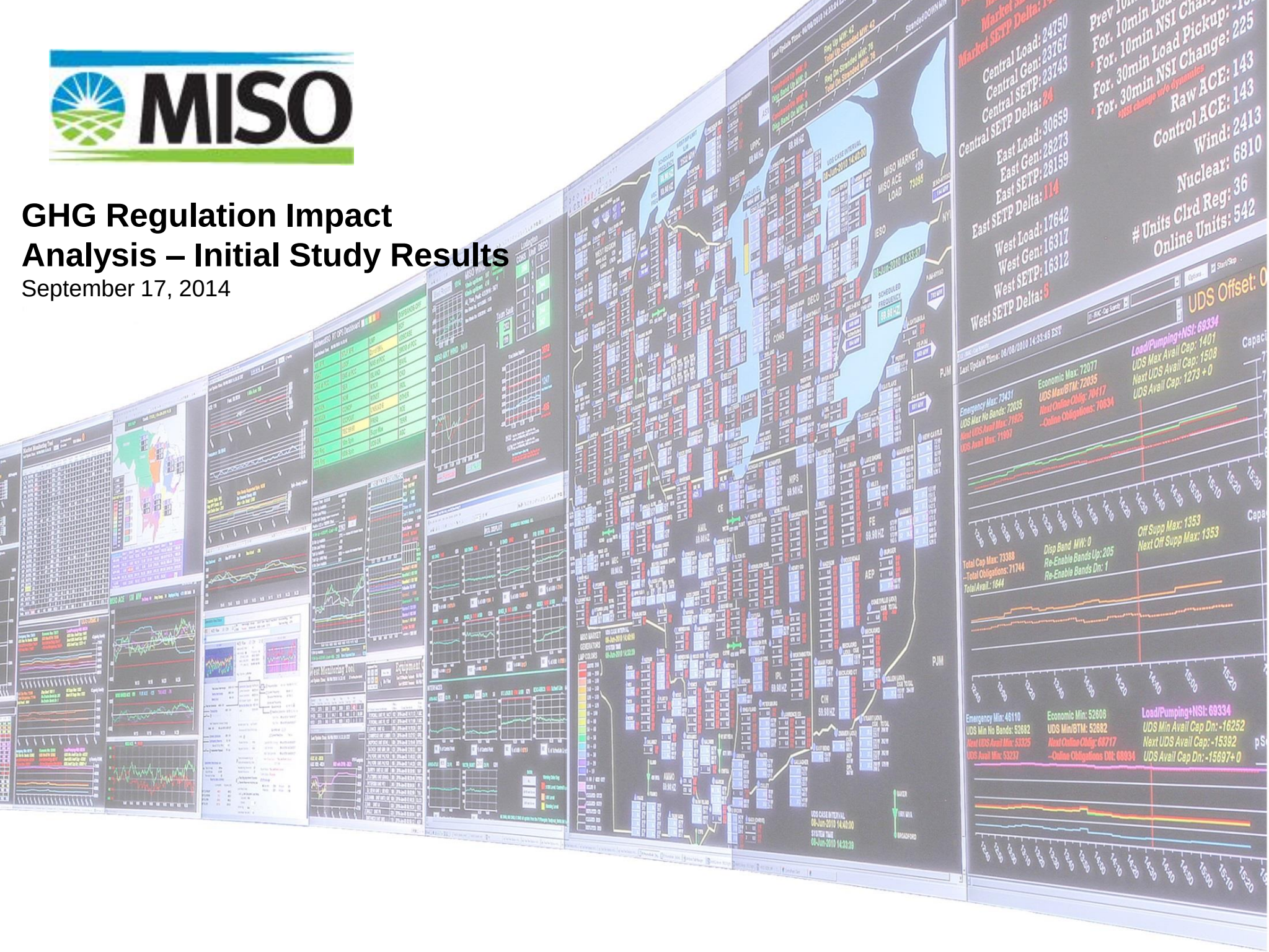
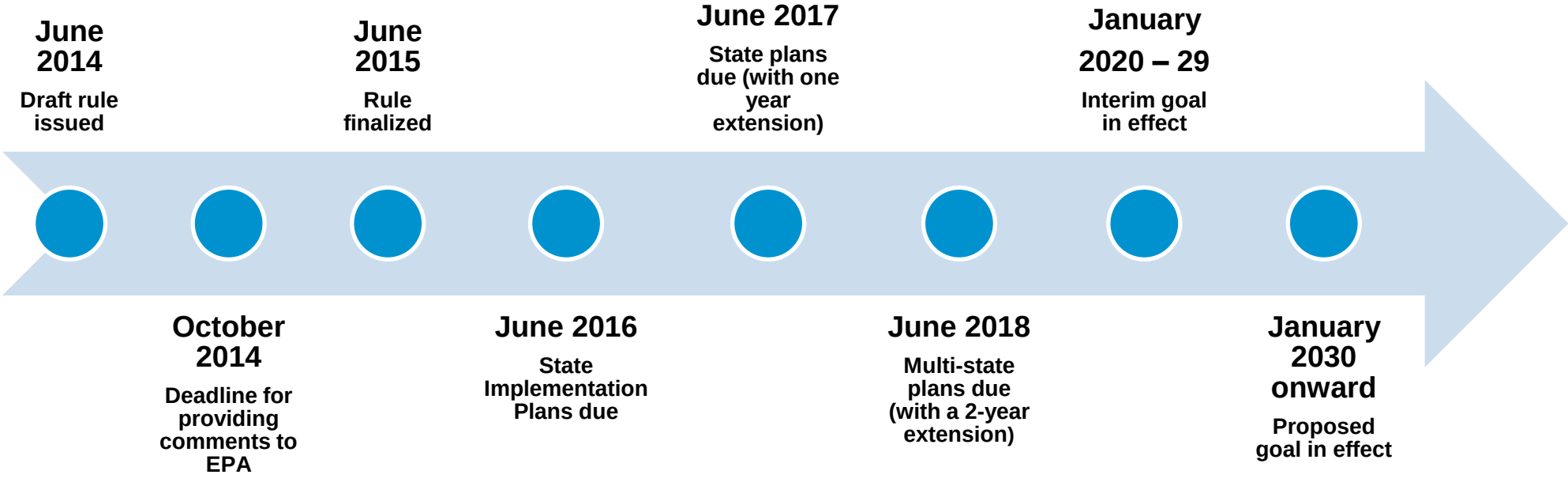
GHG Regulation Impact Analysis – Initial Study Results

