"We have a couple things we do at the ISO level... all we really are is the air traffic controller of what we call the bulk power supply, which is a lot more voltage than you have going to your house...These are kind of like the superhighways of electricity."

-RTO Focus Group participant
70%
• Voluntary, stakeholder-driven organizations
• Neutral party (no ownership of physical assets or position in the market)

THREE TASKS
• Bulk power grid operations for system reliability
• Energy markets
• Transmission system planning
The Electric Grid

- Generation
  - Transmission
    - Transmission lines
    - Transmission substation
  - Distribution
    - Distribution substation
- Industrial
  - Distribution lines
- Service
- Residential
  - Padmount transformer

RTO/ISO
From Sascha von Meier

A diagram illustrating the relationship between Ancillary Services Markets and Energy Markets (Day Ahead and Real-Time). The diagram compares various time frames and services, such as synchrophasors, protective relay operation, dynamic system response, AGC signal, wind and solar output variation, demand response, service restoration (outages), day-ahead scheduling, hour-ahead scheduling, planning for carbon emission goals, and T&D planning. The time frames range from milliseconds to years, highlighting the different scales and durations of these services and markets.
<table>
<thead>
<tr>
<th>Regional Transmission Organization</th>
<th>Jurisdiction</th>
<th>Customers</th>
<th>Generation capacity</th>
<th>Miles of HV Transmission Line (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PJM</td>
<td>Multi-state</td>
<td>61 million</td>
<td>183,000 MW</td>
<td>63,000 (101,000)</td>
</tr>
<tr>
<td>ISO-NE</td>
<td>Multi-state</td>
<td>14 million</td>
<td>32,000 MW</td>
<td>8,000 (13,000)</td>
</tr>
<tr>
<td>MISO</td>
<td>Multi-state</td>
<td>48 million</td>
<td>205,759 MW</td>
<td>65,000 (104,000)</td>
</tr>
<tr>
<td>SPP</td>
<td>Multi-state</td>
<td>15 million</td>
<td>77,366 MW</td>
<td>48,000 (77,000)</td>
</tr>
<tr>
<td>ERCOT</td>
<td>Single state</td>
<td>23 million</td>
<td>84,000 MW</td>
<td>40,500 (65,000)</td>
</tr>
<tr>
<td>CA-ISO</td>
<td>Single state</td>
<td>30 million</td>
<td>59,000 MW</td>
<td>25,900 (41,000)</td>
</tr>
<tr>
<td>NYISO</td>
<td>Single state</td>
<td>19.5 million</td>
<td>37,925 MW</td>
<td>11,005 (18,000)</td>
</tr>
</tbody>
</table>
NSF PROJECT: Decision Making within RTOs

Review of documents and observation of meetings

Semi-structured interviews with stakeholders

Stakeholder Meetings

Stakeholder meetings provide Members with the opportunity for communication and interaction. The purpose of stakeholder meetings is to foster collaboration, not legislation. The two types of meetings are stakeholder groups and symposiums and forums.

Stakeholder Groups
- eData/eDataFeed Stakeholder Group
- PJM Online Tools Refresh
- General Session
- Inter-Regional Planning Stakeholder Advisory Committee - MISO

Symposia and Forums

- 48 interviews in PJM/MISO /CAISO to date
Key Actors in RTO Decision Making

Electric System

Stakeholders

RTO/ISO

Generation Utilities

Distribution Utilities

State- PUC, Energy Office (Policies & Planning), Environmental Office (Siting)

Industrial, Commercial & Residential Consumers

FERC

Federal and State Courts

Civil Society Stakeholders
Current Installed Wind Power Capacity (MW)

Total: 74,472 MW
(As of 12/31/2015)

Data is from the American Wind Energy Association fourth Quarter 2015 Market Report:
http://www.awea.org

U.S. Department of Energy
NREL (National Renewable Energy Laboratory)
“We have the gift of lots of wind, but it doesn’t seem the transmission lines are in the right place. [...] ‘How do you get the wind from here to there without it being too expensive for the wrong people?’ “

--MISO Stakeholder
“We could sit down with crayons and write on a map a few lines that would make all kinds of sense to make stuff move around. Then we would take 20 years to figure out who pays for it.”

