Analysis of EPA's Proposal to Reduce CO_2 Emissions from Existing Electric Generating Units

November 2014

Contents

Study Disclaimer

MISO undertook a study to help stakeholders understand the impact of the U.S. Environmental Protection Agency's (EPA) proposal to reduce CO2 emissions from existing fossil-fired generation. This study is not exhaustive in its assessment of the impact of the rule across MISO's footprint, but rather an initial look at the potential impacts to help stakeholders prepare comments to the EPA, which were initially due on October 16, 2014. On September 15, EPA extended the comment period to December 1, 2014. MISO's analysis is independent and does not make recommendations on what compliance solutions are best: those decisions will need to be made by regulating entities and state officials once a final rule is in effect.

MISO is policy-neutral on EPA's proposed rule to reduce CO_2 emissions. However, MISO recognizes that EPA's proposed rule could impact generation, grid reliability and the delivery of least-cost energy across MISO's footprint. Therefore, MISO is working with its stakeholders to analyze the potential impacts of the proposed rule.

The regional nature of the MISO system provides value to customers by supporting and enhancing reliability and resource adequacy, enabling lower-cost delivered energy and fluid wholesale markets. These benefits are quantified annually through the MISO Value Proposition, which identifies the billions of dollars of benefits MISO provides to customers[1].

This report presents the results of MISO's analysis to-date, and outlines MISO's plan to conduct additional analyses going forward. All the results in this report should be viewed as indicative, as generators, states and other entities that are subject to EPA's rule have not yet developed actual compliance plans.

[1] The MISO Value Proposition can be explored at the MISO website: https://www.misoenergy.org/WhatWeDo/ValueProposition/Pages/ValueProposition.aspx

Executive Summary

The U.S. Environmental Protection Agency (EPA) proposed a rule on June 2, 2014, designed to reduce carbon dioxide (CO_2) emissions from existing fossil-fired generation units.

MISO's initial analysis is focused on the potential compliance costs associated with the proposed rule. CO_2 reduction strategies reviewed were:

- Applying EPA's building blocks on a region-wide (MISO-wide) basis costs approximately $90 billion in net present value over the 20-year study period. This equates to approximately $60/ton of CO_2 emissions avoided from existing fossil-fired units.
- Application of alternative compliance strategies outside of the building blocks (for example, retiring and replacing coal units with combined-cycle gas capacity) costs $55 billion in net present value for a regional approach. This equates to approximately $38/ton of CO_2 emissions avoided from existing fossil-fired units.
- A similar outside-the-blocks strategy at a sub-regional level (using the MISO Local Resource Zones) indicates a cost of $83 billion in net present value. This equates to an approximate average of $57/ton of CO_2 emissions avoided from existing fossil-fired units.

The annual cost avoidance of a regional carbon constraint approach compared to a sub-regional approach is approximately $3 billion. MISO finds that EPA's proposal could put up to an additional 14 GW of coal capacity at risk of retirement in order to achieve lower compliance costs with the CO_2 reductions. This analysis focuses on generation capital investment and production costs. Costs of additional electric transmission system or gas pipeline infrastructure required to implement the CO_2 reduction strategy are not included. Future modeling may consider transmission and pipeline costs.

MISO's review also indicates that the interim targets in the proposed rule will require significant CO_2 reductions in the 2020 timeframe. This study indicates that this short timeline may not allow cost-effective, long-term planning. If coal plant retirements are part of the compliance strategy for 2020, corresponding capacity additions (for reliability and resource adequacy) in a two-year window will be difficult if not impossible. MISO's experience is that new gas plant construction typically requires three to six years. If new transmission and gas pipeline additions are needed to accommodate the capacity expansion, this timeline may be even longer. This finding suggests that in order to meet the 10-year average identified in the proposed rule, it is likely that entities will need to take immediate action. Since it is possible that state plans will not be finalized until the 2018-19 timeframe, there will be little time for decisions and implementation for infrastructure changes before 2020.

MISO intends to conduct additional analysis based on the recommendations and informational needs of its stakeholders, including an assessment of how EPA's proposed rule could affect grid reliability in the footprint. MISO is also developing comments that will be filed with EPA on December 1, 2014. MISO looks forward to continuing its work with stakeholders on this key policy issue to identify ways to continue MISO's mission to ensure reliable, least-cost delivered energy for electricity consumers.

Basic Elements of EPA's Proposed Rule

In general terms, EPA's proposed rule[2] seeks to reduce CO_2 emissions from existing power plants by an average of 30 percent nationally by 2030, relative to 2005 actual level. The proposed rule sets individual CO_2 emissions reduction/intensity targets for 49 states[3], based on the composition of each state's energy mix. Therefore, the rule requires some states to achieve greater emissions reductions than other states. The rule also establishes interim compliance targets that take effect starting in 2020.

EPA's proposed rule does not require entities to use any specific types of emissions-reduction technologies, although the measure does outline four "building blocks" as proven methods of reducing CO_2 emissions as the Best System of Emissions Reduction (BSER). Similarly, the proposed rule allows—but does not require—multiple states to work together in a "regional" or "multi-state" fashion to satisfy their emissions-reduction targets. The "regional" aspect of EPA's proposed rule is a prominent part of MISO's analysis.

1.1 EPA's Proposed Timeline

EPA intends to finalize its proposed rule in mid-2015, with key milestone dates (Figure 1-1). The proposed rule also requires states to submit plans detailing how they intend to reduce CO_2 emissions within their borders, much like they currently file State Implementation Plans (SIPs) for other EPA regulations.

The proposed rule gives states until June 2016 to submit plans, with the possibility of receiving a one-year extension until June 2017. States that elect to work with at least one other state will have until June 2018 to submit their plans, with the possibility of receiving a two-year extension from 2016 if they choose to collaborate and develop a multi-state plan. The timeline also depicts the interim compliance period that begins in 2020, as well as the final goal in 2030.