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 CO_2 emissions from existing electric generating units.



Study objectives and key takeaways

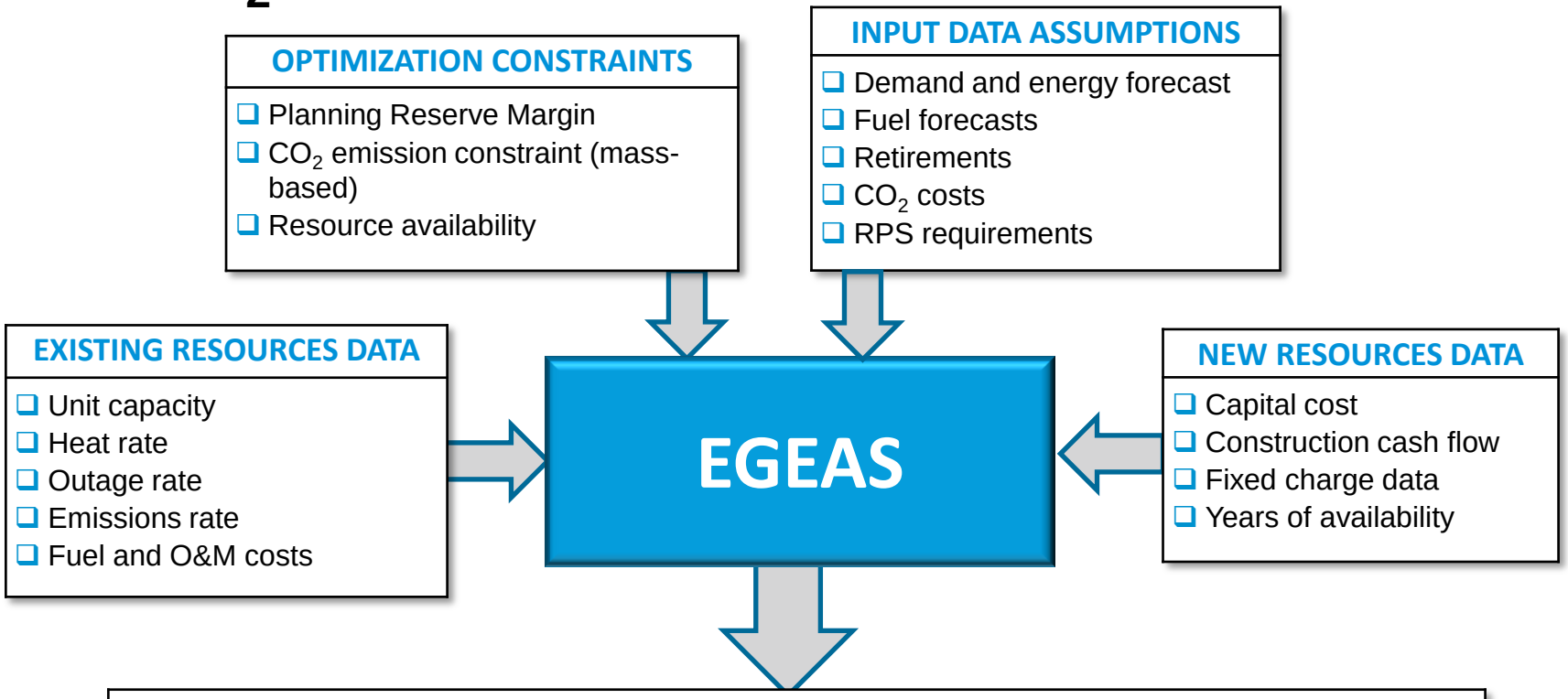
Study Phase	Objectives	Study results indicate that…
Phase 1	Calculation of the compliance costs for regional (MISO footprint) and sub-regional (Local Resource Zones) CO_2 management ➢ Applying the Building Blocks as proposed in the EPA's draft rule ➢ Applying a regional CO_2 constraint, i.e., a regional CO_2 reduction target	**Alternative compliance options outside the building blocks could achieve the proposed level of CO_2 reduction at a lower cost.** **Regional compliance options save approximately $3B annually** compared to sub-regional compliance.
Phase 2	Examination of the range of CO_2 emissions reductions, and associated costs, under various future policy and economic assumptions	**Up to an additional 14GW of coal capacity could be at-risk for retirement.**

