MISO's Analysis of EPA's Final Clean Power Plan
Study Scope
November 2015

Background & Purpose

On August 3, 2015, the U.S. Environmental Protection Agency (EPA) finalized its Clean Power Plan, which is designed to reduce carbon dioxide (CO_2) emissions from existing fossil-fired generation units by approximately 32% from 2005 levels. The final rule includes source-based and state-level CO_2 emissions reduction targets, calculated by application of EPA-determined "best system of emissions reductions". Compliance with the Clean Power Plan has the potential to adversely impact grid reliability and resource adequacy, and to change the economics of the MISO system.

To ensure the continued safe and reliable delivery of least-cost energy to consumers, MISO is working with its stakeholders to assess the potential impacts of the final rule. Analysis performed to-date has focused on impacts of compliance with the *draft* rule. Preliminary figures for future production, capital and operational costs, as well as quantification of generation and transmission impacts under the draft rule were produced and shared with stakeholders. The results of MISO's draft rule analysis, as well as stakeholder feedback, helped drive the development of the scope for the final rule analysis.

MISO's multi-year effort to identify, quantify and interpret grid reliability and economic ramifications of the CPP aims to inform both impacted parties and transmission planning processes at MISO. These efforts will create a bridge between the uncertainty and complexity that exists due to the final CPP and the modeling certainty needed for effective transmission overlay design—the ultimate goal of which is the approval of cost-effective transmission upgrades through MTEP. This document outlines deliverables, scope and schedule for the near- and mid-term study work.

Near, mid and long-term analysis overview

MISO's near-term analysis of the final CPP will focus on the implications of various compliance paths, in an effort to help MISO states formulate appropriate compliance solutions. The near-term analysis uses existing models which include a range of capacity build outs to test the various compliance paths. Using this process expedites results and allows comparisons to the draft rule analysis. Mid-term analysis seeks to bound uncertainty in the MTEP planning process and will provide additional information to help in the creation of transmission planning futures. New models will be built using the latest information and the findings from the near-term analysis on the most relevant compliance paths. This portion of the study will seek to determine likely resource build outs and their locations under three separate futures. This will provide a foundation for transmission development in MTEP17. Long-term analysis seeks to develop transmission overlays to aid in cost effective and reliable implementation of the CPP. This analysis portion is outside the scope of this stand-alone CPP study.