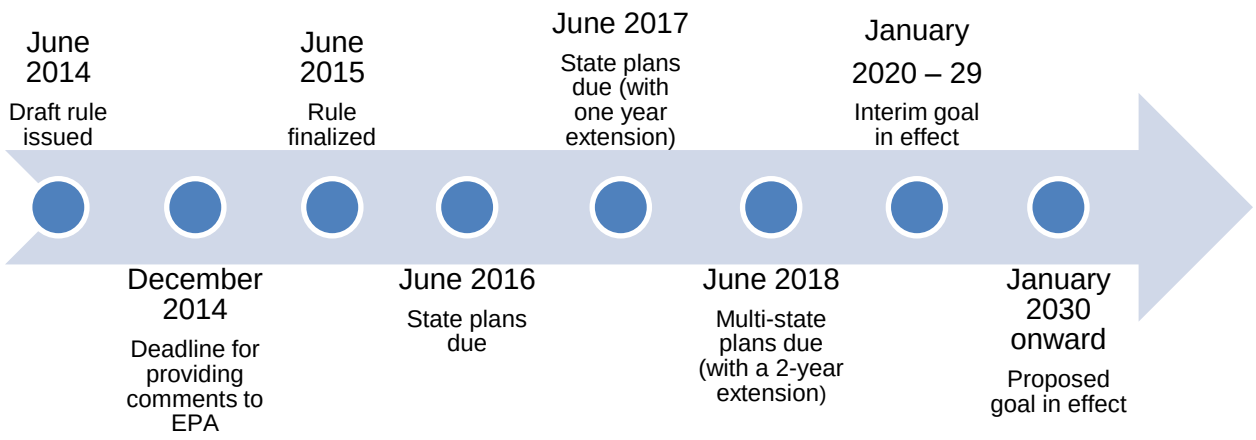

Figure 1-1: EPA's proposed timeline for draft rule

[2] See http://www.gpo.gov/fdsys/pkg/FR-2014-06-18/pdf/2014-13726.pdf.
[3] The State of Vermont does not have a target because it does not have any Electric Generating Units (EGUs) covered by the proposed rule.

1.2 Rate-Based To Equivalent Mass-Based Targets

EPA's proposed rule sets specific emissions-reduction targets that individual states must meet in the interim compliance period (2020-2029) as well as in 2030 and thereafter. EPA expresses those targets in "rate" form, or pounds of CO_2 per MWh via a formula (Figure 1-2).

$$\text{Rate (lbs/MWh)} = \frac{\text{Statewide } CO_2 \text{ emissions from covered fossil fuel-fired power plants (lbs)}}{\text{State electricity generation from covered fossil plants + renewable energy + nuclear (at-risk portion and New) + energy efficiency (EE) (MWh)}}$$

Figure 1-2: EPA's formula for emissions rate calculation

The software that MISO used to analyze EPA's proposed rule can only model CO_2 emissions on a "mass" basis, or tons of CO_2 emitted from all generators within a particular region. Therefore, in analyzing EPA's proposed rule, MISO converts the rate-based emissions-reduction to equivalent mass-based targets. In making those conversions, MISO models only the portions of its member-states that reside within the footprint. To calculate how many tons of emissions come from a particular area, MISO uses the following formula:

> *Emissions in tons = (2012 system generation from covered fossil plants + renewable and EE mandate-driven energy forecast) * (proposed CO_2 emission rate goal for a state)*

The proposal includes these major elements:

- State-by-state targets (expressed as a rate of CO_2 in lbs/MWh) developed based on the four building blocks (Figure 1-3)
- The application of formulaic building blocks to determine each state's reduction capability, and subsequently, each state's emissions reduction target (Figure 1-4) — calculated from a 2012 emissions baseline

BLOCK 1	**BLOCK 2**	**BLOCK 3**	**BLOCK 4**
Improve efficiency of existing coal plants	Increase reliance upon combined cycle (CC) gas units	Expand use of renewable resources and sustain nuclear power production	Expand use of demand-side energy efficiency
6 percent 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 percent	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 percent of prior year's annual savings rate

Figure 1-3: Proposed building blocks and applications

Though the proposal establishes a compliance timeline, it does not prescribe specific methods to meet reduction requirements. Rather, the rule identifies a variety of ways to reduce emissions including via interstate cooperation. It also observes that Independent System Operators (ISOs) and Regional Transmission Organizations (RTOs) "could provide a structure for achieving efficiencies" in implementing the CO_2 emission standards for existing power plants and could help foster those efficiencies "by coordinating the state plan approaches applied throughout a grid region.

1.3 State Carbon Intensity Goals

Each state goal for carbon emissions reduction is actually a pollution-to-power ratio, i.e., a rate for future CO_2 intensity of applicable, existing electric generators in a given state.[4] EPA's building blocks can be applied to reach the state carbon intensity targets (Figure 1-4). The far right of each bar in the figure represents the 2012 emissions baseline; each successive colored bar factors in another building block. The white bar represents the emissions rate per state in 2030, as calculated in the draft rule. The variance in emissions allowances derives from the existing resource mix in each state and EPA's method of determining the feasibility of emissions reduction given existing resources. Under the Clean Air Act, the draft rule's state plan requirement will be addressed by each state's respective air quality office.

