Michigan Compliance Assessment for the Clean Power Plan

MPSC/MDEQ EPA 111(d) Impact Analysis

Prepared for Michigan Public Service Commission, Michigan Department of Environmental Quality, and Michigan Agency for Energy

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FOREWORD

On August 3, 2015, the U.S. Environmental Protection Agency (EPA) finalized the Clean Power Plan—its plan to regulate CO_2 pollution from the electricity sector by setting the first-ever national standards limiting CO_2 emissions from electricity generation at power plants built before 2012. The Clean Power Plan Final Rule mandates that the United States electric sector reduce CO_2 emissions by approximately 32 percent—based on 2005 levels—by 2030 and requires states to choose either a rate-based or mass-based path toward compliance with that reduction goal.

The Clean Power Plan introduces new challenges and opportunities for coordination between state regulators, utilities, and stakeholders. States must determine not only a best path to compliance from amongst a myriad of options, but in some cases also demonstrate that their plans will be successful. Effective planning and use of appropriate modeling tools can engage regulators, utilities, and stakeholders in the process of finding a least-cost path that satisfies states' energy needs. Compliance modeling can also allow states to explore the costs and benefits of various policy constructs, understand equity considerations, examine possible impacts of compliance on state and regional economies, and plan for any significant changes to the electricity grid. While a number of national- and regional-scale studies have been conducted examining possible impacts of the Clean Power Plan, Michigan is amongst the first states to produce public, detailed compliance modeling.

The Michigan Public Service Commission (MPSC) and Michigan Department of Environmental Quality (MDEQ) retained Synapse in August 2015 to help develop potential strategies for the state of Michigan to meet CO_2 reduction targets as identified in the Clean Power Plan. Synapse began work on August 3, 2015, shortly after the finalization of the Clean Power Plan. Throughout the project, Synapse worked with state agencies, including MPSC, MDEQ, and the Michigan Agency for Energy, to develop model structures and compliance scenarios and to establish input assumptions. These state agencies worked with stakeholders to vet reference case runs and determine compliance scenario requirements. Draft compliance scenarios were reviewed by agencies and stakeholders before being finalized with input from all parties.

The sole intent of this project is to inform state discussions on reasonable compliance plans. The modeling conducted was not intended to produce Michigan's final compliance plan for submission to EPA or to produce a comprehensive state integrated resource plan.

Editorial Note: *This version has been revised to reflect an updated list of authors. No other changes have been made to the document.*

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EXECUTIVE SUMMARY

This report was prepared to inform the state of Michigan's compliance planning process for EPA's regulations limiting carbon dioxide (CO_2) from existing generation sources under section 111(d) of the Clean Air Act, also known as the Clean Power Plan.[1] Michigan Public Service Commission (MPSC), Michigan Department of Environmental Quality (MDEQ), and Michigan Agency for Energy (MAE) engaged Synapse Energy Economics to perform an economic impact analysis of the Clean Power Plan using an industry-standard electricity sector model.

The Clean Power Plan offers multiple compliance pathways to states. These include specified mass-based targets, measured in tons of CO_2, or rate-based requirements for individual units or the state as a whole, measured in pounds of CO_2 per unit of energy (megawatt-hour). Based on the assumption that Michigan may join a trading region with neighboring states,[2] this study projected the energy system of the region under a range of Clean Power Plan compliance paths, as well as a non-compliant "Reference case." This analysis evaluated the costs and benefits for Michigan of three mass-based compliance pathways, and sensitivities related to these paths. The compliance pathways modeled for this analysis were guided by a stakeholder process and included:

- **Existing Only**: a mass-based scenario, under which an emissions cap is applied to only existing sources and no mechanisms are used to mitigate leakage of generation and emissions to new sources;
- **Model Rule:** a mass-based compliance scenario, which adds EPA's suggested leakage mitigation strategies but does not restrict emissions from new sources; and
- **Existing+New:** a mass-based compliance scenario, which applies a mass-based cap to both existing EGUs and EGUs that are built after the onset of the compliance requirement in 2022.

The model used in this assessment, System Optimizer, seeks to find a least-cost buildout and dispatch solution for the study region as a whole, building new resources if necessary and changing the utilization of different fuels and resources to achieve emission constraints. While this study did not seek to find a least-cost mechanism of achieving rate-based compliance in the region, it tracked the rate-based compliance position of each scenario examined.

In each of the compliance scenarios, it was assumed that Michigan could freely trade mass-based allowances with the other states in the study region. In this structure, states that reach compliance more readily are able to sell those allowances to states for which compliance is more difficult. The

[1] U.S. Environmental Protection Agency (EPA). 2015. *Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units*. 80 FR 64661.

[2] Including Illinois, Indiana, Iowa, Minnesota, Ohio, and Wisconsin.

model uses a total regional emissions constraint to drive the buildout, and tracks the scarcity price of emissions—i.e. the price of the emissions if traded on an open market.

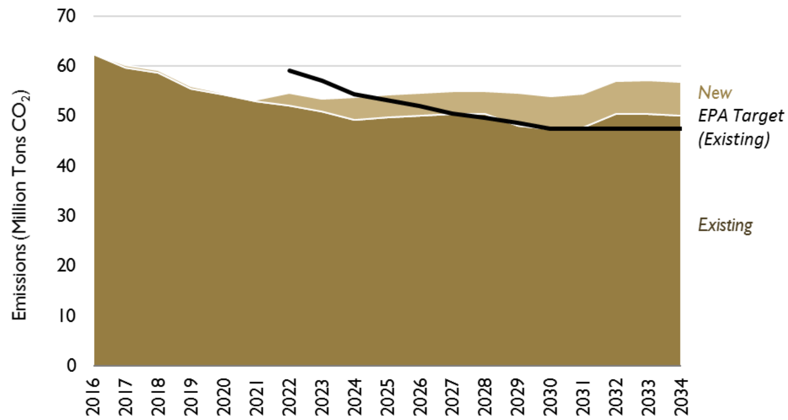
The modeling performed here indicated that different forms of mass-based compliance had a range of impacts on Michigan's generation mix, capacity buildout, and total emissions. Michigan's neighboring states also had substantial changes in fuel mix and buildout depending on the compliance pathway and other sensitivities. Table ES-1, below, shows key results from this study.

Table ES-1. Summary of study results, Michigan

	Reference				***Mass-Based Compliance***					
					Existing+New				**Existing Only**	**Model Rule**
	Base	+EE	+Add'l Coal Ret.	+High Gas Prices	Base	+EE	+Add'l Coal Ret.	+High Gas Prices	Base	Base
Total Change: In-State Capacity, 2016-2034 (GW)	-0.6	-0.6	-1.5	-0.6	4.4	4.4	2.4	6.3	-0.6	-0.6
CO_2 from in-state generators, 2022-2034 (MT CO_2)	790	750	720	880	600	580	570	570	630	640
CO_2 from covered sources, 2022-2034 (MT CO_2)					510	500	480	490	480	490
Net present value difference from Reference Base, 2016-2034 (million 2014$)	-	670	960	(1,750)	3,280	4,880	5,130	1,370	880	1,030

The modeling first sought to establish a consensus Reference Case. In the no-Clean Power Plan Reference case, the model replaces scheduled and anticipated coal retirements in Michigan with natural gas, although not all of the capacity is replaced in kind. Overall, state CO_2 emissions in this case fall from current levels at around 60 million tons to just over 50 million tons by the early 2020s due to low natural gas prices and reduced dispatch from existing coal units. At that point, emissions are already below EPA's target for existing sources (see Figure ES-1, below). Through the end of the study period, emissions from existing sources generally stay at or below EPA's target, still due to low gas prices. New gas generators in Michigan increase the total emissions of the state above EPA's target, but overall emissions do not grow substantially. In the Reference Case, even with emissions from new sources included, Michigan's emissions are below EPA's target until 2025. By contrast, the region as a whole is projected to exceed its collective emissions target by an increasing margin in every year from 2022 through 2034. The state's relatively low emissions under the non-compliant Reference Case suggests that compliance is readily achieved.

Figure ES-1. Reference Base Case emissions from existing and new affected sources in Michigan

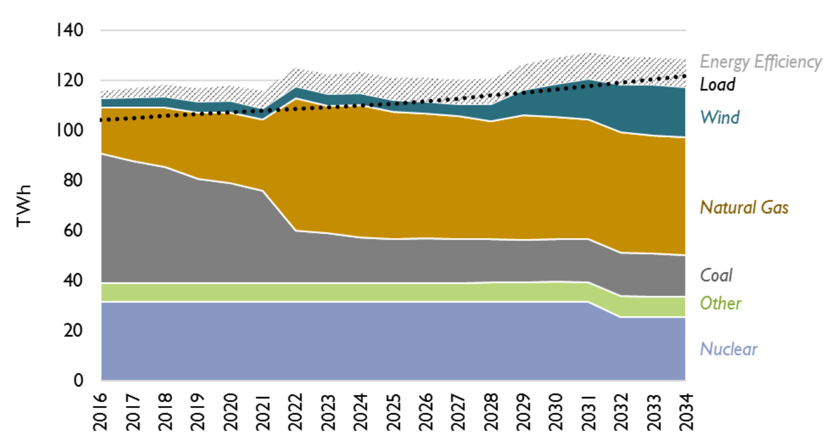


Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

Under the Existing+New compliance pathway, new wind is added into the system in increments in the late 2020s, as allowance prices increase, as shown below in Figure ES-2. When new sources are not covered, as in the Existing Only and Model Rule framework, the price of emissions allowances is substantially lower, and there is less incentive to build new wind capacity. Under nearly every case, Michigan remains a net exporter of energy (including Donald C. Cook Nuclear Plant, which primarily serves generation out-of-state).

Emissions of CO_2 from in-state generators are sensitive to the compliance pathway and emissions prices. In all cases examined here, emissions from the electric sector decline through the early 2020s, primarily as a function of near-term low gas prices. In the high gas price sensitivity without the regulation, emissions increase substantially above 2015 levels by the end of the study period; in all other runs, emissions fall through the remainder of the study period. Table ES-1, above, shows that in all compliance runs, emissions from in-state generators are substantially higher than emissions from covered sources only – up to 30 percent higher in the case where new sources are not covered by the cap.

Figure ES-2. Michigan generation mix over time – Existing+New Compliance Pathway



Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

The analysis here solves for the least-cost compliance in the study region; costs and benefits of each scenario are extracted and assessed for Michigan generators and for the state as a whole. The financial analysis accounts for all generator fuel costs, fixed and variable costs of operation (such as labor and maintenance), capital costs for new units and expected environmental controls at existing fossil units, sales and purchases of energy across state lines, emissions costs, and revenues from the sale of excess allowances. The analysis suggests that, relative to the cohort of states analyzed here, Michigan may realize economic benefits through a mass-based trading mechanism.

Many of the benefits realized by the state are from the sale of excess allowances to other states. As indicated in the final rule promulgated by EPA, the analysis assumes that Michigan is allocated a number of allowances by EPA equal to the emissions allowed under the mass-based cap. The analysis is impartial to the mechanism used to distribute these allowances to in-state entities (either freely, or via an auction, or a combination thereof). The model finds that, due to the incremental cost of generating under an emissions cap, Michigan generators will produce fewer emissions than are available to the state. Under the modeled construct (which assumes open trading), either the state or Michigan's utilities would be able to sell those excess allowances out of state, realizing a relative benefit. If the value of selling excess allowances exceeds the cost of compliance, then compliance with the rule can actually be a net benefit, financially, to the state. This study indicates that mass-based compliance generally results in such a benefit, with variations depending on fuel prices, accelerated efficiency programs or coal retirements, and the compliance pathway.

The analysis finds that, overall, the Existing+New pathway results in the highest benefit (primarily through higher allowance prices), and state-driven mechanisms to reduce emissions outside of the regulation result in more readily achieved compliance—and hence benefits. The modeling finds that in the compliance cases, the benefits are driven by a combination of factors, including fewer expenditures on fuel and plant maintenance, lower energy import costs and higher export revenues, and the sale of substantial allowances to other states. In addition, efforts undertaken by the state or utilities to increase efficiency and retire non-economic coal-fired power plants both reduce the cost (or increase the benefit) of compliance in the state. Under both the base case assumption and in the accelerated coal unit retirement case, the existing plant balance (capital debt) is excluded from consideration as a sunk cost. This implies that retiring generators are effectively provided full recovery of existing plant balance, and that no incremental credit is given to consumers for the retirement of a non-used asset.

This report find that, under a range of scenarios, compliance with the Clean Power Plan will likely entail a relatively low cost for Michigan, and that the state will benefit from a multi-state trading construct. The results of this analysis are relatively robust over a series of sensitivities and are directionally consistent. The analysis also indicates that EPA's mechanism for preventing leakage to new sources under the proposed Model Rule is not substantially more effective than if the mechanism was not in place. Under the case wherein new sources are not covered, emissions from new sources remain effectively unconstrained under EPA's model rule.

There are significant caveats to this analysis, however, only some of which were explored in this effort. First, higher gas prices make compliance less readily achievable by Michigan, and thus reduces the benefit of compliance overall (although system costs rise regardless of compliance with higher gas prices). The study did not assess what would happen if Michigan either joined a different trading region, possibly with states that more readily reach compliance, or what would happen if Michigan's neighbors either chose not to engage in trading or adopted a different compliance mechanism. This analysis did not examine if other states would likely retire existing coal units under a compliance regime. As a capacity expansion model, this framework did not examine hour-to-hour operations of the system under various compliance regimes.

1. INTRODUCTION

1.1 Scope and Intent

The purpose of this report is to aid the state of Michigan in evaluating potential strategies for compliance with the U.S. Environmental Protection Agency's (EPA) Clean Power Plan. In September 2015, Michigan Public Service Commission (MPSC), Michigan Department of Environmental Quality (MDEQ)), and Michigan Agency for Energy (MAE)—together the "Joint Agencies,"—engaged Synapse Energy Economics (Synapse) to perform an economic impact analysis of the possible impacts of the Clean Power Plan in Michigan using an industry-standard electricity-sector model. Compliance scenarios were provided to Synapse by the Joint Agencies. In early 2016, Michigan invited key technical stakeholders to participate by vetting key assumptions of the analysis and developing sensitivity cases. Synapse worked with the state and state-selected stakeholders to identify an appropriate model construct, assumptions about the future, and potential complementary policies or industry practices.

Because of the complexity of both the range of compliance options offered under the Final Rule and the electric system itself, Michigan elected to use a detailed electric-sector planning model to understand how the state and region may respond to different compliance pathways. The model was structured to help illustrate possible outcomes, as well as costs and benefits to the state.

The modeling presented here is not meant to be comprehensive, nor does it offer a formal compliance demonstration under the Clean Power Plan; instead it seeks to provide key insights into the potential impacts of compliance pathways.

The Clean Power Plan Final Rule provides states with a range of compliance options, and the mix of paths chosen by different states may have strong implications for how states interact with each other in the energy system. This analysis reviews several options for how the state of Michigan can meet its compliance requirements. The resulting report is meant to provide additional guidance to regulators, policy-makers, and other stakeholders during the remainder of Michigan's planning process to help ensure economy-wide benefits for Michigan.

1.2 The Clean Power Plan

On August 3, 2015, EPA released the final version of its Clean Power Plan, a rule under Section 111(d) of the Clean Air Act.[3] Under the Clean Power Plan, the U.S. electric sector is expected to reduce carbon

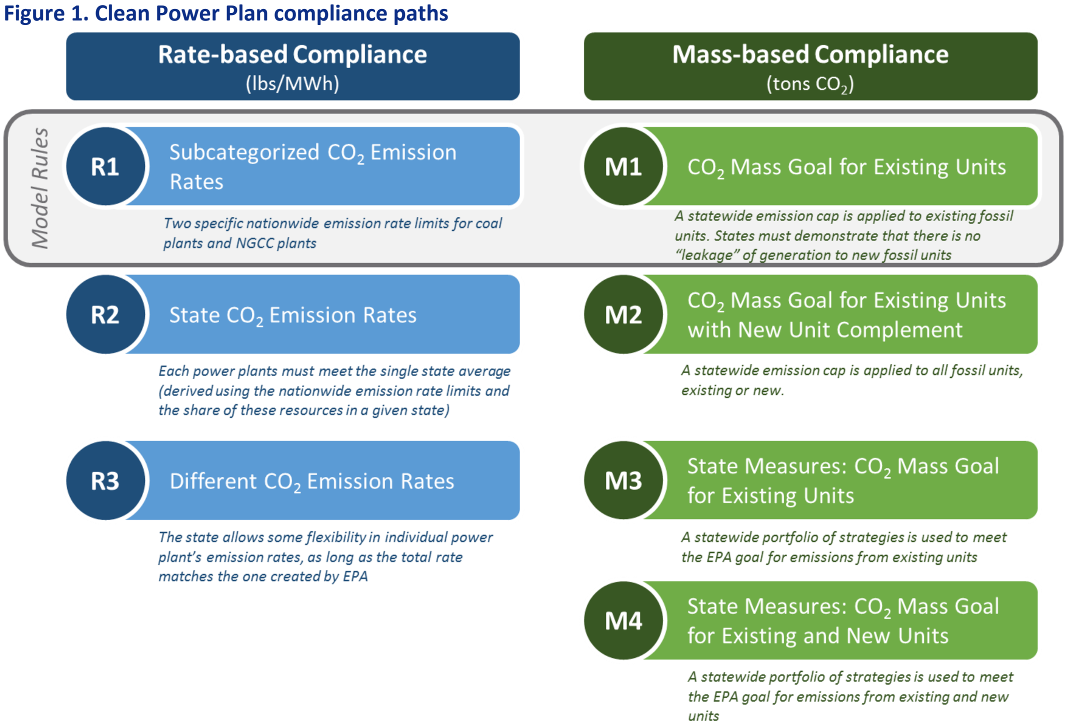
[3] At the time this report was published, the Clean Power Plan was under a stay from the United States Supreme Court. For the purposes of this analysis and report, it was assumed that states would have to comply with the Clean Power Plan and that the compliance timeline would be unchanged from that set forth in the Final Rule in August of 2015.

dioxide (CO_2) emissions from 2005 levels by about 32 percent nationwide by 2030. To do this, EPA established emission performance standards for two electric generating unit (EGU) technology types: existing fossil steam and existing stationary combustion turbines (CTs) (called "affected EGUs").[4] EGUs that commenced construction after January 8, 2014 are not affected EGUs under the Clean Power Plan, but may be covered under some compliance pathways.

The Clean Power Plan provides several distinct compliance pathways for states, including what is generally known as "rate-based" and "mass-based" compliance. Under rate-based compliance, either individual affected EGUs or the fleet of state affected EGUs as a whole, must achieve specified CO_2 emissions rates, measured in pounds of CO_2 per megawatt-hour (lbs/MWh). In a mass-based approach, the fleet of EGUs in a state must emit at or under a specified CO_2 target, measured in short tons of CO_2. In the mass-based approach, EPA has provided options for states to cover only existing (affected) EGUs, or both existing and new EGUs. Within those mass-based compliance pathways, states can either choose to engage in trading or provide evidence that other strategies ("measures") employed by the state will achieve the emissions targets provided by EPA.

The pathways available to states are illustrated in Figure 1, below.

Figure 1. Clean Power Plan compliance paths



Source: Synapse Energy Economics.

[4] By definition, "fossil steam" primarily encompasses coal-fired boilers, while "stationary combustion turbines" generally captures gas-fired combined-cycle units. Simple-cycle combustion turbines, commonly used as peaking units, are not covered under the Clean Power Plan.

The subcategory rate-based approach ("R1" in the figure above) simply assigns each existing fossil steam generator an emission performance rate equal to EPA's subcategorized rate for fossil steam and each existing natural gas combined-cycle (NGCC) generator an emission performance rate equal to EPA's NGCC rate. The state average compliance pathway ("R2") requires every existing unit, regardless of technology type, to meet the single statewide average emission standard. The last rate-based compliance pathway ("R3") allows states to assign unique emission rates to each existing unit as long as the weighted average of these individual units is less than or equal to the statewide average standard set by EPA. In designing the Clean Power Plan, EPA recognized that, as a practical matter, EGUs are not able to substantially reduce their own emissions rates. This is because in the absence of carbon capture technologies, CO_2 emissions are a function of the carbon content of the fuel and the efficiency of the power plant, neither of which can be altered dramatically. As such, to achieve rate-based compliance under the Clean Power Plan, EPA allows EGUs to acquire "emissions rate credits" or ERCs. These are credits produced by no- or low-emissions technologies, by energy efficiency, or by gas-fired power plants that perform better than the statewide average emissions standard under the R2 pathway.

Under mass-based compliance, EPA provides an "allowance" for each ton of CO_2 that sources in a state may emit, where the total tons are set in the final rule. States distribute the allowances to sources (freely, through an auction, or another mechanism), and sources must submit allowances back to the state or EPA equal to the number of tons they have emitted during a compliance period. The first two mass-based compliance pathways ("M1" and "M2") provide for the option for states to set up a trading mechanism with other states. Under these mechanisms, allowances are tradable between both sources and states, such that states who readily achieve compliance can trade excess allowances to states that do not otherwise achieve compliance as easily. Under the M1 pathway, only existing EGUs are covered by the state cap, wherein emissions from those sources must remain under the cap in each compliance period. In the M2 pathway, both existing and new EGUs are covered by a slightly larger cap. Under both pathways, EPA assigns each state a certain number of allowances which are distributed to EGUs through a mechanism decided upon by the state. At the end of each compliance period, each EGU must submit an allowance for each ton of CO_2 emitted. Under M1 and M2, EGUs can trade these allowances. It is up to a state to determine how the distribution and trading of allowances proceeds. The Clean Power Plan allows EGUs to hold or "bank" extra allowances for a future year, called "banking." This provision allows for extra flexibility if a state or EGU has an opportunity to make near-term reductions in excess of requirements.

In designing the criteria for the M1 pathway, EPA recognized a potential for "leakage" to new sources, in which new gas-fired power plants, not covered by the rule, could have an economic incentive to increase output relative to comparable existing sources. In doing so, the existing source emissions reduced by the rule could "leak" from the existing sources to the new sources, thereby attenuating the effectiveness of the rule.[5] To address leakage, EPA added additional mitigation measures to the M1

[5] 80 FR 64887.

pathway, including incentives provided to existing gas-fired EGUs and additional incentives to new renewable energy projects. These two incentive programs are relatively unique to the Clean Power Plan.

The other two state measures programs (“M3” and “M4”) also cover either existing-only or existing and new EGUs, but rely on states to implement emissions reduction programs other than interstate trading. These might include efficiency or renewable energy programs designed to displace existing generators, an intrastate trading program, or scheduled retirements, amongst other options. States choosing an M3 or M4 pathway may not be able to rely on other states to help meet their compliance obligations through interstate trading.

Different states may find benefit in the rate-based or mass-based pathways, depending on their relative compliance position, ability to reduce emissions cost effectively, or ability to build new clean energy resources (including efficiency or energy waste reduction programs). **For this study, Michigan Agencies elected to model only the M1 and M2 pathways, representing trading-ready mass-based compliance pathways.** Under the M2 mass-based standard that covers both new and existing fossil fuel plants, Michigan is allowed to emit approximately 49 million tons of CO_2 in 2030. This represents a 38 percent reduction in Michigan’s electric-sector emissions, relative to 2005.