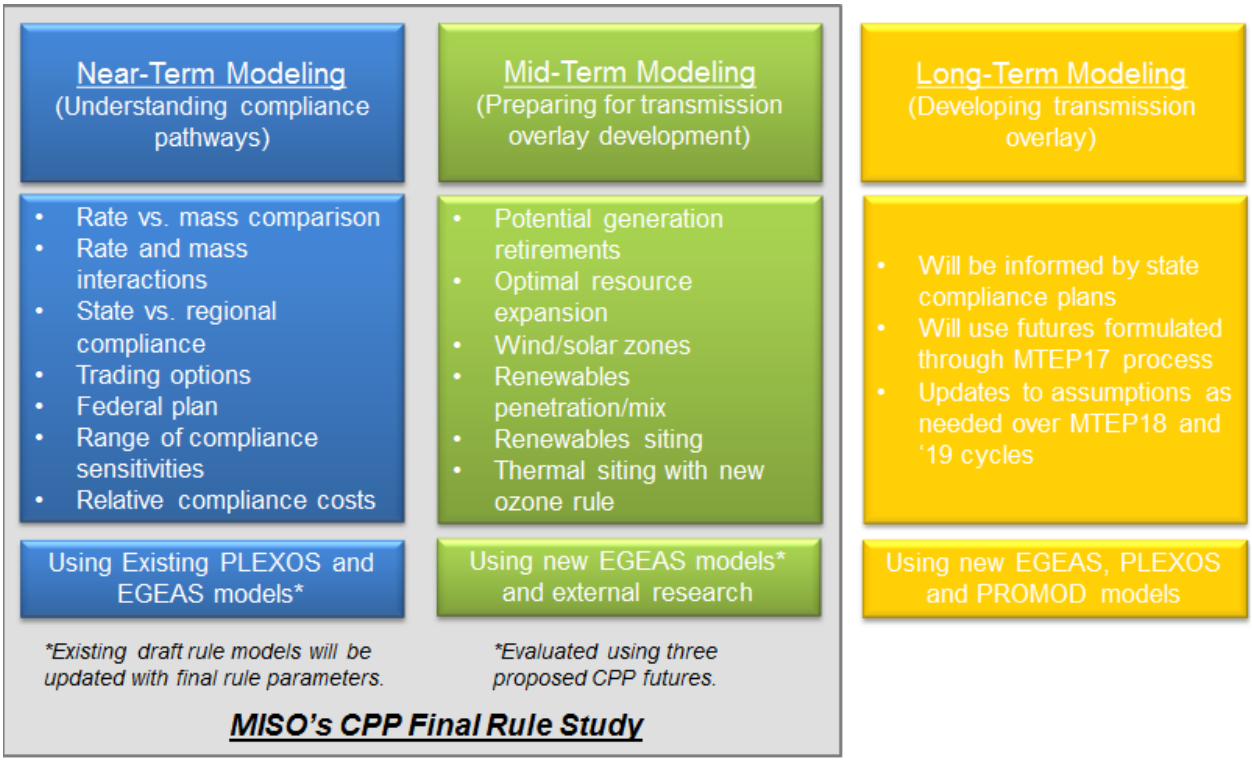

Figure 1: Overview of study portions

Timeline/Schedule

This study will commence based on the requirements in the final CPP rule and is intended to deliver results in time for states' consideration in the formulation of their state plans. The timeline for MISO's study efforts in the period leading up to when state submit final compliance plans are broken into three portions. The first two, near and mid-term analyses, are the focus of this study.

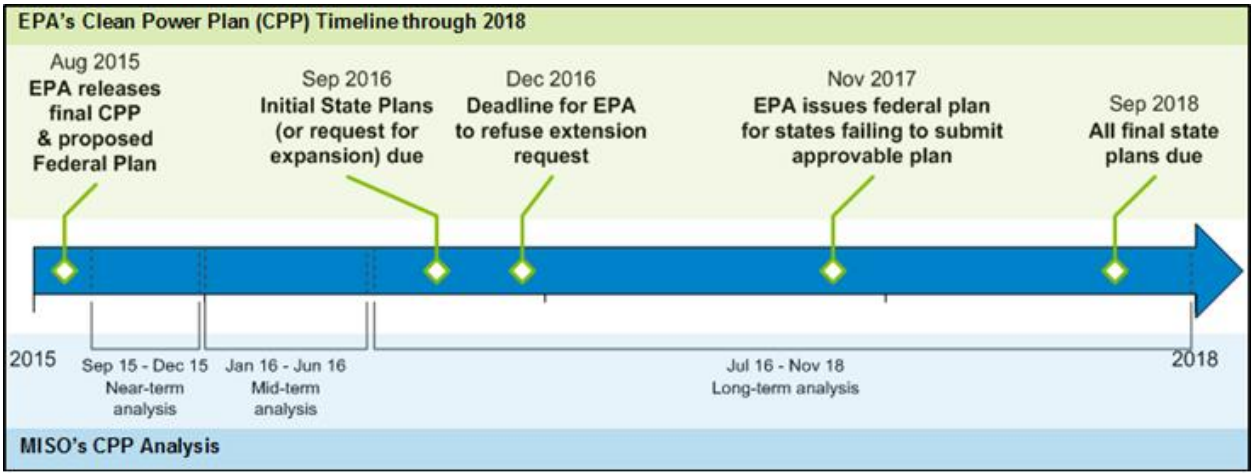

Figure 2: Timeline of analysis steps

The high-level schedule is as follows:

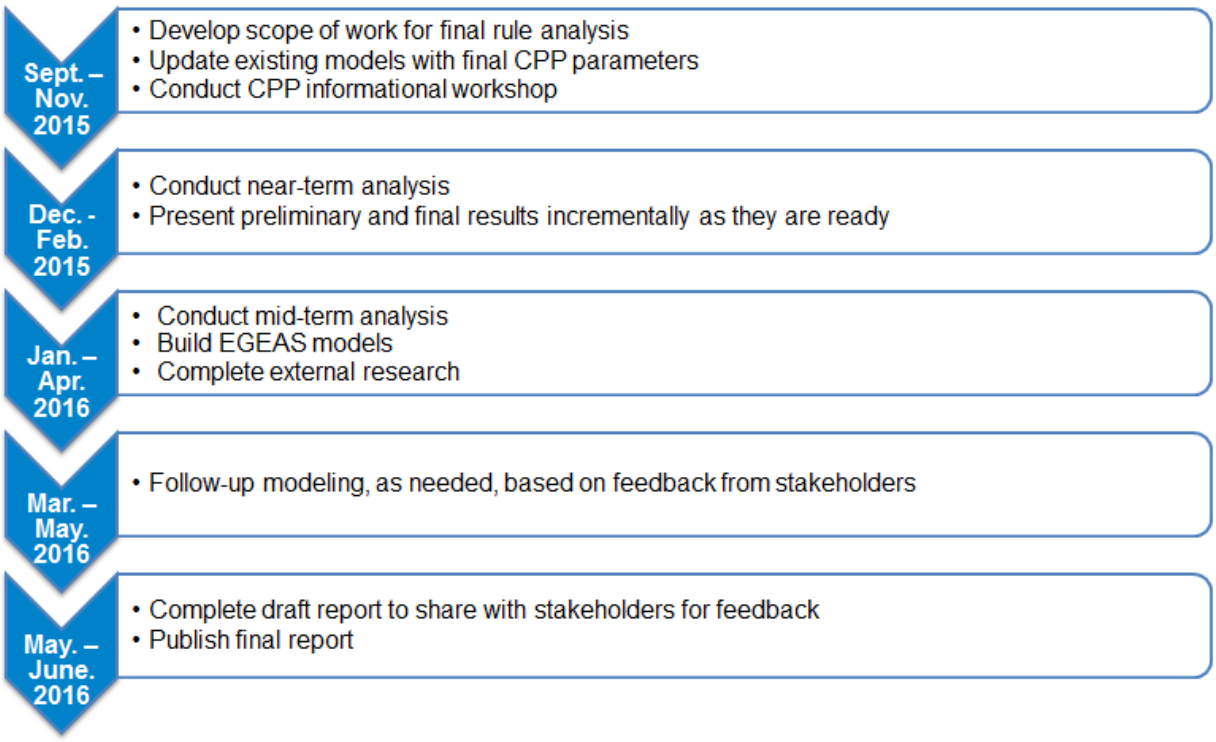

Figure 3: High level schedule

Deliverables

MISO's **near-term** analysis of the final rule will provide insight into various compliance approaches laid out in the final CPP and the proposed federal plan, including impacts on:

- resource expansion
- retirements
- dispatch
- transmission utilization
- compliance cost from a resource expansion and economic dispatch perspective

Specific metrics that will be reported for stakeholder review from the production cost model are:

- CO_2 emissions by resource category, state, market footprint and in total per scenario
- Total fuel usage per scenario
- Allowance/ERC trading between states and regions per scenario
- Capacity factors of units by category per scenario
- Ramping and cycling of units by category per scenario
- Impact of relaxing the must run setting of coal units on retirements
    - By default all coal units with a maximum capacity greater than 150MW are assumed to be always committed. In the draft rule study the must run setting was removed. The appropriateness of this decision will be readdressed to inform future work.
- Number of transmission constraints that are highly binding per scenario
- Generation of new and existing gas units to determine leakage per scenario

Specific metrics that will be reported for stakeholder review from the resource forecasting model are:

- CO_2 emissions per scenario
- Magnitude and type of resource expansion
- Costs to build out the resource expansion

MISO's **mid-term** analysis will produce information to aid in the creation of transmission planning futures for MTEP studies.

