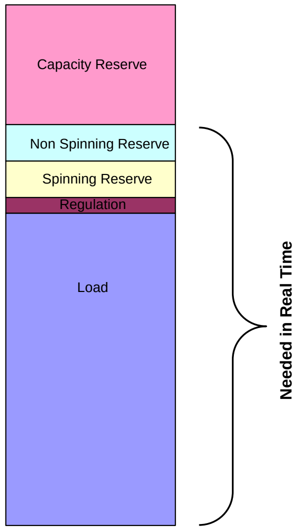

Fig. 3. Ancillary service providers contribute capacity just as peak- and base-load generators do.

3. PRELIMINARY TESTING RESULTS

The Music Road Hotel in Pigeon Forge, Tennessee, agreed to host the spinning reserve tests (Fig. 4). DSI controllers were installed in 162 rooms and on 12 hallway air conditioners (Fig. 5). The primary function of the DSI controllers is energy savings.

Fig. 4. The 162-room Music Road Hotel in Pigeon Forge, Tennessee, agreed to host test DSI's controllers providing spinning reserve.

Fig. 5. DSI controllers can be installed in the power supply cord for self contained room air conditioners or as wall mounted thermostats.

The DSI controllers have a temperature sensor and accept commands from the hotel front desk. When the hotel room is unoccupied (not rented), the controllers override the air conditioner's (or heater's) local thermostat setting and allow the room to reach a hotel selected temperature . When the room is rented, the front desk sends a command that returns temperature to local control. The controllers can also limit room temperature under local control if the hotel desires. Communications to the controllers is provided by Internet-initiated pager signals.

The DSI controller also monitors the power supply voltage and turns the unit off if voltage is inadequate. This feature is designed to protect air conditioning and heat pump compressors from low or high voltage burn out. It also helps the power system avoid voltage collapse.

Spinning reserve capability was added by enabling the power system operator to remotely issue a curtailment command to as many or as few devices as desired. For the loss of a major generator, the power system operator will likely curtail all of the loads simultaneously. A local problem can be addressed by curtailing all of the loads within a region or zone. Device groupings can be predefined for the system operator convenience.

Frequency response capability was also added. Frequency response testing is discussed in Chapter 4.

3.1 HOTEL LOAD PROFILE

Air conditioning and heating loads are, of course, driven by outside temperature. Daily average temperatures during 2007–2008 followed the historic pattern but were 1.9^{o}F higher than normal on average. Fig. 6 shows that the year was reasonably typical without reaching either high or low extreme temperatures. Spinning reserve response testing started in September, after the peak of the cooling season.

