GHG Regulation Impact Analysis – Initial Study Results
September 17, 2014
The purpose of MISO’s analysis…

…is to inform stakeholders of potential impacts on the generation fleet and load resulting from the EPA’s proposal to reduce CO₂ emissions from existing electric generating units.

June 2014
Draft rule issued

June 2015
Rule finalized

June 2017
State plans due (with one year extension)

January 2020 – 29
Interim goal in effect

October 2014
Deadline for providing comments to EPA

June 2016
State Implementation Plans due

June 2018
Multi-state plans due (with a 2-year extension)

January 2030 onward
Proposed goal in effect
## Study objectives and key takeaways

<table>
<thead>
<tr>
<th>Study Phase</th>
<th>Objectives</th>
<th>Study results indicate that…</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td>Calculation of the compliance costs for regional (MISO footprint) and sub-regional (Local Resource Zones) CO₂ management</td>
<td>Alternative compliance options outside the building blocks could achieve the proposed level of CO₂ reduction at a lower cost. Regional compliance options save approximately $3B annually compared to sub-regional compliance.</td>
</tr>
<tr>
<td></td>
<td>➢ Applying the Building Blocks as proposed in the EPA’s draft rule</td>
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<tr>
<td></td>
<td>➢ Applying a regional CO₂ constraint, i.e., a regional CO₂ reduction target</td>
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<tr>
<td>Phase 2</td>
<td>Examination of the range of CO₂ emissions reductions, and associated costs, under various future policy and economic assumptions</td>
<td>Up to an additional 14GW of coal capacity could be at-risk for retirement.</td>
</tr>
</tbody>
</table>
Each state has a proposed state-wide CO$_2$ emissions rate goal calculated as:

\[
\begin{array}{c|c}
\text{Rate} & \text{Statewide CO}_2 \text{ emissions from covered fossil fuel-fired power plants (lbs)} \\
(lbs/MWh) & \text{State electricity generation from covered fossil plants + renewable energy + nuclear (at-risk portion and New) + energy efficiency (EE) (MWh)}
\end{array}
\]

- Numerator – sum of CO$_2$ emissions from existing generating units
- Denominator – electricity generation in the state excludes existing hydro and new thermal resources
- Every state is assigned a different proposed rate goal (lbs/MWh) for the interim (2020-2029) and the final (2030 onward) periods
- For modeling purposes, rate-to-MISO-equivalent mass was calculated:
  - Emissions in tons = (qualifying 2012 system generation + renewable and EE mandate-driven energy forecast) * (proposed CO$_2$ emission rate goal for a state)
  - Only the MISO portion of the state was modeled
EGEAS was used to study potential impacts of the draft CO₂ emissions reduction rule

**OPTIMIZATION CONSTRAINTS**
- Planning Reserve Margin
- CO₂ emission constraint (mass-based)
- Resource availability

**INPUT DATA ASSUMPTIONS**
- Demand and energy forecast
- Fuel forecasts
- Retirements
- CO₂ costs
- RPS requirements

**EXISTING RESOURCES DATA**
- Unit capacity
- Heat rate
- Outage rate
- Emissions rate
- Fuel and O&M costs

**NEW RESOURCES DATA**
- Capital cost
- Construction cash flow
- Fixed charge data
- Years of availability

**OPTIMIZED RESOURCE PLAN**
- 20-year resource expansion forecast
- Amount, type and timing of new resources
- Total system Net Present Value (NPV) of costs
- Annual production costs for system
- Annual fixed charges for new units
- Annual tonnage for each emissions type
- Annual energy generated by fuel type
- Annual system capacity reserves and generation system reliability

Total System Costs = Sum of Production Cost + Fixed O&M Cost + Capital Carrying Costs.
Phase 1: An assessment of EPA’s Building Blocks

Regional (Footprint-wide)

Sub-Regional (Local Resource Zones)