1.3 Challenges in Approaching the Clean Power Plan

New environmental rules in the electric sector can have substantia impacts on costs, operations, and utility decisions. For many recently promulgated rules, the decision matrix for utilities has been straightforward, and the state’s engagement in how a rule was applied was limited. The Clean Power Plan is relatively unique in that it provides substantial flexibility to states in determining an implementation pathway, and the ramifications of these pathways can be quite wide-ranging – both for existing generators, new generators, and other stakeholders in the electricity system. Modeling can help illustrate the different advantages or problems inherent in various pathways, and provide insights on how various stakeholders may be impacted.

When combined with a rigorous input and scenario development process, modeling is one tool that can help tease out the relative merits of different compliance pathways. For the last three decades, utility system modeling has informed general system planning efforts and specific resource decisions. Utilities and regulators have also modeled various types of emissions reduction programs, including unit emissions limits, trading schemes, and emissions “displacement” through clean energy programs or energy waste reduction measures.

However, the Clean Power Plan presents modelers and regulators with new challenges. Most industry-scale electric-sector models do not include any treatment of rate-based compliance and the incremental incentives under the M1 mass-based plan, and therefore do not provide straightforward mechanisms for modeling these pathways. Instead, modeling these policies demands an innovative approach to the use of optimization software. Further complicating matters, the Clean Power Plan creates the opportunity for a patchwork of compliance measures between different interconnected states, with an extremely large number of potential outcomes depending on specific state decisions. Rather than creating a uniform measure by which all EGUs or states are required to reduce emissions, the Clean Power Plan provides a range of pathways, some of which may interact in unpredictable ways. For example, states embarking on a rate-based plan may not trade ERCs with states taking a mass-based approach, and yet states can and will continue to trade electricity on a regular basis. The choice of which states participate in trading programs, which choose rate- or mass-based compliance, and which cover just their existing sources or both new and existing sources makes for a very wide array of uncertainties for any given state or utility. This uncertainty adds to the uncertainties surrounding other state and federal regulations (such as renewable portfolio standards or other pollution regulations), long-term fuel prices, demand, and financial constraints.

There is no single model or model construct that can currently be considered the best, or exclusive, model structure to use for modeling the impacts of the Clean Power Plan. Given a variety of electric-sector models available, analysts choose a structure suited to the nature of the question. Modelers seeking to understand how different states may treat compliance pathways relative to each other may opt for broad-scale, general models with the ability to rapidly test numerous compliance mosaics (e.g. a matrix of rate and mass-based states).. On the other hand, analysts seeking to understand the impact on a specific generator or fleet may opt to use highly detailed hourly models that make assumptions about the compliance choices of other states. In Michigan's case, the state opted to use a modeling platform typical of long-range utility-scale planning, capable of representing individual generators and utility-scale decisions. The considerations of the model are discussed in Section 2.4, and other regional Clean Power Plan modeling efforts are described in Section 2.3.

Ultimately, it is important to keep in mind that modeling is a tool that can inform decision-making. Modeling results are contingent on inputs and assumptions and are not a promise of future outcomes. Moreover, states will be faced with a number of specific implementation decisions even after selecting an overall compliance pathway. The results presented here are meant to aid regulators and stakeholders in understanding the likely impacts of and relationships between different compliance pathways during the remainder of its Clean Power Plan compliance planning process.

1.4 State and Regional Energy Landscape

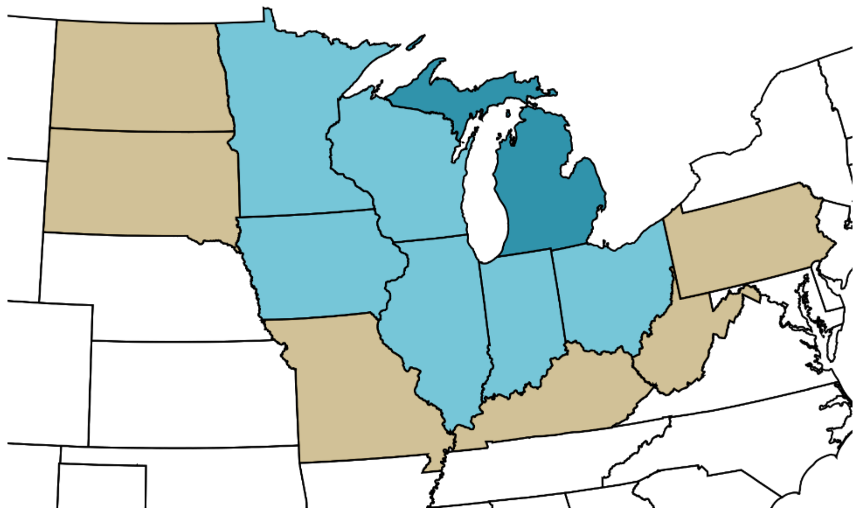
In the present day, Michigan's generation capacity is provided by coal (36 percent), natural gas (36 percent), and nuclear power (13 percent), with the remainder of its nameplate capacity in renewable energy, pumped storage hydroelectric, and oil-fired generators.[6] In-state renewable energy was dominated by hydropower and landfill gas-fired biomass units until 2013, when wind surpassed biomass to become the state's dominant form of renewable energy. Michigan currently has approximately 1.5

[6] U.S. Energy Information Administration (EIA). 2014. EIA Form 860, Table 3.1.

GW of installed wind capacity, built primarily between 2010 and 2015. Over that period, Michigan was the seventh most prolific builder of wind in the United States.[7]

In 2014, half of the energy produced in Michigan was from coal-fired generators, with the rest coming mostly from nuclear (29 percent) and gas (12 percent).[8] Wind was the fourth largest contributor at 4 percent of in-state generation. Over the last decade, the state has fluctuated somewhat between being an overall net importer or exporter of electricity to its neighboring states.[9]

Figure 2. Study area map showing Michigan (dark teal), states fully included in the study area (light teal), and states partially included in the study area (tan)



Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

For the purposes of this analysis, Michigan was modeled along with its immediate neighbors in the Great Lakes Region, as well as several additional bordering states. This group includes Ohio, Indiana, Illinois, Wisconsin, Minnesota, and Iowa.[10] Figure 2 shows the group of seven states in the study region. The basis of the study region is discussed in Section 2.5.

As a group, Michigan and its neighbors include about 17 percent of the population of the United States but almost 30 percent of its coal-fired capacity and, in 2014, more than a quarter of its wind capacity.[11]

[7] EIA. 2016. *Existing Nameplate and Net Summer Capacity by Energy Source, Producer Type and State* (EIA 860) 1990-2014.

[8] EIA Form 923.

[9] EIA Form 923 and EIA Form 861, total electric sector. Note, this generalization includes generation from the Donald Cook nuclear station as a Michigan EGU. Unlike the rest of Michigan, the southwest corner of Michigan (where Donald Cook is located) is connected to the PJM Interconnection, rather than the Midcontinent Independent System Operator (MISO); thus Cook may primarily serve generation out of state. Without Cook, Michigan has been a slight net importer since the late 1990s. For the purposes of this model, the study considers Cook a Michigan generator but dispatched by and connected to a cross-border zone.

[10] Several states were partially included in the study area for modeling purposes (see Section 2.5).

[11] EIA Form 860 (2014).

1.5 Key Research Questions

This study is designed to determine the impact of various compliance pathways on the region generally and on Michigan in particular, for the time period of 2016 to 2034. Several important guiding questions frame the analysis of different compliance paths. The overall impact of different compliance paths can be determined by interrogating:

- The mix of resources that are used to meet demand both before and after the onset of compliance;
- Emissions over time from both affected and unaffected resources under different compliance regimes;
- Michigan's role within the study region and how this role shifts with different compliance paths; and
- The total system cost of various scenarios.

The results sections below present a comprehensive view of each compliance path, organized to address each of these key areas.

1.6 Summary of Findings

The reference case for this model was guided by input from the state and stakeholders. In both the reference and compliance cases, the state sees a number of coal unit retirements based on assumptions provided by the state. In addition, in all cases the state pursues, at minimum, modest energy efficiency gains. Both of these programs (retirements and efficiency gains) result in reduced emissions, and therefore position the state for ready compliance with mass-based emissions targets.

Under a mass-based compliance path, Michigan is expected to be a net exporter of emissions allowances to other states, providing a net benefit to the state. Michigan's electric sector is moving in a direction to meet Clean Power Plan targets and the inputs used for this study assume a continuation of this trend. Given today's relatively low gas price forecasts, Michigan can be expected to be near compliance even without a trading regime or cap. Because of Michigan's relatively robust compliance position, compliance modeling shows it is likely to have significant excess emissions credits under a mass-based cap. These excess allowances are likely to have a market value in a multi-state trading system, and their sale could provide incremental revenue to the state that may outweigh potential compliance costs.

The scenarios modeled here show two general trends of emissions mitigation. In early years, and at low allowance prices, the electricity sector reduces output from existing coal generators and ramps up existing gas-fired generators (both covered and uncovered sources). As allowance prices increase in response to lowered emissions targets, incremental renewable energy is brought online in Michigan and other states. In many of the modeled scenarios, Michigan builds up to 5 GW of new wind before the end of the analysis period.

These findings are relatively robust from a directional standpoint: Michigan's ability to shift readily to its existing gas-fired fleet, reduce generation from its coal-fired fleet, and build incremental renewable energy projects at higher allowance prices means that it sees a benefit from a trading regime at both low and relatively high gas prices. Meanwhile, incremental efficiency programs and additional coal plant retirements result in uniformly lower compliance costs.

The financial analysis performed in this study makes several important assumptions outside of the electric system structure, and upon which the results are contingent.

- First, this study assumes that all of Michigan operates under a vertical utility structure (i.e. generation, transmission, and distribution are all regulated), and that both allowance costs and allowance revenues flow back to Michiganders. In other words, revenues from allowance sales are not simply kept by out-of-state utility shareholders, but are instead returned to either ratepayers or taxpayers. Failing to use this assumption might be considered imbalanced, as it would presume that ratepayers pay compliance costs but shareholders keep compliance revenues.

- Second, by using a forward-looking model, this report implicitly assumes that stranded asset costs from unit retirements are absorbed by Michigan ratepayers. While such decisions are made by MPSC on a case-by-case basis, economic modeling typically excludes consideration of sunk costs and they are excluded here as well. Reversing this assumption would actually provide an additional benefit to ratepayers whenever a unit is retired as remaining capital costs are credited back to ratepayers. In excluding recovery of sunk costs as a credit to ratepayers, the study conservatively accounts for any remaining value of these assets by ensuring that they are fully paid off.

The magnitude of the savings accrued to Michigan during the compliance period is a direct function of Michigan's compliance position and the cost of allowances. At higher allowance costs, Michigan's net compliance position renders greater allowance revenues and thus savings.

The allowance costs determined here are, in turn, a function of the states considered in the assessment and the cost of mitigation. Because the initial least-cost and most rapidly implemented mitigation measure was found to be a switch from dispatching coal-fired units to dispatching gas-fired units, compliance costs are to some degree reliant on the cost of natural gas. At higher gas prices, the cost of compliance is higher; but the cost of allowances is also greater, thus offsetting the higher compliance cost.

The states with whom Michigan trades are also an important consideration. This analysis assumes trading with other states in, roughly, the Great Lakes region. Many of these states are in a less attractive compliance position than Michigan and thus have need of the excess allowances available to Michigan under mass-based trading. If Michigan were to partner with less coal-intensive states, the allowance price could be substantially lower, thus providing less benefit than indicated in this study. Under the circumstance (not explicitly modeled here) that gas prices are higher than presently expected and that Michigan's trading partners have less need for allowances, compliance could foreseeably result in a relatively low net cost to Michigan rather than a net benefit. Under such a hypothetical scenario, it is not clear what route would be taken by Michigan's neighboring states, as the provision of allowances from well positioned states (like Michigan) are likely to provide a low cost compliance solution.

2. PROCESS AND STUDY APPROACH

2.1 Process

The Michigan Clean Power Plan Impact Assessment was developed collaboratively between state agencies, stakeholders, and Synapse, which was retained by the MPSC and MDEQ in August 2015.

In September 2015, Synapse held a daylong kickoff meeting with the Joint Agencies to review key aspects of the still new Clean Power Plan, assess a variety of model structures available to analyze different aspects of compliance planning, and share the outcome of screening-level assessments meant to inform the planning process. Synapse developed draft input assumptions on the study region, price forecasts, load requirements, and electricity system structures such as individual generator parameters and transmission constraints.

In October 2015, the Joint Agencies approved the input assumptions, with various modifications, and Synapse began modeling a reference case. The Joint Agencies invited key technical stakeholders to review input assumptions, the model structure, and potential compliance scenarios. Stakeholders reviewed the reference case results, and provided recommendations to improve the accuracy of the reference case.

Synapse was provided compliance case definitions by the Joint Agencies in January 2016, and then began full compliance case modeling. After modifications, the final reference case was approved by the Joint Agencies and stakeholders in April 2016. The final compliance cases were reviewed by the state and stakeholders in May 2016.

The following sections describe the modeling options and choices made for this compliance impact assessment, as well as some of the key considerations, assumptions, and caveats.

2.2 Survey of Modeling Options

There are multiple approaches available for states to assess the tradeoffs of various compliance pathways, and assessing the impacts of compliance on utilities, consumers, producers, and the state—or states—in question. States may seek to use modeling studies both to inform planning and to develop an approvable compliance plan. For pathways in which states either determine their own rate-based standard (R3) or utilize a mass-based plan with a "state measures" approach (M3 and M4), EPA requires a performance demonstration to verify that compliance is likely. EPA does not specify the exact form of the demonstration, but provides a list of detailed model parameters that must be reported by the states engaging in these pathways. Similarly, states that choose not to cover new sources under a mass compliance cap (i.e. M1 and M3) must provide a demonstration that leakage to new sources will not occur, either by using EPA's presumptively approvable model rule or through an alternative demonstration. Again, EPA does not specify the form of the demonstration that leakage has not occurred. The modeling here is not meant to specifically provide an approvable performance demonstration or leakage demonstration under EPA's rules and technical guidance, but is designed to meet most, if not all, of EPA's requirements should Michigan require such a demonstration.

Non-state entities may also have an interest in modeling Clean Power Plan compliance; they may wish to explore the possible impacts of different compliance options, prepare for likely outcomes of compliance, or advocate for specific compliance paths. A variety of analytical approaches are available, each relying on a different modeling toolset.[12] These model types include: [13]

> ***Production Cost Models:*** Tools that determine the optimal output of the EGUs over a given timeframe (one day, one week, one month, one year, etc.) for a given time resolution (sub-hourly to hourly). These models generally include a high level of detail on the unit commitment and economic dispatch of EGUs, as well as on their physical operating limitations. They are not, however, designed to determine the optimal addition of new EGUs to meet future capacity requirements or the retirement of non-economic EGUs.[14]
>
> ***Utility-Scale Capacity Expansion and Dispatch Models:*** Tools that determine the optimal generation capacity and/or transmission network expansion in order to meet an expected future demand level and comply with a set of regional/state specifications (e.g., reliability requirements, renewable portfolio standards, CO_2 emissions limits). These models operate at the resolution of individual EGUs.[15]
>
> ***National-Scale Capacity Expansion and Dispatch Models:*** Tools that determine the optimal generation capacity and/or transmission network expansion in order to meet an expected future demand level at a national (or large regional) scale. As a result of the higher dimensionality, these models typically exhibit a lower resolution than utility-scale models (e.g., demand represented in "blocks" as opposed to using an hourly resolution; aggregation of similar EGUs into model plants).

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[12] An overview of different modeling approaches and a discussion of the strengths and limitations of each can be found in the report "A Guide to Clean Power Plan Modeling Tools: Analytical Approaches for State Plan CO_2 Performance Projections" by Jeremy Fisher, Nidhi R. Santen, Patrick Luckow, Fernando de Sisternes, Todd Levin, and Audun Botterud (Argonne National Laboratory and Synapse Energy Economics, 2016; available online at: http://www.synapse-energy.com/sites/default/files/Guide-to-Clean-Power-Plan-Modeling-Tools.pdf).

[13] Optimization models are prescriptive—i.e. they seek a specific goal (called an "objective function")—while abiding by a set of constraints that represent the limitations of the system (e.g. capacity requirements, generation needs, fuel availability, transmission limitations, and emission limits). The usual objective function in these models is least cost, or maximum benefit.

[14] Optimal outputs in production cost models typically refer to least-cost operation, inclusive of reliability and other security constraints.

[15] Optimal outputs in capacity expansion models typically refer to "minimum total system cost," total system cost can either be total generation costs or the sum of total generation and transmission expansion costs, depending on the "decision" variables the model represents.

Multi-Sector Models: Tools that explore the interaction between different sectors of the energy system, as well as macroeconomic factors, using either a general equilibrium or partial equilibrium approach.[16] These models typically include transportation, industry, commercial, and residential sectors, in addition to electricity production. These models generally operate at an aggregate level of model plants or technology types, similar to the national-scale capacity expansion models.

Non-Optimization Approaches: Tools that develop approximate predictions of future production and/or investment decisions, or provide detailed bookkeeping of user-based decisions. These tools may make decisions based on expert judgement, heuristic rules,[17] scenario analysis, or statistical analysis. These tools often rely on external projections of supply, demand, and other economic conditions; and they do not explicitly optimize the operation of a power system or simulate economic equilibrium conditions. Non-optimization approaches for compliance planning span a gamut of models and non-models, including simulation models, statistical analyses, bookkeeping methods, and complex spreadsheet-based tools that seek to help stakeholders, researchers, and policymakers answer specific questions. They are distinguished in that they do not necessarily find an optimal set of decisions subject to system constraints; instead, they follow a prescribed set of rules and relationships to simulate the behavior of the system under certain conditions.

It is important to recognize that all models are reduced-form representations of real world systems. The inherent complexity within, and interactions between, the electricity industry's technical, economic, and regulatory systems make the task of projecting CO_2 emissions from electric power systems extremely challenging. Ultimately, each of these model types may be appropriate for different types of studies depending on the main research interest of the study in question. Stakeholders will have varying needs for different modeling structures. Some will seek transparency and increased accessibility, while others will seek engineering or operational detail. These varying needs require compromise. This is particularly true when modeling is conducted by a state or other public agency seeking to meet multiple needs including that of the public at large, the particular entities most directly affected by the compliance plan, and other stakeholders.

[16] General equilibrium models assume that all markets have an effect on every other market, and model all markets simultaneously. Partial equilibrium models assume that changes in one market (or the segment of markets explicitly represented in the model) do not affect other markets; the assumption is that neither the price of every other good (outside the modeled markets) nor income changes.

[17] Heuristics refer to "rules of thumb" and other computationally non-exhaustive methods that allow models to be solved more efficiently.

2.3 Survey of Comparable Studies

A number of Clean Power Plan studies with results for Michigan have been completed since the rule was finalized in mid-2015. These studies take a range of different modeling approaches and focus on state, regional, or national compliance.

2.3.1 Electric Power Research Institute

Electric Power Research Institute (EPRI) worked with Michigan's investor-owned and public utilities to conduct an assessment of Clean Power Plan compliance for Michigan.[18] The study utilized the capacity expansion component of EPRI's US-REGEN model, a 48-state framework that assesses buildout options from 2015 through 2050. Overall, the EPRI model is structurally very similar to that used in this study, captures a slightly wider cohort of states than assessed here, and at a slightly reduced resolution on specific generators and choices in specific years. The EPRI study assessed both mass and rate based compliance pathways.

EPRI's model inputs were derived from similar sources as the study presented here, generally relying on public data when available and based on the same industry databases for unit-specific information. Long-term assumptions in the reference case, such as gas prices, coal retirements, renewable energy operational parameters, and load growth are generally consistent with this study.

EPRI's model results indicated that the state was likely to be in mass-based compliance in the reference case in most years, based largely on announced coal plant retirements, relatively low gas prices, and other existing regulations. The study determined that mass-based compliance was likely a lower cost option than rate-based compliance for the state, and that the state's mass-based pathway would be influenced by the cost of allowances and the state's policies towards building new in-state gas generation. The findings are generally consistent in both direction and magnitude to the findings of this study, conducted independently of the EPRI analysis. Both studies conclude that under the reference case coal retirement and gas price assumptions, Michigan is likely to benefit from the sale of excess allowances to other states under a mass-based approach, and that under almost all circumstances, regional trading provides a lower cost approach than compliance in isolation.

2.3.2 Midcontinent Independent System Operator

The regional transmission system operator, Midcontinent Independent System Operator (MISO) has undertaken a substantial Clean Power Plan analysis covering 15 states, based on the broad scope of its operational control. MISO relied on a variety of methodologies, [19] including national-scale capacity

[18] Electric Power Research Institute (EPRI). 2016. "Understanding Clean Power Plan Choices in Michigan: Options and Uncertainties."

[19] MISO Policy & Economic Studies Department. 2016. "MISO's Analysis of EPA's Final Clean Power Plan Study Report: DRAFT." Available online at: https://www.misoenergy.org/_layouts/MISO/ECM/Redirect.aspx?ID=224648.

expansion modeling with EPRI's Electric Generation Expansion Analysis System (EGEAS) model[20] and production cost modeling using PLEXOS.[21] Both models are proprietary.

MISO's analysis examined several compliance approaches that included rate-based compliance with both subcategory rate and state average rate approaches, as well as mass-based compliance with and without the new source complement. A variety of trading approaches were tested, including state-by-state compliance (without trading), regional trading, and trading among the entire Eastern Interconnect. The resulting report included discussion of a wide variety of compliance paths, but detailed state-by-state cost and resource mix results were not provided.

Due to the computational requirements of PLEXOS, production cost modeling was only completed for three representative years: 2022, 2025, and 2030. Implied CO_2 prices varied widely based on the assumed compliance pathway, from zero to nearly $140/ton—though the highest cost scenarios did not allow for any new resource buildouts or retirements. MISO also found some leakage to uncovered sources. In particular, it found that uncovered CTs could be incentivized to run at up to 85–95 percent capacity factors. The modelers assumed this was unrealistic and placed hardcoded caps on the utilization of these units. Synapse encountered similar challenges in its own analysis.

2.3.3 Union of Concerned Scientists

National-scale capacity expansion modeling was also performed by the Union of Concerned Scientists (UCS),[22] which used the National Renewable Energy Laboratory (NREL)'s Regional Energy Deployment System (ReEDS) model.[23] UCS's modeling assumed that all states would pursue mass-based compliance with the new source complement and would engage in a national allowance trading scheme. UCS used its results to produce state-specific fact sheets, including for the state of Michigan. The UCS study found Michigan was likely to over-comply with the standard, resulting in average annual revenue of $428 million from the sale of carbon allowances.

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[20] EPRI. "Electric Generation Expansion Analysis System (EGEAS) v10.0" Description available at: http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002001929.

[21] Energy Exemplar. "PLEXOS® Integrated Energy Model." Documentation available at: http://energyexemplar.com/software/plexos-desktop-edition/.

[22] Union of Concerned Scientists. 2016. "Meeting the Clean Power Plan in Michigan: A Robust Pathway for Securing a Clean Energy Future." Available online at: http://www.ucsusa.org/sites/default/files/attach/2016/04/clean-power-plan-michigan.pdf.

[23] National Renewable Energy Laboratory (NREL). "Regional Energy Deployment System (ReEDS)." Documentation available at: http://www.nrel.gov/analysis/reeds/.