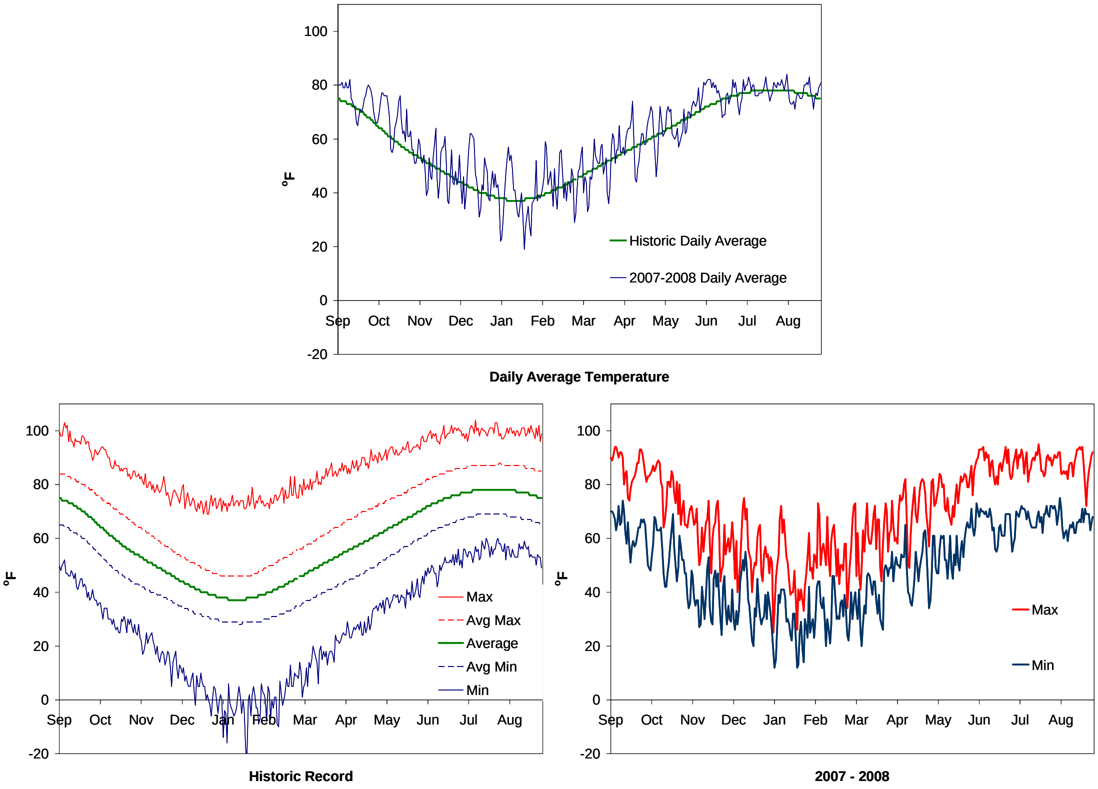

Fig. 6. Actual temperatures during 2007 and 2008 were somewhat milder than the historic extremes but followed the usual pattern.

Monthly average and peak power requirement patterns for the entire hotel (space conditioning, lighting, and other loads) appear to depend on weather and other influences, probably the hotel business cycle, as shown in **Fig. 7**.

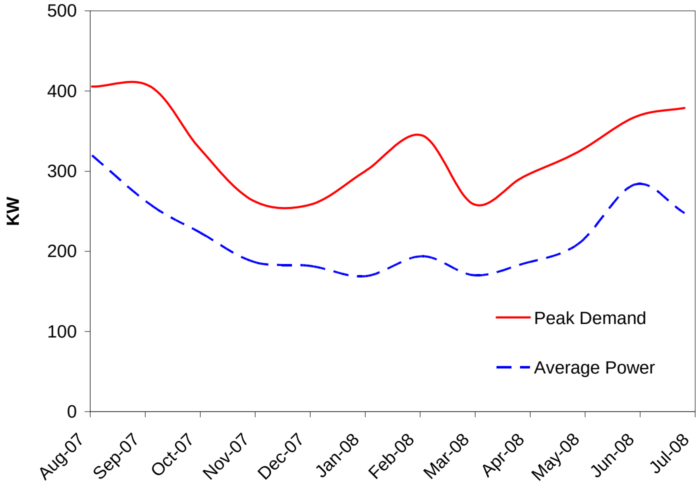

Fig. 7. Hotel peak and average power requirements appear to depend on weather and the hotel business cycle.

The hotel also exhibits a daily load pattern similar to that of the power system itself, though this hotel does not show a weekend decline since it has a large tourist business. The evening load drop is at about 10 pm (**Error! Reference source not found.**) so the hotel should be able to supply spinning reserve well into the evening hours.