Specific metrics that will be reported for stakeholder review from the resource forecasting model are:

- CO_2 emissions per scenario
- Magnitude and type of resource expansion
- Costs to build out the resource expansion

Any reports and/or presentations providing information into the mid-term analysis will be provided separate from this study.

A final study report will be produced in draft form for stakeholder review followed by its final publication.

Stakeholder interaction

The Planning Advisory Committee (PAC) will serve as the primary forum for stakeholder engagement on this study, to be supplemented by workshops and other meetings as needed. Interim study results and preliminary reports will be shared with stakeholders as they become available. Study findings and recommendations will be included in a final report which will be reviewed by stakeholders prior to its final publication.

Primary stakeholder responsibilities are:

- Providing feedback on study scope and models
- Providing updates on state plan formulation, as appropriate
- Providing feedback on study results and draft reports

MISO will also coordinate with neighboring systems on the study of potential CPP impacts, given that there are many states spanning two or more RTO systems.

Development of models and scenarios

Models

The Electric Generation Expansion Analysis System (EGEAS) and PLEXOS models will be used. For near-term analysis, those models used in MISO's Phase I, II[1] and III[2] draft rule analysis will again be used, updated with the parameters and specifications laid out in the final rule.

Near-term analysis - Production cost modeling:

The following scenarios will be used for the production cost portion of the **near-term** analysis. These scenarios are described in detail as part of the Phase III draft rule study[2] and are unchanged for the final rule

[1] For the study report on MISO's Phase I and II Analysis of the Draft CPP see https://www.misoenergy.org/Library/Repository/Communication%20Material/EPA%20Regulations/AnalysisofEPAsProposaltoReduceCO2EmissionsfromExistingElectricGeneratingUnits.pdf.

[2] For the study report on MISO's Phase III Analysis of the Draft CPP see https://www.misoenergy.org/Library/Repository/Communication%20Material/EPA%20Regulations/DRAFT%20CPP%20Phase%20III%20Final%20Report.pdf.

analysis. Study years will be 2022, 2025 and 2030 (per the interim and final compliance periods laid out by the EPA in the final rule).

- **Business-as-usual (BAU)**: This case will not include CPP constraints and results of this case will be used as a reference for those of the CPP scenarios and sensitivities studied.
- **CPP constraints applied (CPP)**: This scenario models system operation such that Clean Power Plan CO_2 emissions targets are met. The CO_2 emissions constraints are applied and the system is dispatched to meet the emission targets. The intent of this scenario is to determine the capability of existing and planned (those with a signed Generator Interconnection Agreement as well as forecasted generation per Planning Reserve Margin requirements) generation and transmission system to meet the EPA goals.
- **CPP constraints applied, with coal-to-gas conversions (C2G):** This scenario models system operation such that the Clean Power Plan CO_2 emission targets are met. This analysis models 25% of the coal capacity in each market region of the Eastern Interconnection as incrementally (5% per year for each year, 2020-2024) converted to gas-fired combined cycle units. The system will then be dispatched to meet emission targets.
- **CPP constraints applied, with coal retirements and gas build-out (GBO):** This scenario models system operation such that the Clean Power Plan CO_2 emission targets are met. Similar to the previous scenario, 25% of the coal capacity in each market region in the Eastern Interconnection is incrementally (5% per year for each year, 2020-2024) retired. New gas-fired generators are modeled incrementally, distributed across the Eastern Interconnection per market region to compensate for the retired generation. A mix of new combined cycle and combustion turbine units are placed at new sites within the same company territory where the generation retirement is assumed. The system will then be dispatched to meet emission targets.
- **CPP constraints applied, with coal retirements and mix of gas and wind build-out (GWS):** This scenario models system operation such that the Clean Power Plan CO_2 emission targets are met. Similar to the previous scenario, approximately 30% of the coal capacity in the Eastern Interconnection is retired. A mix of new gas-fired generators and renewable (wind plus solar) resources are modeled incrementally, distributed across the Eastern Interconnection per market region to compensate for the retired generation. The system will then be dispatched to meet emission targets.
- **CPP constraints applied, with increased Energy Efficiency and wind and solar build-out (EWS):** This scenario models system operation such that the Clean Power Plan CO_2 emission targets are met. Similar to the other scenarios, the CO_2 emissions constraints are applied and the system is dispatched to meet the emission targets. Increased implementation of Energy Efficiency (EE) is modeled, in line with EPA's Building Block 4 from the proposed draft rule. Additionally, wind and solar build-out will be modeled to meet a footprint-wide 15% Renewable Portfolio Standard (RPS).

