Presentation to the IEA
Atlanta, GA
10/12/2004

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Brendan J. Kirby
Topics

- United States Electric Industry Structure
- Opportunities for Network Driven DSM
- Factors Contributing to the Effectiveness of DSM
- Examples
U.S. Energy System - 2002

97.4 Quads (Quadrillion Btu)

- Residential and Commercial: 38.4 Quads
- Industrial: 32.5 Quads
- Transportation: 26.5 Quads
- Petroleum: 38.2 Quads
- Natural Gas: 23.0 Quads
- Nuclear: 8.1 Quads
- Renewables: 5.9 Quads


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Electric Markets

- Competitive
- FERC Regulated
  - Utility Owned
  - ISO Controlled
- State Regulated
- Customers
  - Demand Management
  - Micro-Grids
  - Power Quality
  - Distributed Generation

Data Management Requirements:
- Integration Across Multiple Business Systems Companies & Control Areas
- Data and Information Security

Generation
Transmission
Distribution
Retail

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Electric Interconnections and NERC Reliability Regions
“If the energy structure of this country is inadequate or in some way excessively costly, it will undermine economic growth, and is therefore a major issue that must be addressed.”

Alan Greenspan
Chairman, Federal Reserve Board
January 25, 2001
Blackouts: Rising Occurrences

- Texas ‘03
- New York ‘99
- Delaware ‘99
- New Orleans ‘99
- Detroit ‘00
- San Francisco ‘00
- Atlanta ‘99
- Northern California ‘01

Cost of Power Disturbances: $25 - $188 billion per year
Blackout - August 14, 2003
Interim Blackout Report

Interim Report:
Causes of the August 14th Blackout in the United States and Canada

November 2003
Initial Blackout Responses

- October 10, 2003 - NERC’s Board of Trustees issued letter for near-term actions to protect reliability
- December 24, 2003 - FERC directed FirstEnergy to implement remedial actions by June 30, 2004
- MISO (Midwest RTO) plan to address deficiencies in tools and procedures; new joint operating agreement with PJM
- February 10, 2004 - NERC issued fourteen requirements – DSM was not mentioned in any of the requirements
- Heightened general awareness by all control areas and reliability coordinators
## Evolution of Electricity Markets

<table>
<thead>
<tr>
<th></th>
<th>pre-EPAct</th>
<th>1992-2002</th>
<th>post-SMD NOPR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Industry</strong></td>
<td>Regulated Rate of Return</td>
<td>Financial Uncertainty and Corporate Risk</td>
<td>Corporate bonds derated; difficulty raising capital</td>
</tr>
<tr>
<td></td>
<td>No market incentives to become competitively efficient</td>
<td>Equipment approaching design life, although not requiring immediate action</td>
<td>Equipment past design life, requiring investment or risk system failure</td>
</tr>
<tr>
<td><strong>FERC</strong></td>
<td>Regulated Prices</td>
<td>Wholesale competition? • Order 888/889 • Order 2000</td>
<td>Competition controls; market rules</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Role of RTO uncertain</td>
</tr>
<tr>
<td><strong>States</strong></td>
<td>Regulated Prices</td>
<td>Regional Division • Regulated Prices • Retail &quot;Quasi&quot;-Markets</td>
<td>Conflicting pull on prices: • lower prices to stimulate economic growth and build/maintain constituent support • higher prices to obtain capital for needed investment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R&amp;D in Rates</td>
<td>R&amp;D not in Rates</td>
</tr>
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<td></td>
<td>R&amp;D in Rates</td>
<td></td>
<td>Competitive Energy Markets?</td>
</tr>
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<td></td>
<td>Traditional Regulation</td>
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</tbody>
</table>
Strategic R&D dropped from $160 million to less than $25 million in 7 years.
Relative Transmission Capacity Continues to Decline

Transmission Capacity (1989 = 1)