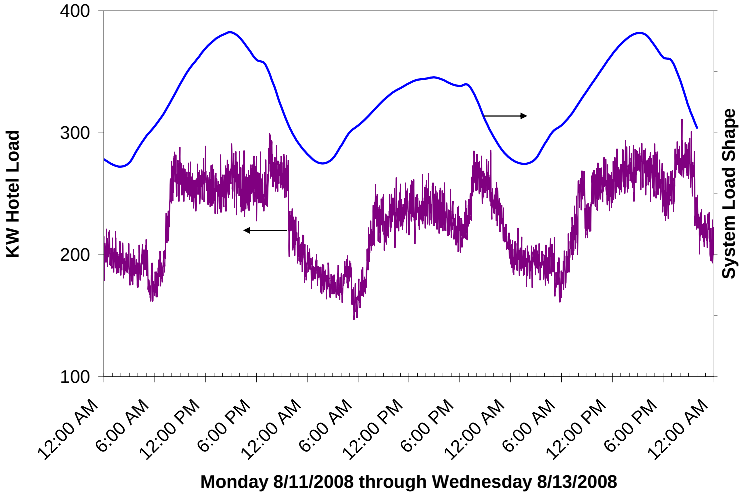

Fig. 8. The hotel shows a typical daily load pattern similar to that exhibited by the power system itself, with the evening drop occurring around 10 pm.

3.2 TESTING SPINNING RESERVE RESPONSE

The first four spinning reserve tests were performed on two days in September 2008. Data from the September 3 tests were recorded at 1-min intervals. Data from the September 5 tests were recorded at 2-second intervals. Results from both tests are shown in Fig. 9 with both the actual data and trend lines plotted. The size of the load reduction differed in each case ranging from a 22% drop at 9 am on September 5 to a 37% drop at 2 pm on September 3. Interestingly, the uncontrolled base load was reasonably consistent (180–195kW). The load drop was very fast in all four cases—as fast as the metering rate. This implies that the curtailment signal was received by all units at the same time and that re-transmission was not required.

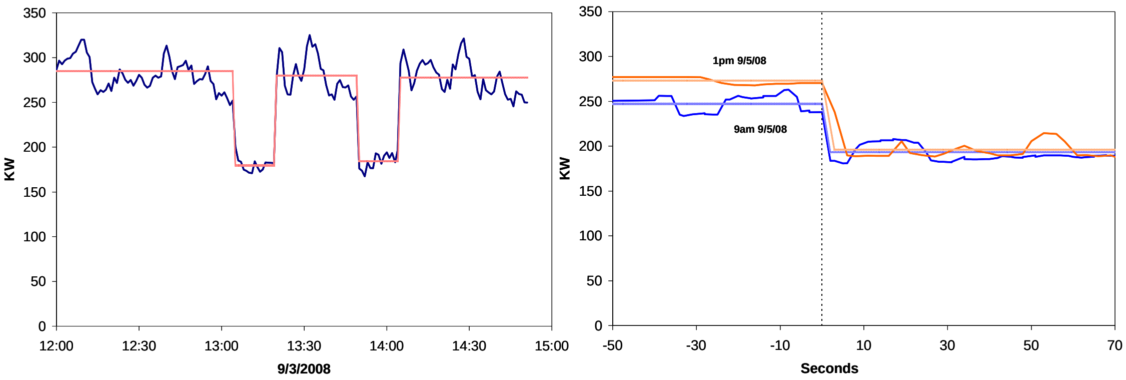

Fig. 9. Four spinning reserve tests were conducted on two days.

Each test curtailed air conditioning load for 15 min. Individual loads returned to service in 5 blocks with 90 seconds between each block restoration. Longer interruptions are controlled by repeating the curtailment command. This feature ensures that no load is left permanently curtailed if a signal is missed. Multiple curtailment signals can be sent to ensure that the curtailment is sustained as long as needed. Meter data show that once the signal was received all units responded promptly. Precise timing data showing the lag between signal initiation and load curtailment were not collected but informal observation showed time delays of 12 to less than 60 seconds.

3.3 ROOM TEMPERATURE AND HUMIDITY RISE

Temperature and humidity were monitored in 12 of the 162 rooms during the first two spinning reserve tests. Rooms were selected on the sunny side of the hotel on the 5th and 7th (top) floors to deliberately bias the results towards a greater temperature rise. On average, the temperature rose 1.7^{o}F and humidity rose 2% during the 15 minute test. Temperature recovered 1.5^{o}F and humidity recovered 0.1% on average during the 15 minutes after the test. Outdoor temperature was 90^{o}F during the temperature rise tests.

