2030 Report

How Michigan Should Meet Its Climate Change Goals

5 lakes energy

MICHIGAN ENVIRONMENTAL COUNCIL

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Executive Summary

The MI Healthy Climate Plan (MIHCP), released by Michigan Gov. Gretchen Whitmer's Department of Environment, Great Lakes, and Energy in April 2022, outlines policies with a goal of reducing greenhouse gas (GHG) emissions from Michigan's economy by 28% below 2005 levels by 2025 and 52% by 2030, and achieving carbon neutrality by 2050. The Plan acknowledges, however, that its policy recommendations do not go far enough to achieve either the 2030 or 2050 goals.

In this report, the Michigan Environmental Council, Natural Resources Defense Council, 5 Lakes Energy, and RMI (formerly Rocky Mountain Institute) offer the Climate Solutions Pathway, the most feasible and ambitious set of policies that would meet Michigan's goals, based on modeling performed with the Energy Policy Simulator (EPS), a free, open-source, peer-reviewed model developed by Energy Innovation Policy & Technology LLC® and RMI. If implemented, the policies in the Climate Solutions Pathway would allow Michigan to reduce its emissions by over 94% from 2005 to 2050, focusing on the largest sources of emissions in the state: electricity generation, transportation, buildings and appliances and industry. Our modeling also finds that achieving carbon neutrality by 2050 requires more aggressive actions in the near-term. From 2020 to 2030, the Climate Solutions Pathway cuts emissions by over 72 million metric tons, compared to about 52 million metric tons based on the policies found in the MIHCP.

The most powerful decarbonization policies in the Climate Solutions Pathway include:

1. A 100% clean electricity standard.
2. Building component electrification coupled with energy efficiency.
3. Clean cars and trucks sales standards.
4. Electrification of industrial energy sources.

Based on our modeling of the next 10 and 20 years, we recommend that Michigan immediately–before 2030–prioritize a slate of policies that lay the groundwork that is needed to ultimately reach carbon neutrality by 2050. These policy recommendations add to and fill in the gaps present in the MIHCP. The most impactful recommended policies that are additional to the MIHCP are:

1. An end to the construction of new gas-fired power plants.
2. Setting a building electrification standard that requires 100% of all new heating equipment sales to be electric by 2035, and interim targets leading up to 2035.
3. Standards that ramp up to 100% electric vehicle (EV) sales in Michigan by 2035 and the introduction of incentives to speed up the transition of vehicles on Michigan's roads from internal combustion engine-driven to fully electric.

Introduction

On April 21, 2022, Michigan Gov. Gretchen Whitmer's administration released the final MI Healthy Climate Plan (MIHCP),[1] a set of policy recommendations on how the state can cut its greenhouse gas emissions by 52% by 2030 relative to 2005 levels.[2] The plan sets Michigan on the path to reach carbon neutrality by 2050, a goal Gov. Whitmer declared through a landmark executive directive issued in September 2020, which also set an interim goal of a 28% carbon reduction below 2005 levels by 2025.

The MIHCP's policies, if enacted, would make important progress toward meeting these targets compared to the current course. The MIHCP acknowledges, however, that its policy recommendations "do not go far enough on their own"[3] to meet the interim goal by 2030 and that "additional policy changes and actions in every sector will be necessary to get all the way"[4] to the 52% reduction. Our modeling of the MIHCP confirms this assertion, as Michigan misses the 52% reduction in 2030 by roughly 3 million metric tons (MMT) of GHG emissions. In addition, while it recognizes the urgency of achieving carbon neutrality by 2050, the MIHCP is not designed to identify the policies needed to meet that longer-term goal, instead outlining strategies that can make incremental progress this decade toward carbon neutrality.[5]

To bolster the effort to decarbonize Michigan's economy, this report lays out a comprehensive set of concrete policies that would enable the state to meet its emission reduction goals by 2030 and 2050. While, as we will explore, market forces are propelling renewable energy, energy storage, and adoption of EVs forward, in the absence of policy action these forces are not likely to reduce emissions as fast as is needed to meet the state's timeline. The policies discussed in this report will be needed to keep the state on track to meet the 2030 and 2050 goals. Policies are also required to ensure that the state and private companies are building the basic infrastructure needed to support the clean energy transition and keep Michigan competitive in a decarbonizing world, such as charging stations to power clean cars and other modes of transportation and transmission lines to connect renewable energy-rich areas to population centers.

Achieving those goals is about much more than living up to commitments made by the directive. The targets reflect the scientific consensus on climate change and the scale and pace of decarbonization that scientists are recommending to avoid the worst impacts of climate change.[6] The goals from the directive are consistent with the commitment from the U.S. as a whole under the Paris Agreement[7] to limit average global temperature increases to 1.5°C by the end of the century.[8,9] The scientific community has identified that 1.5°C milestone as a tipping point after which increases in human mortality and environmental degradation and a range of cumulative effects of climate change become materially worse.[10,11]

This report uses the EPS[12] developed by Energy Innovation® and RMI to determine the most feasible route to put the state's energy use on track for near- and long-term GHG emissions reductions. The EPS is a free, open-source, peer-reviewed model that allows users to estimate climate and energy policy impacts on emissions, the economy, and public health using publicly available data. The model estimates these impacts through 2050 and considers how policies interact with each other.

Using the EPS, we model three scenarios:

1. Business as Usual, which illustrates the consequences of Michigan making no new policy progress to cut emissions beyond actions that are already planned;
2. A scenario that models the policies included in the MIHCP, and;
3. A Climate Solutions Pathway, which is consistent with similar 1.5° C analyses[13,14] and identifies the key policies and milestones across all sectors that must be achieved for Michigan to hit its goals in Executive Directive 2020-10.

The Climate Solutions Pathway is an ambitious, yet feasible, route for Michigan to achieve the state's climate goals, consistent with the Paris targets and limiting average global warming to 1.5°C by the end of the century. In addition, the Climate Solutions Pathway provides an important yardstick against which to measure the recommendations in the final MIHCP.

This pathway, however, by no means represents the complete set of actions that will be needed to implement a fair and just decarbonization plan. To address local pollution and its harmful effects, Michigan will need a plan that prioritizes the communities who have both been historically neglected and are disproportionately bearing the brunt of the impacts of climate change, coupled with decades of pollution burdens. While outside the scope of the EPS model, Michigan policymakers should consult, at minimum, the Justice40 accountability framework[15], which are the guidelines developed by environmental justice movement leaders and academics to ensure that any plan to reduce emissions also prioritizes and outlines clear steps for reducing local emissions. We also recommend direct consultation with frontline and environmental justice communities in Michigan, many of whom submitted detailed comments on the MIHCP. These foundational steps are necessary to ensure that the polluting legacy of the last century is not repeated in the transition to a clean energy economy in Michigan.

This report does not model the Inflation Reduction Act (IRA) that President Biden signed into law in August 2022. Preliminary assessments of the bill's energy provisions have found that it will accelerate baseline U.S. GHG reductions, and so this momentous new law could make Michigan's goals more readily achievable, and more cost-effective, depending on how the state implements the provisions. The IRA, however, does not alter our report's analysis or conclusions about the progress that Michigan must make and the policies that would achieve that progress; in fact, it reinforces them.[16]

Michigan's Greenhouse Gas Emissions Outlook

Michigan has made substantial strides in the last few decades toward lowering its GHG[17] emissions. From 2005 to 2019, economy-wide GHG emissions[18] fell by roughly 27 million metric tonnes (MMT), a decrease of over 15%.[19] While GHG emissions in the transportation and industrial sectors dropped slightly, reductions were largely driven by the closure of several uneconomic and carbon-intensive coal plants–CO_2 emissions from coal-fired electricity generation fell by 30 MMT, or 45% in the same period.[20] In the same period, GHG emissions from buildings increased 7%.

Despite progress in some areas of Michigan's economy–notably electric power generation–Michigan is not on track to reach its 2030 or 2050 targets without a major shift in policy. Our Business As Usual scenario illustrates this point. For one, emissions reductions in the power sector will slow down and quickly stall out as legacy coal plants are replaced by another fossil source: methane gas (commonly marketed as "natural gas" and, in this report, referred to simply as "gas"). Although emissions from coal plants have fallen since 2005, in Michigan, CO_2 emissions from gas generation have increased by 200% over the same timeframe.[21] In 2020, CO_2 emissions from gas in Michigan totaled 22.5 MMT, accounting for more than 42% of total power sector emissions.[22] Shifting from one CO_2-intensive power source to another will seriously delay the speed and scale of emissions reductions necessary to achieve Michigan's climate

THE PROBLEM WITH CARBON OFFSETS

Carbon offsets have been growing in prevalence in Michigan, particularly as investor-owned utilities and large energy users set net-zero emissions reduction goals.[23] Offsets refer to a reduction in GHG emissions used to compensate for emissions that occur elsewhere–which could take place in or near Michigan, or even thousands of miles away on another continent. Unfortunately, reliance on offsets reinforces a system dominated by polluting sources, rather than one that is moving toward increasingly cleaner and emissions-free alternatives. Offsets could keep polluting facilities operating longer, delaying real, local reductions in harmful emissions that impact surrounding communities. In addition, offsetting GHG pollution from a coal plant, for example, does not eliminate its other health-harming air pollution, like emissions that contribute to soot and smog.

