On the Road to 100 Percent Renewables

States Can Lead an Equitable Energy Transition

COPAL

GreenRoots

Michigan Environmental Justice Coalition

Union of Concerned Scientists

Executive Summary

Demands for climate action surround us. Every day brings news of devastating "this is not normal" extreme weather: record-breaking heat waves, precipitation, flooding, wildfires. To build resilience and mitigate the worst impacts of the climate crisis requires immediate action to reduce heat-trapping emissions and transition to renewable energy.

On the Road to 100 Percent Renewables explores actions at one critical level: how leadership states can address climate change by reducing heat-trapping emissions in key sectors of the economy as well as by considering the impacts of our energy choices. A collaboration of the Union of Concerned Scientists and local environmental justice groups COPAL (Minnesota), GreenRoots (Massachusetts), and the Michigan Environmental Justice Coalition, with contributions from the national Initiative for Energy Justice, assessed the potential to accelerate the use of renewable energy dramatically through state-level renewable electricity standards (RESs), major drivers of clean energy in recent decades. In addition, the partners worked with Greenlink Analytics, an energy research organization, to assess how RESs most directly affect people's lives, such as changes in public health, jobs, and energy bills for households.

Focusing on 24 members of the United States Climate Alliance (USCA), the study assesses the implications of meeting 100 percent of electricity consumption in these states with renewable energy in the near term. The alliance is a bipartisan coalition of governors committed to reducing heat-trapping emissions consistent with the goals of the 2015 Paris climate agreement.[1]

On the Road to 100 Percent Renewables looks at three types of results from a transition to 100 percent RES policies: improvements in public health from decreasing the use of coal and gas[2] power plants; net job creation from switching to more labor-oriented clean energy; and reduced household energy bills from using cleaner sources of energy. The study assumes a strong push to electrify transportation and heating to address harmful emissions from the current use of fossil fuels in these sectors. Our core policy scenario does not focus on electricity generation itself, nor does it mandate retiring coal, gas, and nuclear power plants or assess new policies to drive renewable energy in non-USCA states.

Our analysis shows that:

- USCA states can meet 100 percent of their electricity consumption with renewable energy by 2035 even with strong increases in demand due to electrifying transportation and heating.
- A transition to renewables yields strong benefits in terms of health, climate, economies, and energy affordability.
- Renewable electricity standards must be paired with policies that address not only electricity consumption but also electricity generation, both to transition away from fossil fuels more quickly and to ensure an equitable transition in which all communities experience the benefits of a clean energy economy.

Currently, the states in this analysis meet their electricity needs with differing mixes of electricity sources—fossil fuels, nuclear, and renewables. Yet across the states, the study shows significant declines in fossil fuel use from transitioning to clean electricity; the use of solar and wind power—the dominant renewables—grows substantially:

- In the study's "No New Policy" scenario—"business as usual"—coal and gas generation stay largely at current levels over the next two decades. Electricity generation from wind and solar grows due to both current policies and lowest costs.
- In a "100% RES" scenario, each USCA state puts in place a 100 percent renewable electricity standard. Gas generation falls, although some continues for export to non-USCA states. Coal generation essentially disappears by 2040. Wind and solar generation combined grow to seven times current levels, and three times as much as in the No New Policy scenario.

A focus on meeting in-state electricity consumption in the 100% RES scenario yields important outcomes. Reductions in electricity from coal and gas plants in the USCA states reduce power plant pollution, including emissions of sulfur dioxide and nitrogen oxides. By 2040, this leads to 6,000 to 13,000 fewer premature deaths than in the No New Policy scenario, as well as 140,000 fewer cases of asthma exacerbation and 700,000 fewer lost workdays. The value of the additional public health benefits in the USCA states totals almost $280 billion over the two decades. In a more detailed analysis of three USCA states—Massachusetts, Michigan, and Minnesota—the 100% RES scenario leads to almost 200,000 more added jobs in building and installing new electric generation capacity than the No New Policy scenario.

The 100% RES scenario also reduces average energy burdens, the portion of household income spent on energy. Even considering household costs solely for electricity and gas, energy burdens in the 100% RES scenario are at or below those in the No New Policy scenario in each USCA state in most or all years. The average energy burden across those states declines from 3.7 percent of income in 2020 to 3.0 percent in 2040 in the 100% RES scenario, compared with 3.3 percent in 2040 in the No New Policy scenario.

Decreasing the use of fossil fuels through increasing the use of renewables and accelerating electrification reduces emissions

Cover photo: Dennis Schroeder/NREL

of carbon dioxide (CO_2), with implications for climate, public health, and economies. Annual CO_2 emissions from power plants in USCA states decrease 58 percent from 2020 to 2040 in the 100% RES scenario compared with 12 percent in the No New Policy scenario.

The study also reveals gaps to be filled beyond eliminating fossil fuel pollution from communities, such as the persistence of gas generation to sell power to neighboring states. Further, it stresses the importance of policies targeting just and equitable outcomes in the move to renewable energy.

Moving away from fossil fuels in communities most affected by harmful air pollution should be a top priority in comprehensive energy policies. Many communities continue to bear far too large a share of the negative impacts from decades of siting the infrastructure for the nation's fossil fuel power sector in or near marginalized neighborhoods. This pattern will likely persist if the issue is not acknowledged and addressed. State policies should mandate a priority on reducing emissions in communities overburdened by pollution and avoiding investments inconsistent with the need to remove heat-trapping emissions and air pollution at an accelerated rate. And communities must be centrally involved in decisionmaking around any policies and rules that affect them directly, including proposals to change electricity generation, both to retire fossil fuel plants and to build the renewable energy infrastructure.

Key recommendations in *On the Road to 100 Percent Renewables* address moving away from fossil fuels, increasing investment in renewable energy, and reducing CO_2 emissions. They aim to ensure that communities most affected by a history of environmental racism and pollution share in the benefits of the transition: cleaner air, equitable access to good-paying jobs and entrepreneurship alternatives, affordable energy, and the resilience that renewable energy, electrification, energy efficiency, and energy storage can provide. While many communities can benefit from the transition, strong justice and equity policies will avoid perpetuating inequities in the electricity system. State support to historically underserved communities for investing in solar, energy efficiency, energy storage, and electrification will encourage local investment, community wealth-building, and the resilience benefits the transition to renewable energy can provide.

A national clean electricity standard and strong pollution standards should complement state action to drive swift decarbonization and pollution reduction across the United States. Even so, states are well positioned to simultaneously address climate change and decades of inequities in the power system. While it does not substitute for much-needed national and international leadership, strong state action is crucial to achieving an equitable clean energy future.