Temperature rise testing was not perfect. Some room doors were left open to facilitate equipment checking and this allowed relatively hot, humid hallway air to enter the rooms. Still, the test indicated that short curtailments normally associated with spinning reserve events should not be a significant concern. A longer test of temperature rise is scheduled to determine the impact on temperature and humidity of a 1-h curtailment.

4. FREQUENCY RESPONSE

Autonomous frequency response is an important characteristic of spinning reserve. When a substantial contingency occurs (the sudden failure of one or more large generators, for example) to shift the interconnection frequency, generator governors respond automatically to help restore the generation/load balance and return frequency to 60 Hz. They do not wait for the system operator to command the response; they sense the frequency shift and respond immediately. This fast response, though relatively rarely called upon, is critical for maintaining power system reliability.

For responsive loads to supply spinning reserve, they too must respond to power system frequency deviations. The DSI load control units monitor power system frequency and provide rapid autonomous response when frequency declines. Both the underfrequency trip point and the underfrequency duration can be configured to meet the utility reliability requirements. Frequency trip points can be staggered among individual units or among individual hotels to provide smooth frequency response and to create a "droop" curve, as shown in Fig. 10.

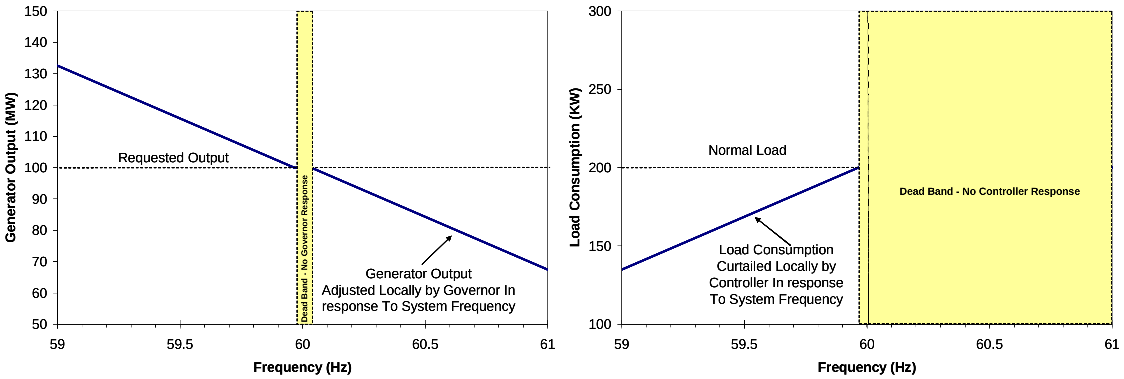

Fig. 10. Generator (left) and load (right) autonomous frequency responses are equivalent reliability resources for underfrequency response.

"Droop" refers to the proportional increase in response provided by generator governors as the frequency deviation increases. It would be undesirable to have all of the online generators provide their maximum output for a small frequency deviation—too much generation might be added and the power system would be out of balance in the other direction. To avoid this, the governors provide increasing output as the power system frequency declines further and further from 60 Hz. Droop is measured in percentage; a 5% droop means that the generator will provide an additional 100% of its rating if frequency declines by 5% (3 Hz). For example, a 100 MW generator would increase output to 200 MW if power system frequency declined to 57 Hz. Clearly, a generator rated for 100 MW would be unlikely to operate at 200 MW, but power system frequency is unlikely to decline to 57 Hz, and if it did, it is even more unlikely to recover, regardless of generator governor action. Instead, a 100 MW generator might be able to provide 110 MW when system frequency declined to 59.7 Hz. Under normal conditions power system frequency is held close to 60 Hz, as shown in Fig. 11. At times system frequency is deliberately offset by ±0.02 Hz for time correction.[5] Generator governors typically have an intentional 0.035 Hz deadband where they ignore system frequency deviations. This lets the generators ignore small system frequency fluctuations that result from normal generation/load imbalances. Generator governors do respond when system frequency declines below about 59.965 Hz. If system frequency continues to decline, then involuntary load shedding starts at a little over 59 Hz. Generators themselves can trip to protect equipment if system frequency drops below about 57.8 Hz.