Offsets are a half measure that do not eliminate emissions and instead only push them elsewhere, slowing down the decarbonization of the rest of the economy, and cannot play a major role in the state's climate strategy. For these reasons, the EPS does not rely on offsets in modeling GHG emission reduction pathways. Instead, we recommend that the MIHCP focus on achieving real, measurable, and local reductions in GHG emissions.

A NOTE ON AGRICULTURE, WASTE, AND NATURAL LANDS

While we do not address the agriculture, waste, and natural lands sectors in this report, they will play a critical role in meeting Michigan's GHG reduction targets and deserve attention from decision makers. Policies in these sectors are difficult to design and quantify in a forward-looking modeling report, but they should not be overlooked. Agriculture and waste comprised 10% of total GHG emissions in Michigan in 2005 and 12% in 2020, emitting over 17 MMT of CO2e in both years. Emissions from this sector are projected to stay constant, rising by 3 MMT of CO2e by 2050. In contrast, natural lands have the potential to be a climate solution, responsible for sequestering large amounts of carbon at 41 MMT of CO2e in both 2005 and 2020–which is projected to increase modestly by 3 MMT of CO2e by 2050. Well-designed state policies can both reduce emissions in the agriculture and waste sectors and increase sequestration opportunities for natural lands, effectively "removing" difficult to reduce emissions in other sectors.

goals. If Michigan does not halt gas capacity additions and make significant investments in renewables, GHG emissions from electricity generation will rise again over the next decade and beyond, as shown by the Business As Usual scenario in this report *(Fig. 1)*. The electric power sector, which has carried the weight of the state's economy-wide GHG reductions over the past two decades, is at risk of losing 15 years of progress without policy action on gas plants.

Fig. 1

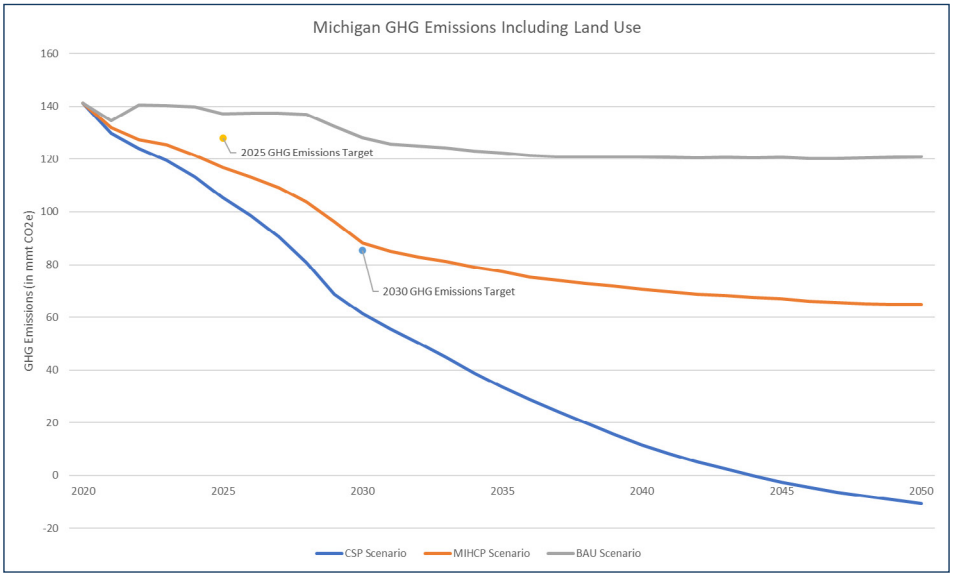
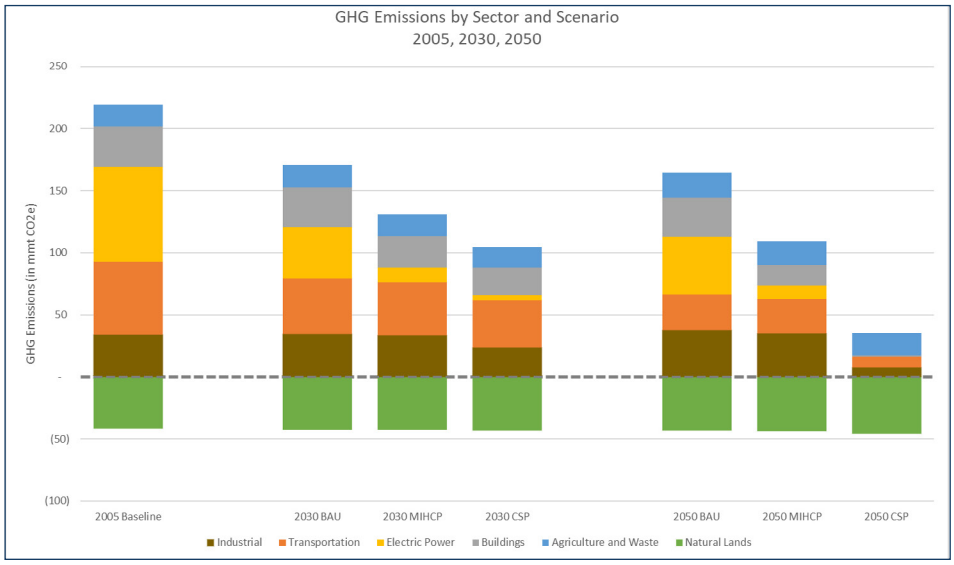


Fig. 2



Adding to the problem, emissions from the buildings, industrial, and agriculture/land use sectors have remained largely static and are not likely to make progress without significant policy intervention. Absent new policy initiatives, emissions will increase in the agriculture, buildings, and industrial sectors *(Fig. 1)*. By 2050, Michigan's overall GHG emissions are projected to decrease by only 32% relative to 2005 in the Business As Usual scenario.

Transportation is an outlier, where emissions are expected to fall by 51% from 2005 to 2050 due to electric passenger vehicles surpassing internal combustion engine vehicles in popularity, even without additional policy intervention (*Fig.* 2). But, as we will discuss later in this report, deeper reductions in transportation emissions are necessary and they will require additional policy interventions to achieve.

Michigan EPS Results

Economy-Wide Results

The Michigan EPS analyzes the emissions impact of a suite of policies in the state.[24] We present three scenarios of policy packages designed in the EPS: a Business As Usual scenario that models future GHG[25] emissions absent any new policy initiatives,[26] a scenario that assumes the policies laid out in the MIHCP are enacted, and the Climate Solutions Pathway (*Figs. 1* and 2).

Compared to the Business As Usual scenario, the MIHCP is a vast improvement. In 2030, economywide GHG emissions would fall by 50% relative to 2005. In contrast, GHG emissions would drop by only 28% by 2030 under the Business As Usual scenario (*Tables 1 and 2*). The MIHCP would put Michigan in a better position than it is now to reach carbon neutrality by 2050 while seeing public health benefits from lower pollution that would otherwise be missed under the Business As Usual scenario.

But more must be done beyond the recommendations of the MIHCP. The Climate Solutions Pathway builds from the MIHCP and drives emissions down even further by 2030, putting the state on a faster track to carbon neutrality by 2050. The scenario also includes additional policies that allow the state to achieve that 2050 goal. Overall, in the Climate Solutions Pathway, emissions fall between 78%–100% in each major economic sector discussed in this report, leading to a total reduction of 106% in 2050 relative to 2005 (*Table 3*).

Table 1

GHG Emissions in Business As Usual Scenario (in MMT of CO2e)

Business As Usual Scenario							
Year	Industrial	Transportation	Electric Power	Buildings	Agriculture and Waste	Natural Lands	Total GHG Emissions
2005	34	59	76	33	17	-41	178
2020	34	57	45	31	17	-42	141
2025	35	52	43	31	18	-42	137
2030	34	45	41	32	18	-42	128
2050	38	29	46	32	20	-44	121
% Change 2005-2050	11%	-51%	-39%	-4%	16%	5%	-32%

Table 2

GHG Emissions in MIHCP Scenario (in MMT of CO2e)

MIHCP Scenario							
Year	Industrial	Transportation	Electric Power	Buildings	Agriculture and Waste	Natural Lands	Total GHG Emissions
2005	34	59	76	33	17	-41	178
2020	34	57	45	31	17	-42	141
2025	35	50	29	29	17	-43	117
2030	33	43	11	25	18	-43	88
2050	35	28	11	16	19	-44	65
% Change 2005-2050	2%	-53%	-85%	-52%	11%	6%	-63%

Table 3

GHG Emissions by Sector in Climate Solutions Pathway Scenario (in MMT CO2e)

Climate Solutions Pathway Scenario							
Year	Industrial	Transportation	Electric Power	Buildings	Agriculture and Waste	Natural Lands	Total GHG Emissions
2005	34	59	76	33	17	-41	178
2020	34	57	45	31	17	-42	141
2025	31	48	25	28	17	-43	105
2030	23	38	4	22	17	-43	61
2050	7	9	0	1	18	-46	-11
% Change 2005-2050	-78%	-85%	-100%	-97%	4%	11%	-106%

A full list of the policy assumptions in each sector and scenario is included in *Table 4* in the Appendix.

Next, we summarize the policy recommendations from the Climate Solutions Pathway for each sector, followed by a more detailed sector-by-sector analysis that compares the Climate Solutions Pathway to the other two scenarios.

Policy Recommendations

The four most impactful policies that can put Michigan on a trajectory to meet its climate goals are:

1. The 100% clean electricity standard.
2. Building component electrification coupled with energy efficiency.
3. Clean cars and trucks sales standards.
4. Electrification of industrial energy sources (or for hard-to-electrify applications, an alternative zero-emissions fuel).