Each state has a proposed state-wide CO_2 emissions rate goal calculated as:

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

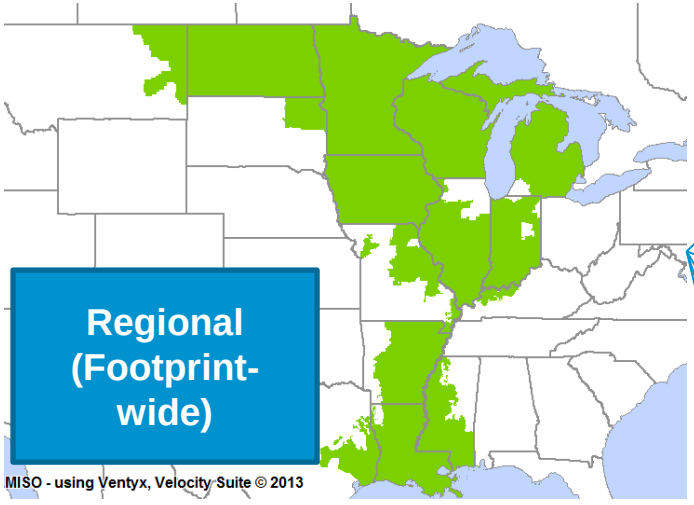
- Numerator – sum of CO_2 emissions from existing generating units
- Denominator – electricity generation in the state excludes existing hydro and new thermal resources
- Every state is assigned a different proposed rate goal (lbs/MWh) for the interim (2020-2029) and the final (2030 onward) periods
- 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

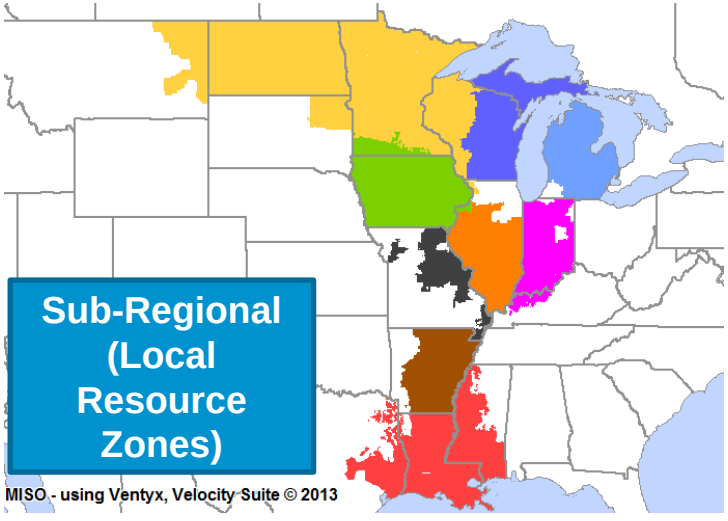
EGEAS was used to study potential impacts of the draft CO_2 emissions reduction rule



Total System Costs = Sum of Production Cost + Fixed O&M Cost + Capital Carrying Costs.

Phase 1 : An assessment of EPA's Building Blocks





- Building Block 1
  - Cost of Compliance
  - Emissions Reduction Achieved
- Building Block 2
  - Cost of Compliance
  - Emissions Reduction Achieved
- Building Block 3
  - Cost of Compliance
  - Emissions Reduction Achieved
- Building Block 4
  - Cost of Compliance
  - Emissions Reduction Achieved
- All Building Blocks
  - Cost of Compliance
  - Emissions Reduction Achieved

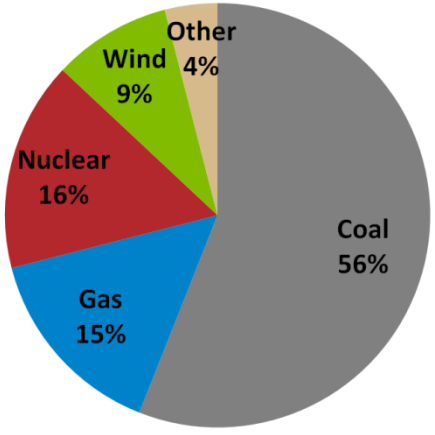
Reference case & Phase 1 scenarios

Scenario	EPA Assumptions and Methodology	Cost per ton of CO_2 reduction ($/ton) *
Reference Case	MISO's MTEP-15 Business As Usual future assumptions**	-
Building Block 1	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).	5
Building Block 2	Calculate and enforce, starting in 2020, a minimum fuel burn for existing CC units to yield an annual 70% capacity factor.	53
Building Block 3	Calculate and add the equivalent amount of wind MWs to meet the incremental regional non-hydro renewable target.	237 Present value calculation for costs is the driver for the higher cost.
Building Block 4	Calculate the amount of energy savings for the MISO footprint and incorporate it as a 20-year EE program in the model.	70
All Building Blocks	Application of all building blocks.	60
CO_2 Constraint	Application of a mass-based CO_2 reduction target, allowing the model to optimize.	38