Introduction

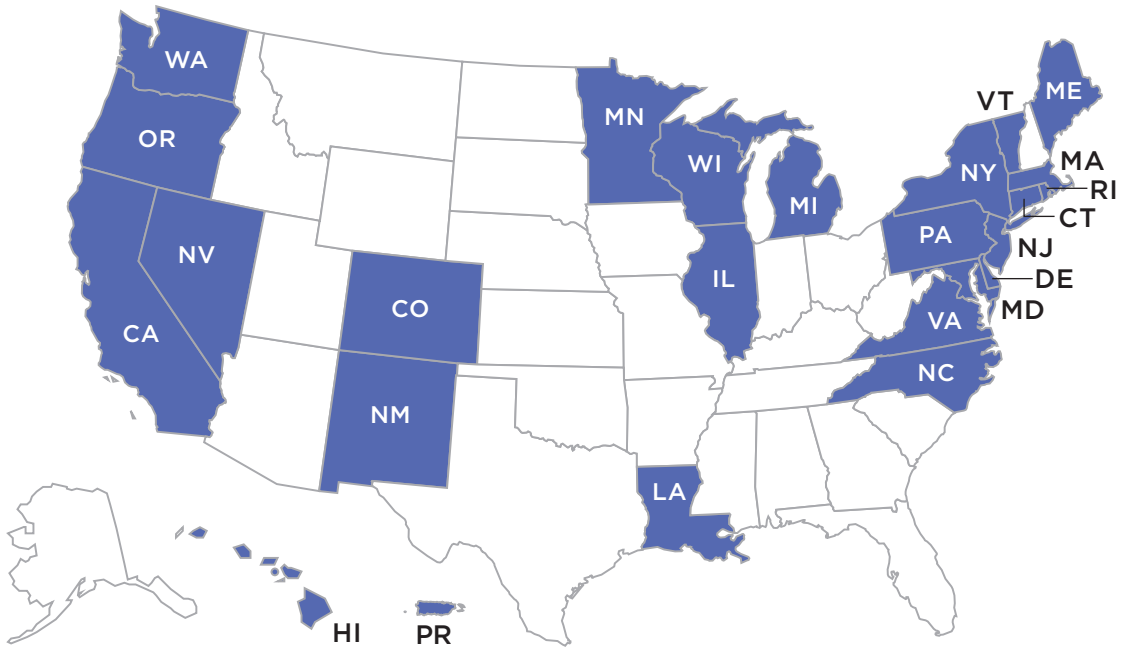
Demands for climate action surround us. Each day brings news of devastation from "this is not normal" extreme weather events: record-breaking heat waves, precipitation, flooding, wildfires. More than half of US residents (52 percent) now report they have personally experienced the effects of climate change (Leiserowitz et al. 2021). Across most of Michigan, for example, where average temperatures have increased by up to 3°F, changing weather patterns create major concerns about heat-related and respiratory illnesses, among other health effects (Michigan Department of Health and Human Services, n.d.). In 2021, following severe summer rainfall, Detroit-area families lost furnaces and water heaters when their basements flooded; many families lost power and internet for up to a week (Barrett 2021). These are among the many consequences of decades of inaction.

Nor are the impacts of climate change triggered by fossil fuel emissions limited to the environment: they also affect health, jobs, and earnings. Nationally, if we continue with business as usual, 18.4 million outdoor workers will experience seven or more unsafe workdays per year by midcentury, according to a Union of Concerned Scientists (UCS) study (Dahl and Licker 2021). Black/African American and Hispanic/Latino outdoor workers will see disproportionate impacts, with $7.5 billion to $16.1 billion of earnings at risk every year, respectively (Dahl and Licker 2021). Globally more than 8 million people died in 2018 due to air pollution from burning coal, diesel, and other fossil fuels, which are key sources of heat-trapping emissions. The pollution contributed to about one in five deaths worldwide (Vohra et al. 2021).

Yet each day also brings opportunities to think differently about the global impact of our energy choices. National and international actions are crucial to reducing heat-trapping emissions, but there is also great potential more locally to drive change. In particular, US states have an opportunity—indeed, an obligation—to help the nation as a whole address climate change by transitioning to renewable energy as quickly as possible. At the same time, states can address effects of our energy choices even beyond climate change and its impacts.

To analyze opportunities and needs in the clean energy transition from both a technical perspective *and* from the perspective of frontline communities likely to be most affected by the transition, *On the Road to 100 Percent Renewables* is a collaboration among UCS and three local environmental justice organizations—COPAL in Minnesota, GreenRoots in Massachusetts, and the Michigan Environmental Justice Coalition—with contributions from the Initiative for Energy Justice, a national organization. Also, partnering with the energy research organization Greenlink Analytics, the project explored the most direct effects

FIGURE 1. Members of the US Climate Alliance



Twenty-four states, plus the US territory of Puerto Rico, currently comprise the US Climate Alliance, a bipartisan coalition of governors committed to reducing heat-trapping emissions consistent with the goals of the Paris Agreement.

Note: Our modeling did not include areas outside the contiguous United States (Hawaii and Puerto Rico); it did include Montana, which withdrew from the USCA in 2021.

of a clean energy transition on everyday lives—changes in public health, jobs, and household energy bills.

To assess the power of state leadership, we examined what would happen if 24 states in the United States Climate Alliance (USCA) (Figure 1) follow the call from environmental justice groups and rapidly transition to 100 percent renewable energy to decarbonize the electricity grid and help limit global warming. The USCA is a bipartisan coalition of governors committed to reducing heat-trapping emissions consistent with the goals of the 2015 Paris climate agreement (USCA, n.d.). The study modeled state commitments to meeting 100 percent of their electricity consumption with renewable energy by 2035 as states act to electrify transportation and heating; that date aligns with the Biden administration's goal for achieving electricity that is free of carbon pollution. The study also modeled three additional scenarios, assessing different policy design elements with an eye toward informing our recommendations.

Our analysis had two key aims:

- Assess the technical and economic feasibility for a large portion of the United States to demonstrate a high level of clean energy leadership by moving to 100 percent renewable electricity; *and*
- Identify key recommendations toward ensuring a just and equitable transition to 100 percent renewable electricity, including the resulting distribution of health, job, wealth, and energy-affordability benefits.

Energy choices touch people's lives in many ways. Thus, the transition to clean energy should take place with strong attention to maximizing the potential public health benefits, especially for communities that have been historically most affected by environmental racism and pollution. In creating conditions for strong job creation, the transition should guarantee equitable access to job training and promote local ownership and wealth-building. And it should ensure that the savings from moving away from fossil fuels reduces energy bills for those least able to handle extra expenses.

Analyzing State Transitions to 100 Percent Renewables

How We Looked at Leadership

The analysis focused on states that have indicated strong interest in leading in a transition to clean energy—specifically, states that are part of the USCA, who have committed to developing "policy pathways and programs to decarbonize the electricity grid"

(USCA 2021). Looking at USCA states in the contiguous United States, our analysis assessed the effects if a large portion of the country fulfills that level of leadership in the absence of strong federal action. We performed a deeper analysis for Massachusetts, Michigan, and Minnesota in light of their current proposals to commit to 100 percent clean or renewable electricity.[3]

The analysis centered on two stages of modeling. The first involved the Regional Energy Deployment System (ReEDS), an electricity-sector planning model from the National Renewable Energy Laboratory (NREL, n.d.c). ReEDS considers various electricity-sector policies and projects their effects, using forecasts of costs for gas, coal, and other fuels, along with cost and performance projections for generation and other technologies. It models complex interactions among various policies, technology costs, and performance measures, at the same time ensuring the reliability of the electric system within the resolution and scope of the model.[4] ReEDS outputs include data on the construction, retirement, and use of power generation, electricity transmission, and energy storage; pollution emissions; and wholesale power prices and electricity system investments and costs.

The second stage of modeling assessed a clean energy transition in terms of direct impacts on everyday lives: changes in jobs, public health, and household energy bills. This stage used outputs from the ReEDS modeling as inputs for the Greenlink Energy Map, developed by the project partner Greenlink Analytics.

The analysis focused on two primary scenarios:

- The *No New Policy* scenario—business as usual—models existing electricity-sector policies as of July 2021. These policies include the 29 state-level renewable electricity or clean electricity standards (RESs/CESs) as well as federal tax credits that reduce the costs of solar, wind, and other renewable energy technologies with subsidies up front or per unit of electricity. This scenario includes certain announcements that electric utilities have made about retiring power plants or proposing to build new electrical generation capacity.
- The *100% RES scenario*, our core policy case, assumes that all USCA states commit to meeting 100 percent of their electricity needs with renewable energy by 2035. Most USCA states that have committed to this allow participation by a broader suite of technologies than just renewable energy, but our study focuses on renewables, which are expected to be the dominant sources of the new electrical generating capacity that results as states shift to 100 percent zero-carbon electricity. Also, renewable energy has broader support from environmental justice organizations than does the buildout of other low- or zero-carbon technologies.