Missing the mark on any of these four broad policies would make achieving Michigan's emissions reduction goals extremely difficult.

In addition to these four foundational policies, based on the results of the Climate Solutions Pathway, we include the following recommendations by sector.

Electric Power Sector

Emissions pathway: 94% reduction in power sector GHG emissions by 2030 and 100% reduction by 2050 relative to 2005.

Policy recommendations to meet this pathway:

1. Renewable Portfolio Standard of 60% by 2030, followed by an 80% GHG-free standard by 2030 and a 100% GHG-free standard by 2035.
2. Retire all coal plants within the state of Michigan by 2030.
3. Commit to building no new gas plants in Michigan after 2022, and retire non-peaking gas plants gradually by 2040 to shrink the size of the current gas fleet to reflect reduced utilization as the power fleet decarbonizes.
4. Significantly expand renewable energy, battery storage, transmission capacity and demand response to enable the state to transition to clean power, while creating a more resilient, reliable and flexible grid.
5. Support improved planning for transmission, which will be a foundational need for the clean energy transition, including continuing to advocate that the Midcontinent Independent System Operator (MISO) conduct regional transmission planning that aligns with strong state clean energy goals.

Transportation Sector

Emissions pathway: 35% reduction in transportation sector GHG emissions by 2030 and 85% reduction by 2050 relative to 2005.

Policy recommendations to meet this pathway:

1. Adopt the clean cars standards (low-emission vehicles and zero-emission vehicles), advanced clean truck standard, and heavy-duty omnibus regulation.
2. Reform electric rates to account for the benefits and flexibility that electric vehicles bring to the grid, and to ensure new electric load is managed and optimized.
3. Implement incentives for EV purchases to ensure that Michigan is able to meet an ambitious goal of reaching 50% electric sales of passenger/freight light-duty vehicles, heavy-duty vehicles and motorbikes by 2027 and 100% by 2035.
4. Build enough EV chargers to accommodate the clean cars standards, ramping up to 255 chargers/100k population by 2050.
5. Reduce vehicle miles traveled by supporting multi-modal transportation and land use reform measures that can reduce car dependence. Policies include investment in public transit (e.g. bus rapid transit, commuter rail) and support to local governments to invest in transit-oriented development and reduce exclusionary zoning and minimum parking requirements.

Buildings Sector

Emissions pathway: 34% reduction in buildings sector GHG emissions by 2030 and 97% by 2050 relative to 2005.

Policy recommendations to meet this pathway:

1. Strengthen energy waste reduction requirements to a 2.5% annual savings target for electric and a 1.5% annual saving target for gas with a strong focus on whole home efficiency and the building envelope to ensure that homes are prepared for the building electrification transition.
2. Allow fuel-switching and electrification as a part of Michigan's energy waste reduction programs.
3. Set clear, state-level targets for installation of electric heat pumps in residential homes, with a focus on low-income and underserved households (e.g.,100,000 electric heat pumps installed by 2025). Targets should be ambitious enough to set Michigan on a path to 100% of all newly sold appliances and HVAC to be electric by 2035.
4. Adopt the 2021 International Energy Conservation Code this year, the building decarbonization overlay designed by the New Buildings Institute,[27] and all-electric commercial and residential codes in new construction built after the year 2026.

5. Create an incentive program to encourage manufacturers to produce heat pumps and to help residents purchase and install heat pumps and induction stoves.
6. Develop strong workforce training and attraction/retention programs that ensure Michigan has a robust contractor network well versed in decarbonized building work.
7. Reform electric rates to account for the benefits and flexibility that electric appliances bring to the grid.

Industrial Sector

Emissions pathway: 31% reduction in industrial sector GHG emissions by 2030 and 78% by 2050 relative to 2005.

Policy recommendations to meet this pathway:

1. Increase incentives and requirements for industrial equipment efficiency, emissions controls and clean technology upgrades. Examples include loans and grants to support industrial efficiency programs and setting requirements to phase out high emissions technologies.
2. Work with utilities, industrial firms, federal agencies, and other stakeholders to accelerate the electrification of industrial processes and the development of alternative zero-carbon options for hard-to-electrify processes.

Electric Power Sector

The electric power sector was the second-largest contributor to Michigan's GHG emissions with 45 MMT of GHG emissions in 2020. Reducing the carbon intensity of electricity generation will reduce emissions for nearly every other sector. As the transportation, buildings, and industrial sectors electrify, economy-wide decarbonization occurs more rapidly. This result underscores the importance of pursuing a 100% carbon-free electric grid as fast as possible, with the bulk of reductions occurring this decade. Cutting pollution from the electricity sector is also critical for public health, including decreasing the number of premature deaths and asthma attacks associated with particulate matter emissions from the burning of fossil fuels.[28] In addition, the clean electricity sector is an economic powerhouse, creating immense opportunities for new, high-quality jobs.[29]

In the model's Business As Usual scenario, emissions remain between 42-46 MMT per year through 2050, due primarily to coal-fired power plants retiring and gas-fired power plants replacing them. But while that replacement leads to near-term emissions reductions because gas-fired power plants emit about 50% less CO_2 than coal-fired, these reductions level out over time given that gas-fired generation is still emissions-intensive. As a result, electricity sector emissions are projected to be higher in 2050 than 2030. (*Fig. 3*)

The Business As Usual scenario for the electricity sector closely reflects currently-approved utility integrated resource plans, in which Michigan's large investor-owned utilities have announced or completed several coal plant retirements (See *Tables 5* and 6 and *Fig. 14* in the Appendix).[30,31] Given current utility commitments and market conditions, the power sector continues to add more carbon-free sources. But because gas-fired generation keeps being built and existing gas plants are not retired, absent additional state clean energy policies Michigan's generation will remain dependent on fossil fuel sources and nuclear with only modest generation from renewables this decade (*Fig. 4*).

Fig. 3

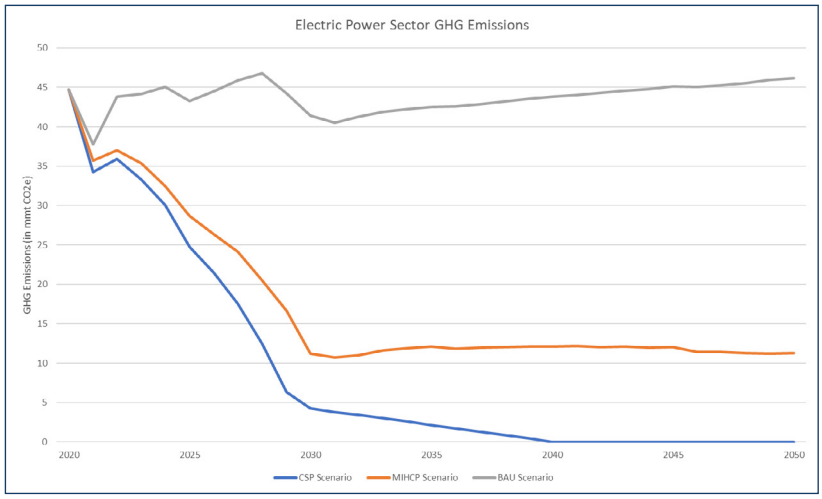
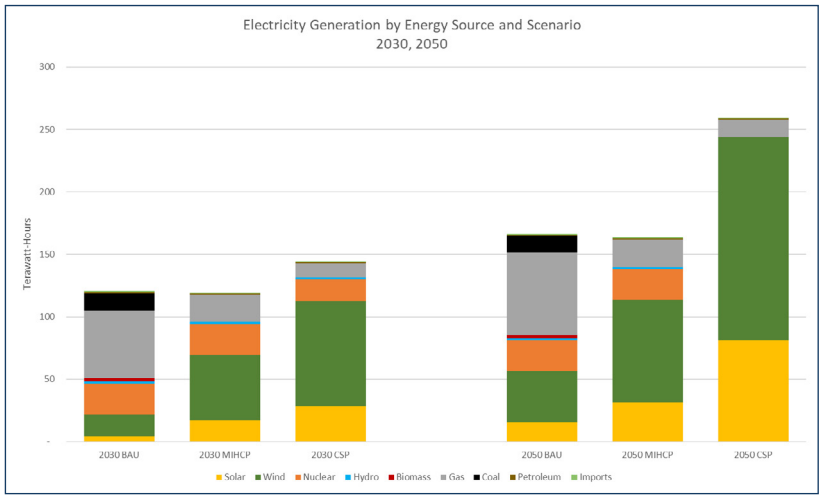


Fig. 4



The MIHCP mitigates this emissions rebound by increasing the amount of clean energy on the grid through policies like a 50% renewable energy standard and energy storage targets. As a result, our modeling finds that by 2030 the MIHCP will reduce electricity sector GHG emissions by 65 MMT, an 85% decrease relative to 2005 levels. In contrast, by 2030 in the Business As Usual scenario, GHG emissions drop by only 35 MMT per year relative to 2005. As of 2020, however, this sector has already reduced emissions by 31 MMT per year, meaning no progress is expected over the next decade or beyond, absent additional policies. In other words, by 2030, the MIHCP policies would reduce GHG emissions from the electricity sector by another 30 MMT as compared to the Business As Usual scenario.