2.3.4 Energy Information Administration

The Energy Information Administration (EIA)'s Annual Energy Outlook (AEO) uses a well-established national-scale capacity expansion model called the National Energy Modeling System (NEMS).[24] In the AEO 2016 release, EIA assessed Clean Power Plan compliance in the reference case, assumed to be met with regional, mass-based trading. EIA also considered several alternative approaches, including rate-based compliance and wider trading regions, as well as alternative allowance allocation schemes. Allocating allowances to generators, rather than load-serving entities, resulted in higher retail electricity prices because EIA assumed those allowance revenues were not refunded back to ratepayers.[25,26]

While the NEMS model is not state specific, Michigan is largely represented by its own region. EIA's assessment finds that in the sensitivity case **without** the Clean Power Plan, Michigan's CO_2 emissions decrease moderately, from about 75 million short tons (MMst) in 2015 to about 60 MMst in 2022, and then grow slowly through 2040. These findings imply that Michigan would reach compliance at the rule onset, but not afterwards. The mass-based compliance reference case run shows total electric-sector emissions near, but not below, target requirements (51 MMst in 2030).

2.3.5 Other Regional Clean Power Plan Studies

A variety of stakeholder groups have performed non-optimization modeling with the aim of testing or promoting specific compliance paths. No compliance constraints are applied in these models. Rather, a variety of approaches are simulated and evaluated in the context of EPA's emissions targets. For example, the World Resources Institute (WRI) used an in-house spreadsheet model to estimate the emissions reductions that Michigan could achieve by increasing its energy efficiency and renewable energy targets, increasing use of its existing NGCCs, and increasing the efficiency of its coal-fired fleet.[27] The costs of these approaches were not evaluated.

Similarly, the Natural Resources Defense Council (NRDC) used M.J. Bradley and Associates' Clean Power Plan Evaluation Tool[28] to propose that Michigan can meet its mass-based target (with the new source

[24] EIA. "National Energy Modeling System (NEMS)." Documentation available at: https://www.eia.gov/forecasts/aeo/nems/documentation/.

[25] EIA. 2016. "Annual Energy Outlook 2016 Early Release." Available at: http://www.eia.gov/forecasts/aeo/er/index.cfm.

[26] EIA. 2016. "Effects of the Clean Power Plan." Available at: http://www.eia.gov/forecasts/aeo/Clean Power Plan.cfm.

[27] Gasper, R., K. Meek, and N. Kaufman. 2016. "How Michigan Can Meet its Clean Power Plan Targets." World Resources Institute. Available online at: http://www.wri.org/sites/default/files/Michigan_full_fact_sheet.pdf.

[28] M. J. Bradley & Associates. "Clean Power Plan Evaluation Tools." Available online at: http://www.mjbradley.com/about-us/case-studies/clean-power-plan-evaluation-tools.

complement) by increasing its energy efficiency target to 2 percent savings per year and its renewable energy standard to 25 percent by 2030.[29]

The Niskanen Center commissioned Anderson Economic Group (AEG) to examine the impacts of Clean Power Plan compliance.[30] AEG's in-house price sensitivity model (referred to as the Sectoral Business Decision model) tests what level of carbon pricing would be necessary for Michigan to achieve compliance primarily through reductions in in-state electricity consumption, assuming a relatively static electricity system and substantial price responsivity in consumers' demand for electricity.

2.4 Synapse's Study Approach

2.4.1 Choice of Model

For this analysis, Synapse supported Michigan's state planning process with the use of an industry-standard utility-scale capacity expansion model called System Optimizer (from ABB Group). Synapse and the Joint Agencies chose to employ System Optimizer due to its ability to handle individual EGU build and retire decisions, and to represent a relatively large number of individual units in a linear program structure. The modeling framework is equipped to assess technical constraints such as regional transmission limits, resource decisions including renewable energy acquisitions, and the imposition of policies such as emissions trading programs and mass-based emissions limits. The System Optimizer model is used by a number of large utilities for integrated resource planning and discrete resource decisions.

Synapse developed Michigan-specific inputs to the model in collaboration with the Joint Agencies and stakeholders (including planners from Michigan utilities and also local consumer, industry, and environmental groups), as well as from independent research. To expedite the modeling process, Synapse acquired the proprietary model with pre-packaged datasets for states in the Eastern Interconnect, including near-term base data, populated with detailed EGU specifications, costs, and constraints from Velocity Suite (a comprehensive market intelligence report). Synapse licensed unit-specific data from ABB for the entire Eastern Interconnect and supplemented this with additional research on unit characteristics within Michigan as well as required unit additions and expected retirements going forward.

The model outputs include unit-specific generation and emissions over time, capital expenditures for building new plants, and predicted allowance prices in compliance scenarios. Synapse used a

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[29] Natural Resources Defense Council. 2015. "Michigan's Pathway to Cutting Carbon Pollution." Available online at: https://www.nrdc.org/sites/default/files/Clean Power Plan-Michigan-Compliance-IB.pdf.

[30] Anderson, P.L. and T. Taylor. 2016. "Analysis of Michigan's Options Under the EPA's Clean Power Plan: Comparing Baseline, Cap-and-Trade, and Carbon Tax Scenarios." Anderson Economic Group on behalf of the Niskanen Center. Available online at: http://www.andersoneconomicgroup.com/Portals/0/Users/028/28/28/AEG%20Niskanen_CleanPowerPlan_04-20-2016_star%20print.pdf.

spreadsheet-based framework to aggregate these outputs by state and fuel type, and to produce both a comprehensive picture of state and regional energy landscapes and an analysis of Michigan's financial and compliance positions in different scenarios.

2.4.2 Approach to Modeling

To address the wide range of uncertainties inherent in long-term planning, a modeling exercise such as that conducted for this study must make a series of simplifying assumptions and choose to exclude some uncertainties on an *a priori* basis. These assumptions are presented in Section 2.6, below. For the purposes of this exercise, the Joint Agencies opted to focus on compliance under the M1 and M2 pathways only, and made assumptions about the implementation of the Clean Power Plan regionally. These assumptions include:

1. That Michigan would participate in emissions trading if available;
2. That neighboring states in the Great Lakes region provided a reasonable representation of potential trading partners;
3. That states in the trading region would all participate in the same program and could trade without restriction; and
4. That both the costs of and revenues from emissions trading would flow from and to Michigan ratepayers, and stay within the electric system.

Overall, this model is indifferent to the mechanism by which allowances are allocated to EGUs, whether freely on the basis of historical emissions or generation, or auctioned. In both circumstances, EGUs would experience an allowance cost: if auctioned, EGUs would face a real cost to obtain allowances while if freely allocated to EGUs, the choice to use an allowance to emit rather than to sell it to other emitting entities represents an opportunity cost. The approach used here treats these circumstances as indistinguishable as it assumes that in both cases the costs of obtaining allowances and the revenues from their sale would flow through to ratepayers as expenses and/or revenues. In keeping with extensive utility literature, this study assumes that consumer behavior is relatively unaffected by minor changes in electricity prices. Finally, this modeling treats Michigan as a whole, and does not distinguish individual utility ownership or regulator structure.

2.5 Study Boundaries

2.5.1 Study Period

The analysis presented here commences in 2016 and continues through 2034. The Clean Power Plan Final Rule sets out a declining emissions path from 2022 through 2030, and then requires emissions to remain at or below that level in years beyond. The rule requires compliance to be assessed every three years for the first six years after 2022, and then every two years thereafter. This analysis runs through 2034 to include a full additional interim compliance period after the re-licensure and potential retirement of nuclear-powered units in Michigan in 2031.[31] The period from 2016 to 2034 is referred to here as the "study period."

2.5.2 Study Region

Michigan was modeled as part of a "study region," designed to include Michigan's immediate neighbors and major linked sources of generation.

Rather than conforming to political boundaries, the study region was defined based on the edges of control areas representing major balancing areas in the electrical grid system. Transmission between these balancing areas is represented by aggregate "paths" specified in megawatts (MW) of transfer capacity.

Balancing areas are generally associated with the operating territory of large power companies. The study region used for this analysis incorporates the entirety of Michigan, Ohio, Indiana, Illinois, Wisconsin, Minnesota, and Iowa. In addition, small portions of several adjacent states were included as they are within modeled balancing areas. Mass-based emissions caps were adjusted to include the caps of these partially modeled states on a pro-rata (by emissions) basis.

The state of Michigan itself was split into two balancing areas—the Upper Peninsula and Lower Peninsula. The Lower Peninsula region includes the service territories of both of Michigan's large investor-owned utilities, DTE Energy and Consumers Energy, as well as a number of municipal utilities, cooperatives, and a portion of Indiana Michigan Power. As in most regional planning assessments, this analysis assumes that individual generators act competitively and dispatch economically, regardless of their public or private ownership, whether or not they participate in a centralized energy market, or with which energy market or transmission organization they coordinate.

A map of the overall study region is shown in Figure 2 on page 6.

Any definition of a particular study region comes with clear tradeoffs when deciding what study region to use. A larger study region will impose substantially greater computational requirements for the model to optimize dispatch and capacity expansion, while a smaller study region limits the ability to incorporate changes in imports and exports across the region, and to model the dynamics of simultaneous Clean Power Plan compliance with trading.

This study does not model Canada. International imports to Michigan were held constant across years at 6,164 GWh annually.[32] Transfers between states in the study region changed across years, depending on the relative economics of generation and new-build options in those states, and on the available transfer capacity. Imports to or exports from the broader seven-state study region are held constant at

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[31] This analysis includes only the retirement of Palisades Unit 1.

[32] International imports are 2013 levels. From EIA SEDS. http://www.eia.gov/electricity/state/.

2015 levels. This study's Clean Power Plan compliance runs all allow for trading of allowances among all states within the study region.

2.5.3 Allowance Trading Region

All compliance case modeling was based on the assumption that trading of CO_2 allowances or ERCs would be allowed within the study region. The potential exists for Michigan to join a national trading region or a trading region including a different set of states than is included in this analysis. In the event that Michigan joins a study region different from that modeled in this study, compliance results may differ from those presented here due to variations in the trading region's resource mix and other factors.

For the purposes of this analysis, it is assumed that allowances are allocated freely to utilities, and that any utility savings and or profits from this free allocation of allowances are passed, in full, back to ratepayers.

2.6 Key Assumptions

This study relies on several important input assumptions in modeling the future of the study region. Assumptions were developed and vetted with stakeholders representing the views of state regulators, utilities, environmental advocates, and other knowledgeable parties.

Load forecasts for Michigan and the study region as a whole, fuel prices, renewable energy capital cost forecasts, and non-Clean Power Plan environmental regulatory costs were developed by Synapse, and assessed by stakeholders. Specific resource additions and retirements were provided as input by stakeholders and state regulator assumptions. In modeling the region's energy system, these assumptions determined how much capacity and generation had to be added to the system and in what time frame, as well as informing what resources were available and the relative favorability of these resources.

2.6.1 Demand Forecast

Synapse worked with MPSC to determine a long-term sales growth forecast for Michigan utilities. For the purposes of a reference case, it was assumed that Michigan would see reduced consumption due to existing and incremental federal appliance standards (FAS) and would continue pursuing state-specific utility energy waste reduction (EWR) programs.[33] Based on MPSC input, this study used an underlying long-term growth rate of 1.2 percent per year with no incremental efficiency programs—utility, state or federal. Overall, this assumption would result in a growth in demand from about 103 TWh in 2014 to 130 TWh in 2034.

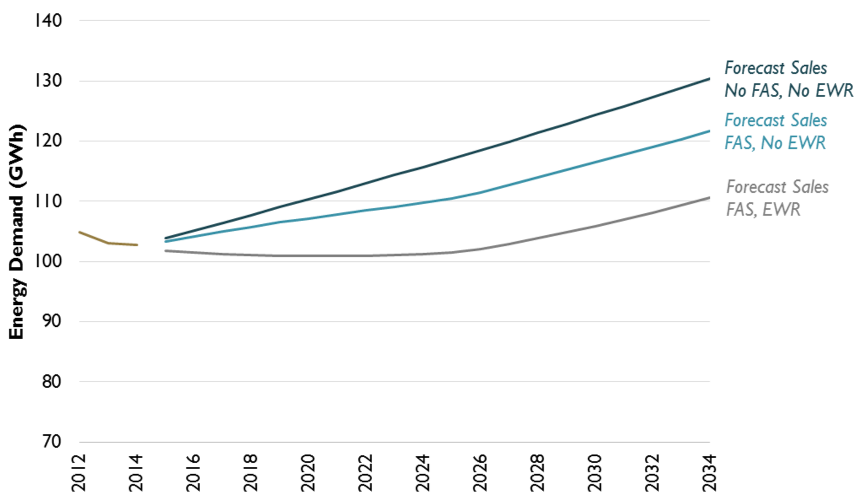
[33] Energy Waste Reduction programs are also known as energy efficiency programs in other states and forums.

Synapse assessed current and impending FAS. Synapse's assessment of existing and impending FAS resulted in an expectation of incremental reductions in demand of about 0.5 percent per year through 2025, falling off thereafter. In consultation with the Joint Agencies, Synapse assumed a continuation of the Energy Optimization Standard in the Reference case,[34] with incremental EWR savings of 1 percent per year. The combination of the native growth, in demand with FAS and EWR assumptions resulted in a forecast of flat consumption at around 102 TWh from 2015 through 2026, with demand rising thereafter to 111 TWh between 2026 and 2034.

Synapse assumed a 4 percent distribution system loss factor, with increasing generation demand to account for these losses.

Synapse used ABB default assumptions for projections of regional load.

Figure 3. Reference case demand forecast development for Michigan



2.6.2 Fuel Price Forecasts

Synapse utilized publicly available fuel price forecasts for coal, natural gas, and fuel oil, focusing primarily on EIA's 2015 AEO Reference case. [35] Due to the recent decline in natural gas prices, Synapse used the AEO 2015 High Oil & Gas Supply sensitivity forecast for long-term natural gas prices in the base case, supplemented by NYMEX futures for the first several years. The resultant price trajectory, which is substantially lower than the AEO 2015 Reference case, maintains a Henry Hub price of $3/MMBtu through 2020 and before rising to below $4/MMBtu (2014$) by the end of the analysis period. A higher price forecast based on the AEO 2015 Reference case was also used for sensitivity analysis. This forecast deviates from the base trajectory starting in 2019, and rises to just over $6/MMBtu by the end of the analysis period.

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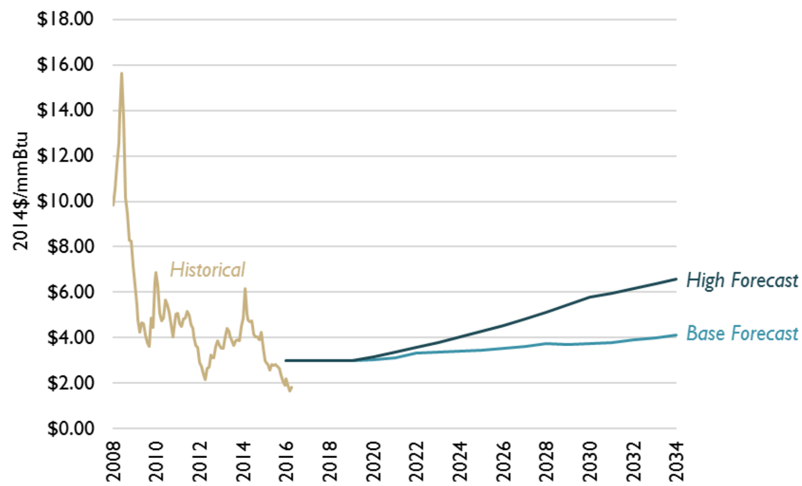
[34] Michigan, State of. *Clean, Renewable, and Efficient Energy Act, PA 295*. Available online at: http://www.michigan.gov/mpsc/0,4639,7-159-52495_53472---,00.html.

[35] EIA. 2015. "Assumptions to the Annual Energy Outlook 2015." DOE/EIA-0554 (Washington, DC, to be published). Available at: http://www.eia.gov/forecasts/aeo/assumptions.

AEO 2016 was released shortly before the publication of this report. That updated forecast indicates gas prices rising to just under $4.5/MMBtu by 2020, but then maintaining at or below $5/MMBtu through the analysis period. As of the writing of this paper, NYMEX futures maintained approximately $3/MMBtu through 2020, after which trading is substantially thinner and less reliable.

Figure 4. Assumed Henry Hub Natural Gas Price Forecast (2014 $/MMBtu)



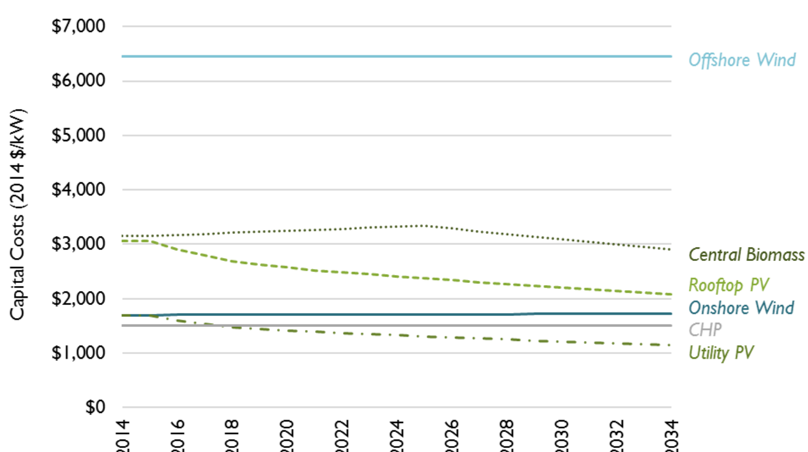
Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

The ABB dataset used for this analysis includes region- and plant-specific basis adders for coal and gas.

2.6.3 Renewable Energy Cost and Potential

For new renewable resource selection, Synapse used assumptions consistent with the *2015 Michigan Renewable Resource Assessment* conducted by the Vermont Energy Investment Corporation (VEIC). Figure 5 shows the capital cost trajectories for renewable energy options.

Figure 5. Renewable energy capital costs



Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

Maximum allowable resource builds were also informed by the VEIC study. For onshore wind, however, Synapse reduced the maximum allowable wind build from 11,734 MW to 5,000 MW based on stakeholder feedback. As of 2014, Michigan had about 1,500 MW of wind capacity online,[36] primarily developed over the last four years. The trend recently has been for Michigan to add about 340

[36] EIA.

MW of new wind capacity per year on average (2011-2014).

The amount of rooftop photovoltaics (PV) were input as a fixed trajectory (i.e. not an optimized choice) and held constant for all scenarios. The assumed trajectory was based on research conducted in 2014 using NREL's ReEDS model.[37] This study assumes that rooftop PV rises from approximately 25 MW today to around 40 MW in 2026 and to 80 MW by the end of the study period.

2.6.4 Existing Unit Retirements

Nuclear, coal, and oil unit retirements within Michigan were set exogenously,[38] based on assumptions from MPSC staff. (Figure 6). Overall, the Reference case assumes 1,300 MW of coal unit retirements in 2016, rising to 2,400 MW by 2022 and 3,000 MW in 2023. These aggregate retirement figures represent the total capacity of multiple individual unit retirements. In addition, the Reference case assumed that Palisades nuclear station (812 MW) did not pursue re-licensure in 2031 and retires in that year.

Figure 6. Existing unit retirement assumptions in Michigan, by fuel type

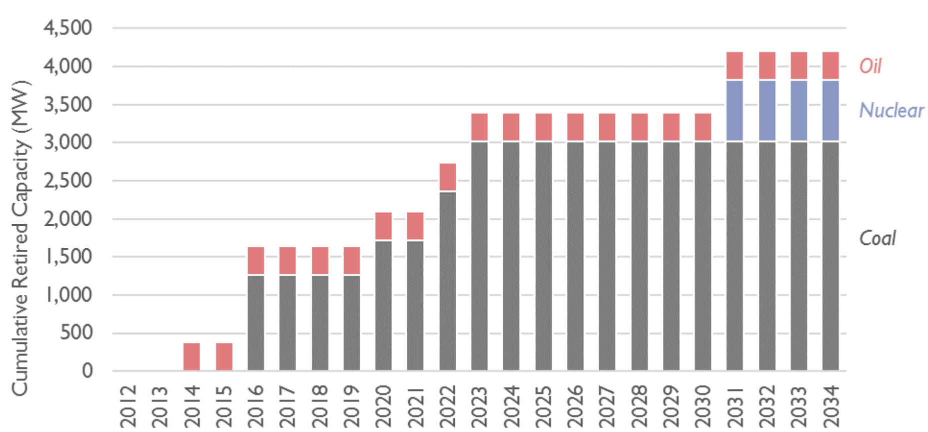


ABB default assumptions were used for all potential unit retirements outside of Michigan.

2.6.5 New Unit Additions

Capacity expansion models are able to choose which new generation units should be added to a system and when they should be added, based on costs and constraints. The aim in general is to minimize system cost. This study allowed the model to select incremental capacity additions in all regions, including Michigan. In addition to those added by the model, a number of units were hard-coded into the assessment. On advice of MPSC staff, Synapse assumed the presence of Alpine Power Plant (Wolverine Power, 432 MW) in 2016, Holland Energy Park (City of Holland, 114 MW) in 2018, and an Invenergy project (280 MW) in 2017. In addition to these currently proposed or permitted units, MPSC staff also requested that three 750 MW NGCC units be added through the analysis period (in years 2022, 2024, and 2029) as a baseline assumption.

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[37] Sigrin, B., M. Gleason, R. Preus, I. Baring-Gould, and R. Margolis. 2016. *The Distributed Generation Market Demand Model (dGen): DocumentationPDF*. NREL/TP-6A20-65231. National Renewable Energy Laboratory (NREL).

[38] Exogenously: outside of the model framework, or not chosen by the model. In other words, all retirements were assumed and held constant within the model framework, and the model was restricted from choosing to retire units.

Synapse used the ABB default renewable energy scenario for all modeling runs. This scenario assumed a certain set of units will be added to comply with existing renewable portfolios policies and other standards across states in the study region runs.

Apart from these additions, all new units were chosen endogenously (i.e., by System Optimizer). Because exogenous units are common across all scenarios, only endogenous unit additions are represented in capital expenditures.

2.6.6 Cost of Energy Waste Reduction

An assessment of EWR (or energy efficiency) prices reported by state EWR programs[39] suggested that EWR costs between 13¢¢–14¢/kWh (2014$) on a first-year basis (or 1.7¢¢–1.9¢/kWh on a lifetime cost basis)[40] Following feedback from MPSC staff, it was assumed that this cost would increase linearly (in real terms) to 26¢ by 2020, and then remain at that cost through the end of the analysis period.

Other states were not assumed to have efficiency programs above and beyond those embedded in load assumptions in the reference database.

2.7 Financial Analysis

In order to evaluate the economic impacts of Clean Power Plan compliance on the state of Michigan, this study conducted financial and employment analysis in addition to the energy system modeling described above. This analysis focused on the annual costs of the power system for various policies and compliance paths. Total scenario costs are compared on a net present value (NPV) basis for incremental costs. In other words, the analysis (a) only reviews new forward-going costs starting in the year 2016, and (b) sums these costs over all years (2016-2034) on a present value basis.[41] For this study, we used a discount rate of 6.64 percent (nominal), which is the simple average of DTE Energy and Consumers Electric weighted average cost of capital.[42] The study is conducted in constant 2014$ dollars, with inflation set at 1.9 percent to adjust nominal terms.

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[39] Michigan Public Service Commission. 2014. *2014 Report on the Implementation of P.A. 295 Utility Energy Optimization Programs, in Compliance with Public Act 295 of 2008*; Michigan Public Service Commission. 2015. *2015 Report on the Implementation of P.A. 295 Utility Energy Optimization Programs, in Compliance with Public Act 295 of 2008*.