TABLE 1. Key Assumptions for Each Scenario

Scenario	Key Assumptions
No New Policy	Electricity-sector policies in place as of July 2021, including the state renewable electricity or clean electricity standards and federal tax credits
100% RES	Commitment by each USCA state to meeting 100% of its electricity needs with renewable energy by 2035 56% increase in electricity demand in USCA states by 2040, reflecting strong electrification of other sectors of the economy
Electrification Without Decarbonization	Electricity-sector policies in place as of July 2021 56% increase in electricity demand in USCA states by 2040
Restricted Fossil Fuel	Focus on three states: Massachusetts, Michigan, and Minnesota Constraint on developing new gas-fueled power plants after 2025 Accelerated retirement of coal plants by 2030
Clean Electricity Standard	Inclusion of renewable energy, nuclear energy, and carbon capture and storage for meeting state 100-percent-by-2035 requirements

In the 100% RES scenario, existing nuclear plants, though not counting toward the 100 percent requirement, continue generating electricity until the end of their design lives—past 2035, in many cases—including electricity for export to non-USCA states. The scenario does not address fossil fuel plants; these may continue operating to serve non-USCA states given the interconnectedness of regional power grids and flows of electricity across state lines. This scenario incorporates significant increases in electricity demand, reflecting strong electrification of other sectors of the economy, such as transportation and home heating (NREL, n.d.a).[5] It does not include additional policies aimed at making homes and businesses more energy efficient.[6]

To consider some other electricity futures of interest, the modeling looked at three additional scenarios (Table 1):

- *Electrification Without Decarbonization:* This scenario involves the same high levels of electrification as the 100% RES scenario but without the scaled-up requirements to clean the electricity grid.
- *Restricted Fossil Fuel:* This scenario, focused on three USCA states, constrains the development of new gas-fueled power plants and accelerates the retirement of coal plants.

- *Clean Electricity Standards:* This scenario allows nuclear energy and "carbon capture and storage" (capturing and storing carbon dioxide before it is released into the atmosphere) to qualify as states seek to meet the 100-percent-by-2035 requirements. Many USCA states have taken similar approaches.

See the technical appendix at *www.ucsusa.org/resources/road-100-percent-renewables* for additional information about the study methodology.

The Findings: How the Electricity Sector Changes

The modeling projects a mix of power plants and electricity supply that ensures reliable power at the lowest cost in each scenario's demands and constraints. In both main scenarios—No New Policy and 100% RES—the country's fleet of power plants and their use evolve in the USCA states in ways that have important consequences for the residents of those and neighboring states. How much electricity we use, what its sources are, and where power plants are located all directly affect the health of individuals and communities. The amount of generating capacity fueled by the different power sources changes as some plants get built and others retire, and those changes affect the availability of jobs. How much utilities, other power-sector developers, and utility customers themselves invest in different technologies and in the electric system can affect energy bills for households and other customers.

Electricity Supply and Demand

No New Policy scenario: Electricity demand in the USCA states grows 15 percent over the next two decades. Renewable energy grows based on current policies and the favorable economics of solar and wind power, going from 25 percent of electricity supply in 2020 to 45 percent by 2040, while meeting the growth in electricity demand. However, renewables displace only some existing fossil fuel generation. Electricity from coal drops 16 percent by 2040; generation from gas remains constant. Overall, the share of electricity from fossil fuels falls from 51 percent in 2020 to 42 percent by 2040.

100% RES scenario: The move to renewable energy accelerates in USCA states to meet the 100-percent-by-2035 requirement for electricity consumption, including meeting increased demand from accelerated electrification. Electricity demand in the USCA states increases 56 percent by 2040. The bulk of increased generation comes from solar and wind: from 2020 to 2040, solar generation in these states grows nearly ninefold and wind generation more than sevenfold.

More renewable energy accelerates reductions in fossil fuel generation faster in the 100% RES scenario than in the No New Policy scenario. In the absence of additional policies directed at generation technologies, the modeled 100 percent policies target in-state consumption, not generation. Although the USCA states meet all their own electricity needs with renewables, plants fueled by coal, gas, and nuclear can continue operating because the principal US power grids are interconnected across many states, with power shared across state lines. That said, from 2020 to 2040, coal generation falls by 88 percent in the 100% RES scenario, and from 12 percent of electricity supply to 1 percent. Gas generation falls 34 percent, and drops from 40 percent of overall generation in 2020 to 17 percent in 2040.

In both scenarios, nuclear generation falls 37 percent from 2020 to 2040 in the USCA states with the retirement of some nuclear power plants.

The results include dramatically different electricity mixes (Box 1, p. 7). In the No New Policy scenario, the generation mix in USCA states moves from 51 percent fossil, 23 percent nuclear, and 25 percent renewable in 2020 to 42 percent fossil, 13 percent nuclear, and 45 percent renewable in 2040. In the 100% RES scenario, electricity generation in 2040 is 73 percent renewable, 18 percent fossil, and 9 percent nuclear (see Figure 2, p. 8).

Power Plant Capacity

No New Policy scenario: Solar power capacity more than triples in the USCA states, from 61 gigawatts (GW) in 2020 to 195 GW by 2040; wind power capacity almost doubles from 2020 levels, increasing to 81 GW by 2040 (Figure 3, p. 8). Between 2021 and 2040, close to 60 percent of net new capacity is based on renewable energy. Fossil fuels continue to play a significant role, however. No new coal plants are built, and nearly 37 GW of coal retire by 2040, largely because the economics of coal are increasingly unfavorable relative to other generation options. Yet the retirements leave half of the existing coal fleet in place, and the capacity of gas power plants (net of new plants and retirements) increases close to 20 percent, from 185 GW in 2020 to 218 GW by 2040.

100% RES scenario: Solar power capacity in USCA states increases to eight times the 2020 amount by 2040, growing to 504 GW, and wind power to five times, achieving 218 GW. The combined solar and wind capacity increases an average of 30 GW per year—enough to meet the annual electricity needs of more than 8 million typical US households. That capacity increase is three and a half times the projection in the No New Policy scenario for those states, but it is less than the wind and solar capacity added nationwide in 2021 (ACP 2022; Davis et al. 2022). The 100% RES scenario adds substantial amounts of new batteries for energy storage, important for matching the variable electricity supply from solar and wind to round-the-clock electricity demand. Storage increases from 3 GW in 2020 to 178 GW in 2040; the increase is to 40 GW in the No New Policy scenario.

BOX 1.

Different States, Different Paths to 100 Percent

Just as each state starts with its own electricity profile, each undergoes different changes to meet 100 percent of its electricity consumption with renewables. Our modeling illustrates this by looking at three states.

Massachusetts

The Bay State retired its last coal plant in 2017 and its last nuclear plant in 2019, leaving a power plant mixture dominated by gas and meeting much of its electricity consumption with imports from neighboring states and Canada. Offshore wind, required by a series of state laws beginning in 2016, is a big part of ramping up renewable energy capacity and generation in both the No New Policy and 100% RES scenarios. In the latter, gas largely disappears from the generation mix, and much more solar capacity appears—more than five times as much in 2040 as in 2020, and nearly four times as much as in the No New Policy scenario. Wind and solar together power 98 percent of generation in 2040.

Michigan

The Great Lakes State currently generates more than half of its in-state electricity from coal and gas plants and about a quarter from nuclear. The state's major utilities have built wind facilities to comply with Michigan's RES, and they plan to add significant amounts of solar to replace several coal-fired power plants slated to retire over the next decade. In addition, Governor Gretchen Whitmer's draft 2022 climate action plan aims to end coal generation no later than 2035 (Michigan Department of Environment, Great Lakes, and Energy 2022). In the 100% RES scenario, the state displaces all coal generation and meets increased demand from electrification with new solar and wind power. By 2040, solar and wind supply close to 60 percent of in-state electricity generation. Further action retiring all in-state coal generation by 2030 and constraining new gas development, as explored in our Restricted Fossil Fuel scenario, reduces fossil fuels to 4 percent of electricity generation by 2040.

Minnesota

The Land of 10,000 Lakes uses coal and gas for about half of its in-state electricity generation and nuclear for about 20 percent. However, Minnesota, an early adopter of wind power, has made significant investments in it. In the 100% RES scenario, Minnesota builds on that foundation, nearly tripling wind capacity by 2040 to supply 55 percent of the state's electricity generation. Solar also ramps up, from a low baseline to 26 percent of electricity supply. As with Michigan, the Restricted Fossil Fuel scenario points to the need to address fossil fuel generation in the transition to renewable energy, with fossil fuel nearing zero by 2040.