But while this progress in the MIHCP is important, it is still insufficient to keep Michigan on track with its climate goals and ensure the power sector transitions to clean energy fast enough to support electrification and emissions reductions in cars, buildings, and industry.

In contrast, the Climate Solutions Pathway achieves full decarbonization of the power sector by 2040. Critically, the Climate Solutions Pathway incorporates two policies that are not present in the MIHCP and, if acted upon, would close the emissions gap and enable Michigan to reach a fully decarbonized power sector. The first policy is halting the construction of new gas-fired generation starting this year.[32] The second is a clean energy standard requiring 80% emissions-free electricity by 2030 and 100% by 2035 and thereafter.[33]

While the EPS models each policy separately, the power sector is a complex system, and in practice, policy impacts are interwoven and could—and should—be aggregated. The clean energy standard works in tandem with other policies to drive down emissions. As fossil reliance decreases in the Climate Solutions Pathway, renewable resources, primarily onshore wind and solar, expand to meet energy demand. The model also takes into account the need to preserve reliability and resource adequacy by selecting for flexible resources that can compensate for the intermittency of renewable energy, such as battery storage and demand response. Policies assisting the clean energy standard through 2050 include a 113% increase in transmission capacity, an increase in demand response resources from 2,900 MW in 2020 up to 8,200 MW by 2050, and the buildout of battery storage from 50 MW up to 16,000 MW in the same period.[34]

Under the Climate Solutions Pathway, wind, solar, biomass, nuclear, hydropower, and geothermal energy account for 91% of the state's electricity needs by 2030 and 94% by 2050. Flexible, non-emitting resources that require technological advancement to implement at scale, such as gas peaker plants with carbon capture and sequestration and long-duration energy storage, supply the remaining 6%. Existing nuclear plants (which does not include the Palisades plant, as the model assumes it has retired) generate electricity for a time, but that generation declines in the coming years because after 2033 it is uneconomic relative to wind and solar energy.

With these policies in place, GHG emissions from electricity production drop by 94% relative to 2005 levels in 2030 and drop to zero by 2040.

Transportation Sector

The shift to EVs is already underway as charging infrastructure is built and EVs become cheaper and more widely available. In addition, spiking gasoline prices in the wake of global instability and shifts in oil production have the potential to increase market uptake of EVs. For many drivers, the lifetime ownership costs of EVs are already less expensive than internal combustion engine (ICE) vehicles.[35]

These trends will lead to higher EV adoption over time, and as a result, lower emissions from transportation. Our modeling of the Business As Usual scenario shows transportation-related GHG emissions falling from around 57 MMT in 2020 to around 29 MMT in 2050 (*Fig. 5*). However, this decline is not sufficient to achieve the level of emissions reductions required to meet Michigan's climate goals.

In the Business As Usual scenario, sales of electric passenger cars and SUVs (i.e., light-duty EVs) exceed gasoline vehicle sales by 2040 (Fig. 6). This EV growth, however, is not fast enough to lower emissions by the necessary extent. Light-duty EVs grow over the decades to reach roughly 66% of new vehicle sales in 2050.

Other sectors of transportation, while not as significant in terms of total GHG emissions as passenger light-duty vehicles, show little progress toward decarbonizing in the Business As Usual scenario. Sales of electric buses and heavy-duty freight vehicles, which are essential to reduce local diesel pollution in communities, only account for 13% and 15% of total sales, respectively, by 2050 (*Fig. 7*).

While emissions from passenger vehicles are forecast to peak in 2021 and fall, the consequence of the sluggish rate of adoption in the Business As Usual scenario is that emissions from transportation fall slowly, driven mainly by emission reductions in the passenger light-duty vehicle category by 2050. Emissions from light and medium-duty freight trucks also fall modestly due to electrification. However, emissions in most other sectors of transportation *increase*, notably in aircraft sectors and heavy-duty freight vehicles.

Fig. 5

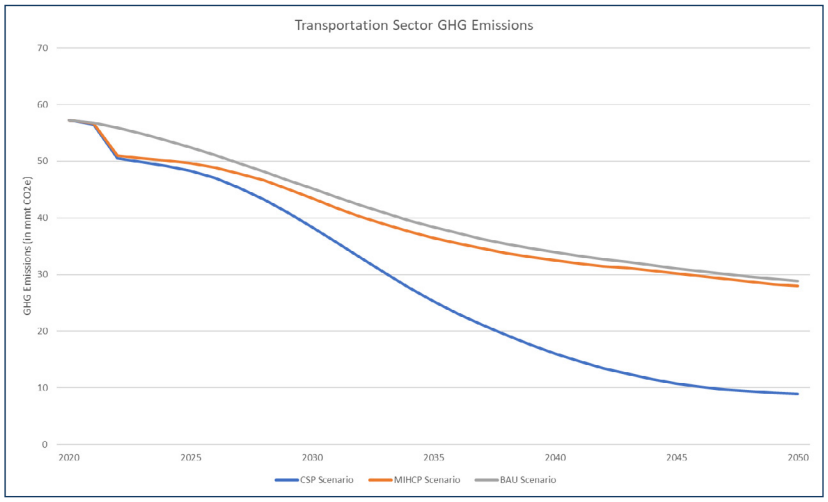


Fig. 6

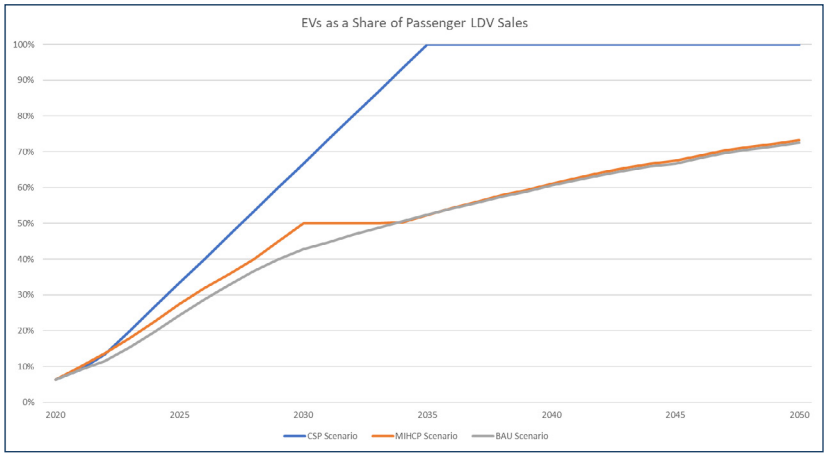
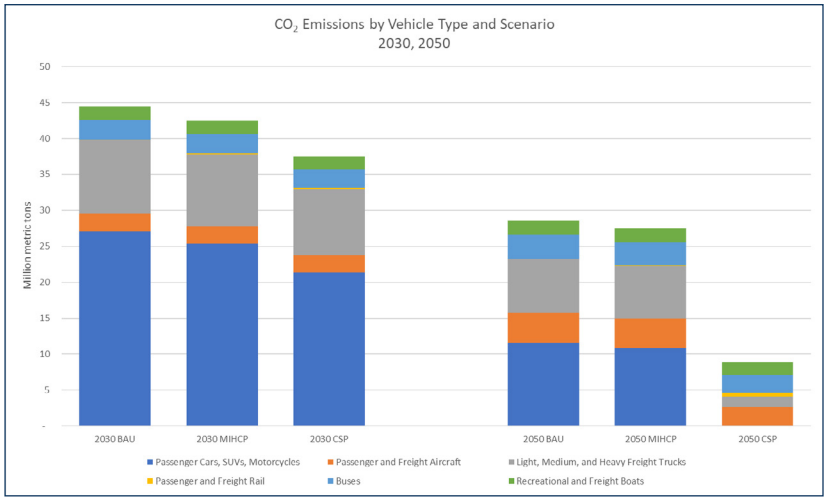


Fig. 7



In comparison, the MIHCP shifts more quickly to EVs, but cuts GHG emissions only slightly relative to the Business As Usual scenario. The most impactful transportation measure from the MIHCP for cutting emissions is the recommendation that by 2030, Michigan "should aim for electric models to account for at least 50 percent of light-duty vehicle sales, 30 percent of medium- and heavy-duty vehicle sales and 100 percent of public transit vehicles and school [bus]" sales.[36] The state plan does not specifically name all of the policies that would achieve these targets, and without clear policies in place to reach these sales goals, Michigan simply will not get there on the timeline necessary to meet its climate goals. Given that omission, we recommend the state implement policies that require a certain percentage of vehicle sales as EV sales by a certain date, similar to those that have been proposed or passed in Washington[37] and Canada[38] and the zero-emission vehicles and advanced clean truck policies in California.[39, 40]

The MIHCP also includes new incentives and financing programs for the purchase of EVs and the installation of EV infrastructure, which are included in the EPS model. The plan also calls for increasing access to clean transportation options, which include public transit, by 15% each year, as well as increasing the availability of safe walking and biking options. Overall, the MIHCP achieves a 27% reduction in transportation-related emissions by 2030 relative to 2005, only a 3% greater reduction than projected in the Business As Usual scenario.

The Climate Solutions Pathway goes several steps further and specifies clear sales requirements—similar to the clean car standards in other states—to ensure that all new light-duty vehicles are electric by 2035. We also go beyond the MIHCP's actions on public transit and school buses and require that sales of electric buses and heavy-duty freight vehicles reach 100% by 2035 (*Fig. 16*). As a result of these more aggressive policies, the fleet of vehicles turns over more quickly and ICE vehicles are increasingly replaced by EVs, making it possible to drive transportation-related emissions down to 9 MMT by 2050—an 85% decrease from 2005 levels. In contrast, by switching to EVs more slowly, the MIHCP scenario has fewer of these turnover effects and transportation-related emissions remain at 28 MMT by 2050, or a 53% decrease relative to 2005.