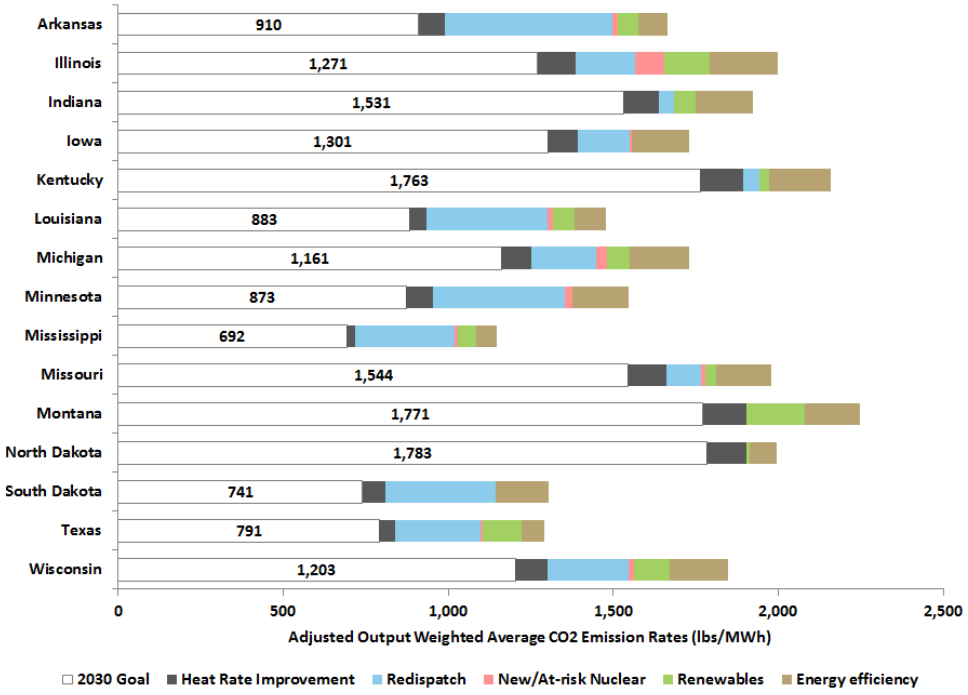

Figure 1-4: Application of EPA building blocks to MISO states' carbon emissions rates[5]

Analysis Included Asking a Series of Questions

In its efforts to understand the impacts of the draft rule, MISO posed a set of questions that ranged from EPA's building blocks to studying various alternatives to comply.

[4] See http://blog.epa.gov/epaconnect/2014/06/understanding-state-goals-under-the-clean-power-plan/

[5] Note: these rate reductions would apply to the state as a whole, while MISO's initial analysis is performed on the portion of the state that is in the MISO footprint.

Question 1: Costs

What does it cost to implement the building blocks and do they achieve the required level of emissions reduction under a regional generation dispatch?

For the MISO system, application of the building blocks as described in the EPA proposal costs $90 billion in net present value (over 20 years, 2014-2033) at an indicative cost of $60/ton and achieves the required levels of CO_2 emissions reduction (Table 2-1). MISO analyzes EPA's proposed rule by reviewing the building blocks EPA used to set the state-specific levels of CO_2 reductions[6] and then by comparing the costs of achieving compliance at a regional level and at sub-regional Local Resource Zone (LRZ) levels. MISO estimates the compliance costs of using the four CO_2-reducing building blocks that EPA outlined in its proposed rule individually, as well as in combination with each other. MISO calculates the total compliance cost of applying the building blocks on a "regional" basis across the entire 15-state footprint.

Under the regional approach, the demand and energy needs are modeled as being met using resources across the entire MISO system. Under the sub-regional approach, each LRZ would have to meet its equivalent CO_2 emission reduction target. Companies within each LRZ are modeled as meeting their demand and energy needs with resources they own while adding new resources, as needed, to maintain a minimum reserve margin (for resource adequacy purposes for the foreseeable future).

Scenarios	Modeling Assumptions (per EPA's Clean Power Plan) and Methodology
Reference Case	MISO's Transmission Expansion Plan-15 (MTEP-15) Business As Usual future assumptions (Matrix is available at https://www.misoenergy.org/Events/Pages/PAC20140820.aspx)
Building Block 1 (BB1)	In 2020, apply a 6 percent heat rate improvement to all the coal-fired units at a capital cost of $100/kW (amortized over 10 years).
Building Block 2 (BB2)	Calculate and enforce, starting in 2020, a minimum fuel burn for existing CC units to yield an annual 70 percent capacity factor.
Building Block 3 (BB3)	Calculate and add the equivalent amount of wind MWs to meet the incremental regional non-hydro renewable target.
Building Block 4 (BB4)	Calculate the amount of energy savings for the MISO footprint and incorporate it as a 20-year EE program in the model.
All Building Blocks	Application of all building blocks.

Table 2-1: Scenarios, modeling assumptions and methodology

MISO's analysis makes no judgment on the technological or economic feasibility of EPA's building blocks. Instead, MISO simply models its interpretation of the building blocks using the assumptions and parameters that EPA outlined in its proposed rule. There are certain additional costs associated with the building blocks that EPA acknowledges it did not attempt to quantify in its proposed rule. For example, EPA did not attempt to estimate the costs of building the additional natural gas infrastructure that would likely be required to increase the capacity factor of combined cycle units up to 70 percent (building block

[6] The four building blocks are: (1) improving the heat rate of coal units by 6 percent; (2) increasing the capacity factor of existing and under-construction combined cycle gas units to at least 70 percent; (3) expanding the use of renewables and sustaining at-risk nuclear generation; and (4) expanding the use of demand-side energy efficiency. MISO's analysis makes no judgment on the technological or economic feasibility of EPA's building blocks. Nor does it reflect certain additional costs that application of the building blocks would likely incur, such as the natural gas infrastructure expansion related costs that may be needed to increase the capacity factor of combined cycle units up to 70 percent.

2). In this initial phase of the analysis, MISO did not model the costs of likely electric and natural gas infrastructure upgrades necessary.

MISO also analyzes how utilizing the building blocks would change energy generation mix in the year 2030 from coal, gas and other fuels. MISO first modeled a "reference case" scenario that assumes current policies would be continuing without EPA rule to limit CO_2 emissions from existing units. MISO forecasts that 56 percent of the footprint's total energy needs (measured in GWh) in 2030 would be generated by coal-fired resources (Figure 2-1)

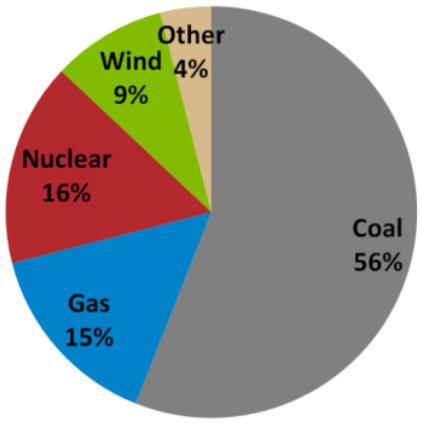

Figure 2-1: 2030 MISO system energy dispatch for the Reference Case (Business As Usual)

The energy generation mix in the MISO footprint would change with the application of EPA's four building blocks (Figure 2-2). BB1 would make the coal-fired units more efficient and therefore the system would marginally increase energy production from coal resources in 2030 (the pie-charts show it to be the same (56 percent) in the BB1 and reference case due to rounding). BB2 would increase energy production from existing gas resources from 15 percent to 26 percent while reducing energy production from coal-fired units. BB3 increases energy production from renewable resources (wind was used as a proxy) from 9 to 12 percent while displacing energy from both coal and gas resources. BB4 increases the energy reduction from EE resources shown in the other category – while displacing predominantly gas and some coal-fired energy production. MISO finds that applying all four of the building blocks together would increase the fraction of gas-fired energy in its footprint to 24 percent of the total, while decreasing coal-fired energy to 33 percent.