Also in the 100% RES scenario, coal capacity drops by 46 GW as coal plants shut down, to 63 percent below 2020 levels by 2040 in USCA states. Despite the often-promoted role of gas in integrating renewables like wind and solar and balancing electricity supply and demand, its capacity in USCA states grows by only 10 percent from 2020 to 2040, and its portion of overall capacity drops from 34 percent in 2020 to 16 percent in 2040; the growth in battery storage helps ensure reliability as electricity demand increases.

In both scenarios, no new nuclear capacity is built: nuclear is too costly relative to other technologies. Existing nuclear capacity drops the same across each scenario, to 37 percent below 2020 levels by 2040, based solely on projected end-of-life retirements.

Electricity System Investments

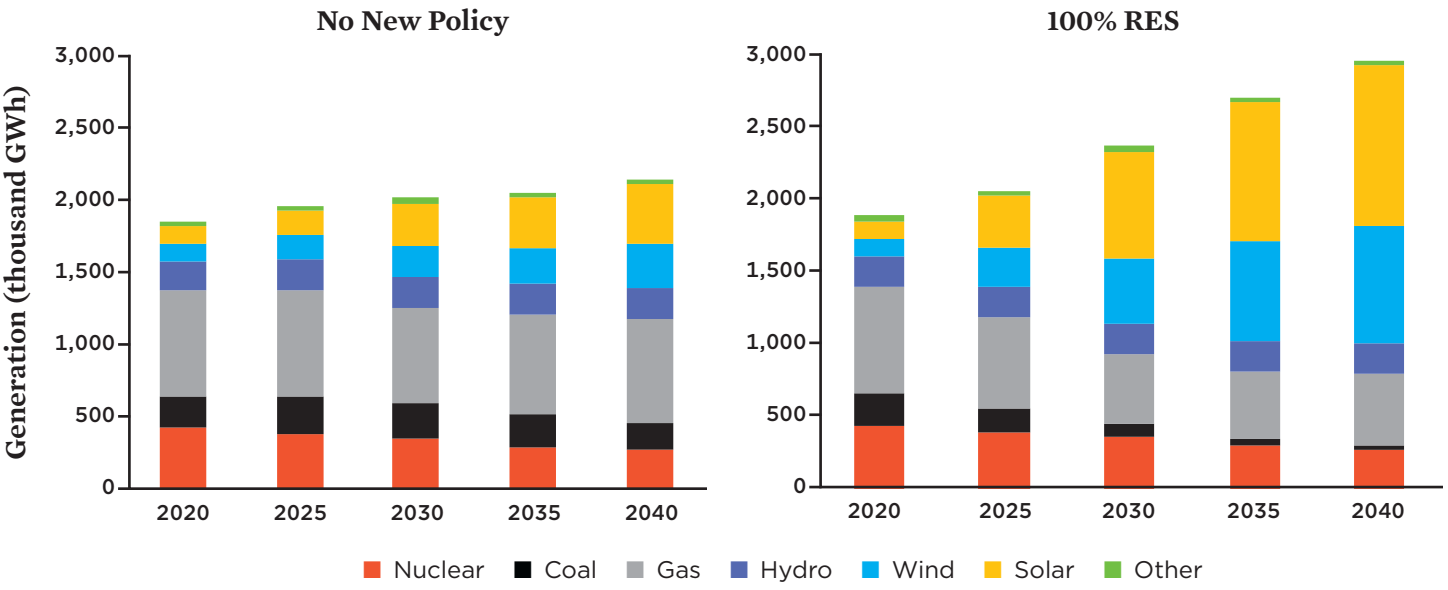
The push for 100 percent renewable electricity in USCA states leads to substantial new investment in wind projects, solar arrays, battery storage, and associated electricity transmission. Investments in power generation are 75 percent higher in the 100% RES scenario than in the No New Policy scenario over 20 years—$995 billion vs. $568 billion.[7] Transmission investments are almost twice as high.

Because solar and wind entail zero fuel costs, lower operating costs over that 20-year period partly offset the added upfront investment for the 100% RES scenario. Fuel costs due to the remaining fossil fuel power plants are 21 percent lower than in the No New Policy scenario; operation and maintenance costs are essentially the same.

What Renewable Energy Can Bring

The accelerated move toward renewable energy in the 100% RES scenario yields a range of benefits in our modeling, particularly for people living in the USCA states. Those benefits include better air quality, improved public health, fewer heat-trapping emissions, lower energy costs, and more power-sector jobs.

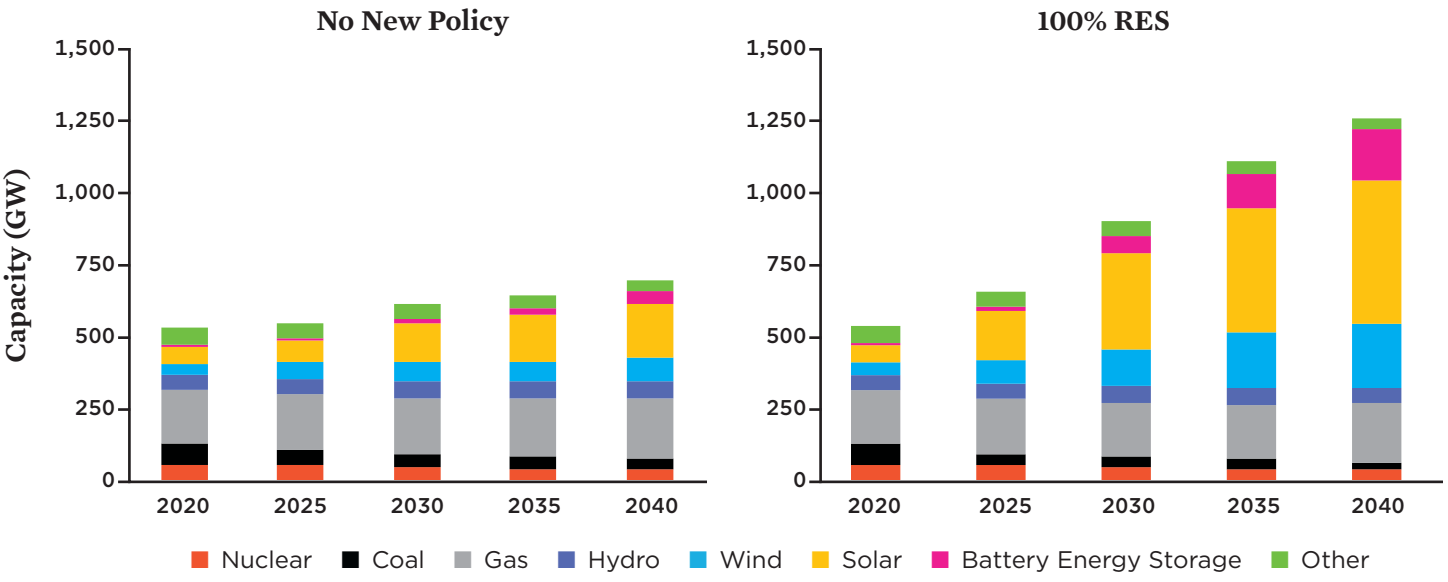
FIGURE 2. Electricity Generation in USCA States in Two Scenarios, 2020–2040



The 100% RES scenario leads to much greater use of renewable energy, chiefly wind and solar; a decrease in the use of gas; and the virtual elimination of coal generation.

Notes: GWh=gigawatt-hours. "Solar" includes utility scale, distributed solar, and concentrating solar-thermal power. "Wind" includes land-based and offshore wind. "Gas" includes combined-cycle and combustion turbine. "Other" includes oil-gas-steam, biopower, landfill gas, geothermal, and Canadian imports.

FIGURE 3. Electricity Capacity in USCA States in Two Scenarios, 2020–2040



Solar and wind capacity grow much more quickly in the 100% RES scenario, along with battery capacity. Gas capacity increases more slowly, and coal capacity also drops more quickly.