Market regions defined in the model include: Manitoba Hydro, MISO, MRO (non-MISO), NYISO, PJM, SERC, SPP, TVA, and TVA-Other.

The following compliance pathways, and associated assumptions, will also be modeled in **near-term** production cost analysis using select scenarios from the list above (CPP, C2G, GBO, GWS, EWS):

- Mass-based compliance with interstate trading
  - Leakage is evaluated
  - States can trade allowances
- Mass-based compliance with new source complement and interstate trading
  - Leakage is addressed through new source complement
  - States can trade allowances
- Mass-based compliance without interstate trading
  - Leakage is evaluated

    - States cannot trade allowances
- Mass-based compliance with new source complement without interstate trading
    - Leakage is addressed through new source complement
    - States cannot trade allowances
- Rate-based compliance with interstate trading
    - State-wide rates are assigned to each unit
    - Emission rate credits (ERCs) can be traded among states
- Rate-based compliance without interstate trading
    - State-wide rates are assigned to each unit
    - ERCs cannot be traded among states
- Mix of mass and rate based compliance among MISO states
    - Compare results of mass and rate runs and assign targets to each state accordingly
    - Allow trading among mass states and trading among rate states

The modeling of sub-category emission rates and the Clean Energy Incentive Program (CEIP) is complex and will be further reviewed as the study progresses.

Implementation of the CPP into the production cost model:

- For mass-based compliance scenarios, allowance allocation is based on the federal plan unless otherwise specified.
- For rate-based scenarios, ERCs are assumed to be generated as detailed in the federal plan.
- Test varying allowance allocation and ERC generation methods.
- Allowances given to retiring units will be retained in the system after the unit retires.
- Trading is implemented by aggregating entities subject to compliance into a larger pool. Allowances and ERC can be distributed among the entities within the compliance pool, but not between compliance pools.
- Trading levels will be determined after the simulation is complete by calculating the number of allowances or ERCs a resource would need or would produce and then summing them up on a state and regional basis.
- Leakage will be evaluated first by running the model without any leakage provision, then with the new source component and then with set asides, but without the new source component. At each stage, leakage will be measured and leakage mitigation will be examined in the subsequent stages.
- Set asides for combined cycle units will be implemented by decrementing the bid price of those units receiving them at a price determined by the case without set asides. This price will be reflective of the price of CO_2 resulting from compliance with the CO_2 targets.
- In the case where interstate trading is not allowed, intrastate trading is still being modeled.

<u>Near-term analysis - Resource forecasting modeling</u>:

Resource forecasting in the **near-term** analysis will examine the impacts of the implementation of the EPA's building blocks which were used as part of goal setting along with examining the impact of a range of sensitivities on the CO_2 emission in MISO to determine cost effective compliance options. These will be evaluated for the years 2014-2035.