Cost of Compliance

Emissions Reduction Achieved

Cost of Compliance

Emissions Reduction Achieved

Cost of Compliance

Emissions Reduction Achieved

Cost of Compliance

Emissions Reduction Achieved

Cost of Compliance

Emissions Reduction Achieved

Cost of Compliance

Emissions Reduction Achieved
## Reference case & Phase 1 scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>EPA Assumptions and Methodology</th>
<th>Cost per ton of CO₂ reduction ($/ton) *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference Case</td>
<td>MISO’s MTEP-15 Business As Usual future assumptions</td>
<td>-</td>
</tr>
<tr>
<td>Building Block 1</td>
<td>In 2020, apply a 6% heat rate improvement to all the coal-fired units at a capital cost of $100/kW (amortized over 10 years).</td>
<td>5</td>
</tr>
<tr>
<td>Building Block 2</td>
<td>Calculate and enforce, starting in 2020, a minimum fuel burn for existing CC units to yield an annual 70% capacity factor.</td>
<td>53</td>
</tr>
<tr>
<td>Building Block 3</td>
<td>Calculate and add the equivalent amount of wind MWs to meet the incremental regional non-hydro renewable target.</td>
<td>237, Present value calculation for costs is the driver for the higher cost.</td>
</tr>
<tr>
<td>Building Block 4</td>
<td>Calculate the amount of energy savings for the MISO footprint and incorporate it as a 20-year EE program in the model.</td>
<td>70</td>
</tr>
<tr>
<td>All Building Blocks</td>
<td>Application of all building blocks.</td>
<td>60</td>
</tr>
<tr>
<td>CO₂ Constraint</td>
<td>Application of a mass-based CO₂ reduction target, allowing the model to optimize.</td>
<td>38</td>
</tr>
</tbody>
</table>

* The cost per ton of CO₂ reduction is indicative – actual values may vary depending on different input assumptions, etc.

** Assumptions matrix is available at [https://www.misoenergy.org/Events/Pages/PAC20140820.aspx](https://www.misoenergy.org/Events/Pages/PAC20140820.aspx)
In all the scenarios except the CO\textsubscript{2} constraint, energy production from new gas is less than 2.3%.

“Other” category includes energy from biomass, hydro, demand response, energy efficiency and solar.

The results shown for the CO\textsubscript{2} Constraint case are indicative. Further model optimization is required as shown in Phase 2 which indicates potential additional value from increased energy efficiency and coal retirements.
MISO system CO\textsubscript{2} emissions forecast under Phase 1 scenarios
Thinking outside the blocks

• The model can select a least-cost solution that meets a user-defined CO$_2$ target by considering various alternatives.
  – For example, adding new Combined Cycle generation to meet demand and energy needs could be a least-cost solution as its emissions are not included in the proposed EPA’s emissions rate calculation

• Using the model’s functionality:
  – Set equivalent mass reduction targets as a CO$_2$ constraint for regional and sub-regional cases
  – Compare the total cost of the regional vs. sub-regional cases
  – Compliance cost is defined as the difference in the net present value of total system costs between the scenario and the reference cases
Regional compliance options save approximately $3B annually compared to sub-regional compliance.
Phase 2: All possible combinations of the following policy and economic sensitivities were modeled:

- Energy Efficiency as a % of sales:
  - Base
  - 50% of EPA’s Building Block 4
  - EPA’s Building Block 4

- Nuclear Retirements:
  - No Nuclear Retirements
  - 60-year life Nuclear

- Additional Coal Retirements:
  - No additional
  - 25% (13.9GW)
  - 50% (28.3GW)

- CO₂ Costs ($/ton):
  - 0
  - 10
  - 25
  - 50

- Renewable Portfolio Standards:
  - Existing RPS Mandates
  - 15% Regional
  - 20% Regional

- Natural Gas Prices ($/MMBtu):
  - 3.44
  - 4.30
  - 5.16

- Demand and Energy Growth Rates:
  - 0.80%
  - 1.50%
Lower cost compliance strategies to implement the proposed CO$_2$ rule put an additional 14GW of coal capacity at-risk for retirement.
Study findings

• The Phase 1 results indicate that:
  – Alternative compliance options could achieve the proposed level of CO$_2$ reduction at a lower cost relative to the application of all the EPA building blocks
  – Regional compliance options save approximately $3B annually compared to sub-regional compliance