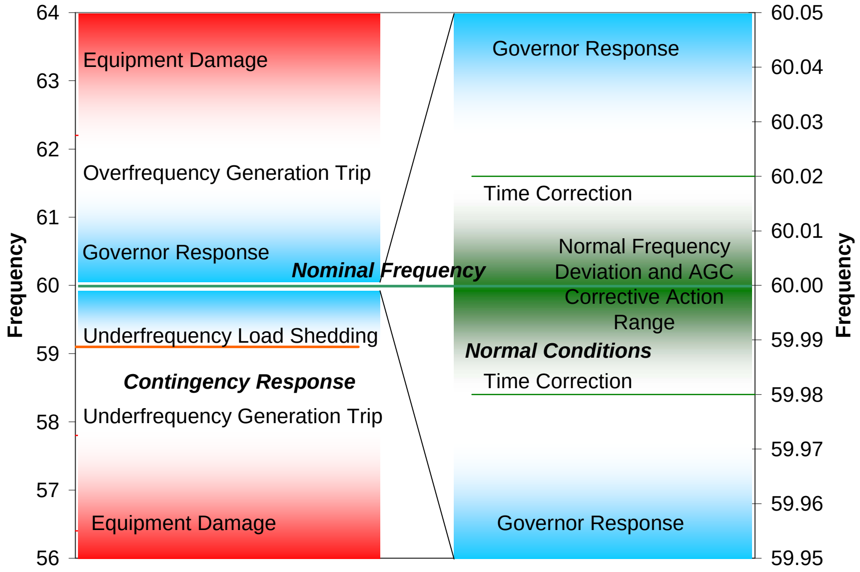

Fig. 11. Power system frequency is tightly controlled under normal conditions.

When responsive loads provide spinning reserve, they must provide response equivalent to that offered by generators. Most importantly, loads providing spinning reserve must respond to frequency deviations in the governor response range shown in Fig. 11. This is well above the frequency at which involuntary load shedding occurs.

It is also important for load frequency response to provide, in aggregate, a droop characteristic similar to that provided by generation. An individual load may not be able to provide a linear droop response, but a collection of loads can. By setting a slightly different frequency trip point for each individual load, the aggregate load frequency response characteristic can be tailored to any desired response. Note that the Fig. 10 load response differs from the generator governor response in that the load does not provide response for high frequencies. While this is a difference, it is not generally a power system reliability problem for two reasons. First, high frequency events are less common than low frequency events because large generator trips are more common than large load trips. Perhaps more importantly, the power system is inherently better equipped to deal

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[5] The power system is deliberately accelerated or decelerated slightly to make up for accumulated unintentional frequency deviations that would otherwise result in clocks that rely on the constant 60-Hz frequency being either fast or slow.

with over-generation conditions than under-generation conditions. Most (not all) generators can reduce output in an emergency, and there is almost always an abundance of generation that can be backed down in an emergency, while there may not be excess generation that can immediately increase.

4.1 TESTING FREQUENCY RESPONSE

Testing generator or responsive load frequency response in actual operation is difficult, especially in the eastern interconnection. Large frequency events are fortunately rare. It is necessary to move the frequency response points closer to 60 Hz so there will be a reasonable number of frequency events to respond to in a reasonable amount of time. A response frequency of 59.95 Hz was selected to provide about two test events per day based on the recent eastern interconnection frequency behavior shown in Fig. 12. All units were set to respond at the same frequency so that total response could be monitored by observing the total hotel power consumption.