The CPP final rule includes three Building Blocks used to calculate technically feasible emissions reduction standards per state. Each of the building blocks will be modeled in a separate run, in addition to all four blocks modeled in combination. All assumptions used in the case development were from the MTEP15 Business-as-Usual (BAU) future assumption set and the assumptions for the three building blocks were provided by EPA in its Technical Support documents.

Building Block #1 assumes that coal-fired electric generating units (EGUs) in the Eastern Interconnect can, on average, improve their heat rate efficiency by 4.3 percent (i.e. can decrease their heat rate by 4.3 percent). In 2022, a reduction in heat rate of 4.3 percent was applied to all coal-fired units at a cost of $100/kW to reflect the capital cost expenditure amortized over 10 years book life.

Building Block #2 assumes that the existing and under-construction combined cycle (CC) units can operate at an annual average capacity factor of up to 75 percent. This assumption is captured in the EGEAS model by calculating the amount of fuel used by CCs at a 75 percent capacity factor based on their net summer capacity. The total amount of fuel is then set as a minimum burn constraint for all these CC units.

Building Block #3 is based on increased use of zero- and low-emitting power sources. This includes renewable resources such as wind, solar, geothermal, and hydro. The building block modeling focuses solely on increased use of renewables. This building block is modeled by taking the projected level of RE generation assumed by the EPA in 2021, applying the five year average increase in capacity through 2023, and then applying the maximum annual capacity increase through 2030. Next, the amount of RE generation determined for the entire US is broken down by state based on a state's share of affected source generation, then is split further based on the share of state emissions in MISO. The RE generation is captured in EGEAS by building out the amount of renewable resources that meet the BB3 level.

Cost effective compliance options will be examined through the modeling of a number of sensitivities, as shown in Figure 4:

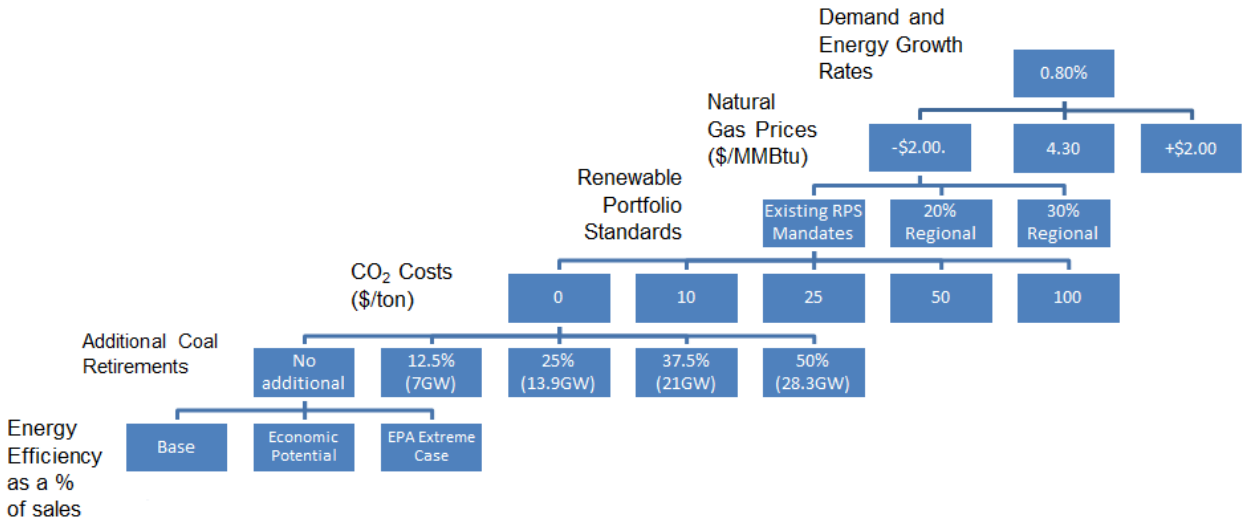

Figure 4: Sensitivities for resource forecasting in near term modeling

Each of the sensitivities in Figure 4 represents a unique scenario consisting of a specific policy and economic condition from the various levels of gas prices, coal retirements, renewable energy and energy efficiency usage, and CO_2 costs. While compliance may be achieved by applying EPA's building blocks, taking other actions beyond that framework such as the options in the sensitivities could reduce compliance costs.