[40] Lifetime cost assumes 10-year measure life and 6 percent discount rate.

[41] Present value represents the value, today, of a cost incurred in a future date and is a standard accounting, ratemaking, and planning construct within the utility and business sectors. This study uses a weighted average utility discount rate for Michigan's investor-owned utilities, representing the cost of capital for an investor-owned utility. The present value represents the investment that would need to be made today to have capital available in a future year. The total cost of a scenario is taken as the sum ("net") of all future costs and revenues on a present value basis.

[42] Order from MI PSC Case No. U-16794, as provided by MI PSC.

Synapse relied primarily upon System Optimizer outputs to calculate the annual power costs incurred by Michigan under each scenario. The annual plant-level cost outputs generated directly by System Optimizer include costs for fuel, variable operations and maintenance (O&M), fixed O&M, and new plant construction. Outputs on regulated CO_2 emissions were multiplied by endogenously calculated CO_2 allowance clearing prices to determine annual emissions costs. To calculate the total value of Michigan's allowance pool, Synapse multiplied the number of allowances allocated to Michigan under the Clean Power Plan in each year by that year's allowance clearing price. Allowance revenue was then calculated as the difference between the value of the total allowance pool and the value of the allowances used by in-state EGUs. The cost of EWR (energy efficiency) was calculated on a first-year investment basis and was limited to costs incurred by utility companies.

Synapse used electricity price and import/export outputs to calculate electricity import costs and export revenues at the transmission-area level, and then calculated state-wide costs and revenues by summing these costs across transmission areas located within Michigan. For the two transmission areas located fully within Michigan, hourly price, import, and export data generated by System Optimizer were used to calculate net import costs. For the sections of the two transmission areas that fall partially within Michigan, Synapse estimated Michigan's pro-rata share of sales based on 2014 EIA data and forecasted annual generation for the identified Michigan power plants in those transmission areas. Annual net import estimates were then multiplied by the transmission area's modeled annual average electricity price to estimate annual net import costs.

2.7.1 Total System Cost

The definition of "total system cost" used here is similar to that used in long-term planning for vertically integrated utilities. Total system cost includes all forward-looking costs of operating EGUs in Michigan, including the per-unit costs of fuel costs, fixed costs of O&M, and maintenance (O&M), variable O&M costs. It also includes incremental capital requirements for existing generators, the capital costs of new generators, the net cost of energy purchases from and the revenues from energy sales to neighboring states, and the cost (real or opportunity) of purchasing emissions credits or allowances. As a whole-state analysis, performed on behalf of the state, this study maintains the value of allowances allocated to the state by EPA as a revenue stream to the state. EPA will distribute a known number of allowances to each state, and depending on the ultimate cost of compliance, these allowances will have an implicit or explicit value.[43]

If Michigan generators were to substantially reduce emissions below the number emissions target set by EPA, they would consume fewer allowances than allocated to the state, leaving an excess of allowances unused by Michigan EGUs. These excess allowances could be sold out of state. The difference between how much generators pay for allowances and how much value is implicit in the allowances allocated to

[43] Allowance value will be implicit if trading is performed through strictly non-monetary measures such as state cooperative agreements; allowance value will be explicit if trading is performed through any form of market, whether bilateral or public.

the state provides a stream of either net costs or net revenues to the state. For example, if generators consumed exactly the number of allowances provided to the state, there would be no emissions cost to the state as a whole. If generators consume less than the allowances allocated, the state would realize a revenue stream. The electric system model is agnostic to whether revenues from those sales flow to the state (i.e. to reduce taxes) or to ratepayers directly.

2.7.2 Stranded Asset Cost

As is standard practice for a forward system planning process, this impact assessment reviewed only forward-looking costs and did not consider the disposition of sunk costs. EGUs that are taken offline at the end of their useful lives (defined on an economic basis or otherwise) may not be fully paid off, leaving a so-called "stranded investment." Determining how to treat such stranded investments can be a critical question for utilities and state utility regulators, but engagement with these issues is not generally part of forward planning. As a matter of general economic principle, decisions should be made on the basis of opportunity costs—i.e. the opportunity to make a different decision at a higher value or a lower cost. There is no opportunity to avoid paying stranded costs—those costs are borne by either the owner or customers (or in some cases, taxpayers).

In this modeling effort, units that retire avoid forward-going fixed O&M costs, fuel costs, and other variable costs of operation, but neither incur additional costs for retirement nor provide an incremental monetary benefit to consumers aside from the provision of possibly lower-cost power and reduced emissions. In ignoring the recovery of sunk costs in the model, this analysis implicitly assumes that costs are fully recovered by the utility. Any result other than full recovery would entail providing a benefit to consumers in the form of a rate credit (i.e. a reduction of revenue requirements). This analysis, therefore, takes into account useful lives by excluding consideration of sunk costs and assuming that full recovery is provided.

This analysis is not meant to provide guidance on the disposition of specific existing units, and the results should not be construed to provide a valuation of any given asset. Rather, the results provide insight on the impact and cost of various general compliance pathways.

2.8 Caveats and Data Limitations

In considering the results of modeling scenarios that span long timeframes, it is important to remember that this study relies on forecasts of key inputs (e.g., loads, fuel prices and resource costs) over a 20-year period. Over at least the latter half of this period, these forecasts are highly uncertain, and thus the modeling results should be viewed carefully. In electric utility planning, it is common to evaluate a range of scenarios and sensitivities to understand the implications of near-term decisions given reasonable variation in long-term assumptions and forecasts. This study focuses on several key uncertainties identified by the stakeholder group, but is not comprehensive.

In this modeling work, several key aspects of the tested scenarios were developed "exogenously" and entered into the model as inputs. For example, trajectories for energy efficiency, wind resource limits, and rooftop PV installations were treated as input assumptions. The total allowable amount of new wind capacity was also assumed to be limited. Several other factors are not addressed or are simplified in this analysis, as described below.

2.8.1 Choice of Study Region

In coordination with the PSC and stakeholder group, Synapse arrived at a seven-state model region. This study assumed trading of mass-based Clean Power Plan allowances across this region. Defining a region consisting of a different set of states could change the value of emissions allowances, and the revenue received by Michigan for the sale of those allowances. The analysis presented here found Michigan to be a net seller of allowances in all scenarios. It is highly unlikely that different regional choice would require Michigan to be a net purchaser of allowances.

2.8.2 Cooperative Regional Compliance Pathway Choice

This study assumes that all of the states in the study region choose a similar compliance pathway **and** choose to engage in cooperative allowance trading. It is feasible that neighboring states may choose different pathways, resulting in a compliance patchwork of non-trading mass and rate states. In other cases, some states may impose restrictions on their anticipated trading partners (if such restrictions prove to be legal). It is difficult to predict the pathway likely to be chosen by every state, and similarly difficult to assess what impact patchwork compliance would have on allowance prices, rate-trading states, and the efficacy of the rule. The assumption that most states will choose a similar compliance pathway is common to many modeling efforts.

2.8.3 Retirements

The model made no endogenous retirement decisions based on economics. Plants were retired at their regulatory established end of life, or based on announcements. For the state of Michigan, retirement decisions were made *a priori* in consultation with the State. Further economic retirements in the MISO region are very possible and would likely have the effect of lowering allowance prices.

2.8.4 Local Reliability Analysis

The model is constrained to have a planning reserve margin requirement in each transmission area, as well as the broader PJM and MISO areas. RTOs such as PJM and MISO conduct regular reliability analyses themselves and may institute additional local capacity requirements. MISO, for example, includes a Local Clearing Requirement for each of its defined resource zones. This study does not attempt to forecast the evolution of such requirements, which are frequently dependent on local transmission constraints. Similarly, MISO institutes Capacity Import Limits (CIL) based on the need to respond to a transmission outage.

A true reliability analysis would characterize transmission flows and local requirements in more detail using power flow models, which inform the development of MISO LCR and CIL requirements. Such analyses are not typically done with resource planning models, due to computational limitations.

2.8.5 Resource Siting Constraints

System Optimizer assumes a new plant (fossil or renewable) can be built if it is economic. Other local considerations may prohibit or delay the installation of new facilities. Maximum resource limits such as the model's 5,000 MW cumulative cap on wind additions, are informed by a resource assessment incorporating siting constraints. When a planning model such as System Optimizer indicates that such resources are economic, an important next step is to consider these constraints.

2.8.6 Operational Considerations

Long-term capacity expansion models typically take a limited approach to unit commitment and dispatch by bundling a number of hours with similar loads into load blocks. This allows these models to approximate the day-to-day dispatch, while devoting computation resources towards the comparison of new resource alternatives. A production cost model could alternatively be used to consider an 8760 hour unit commitment and dispatch, enforcing constraints such as limitations on the ability of fossil plants to ramp up and down in response to changing net load patterns.

2.8.7 Leakage Mitigation

This study relied on EPA guidance to develop a scenario to minimize the incentive for new, uncovered NGCC plants to increase generation under an "existing sources only" compliance pathway. This EPA guidance included the free allocation of some allowances to existing NGCC units, as well as new renewable installations (referred to as output-based allocation and renewable energy set-asides). Alternative approaches could be envisioned.

2.8.8 Heat Rate Improvements

No economic heat rate improvements were modeled as an emissions mitigation opportunity, although System Optimizer has the capability to model such decisions. For the long-term, state-wide purposes of this study, the team focused on renewable energy, energy efficiency, and dispatch shifts.

2.8.9 Data Limitations

Synapse conducted a comprehensive analysis of near-term resource additions and retirements in Michigan. This study relied on Ventyx/ABB data for this analysis in the rest of the study region. Changes made since the development of that dataset would not be reflected in this analysis.

2.8.10 International Imports

Canada was not part of the study region in this analysis, but remains an important source of electricity supply. In this study, net imports to Michigan from Canada are maintained at current levels throughout the remainder of the study period. An alternative approach would be to model supply and demand in the neighboring region of Canada and let the model decide future trends based on economics.

3. Scenarios and Sensitivities

The following section describes the scenarios and sensitivities selected for modeling by the Joint Agencies and stakeholders. As noted previously, the state and stakeholders oriented the assessment presented here towards understanding the impacts of various mass-based compliance options, with particular emphasis on probing the potential differences between the case in which all sources are covered and cases in which only existing (affected) sources are covered by the requirement.

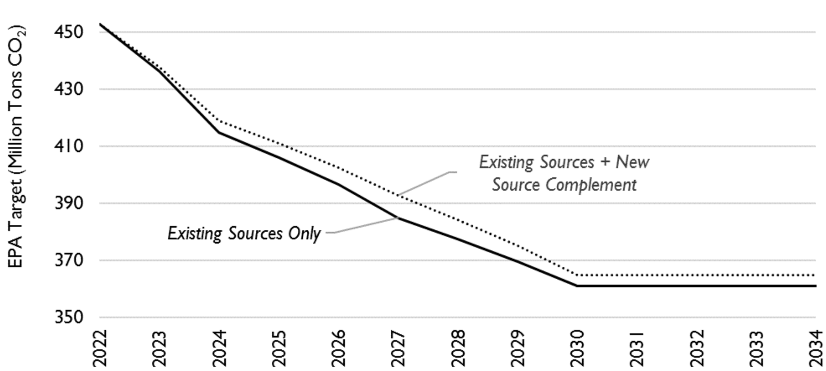
3.1 Reference Scenario

In order to evaluate the impacts of Clean Power Plan compliance, modeling included a Reference scenario in which compliance is *not* required. The purpose of this scenario is to establish a baseline from which the impact of the Clean Power Plan may be evaluated, and from which the state and planners may assess the actions and/or policy constructs that may be needed to reach compliance. The inclusion of the Reference case serves to put the results presented here in context, enabling isolation of the impact of the Clean Power Plan from the effects of changing gas prices, renewable energy capital costs, load, and other factors that influence the region's energy landscape. This scenario should not be construed as a viable compliance mechanism.

3.2 Mass-Based Compliance Scenarios

The modeling presented here includes three mass-based compliance scenarios. In these scenarios, a total cap on allowable CO_2 emissions was applied to affected generating units within the study region. As above, all scenarios incorporated trading of emissions allowances within the multi-state study region. No trading was allowed with states outside of the region. In other words, a given year's mass cap acts as an exact and absolute limit on the amount of CO_2 that may be emitted by the region's capped units in that year. The study did not examine inter-annual banking of allowances, in which a state or region over-complies in early years to reduce costs in later years.

Figure 7. Regional caps on emissions for mass-based compliance, with existing sources only or both existing and new sources



Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

The scenarios vary from one another primarily based on the set of units covered by the cap. For two scenarios, only existing affected units are covered by the cap. In the third scenario, both existing and new units are covered by the cap. States opting to cover both new and existing sources are given a slightly higher cap, in the form of the "new source complement." The value of these two emissions caps for the entire study region are shown in Figure 7.[44] This cap represents the total tons of emissions allowed in the seven-state region, as well as a ratable fraction of the states only partially covered by the model.

3.2.1 Existing Only Mass-Based Compliance Scenario

The simplest compliance scenario modeled in this study applies a mass-based emissions cap only to affected sources as defined by the rule, including existing steam boilers and combined-cycle electricity generating units. This path is referred to here as the "Existing Only" scenario. The cap does not apply to CTs, or to units that commenced construction after January 8, 2014. For the purposes of this study, if a new generator is constructed during the study period, its absolute CO_2 emissions are unconstrained in this scenario.[45]

EPA has recognized that as the cap on emissions is tightened, uncovered sources may be incentivized to produce incrementally more generation. To the extent that this includes emitting resources, this incentive may result in an increase in emissions from uncovered sources, an effect known as "leakage." Because of this effect, a simple Existing Only compliance path is not legal under the final Clean Power Plan unless a state can decisively demonstrate that leakage is unlikely to occur as a result of unique factors or existing state policies.[46] The scenario presented here is meant to help illustrate potential leakage in Michigan.

3.2.2 Model Rule Mass-Based Compliance Scenario

EPA provides for a mechanism by which states can address leakage while still only covering existing sources under a mass-based cap. The rule offers that states can "use allocation methods in the state plan that counteract incentives to shift generation from affected EGUs to unaffected fossil-fired sources."[47] EPA lays out a series of presumptively approvable allocation methods in the simultaneously proposed Model Rule.[48] The Model Rule path modeled here caps emissions from existing sources only, and implements the allocation methods proposed in the Model Rule to the extent feasible. This modeling effort is meant to review the impact of the M1 pathway (see Section 1.2 on page 1).

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[44] Readers should note that the vertical axis of this figure begins at 350 million tons of CO_2, rather than zero.

[45] New sources of CO_2 emissions in this model are limited to natural gas combined cycle (NGCC) and combustion turbine (CT) units. EPA's New Source Performance Standard (NSPS) for CO_2 restricts the emissions rate from new sources to 1000 lbs/MWh limit for gas units and 1,400 lbs/MWh for coal-fired units. It is generally understood that the gas subcategory rate is achievable with current commercial technology, while the coal subcategory rate for new units would require carbon capture and sequestration (CCS). For the purposes of this study, new coal units with CCS were not examined as a viable Michigan resource.

[46] 80 FR 64890.

[47] 80 FR 64888.

[48] 80 FR 64965. "Federal Plan Requirements for Greenhouse Gas Emissions From Electric Utility Generating Units Constructed on or Before January 8, 2014; Model Trading Rules; Amendments to Framework Regulations."

The Model Rule lays out two allocation mechanisms unique to this pathway and meant to mitigate leakage. By all indications in the proposed Model Rule, both of these allocations must be implemented for a plan to be approvable.

In the first mechanism, existing NGCC units only are provided a set number of allowances, which are allocated to individual generators based on their generation—existing NGCC units that produce more power are provided incremental allowances (or more specifically, access to a set-aside allowance pool). This mechanism, known as an "output-based allocation" provides an incremental incentive to *existing* NGCCs to increase their output, thus theoretically offsetting the incentive provided to *new* sources and mitigating leakage. The value of that incentive decreases as the output of NGCCs as a group rises.

In the second mechanism, renewable energy projects are awarded allowances from a set-aside pool that can then be sold on the market for additional revenue. Both the output-based allocation of allowances to NGCCs and the allocation of allowances from the renewable energy set-aside (RESA) pool function as financial incentives to these generators. These incentives are not granted to uncovered emitting sources.

3.2.3 Existing+New Mass-Based Compliance Scenario

The last compliance scenario applies a mass-based emissions cap to all existing and new affected sources—the M2 pathway. For the purposes of this study, this compliance path is referred to as the Existing+New scenario.

EPA provides this pathway as a mechanism of addressing leakage by covering the units most likely to increase generation and emissions if left outside of the cap. This pathway does not require the specialized allocation mechanisms of the Model Rule, as described above.

The cap in the Existing+New scenario includes the amount of emissions allowed for existing units as well the new source complement. Therefore, the cap in the Existing+New scenario allows incrementally more emissions than the cap used in both the Existing Only and the Model Rule scenarios.

3.3 Sensitivities

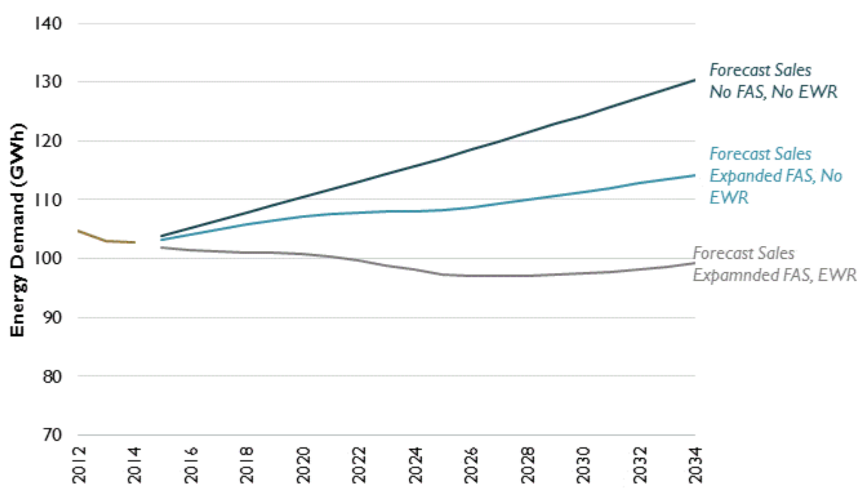
In addition to a base case examination of each compliance scenario, three sensitivity cases were modeled for the Reference scenario, as well as for the Existing+New, Existing Only, and Model Rule compliance scenarios.

Sensitivities were selected by the Joint Agencies and stakeholders, and were designed to illustrate the most substantial uncertainties or potential changes driving the cost or impacts of compliance.

3.3.1 High EE Sensitivity

The High EE sensitivity is meant to illustrate a case in which Michigan pursues a more rigorous EWR (or efficiency) program and where federal appliance standards (FAS) are expanded incrementally. In total, efficiency programs expand to 2 percent incremental savings per year, as compared to 1 percent per year in the base case, resulting in net load reductions from 2015. For the purposes of the financial analysis, it is assumed that incremental EWR is priced at the same level as in the base case. As in the base case, this sensitivity assumes that the state or its utilities pay only for EWR and not the federal appliance standards.

Figure 8. Forecast sales under the High EE sensitivity



3.3.2 Additional Coal Retirements Sensitivity

This case includes the retirement of additional coal-fired units within the state of Michigan, totaling 3.7 GW of capacity. All additional unit retirements occur towards the end of the study period. No additional retirements outside of Michigan were included.

3.3.3 High Gas Sensitivity

This case relies on a higher forecast of natural gas prices than the base case (see Figure 4, section 2.6.2), following AEO 2015 reference case assumptions.

3.4 Potential Interactions between Scenarios

The sensitivity cases modeled here, taken as a group, vary some of the most pivotal inputs that go into modeling a compliance scenario, including: the load seen by the fossil fleet, the resource mix available to meet that load, and the relative prices of those resources. Each sensitivity was modeled as occurring independently. In other words, modeling did not include a scenario in which Michigan implements additional energy efficiency *and* gas prices rise faster than expected.

It is entirely possible that both of these situations may occur simultaneously. Moreover, other important sensitivities are not captured here, such as patchwork compliance (see Section 2.8.2), substantial new transmission, coal retirements in other states, or substantial changes in the cost of renewable resources (see caveats in Section 2.8). However, because the directionality of the results below is very consistent (for example, sensitivities that tend to decrease costs do so regardless of compliance), these results provide some guidance as to what can be expected if multiple important factors shift during the same time period. Therefore, although they do not represent a comprehensive range of uncertainties, the sensitivity analyses presented here demonstrate how important assumptions affect the modeled compliance outcomes for the state of Michigan.

4. RESULTS

4.1 Guide to Results

The sections below present modeling and analysis results from the key scenarios tested in this study: the base cases of the Reference scenario and three compliance scenarios, as well as the Reference and Existing+New compliance scenarios of each sensitivity case. Sensitivity results for Existing Only and Model Rule compliance scenarios can be found in the accompanying Technical Appendix.

In each section, results describe the energy landscape, emissions trajectory, and financial metrics associated with a given scenario or sensitivity. Energy results are presented for Michigan in all cases and the region at large in the base case of the Reference scenario. These results include both the generation mix over time and the capacity build-out (the additions and retirements of capacity over the study period).

Each of the modeling runs performed tracked generation and emissions on a unit-by-unit basis. For the purposes of this report, CO_2 emissions are reported only for Michigan except in the Reference case, which includes a discussion of regional emissions. In the compliance cases, regional emissions from covered sources are constrained by EPA's targets. Each section here provides an assessment of Michigan's compliance position (i.e. whether the state is short or long on emissions allowances on a net basis). Generation, capacity, and emissions results are presented on an absolute basis, rather than relative to the Reference case.

The financial analysis shows the differences in power system costs in Michigan resulting from Clean Power Plan compliance paths by themselves, as well as due to the sensitivity cases described above (additional energy efficiency, accelerated coal retirements, and high natural gas prices). All financial results are shown on a net present value basis (2016-2034) in 2014$.[49] Absolute financial results are shown for the base case of the Reference scenario only. Otherwise, financial results are shown relative to the base Reference case.

Savings relative to the Reference scenario are assumed to be passed on to customers in the form of bill savings or lower rates. For further detail on the financial impact methodology, see the Technical Appendix.

While the sensitivities were run for all scenarios, the discussion of results focuses on the contrast between the Reference case and the Existing+New Scenario. This scenario stands out as both the case with the most notable contrasts in the sensitivities, and lowest-cost outcome on a consistent basis.