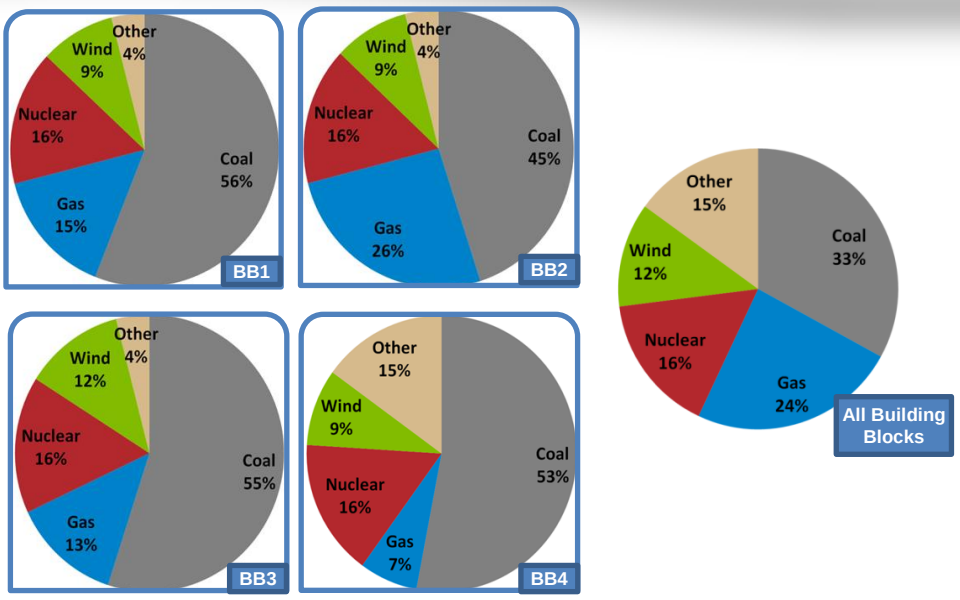

Figure 2-2: 2030 MISO System energy dispatch for the building blocks

MISO also observes the CO_2 emissions reductions from existing units change by the application of building blocks individually and all together (Figure 2-3). BB1 reduces carbon emissions from existing units as the coal fleet becomes more heat rate efficient beginning in 2020 with the application of 6 percent heat rate improvement. BB2 achieves the highest CO_2 emissions reduction in 2020 and then the emissions reduction would reduce for the future years as the existing units are trying to meet increased demand and energy requirements for the system. BB3 reduces emissions from existing and future units (whose emissions are not counted in the rate goal calculation) and hence the emissions from existing units are only reduced marginally. BB4 also has a similar effect as it reduces emissions from existing and displaces the need for future units compared to the reference case. BB4 shows a continuous reduction in emissions as it reduces the system's demand and energy needs for the future. The model assumes that there are no fuel limitation constraints or unit operational constraints. While it may appear that the application of the building blocks verbatim achieve compliance, the most important is to look at the technical, operational and economic feasibility of implementing them.

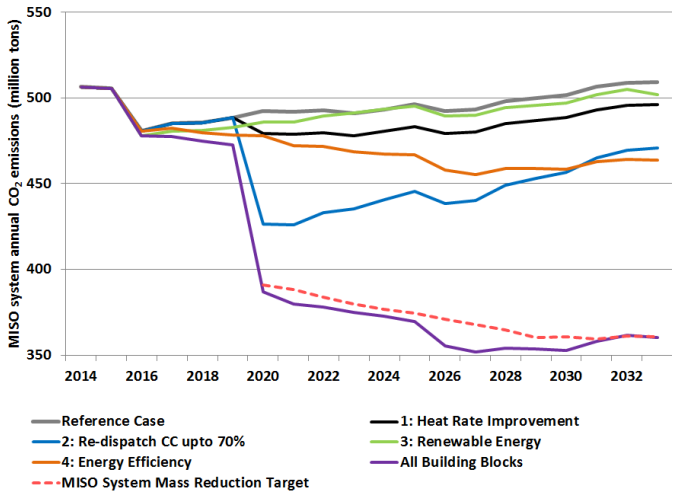

Figure 2-3: MISO System CO_2 emissions reduction (from existing units only)

Question 2: Alternatives

What does MISO's analysis of alternative compliance strategies show?

The proposed regulation allows flexibility in developing compliance plans and offers possible compliance options (Figure 2-4).