Notes: "Solar" includes utility scale, distributed solar, and concentrating solar-thermal power. "Wind" includes land-based and offshore wind. "Gas" includes combined-cycle and combustion turbine. "Other" includes biopower, landfill gas, geothermal, oil-gas-steam, and Canadian imports.

Less Fossil Fuel Generation Means Power Plants Have Less Impact on People's Health

The shift from fossil fuels to clean electricity helps reduce pollutants such as sulfur dioxide (SO_2), nitrogen oxides (NO_x), particulate matter, and toxic emissions like mercury. Air pollution from burning fossil fuels has dangerous health impacts, including causing or exacerbating lung and heart ailments, asthma, diabetes, and developmental problems in children, and it leads to premature deaths (State Energy & Environmental Impact Center, n.d.). In 2018, for example, more than 350,000 people died prematurely in the United States due to effects from burning fossil fuels (Vohra et al. 2021).

While air pollution is already lower in the USCA states as a whole than in non-USCA states (USCA 2021), the modeling shows the potential for much steeper reductions. In the 100% RES scenario, SO_2 emissions from power plants in USCA states fall 88 percent from 2020 levels by 2040 compared with 27 percent in the No New Policy scenario (Figure 4). By 2040, NO_x emissions are 75 percent lower in the 100% RES scenario compared with 18 percent lower in the No New Policy scenario (Table 2, p. 10).

Such changes translate to notable public health improvements even excluding the effects of pollution reduction from replacing fossil fuels with electricity to power vehicles and heat buildings. In the USCA states as a whole, the 100% RES scenario leads to approximately 6,000 to 13,000 fewer premature deaths, more than 140,000 fewer cases of asthma exacerbation, and 700,000 fewer workdays lost to illness from 2022 to 2040 than in the No New Policy scenario.

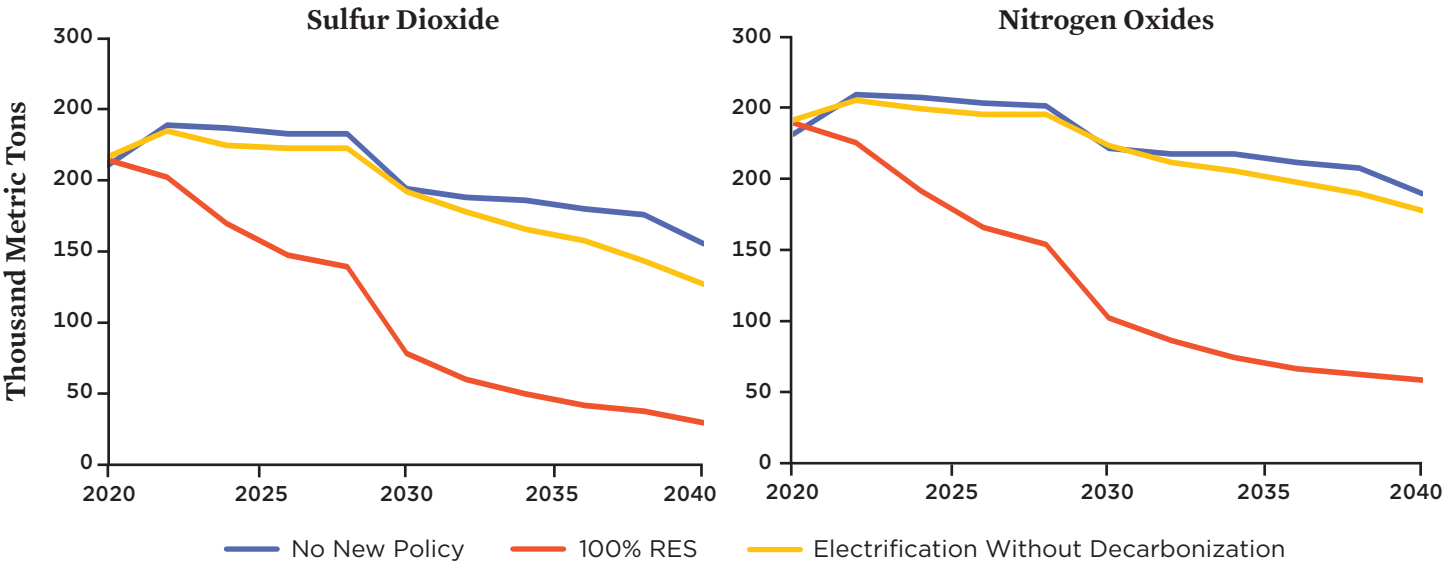
In Michigan, a state with many coal and gas power plants in densely populated urban centers, harmful air pollution from the power sector is expected to decline due to planned retirements of coal plants. That said, a faster transition to renewables yields further health benefits. In the 100% RES scenario, the state could see between 400 to 900 fewer premature deaths, 9,000 fewer cases of asthma exacerbation, and 43,000 fewer lost workdays over those two decades (Figure 5, p. 10).

In the 100% RES scenario, states experience monetary health benefits in addition to physical public-health benefits as a result of reducing air pollution from power plants. The USCA states together secure almost $280 billion in additional health benefits from 2022 to 2040. For example, in Michigan, the savings are $14.9 billion; in Massachusetts, $1.7 billion; and in Minnesota, $1.2 billion.

Deploying Renewable Energy Faster Means More Jobs

Changes in the electricity supply affect employment. Accelerating the deployment of renewable energy creates new opportunities in solar-array and wind-facility installation, increasing the need

FIGURE 4. SO_2 and NO_x Emissions in USCA States in Three Scenarios, 2020–2040



SO_2 and NO_x emissions from power plants have dangerous health impacts. The biggest and fastest reductions of these pollutants occur in the 100% RES scenario. Emissions from power plants in the Electrification Without Decarbonization scenario are almost as high in the No New Policy scenario. Electrification of vehicles and heating brings additional reductions not captured here.

TABLE 2. Key Results in Modeling the Energy Transition in Four Scenarios, 2020–2040

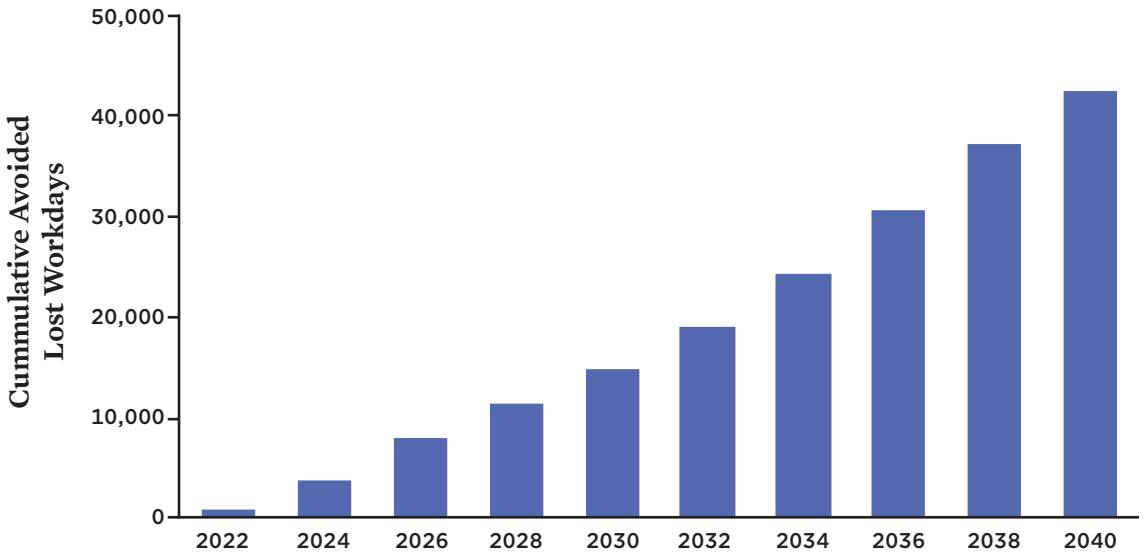
Scenario	Change Relative to 2020 Levels					
	Renewables Generation	Coal Generation	Gas Generation	CO_2 Emissions	SO_2 Emissions	NO_x Emissions
No New Policy	+205%	–16%	0%	–12%	–27%	–18%
100% RES	+461%	–88%	–34%	–58%	–88%	–76%
Electrification Without Decarbonization	+289%	–37%	+34%	+1%	–43%	–26%
Clean Electricity Standard	+369%	–67%	+25%	–45%	–82%	–67%