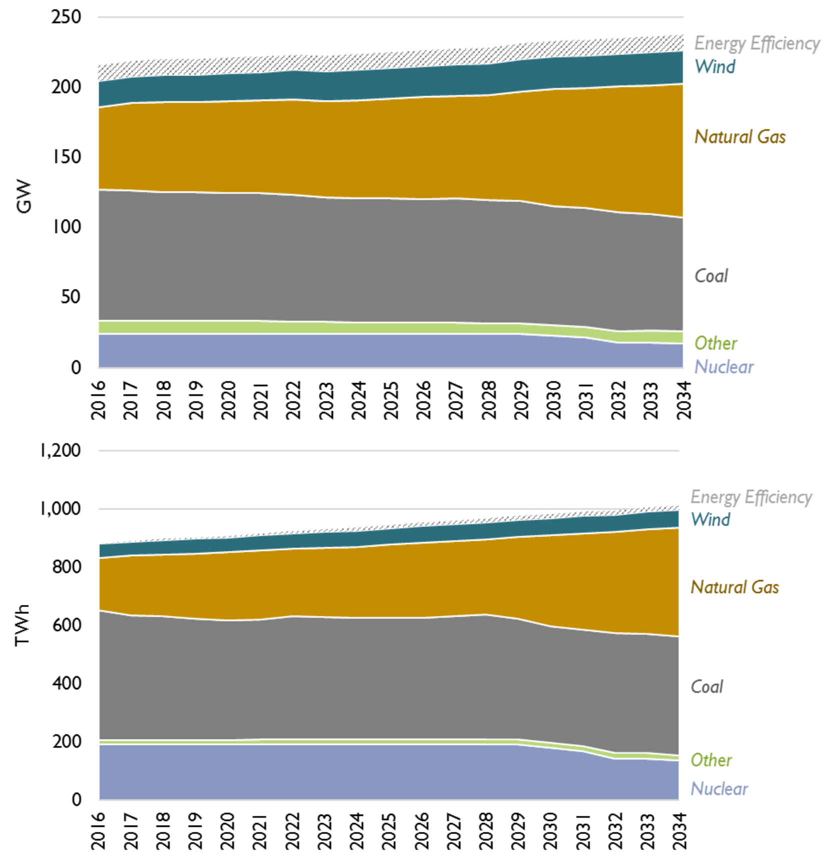
[49] Using a discount rate of 6.64 percent in nominal terms, and inflation rate of 1.9 percent to adjust nominal terms to constant 2014$.

4.2 Reference Scenario

4.2.1 Energy Landscape

The base case of the Reference scenario represents what the energy landscape of the region may look like over the next 20 years without the need to comply with Clean Power Plan. Emissions in this case are unbounded. Without restrictions on emissions or significant changes in fuel prices, load forecasts, or resource availabilities, the regional energy mix stays relatively stable over the study period. Capacity by fuel for the region over the course of the study period is shown in Figure 9(a), with the regions generation mix shown in Figure 9(b). The inclusion of scheduled and announced coal retirements causes coal capacity in the region to drop moderately after 2030. Existing plants run more to make up the slack, meaning that total generation from coal-fired plants remains essentially stable. As regional load increases, increases in regional demand are met primarily by existing and new gas-fired generation. Very little new renewable energy is built.

Figure 9. Regional (a: top) capacity and (b: bottom) generation by fuel over the study period in the Reference case

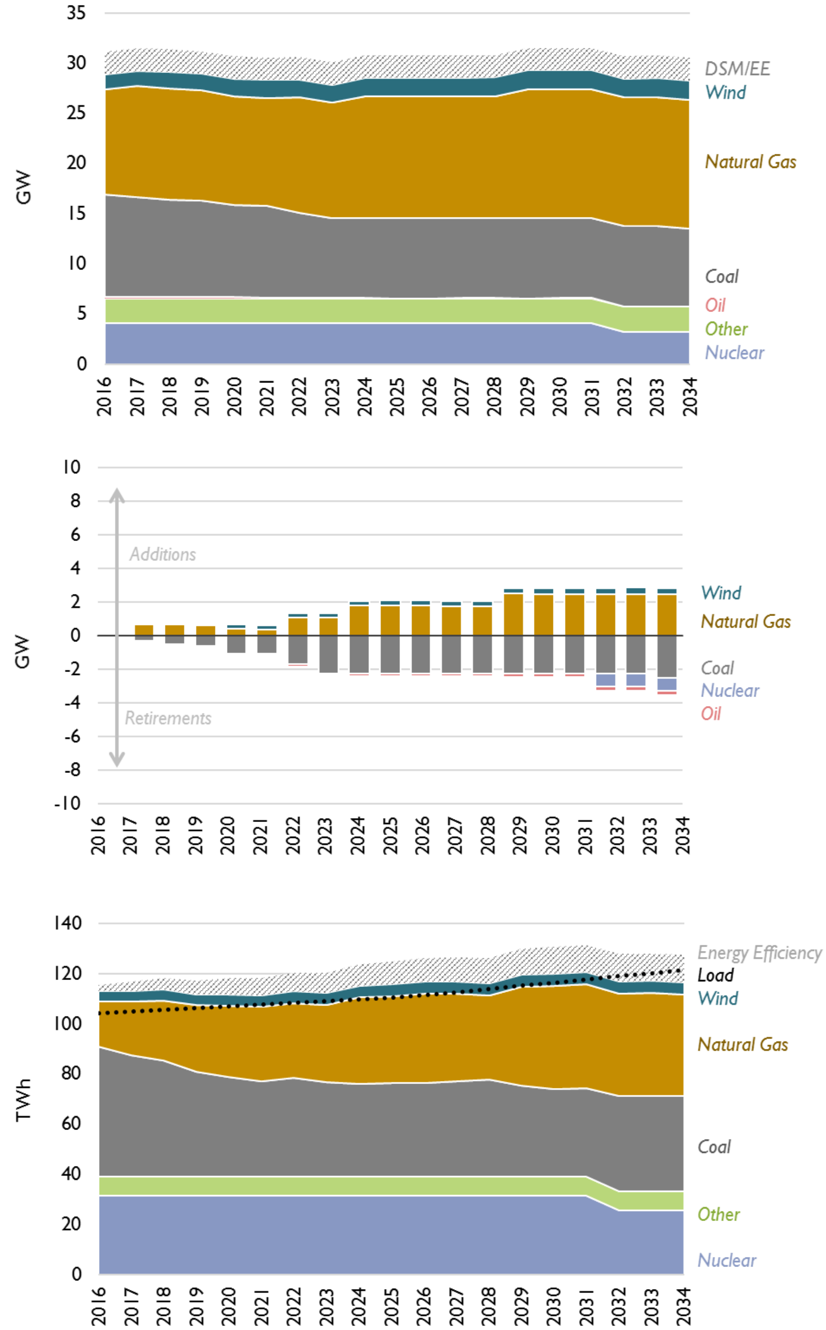


Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

In this case, Michigan follows the trends of the region at large. Figure 10(a) shows Michigan's capacity mix by fuel while Figure 10(b) shows cumulative annual changes in capacity. Unit retirements are shown as negative and additions are shown as positive. Each year's values represent the total change in capacity by fuel since 2016. Figure 10(c) shows Michigan's generation mix by fuel.

Approximately one-fifth of the coal retirements expected in the Reference case occur in Michigan. This capacity is expected to be replaced by new NGCCs. Therefore, in-state capacity remains approximately stable over the study period. Energy efficiency and gas-fired generation are used to meet increases in demand. As gas-fired generation becomes more economically favorable, coal-fired generation decreases both inside and outside of the state. Declines in coal-fired generation in Michigan's neighboring states, along with other factors, lead to Michigan acting as a net exporter of power.

Figure 10. Michigan (a: top) capacity, (b: middle) change in capacity, and (c: bottom) generation by fuel over the study period in the Reference case

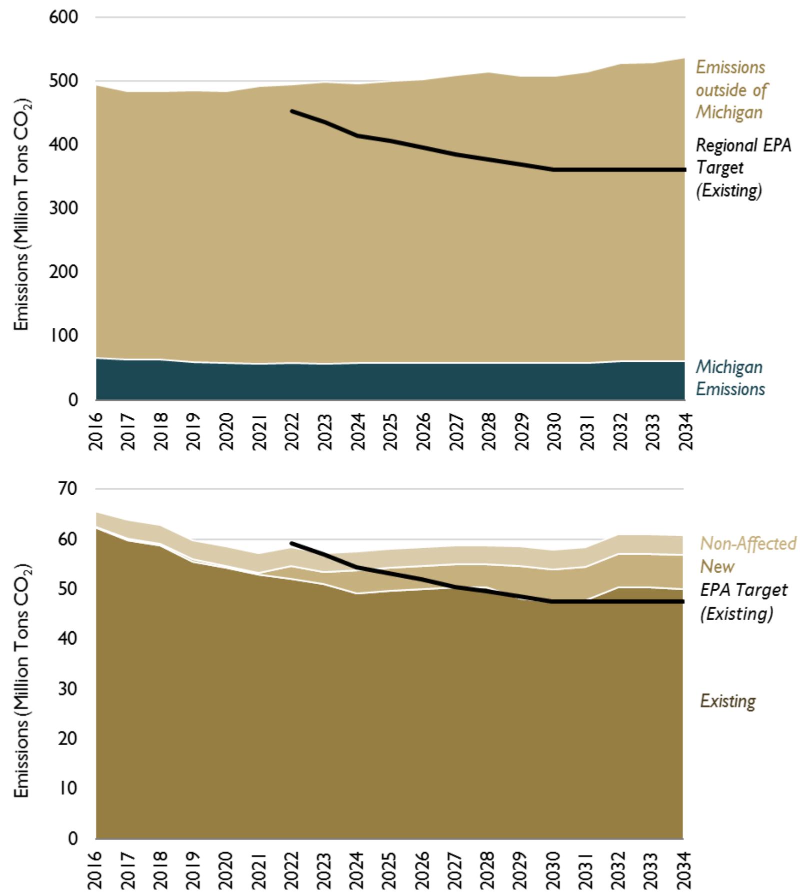


Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

4.2.2 Emissions

In the absence of a requirement to comply with the Clean Power Plan, emissions in the study region rise gradually throughout the study period, as shown in Figure 11(a). Since EPA's cap on emissions becomes more stringent over time, the region's increase in emissions means that it moves farther and farther from compliance as time passes. In the Reference case, emissions within the state of Michigan are relatively close to conforming with EPA's mass-based goal for the state (Figure 11(b)).[50] Emissions from existing affected sources are below Michigan's state-specific cap until the early 2030s.[51] When new affected sources are included, Michigan's emissions exceed its cap only after 2025, and by at most 17 percent in any given year. Meanwhile, the region as a whole exceeds its cap (with new sources included) by 16 percent in 2022 (the first year for which compliance would be required) and by 38 percent in 2034. Because Michigan's emissions are closer to conforming with its cap than is the case for the region as a whole, this result suggests that Michigan is positioned to act as an exporter of emissions allowances within the context of this study region.

Figure 11. (a: top) Regional and (b: bottom) Michigan emissions from power generation in the Reference base case.



Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

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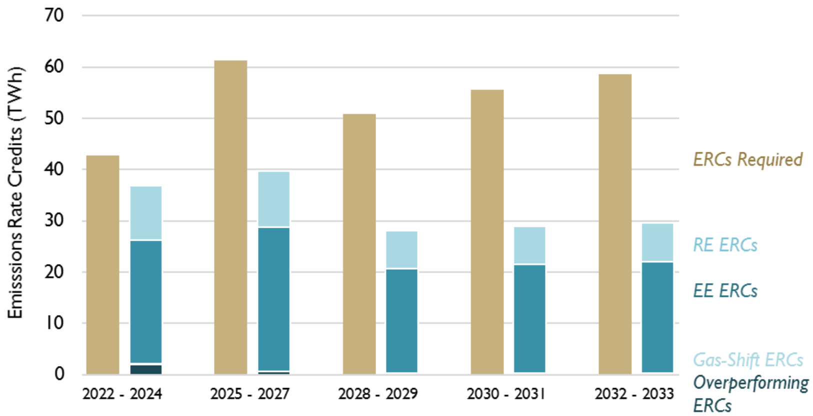
50 Emissions from non-affected sources are shown for informational purposes only and do not affect Michigan's compliance position.

51 Michigan's existing source emissions are under the state's cap for all years through 2030 except 2028.

An analysis of Michigan's position in the Reference case vis-à-vis rate-based compliance targets indicates that rate-based compliance may be more difficult to achieve than mass-based compliance given the assumptions used here. If Michigan chose to comply using subcategory rates (i.e., by requiring that in-state coal-fired generators and NGCCs each meet a technology-specific emissions rate goal), it would have an ERC shortage during every compliance period, as illustrated in Figure 12. Michigan would need to purchase 14 percent of its required ERCs in the first compliance period (2022-2024), which would rise to 49 percent by the last compliance period (2032-2033). If Michigan chose to use the state average emissions rate goal set by EPA, it would over-comply in the first compliance period but would need to purchase additional ERCs thereafter. Michigan's ERC shortage in the last compliance period would be 41 percent of those required. Because Michigan would need to import ERCs or take greater action to achieve its rate-based goals in-state than its mass-based goals, it was determined that mass-based compliance provides a more promising path for the state. Consequently, the remainder of this study focuses on Michigan's options for mass-based compliance and the resulting impacts.

Figure 12. ERCs required by the subcategory rate compliance path and ERCs generated in Michigan in the Reference base case



Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

4.2.3 Finance

Apart from the capital expenditures related to building assumed units, Michigan's total power system costs during the study period amount to approximately $55 billion on a net present value basis in the Reference scenario base case. This value serves mainly to provide context for the relative compliance scenario costs presented in the sections below. In general, compliance scenario system costs vary from the Reference scenario by single-digit percentage values. In the context of utility system planning, these variations are substantial.

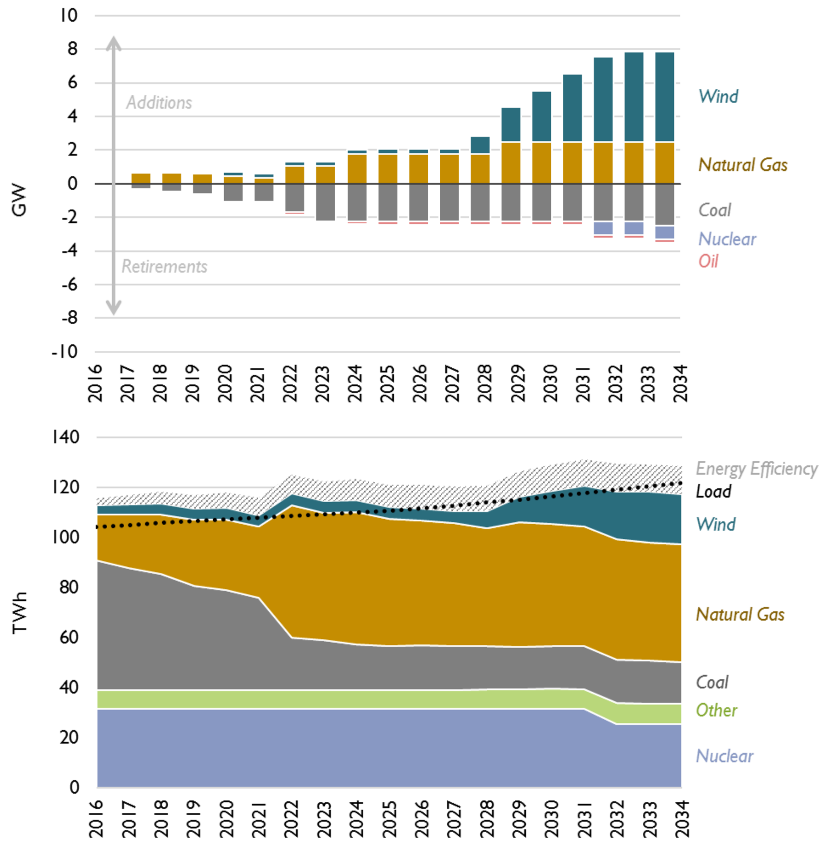
In the Reference case, there is no compliance obligation and therefore no need to sell or buy allowances for compliance. Michigan sees no allowance costs and receives no revenue from the sale of allowances in this scenario. Instead, the only source of revenue is exported power, from which the state gains approximately $6 billion (NPV) over the study period. About half of expenditures in the power system are for fuel ($31 billion), with the remainder split between O&M costs of EGUs ($25 billion), energy efficiency programs ($3.3 billion), and the cost of imported power ($2.1 billion). Importantly, no capacity is built in Michigan in the Reference scenario base case apart from capacity that is assumed to be added in all scenarios. As such, no capital expenditures are represented in these costs.

4.3 Existing+New Mass-Based Compliance

4.3.1 Energy Landscape

The Existing+New compliance scenario is based on a requirement of mass-based compliance, covering all CO_2 emissions from both the study region's existing affected sources as well as new affected sources built within the study period (effectively, any new NGCC units). This scenario therefore presents the most comprehensive compliance requirement of all the base compliance cases. The modeled build-out plan for Michigan under Existing+New compliance is shown in Figure 13(a). The same retirements and additions of new NGCC units were included in the Reference case. However, the Existing+New compliance scenario also includes growth in in-state wind capacity, as discussed further below.

Figure 13. (a: top) Capacity changes and (b: bottom) generation mix in Michigan under Existing+New compliance



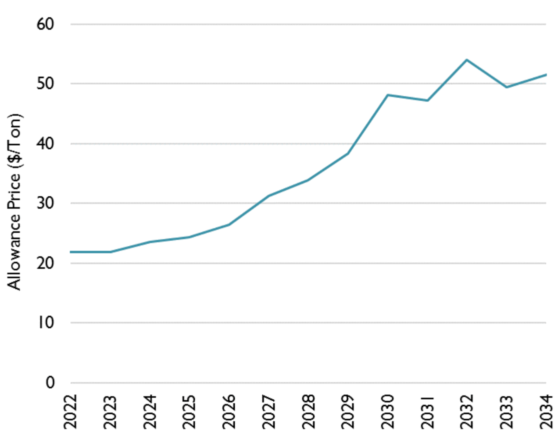
Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

Expected generation within Michigan is illustrated in Figure 13(b). Compared with the Reference case, coal-fired generation is seen to decrease significantly. Generation from coal within Michigan falls by approximately 31 TWh between 2016 and 2022, and declines by a further 4.3 TWh over the remainder of the study period. Some of this decline is due to expected retirements, but remaining coal-fired units are also expected to run less given the additional expense of a price on emissions, which is established in 2022 due to the restriction on emissions. This emissions price raises the variable cost of generation for conventional fossil-fired resources. Because coal-fired generation is generally more carbon-intensive than gas-fired generation on a per-MWh basis, the emissions price raises the price of coal-fired generation relative to gas-fired generation. When combined with the slow growth in gas prices in the base forecast, the imposition of an emissions price results in a sharp decline in coal-fired generation. The general trends found in Michigan also hold true for the region as a whole. Regional generation from coal-fired units falls almost 40 percent from 2016 to 2022 while regional coal capacity falls by only 3 percent over the same period.

Across the region, gas-fired generation increasingly meets demand in early compliance years. In essence, the region achieves compliance in early years by shifting from use of coal to use of gas. Some of the increase in gas-fired generation comes from new NGCCs, primarily outside of Michigan. However, existing combined-cycle units also increase their generation substantially within the model. In the years 2016–2021 (prior to the onset of the compliance period), existing gas-fired generators in Michigan increase their output by over 50 percent. This increase, which occurs before the imposition of a compliance requirement and therefore is likely a response to the changing relative variable prices of coal- and gas-fired generation, translates to most existing NGCCs in Michigan operating at capacity factors of 80 percent or more. The operational pattern seen in existing NGCC units in the early 2020s leaves little room for additional increased generation from these units. Indeed, generation from existing NGCCs is predicted to be lower in 2034 in this scenario than in 2021, with substantial increases in gas-fired generation after 2022 resulting mainly from the use of new gas-fired units.

Notably, the increase in generation costs that results from a restriction on emissions causes generation from simple-cycle CTs (which are not covered by the cap on emissions) to rise. The variable price of generation of CT units is, under most circumstances, higher than that of coal-fired units or NGCCs. These units are conventionally used only in peak demand hours. The impact of the emissions cap, however, serves to bring the variable costs of NGCC units into relative parity with those of CTs. Although other factors prevent CTs from generating as much as NGCCs,[52] this shift in the relative economics of different unit types is one notable change that occurs due to the compliance requirement. This effect was also observed in MISO's analysis of the Clean Power Plan.[53]

Figure 14. Allowance price ($/ton) under Existing+New compliance



Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

As the cap tightens in the late 2020s and early 2030s, the demand for allowances increases. As this analysis assumes that allowances are available for purchase by the highest bidder throughout the study region, increases in demand cause the price for allowances to rise (Figure 14). Notably, allowance prices found in this scenario are higher than those found in other studies of national Clean Power Plan compliance. This is largely because the

[52] Further discussion of this issue can be found in the Technical Appendix.

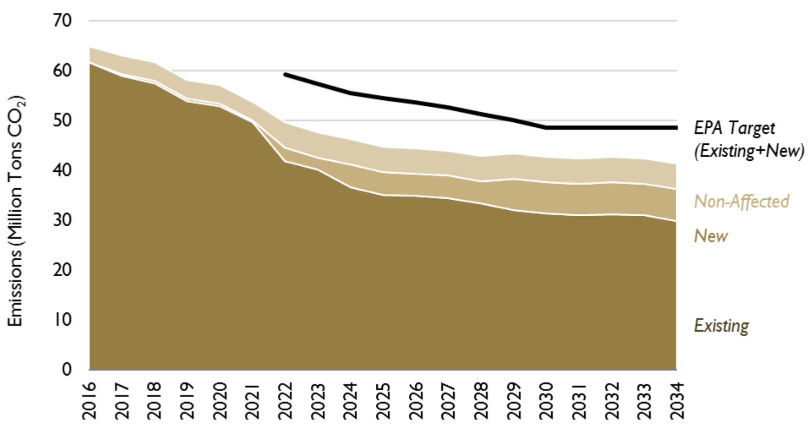
[53] MISO Policy & Economic Studies Department. 2016. "MISO's Analysis of EPA's Final Clean Power Plan Study Report: DRAFT". P57. Available online at: https://www.misoenergy.org/_layouts/MISO/ECM/Redirect.aspx?ID=224648.

study region's fuel mix is disproportionately coal-heavy compared to the nation at large. As such, a study region with a lower proportion of existing coal-fired capacity would be expected to experience lower allowance prices overall, given otherwise consistent assumptions.

Under the assumptions used here, the study region's compliance strategy is observed to shift away from gas and toward construction of new wind-powered generation once allowance prices rise above $30/ton. This pattern is seen starting in 2028. Approximately 15 percent of the study region's new wind capacity is modeled as being built in Michigan. Due to siting considerations and other constraints, it was assumed for all modeling that a maximum of 5 GW of new wind could realistically be constructed in Michigan during the study period. In this case, that limit is reached in 2032—two years before the end of the study period. In this scenario, wind power makes up 18 percent of Michigan's generation by 2034. Because Michigan is modeled as producing additional generation from wind power but experiences only modest increases in load in the base case, this scenario finds Michigan's total generation to be higher than its load in all years. Therefore, Michigan is a net exporter of power for every year of this compliance scenario.

4.3.2 Emissions

Figure 15. Michigan emissions from power generation in the Existing+New base compliance scenario



Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

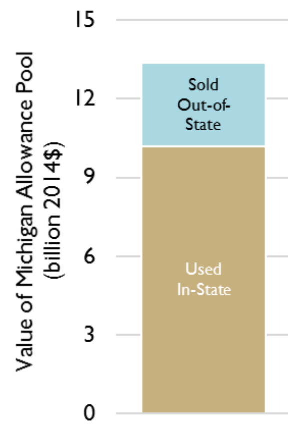
In the base case of the Existing+New compliance scenario, Michigan's total emissions from power generation are well under the state-specific cap set by EPA (Figure 15). This result proceeds from the structural assumption that all states which over-comply with their state emissions targets will have the opportunity to export allowances at a profit. Under this assumption, a regional generation pattern that includes lower emissions within Michigan is found to be a least-cost strategy for the region as a whole (including Michigan). As such, emissions from Michigan's existing sources fall by over 50 percent from 2016 to the end of the study period. This represents a drop in annual emissions by over 30 million tons of CO_2 in 2034. Meanwhile, only about 6 million tons of CO_2 are emitted in 2034 by new sources. In total, Michigan's affected emissions are low enough that, on average, the state over-complies with its goal by approximately 13 million tons of CO_2 yearly. Because Michigan's emissions are below the state's cap, in-state entities have excess allowances that can then be sold to the state's trading partners.