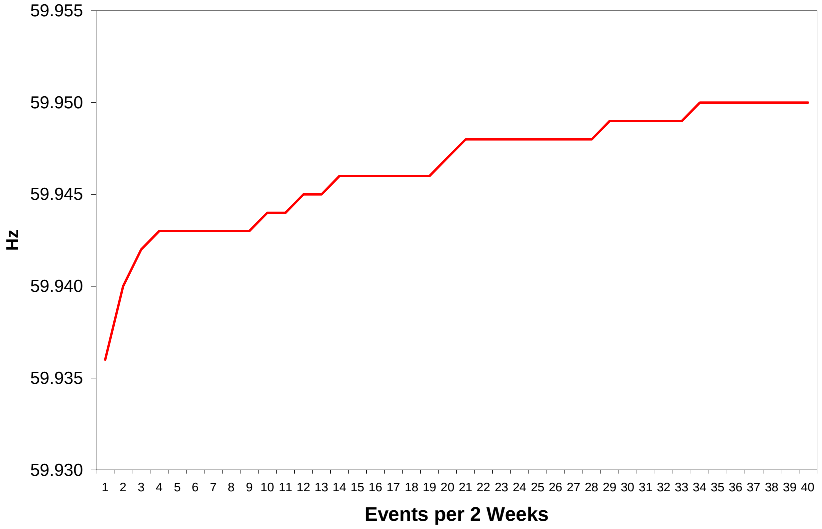

Fig. 12. Eastern interconnection frequency history from 6/24/2008 through 7/8/2008.

Initial testing resulted in numerous trips per hour rather than the expected two trips per day. Further investigation showed that local power quality events were resulting in momentary frequency deviations that the load controllers were responding to as system frequency events. Fig. 13 provides a plot of frequency taken from a power quality meter installed at the hotel. Frequency response testing was suspended as other testing commenced but is expected to resume shortly.

4.2 INERTIA AND STABILITY CONCERNS

When responsive load is used to provide spinning reserves, it reduces the amount of generation that is online. This necessarily results in a reduction in system inertia: the total mass of the rotating generators. There is a legitimate concern that this will reduce power system stability. Interestingly, when implemented correctly, load response can improve power system stability. This is because responsive loads like the DSI hotel air conditioning controllers can provide *full* response much faster than synchronous generators can. Generation typically takes the full ten minutes allowed for ramping up spinning reserve response, while responsive load can typically provide its full response in cycles to seconds for a frequency disturbance.

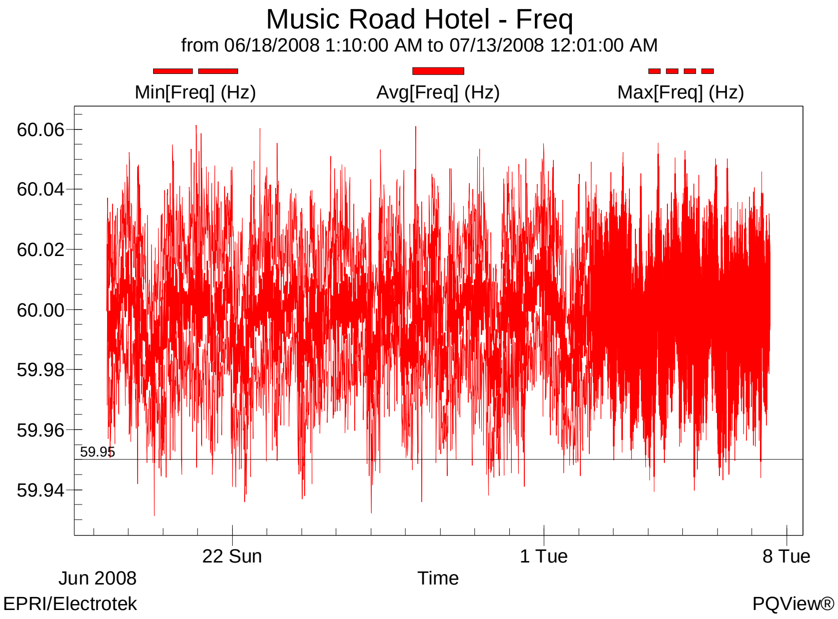

Fig. 13. Local frequency measurements revealed power quality concerns.