Note: For USCA states in 2020, renewable energy accounted for 25 percent of electricity supply, coal accounted for 12 percent, and gas accounted for 39 percent. Emissions reductions are from the power sector only.

for electricians, pipefitters, and welders, for example. It also creates opportunities in component manufacturing, sales, financing, and maintenance for those and other renewable energy technologies.[8]

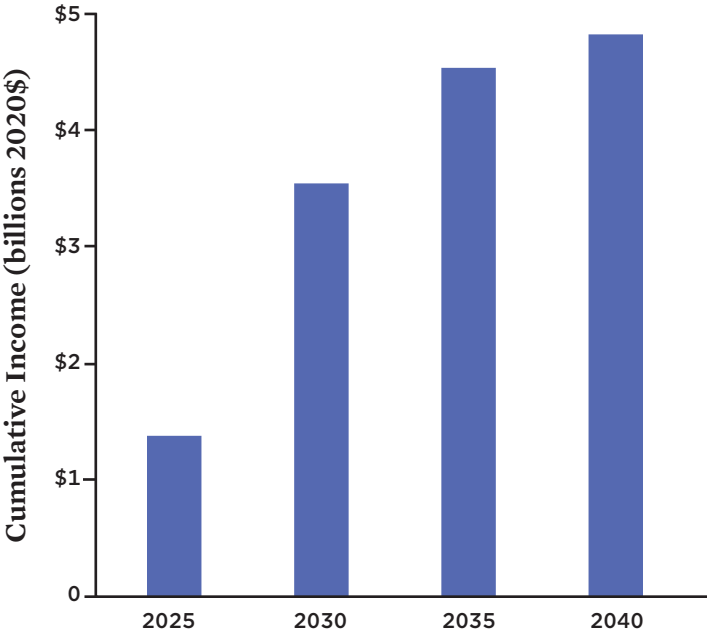
In the three states examined in more depth, almost 200,000 more people are employed in installing new generating capacity—overwhelmingly for renewable energy—in the 100% RES scenario than in the No New Policy scenario. For example, Minnesota gains more than 160,000 additional job-years—meaning more than 40,000 jobs[9]—by 2040, totaling $4.9 billion in additional labor income over those 20 years (Figure 6). Decreasing the use of fossil fuel power plants leads to job losses for those dependent on the fossil fuel industry. Yet the expected additional job growth in the 100% RES scenario is considerably greater than the total employment in coal, gas, and oil-fueled power plants in the states examined. In Minnesota, for example, fossil fuel power plants employed some 2,100 people in 2021 (DOE 2021). Only a portion of job losses would come in a given year, or even by 2040.

FIGURE 5. Reductions in Lost Workdays in Michigan, 2022–2040



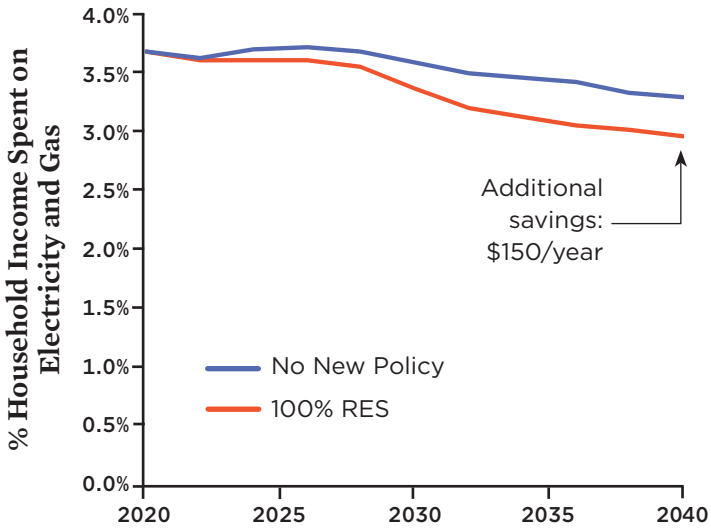
Reduced use of coal and gas plants in the 100% RES scenario leads to notable public health improvements, such as fewer workdays lost due to illness, in Michigan and elsewhere. Less fossil fuel use to power vehicles and heat buildings leads to additional health benefits, not captured here.

FIGURE 6. Additional Labor Income in Minnesota, 2022–2040



Greater job creation in installing solar panels, wind turbines, and other new electricity generating capacity in the 100% RES scenario leads to additional labor income adding up to billions of dollars by 2040.

FIGURE 7. Household Energy Burdens in USCA States in Two Scenarios, 2020–2040



Average household spending on electricity and gas as a percentage of income declines under either scenario, but declines more quickly in the 100% RES scenario. Additional savings, not included in these calculations, come from reduced spending on other fossil fuels based on electrification, including avoided gasoline costs for transportation and avoided oil or propane use for home heating.

More Renewable Energy and Electrification Can Help Make Energy More Affordable

Moving to renewable energy and electrifying cars and heating systems can lower overall energy expenses, in turn lowering average energy burdens—the portion of typical household income spent on energy. Energy burden is a particular challenge for many lower-income households. Their national average energy burden for electricity and gas alone is 8.1 percent, compared with an average of 2.3 percent for non-low-income households (Drehobl, Ross, and Ayala 2020). Renewable energy can reduce household electricity costs by displacing more expensive electricity generation from fossil fuels; renewable energy policies, as in the 100% RES scenario, can accelerate that change. Electrification can shift energy use for heating from gas or heating oil to electricity, and shift energy use for transportation from gasoline to electricity. Overall, electrification can reduce energy costs because of the higher efficiency of electric heat pumps and electric vehicles.

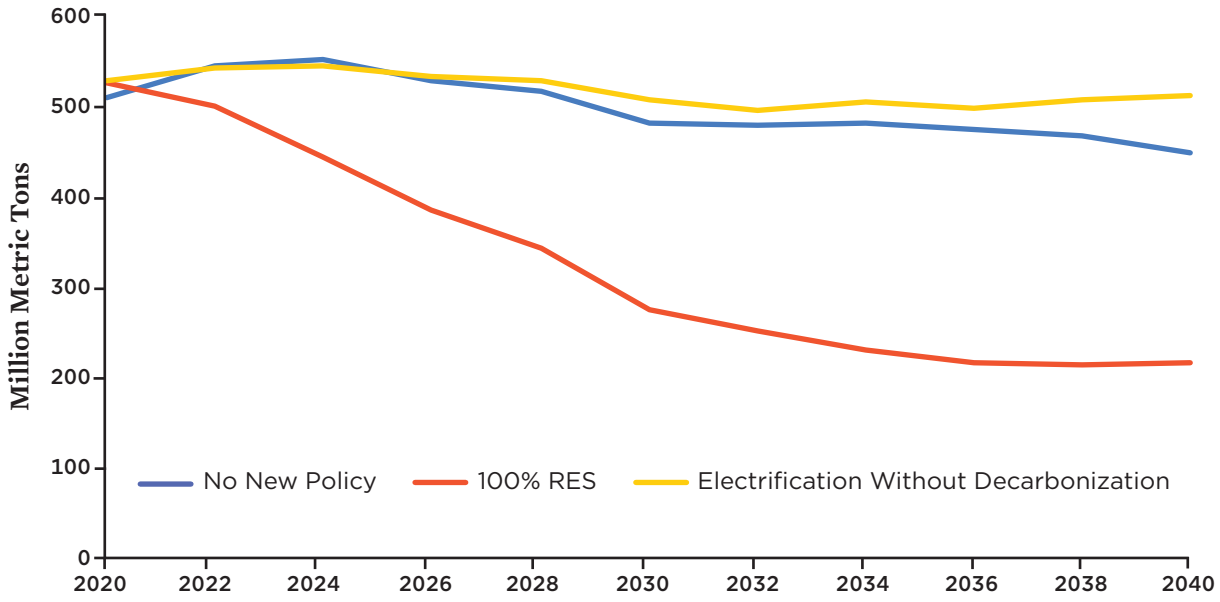
Even considering solely electricity and gas expenses, energy burdens in the 100% RES scenario are consistently at or below those in the No New Policy scenario in each USCA state in most or all years. The average energy burden across those states declines from 3.7 percent in 2020 to 3.0 percent in 2040 in the 100% RES scenario; the decline is to 3.3 percent in 2040 in the No New Policy scenario (Figure 7).