Additionally, a CO_2 constraint case will be evaluated to determine the optimal generation addition and redispatch of the system that achieves compliance under the final rule.

Mid-term analysis

The following three Futures will be used for **mid-term** analysis:

- **CPP Future**: CO_2 emissions reduction targets are modeled (34% CO_2 emissions reduction in the MISO footprint by 2030)
- **Accelerated CPP Future**: Accelerated economic maturity of renewables and demand-side resources drive by technological advancements and public policy, along with sustained competitive gas prices. CO_2 emissions reduction targets are far exceeded. (43%)
- **Partial CPP Future**: Legal or political challenges to the rule slow or halt compliance, resulting in partial CPP implementation. Early CO_2 reduction targets are achieved but further reduction is not pursued and 2022 emissions levels continue for perpetuity. (17%)
    - The intent of this future is to model the actions generator owners may take to achieve early compliance without later achieving full compliance, and the subsequent impacts of these decisions.

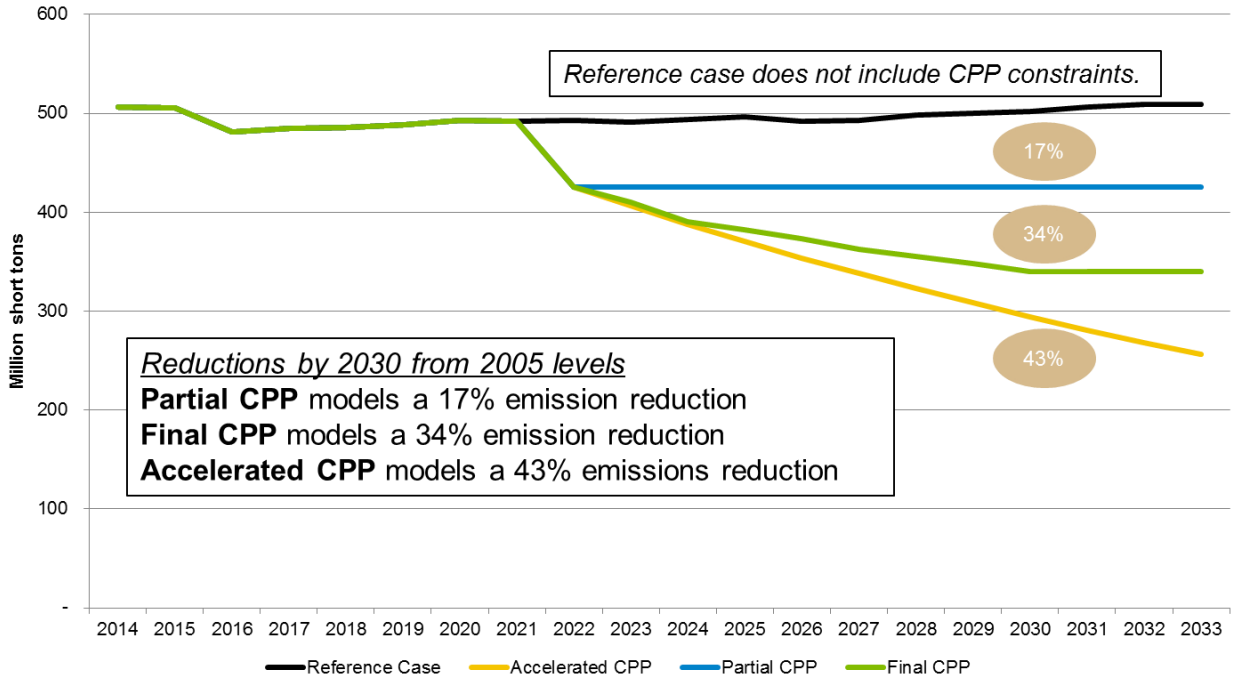

Figure 5: CO_2 reduction by year for the three mid-term futures

Assumptions on energy and demand growth rates, capital costs, fuel costs, emissions costs, economic variables and Renewable Portfolio Standard requirements will largely be aligned with MTEP16 BAU models. Analysis will be performed to determine retirement projections per Future. Likewise, preliminary analysis will be performed to determine appropriate levels of renewable penetration beyond RPS requirements per Future.

MISO's **mid-term** analysis will produce information to aid in the creation of transmission planning futures for MTEP studies. Input assumptions are as follows:

- Clean Power Plan (CPP) compliance pathway
  - Assumptions for modeling the CPP will be based on the results of the near-term analysis.
  - The exact compliance pathway will be determined through consultation with stakeholders.
- Updates to renewable generation mix, penetration siting, and profiles
  - MISO has commissioned Vibrant Clean Energy (VCE) to do a study looking at what the MISO footprint would look like if the grid is co-optimized between wind, solar PV, natural gas and transmission when considering a base case without CO2 reduction compared with one where CO2 is reduced from 2005 levels to 30% by 2030, 50% by 2036 and 80% by 2050?
  - Study will use detailed renewable information provided by the National Oceanic and Atmospheric Administration (NOAA)