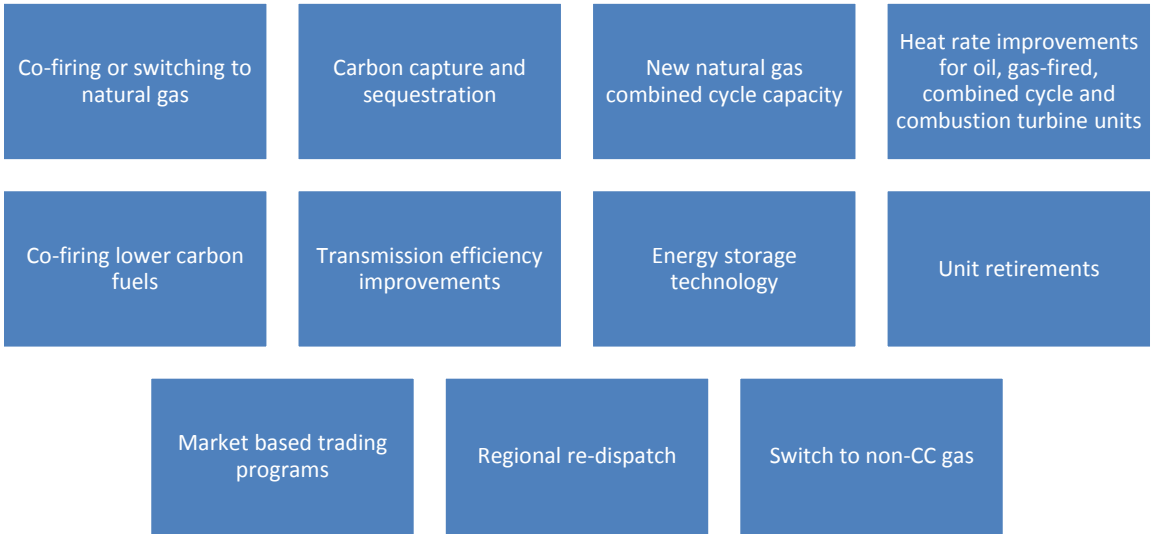

Figure 2-4: Alternative compliance strategies identified in the proposal

MISO's analysis finds that using all four of the building blocks to comply with EPA's proposed rule would cost an aggregate $90 billion (net present value) over 20 years, or $60 per ton of avoided CO_2 from existing units. A key take-away of the analysis is that using CO_2-reduction strategies *other* than the building blocks, such as building new gas capacity and retiring coal units appears to be a more cost-effective means of complying with EPA's proposed rule. MISO finds that using strategies other than the building blocks could significantly reduce the costs of complying with EPA's proposed rule. Specifically, results indicate that this approach would cost $55 billion (net present value) over 20 years, or $38/ton of avoided CO_2 emissions from existing units. While those indicative costs are still significant, they are markedly lower than the costs of complying with EPA's proposed rule using only the building blocks.

This aspect of the analysis is referred to as the "CO_2 constraint scenario" (Figure 2-5) because to model it, MISO translated EPA's rate-based emissions targets into an equivalent CO_2 mass limit for the footprint and used the Electric Generation Expansion Analysis System (EGEAS) model to come up with a least-cost means of complying with EPA's rule. Emissions from new generation (for example, new combined cycle units that are added to the system) are not counted in the rate goal calculation under EPA's proposal as they are regulated under the New Source Performance Standards in Section 111(b) of the Clean Air Act.

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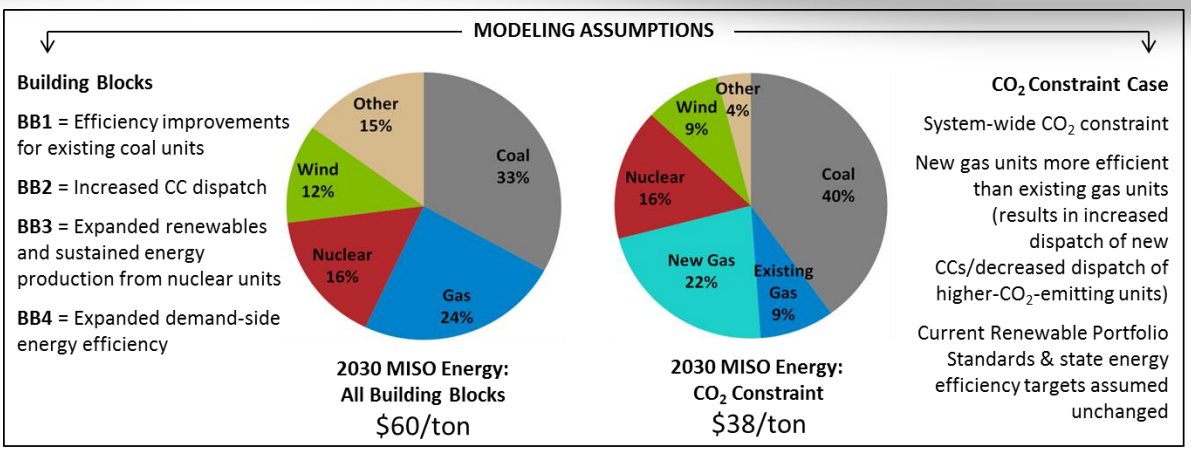

Figure 2-5: An assessment of alternative regional compliance strategies

Question 3: Regional Collaboration

Regional markets provide a wide spectrum of economic and operational benefits to its members. Are there economic benefits in a regional collaboration for carbon compliance?

MISO's analysis finds that taking a regional, footprint-wide compliance approach to EPA's proposed rule could reduce aggregate compliance costs by approximately 40 percent compared to undertaking similar emissions reductions on a sub-regional (LRZ) basis. Specifically, MISO finds that compliance with the draft rule using a regional approach would cost $55 billion over 20 years, compared to $83 billion for a sub-regional approach[7].

While there are significant compliance costs associated with any approach to EPA's proposed rule, MISO finds that a regional approach could save regulated entities an aggregate $3 billion per year. This finding is consistent with previous analysis MISO conducted on regional versus sub-regional approaches to regulating CO_2 emissions. Figure 2-6 illustrates the regional-related cost savings that MISO finds in the current analysis.