--CAISO Stakeholder
Powerline
The First Battle of America's Energy War

PAUL WELLSTONE and BARRY M. CASPER

Foreword by Tom Harkin
MVP Portfolio

MISO - using Ventyx, Velocity Suite © 2011
Cost Allocation = Blood Sport
Regional Transmission Organizations
Dispatchable Intermittent Resources (DIR)

Unconstrained

Nearby Congestion

Source: JT SMITH, MISO
Figure A51: Day-Ahead Scheduling Versus Real-Time Wind Generation
2012–2013

Figure A52: Seasonal Wind Generation Capacity Factors by Load Hour Percentile
MISO and the RPS

Monthly Energy Contribution from Wind

- Total Monthly Wind Energy
- Estimated Renewable Energy Target

GWh:

- Oct-12: 3,256
- Nov-12: 3,049
- Dec-12: 2,900
- Jan-13: 3,866
- Feb-13: 3,026
- Mar-13: 3,139
- Apr-13: 3,450
- May-13: 3,235
- Jun-13: 2,359
- Jul-13: 1,927
- Aug-13: 1,568
- Sep-13: 2,515
- Oct-13: 3,047

RPS data extracted on October 04, 2013. Values may change due to resettlement.

*Sum of hourly State Estimator data.

Monthly wind energy generated (light blue) compared to monthly renewable energy target (yellow bar) to satisfy aggregate State RPS mandates within MISO’s market footprint. While wind may be in excess today, internal projections show that current wind production may not be sufficient to meet the future needs as soon as 2014. Additional information can be found under Stakeholder Center/Committees, Work Groups, and Task Forces/Informatonal Forum – Related Documents.

** Yellow bar represents the annual renewable energy target distributed by month based on monthly capacity factor expectations of the MISO system.
"Come into my algorithm, and I can dispatch you down for five minutes rather than for five hours, and then bring you back up once my congestion issue is gone."

- MISO Focus Group participant
Rules Matter

(A lot)
Smart Grid (R)Evolution
Electric Power Struggles

ENERGY LAW AND POLICY

Lincoln L. Davies, Alexandra B. Klass,
Hari M. Osofsky, Joseph P. Tomain,
& Elizabeth J. Wilson

JENNIE C. STEPHENS
ELIZABETH J. WILSON
TARLA RAI PETERSON
Decision-Making in Regional Transmission Organizations

Co-conspirators: Natalie Nelson Marsh, David Solan, Stephanie Lenhart (Boise State), Seth Blumsack and Nicholas Johnson (Penn State), Benjamin Stafford (UMN)

Acknowledgement: NSF #SES-1261867
Stakeholder Classes

**PJM (5)**
- Transmission Owners
- Generation Owners
- Electricity Distributors
- End Use Sectors
- Others

**MISO (10)**
- Transmission Owners
- Generation Owners/Independent Power Producers
- Power Marketers
- Transmission Dependent Utilities (munis/co-ops)
- Eligible End Use Customers
- Coordinating Members
- Transmission Developers
- State Regulators (OMS)*
- Consumer Advocates*
- Environmental/Other*

**CAISO (6)**
- Transmission Owners
- Generation Owners
- Transmission Dependent Utilities
- End Users & Retail Energy Providers
- Alternative Energy Providers
- Public Interest Groups
- Marketers

* Non Paying
Follow the Rules

What is a Successful Stakeholder Process?

“Well, I feel that this has been very successful. Everyone is equally dissatisfied.”

--MISO
Need for Interdisciplinary Study:

[T]his is a team sport. It’s a complicated world.