• The Phase 2 results indicate that up to an additional 14GW of coal capacity could be at-risk for retirement
Next Steps…

• MISO can provide additional details behind the modeling, including sub-regional data, based on stakeholder interest

• MISO will develop the scope of work for the next round of analyses based on stakeholder feedback
  – Thank you for the feedback already submitted
  – Please provide any additional feedback to Aditya Jayam Prabhakar (ajayamprabhakar@misoenergy.org)
Additional questions? Please contact:

- Aditya Jayam Prabhakar
  - ajayamprabhakar@misoenergy.org
Appendix
Promulgated under the authority of Section 111(d) of the Clean Air Act, the EPA’s CO₂ emissions rule for existing power plants:

• Proposes state-specific emission rate-based CO₂ goals with various options for flexibility in compliance.

• Offers guidelines for the development, submission and implementation of state plans to address greenhouse gas (GHG) emissions from existing fossil-fired electric generating units (EGUs).

• Reflects the emissions reductions that can be achieved by the application of the Best System of Emission Reduction (BSER) … adequately demonstrated.
The EPA’s definition of BSER is based on four “building blocks” of emissions reduction:

<table>
<thead>
<tr>
<th>Building Blocks</th>
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<tbody>
<tr>
<td>1. Improve efficiency of existing coal plants</td>
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<tr>
<td>2. Increase reliance upon CC gas units</td>
</tr>
<tr>
<td>3. Expand use of renewable resources and sustain nuclear power production</td>
</tr>
<tr>
<td>4. Expand use of demand-side energy efficiency</td>
</tr>
</tbody>
</table>

**EPA Calculations/Assumptions in the Proposed State Goal Development**

- 6% efficiency (heat rate) improvement across the fleet, assuming best practices and equipment upgrades
- Re-dispatch of CC gas units up to a capacity factor of 70%
- Meet regional non-hydro renewable target, prevent the retirement of at-risk nuclear capacity and promote the completion of nuclear capacity under construction
- Scale to achieve 1.5% of prior year’s annual savings rate
Application of the EPA’s Building Blocks to each MISO state’s power generation resource mix

<table>
<thead>
<tr>
<th>State</th>
<th>Adjusted Output Weighted Average CO2 Emission Rates (lbs/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arkansas</td>
<td>910</td>
</tr>
<tr>
<td>Illinois</td>
<td>1,271</td>
</tr>
<tr>
<td>Indiana</td>
<td>1,531</td>
</tr>
<tr>
<td>Iowa</td>
<td>1,301</td>
</tr>
<tr>
<td>Kentucky</td>
<td>1,763</td>
</tr>
<tr>
<td>Louisiana</td>
<td>883</td>
</tr>
<tr>
<td>Michigan</td>
<td>1,161</td>
</tr>
<tr>
<td>Minnesota</td>
<td>873</td>
</tr>
<tr>
<td>Mississippi</td>
<td>692</td>
</tr>
<tr>
<td>Missouri</td>
<td>1,544</td>
</tr>
<tr>
<td>Montana</td>
<td>1,771</td>
</tr>
<tr>
<td>North Dakota</td>
<td>1,783</td>
</tr>
<tr>
<td>South Dakota</td>
<td>741</td>
</tr>
<tr>
<td>Texas</td>
<td>791</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>1,203</td>
</tr>
</tbody>
</table>

Legend:
- □ 2030 Goal
- ■ Heat Rate Improvement
- □ Redispatch
- □ New/At-risk Nuclear
- □ Renewables
- □ Energy efficiency
The regulation allows flexibility in developing state compliance plans, and offers possible compliance options:

- Co-firing or switching to natural gas
- Carbon capture and sequestration
- New natural gas combined cycle generation capacity
- Heat rate improvements for oil, gas-fired, CC and combustion turbine (CT) units
- Co-firing lower carbon fuels
- Transmission efficiency improvements
- Energy storage technology
- Retirements
- Market-based trading programs