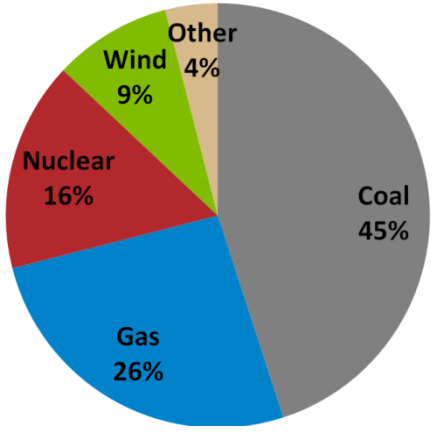
*** The cost per ton of CO_2 reduction is indicative – actual values may vary depending on different input assumptions, etc.**

**** Assumptions matrix is available at https://www.misoenergy.org/Events/Pages/PAC20140820.aspx**

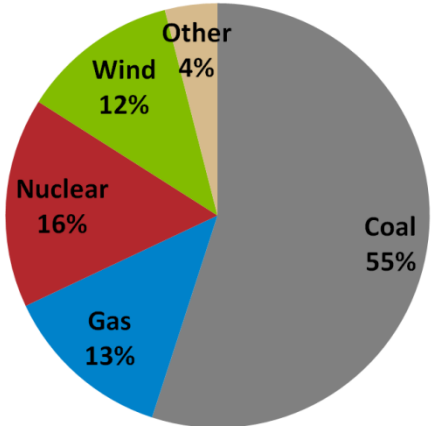
2030 MISO system energy generation forecast under Phase 1 scenarios



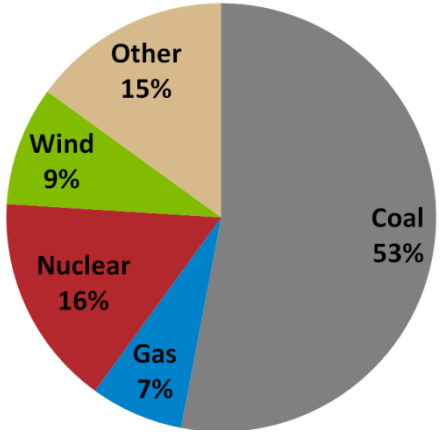
1: Heat Rate Improvement



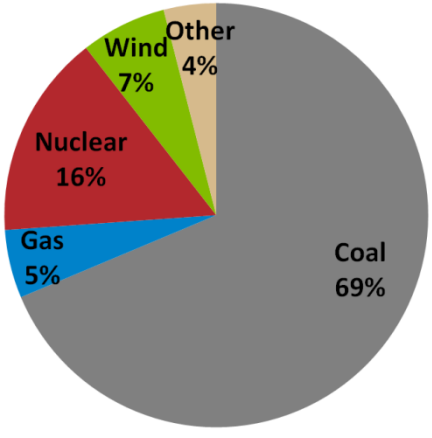
2: Re-dispatch CC up to 70%



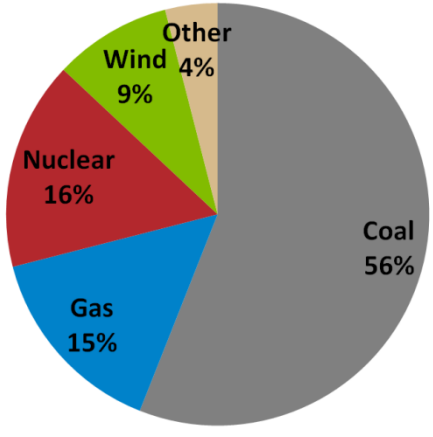
3: Renewable Energy



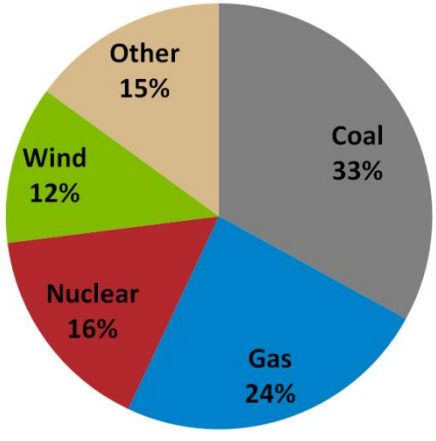
4: Energy Efficiency



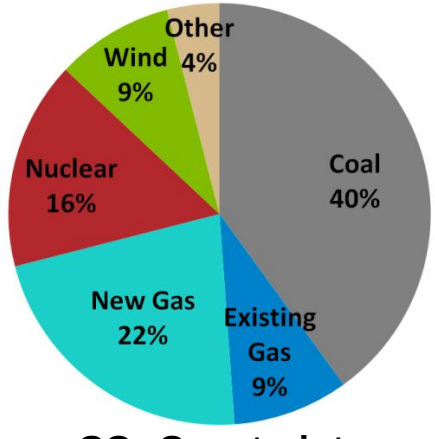
2014: Where are we today?