Unaffected emissions, which are mainly from CTs, almost double (from about 3 million tons per year to about 5 million tons per year) once compliance is required starting in 2022. Emissions from CTs do not affect Michigan's compliance position. However, increased emissions from these relatively costly sources reflect the finding that the compliance requirement increases the cost of generation for covered resources, making otherwise expensive resources more favorable in comparison.

4.3.3 Financial Metrics

The financial analysis conducted in this study suggests that Michigan's power system as a whole would be less costly under Existing+New compliance as compared to the Reference case. These results find that, in the Existing+New compliance case, the state spends less on fuel and more on capital than in the Reference case, primarily due to the construction of new in-state wind infrastructure. Under this model construct, Michigan is able to export both power and emission allowances to its neighbors. As such, on a net present value basis, Michigan realizes over $3 billion of net allowance revenue and approximately $1 billion more net import/export revenue than in the Reference scenario. When considering all changes in costs and revenues, total power system costs are approximately $3.3 billion lower for Michigan in the base case of the Existing+New compliance scenario than in the Reference case.

Figure 16. Net present value of Michigan's allowance pool under Existing+New compliance



4.4 Existing Only Compliance

4.4.1 Energy Landscape

In the Existing Only compliance scenario, only the region's existing affected sources must reduce their emissions. Emissions from newly constructed EGUs are not constrained by Clean Power Plan-related policies in this scenario. Moreover, this scenario does not include additional compensatory measures to incentivize generation from existing NGCCs or non-emitting (renewable) EGUs. Without such measures, leakage (the shifting of generation, and therefore emissions, from existing to new units) is heavily incentivized. This scenario was included to demonstrate leakage and add context to the Model Rule results presented below.

When combined with the moderate increase in gas prices expected in the base assumption set, the lack of measures to prevent or attenuate leakage results in an increase in gas-fired generation in the region at large and in minimal additions of renewable capacity.

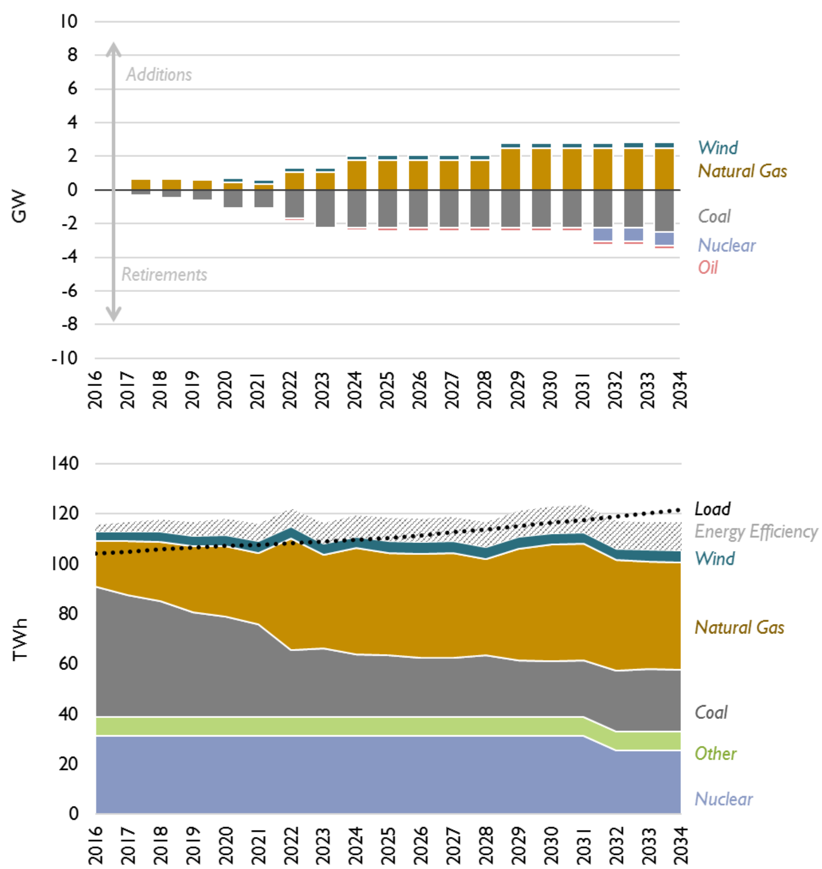
In Michigan, capacity changes under the Existing Only compliance pathway are nearly identical to the base case of the Reference scenario (Figure 17(a)). Because the emissions restriction in this scenario is less comprehensive, emissions prices are lower than in the Existing+New scenario. The allowance prices in this scenario were found to be insufficient to drive the substantial increase in wind capacity that is seen in the Existing+New scenario. 5.3 GW of wind is built in the study region during the study period, of which less than a gigawatt is in Michigan. The proportion of generation made up by wind is therefore relatively constant at 4–5 percent in Michigan and 5–6 percent in the region as a whole over the entire study period.

Compliance in this scenario is achieved almost exclusively using gas-fired generation. In the region as a whole, over 50 GW of new gas capacity is added over the study period, with 35 GW of that capacity added during the compliance period. On a regional basis, less new gas capacity is constructed in this scenario than in the Existing+New scenario. This result is likely due to the lower emissions prices found in this scenario, which imply a lower overall price of generation for existing resources and therefore a lessened incentive to construct new resources.

Redispatch from coal to gas for compliance purposes can be observed clearly in Michigan's generation mix (Figure 17(b)). Coal-fired generation decreases from 52 TWh in 2016 to 26 TWh in 2022 and falls by an additional 2 TWh over the course of compliance. As such, by 2034, coal-fired generation in Michigan is less than half of its 2016 value. Meanwhile, gas-fired generation in Michigan grows from 29 TWh/year in 2021 (before compliance is required) to 45 TWh/year in 2022 (during compliance). After 2022, total gas-fired generation in Michigan remains relatively constant at this level for the entire compliance period, representing approximately 40 percent of Michigan's total generation mix. However, the composition of the units providing this generation is found to shift over time. In 2022, existing affected sources account for 70 percent of gas-fired generation (29 percent of total generation). New NGCCs provide only 12 percent of gas-fired generation (5 percent of total generation) in 2022. The remainder of gas-fired generation is from non-affected CTs.

By 2034, however, only 51 percent of gas-fired generation (22 percent of total generation) is from existing sources, with new NGCCs accounting for 38 percent (17 percent of total generation). Ultimately, modeling results suggest that generation from new NGCCs in Michigan triples during the compliance period without mechanisms to

Figure 17. (a: top) Capacity changes and (b: bottom) generation mix in Michigan under Existing Only compliance



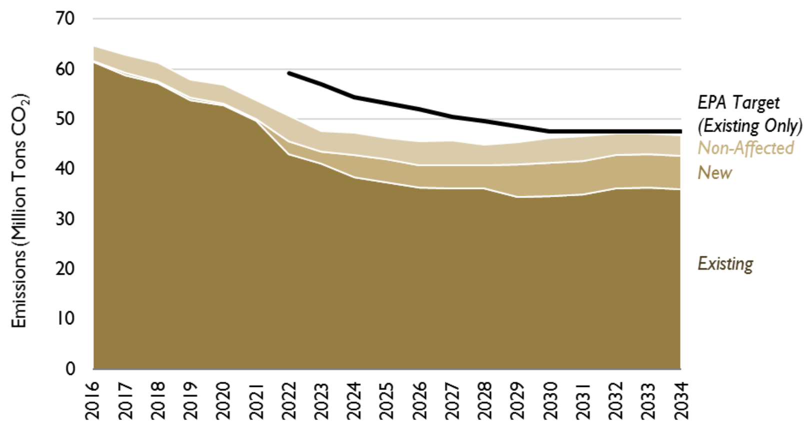
Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

mitigate leakage. This indicates that new NGCC units within Michigan respond as expected to the incentive provided by an existing sources-only cap on emissions. Generation from uncovered CTs, by contrast, does not increase to the extent seen in the Existing+New scenario. This result suggests that when both CTs and NGCCs are uncovered sources, new NGCCs will be chosen preferentially.

4.4.2 Emissions

Total emissions from power generation in Michigan over the study period are 965 million tons of CO_2, 32 million tons higher than under Existing+New compliance. During compliance, Michigan's emissions from new sources are modeled as growing from 2.5 million tons/year to 6.7 million tons/year (Figure 18). By 2034, emissions from new sources comprise 14 percent of state emissions. As new sources are not covered by the cap in this scenario, emissions from new sources do not affect Michigan's compliance position.

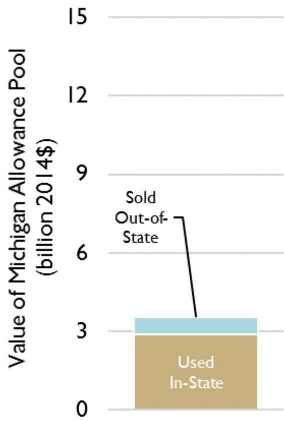
Figure 18. Michigan emissions from power generation in the Existing Only base compliance scenario



Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

Emissions from Michigan's existing covered sources are, on average, 14 million tons per year lower than the state cap in the Existing Only scenario. Therefore, Michigan still over-complies with its state goal and is able to capture value by selling allowances. In fact, Michigan's revenue from the sale of allowances represents 28 percent of the value of its total allowance pool (on a net present value basis for the entire compliance period), the highest of any scenario. However, because the price of allowances is low in this scenario, Michigan realizes the least value from the sale of allowances on an absolute basis.

Figure 19. Value of Michigan's allowance pool under Existing Only compliance



4.4.3 Finance

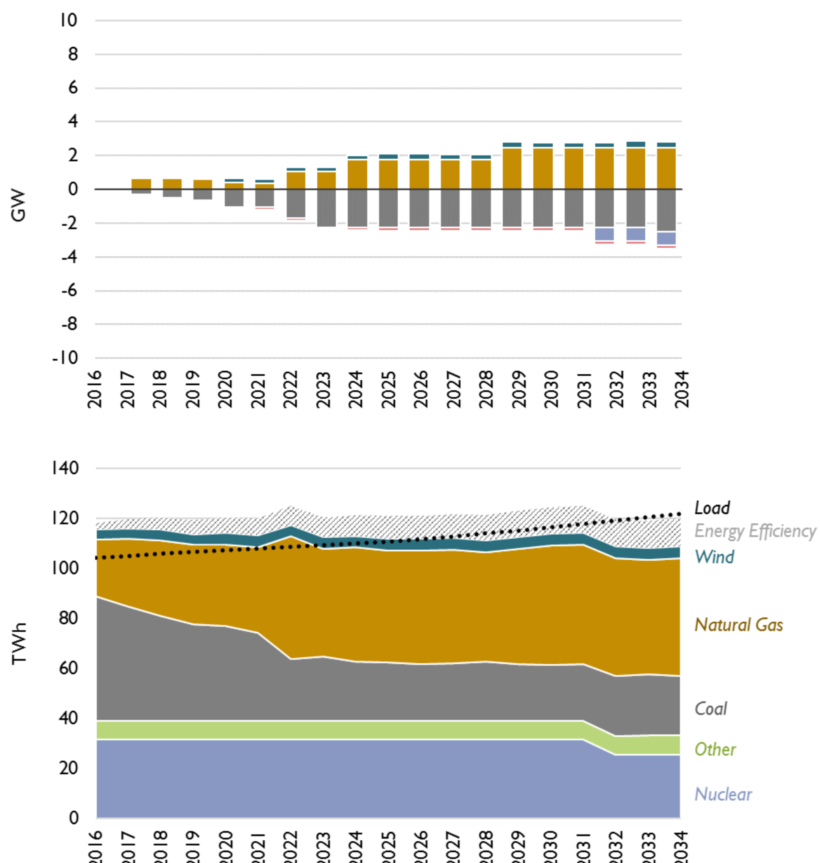
Total power system costs of the Existing Only compliance scenario are the highest of all base compliance scenarios modeled here. In this scenario, Michigan is expected to spend less on fuel and O&M than in the Reference case. However, imported power costs are found to be higher in this scenario and Michigan is found to gain less export revenue. The value of the allowance pool sold out-of-state ($960 million, as shown in Figure 19[54]) is the main source of incremental revenue in the scenario as compared to the Reference case. In sum, total power system costs in the Existing Only scenario are found to be approximately $2.4 billion more expensive than in the Existing+New compliance case but $880 million less expensive than the Reference case.

4.5 Model Rule Compliance

4.5.1 Energy Landscape

Like the Existing Only compliance scenario, the Model Rule compliance scenario assumes that only existing sources must comply with the Clean Power Plan. As such, no absolute limit on emissions from new sources is imposed. However, in this scenario Michigan and its neighbors are assumed to employ EPA's proposed model rule policies for leakage mitigation. Existing NGCC units are allocated a certain number of allowances based on their

Figure 20. (a: top) Capacity changes and (b: bottom) generation mix in Michigan under Model Rule compliance



Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

[54] Readers should note that the axis on this figure is consistent with that of the corresponding figure for the Existing+New scenario (Figure 16 on page 41).

generation (a policy known as output-based allocation), which acts as a financial incentive to generate. Renewable EGUs are awarded allowances from a separate allowance pool (these allowances are called renewable energy set-asides or RESAs), which similarly function as an incentive to these units.

The use of output-based allocations and RESAs was found to have a minimal impact on the capacity build-out both within Michigan and in the region as a whole. On a regional basis, slightly less new gas is built in this scenario as compared to the Existing Only scenario; however, the difference is very small (approximately 1.2 GW as compared to approximately 50 GW total). More wind is built in the Model Rule scenario than in the Existing Only scenario, but the increase is less than a gigawatt. The capacity build-out within Michigan (Figure 20(a)) is identical between the two scenarios.

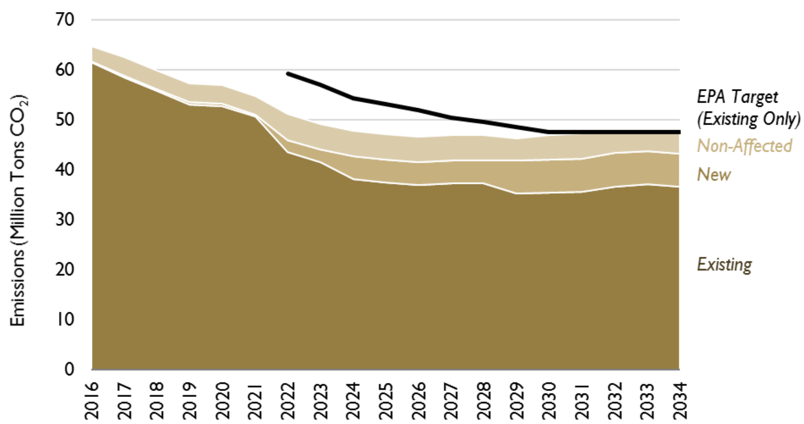
Given an assumption of moderately increasing gas prices, generation from both existing and new gas-fired units increases over the study period. Generation from existing gas-fired units within Michigan (Figure 20(b)) increases from 20 TWh/year to 33 TWh/year between 2016 and 2022. This increase in gas-fired generation primarily displaces generation from coal, resulting in reduced emissions in advance of the compliance period. During compliance, generation from existing gas-fired units falls gradually before stabilizing at approximately 25 TWh/year for the years 2029–2034. Generation from new in-state gas-fired units increases from 5 TWh/year to 16 TWh/year over the course of compliance. Meanwhile, wind-powered generation is essentially stable throughout the study period, and never represents more than 5 percent of Michigan's generation mix in this scenario.

As such, it can be concluded that, as in the Existing Only scenario, compliance in this scenario is achieved almost exclusively by replacing coal-fired generation with gas-fired generation. This is true both within Michigan and in the region as a whole. Generation from new NGCCs in Michigan plays a marginally lesser role in this scenario than in the Existing Only scenario. By 2034, 16 percent of Michigan's total generation is provided by new gas-fired EGUs, as compared to 17 percent in the Existing Only scenario and 14 percent in the Existing+New scenario.

Notably, the proportion of Michigan's generation from existing NGCCs is greatest in this compliance scenario, representing 24 percent of Michigan's total generation under Model Rule compliance versus 22 percent in the Existing Only scenario and 19 percent in the Existing+New scenario. These results suggest that the leakage mitigation mechanisms found in the Final Rule are effective to some degree in incentivizing generation from existing NGCCs.

4.5.2 Emissions

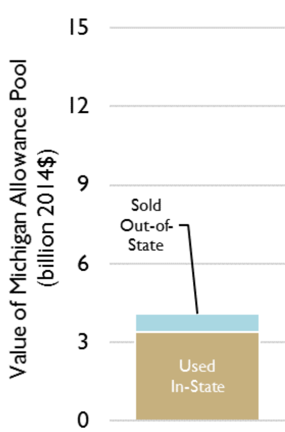
Figure 21. Michigan emissions from power generation in the Model Rule base compliance scenario



Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

At 976 million tons of CO_2, Michigan's modeled emissions from power generation (including both covered and uncovered sources) are the highest in this scenario of all base compliance scenarios. With respect to covered sources only, Michigan is found to over-comply with its state goal as is the case in the other compliance scenarios (Figure 21). On average, Michigan's existing sources would have room to emit an additional 13 million tons of CO_2 every year. In other words, Michigan complies by a narrower margin in this scenario than in the Existing Only scenario, reflecting the overall increase in state emissions. Accordingly, Michigan realizes a smaller proportion (26 percent) of the potential value of its allowance pool as revenue. This proportion is nonetheless larger than the proportion of total allowance value realized as revenue in the Existing+New scenario (24 percent). However, because the price of allowances is lower in this scenario than in the Existing+New scenario, Michigan's revenue from allowances in this scenario is smaller in absolute terms (Figure 22).[55]

Figure 22. Value of Michigan's allowance pool under Model Rule compliance



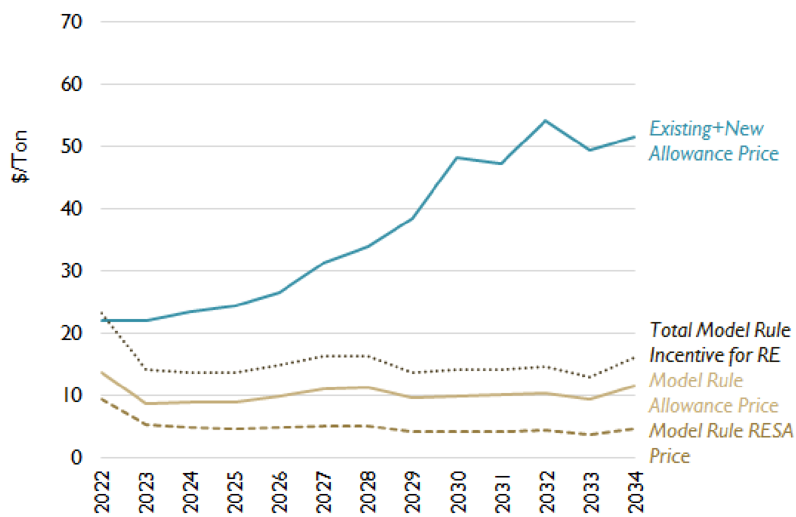
The resource mix responsible for Michigan's emissions in this scenario, as compared to the others, provides interesting insight into the effects of output-based allocations and RESAs. Total emissions during the study period from in-state sources in the Model Rule scenario are 6 million tons higher than in the Existing Only scenario. Indeed, total study-period emissions from Michigan's existing covered gas-fired EGUs increase by approximately 32 million tons between the two scenarios (while emissions from coal-fired generation decrease). As above, this suggests that output-based allocations do have an impact on the generation patterns of existing NGCCs. However, given the gas price trajectory assumed in the base case, this impact is insufficient to prevent the construction of significant amounts of new gas-fired capacity in the region. Thus, leakage occurs despite the mechanisms employed to

55 Readers should note that the axis on this figure is consistent with that of the corresponding figure for the Existing+New scenario (Figure 16 on page 41).

prevent it. Within Michigan, total emissions during the study period from new sources are only 1 million tons lower in the Model Rule scenario than in the Existing Only scenario.

Meanwhile, the total effective incentive for renewable energy generation (the sum of the price of emissions that existing sources must pay and the effective per-MWh value of RESAs received by renewable sources) is much lower than the price on emissions in the Existing+New scenario (Figure 23). This result is reflected by the relative stability in the amount of wind-powered capacity and generation in this scenario, which suggests that the incentive provided to renewable EGUs in this scenario is insufficient to alter the relative economics of wind versus gas-fired generation given the resource mix within the study region and the relatively low base gas price forecast assumed here.

Figure 23. Total incentive for renewable energy generation under Existing+New and Model Rule compliance scenarios



Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

4.5.3 Finance

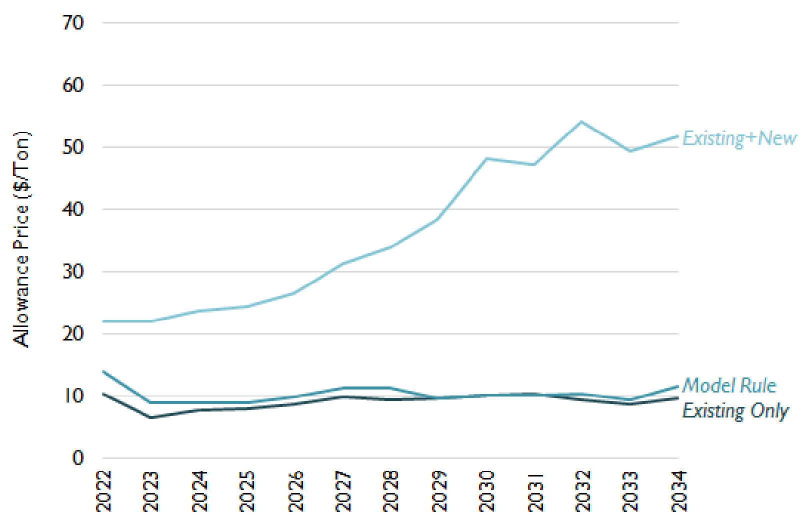
In this scenario, Michigan spends modestly less on fuel and station O&M as compared to the Reference case, and wheels more power, both importing and exporting more than the Reference case. The total savings of the scenario are almost exactly equal to the value of Michigan's out-of-state sales of allowances. In sum, the Model Rule scenario is approximately $1 billion less costly than the Reference case but approximately $2.2 billion in costlier than the Existing+New compliance scenario.

4.6 Compliance Trends

4.6.1 Energy and Emissions

The modeling results presented here demonstrate important differences between mass-based compliance paths. The energy landscape in Michigan is found to be nearly identical between Existing Only compliance and Model Rule compliance, regardless of the use of output-based allocations and RESAs to mitigate leakage. Notably, both scenarios bear a strong resemblance to the Reference scenario. No incremental units within Michigan are selected endogenously in the Reference, Existing Only compliance, and Model Rule compliance cases, meaning that all three scenarios see identical capacity build-out trajectories in Michigan. This modeling suggests that, within Michigan, the main impact of a compliance requirement covering only existing sources is likely to be a depression of coal-fired generation and promotion of gas-fired generation. In 2034, Michigan's coal-fired units produce 38 TWh in the Reference scenario as compared to approximately 25 TWh under the two compliance paths that apply to only existing units. Meanwhile, gas-fired generation is 41 TWh in the Reference case in 2034 but rises to 43 TWh under Existing Only compliance and 47 TWh under Model Rule compliance.