These figures understate the average savings: they include neither avoided gasoline expenditures for households that switch to electric vehicles nor avoided heating oil or propane expenditures for homes switching from those fuels.[10] Average annual household gasoline expenses in recent years have ranged from $1,600 to $2,100, for example (BLS 2021). Replacing an oil system with an air-source heat pump designed for cold climates can save a household around $1,000 per year (Efficiency Maine, n.d.; NEEP 2014).

Phasing Down Fossil Fuel Generation Reduces Global Warming

Carbon dioxide (CO_2) is the primary heat-trapping gas contributing to global warming. With the reduction in fossil fuel use in the 100% RES scenario, CO_2 emissions from power plants in the USCA states are 58 percent below 2020 levels by 2040; the reduction is only 12 percent in the No New Policy scenario (Figure 8, p. 12).[11] In 2040 alone, the total CO_2 *not* emitted by power plants in the 100% RES scenario compared with the No New Policy Scenario equals the tailpipe emissions from 100 million typical cars driving from New York to Los Angeles and back.

FIGURE 8. Power-Sector Emissions of CO_2 in USCA States in Three Scenarios, 2020–2040



Reduced use of coal and gas leads to CO_2 emissions from power plants falling almost 60 percent in the 100% RES scenario, while they stay largely flat in the No New Policy and Electrification Without Decarbonization scenarios. Electrification of transportation and heating bring additional CO_2 reductions not captured in these numbers.

While not calculated in this analysis, electrifying the transportation and heating sectors would lead to further reductions. The electrification study incorporated in this analysis (NREL 2018) envisions, by 2040, electrification of transportation, heating, and other sectors leading to reductions in the use of gasoline (53 percent), gas (22 percent), and diesel (24 percent) relative to business as usual.

Selected Results from Other Scenarios

The power sector might evolve in other ways, as in the scenarios summarized below, with different implications for people and communities.

Electrification Without Decarbonization: A strong push to electrify transportation and heating without an accompanying commitment to meeting that increased demand with clean electricity could reduce pollution from the transportation and heating sectors yet increase pollution from the power sector. In such a scenario, gas capacity grows over the coming decades in the USCA states, with gas generation supplying almost half of the increased electricity demand. Extra coal retirements expected in the 100% RES scenario do not happen under electrification without a strong push for renewable energy. The Electrification Without Decarbonization scenario leads to power plant emissions that are nearly five times higher for SO_2, more than three times higher for NO_x, and more than twice as high for CO_2 by 2040 than in the 100% RES scenario; CO_2 emissions are higher even than in the No New Policy scenario, by 14 percent. Power plant pollution has disproportionately affected low-income and marginalized communities historically, and such pollution increases are likely to perpetuate that inequity.

Restricted Fossil Fuel: Because the 100% RES scenario targets only in-state consumption, not generation, this scenario aims at reducing reliance on fossil fuel generation. Looking at Massachusetts, Michigan, and Minnesota, constraining new gas power plants after 2025 and accelerating the retirement of coal plants by 2030[12] leads to 92 percent less gas generation in 2040 in those states than in the No New Policy scenario, and 90 percent less than in the 100% RES scenario. Harmful power plant emissions of SO_2 and NO_x almost disappear by 2030 in Michigan, and in Massachusetts they are slightly lower than in the 100% RES scenario. Bulk system electricity prices (covering the cost of the complete electricity system) in 2040 are 0.2 percent higher in Massachusetts, 15.3 percent higher in Michigan, and 1.2 percent higher in Minnesota than in the 100% RES scenario. However, those price increases do not account for savings from reducing other energy costs through electrification, improving public health, or reducing heat-trapping emissions.

Clean Electricity Standard: A scenario assuming that nuclear energy and carbon capture and storage (CCS) are eligible to meet state 100-percent-by-2035 standards for clean electricity leads to less renewable energy development in USCA states. Existing nuclear generation satisfies some of the demands of 100 percent policies, though no new nuclear (or CCS facilities) appear because of their relative costs. The slower growth of renewable energy leads to slower declines in coal and gas generation. For example, gas generation in 2040 is 29 percent higher than in the 100% RES scenario. Coal and gas generation are also higher in non-USCA states due to lower growth in renewables and reduced net exports from USCA states.

The added fossil fuel generation in turn leads to higher emissions of CO_2 (32 percent), SO_2 (54 percent), and NO_x (38 percent) in USCA states in 2040 than in the 100% RES scenario. As with the Electrification Without Decarbonization scenario, low-income and marginalized communities likely disproportionately suffer from the increases in power plant pollution. However, including nuclear decreases the cost of complying with clean electricity standards, with bulk system electricity prices 7 percent lower in 2040. By reducing the expansion of renewable energy and its associated electricity transmission, use of the existing nuclear capacity also reduces transmission additions in USCA states between 2020 and 2040 by 47 percent.

Recommendations: Ensuring a Just and Equitable Energy Transition

"Energy justice requires not only that traditionally excluded voices become a central part of the energy policy conversation, but that they are first in line to receive the benefits of policies adopted to facilitate the energy transition." —Initiative for Energy Justice (Baker, DeVar, and Prakash 2019).

Advancing energy justice requires policies that address a range of challenges and opportunities. Our findings show that a transition to renewable energy and away from fossil fuels requires attention to ensuring that everyone can experience the benefits, while simultaneously avoiding the perpetuation of historic inequities in the energy sector.

Our findings suggest that USCA states pledging to cut carbon emissions can meet 100 percent renewable electricity standards for energy consumption. Such efforts are technically feasible, and they offer valuable health and net job-creation benefits, lower the cost of energy and energy burdens relative to the No New Policy scenario, and significantly reduce heat-trapping emissions from the power sector. While modeling a renewable energy transition for the nation as a whole would lead to somewhat different results, this study points to the possible outcomes from the leadership of the USCA states as they have stepped up to lead in CO_2 reductions for the United States.[13]

Nevertheless, the modeling also shows a potential for negative outcomes even in high-achieving states if they do not address the electricity system comprehensively. A suite of policies building on renewable energy standards is required to move away from fossil fuels in electricity generation as well as in consumption, reduce pollution, and promote equitable outcomes in the transition to renewable energy. Moreover, while aggressive policy action in leadership states offers important benefits and helps build momentum for clean energy, a comprehensive national approach that includes all states is essential to reaching our climate goals *and* achieving the equitable outcomes we seek.

On the Road to 100 Percent Renewables, like other research, suggests a range of issues and opportunities in moving toward equitable, 100 percent clean electricity. Here we frame key recommendations around moving away from fossil fuels and toward clean energy, while improving affordability and access to benefits for low- and moderate-income households and frontline communities most affected by pollution, and integrating good decisionmaking throughout.

Moving Away from Fossil Fuels and Related Pollution

Target Reductions in Power Plant Pollution

Some communities bear a much greater legacy burden from decades of placing infrastructure for a fossil-fueled power sector in or near marginalized neighborhoods. In New York City, of the 750,000 people living within one mile of "peaker" power plants (plants used only during periods of high electricity demand), almost 80 percent either have low incomes or are people of color (Strategen Consulting 2021). Although these plants run much less often than others, they emit higher levels of pollutants relative to the electricity they generate. States should prioritize reducing emissions in communities overburdened by pollution. For example, New York State curtails the allowable level of NO_x emissions to help meet air-quality standards (Snyder 2020).