Reference Case



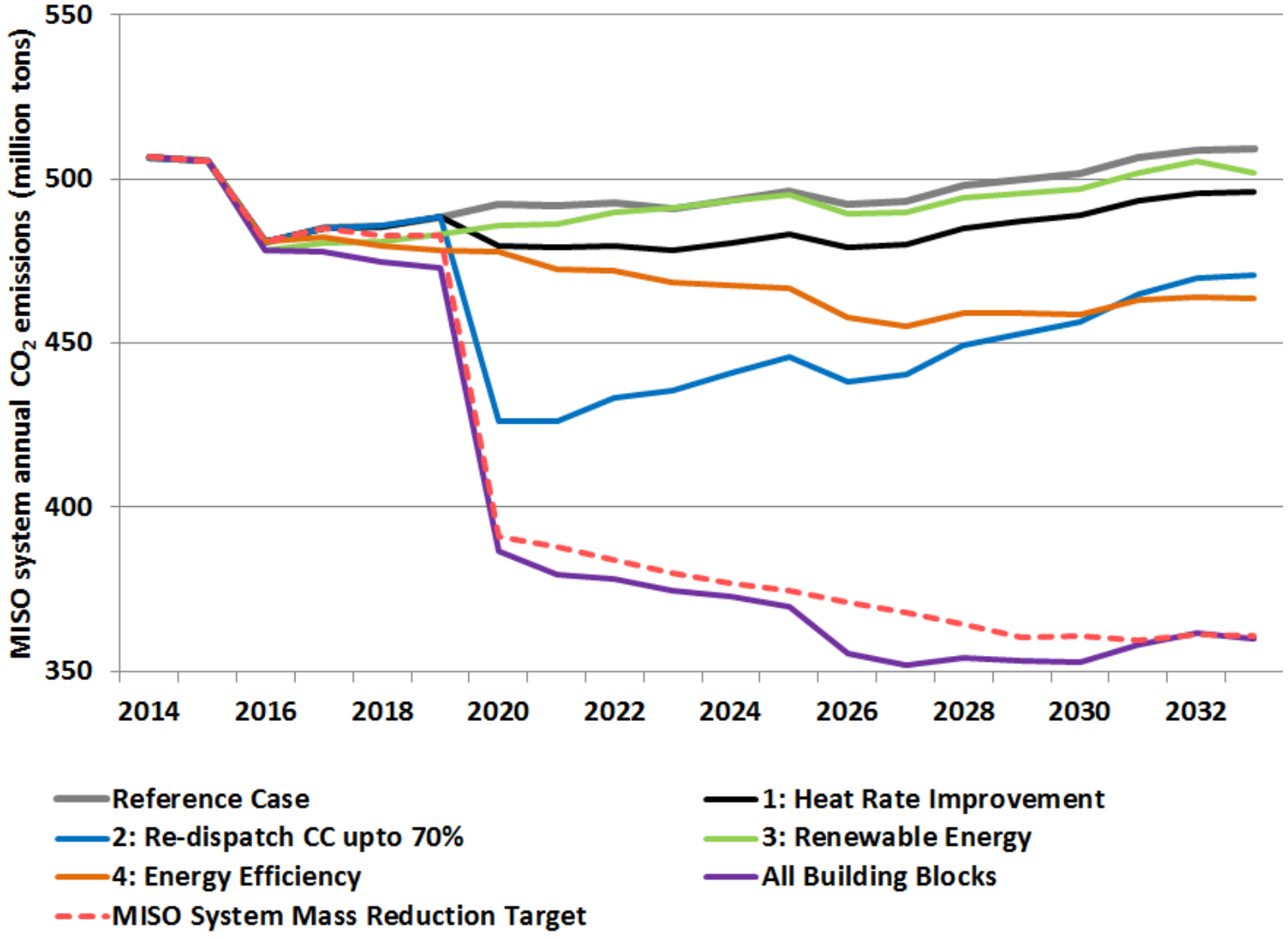
All Building Blocks



CO_2 Constraint

In all the scenarios except the CO_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_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.