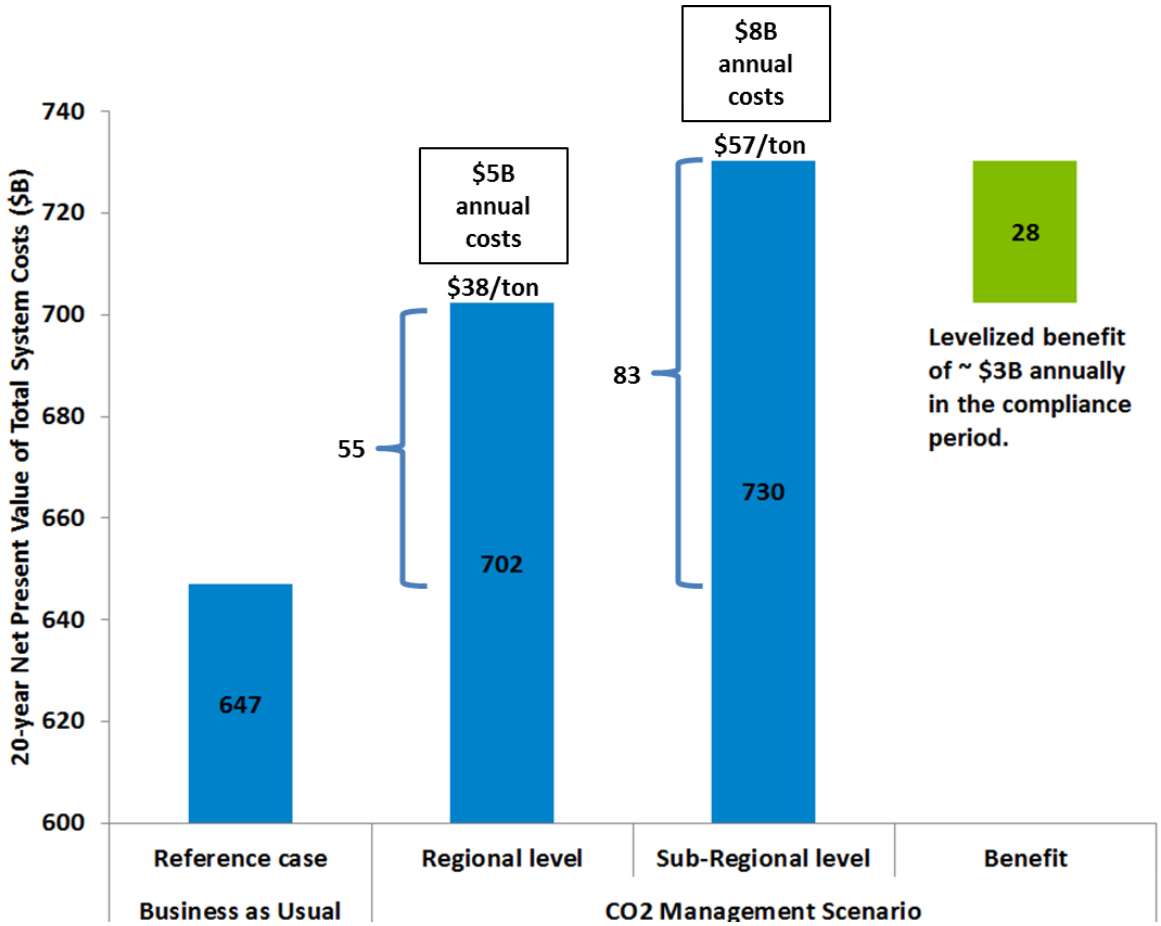

Figure 2-6: Total MISO system costs

[7] Cost figures cited are incremental or relative costs of compliance with the draft rule, as opposed to total system costs.

The regional carbon management approach is developed by the application of a carbon cap to the MISO Business-As-Usual scenario and calculating the compliance cost to achieve the CO_2 emissions reduction. The compliance cost is $55 billion in net present value over the 20-year study period (2014-2033) at a cost of $38/ton of CO_2 reduction.

The sub-regional carbon management is developed by the application of a carbon cap to each of the nine Local Resource Zones and calculating the compliance cost to achieve the required level of CO_2 emissions reduction. The total compliance cost is $83 billion in net present value over the 20-year study period at an average cost of $57/ton of CO_2 reduction achieved across all zones.

The difference in compliance costs is $28 billion in net present value when annualized (at a discount rate of 2.5 percent) over the compliance portion of the study period (2020-2033), which results in annual cost avoidance of $3 billion. The main driver for the cost savings is from the timing of resource additions that the sub-regions would require compared to the regional carbon management. The Planning Reserve Margin target (expressed as a percentage of the coincident peak load that the system must carry such that the loss of load expectation is one day in 10 years) for each of the nine local resource zones is set such that the Planning Reserve Margin Requirement (the total capacity required to reliably serve the system) is the same for both the regional and sub-regional cases.

Question 4: Sensitivities

Is there a strategy that achieves compliance with EPA's proposed regulation at a lower cost?

MISO's annual planning process (the MISO Transmission Expansion Plan or MTEP) is a stakeholder-collaborative process that recognizes a variety of policy and economic conditions that impact generation and transmission costs. Through that process, MISO identified a number of variables that could have significant impacts over the long-term. MISO analyzed 1,296 different cases by creating all possible combinations of the sensitivities (Figure 2-7) - understanding fully that some of the variables are not mutually exclusive, but treating them so gives ideas of what level of impacts that one variable change can have on the outcome.

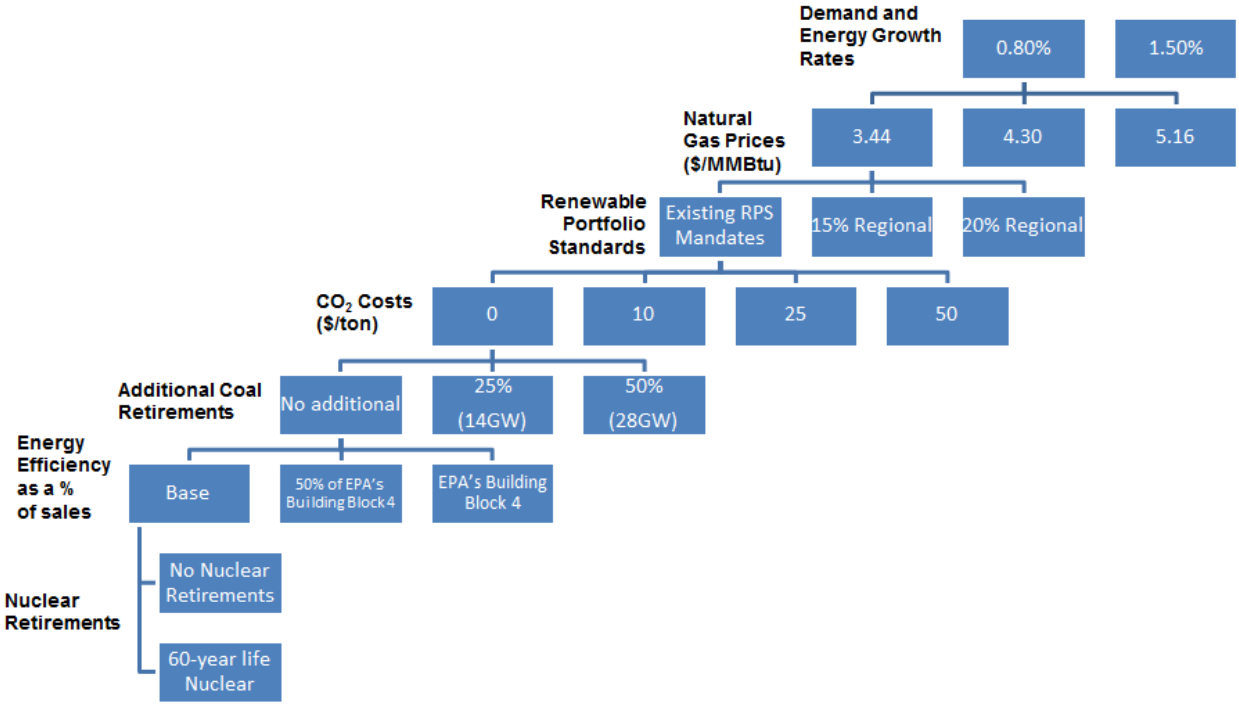

Figure 2-7: All possible combinations of policy and economic sensitivities (1,296) were evaluated

