Current Scope of Operations

- **Generation Capacity**
  - 180,051 MW (market)
  - 194,673 MW (reliability)

- **Historic Peak Load**
  (July 20, 2011)
  - 127,125 MW (market)
  - 131,181 MW (reliability)

- **Historic Wind Peak**
  (February 19, 2016)
  - 13,088 MW

- 65,800 miles of transmission

- 5-minute dispatch

- 2,483 pricing nodes

- $24.7 billion gross market charges (2015)

- 432 market participants

- 42 million end-use customers
Inherent characteristics of wind generation have significant impacts on system operations...

<table>
<thead>
<tr>
<th>Driver</th>
<th>Market Issue</th>
<th>Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Variability of wind</td>
<td>• Congestion management</td>
<td>• Forward Planning</td>
</tr>
<tr>
<td>• Negative correlation of wind and load</td>
<td>• Over and under generation</td>
<td>• Market dispatch of intermittent units (DIRs)</td>
</tr>
<tr>
<td>• Transmission congestion caused by wind location</td>
<td>• Ramp management</td>
<td>• Effective wind forecasting</td>
</tr>
<tr>
<td></td>
<td>• Surplus generation events</td>
<td>• Ramp capability enhancement</td>
</tr>
</tbody>
</table>

DIR: Dispatchable Intermittent Resources
... and wind generation in MISO is growing rapidly

Registered nameplate wind capacity in MISO
(in MWs)

MISO RPS Mandates by 2021 = ~20,770 MW

RPS: Renewable Portfolio Standards
Rapid development of wind generation adversely affected congestion management

• Wind generation increased 400% between 2007 and 2011, up to 10,000 MW

• High penetration of wind generation in areas that have historically had little generation

• Development of wind generation outpaced the necessary transmission development

• Original market design classified wind as an ‘Intermittent Resource’ that could not be economically dispatched

• In areas with high wind penetration, it was difficult for the SCED to manage congestion with limited dispatchable resources

Reliability Coordinators needed to manually curtail wind resources adversely impacting constraints, which was inefficient

SCED: Security Constrained Economic Dispatch
The solution was to expand the transmission system...
...and to make wind resources closely mimic traditional generators

- Eligible for the FRAC rebid process
- Same commitment and dispatch obligations
- Same physical and economic parameters
- Ineligible to offer Operating Reserves
- Same DA & RT market timelines & outcomes
- Source of Max Limit is different

 Ability to “dispatch” wind greatly enhanced congestion management and improved utilization of wind generation in the market

DIR: Dispatchable Intermittent Resource
DA: Day Ahead
RT: Real-time
FRAC: Forward Reliability Assessment Commitment
Recently, MISO implemented its Ramp Capability Product

- MISO is the first RTO/ISO to successfully develop and implement a Ramp Capability Product
- The Ramp Capability Product increases reliability and decreases the cost of serving load
  - Provides more transparent price signals, resulting in economic incentives for resource flexibility
  - Manages the ramp capability from controllable resources to better position them to respond to non-controllable variables, such as unexpected or sudden changes in wind generation or in load
  - Mitigates ramp constraints that otherwise could lead to short-term reserve scarcity events and associated price spikes
Current market conditions will not last as public policy and economics will drive portfolio evolution in the footprint.

Energy mix in 2016
(Source: MTEP17, Existing Fleet ie Business As Usual)

- Coal: 53%
- Gas: 20%
- Nuclear, oil, pumped storage, interconnection ties: 17%
- Renewables: 10%

Energy mix in 2031
(Source: MTEP17 Accelerated Alternative Technologies)

- Coal: 28%
- Gas: 26%
- Nuclear, oil, pumped storage, interconnection ties: 15%
- Renewables: 26%
- DSM: 5%