- NPCC
- WECC
- FRCC
- MAPP
- MAAC
- SERC
- U.S. Total
- MAIN
- SPP
- ECAR
- ERCOT

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Total Utility Cost

Data from USDOE, EIA

Cost In Dollars

Year

Oak Ridge National Laboratory
U. S. Department of Energy

UT-BATTELLE
## Public Benefits Energy Efficiency Program

### Cost-effectiveness

<table>
<thead>
<tr>
<th>State</th>
<th>Benefit/Cost All programs</th>
<th>B/C Comm/Ind programs</th>
<th>B/C Residential programs</th>
<th>Cost of saved energy ($/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>2.0 – 2.4</td>
<td></td>
<td></td>
<td>0.03</td>
</tr>
<tr>
<td>Connecticut</td>
<td>NA</td>
<td>2.4 to 2.6</td>
<td>1.5 to 1.7</td>
<td>0.023</td>
</tr>
<tr>
<td>Maine</td>
<td>1.3 – 7.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Massachusetts</td>
<td>2.1</td>
<td>2.4 to 2.7</td>
<td>1.3 to 2.1</td>
<td>0.04</td>
</tr>
<tr>
<td>New Jersey</td>
<td></td>
<td></td>
<td></td>
<td>0.03</td>
</tr>
<tr>
<td>New York</td>
<td></td>
<td></td>
<td></td>
<td>0.044</td>
</tr>
<tr>
<td>Rhode Island</td>
<td>2.5</td>
<td>3.3</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Vermont</td>
<td></td>
<td></td>
<td></td>
<td>0.03</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>2.5 3.0</td>
<td>2.9 2.0</td>
<td>1.8 4.3</td>
<td></td>
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<tr>
<td><strong>Median</strong></td>
<td>2.1 to 2.5</td>
<td>2.5 to 2.6</td>
<td>1.6 to 1.7</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Source: ACEEE 2004, LBNL - Goldman
Public Benefit Energy Efficiency Programs: Conclusions

• Public benefits energy efficiency has been clearly demonstrated as a successful concept
  – Most significant new policy mechanism for advancing EE in U.S. during past decade
  – ‘Rescued’ utility sector energy efficiency from imminent demise in late 1990s
• Available evaluation results suggest good savings impacts and cost-effective
• Concept enjoys broad-based support from key stakeholder groups in states

Source: ACEEE, 2004, LBNL - Goldman
But, Participation in Voluntary RTP Programs Is Tiny

- ~2700 non-residential customers enrolled in ~40 programs
- ~11,000 MW of customer load enrolled in RTP in 37 tariffs;
  - Georgia Power and TVA account for 75% of total load enrolled

Source: Barbose, Goldman and Neenan, Lawrence Berkeley National Laboratory Oct. 2004
Customer Price Response in Voluntary RTP Programs

- Most utilities report modest amounts of load response (<1% of system peak), except for Georgia Power (5%)

Source: Barbose, Goldman and Neenan, Lawrence Berkeley National Laboratory Oct. 2004
## Electric Market Challenges

<table>
<thead>
<tr>
<th>State Issues</th>
<th>DOE Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail competition stalled</td>
<td>Focus on wholesale; help niches like green power</td>
</tr>
<tr>
<td>Provide Default Service for “Non-Switchers”</td>
<td>Develop tools for competitive bidding and resource acquisition (portfolio mgt)</td>
</tr>
<tr>
<td>Resource and Fuel Diversity</td>
<td>Portfolio Management</td>
</tr>
<tr>
<td>Need Price Responsiveness</td>
<td>Encourage Demand Response at State and Regional Level</td>
</tr>
</tbody>
</table>
## Electricity Market Challenges (Continued)

<table>
<thead>
<tr>
<th>Regional Issues</th>
<th>DOE Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolving transmission congestion and reliability problems</td>
<td>Encourage regional planning; Implement DOE Grid Study recommendations – bottleneck ID process</td>
</tr>
<tr>
<td>Overcoming “boom &amp; bust” investment cycle</td>
<td>Above plus get mkt certainty by energy legislation and FERC rules</td>
</tr>
<tr>
<td>Demand response needed for competitive wholesale markets</td>
<td>DR tech. assistance: policy, “best practices” program design, evaluation</td>
</tr>
</tbody>
</table>
Opportunities and Challenges for Network Driven DSM
DSM Uses

- Energy Efficiency
- Peak Reduction
- Feeder Relief
- Contingency Reserves
  - Spin
  - Non Spin
- Regulation
Important Concepts

- **Demand Elasticity** exists when some customers elect to reduce consumption of a particular commodity during periods of high price. The Level 1 response is to provide demand elasticity.

