Grid Optimization and Smart Grid

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Midwest ISO provides a variety of valued services to the Midwest Region

<table>
<thead>
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<th>What We Do</th>
<th>Implications</th>
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<tr>
<td>Provide independent transmission system access</td>
<td>&gt; Equal and non-discriminatory access</td>
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<td>&gt; Compliance with FERC requirements</td>
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<td>Deliver improved reliability coordination through efficient market operations</td>
<td>&gt; Improved regional coordination</td>
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<td>&gt; Enhanced system reliability</td>
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<td>&gt; Lowest cost unit commitment, dispatch, and congestion management</td>
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<td>Coordinate regional planning</td>
<td>&gt; Integrated system planning</td>
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<td>&gt; Broader incorporation of renewables</td>
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<td>Foster platform for wholesale energy markets</td>
<td>&gt; Encouragement of infrastructure investments</td>
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<td>&gt; Facilitation of regulatory initiatives</td>
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Midwest ISO’s geographic footprint is broad and diverse

- **Membership**
  - 34 Transmission Owners with $15.9 billion in transmission assets under functional control

- **Installed Generation Capacity**
  - 131,306 MW (market footprint)
  - 159,000 MW (reliability footprint)

- **Midwest Market Highlights**
  - $41 billion annual gross market charges
  - 300 Market Participants serving 40+ million people

- **Recent New Transmission-Owning Members**
  - MidAmerican Energy
  - Muscatine Power & Water
  - Municipal Electric Utility of the City of Cedar Falls, Iowa

- **Pending New Transmission-Owning Members**
  - Dairyland Power Cooperative
  - Big Rivers Electric Corporation
The Midwest ISO 2009 Value Proposition

Benefit by Value Driver\(^1\)
(in $ millions)

- **Improved Reliability**: $263-$394
  - Dispatch of Energy ($210 - $264)
  - Unloaded Capacity ($199 - $213)
  - Regulation ($184 - $194)
  - Spinning Reserves ($76 - $81)

- **Market – Commitment and Dispatch**
  - $669-$752
  - ($250)
  - Dispatch of Energy ($210 - $264)
  - Unloaded Capacity ($199 - $213)
  - Regulation ($184 - $194)
  - Spinning Reserves ($76 - $81)

- **Midwest ISO Cost Structure**
  - $682-$896

- **Net Benefits**
  - $528-$662
  - $1,210-$1,558

- **Generation Investment Deferral**
  - Footprint Diversity ($217 - $272)
  - Gen. Availability Improvement ($249 - $311)
  - Dynamic Pricing ($4 - $7)
  - Direct Load Control / Interruptibles ($58 - $72)

\(^1\)Figures shown reflect annual benefits and costs for 2009
We must look to the future in evaluating Smart Grid options
Envision what the grid will / could look like in 20 years

- Do not be “lulled” to sleep by today's overcapacity situation
- Do not miss tomorrow’s opportunities by thinking of yesterday’s issues and technologies
- Look at future generation portfolio possibilities to understand future issues and the value of emerging business models

Current Electricity Production

Future Electricity Production

Supply versus Demand (Forecast)

- Coal
- Nuclear
- Natural Gas
- Wind
- Other
- Coal
- Nuclear
- Natural Gas
- Wind
- Demand Response
Wholesale Smart Grid is alive and well - Driven by reliability, efficiency and emerging energy policy

Reliability
- Transmission Automation
- Wide-Area Visualization

Congestion Management

Generation Optimization
- Energy
- Regulation
- Reserves

Generation Portfolio Evolution
- Renewables (Wind / Solar)
- Storage
- Demand Response

Initial Midwest ISO operations focused on using Smart Grid to improve reliability

Wholesale markets used Smart Grid applications to improve congestion management and optimize the commitment and dispatch of the existing generation fleet

New Smart Grid applications should integrate retail load into the wholesale market’s optimization of the generation portfolio to moderate peak growth and manage the volatility of renewable generation
Significant progress has been made on the wholesale Smart Grid applications because they improve reliability and reduce costs. New applications must enhance those benefits while also enabling energy policy changes.

**Wholesale**
- Established
- Emerging

**Improve Reliability**
- Wide-Area Visualization
  - State Estimation
  - Contingency Analysis
  - Synchrophasor Monitoring
- Congestion Management
- Transmission Automation

**Generation Optimization**
- Energy
- Regulation
- Reserves

**Generation Portfolio Evolution**
- Renewables (Wind / Solar)
- Storage
- Demand Response
Many retail Smart Grid applications have struggled to prove their economic value – cost and benefit concerns

Smart Distribution
- Automated Switching
- Outage Analysis
- Distributed Generation

Usage Monitoring – AMI / Smart Meters

Usage Modifications
- Price Responsive Demand (Consumer Choice)
  - Example: Programming pool pumps to turn off when price of electricity is high
- Direct Load Control (Utility Choice)
  - Example: Utility deferring use customers’ water heaters & HVAC
- Direct Load Control (Wholesale Dispatched)

Transportation Electrification
- PHEVs
- EVs
The key to Retail Smart Grid adoption is leveraging it to improve wholesale generation dispatch optimization and reduce generation portfolio evolution costs.

**Wholesale**

- Generation Optimization
  - Energy
  - Regulation
  - Reserves

- Generation Portfolio Evolution
  - Wind
  - Solar
  - Storage
  - Demand Response

**Interoperability**

- **Reliability**
- **Incentives**
- **Alignment**

**Retail**

- Usage Modifications
  - Price Responsive Demand
    - *Consumer choice*
  - Direct Load Control
    - *Utility choice*

- Transportation Electrification
  - PHEVs
  - EVs
Interoperability requirements start with appropriate price signals to retail customers

- Price signals enable consumers to make their own choices on when to modify usage – resulting in varying degrees of energy efficiency, peak shaving and valley filling
However, the real value occurs when loads are enabled as supply-side resources and deployed optimally alongside generation resources.

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**Direct Load Control**
(Wholesale Dispatch)

**Direct Load Control**
(Deployed by LSE / ARC)

**Price Responsive Demand**

Advantages/Benefits:
- Energy efficiency
- Peak shaving
- Valley filling
- Peak shaving
- Valley filling
- Ramp management
- Regulation provider
- Operating reserves provider
- Uncertainty management
The Midwest ISO is enabling DR in all areas of the market, but much work is still required to unlock the true value of this resource.

- Existing opportunities for DR to participate in the Midwest ISO
  - Resource Adequacy
    - Load Modifying Resource
    - Demand Response Resource
  - Energy Market
    - Price Responsive Demand (Day-Ahead Market only)
    - Demand Response Resources
  - Ancillary Markets (Regulation / Spinning Reserves / Supplemental Reserves)
    - Demand Response Resources
  - Emergency Demand Response
    - Emergency Demand Response

- Emerging opportunities for DR to participate in the Midwest ISO (programs currently pending FERC approval)
  - Aggregator of Retail Customers – will allow participation in Resource Adequacy, DA Energy Market, and Ancillary Services Markets
  - DRR Type I – will expand participation to Spinning Reserve Market