Other policies enacted in the transportation sector in the Climate Solutions Pathway include building out EV infrastructure so that there are 255 EV chargers per 100,000 people, fleet-wide fuel economy improvements, vehicle miles traveled reductions due to better and expanded transit and non-motorized modes of travel, and a near-term, small subsidy for EV purchases. EPS also models further declines in transportation-related emissions from the gains in EV range and owner experience that come with the vehicles rising in popularity. However, the clean car and truck standards across vehicle categories is still the largest driver of GHG reductions in the Climate Solutions Pathway scenario. Emissions in all vehicle categories fall. Some emissions from transportation remain, specifically from aircraft, heavy-duty trucks, and some recreational vehicles like boats by 2050.

In summary, our modeling shows that to decarbonize our transportation sector we must adopt policies that reduce overall vehicle miles traveled, while using clear and strong sales standards to ensure

the remaining vehicles on the road are all-electric. To accomplish this, the Climate Solutions Pathway recommends substantially increasing access to charging stations; requiring sales of light-duty vehicles, heavy-duty vehicles, and motorbikes to be electric by 2035 (e.g. clean car and truck standards); and reducing driving by expanding transit and non-motorized transit options.

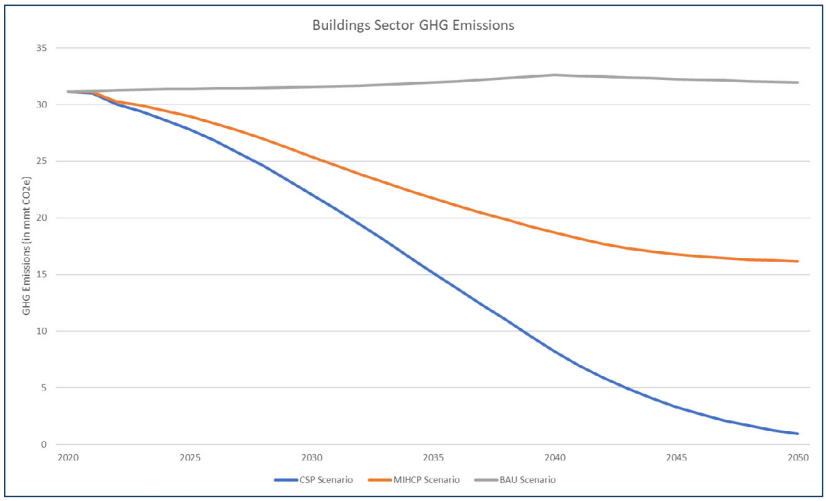
Buildings and Appliance Sector

Reducing energy use through efficiency improvements to buildings and switching to highly efficient electric space and water heating and cooking are critical to meeting Michigan's GHG reduction goals. In the Midwest, emissions associated with on-site fossil fuel combustion in buildings have been stubbornly consistent for several decades, accounting for 15-20% of total emissions depending on the state, largely attributed to home heating needs.[41] This is not surprising when one considers the fact that Michigan relies more heavily on fossil fuels for home heating than the national average. More than 80% of the state's homes use either gas or propane for space heating.[42]

The Climate Solutions Pathway models several building policies which, in conjunction with decarbonization of the electric grid, reduce total energy use and direct emissions from Michigan's building stock. The most important policy in this sector is a sales standard requiring 100% of all new heating equipment sales to be electric by 2035 and setting interim targets leading up to 2035.

Due to a lack of policies to spur the market and increase consumer incentives for electric appliances, both energy use and emissions from buildings increase between 2020 and 2050 in the Business As Usual scenario (*Fig. 8*). Gas use in buildings increases over time as decarbonization stalls and gas remains the dominant fuel. GHG emissions from buildings in the Business As Usual scenario increase by 5% to 32.5 MMT from 2020 to 2050. In this case, adoption of electric appliances and HVAC equipment is trivial in the absence of policy drivers; while electricity used in buildings increases by 30% from 2020 to 2050, it is still significantly less than total gas usage.

Fig. 8



The MIHCP heavily relies on energy efficiency as the key driver of emissions reductions in the buildings sector. Critically, the plan calls for an increase in Michigan's energy waste reduction standards. In addition, the MIHCP mentions a goal of

cutting emissions from heating homes and businesses by 17% by 2030, but does not include specific policies for how to achieve that reduction. Because the EPS models policies, the lack of specific policy direction in the MIHCP meant that we were unable to model the 17% target. Included in this scenario, however, is MIHCP's recommendation to use building codes to ensure building efficiency continues to improve and to require that new buildings include EV charging capability. We also model the MIHCP recommendation for customer incentives to purchase electric appliances with an assumption that 21% of newly sold non-electric building components will be electric by 2030. Despite embracing energy efficiency, the MIHCP falls short of needed GHG emissions reductions because it fails to prioritize electrification of buildings. Overall, emissions in the buildings sector fall by 24% in 2030 and 52% in 2050 relative to 2005 in the MICHP scenario.

In contrast to the MIHCP, the Climate Solutions Pathway requires 100% of new building appliances and heating systems sold to be electric by around 2035. We also speed up building retrofits to increase energy efficiency and help electrify existing building stock. Because of the long lives of buildings as an asset and the infrequent turnover of building appliances, these steps have important, long-lasting effects on emissions after 2030. This scenario confirms that policy action that moves buildings toward electrification and efficiency as soon as possible pays dividends through the 2050 timeframe.

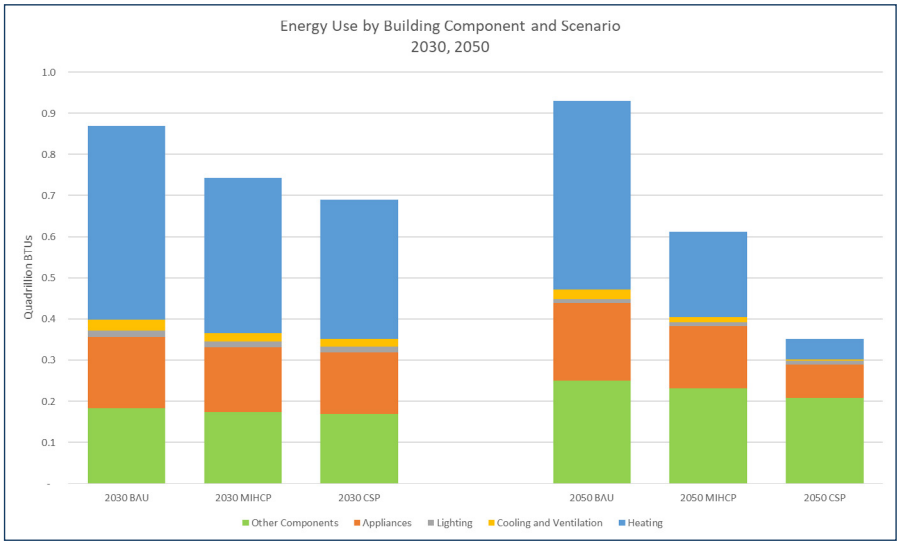
Michigan regulators will be making a decision in 2022 on whether or not to adopt the 2021 International Energy Conservation Code. Adopting that code and the New Buildings Institute's Building Decarbonization Code overlay would make new buildings more efficient and require them to be "electrification-ready" by, for example, ensuring that buildings have the correct outlets for electric appliances should a resident choose that path, among many other provisions. While the policies assumed in the Climate Solutions Pathway would require a far greater degree of building electrification than these code revisions would achieve, adopting the 2021 International Energy Conservation Code and Building Decarbonization Code overlay now would be an important foundational step and help the buildings sector transition more cost effectively down the road.

The shift to electric appliances in our buildings will take time and effort so it is imperative that we make incremental progress on it in the next several years. Electrification is fundamentally a problem of scale, requiring the replacement of millions of pieces of equipment. These replacements typically occur when an existing HVAC system breaks or reaches the end of its life. Thus, it is necessary to create incentives and programs now that make air source and other electric heat pumps and induction stoves readily available and easy to install. Electric building components, including induction cooktops and the new generation of highly efficient electric heat pumps, are approaching (or have already achieved) cost parity with their gas-fired counterparts while operating more efficiently with no indoor emissions or health effects.[43]

In addition to a clear target for electric appliance sales, the Climate Solutions Pathway also includes deep energy efficiency retrofits of all buildings built prior to 2020. To achieve this Michigan will need increased energy efficiency standards and programs that target improved building envelopes and offer

contractor training, among other measures. In the Climate Solutions Pathway, *electricity* use in buildings rises by 2050 relative to 2020, but overall *energy* use in buildings decreases by more than half, primarily due to the shift from gas furnaces to efficient electric heating systems. Total energy use for heating buildings decreases by 87% from 2020 to 2050 (*Fig. 9*). By 2050, these policies will reduce emissions by 97% relative to 2005 levels in the Climate Solutions Pathway scenario.

Fig. 9



Industrial Sector

Industry in Michigan is diverse, with large industrial activity from waste, mineral, and metal production; pulp and paper processing; petrochemical refineries; and more.[44] Many of these processes involve directly burning fossil fuels. The industrial sector is responsible for 24% of Michigan's GHG emissions in 2020, rising to 31% by 2050 in the Business As Usual scenario.