- **Dispatched Load** means that the Independent System Operator (ISO) has determined that because of system conditions, it needs to drop load in a certain area to provide reliability. The ISO issues a control signal that turns off the load. This is the dispatched response, or the Level 2 response.

- Better for the load: shorter, less frequent disruption
- Better for the power system: faster response than generation, more reliable, better use of generation
- Better for other loads: reduced energy and ancillary service prices
- Better for society: reduced need for generation and transmission

Power System Reliability
Events Are Fast, Infrequent and Relatively Short
A Series of Reserves Respond To Contingency Events

Contingency Occurs
Frequency Responsive Reserve
Spinning & Supplemental Reserve
Replacement Reserve

Minutes

FREQUENCY (Hz)

TIME (pm)

2600-MW Generation Lost
GOVERNOR RESPONSE
GC RESPONSE
RESPONSIVE RESERVE

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U.S. DEPARTMENT OF ENERGY
Spinning Reserve:
- Twice as Expensive as Supplemental
- Highest Priced When Load is Available
It Is Now Possible and Desirable for Loads to Provide Spinning Reserves

- Historically, loads have not been allowed to provide spinning reserves, the fastest, highest price contingency reserves.
- Advances in communications and control now make it technically possible.
- Power system reliability needs now make it desirable.
- Many loads are better matched to providing spinning reserve than demand reduction.
- Spinning reserve is capacity.
Loads Can Be Ideal Suppliers of Ancillary Services – Especially Spinning Reserve

- Provides Redundancy – two methods for supplying spinning reserve
- Fewer and shorter interruptions than demand reduction or energy market response
  - less storage required
  - less disruption to normal load operations
- Complements energy management and price response, some loads are seeking ways to be better citizens and to save money.
- Only looking for a small percentage of load to respond
Load Can Provide Spinning Reserve While Providing Peak Reduction
Statistical Response is **Better** Than Monitored Response

An aggregation of many (smaller) individually lower reliability resources still provides higher guaranteed response than fewer (larger) individually higher reliability resources.
Factors Contributing to the Effectiveness of DSM
Supplying Spinning Reserve from Load

• During a contingency, load drop is much more helpful to the grid than increasing generation at a distant generator:
  – The losses involved in transmission and distribution.
  – The reactive power that is consumed by the increase in flow on the transmission line.
  – Load drop is fast.
  – Load drop could be spread smoothly over the load area.
• The August 14 blackout was so widespread because of flow triggered stability problems.
Often Heard Reasons Not to Supply Spinning Reserve from Load, Contd.

- Generator rotational inertia is needed to slow the frequency decay (A to C) on initial generator loss before generator speed droop compensation begins to restore frequency.

**Response:** It is true that the slope of the curve from A to C is impacted by the inertia of the system. But even if all the spinning reserve presently required by the WECC were supplied by load, there would be no noticeable impact on the transient undershoot.
Often Heard Reasons Not to Supply Spinning Reserve from Load

- Generator rotational inertia helps to dampen oscillations. If spin were supplied from load, the system inertia would be less, and the system would be more susceptible to transients and oscillation.

**Response:** Dynamic modeling has shown that when the inertia of generators is scaled, system stability could be maintained even when Southern California inertia was reduced 80% below the minimum limits shown on the SCIT nomogram.
Often Heard Reasons Not to Supply Spinning Reserve from Load, contd.

• How do you get the frequency responsive droop characteristic of spinning reserve from generation?