Each of the outcomes (denoted as diamond shapes) in Figure 2-8 represents a unique scenario consisting of a specific policy and economic condition from the various levels of gas prices, coal and nuclear retirements, renewable energy and energy efficiency usage, and demand and energy growth rates.

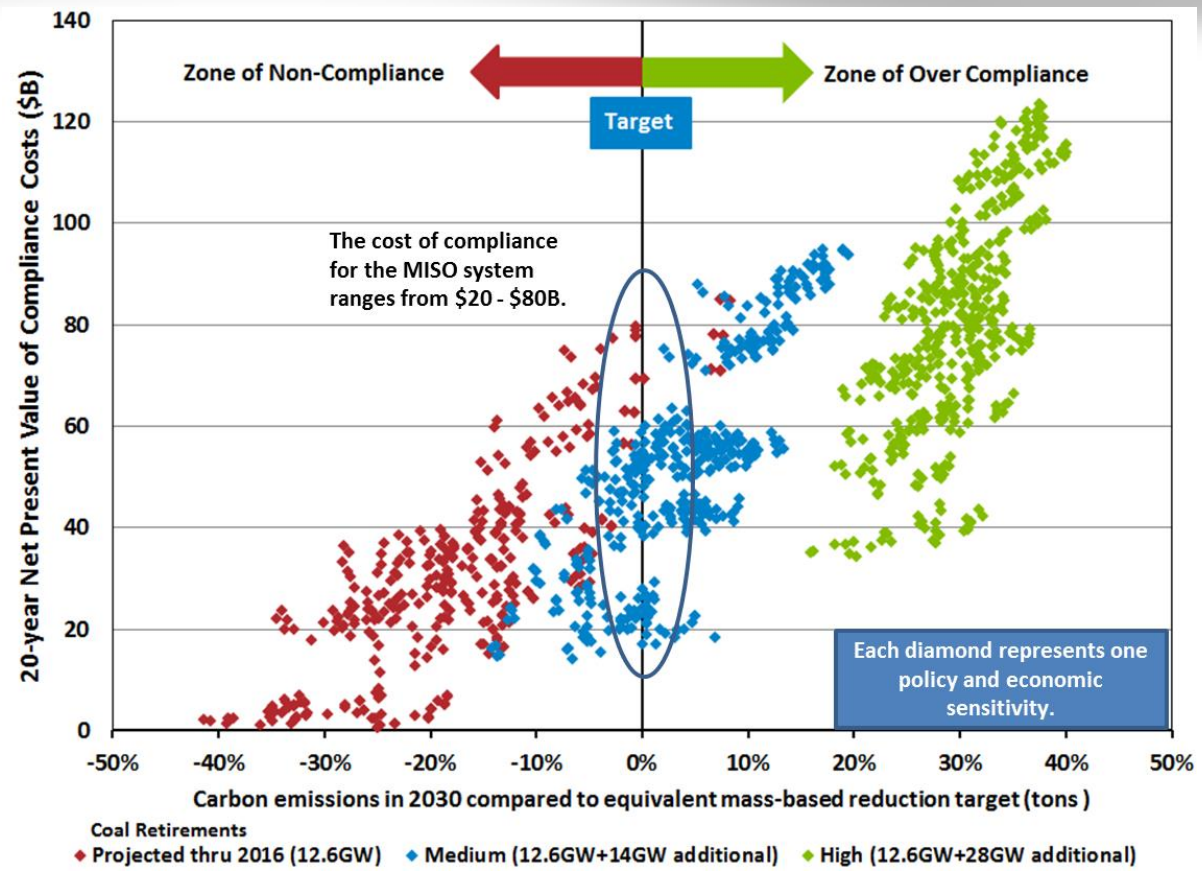

Figure 2-8: Sensitivity analysis results highlighting retirement scenarios

MISO finds that entities may be able to comply with EPA's proposal by limiting coal retirements to the 12.6 GW that MISO previously estimated was at risk of retirements due to MATS. However, not all cases achieve the required levels of compliance. Sensitivities that achieve compliance at lower costs have approximately 14GW of coal-fired capacity, above and beyond the previously identified 12.6 GW (an additional 25 percent of the remaining coal fleet at risk for retirement). This analysis concludes that cost-effective strategies for compliance with EPA regulation may put an additional 14 GW of coal-fired generation at risk for retirement.

The diamonds are colored (red, blue and green) based on the coal retirement assumption studied in that scenario. The red-colored scenarios include only the 12.6 GW of coal units that MISO previously identified to be at risk of retirement by 2016 due to MATS. As the chart illustrates, it is possible to meet (and in some cases, even over-comply with) EPA's emission-reduction targets by retiring no more than the previously identified 12.6 GW of existing coal capacity. It is important to note that the revenue from carbon costs is not showing up in the compliance costs calculated.

The blue-colored scenarios in the chart include the 12.6 GW of coal retirements associated with MATS, plus additional retirement of 25 percent of the remaining coal fleet (or approximately 14 GW) after projected MATS retirements. The blue-colored scenarios cluster around the target line at lower compliance costs than the red-colored scenarios. That is the basis of MISO's discovery that 25 percent of the remaining (after the 12.6 GW of retirements) coal fleet in the footprint, or approximately 14 GW, may be at risk of retirement due to EPA's proposed CO_2 rule.