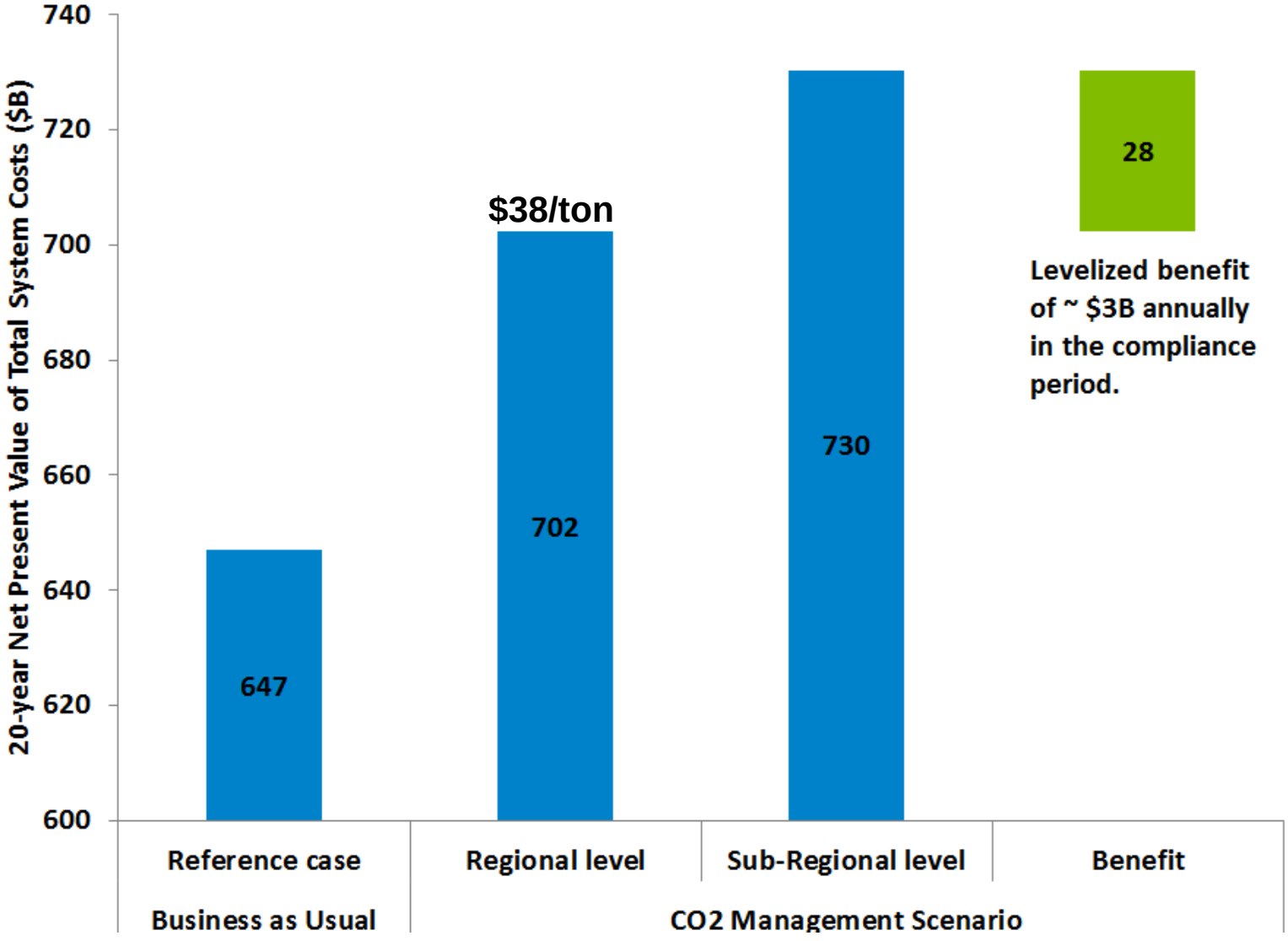
MISO system CO_2 emissions forecast under Phase 1 scenarios