Figure 24. Allowance prices under different compliance paths

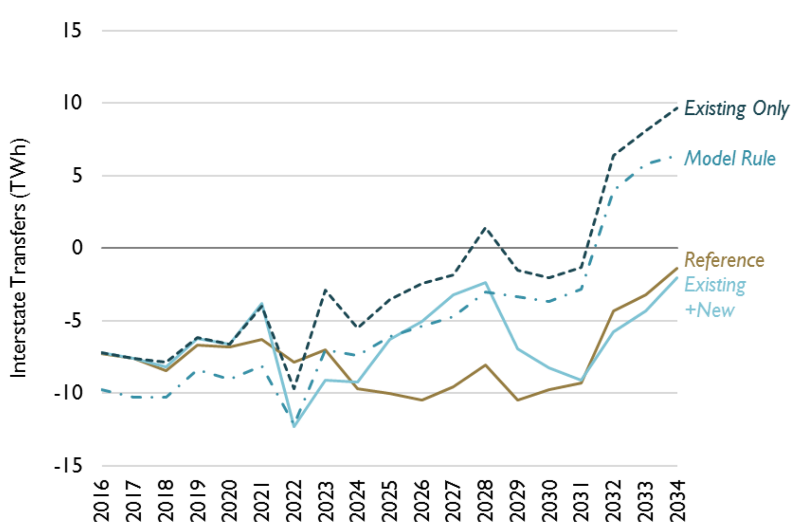


Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

Modeling results from the Existing+New compliance scenario present a very different energy landscape. The more comprehensive limit on emissions leads to higher prices on emissions in this scenario than are seen in the other compliance scenarios (Figure 24). High emissions prices alter the relative economics of different generating resources in favor of renewable generators. Therefore, more new renewable energy (primarily made up of wind-powered generation) is built in this scenario than in any other base case. In the Existing+New compliance scenario, wind energy makes up almost a fifth of Michigan's generation mix by the end of the study period. High emissions prices also raise the value of Michigan's allowance pool, as discussed below.

The Existing+New scenario is the only base scenario which sees a net addition of generating capacity within Michigan. By contrast, the Reference, Existing Only, and Model Rule scenarios all project a net decrease in Michigan's in-state generating capacity of approximately 620 MW. The increase in in-state capacity observed in the Existing+New scenario consists mainly of the substantial build of new wind in Michigan that is prompted by high allowance prices. Because it is longer on capacity in this scenario, additions of new wind under Existing+New compliance allow Michigan to remain a net exporter of energy even into the later years of the study period, when Michigan's

Figure 25. Net energy purchases by Michigan from neighboring states (positive values represent net imports)



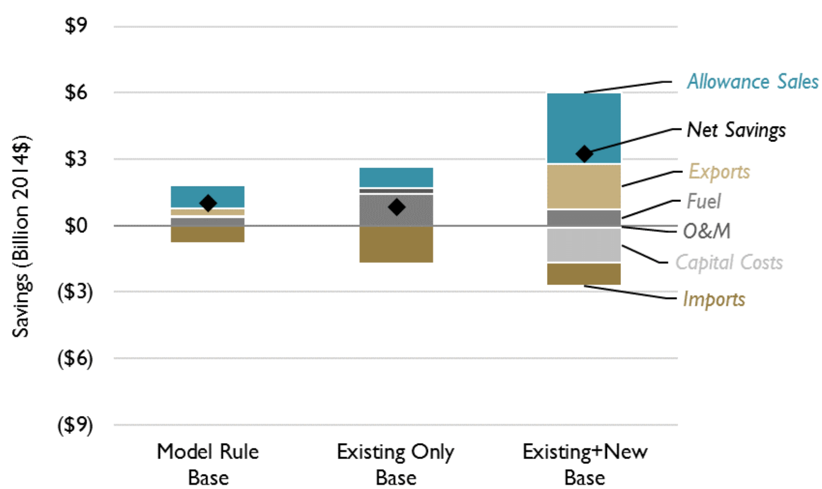
Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

neighbors are projected to have constructed considerable amounts of cheap gas-fired capacity. By contrast, Michigan becomes a net importer in the early 2030s in the Existing Only and Model Rule compliance scenarios. A comparison of Michigan's net domestic import/export position in different scenarios can be found in Figure 25. The additional revenue from exports and reduced spending on imports in the Existing+New scenario contribute to the high total savings realized by Michigan under this compliance path.

4.6.2 Finance

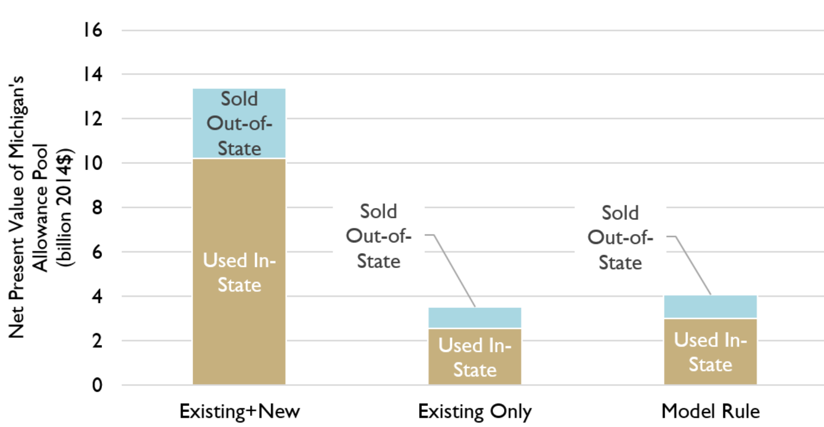
Detailed financial results comparing each compliance scenario are shown in Figure 27, which separates net savings into changes in utility spending on cost categories, including station-related fixed and variable costs and interstate transfers. Notably, every Clean Power Plan compliance scenario analyzed here results in decreased overall spending on the power system within Michigan relative to the Reference case. In the Model Rule and Existing Only scenarios, net savings consist in large part of the savings in total fuel costs expected given a shift from coal-fired generation toward more-efficient natural gas generation. These scenarios do not incur any change in capital costs, as no new power plants are built that are not also built in the Reference case. Nonetheless, coal plants run less often—and natural gas plants run more often—than in the Reference case, causing changes in variable costs. In the Existing+New scenario, increased capital costs and import costs are outweighed by increased revenues from exporting energy and selling emission allowances. This leads to lower costs for Michigan's regulated utilities, creating savings that are assumed to be passed through to consumers.

Figure 27. Cost implications of different compliance scenarios as compared to the Reference base case



Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

Figure 26. Value of Michigan's allowance pool under difference compliance paths



Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

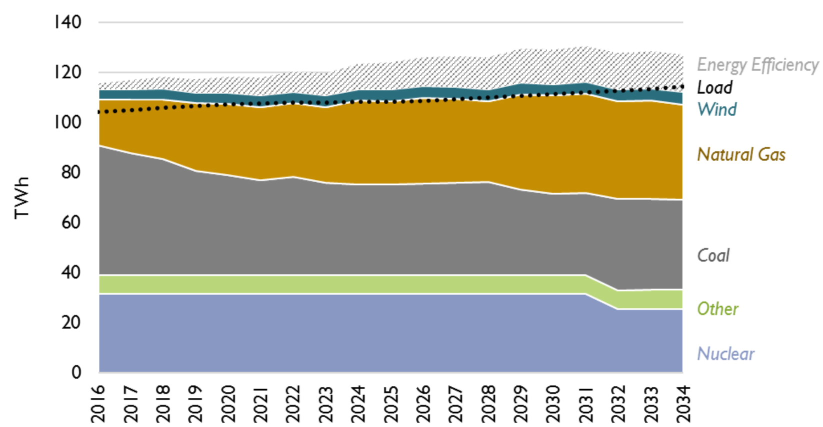
As described above, the proportion of the value of Michigan's allowance pool that is realized as revenue is lowest in the Existing+New scenario. However, that scenario also presents the highest total value of the revenue gained through out-of-state sales of allowances (Figure 26). This is because allowance revenue is a function of both allowance price and the number of allowances required by in-state generators. Importantly, while factors such as choice of study region may affect allowance prices, they are likely to do so in a consistent manner. As such, it is likely that even if allowance prices were lower in all compliance scenarios, total revenue from the sale of allowances would still be maximized under Existing+New compliance.

4.7 High EE Sensitivity

4.7.1 Reference Case vs. Existing+New Compliance

In the High Energy Efficiency (High EE) sensitivity case, the state of Michigan implements additional energy efficiency amounting to 2 percent savings per year (see Figure 8, Section 3.3). In both Reference and compliance cases, the increase in energy efficiency results in a decrease in the load seen by the region's (and primarily Michigan's) fossil fleet. Because the increased energy efficiency trajectory only affects load within Michigan, however, the impact on the region's capacity build-out and generation mix is minimal.

Figure 28. Generation mix in Michigan in the Reference High EE sensitivity case

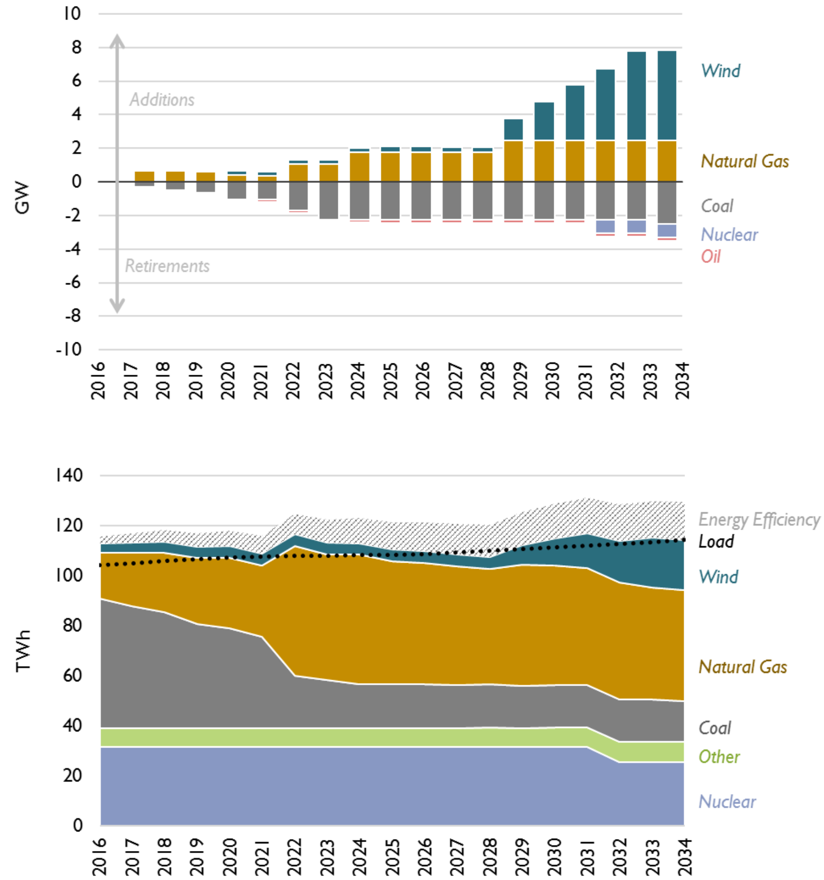


Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

In the Reference case, Michigan's capacity build-out is found to be identical with and without increased implementation of energy efficiency (thus, the change in capacity is not shown as it is identical to the Reference base case). As seen in Figure 28, the primary generation impact is a moderate decline in gas-fired generation in later years due to decreased demand. Overall, with lower demand in Michigan, modeling results suggest that the state's generators would choose to serve more out-of-system load, increasing net exports, as opposed to simply generating less. As such, the higher energy efficiency trajectory does not substantially impact the amount of generation provided by in-state EGUs.

Under Existing+New compliance, the decrease in total system load leads to a slight decrease in the price of allowances in most years. Increases in gas-fired generation and decreases in coal-fired generation are still seen in the early part of the compliance period (Figure 29). However, the build-out of new wind is observed to occur in later years in this sensitivity case due to lower allowance prices as compared to the base case. This effect is modest; the build of new wind in Michigan still reaches its assumed maximum (5 GW), albeit a year later than in the base case.

Figure 29. (a: top) Capacity changes and (b: bottom) generation mix in Michigan under Existing+New compliance in the High EE sensitivity case

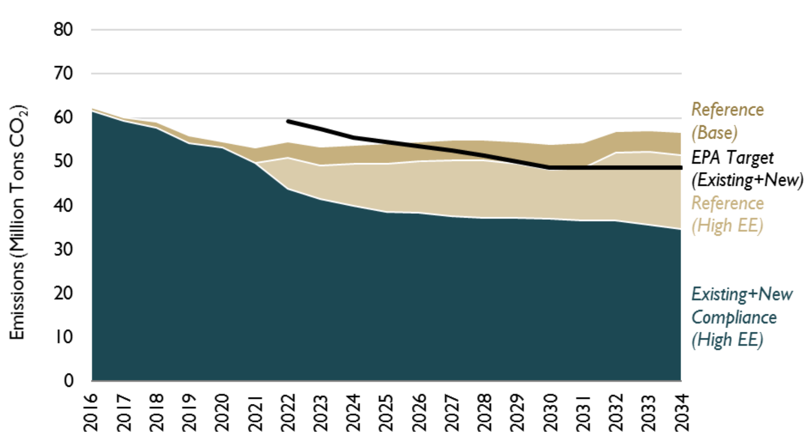


Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

4.7.2 Emissions

As above, the drop in demand seen by the state's EGUs due to increased energy efficiency results in a slight decrease in generation and, subsequently, emissions. This effect is especially pronounced within Michigan (Figure 30). In the Reference scenario, increased energy efficiency leads to annual emissions decreases of 3–11 percent as compared to the base case. This ultimately results in a total decrease in emissions of 78 million tons CO_2 over the course of the study period. Of that drop, 63 million tons are saved during the years in which compliance would be required. This decrease in emissions within Michigan means that the state's total emissions from existing and new affected sources are lower than in the Reference base scenario. Indeed, total emissions observed in this

Figure 30. Emissions from existing and new sources in Michigan in the Reference base case, Reference case with additional energy efficiency, and under Existing+New compliance with additional energy efficiency



Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

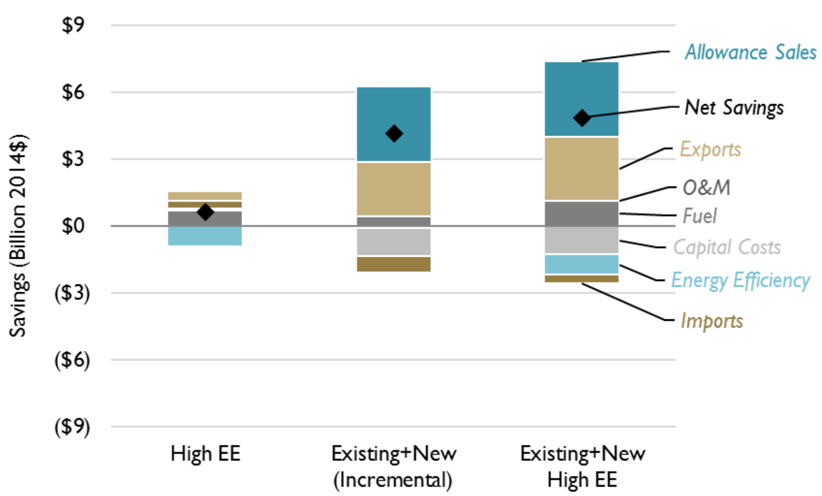
cohort of units are below the comprehensive cap through 2029, despite the fact that no compliance requirement is imposed in the Reference case.

The impact of energy efficiency on emissions given Existing+New compliance is modest, totaling a reduction of 14 million tons CO_2 during the study period, primarily as a function of the increased exports from Michigan.

4.7.3 Finance

The sensitivity results suggest that energy efficiency reduces overall costs for Michigan. These results are summarized in Figure 31, which shows total savings by category as compared to the base Reference scenario. Negative values represent increased spending versus the Reference base case. Savings are shown for the Reference High EE sensitivity case, the Existing+New High EE sensitivity case, and the difference between the two. This difference, which is labeled Existing+New (incremental), demonstrates the impact of compliance as isolated from the impact of the sensitivity case policy.

Figure 31. Cost implications of High EE sensitivity cases as compared to the Reference base case



Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

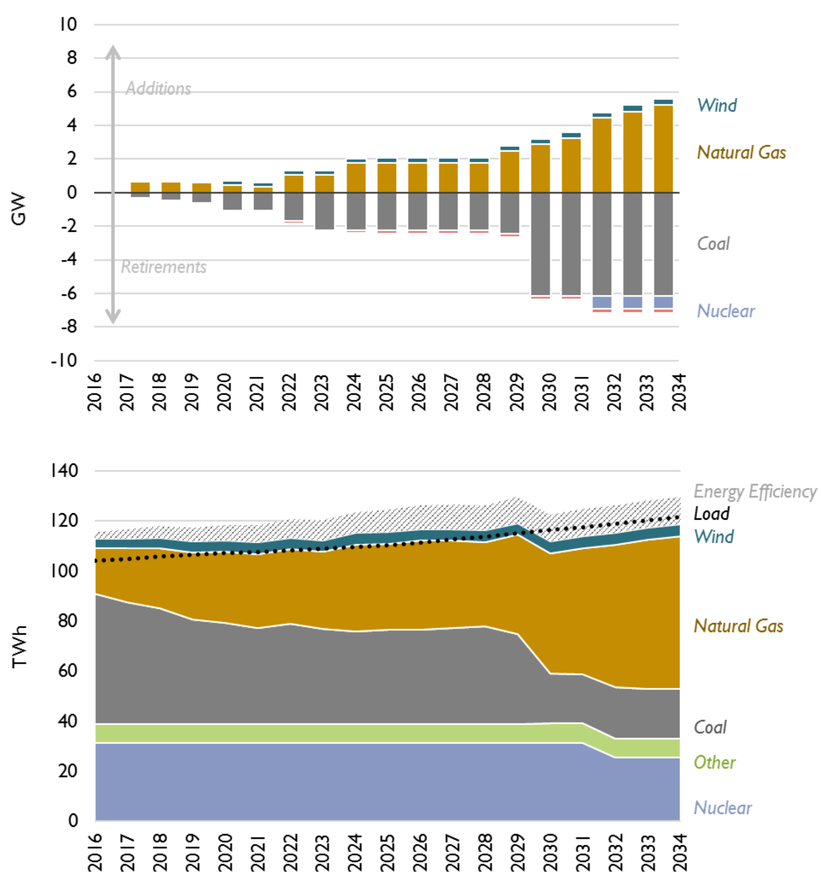
In the Reference scenario, Michigan's power system costs are lower in every category as compared to the base case, with the exception of increased spending on energy efficiency as compared to the base efficiency trajectory. The total cost of the incremental energy efficiency assumed in the High EE sensitivity is approximately $900 million on a net present value basis. In addition to reduced spending on in-state EGUs and imported power, Michigan gains more revenue from exports in the High EE sensitivity case. In sum, Michigan's spending on the power system is reduced by a total of $670 million in the Reference case through implementation of increased energy efficiency.

In the Existing+New scenario, the reduction in generation by fossil-fired units leads to a slight decrease in the price of allowances in most years. Because lowered allowance prices suggest lower demand for allowances, these results can be interpreted as the use of energy efficiency to meet compliance in part. Michigan realizes slightly less revenue from the sale of allowances than in the base case, but increased export revenue and decreased fuel costs are found to offset the reduction, resulting in overall lower system costs. Overall, spending on Michigan's power system is $4.9 billion less in the High EE case of the Existing+New compliance scenario than in the Reference base case, of which over $4 billion can be ascribed to the implementation of compliance rather than energy efficiency. Notably, this incremental compliance benefit is greater than the total savings of the base Existing+New base case as compared to the Reference scenario. This result suggests that compliance reduces system costs by a greater degree in the presence of additional energy efficiency than in its absence. Some of this impact can be explained by the delay in construction of new wind power discussed above. Because this study examines total system costs on a discounted net present value basis, delaying expenditures has the effect of reducing their impact on total system costs.

4.8 Additional Coal Retirements Sensitivity

4.8.1 Reference Case vs. Existing+New Compliance

Figure 32. (a: top) Capacity changes and (b: bottom) generation mix in Michigan in Reference Additional Coal Retirements sensitivity case

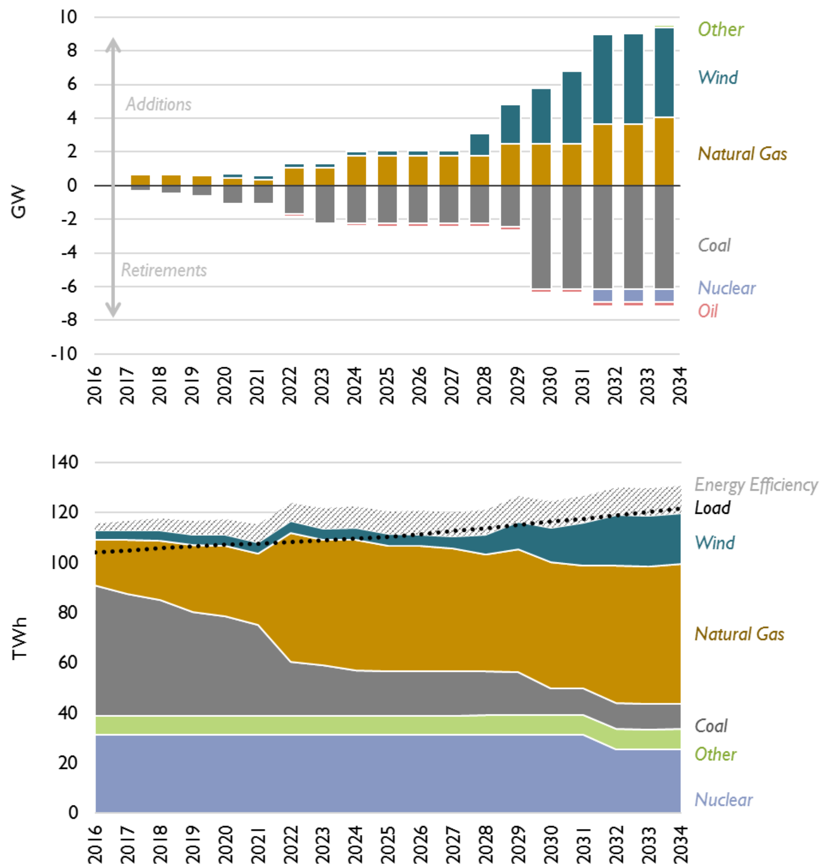


Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

The Additional Coal Retirements sensitivity is defined by the assumption that an incremental 3.7 GW of coal-fired generation within Michigan retires during the study period as compared to the base case. These retirements occur in the later years of the study (2029 and thereafter). Accordingly, the early years of these sensitivity scenarios are very similar to the base cases. As coal capacity is removed from the system toward the end of the study, 2.7 GW of new in-state gas-fired capacity is added endogenously in the Reference case (Figure 32). In total, the Additional Coal Retirements case of the Reference scenario projects over twice as much new gas in Michigan as the base case. These modeling results suggest that additions of new gas-fired units to compensate for the loss of coal-fired units is a least-cost path. Importantly, however, the model does not contemplate factors such as additions of gas pipeline capacity that may be necessary to support new units.