--MISO stakeholder
Primary energy world consumption
Million tonnes oil equivalent

- Coal
- Renewables
- Hydroelectricity
- Nuclear energy
- Natural gas
- Oil

[Graph showing the consumption of primary energy sources from 1987 to 2012, with coal, natural gas, and oil clearly visible.]
Primary energy regional consumption pattern 2012
Percentage

North America
S. & Cent. America
Europe & Eurasia
Middle East
Africa
Asia Pacific
## Table - Focus Groups Conducted in Seven States

<table>
<thead>
<tr>
<th>Stakeholder and State</th>
<th>RTO</th>
<th>Regulatory</th>
<th>IOU</th>
<th>Co-op/Muni</th>
<th>Tech/Acad.</th>
<th>Environmental</th>
<th>Consumer</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA</td>
<td>Holyoke</td>
<td>Boston</td>
<td>Worcester</td>
<td>Shrewsbury</td>
<td>Worcester</td>
<td>Boston</td>
<td>Boston</td>
</tr>
<tr>
<td>VT</td>
<td>Holyoke, MA</td>
<td>Montpelier</td>
<td>Rutland</td>
<td>Johnson</td>
<td>Burlington</td>
<td>San Francisco</td>
<td>Montpelier</td>
</tr>
<tr>
<td>MN</td>
<td>St. Paul</td>
<td>St. Paul</td>
<td>Minneapolis</td>
<td>Maple Grove</td>
<td>Minneapolis</td>
<td>Minneapolis</td>
<td>St. Paul</td>
</tr>
<tr>
<td>IL</td>
<td>St. Paul, MN</td>
<td>Springfield</td>
<td>Oakbrook Terrace</td>
<td>Champaign</td>
<td>Urbana</td>
<td>Chicago</td>
<td>Chicago</td>
</tr>
<tr>
<td>TX</td>
<td>Taylor</td>
<td>Austin</td>
<td>Austin</td>
<td>College Station</td>
<td>College Station</td>
<td>Austin</td>
<td>Austin</td>
</tr>
<tr>
<td>CA</td>
<td>Folsom</td>
<td>San Francisco</td>
<td>San Francisco</td>
<td>Sacramento</td>
<td>Sacramento</td>
<td>San Francisco</td>
<td>San Francisco</td>
</tr>
</tbody>
</table>

Blue = focus groups conducted after Superstorm Sandy. Light green = focus groups conducted before Sandy.
<table>
<thead>
<tr>
<th><strong>Independent System Operator</strong></th>
<th><strong>Regional Transmission Organizations</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;...an organization formed at the direction or recommendation of the [FERC]...&quot;</td>
<td>&quot;...designated by the [FERC] to direct operation of the regional electric transmission grid in its area...&quot;</td>
</tr>
<tr>
<td>&quot;...a neutral party responsible for the management and control of the electric transmission grid in a state or region...&quot;</td>
<td>&quot;...coordinates, controls and monitors an electricity transmission grid that is larger with much higher voltages than the typical power company's distribution grid...&quot;</td>
</tr>
<tr>
<td>&quot;...operates an electric-transmission system that it does not own...&quot;</td>
<td>&quot;...coordinates power generation and transmission within an integrated regional market...&quot;</td>
</tr>
<tr>
<td>&quot;...an independent, Federally regulated entity...&quot;</td>
<td>&quot;...an independent governing body...&quot;</td>
</tr>
<tr>
<td>&quot;...ensure[s] the safety and reliability of the electric system...&quot;</td>
<td>&quot;...[responsible] for electric transmission grid operations, short-term electric reliability and transmission services within a multi-state region...&quot;</td>
</tr>
<tr>
<td>&quot;...for the purpose of providing open access to retail and wholesale markets for supply...&quot;</td>
<td>&quot;...serve as the independent operator of the regional electric market...&quot;</td>
</tr>
</tbody>
</table>

Various definitions from web-based glossaries
The FAMOUS CA ISO Duck Diagram

Growing need for flexibility starting 2015

Net load

Significant change starting in 2015

Increased ramp

Potential over-generation

Megawatts

27,000

25,000

23,000

21,000

21,000

19,000

17,000

15,000

13,000

11,000

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Texas “Wind Incident”
February 26, 2008

• 2000 MW to 300 MW in 3 hours
• Multiple providers below scheduled production
• Load increasing
• Power frequency declines to 59.19 Hz

• Solved by a combination of demand response and diesel generators and purchasing 30 MW of power from Mexico