In the MIHCP, industrial GHG emissions also rise, but by 2% in 2050 relative to 2005 levels, representing less of an increase than in Business as Usual. This difference in the MIHCP can be attributed to decreased industrial activity in chemicals, energy pipelines, and gas processing. However, emissions increases from many other sectors, such as construction and cement, offset these gains between 2020 and 2050. The MIHCP encourages several other steps to reduce industrial emissions, such as incentives and technical assistance for energy efficiency in the industrial sector, developing "clean innovation hubs," and "explor[ing]" the use of carbon capture and sequestration for hard-to-electrify industries. However, these recommendations lack sufficient policy detail and were therefore not included in our modeling of the MIHCP scenario. It is notable that the MIHCP largely omits industrial sector electrification in its policy recommendations, which limits the amount of emissions reductions that the MIHCP can achieve in this sector.

In contrast, the Climate Solutions Pathway models a shift largely to electrified end uses where possible in addition to other limited but emerging decarbonization options, such as hydrogen produced using

renewable energy (i.e., green hydrogen), for a small proportion of the hardest-to-electrify industrial applications. *Fig. 10* shows the significant decrease in emissions achieved by these additional steps.

Michigan also has significant gas transmission and processing activity, which is a source of methane leakage and uncaptured emissions. The Climate Solutions Pathway models full methane capture and destruction, fluorinated gas emissions reductions, cement clinker substitution, moderate industrial energy efficiency, and some recycling measures. For industrial processes that are particularly hard to electrify–like chemicals, cement and metals–we model partial carbon capture and sequestration. Overall, industrial GHG emissions fall by 78% by 2050 with the largest reductions by magnitude coming from iron and steel, cement, chemicals, oil and gas extraction and refining, and construction.

Fig. 10

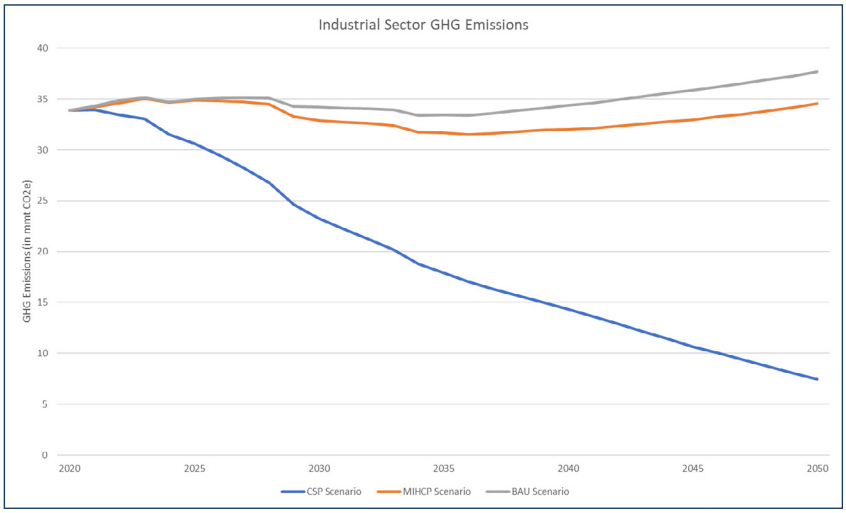
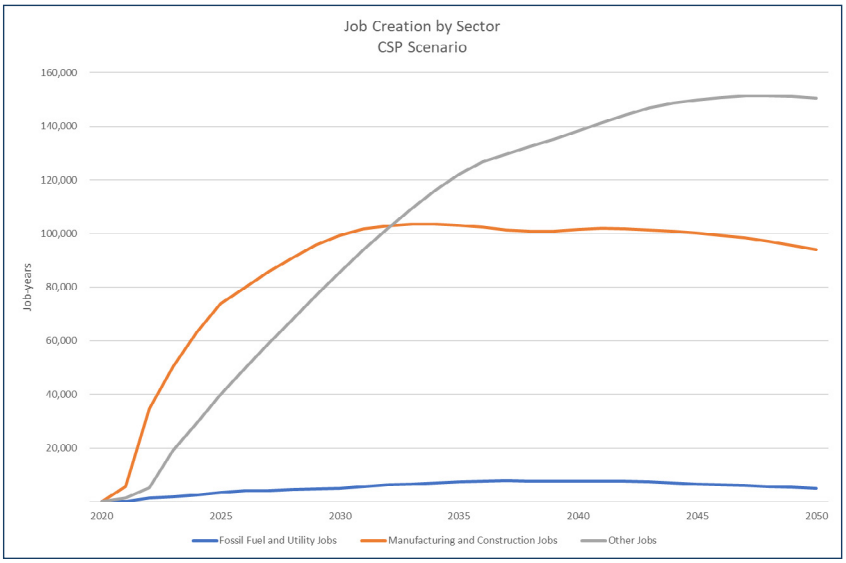


Fig. 11



Economic and Public Health Benefits

The policies included in the Climate Solutions Pathway will require new solar and wind projects, retrofitting buildings, installing vehicle charging infrastructure, and much more. The state-level input-output analysis embedded in the EPS estimates that these policies can support roughly 190,000 net full-time equivalent (FTE) job-years in 2030, including 100,000 in construction and manufacturing alone, and 250,000 net FTE job-years in 2050 (*Fig. 11*).[45] The effects of job growth ripple outward, adding a net $28 billion to Michigan's GDP by 2030 and over $45 billion in 2050 (in 2020 dollars).

Additional policies not modeled by the EPS will be necessary to ensure these newly created jobs benefit communities historically reliant upon or harmed by the fossil fuel economy with high-quality jobs paying fair wages. Policy can support a sustainable, equitable, and just transition by considering impacted communities when choosing the location of new clean energy infrastructure projects. Michigan must also ensure we prioritize incentives for residents that are low-income and Black, Indigenous and other people of color so they can access energy efficiency, electrification, public transit, EVs, and other clean energy programs. Policymakers can also create training programs to equip transitioning workers and residents of frontline communities with the required energy sector skills, among other efforts. Other policies can provide for basic needs such as healthcare or other financial assistance to ease the transition.[46]

The Climate Solutions Pathway also unlocks significant health benefits. Fossil fuel power plant retirements, emissions-free building appliances, zero-emission, on-road vehicles, and industrial fuel switching all reduce harmful particulate matter in the air we breathe and secondary atmospheric pollution created by burning fossil fuels. The Michigan EPS—which includes a simple assessment of these benefits based on regional emissions factors by fuel and end use[47] estimates that the Climate Solutions Pathway policies would prevent more than 300 deaths and over 3,900 asthma attacks per year by 2030 and more than 1,000 deaths and over 13,000 asthma attacks per year by 2050. Including a conservative estimate of the benefits of reduced climate pollution,[48] the monetized health and other social benefits reach nearly $21 billion per year by 2050 (*Fig. 12*).

Fig. 12

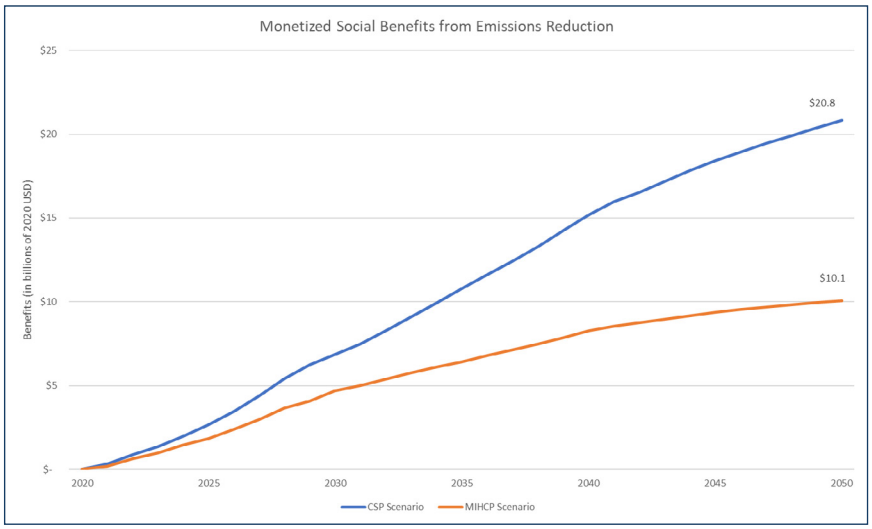
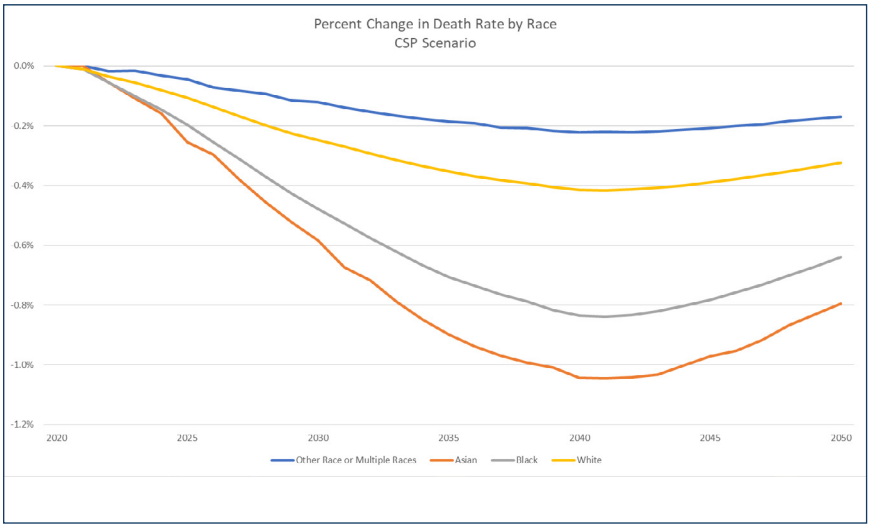
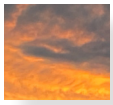


Fig. 13



It is well-documented that low-income households and racial and ethnic minorities are exposed to higher amounts of air pollution. As a result, they suffer from higher incidences of negative health effects and higher premature mortality rates compared to other groups.[49] The EPS model shows that the highest magnitude percent reduction in death rate occurs for Black and Asian residents (*Fig. 13*).