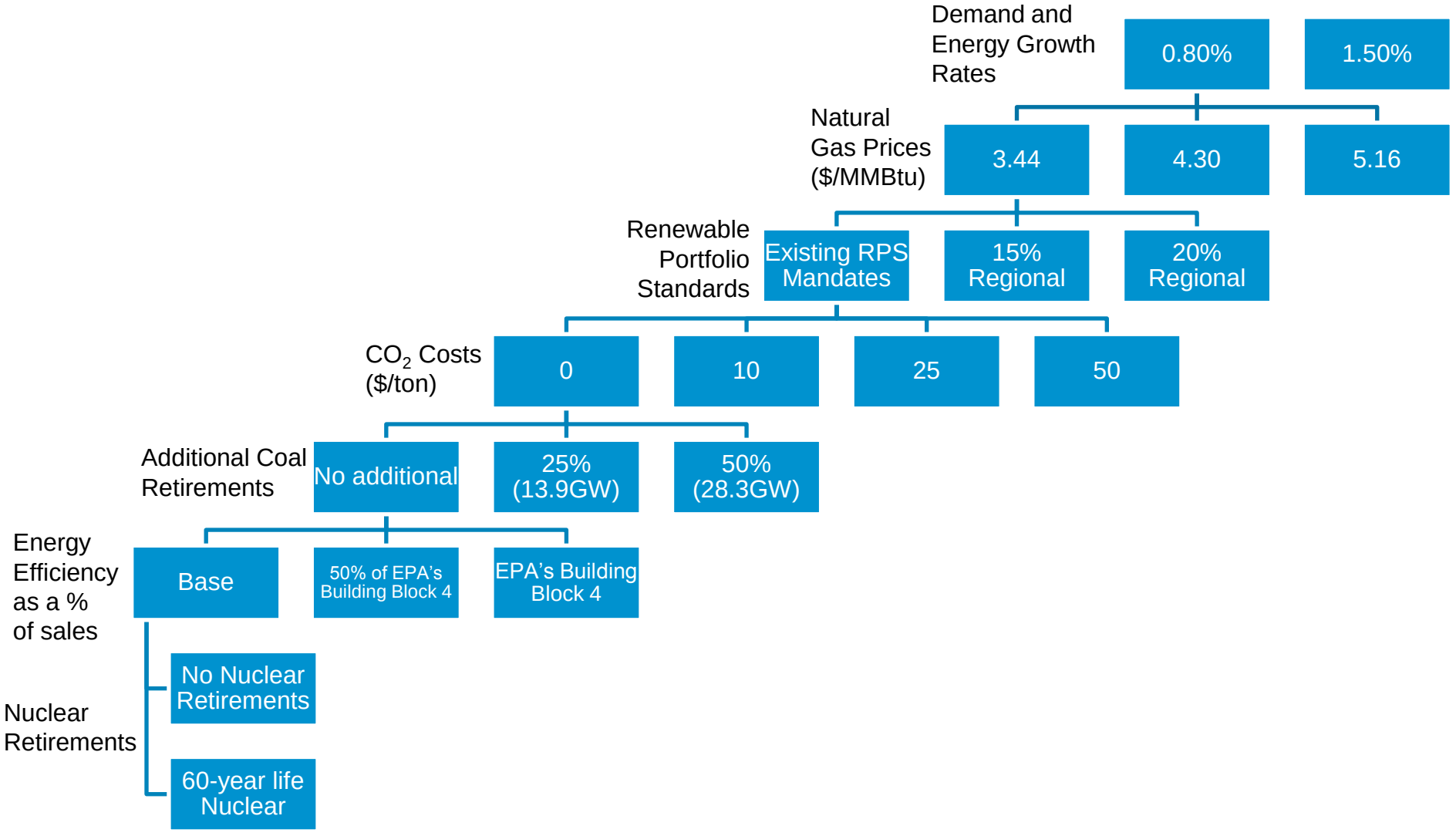
Thinking outside the blocks

- 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

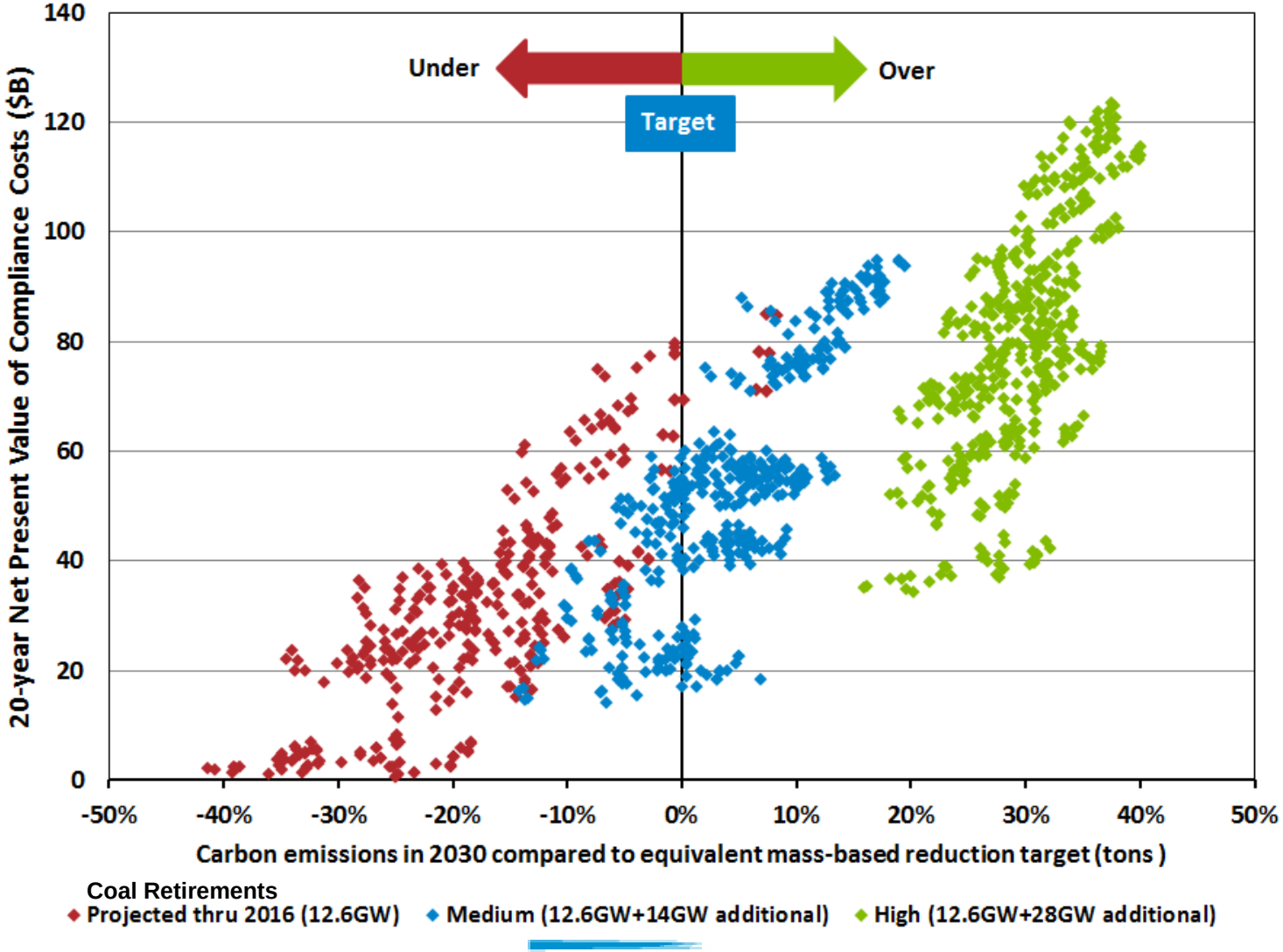
Regional compliance options save approximately $3B annually compared to sub-regional compliance