The green-colored scenarios in the chart include the 12.6 GW of coal retirements associated with MATS, plus retirement of an additional 50 percent of the remaining coal fleet (or approximately 28 GW) for compliance with EPA's proposed CO_2 rule. Retiring that level of coal capacity would exceed the emissions-reduction targets in EPA's proposed rule. As such, MISO does not anticipate that coal retirements will greatly exceed the 14 GW mark as a result of EPA's proposed CO_2 rule.

Question 5: Timeline

Is there enough time to implement low cost compliance strategies?

Lower-cost compliance strategies include the retirement of existing coal-fired units and replacing them with new gas-fired combined cycle (CC) units. From a timeline perspective, it is anticipated that EPA would issue a final rule in June 2015. States and EPA may take until 2018 to finalize and approve the implementation strategies. With reserve margins in MISO's footprint already in decline due to MATS and other factors, carbon-intensive generation retired for the purposes of complying with EPA's proposal will need to be replaced fairly quickly. Investment in new generation would not start, at the earliest, until after the compliance plans are approved, which is likely to be in the 2017 to 2018 timeframe. MISO's analysis found that compliance owners may need to significantly reduce their CO_2 emissions as early as 2020 in order to meet the averaging period of EPA's 2020-29 interim target. The majority of the CO_2 emissions reductions have to be achieved by 2020 to comply with the interim target. These timing-related issues are illustrated in Figure 2-9. If the interim targets have to be met – then the compliance owners would have to utilize less cost-effective solutions to achieve required levels of reduction.

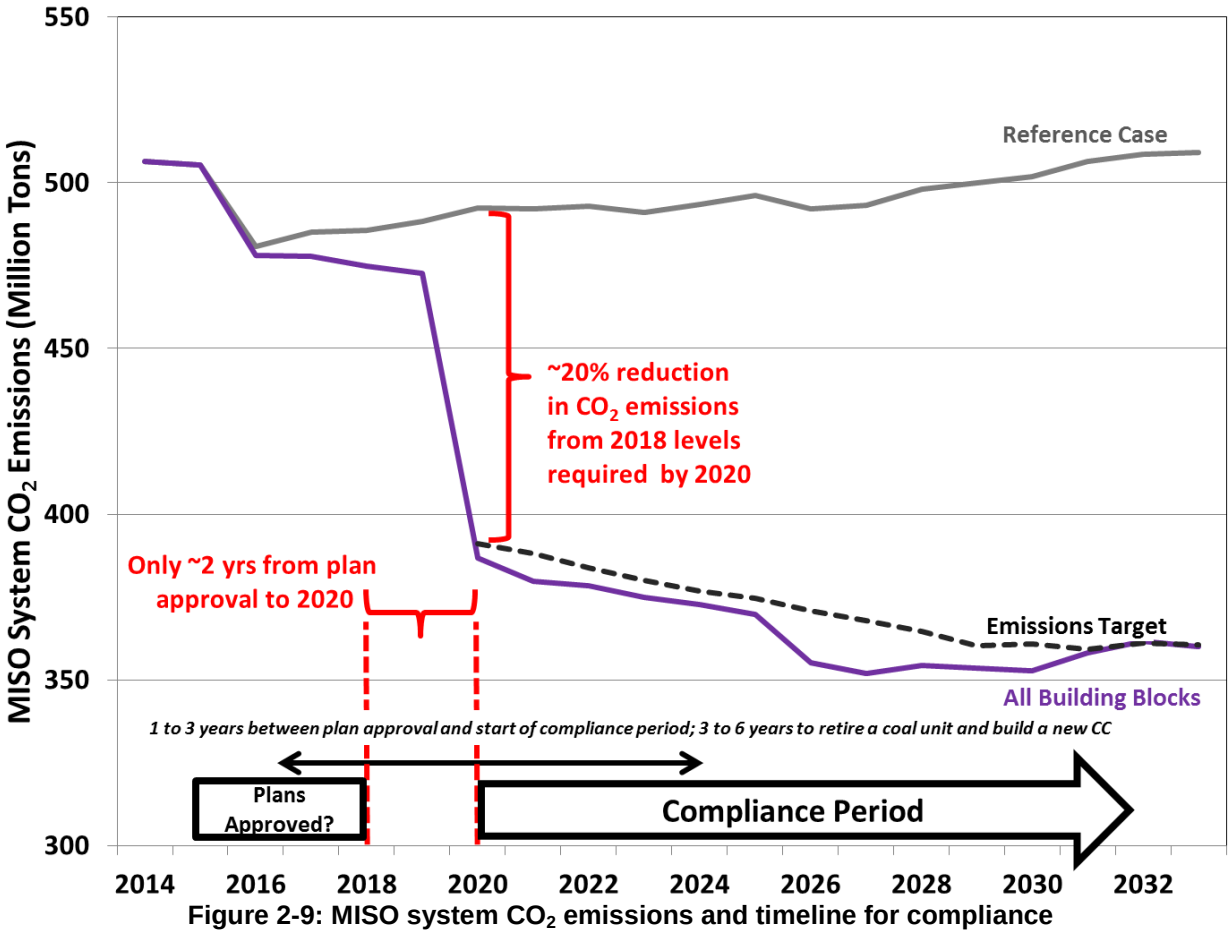

Figure 2-9: MISO system CO_2 emissions and timeline for compliance

It takes an expected 36 to 72 months to build a new CC unit or a combustion turbine from planning to commercial operation. If plans to construct a new CC unit are started right after the state's compliance plan is approved by EPA sometime in 2018, the first unit could be interconnected to the grid by 2021-2023 timeframe. Lack of certainty and time to implement lower-cost compliance solutions could potentially impact reliability.

Next Steps

This report describes the compliance cost analysis that MISO has conducted as of October 2014 on EPA's proposed rule. MISO intends to conduct additional analysis based on the recommendations and informational needs of its stakeholders, including an assessment of how EPA's proposed rule could affect grid reliability in the footprint. MISO may also study the costs of building additional natural gas pipelines and other necessary infrastructure that EPA excluded from its assumptions in its proposed rule. Based on stakeholder input, MISO will file public comments with EPA about the proposed rule. MISO will continue to solicit input from its stakeholders on these and other issues as EPA moves towards finalizing its rule in mid-2015