Response:

– Either individual loads, or the load aggregator, would have to monitor frequency.
– Loads could be set to drop sequentially with increasing frequency droop, creating a droop characteristic.
– This could even be done as a market function, loads that are more likely to be interrupted (59.064 Hz) could be paid more for their availability than loads at 57 Hz.
– Distribution circuit commands could be layered by frequency setpoint, so that additional load could respond if the decay continued.
Often Heard Reasons Not to Supply Spinning Reserve from Load, contd.

• How do you know that the dispatched amount of load has been shed?

Response:
  – Large loads could be tested and certified just like generation.
  – A statistical response from a large number of small loads is going to be better than the actual response from a few large loads.
  – The individual control areas could set standards for communication.
Communications Requirements Are Asymmetric (This is a Big Benefit)

- System-to-load communications are typically broadcast
  - Resource need – MW of response desired
  - Price
  - Deployment – respond *Now!*

- Load-to-system communications are typically individual
  - Capabilities and price offer
  - Performance monitoring – conceptually can be slower
  - Aggregator may help
Often Heard Reasons Not to Supply Spinning Reserve from Load, contd.

- Generators connected to the grid but operating at a “backed off” power level provide a large reactive power reserve.

**Response:** This argument is valid. Each control area, however, ensures that they have adequate dynamic reactive reserves. This requirement should not be lumped into the spinning reserve requirement.
VAR consumption increases with square of load

Based on a 100-mile 500-kV Line
Additional Concerns
Forecasting Demand Elasticity

Response: How can accuracy be estimated?

• Can the forecast be accurate?
  – Barrier: Forecast becomes complex.
  – Desired Outcome: Accurate, reliable forecast.
Confidence in Dispatchable Response: Just like generators, controllable and observable.

• How is this certainty provided?
  – Barrier: Expense, how do you observe an aggregation?
  – A reliable, functional, cost effective method.
Communication of price and load response

• How can the communication be done?
  – Barrier: Minimal expense in required user time and infrastructure.
  – Desired Outcome: Simple, low priced system.
Understanding the total cost of response: Impact on load, cost to ISO, infrastructure, payment.

• What are the costs?
  – Barrier: Communications, load impact, staffing, cost per MW, cost to customer?
  – Desired Outcome: An accurate picture of overall program implementation costs.
Examples of Network Driven DSM Applications
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.

Jim Williamson
Xcel Energy
303-808-1849

An immediate opportunity

• 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?
CDWR Manages Pumping Loads To Reduce Energy Costs

Spinning Reserve Opportunities and Revenues Are Still Substantial
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
Communications and Control

- Designed for multi-hour peak reduction
- Deployment signal <90 seconds
- Verification delayed to protect paging system
- Grouping by location, type, or any other criteria
- Customer override allowed for peak shaving, not for spinning reserve
- Control can be duty cycle, set point, or turn off
- Monitors temperature, run time, communications
- Customer remote monitoring and control web interface
Substantial Installed Capacity That Could Be Tested Today

<table>
<thead>
<tr>
<th></th>
<th>Units</th>
<th>Demand Reduction</th>
<th>Spinning Reserve</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIPA</td>
<td>23,400</td>
<td>25 MW</td>
<td>75 MW</td>
</tr>
<tr>
<td>Con Ed</td>
<td>25,000</td>
<td>25 MW</td>
<td>75 MW</td>
</tr>
<tr>
<td>SCE</td>
<td>50,000</td>
<td>50 MW</td>
<td>150 MW</td>
</tr>
<tr>
<td>SDG&amp;E</td>
<td>5,000</td>
<td>5 MW</td>
<td>15 MW</td>
</tr>
</tbody>
</table>
Spinning Reserves From Commercial 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 Digi-Log Technologies; tested for energy savings by ORNL

• **Spinning reserve is an easy add-on**
  – Modified to operate by pager signal from utility
  – Demo with LIPA and possibly others

• **Will work with many technologies**
DigiLog Motel Energy Management System Provides Spinning Reserve

- 80 room Howard Johnson motel
- 1 minute revenue metering
- Pager deployed spinning reserve
- 34kW, 36% load drop in 1 minute
Common Concerns: *Overrides* – A Benefit and a Problem, But Less of a Problem for Spinning Reserve