Phase 2: All possible combinations of the following policy and economic sensitivities were modeled



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

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Appendix

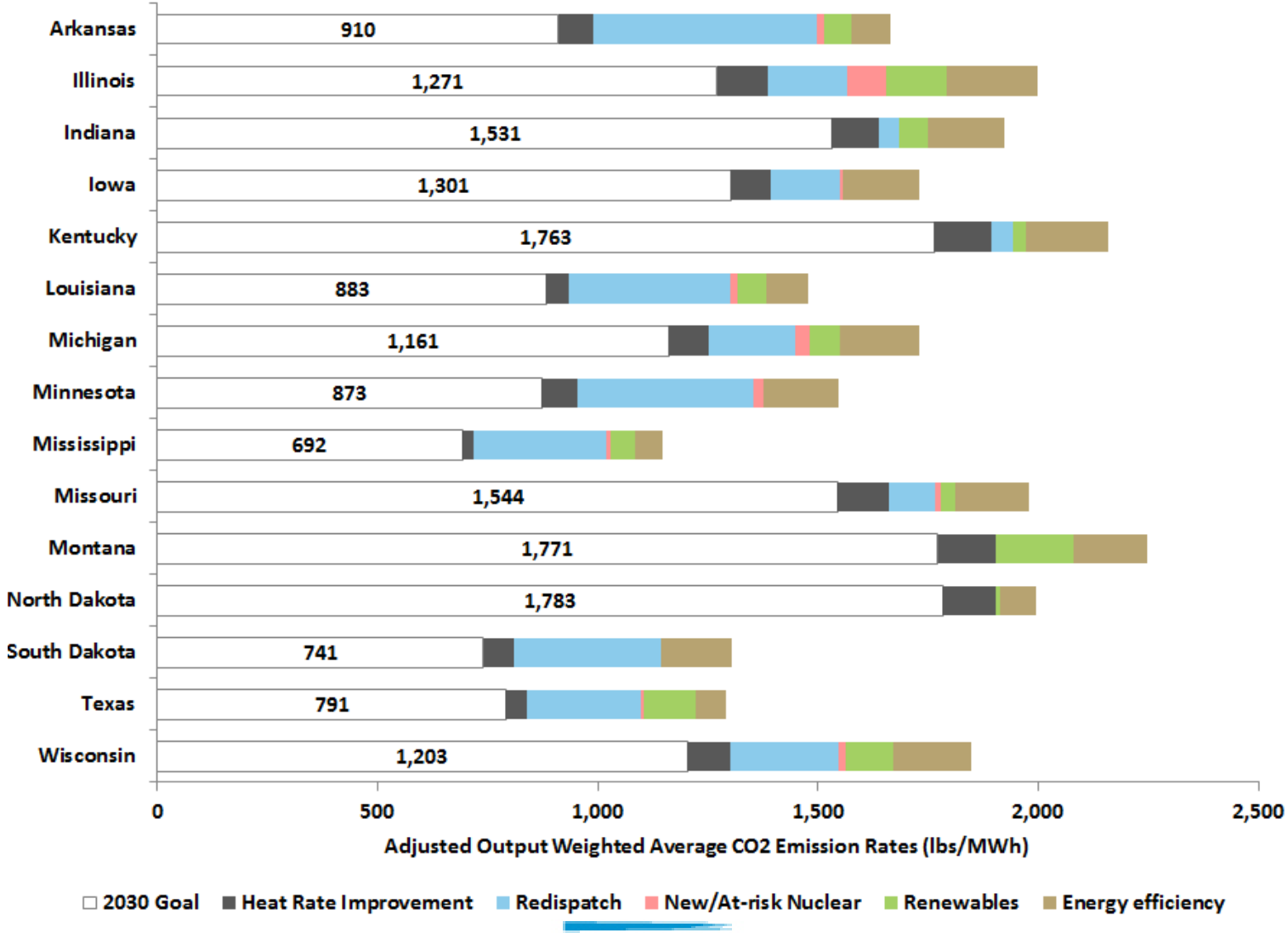
Promulgated under the authority of Section 111(d) of the Clean Air Act, the EPA's CO_2 emissions rule for existing power plants:

- Proposes state-specific emission rate-based CO_2 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

Building Blocks			
1. Improve efficiency of existing coal plants	2. Increase reliance upon CC gas units	3. Expand use of renewable resources and sustain nuclear power production	4. Expand use of demand-side energy efficiency
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



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