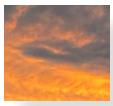
The Climate Solutions Pathway reduces these harms by eliminating the sources of air pollution that disproportionately affect already overburdened communities rather than relying on carbon credits and offsets. This includes reducing emissions from fossil fuel-burning power plants,[50] the burning of gas and other fossil fuels in buildings that contribute to poor indoor air quality,[51] and transportation-related pollution such as harmful diesel exhaust from medium- and heavy-duty trucks that harms communities close to highways and areas of high traffic.[52]



Conclusion

Gov. Whitmer's Executive Directive 2020-10 made clear that the transition to carbon neutrality "will require sustained and concerted effort from every sector of this state's economy, and it must be done right to ensure that all workers, businesses and communities can meet its challenges and reap its benefits in equal measure. But Michiganders know hard work and are up to the task at hand: for the sake of our present and our future."

The policy actions that make up the Climate Solutions Pathway will indeed require hard work from a multitude of actors across the state's economy and government, including policymakers at the state, local and, in some cases, federal levels. But the health of Michigan's people, environment, and economy depend on that hard work and on Michigan's leadership making decisive policy progress this decade to put us on track to tackle the climate crisis longer term. We have the opportunity to leverage all of the policy tools at our disposal in the power, transportation, buildings, and industrial sectors to ensure a livable climate and a more prosperous and healthy state for generations to come.



Appendix

Table 4

Policy Levers by Scenario				
Sector	**Strategy**	**Expressed as**	**Climate Solutions Pathway Scenario**	**MIHCP Scenario**
ELECTRICITY	Clean Electricity Standard	% of generation from non-emitting sources	42.6% of electricity from non-emitting sources in 2021, rises to 80% in 2030, 100% in 2035	60% of electricity is generated from renewables in 2030 to represent 50% RPS and 10% from distributed generation and other sources
	Early Retirement of Power Plants	MW retired per year by generator type	Accelerated coal plant retirements, all coal retired by 2030, gas nonpeakers retired gradually by 2040	Accelerated coal plant retirements, all coal retired by 2030
	Demand Response	% of demand response potential achieved	100% of demand response potential achieved in all years 2021-2050, up to 8,000 MW	
	Grid-Scale Energy Storage	MW of energy storage	Up to 16,500 MW of grid-scale energy storage by 2050	Follows MI Energy Storage Roadmap storage deployment targets
	Ban New Power Plants	Yes/No	No new fossil, nuclear or hydro plants	No new fossil, nuclear, or hydro plants
	Increase Transmission	% increase relative to Business As Usual scenario	113% increase available, up to 3756 MW	
	Carbon Capture and Sequestration	% of carbon emissions captured/sequestered	100% carbon capture/sequestration on all carbon-emitting plants achieved linearly from 0% in 2025 to 100% in 2040	
TRANSPORTATION	EV Sales Standard	% of new vehicles sold	100% electric sales of passenger/freight light- and heavy-duty vehicles, and motorbikes by 2035	50% electric sales of passenger light-duty vehicles by 2030; 30% of light- and medium- duty commercial vehicles, freight heavy-duty vehicles and buses by 2030
	EV Subsidy	% of new vehicle cost after federal subsidies	7% subsidy reflecting $2500 credit in 2023-2025, phasing out to 0% linearly by 2030	7% subsidy reflecting $2500 credit in 2022-2025, phasing out to 0% by 2031
	Fuel Economy Standard	% increase in fuel economy	50 to 60% increase in fleet fuel economy for most on-road vehicles, 25% increase in rail fuel economy	
	Low Carbon Fuel Standard	% reduction in carbon emissions	–	5% reduction in emissions by 2030
	Mode Shifting	% of trips shifted	15% reduction in passenger light-duty vehicle trips and 6% reduction in freight heavy-duty vehicle trips by 2035	2.7% of trips shifted by 2030, 3% by 2050
BUILDINGS	Building Component Electrification	% of newly sold building components	90% electric sales of all building components by 2040, 100% by 2050	90% electric sales of all building components by 2040, 100% by 2050
	Building Energy Efficiency Standards	% reduction in energy use	75% reduction in envelope energy usage, 11% to 16% reduction in energy usage for heating, cooling, ventilation, lighting, and appliances	75% reduction in envelope energy usage, 11% to 16% reduction in energy usage for heating, cooling, ventilation, lighting, and appliances
	Contractor Training	On/Off	On	On
	Improved Labeling	On/Off	On	On
	Retrofit Existing Buildings	% of existing buildings	Accelerated retrofit of all pre-existing buildings prior to 2050	Accelerated retrofit of all pre-existing buildings prior to 2050
	Rebate for Efficient Products	On/Off	On	On

Table 4 (Continued)

Policy Levers by Scenario (Continued)				
Sector	**Strategy**	**Expressed as**	**Climate Solutions Pathway Scenario**	**MIHCP Scenario**
INDUSTRY	Carbon Capture and Sequestration	% of emissions captured/ sequestered	50% of process emissions captured in chemicals, cement, and iron and steel production by 2050	
	Cogeneration and Waste Heat Recovery	% of potential emissions reductions achieved		20% of potential achieved by 2030
	Cement Clinker Substitution	% of potential achieved	100% of potential achieved, reducing the share of clinker in cement to 60% by 2030	
	Industry Energy Efficiency Standards	% reduction in energy use	14% reduction in industrial fuel use across all industry categories by 2050	
	Electrification and Hydrogen	% of fuel shifted	Multiple values for industrial fuel shifting to both hydrogen (6% to 8%) and electricity (29% to 94%) across all industry categories	
	F-Gas Substitution, Destruction, Recovery, Maintenance, and Retrofits	% of potential achieved	100% of potential achieved by 2030	
	Material Efficiency, Longevity, and Re-Use	% of demand reduction	10% of demand reduced for cement, 15% of demand reduced for iron and steel by 2050	10% of demand reduced for cement, iron, and steel. 22% demand reduced for water and waste
	Methane Capture and Destruction	% of potential achieved	100% of potential achieved for oil and gas extraction; energy pipelines and gas processing; coal mining; and water/waste by 2030	
AGRICULTURE, LAND USE, AND FORESTRY	Afforestation and Reforestation	% of potential achieved	20% of potential afforestation/ reforestation achieved by 2030 representing roughly 23,000 acres per year	5% of potential achieved by 2030 representing roughly 5,750 acres per year
	Forest Set-Asides	% of potential achieved	20% of potential reduced timber harvesting by 2030	
	Cropland and Rice Measures	% of potential achieved	100% of potential achieved by 2030 reducing agricultural process emissions by 2%	10% of potential achieved by 2030 reducing agricultural process emissions by 0.2%
	Improved Forest Management	% of potential achieved	100% of potential achieved by 2030	5% of potential achieved by 2030
	Livestock Measures	% of potential achieved	100% of potential achieved by 2030 reducing agricultural process emissions by 10%	
OTHER	Shift Hydrogen Production to Electrolysis	% of hydrogen production	100% of hydrogen production shifted to electrolysis by 2050	

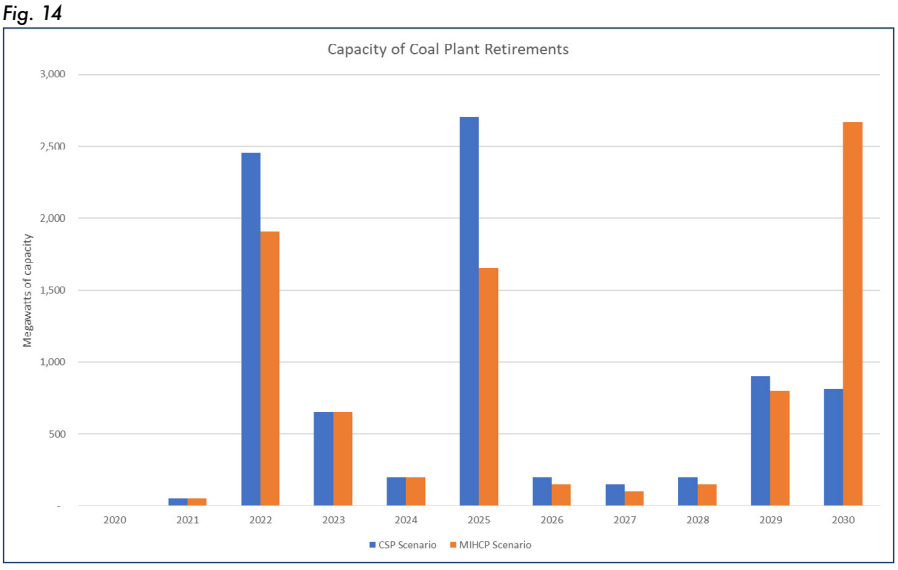
Table 5

Climate Solutions Pathway Scenario Coal Plant Retirements			
Year	**Coal Capacity (MW)**	**Coal Retirements (MW)**	**Retiring Plant Name**
2020	8334	0	
2021	8284	-50	Eckert Station
2022	5827	-2457	River Rouge 3, St Clair 2, St Clair 3, St Clair 6, St Clair 7, Trenton Channel 9, Erickson Station 1
2023	5175	-652	Dan E Karn 1A, Dan E Karn 1B, Dan E Karn 2A, Dan E Karn 2B
2024	4974	-201	
2025	2267	-2708	J H Campbell 1, J H Campbell 2, J H Campbell 3, Belle River 1, Belle River 2
2026	2066	-201	
2027	1916	-150	
2028	1715	-201	
2029	813	-903	Monroe 1, Monroe 2
2030	0	-813	Monroe 3, Monroe 4