Under Existing+New compliance, Michigan is also observed to add new capacity in later years to fill the gap left by retiring coal (Figure 33). Unlike in the Reference scenario, however, endogenous capacity additions are divided between wind and gas. The assumed limit on new wind is reached in 2032, while the last new gas unit is added in 2034 (the last year of the study period). Ultimately, 1.6 GW more new gas is selected for construction by the model in Michigan in the Additional Coal Retirements sensitivity than in the base case of the Existing+New scenario. As a result, gas plays a larger role in Michigan's generation mix by the end of the study period than in the base case. Lifting the wind build cap in this scenario would likely result in additional economic wind built in Michigan during the analysis period.

Figure 33. (a: top) Capacity changes and (b: bottom) generation mix in Michigan under Existing+New compliance in the Additional Coal Retirements sensitivity case

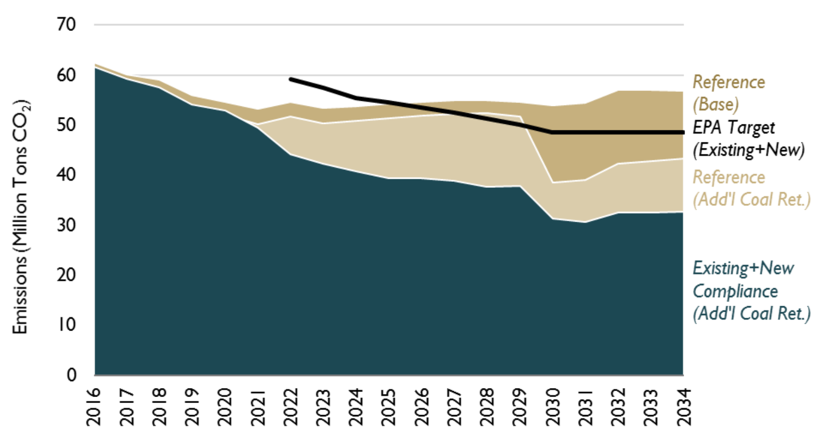


Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

4.8.2 Emissions

Emissions are generally lower given additional coal retirements than in the base case (Figure 34). In the Reference scenario, emissions from existing sources drop by almost 20 million tons in the later years of the study period as coal-fired units are removed from the system. Emissions from new sources are observed to gradually increase as these

Figure 34. Emissions from existing and new sources in Michigan in the Reference base case, Reference case with additional coal retirements, and under Existing+New compliance with additional coal retirements



Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

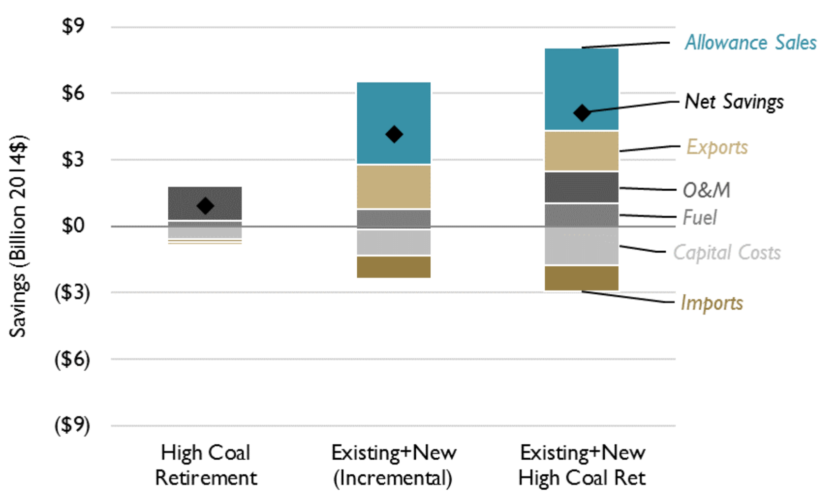
resources increasingly supply generation.

Under Existing+New compliance, Michigan emits 30 million fewer tons of CO_2 from power generation during the study period in the Additional Retirements sensitivity than in the base case. The decrease in coal-fired generation leads to a 46 percent drop in emissions from Michigan's existing sources during the compliance period. Michigan's compliance position benefits from additional coal retirements, which allow the state to leverage an over-compliance buffer of 15 million tons CO_2/year on average. The existence of this buffer suggests that even if more new gas-fired capacity were to be built in-state to replace retiring coal units, Michigan's compliance position would be secure. However, because emissions from affected sources are lower in this sensitivity case, there is less demand for allowances and the total value of Michigan's allowance pool decreases by about $370 million as compared to the base compliance case.

4.8.3 Finance

Michigan's total power system costs decline versus the base cases when the additional coal retirements identified in this study are assumed. The cost of the power system decreases relative to both the Reference base case and the base case of Existing+New compliance (Figure 35). Additional coal retirements in the Reference scenario result in decreased spending totaling approximately $1.0 billion, as increased expenditures on capital and imports are more than offset by decreased spending on fuel and O&M. An incremental $4.2 billion in net savings results from implementing the Existing+New policy in the context of accelerated coal retirements. The coal retirement trend is observed to increase Michigan's emissions allowance revenue by enabling Michigan to further over-comply with its Clean Power Plan targets, despite lower overall allowance prices. In total, compliance with additional coal retirements is $1.9 billion cheaper than compliance alone and $5.1 billion cheaper than the Reference base case. Given the assumptions used here (which include the moderate base gas price forecast), compliance and coal retirements together were found to result in the least costly scenario of all those modeled for this study.

Figure 35. Cost implications of Additional Coal Retirement sensitivity cases as compared to the Reference base case



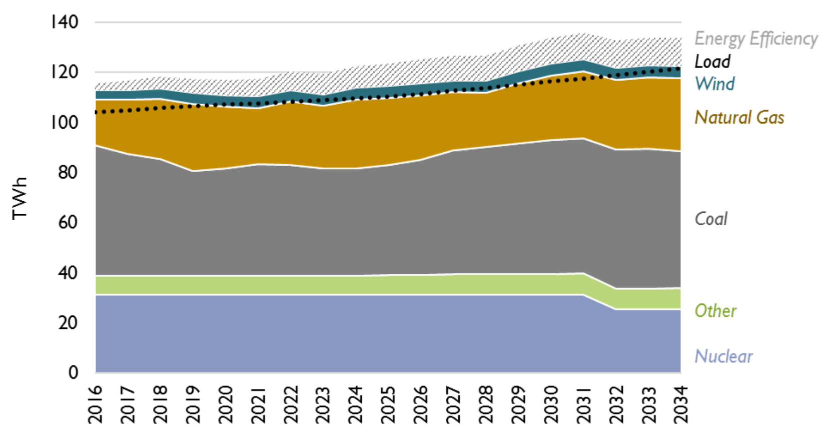
Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

4.9 High Gas Sensitivity

4.9.1 Reference Case vs. Existing+New Compliance

Natural gas prices are one of the key assumptions in this study. As such, the High Gas sensitivity case results are different in important ways from the results of any other scenario modeled here. Because the gas price forecast used for this sensitivity diverges from the base case assumption after 2019, changes from the base case are only seen in 2020 and later years.

Figure 36. Generation mix in Michigan in the Reference High Gas Price sensitivity



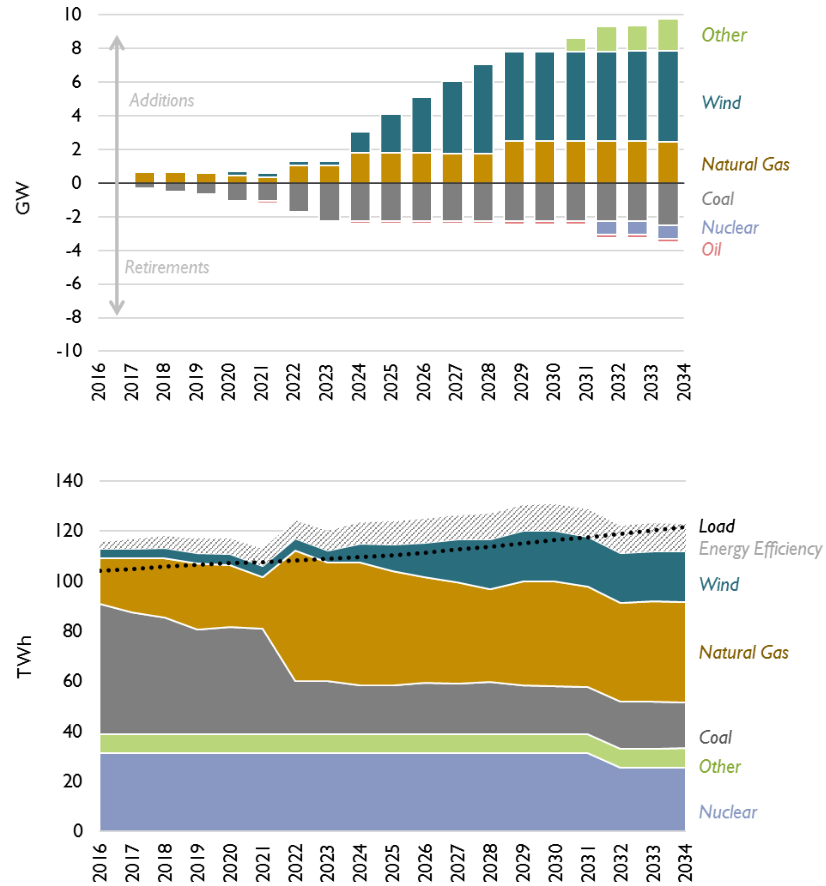
Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

In the Reference case, higher gas prices prevent gas-fired generation from displacing existing coal, as seen in other scenarios. Instead, while gas displaces coal-fired generation moderately through 2019, coal generation recovers after the onset of relatively steep increases in gas prices in the early 2020s. Michigan's coal-fired generation is observed to gradually build back to 2016 levels (which are still low historically) by 2030. Gas-fired generation stays relatively stable throughout the study period. The generation mix for Michigan in the High Gas case of the Reference scenario is shown in Figure 36. The capacity build-out is identical to the base Reference case and not shown here.

Modeling results for the High Gas sensitivity of the Existing+New compliance scenario present a different strategy to meet compliance requirements than is seen in other compliance cases (Figure 37). As in the other compliance scenarios, the imposition of a limit on emissions is seen to lead to a steep decrease in coal-fired generation. After 2022, coal-fired generation stays at a steady and minimal level throughout the compliance period. Initially, generation is redispatched to gas as the first observable compliance method, a pattern which is seen in other compliance scenarios as well. However, as gas and allowance prices rise, wind-powered generation becomes a more attractive mitigation option. As such, new wind capacity is brought online in earlier years than is observed in any other case. Additions of new wind capacity and wind's role in Michigan's generation mix both increase steadily after 2024 (two years after the onset of the compliance requirement). Increasing generation from wind takes the place of decreasing gas-fired generation.

The assumed 5 GW limit on new wind in Michigan is reached in 2028. Without the ability to add additional wind power to the system, the model selects more expensive resources such as solar PV and biomass to meet compliance and capacity requirements in the last four years of the study period. By 2034, Michigan is found to install almost 500 MW of utility scale solar and 1.5 GW of biomass-fired generation. This is the only scenario in which non-negligible amounts of PV and biomass are installed in Michigan. While the specifics of this result may be an artifact of the model structure and limits imposed in this analysis, the substantially different buildout observed in this scenario demonstrates that higher gas prices have the potential to substantially alter the relative economics of different generating resources.

Figure 37. (a: top) Capacity changes and (b: bottom) generation mix in Michigan under the Existing+New compliance High Gas Price sensitivity case

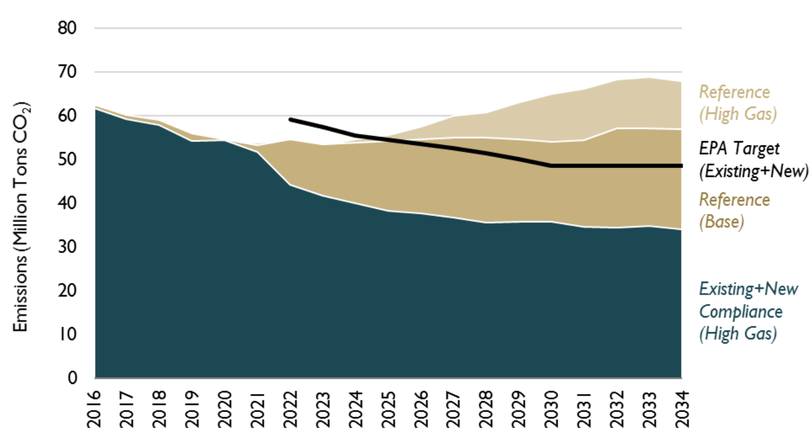


Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

4.9.2 Emissions

In the Reference scenario, higher gas prices lead to increased coal generation as compared to the base case and therefore to higher emissions (Figure 38). Emissions from Michigan's existing sources are higher in 2034 (at 63 million tons CO_2) than in 2016 (61 million tons). Meanwhile, emissions from new sources grow through the late 2020s and early 2030s, eventually reaching 5 million tons

Figure 38. Emissions from existing and new sources in Michigan in the Reference base case, Reference case with higher gas prices, and under Existing+New compliance with higher gas prices



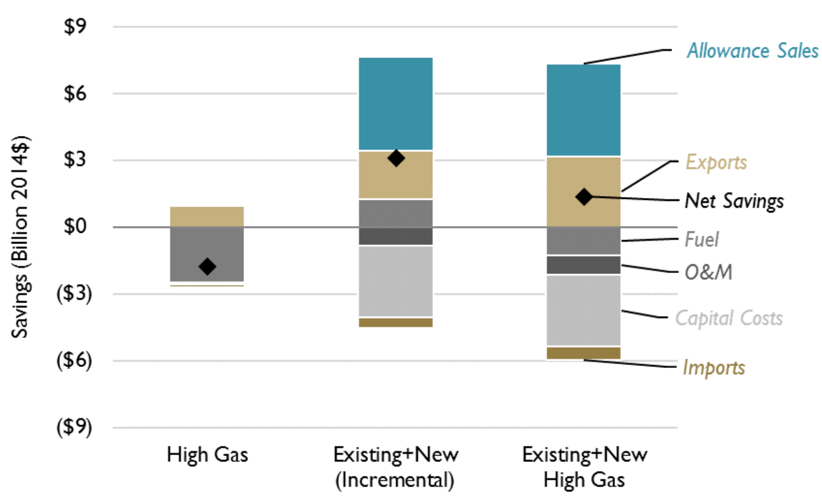
Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

by the end of the study period. In Reference scenario, Michigan is found to exceed its state-specific cap starting in 2026. By 2034, the state's existing and new sources would have to reduce their emissions by almost 20 million tons, or about 28 percent, in order to meet EPA's target.

Under Existing+New compliance, however, higher gas prices have the effect of reducing Michigan's emissions as compared to the base case. Total emissions from power generation during compliance in the High Gas sensitivity case are 25 million tons lower than in the base case. This allows Michigan to have more room under its emissions cap. The state over-complies by 15 million tons on average during the compliance period. Higher gas prices also increase demand for allowances from the region as a whole, leading to higher emissions prices. The resulting worth of Michigan's allowance pool is over $15 billion, which is the highest value of all the scenarios in this analysis.

4.9.3 Finance

Figure 39. Cost implications of High Gas Price sensitivity cases as compared to the Reference base case



Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

Despite high allowance prices, comparatively high gas prices are found to increase total power system costs in Michigan (Figure 39). Unsurprisingly, higher natural gas prices result in a significant increase in fuel costs. In the High Gas sensitivity of the Reference case, higher gas prices generate net costs of nearly $1.8 billion as compared to the base case. A higher gas price regime also decreases the incremental savings associated with instituting the Existing+New policy. Since natural gas more expensive in this scenario, and increased coal generation is incompatible with Clean Power Plan policies, Michigan spends more on the construction of new, renewable generation resources than in any other scenario. However, the incremental Existing+New policy still results in $3.1 billion in savings as compared to the Reference base case. Importantly, the High Gas Existing+New sensitivity case sees total system costs that are $4.9 billion lower than the High Gas Reference case, primarily due to increased export and emission allowance revenues. This result indicates that, given consistent sets of assumptions, Existing+New compliance is likely to be lower cost than the Reference case even in the presence of factors that lead to an increase in system costs generally.

4.10 Sensitivity Trends

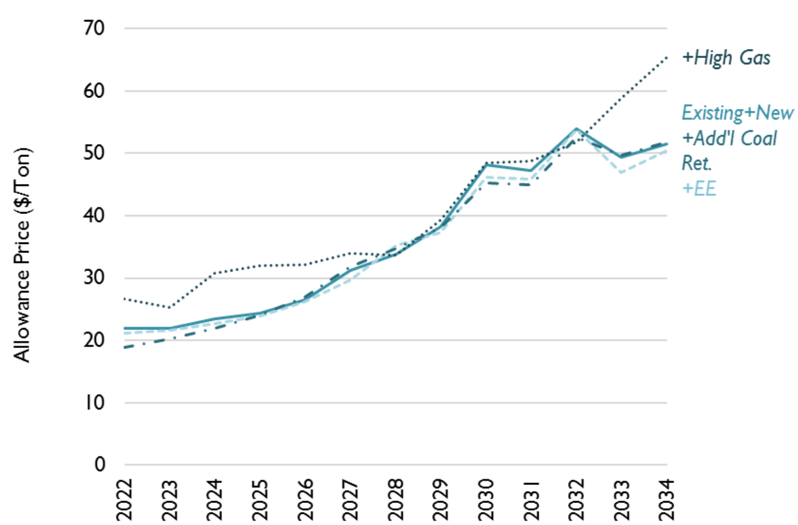
The sensitivities analyzed here suggest that the impacts of compliance are directionally robust. Existing+New compliance results in increases in wind capacity in Michigan and decreases in total system costs in all sensitivity cases. This trend holds regardless of whether system costs are otherwise higher (as is the case in the High Gas sensitivity) or lower (as in the High EE and Additional Coal Retirements sensitivities) than the base case. Moreover, savings are observed under compliance even given lower allowance prices, as are found in the High EE and Additional Coal retirements sensitivities as compared to the base case (Figure 40). Decreased allowance prices in these sensitivities arise due to decreased demand (in the High EE sensitivity) or emissions (in the Additional Retirements sensitivity). In all cases, Michigan's ability to gain revenue by exporting allowances results in total savings.

Similarly, the High EE and Additional Coal Retirements sensitivities are observed to lower system costs regardless of the presence or absence of a compliance requirement. However, the reasons underlying these trends differ. The High EE sensitivity reduces demand and, therefore, overall spending on the power system (despite increased spending on energy efficiency). Reduced demand also allows capital expenditures on new units to be delayed in the Existing+New compliance scenario, lessening their impact on a net present value basis.

Additional coal retirements demand additional builds of new units in Michigan in both the Reference and Existing+New compliance cases as compared to the base cases. Results from the Additional Coal Retirement sensitivity indicate that, given an expectation of slow growth in natural gas prices, Michigan may see lower system costs by replacing coal-fired generation with gas-fired generation (or a mix of gas and wind). However, a scenario combining additional coal retirements with a high gas price trajectory was not examined in this study.

The results presented here suggest that the possibility of substantial increases in natural gas prices poses a risk to Michigan and the region at large. In the Reference scenario, relative increases in natural gas prices make gas-fired generation less favorable, leading to increased coal-fired generation. Because shifts in generation from coal to gas is found to be a prominent compliance mechanism, compliance is costlier in the high gas price scenario than in the base case. Increased gas prices lead to increased allowance prices and an

Figure 40. Allowance prices under different compliance paths



Source: MPSC/MDEQ EPA 111(d) Impact Analysis, 2016.

accelerated build-out of renewable energy. The paired constraints of compliance and higher gas prices lead Michigan to rely on imports and more expensive renewable resources in the early 2030s to meet capacity and compliance requirements. Combined with the direct impact of higher fuel prices, these effects raise spending on the power system overall. The risk of reliance on natural gas as a singular compliance mechanism should be considered in decision making.

5. CONCLUSIONS

Modeling suggests that Michigan's least cost compliance path is to trade allowances under a mass-based emissions cap covering both existing and new sources.

Michigan's participation in allowance trading could provide substantial revenues to the state in the form of excess allowances. The model finds that Michigan would likely comply with a mass-based cap by shifting generation from existing coal-fired resources to existing gas-fired resources in early years, and building new renewable resources at higher emission cost price points. If Michigan chooses a compliance path that covers both existing and new sources, its dominant compliance strategy in later years is to build new wind-powered generation. However, if Michigan's compliance path covers only existing sources, it relies primarily on existing and new gas-fired generation in later years, resulting in increased emissions from covered and uncovered sources, and less benefit from a robust allowance market.

Complying with the Clean Power Plan reduces costs for Michigan relative to a case with unrestricted emissions.

Every compliance case modeled in this study results in savings in the energy system as compared to the Reference scenario. These savings come from both increased revenue (from exports of power and sales of allowances) and decreased spending (on imports, fuel, and O&M). Clean Power Plan compliance is likely to result in significant net savings in Michigan even if future natural gas prices are higher than anticipated. The greatest savings are realized under a policy that encompasses both new and existing sources of emissions. Implementing complementary policies to encourage energy efficiency and accelerate coal retirements could substantially increase savings. The reduced costs for Michigan compliance are realized if Michigan trades with less well-positioned neighboring states.

Michigan can act as an exporter of both allowances and energy.

Demand for emission allowances could be high amongst Michigan's neighboring states if those entities do not see significant retirements. By shifting generation primarily from its existing coal-fired resources to its existing gas-fired resources, Michigan may export both power and surplus allowances. However, if Michigan and its neighbors use a compliance cap that covers only existing sources, Michigan's in-state generation may be out-competed by relatively low-cost gas-fired generation in neighboring states by the early 2030s, causing Michigan to become a net importer of power.

A more comprehensive cap on emissions creates higher demand for allowances. Higher demand raises the value of Michigan's allowance pool, leading to increased revenue from allowance sales. Higher allowance prices also level the playing field for renewable energy. Modeling suggested that Michigan would build up to the 5 GW cap on new wind in-state. This outcome only occurred in the compliance paths that limited emissions from both existing and new resources. Increased in-state generation from renewable resources in later years means that Michigan can remain a net exporter of power as well as allowances through the mid-2030s.

Michigan can comply even without trading, but doing so may be costly.

According to the modeling here, Michigan is close to mass-based compliance in the Reference case (i.e., without any constraint on emissions) – primarily as a function of low gas prices. Therefore, if gas prices remain near the estimated base case modeled here, Michigan could theoretically comply without entering a trading construct, but would lose any opportunity to realize revenues from the sale of excess allowances. Under any of the emissions constraints, Michigan over-complies by a meaningful margin and thus has excess allowances available to trade. By giving up this source of revenue, compliance would become more expensive for Michigan. Along the same lines, the sizable gap between Michigan's emissions and its cap in most compliance scenarios implies that were Michigan to join a trading region, it would have room to comply even if important factors were to change in a way that would lead Michigan to emit more (for example, if Michigan's neighbors didn't build as much new gas-fired capacity).

The analysis finds that if Michigan enters a mass-based trading regime with other states seeking mass-based allowances, the state would see substantial revenue from the allowance market – thus realizing savings through the compliance pathway. Energy efficiency and the retirement of less-economic coal-fired units provide a benefit to Michigan even in the absence of the Clean Power Plan, but the state is able to harness yet additional savings under a compliance plan if these complementary policies are pursued as well. If it pursues a multi-state mass-based trading scheme covering both existing and new sources, Michigan's strong compliance position means that it is poised to not just comply with but also benefit from the Clean Power Plan.