![Graph showing dropout rate over hours into curtailment for commercial and residential categories.](image-url)
Service Definitions Are Critical

- Most generators do not care if they run for 30 minutes or 8 hours
  - May have minimum run times
  - May have emissions limits
- A load may be able to respond for 10-30 minutes but not 2 hours
  - Can re-arm immediately if not used frequently
- Response capability matches spinning contingency reserve much better than demand relief
Technical Conclusions

• Communications and control technology now makes spinning reserve from load possible
• There are advantages to the responding loads, the power system, other customers, and society
• Spinning reserve is a better match for some loads than peak reduction

Rules are absolutely critical
Basic Economics Do Work
Market & Regulatory Rules Do Not

- Capital cost less than CT
- Spinning reserve is capacity (total needed generation)
- Responsive load spinning reserve naturally rises and falls with system need
  - Forecast error
  - Daily load shape
Problem: New Reliability Enhancing Technologies Are Not Deployed

Some new technologies appear to be well matched to providing ancillary services, but:

- Reliability services (ancillary services) are procured through markets
- System operators do not aggressively seek new reliability enhancing technologies
  - System operators must remain market neutral
- Existing ancillary service markets are designed around the large generating resources that have historically provided the services
- Changing market rules to accommodate new technologies is very risky and slow
  - Rule changes apply to all new and old market participants
  - Rule changes can have unintended consequences
  - Reliability can be threatened
  - Cost/market impacts can be large
Penalties Are Rigid - Rewards Are Not

• New technology must meet all existing requirements
  – Monitoring
  – 2 hour response duration
  – 24/7 response…

• New benefits are not valued
  – Regulation response accuracy
  – Spinning reserve response speed
  – Increased statistical reliability from smaller resources
  – Response matched to system load…

**Current rules are often tied to existing generation technology, not system physical requirements**
New Technology Hurdles
(Just to Be Allowed to Try to Compete)

• Technology must actually work
• Technology must be perceived as working
• Aggregate resource must be perceived as large enough to be of value
  – Physically (there has to be enough physical response capability)
  – Economically (technology must be perceived as economically viable enough to capture a large market)
• Must meet all existing requirements
  – Even if they are irrelevant to the new technology
  – Any required rule changes can not adversely impact existing technology reliability

The economic push available to new central generation technologies is not available to small distributed technologies
System Operator Fears Are Well Founded In A Restructured Industry

• System operator controls the market, not the resource
• Limited ability to “try” something new
• Relationships are competitive and contentious by design
• The problem is universal
  – CAISO, WECC, ISO NE, PJM, AEP, NY, …
There May Be An Alternative: Regulated Resources to Manage Risk

- The regulator could evaluate a technology and determine if it offers advantages for rate payers
  - It might reduce the need for an ancillary service and save rate payers money while increasing reliability
- The regulator could approve a limited deployment (at rate payer expense) to test the technology
- The ancillary service could be offered at no cost to the system operator, 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 test 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
Treating Appropriate Ancillary Service Technologies as Regulated Resources Will:

• Minimize power system reliability risk
• Minimize developer and system operator financial risk
• Maximize customer reliability and economic benefit
• Separate technical from market design challenges
• Develop confidence in new technologies by controlling deployment
Publications


- Water Heaters to the Rescue: Demand Bidding in Electric Reserve Markets, *Public Utilities Fortnightly*
- Allocating Costs of Ancillary Services: Contingency Reserves and Regulation, *ORNL/TM 2003/152*
- The Distribution System of the Future, *The Electricity Journal*
- Technical Issues Related To Retail-Load Provision of Ancillary Services, *New England Demand Response Initiative*
- Spinning Reserve From Responsive Loads, *ORNL/TM 2002/19*
- Spinning Reserves from Controllable Packaged Through the Wall Air Conditioner (PTAC) Units, *ORNL/TM 2002/286*
- Technical Potential For Peak Load Management Programs in New Jersey