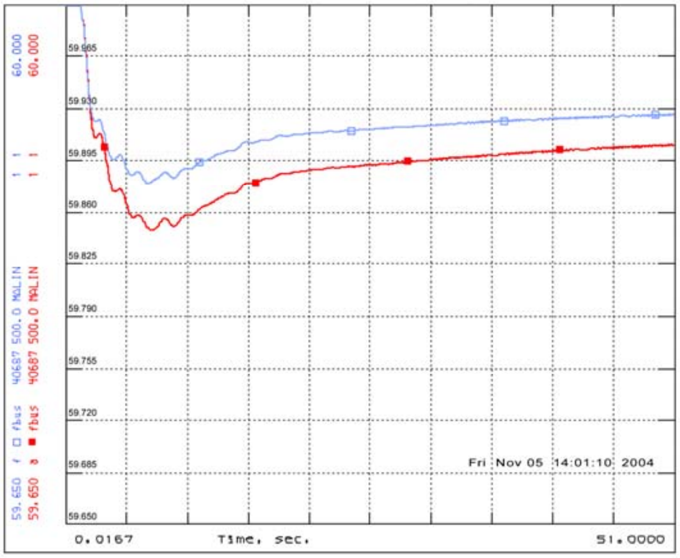

Fig. 14. WECC system stability is enhanced when 300 MW of responsive load (upper blue curve) replaces an equal amount of generation (lower red curve). Stability runs performed by Donald Davies of WECC.

An example where responsive load provides superior spinning reserve when compared with generation can be seen in Fig. 14. WECC interconnection frequency response is shown for the sudden loss of the Palo Verde unit 1 generator. The lower red curve shows system frequency response with generators providing all of the spinning reserve. The upper blue curve shows that system frequency would not dip as low and would recover more quickly if 300 MW of spinning reserve were provided by a large pumping load instead of from generation.

5. CONCLUSIONS AND FUTURE WORK

Digital Solutions, Inc., adapted its hotel air conditioning control technology to supply power system spinning reserve. This energy saving technology is primarily designed to provide the hotel operator with the ability to control individual room temperature set-points based on occupancy (25% to 50% energy savings based on an earlier study). DSI added instantaneous local load shedding capability in response to power system frequency and centrally dispatched load shedding capability in response to power system operator command so the technology could be used to provide spinning reserve to the power system.

Preliminary testing at the 162 room Music Road Hotel in Pigeon Forge, Tennessee, showed that load can be curtailed by 22% to 37% depending on the outdoor temperature and the time of day. It is significant that these results are prior to implementing control over the common area air conditioning loads and for testing in September rather than the peak load months of July and August. Full response occurred in 12 to 60 seconds from the time the system operator's command to shed load was issued, much faster than generation-based response. The load drop was very rapid, essentially as fast as the 2 second metering could detect, with all units responding essentially simultaneously. Load restoration was ramped back up in several minutes. The restoration ramp can be adjusted to the power system needs.

Frequency response testing was not completed. Although initial testing showed that the units respond very quickly, problems with local power quality generated false low frequency signals that required testing to be stopped. This should not be a problem in actual operation since the frequency trip points will be staggered to generate a droop curve that mimics generator governor response. The actual trip frequencies will also be low enough to avoid power quality problems. Frequency response testing will resume once the local power quality problem is fully understood and reasonable test frequency settings can be determined.

Overall, the preliminary testing was extremely successful. The hotel response capability matches the power system reliability need, being faster than generation response and inherently available when the power system is under the most stress (times of high system and hotel load). Periodic testing is scheduled throughout the winter and spring to characterize hotel response capability under a full range of conditions. More extensive testing will resume when summer outdoor temperatures are again high enough to fully test hotel response.

DSI has developed a hot water heater controller based on the same communications and control technology. The system is designed for use in peak reduction and for the provision of spinning reserve. The water heater controllers respond to system operator commands but they also respond to power system frequency and system voltages, just as the hotel room controllers do. Testing the hot water heater response is expected as soon as a suitable host utility is identified.

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