Table 6

MIHCP Scenario Coal Plant Retirements			
Year	**Coal Capacity (MW)**	**Coal Retirements (MW)**	**Retiring Plant Name**
2020	8334	0	
2021	8284	-50	Eckert Station
2022	6378	-1905	River Rouge 3, St Clair 2, St Clair 3, St Clair 6, St Clair 7, Trenton Channel 9
2023	5726	-652	Dan E Karn 1A, Dan E Karn 1B, Dan E Karn 2A, Dan E Karn 2B, Erickson Station 1
2024	5526	-201	
2025	3871	-1655	J H Campbell 1, J H Campbell 2, J H Campbell 3
2026	3721	-150	
2027	3620	-100	
2028	3470	-150	
2029	2668	-802	Belle River 1, Belle River 2 (phased out 2026 to 2029)
2030	0	-2668	Monroe 1, Monroe 2, Monroe 3, Monroe 4

Fig. 14



Understanding Business as Usual (Business As Usual) Assumptions

Energy Innovation® and RMI built a forecast of Michigan's economy-wide GHG emissions through 2050 using publicly available, national models of energy consumption (The US Energy Information Agency [EIA] Annual Energy Outlook[53] and the National Renewable Energy Laboratory [NREL] Electrification Future Study). The Business As Usual Scenario is the model's foundation, capturing projected changes based on economic growth, technology, cost changes, and existing policy commitments.

Table 7 below summarizes the policies included in the Business As Usual scenario.

Table 7

Sector	Business As Usual Scenario
Electricity	• Does not include recent federal policy (Energy Act of 2020/ Infrastructure Investment and Jobs Act) • Assumes all currently planned retirements are completed on time
Buildings	• From EIA's Annual Energy Outlook and NREL • Assumes some equipment performance improvements over time, based on market data[54]
On-Road Transportation	• From EIA's Annual Energy Outlook and NREL • Includes 2012 Federal Corporate Average Fuel Economy Standards (CAFE) standards[55] • Federal EV subsidies • Economic adoption of EVs[56]
Industry	• From EIA's Annual Energy Outlook and NREL • Assumes equipment performance improvements over time[57] • Does not include implementation of the Kigali Amendment to the Montreal Protocol
Land Use/Agriculture	• Agriculture, biomass, and forestry projections
Imports/Exports	• Imported electricity emissions held constant

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Table 5

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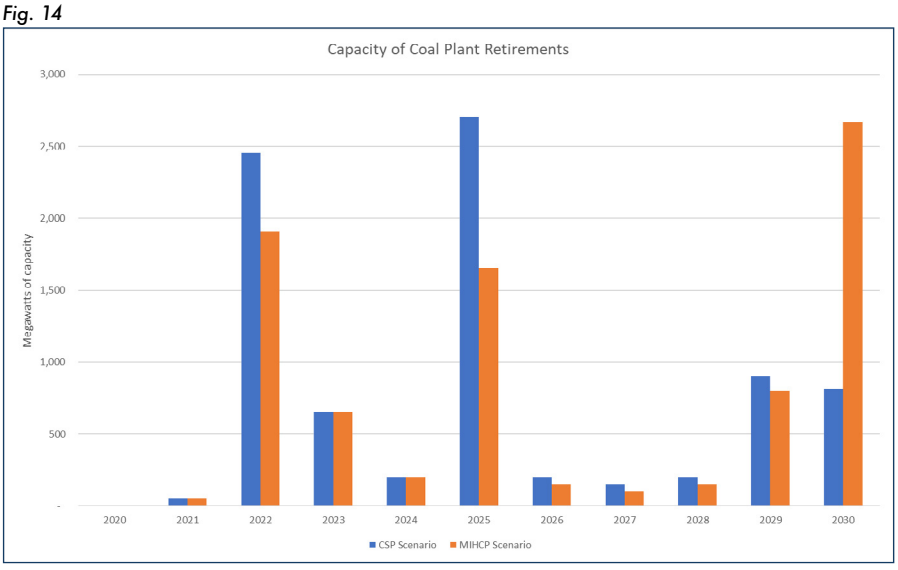
2025	3871	-1655	J H Campbell 1, J H Campbell 2, J H Campbell 3
2026	3721	-150	
2027	3620	-100	
2028	3470	-150	
2029	2668	-802	Belle River 1, Belle River 2 (phased out 2026 to 2029)
2030	0	-2668	Monroe 1, Monroe 2, Monroe 3, Monroe 4

Fig. 14



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17. While the model can report emissions by GHG pollutant, sector-wide or policy-wide emissions are reported in terms of energy-related CO_2. Other GHGs are still impactful, especially in certain sectors such as industrial where methane and f-gases comprise a larger share of GHG emissions. However, CO_2 represents the majority of GHG emissions in terms of warming potential.

18. "Energy-related CO_2 emissions" includes emissions from burning fossil fuels. They include emissions from power plants, vehicles and fuels used to power building systems (such as propane or methane gas burned for heating) and industrial processes. Non-energy related emissions could include emissions from agriculture, land use or forestry among other sources. We choose to omit these sources from our report, not because they are insignificant, but because they are difficult to quantify reliably.

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23. Major Michigan corporations such as General Motors have set aside a significant role for offsets in their plans to account for GHG emissions reductions. A major part of DTE's net-zero emissions plan is to invest in forest protection to generate carbon credits that the company can sell to offset emissions from gas use. General Motors, General Motors, the Largest U.S. Automaker, Plans to be Carbon Neutral by 2040, January 2021, https://media.gm.com/media/us/en/gm/home.detail.html/content/Pages/news/us/en/2021/jan/0128-carbon.html. Midland Daily News, Nation's first carbon offset project on state forest land is in Michigan, Aug. 30, 2021, https://www.ourmidland.com/news/article/Nation-s-first-carbon-offset-project-on-state-16414493.php#:~:text=DTE%20 Energy%20will%20offer%20these,Forest%20during%20 the%20first%20decade.

24. The Michigan EPS complements but does not replace more granular analytical approaches such as energy demand, infrastructure turnover, energy supply optimization, electricity system reliability analysis, and mapping to ensure policies enhance equity and improve environmental justice outcomes. Many policies included in a specific EPS policy package induce emissions changes across economic sectors. The EPS cannot attribute these changes accurately between economic sectors.

25. While the model can report emissions by pollutant, sector-wide or policy-wide emissions are reported as "GHG emissions" in terms of CO2-equivalent (CO2e), reflecting that other emissions, such as methane or fluorinated gases, also contribute to atmospheric warming.

26. This scenario reflects emissions by sector assuming existing policy commitments, expected technology and cost changes, announced power plant retirements, population growth, building turnover, market-driven renewable energy, EV adoption, and certain forecasted federal policy assumptions. See *Table 4* in the Appendix for a list of policies assumed by the Business As Usual scenario.

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29. E2, *Clean Jobs America* 2022, August 3, 2022, https://e2.org/reports/clean-jobs-america-2022/.

30. The EPS uses a process called "quantization" such that plant retirements in the model are based on summer capacities but altered slightly. For simplicity, we report the summer capacity of embedded plant retirements.

31. The EPS does not include accelerated retirements announced in recent utility IRPs, nor does it allow for the continued operation of the Palisades nuclear plant. To maintain grid reliability amidst moderate load growth and capacity retirements, the model adds capacity for several resource types between now and 2050. *Fig. 14* shows capacity additions and subtractions over time by generator type.

32. From 2023 to 2039, gas nonpeaker capacity is retired, with annual retirements incrementally ramping up from 150 to 700 MW/year gradually. Gas nonpeaker capacity is completely retired by 2040.

33. The resources qualifying as "non-emitting" under this standard are wind, solar, biomass, nuclear, hydropower, and geothermal. Some peaking plants remain online for resource adequacy and emit less than 5 MMT of CO2e per year from 2035 to 2040.

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35. Consumer Reports, *EVs Offer Big Savings Over Traditional Gas-Powered Cars*, Oct. 8, 2020, https://www.consumerreports.org/hybrids-evs/evs-offer-big-savings-over-traditional-gas-powered-cars/.

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37. Utility Dive, *Washington legislators again mandate 100% electric new car sales by 2030*, March 14, 2022, https://www.utilitydive.com/news/washington-legislators-again-mandate-100-electric-new-car-sales-by-2030/620303/.

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