  - All futures will include the current state renewable portfolio standards as a minimum constraint.
- Renewable energy zones
  - Based on the results of the study with VCE MISO will produce initial renewable energy zones which will then be further developed in collaboration with stakeholders.
- Magnitude and distribution of demand response, energy efficiency and distributed energy resources
  - Input assumptions will be based on the on-going MISO-commissioned Applied Energy Group (AEG) study[3]. These will then be included along with other planning alternatives in the economic resource forecast.
- Capital and operation and maintenance (O&M) costs for renewable resources
  - Capital and O&M cost assumptions will be based on NREL's *Annual Technology Baseline and Standard* Scenarios Report.
  - The Energy Information Administration (EIA) *Annual Energy Outlook* (AEO) report will not be used since the EIA has not updated capital cost information since 2013.
- Gas prices
  - Average monthly and yearly gas prices will be based on IHS CERA Energy North American Monthly Gas Market Outlook.
  - Gas transportation charges will be based on a study MISO has commissioned with Levitan and Associates, Inc.
- Demand and energy
  - Demand values for years 1 - 10 of demand growth are derived from Module-E; Years 11-20 are extrapolated
  - Energy values are calculated using the corresponding demand forecast and historical load factors.
- Resource retirements
  - A profitability analysis will be conducted for the resources in each future to determine how many of them would be likely to retire. This analysis is conducted by ranking the profitability of each unit. These units are then retired one by one from the least profitable until all remaining units are profitable. The profitability list is recreated after each unit is retired since the remaining units are likely to become more profitable. Results will be presented in aggregate.
  - Actual retirements driven by the EPA's Mercury and Air Toxics Standard (MATS) rule are now mostly known and are included in the base dataset. The 12.6GWs of coal retirements used as a proxy is no longer necessary.

[3] See https://www.misoenergy.org/Library/Repository/Meeting%20Material/Stakeholder/Workshops%20and%20Special%20Meetings/2015/DR%20EE%20DG%20Workshops/20150915/20150915%20DR%20EE%20DG%20WS3%20Presentation.pdf.

Input assumptions will be assessed as part of the results reporting of the mid-term analysis. A recommendation for each of the assumptions will be passed on to the MTEP17 futures development process.