Avoid New Investments in Fossil Fuel Power Infrastructure

Fossil fuel generation persists in the USCA states in the 100% RES scenario, and additional gas power plants appear, largely to meet electricity demand from states that do not fully commit to clean energy. Some states and regions rely heavily on gas generation, putting them at risk of shortages and extreme price fluctuations (UCS 2015). States should avoid investments inconsistent with the need to remove heat-trapping emissions from the power sector and the economy as a whole, and they should enact policies to reduce the risks of overreliance on gas.

Retire Fossil Fuel Plants Faster

The persistent use of fossil fuels in power plants points to the importance of comprehensive state action with regard to retiring fossil fuel generators even as these states ramp up renewable energy. Some states have begun addressing this issue. For example, in Illinois, the 2021 Climate and Equitable Jobs Act prescribes a retirement schedule focused on pollution reductions, with a priority on communities historically most affected by pollution (Collingsworth 2021).

Enact a National Clean Electricity Standard

States that do not commit to rapid decarbonization of their electricity systems can drive the persistence of existing fossil fuel generation and new investments in it. Congress should enact a national standard to accelerate air pollution reductions, renewable energy development, and decarbonization in all states. The EPA should implement strong standards regarding power plant pollution.

Promote Just Transitions for Fossil Fuel Workers and Communities

While many communities will benefit from net increased employment in the transition to clean energy, some will be hit harder by job losses than others. States should invest in supporting workers and communities in moving beyond fossil fuels—for example, through job training and incentives for responsible siting of clean energy investments and manufacturing. In addition, states can reduce harmful legacy effects by mandating pollution-cleanup efforts, such as reclaiming mine and power plant sites and properly disposing of coal ash. Just as important, while dislocated workers prepare for what comes next, they need income supports for a period of time, including wage replacement, health coverage, and continued employer contributions to retirement funds or pension plans (Richardson and Anderson 2021).

Promoting Equity in the Clean Energy Transition

Broaden Access to Rooftop Solar

Our modeling limited consideration of rooftop solar and other distributed-generation technologies,[14] but real life also has constraints, particularly around access for low- and middle-income communities and communities of color.[15] Some households have less access to capital, financing, and incentives for acquiring solar systems, less information about options, or fewer local solar suppliers. Renters and occupants of multifamily buildings have no roofs of their own. States should ensure support for solar, placing a priority on reaching historically underserved people and communities through such tools as community/shared solar and energy storage, as well as by broadening the tax credits that have been important for solar energy's expansion but less accessible to lower-income households (Rogers 2021). Such tools can increase resilience for individuals and communities and provide more equitable, more direct access to other benefits of clean energy, including for renters and property owners with less access to solar.

Broaden Access to Energy Efficiency

Energy efficiency is key to reducing home energy costs, but efficiency efforts skew away from low- and middle-income households, which are less able to invest in upgrades and have less access to affordable financing. Such households often have higher-priority housing and other needs, and they are more likely to rent instead of own their homes. State energy-efficiency programs should be inclusive and make available lower-cost financing and investment programs. For example, "pay as you save" initiatives enable households to pay back the cost of energy-efficiency projects through the savings they incur on their monthly utility bills (Leventis et al. 2017). In Minneapolis, the 4D Affordable Housing Incentive Program offers cost-sharing options for energy efficiency improvements and solar installations (City of Minneapolis, n.d.). State green banks, such as those in California, Connecticut, and Nevada, can provide low-income households and marginalized communities with low- or no-cost financing and other incentives for investments in clean energy, including energy efficiency (NREL, n.d.b).

Broaden Access to Electrification

Electrifying transportation and heating requires upfront investments that may be beyond the reach of low- and moderate-income households. Owning an electric vehicle also requires access to charging infrastructure, which is much less readily available to renters or residents of marginalized communities (Huether 2021). State and federal programs to encourage electrification should include affordable financing for households and promote the development of accessible charging infrastructure.

Target Transmission Additions and "Non-Wires" Alternatives at Reducing Reliance on Urban-Based Fossil Fuel Plants

Responsibly sited electric transmission and non-wires alternatives, such as distributed generation, energy storage, and energy efficiency, are needed to expand renewable electricity, accelerate the closure of fossil plants, and mitigate the harms in communities most exposed to power plant pollution. Regulators and other state leaders can push the operators of regional electricity grids to consider ways to maintain reliability while retiring fossil fuel plants. Michigan regulators recently did this with the grid operator that conducts transmission planning and runs the power

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grid in much of Michigan and nearby states (Balaskovitz 2020). Additionally, as states update and electrify the grid, communities affected by transmission decisions must be involved in siting and other transmission planning.

Reduce Energy Burdens

The move to clean energy will likely reduce average household energy costs, but, without due attention, it could increase burdens for low- and moderate-income households, at least in the short term. Unequal access to tools like energy efficiency and rooftop solar could prevent low- and moderate-income households from reducing their energy burdens. States should ensure that costs incurred by electric utilities for clean energy—and legacy costs spread over declining numbers of gas users (Dyson, Glazer, and Tepin 2019)—are addressed through either targeted energy rates or statewide policies, including energy-efficiency measures to reduce consumption.

Develop a Renewable Energy Workforce That Reflects the Country

Women represented only 26 percent of the solar workforce in 2018, Hispanic or Latino workers 17 percent, Asian workers 9 percent, and Black or African American workers 8 percent. Racial and gender representation is even worse at leadership levels (The Solar Foundation 2019). As the renewable energy industry, still relatively young, grows exponentially to meet the nation's decarbonization needs, its workforce should represent the communities it serves. Companies should invest in a diverse workforce, and state and federal support should encourage training programs targeting historically marginalized communities and support for businesses owned by women and people of color.

Ensure High-Quality, Well-Paying Jobs

Good jobs should be the standard of the renewable energy industry. The BlueGreen Alliance's state policy toolkit offers a suite of actions designed to ensure that projects uphold high standards for workers, including encouraging "project labor agreements" (PLAs) (BlueGreen Alliance 2020).[16] For example, the Southeastern Massachusetts Building Trades Council and the developers of what is likely to be the first large-scale US offshore wind project signed a PLA in 2021 (Vineyard Wind 2021). Requiring prevailing wages can also help provide a floor so that all contractors for government-supported projects pay at or above market wages (Callahan et al. 2021).

Advance Energy Resilience

The deployment of solar, energy storage, and other distributed generation technologies helps mitigate the impacts of climate change, reduces the need for transmission buildout, and plays a vital role in increasing resilience, keeping the lights on and powering critical infrastructure even during grid blackouts due to extreme weather. In 2018, Hurricane Maria, which left Puerto Rico facing the largest power outage in US history, is but one of too many disasters that highlight the importance of distributed-generation resources and microgrids to power health systems, emergency shelters, and water pumping systems (García 2018). States should think creatively and advance decentralized approaches in the electricity system that can translate into savings for ratepayers, increased reliability, and improved community-level resilience in the face of extreme weather. For example, Glendale, California, dropped a $500 million gas peaker project in favor of a clean energy portfolio that will similarly support the electricity grid but save ratepayers $125 million (Spector 2019).

Address Life Cycle Issues

Renewable energy reduces or eliminates pollution from generation, but it still requires attention to ensure sustainable and responsible life cycles for the technologies involved—from manufacturing to siting to decommissioning at the end of service lives. State policies should encourage project developers to ensure responsible supply chains, incentivize the use of local manufacturers of renewable equipment, improve siting processes to better manage environmental and community considerations, and ensure recycling and reuse opportunities are available and required.

Ensuring Broad Participation in Decisionmaking: Let Communities Choose

Many low-income communities and communities of color, having disproportionately experienced the pollution and associated health and economic effects of an electricity system cen-

tered on fossil fuels, are demanding an electricity system that is safe, resilient, affordable, and community-controlled (Gignac et al. 2021). State and federal decisionmakers should take the lead from local community organizations, especially in places historically affected by pollution and the closures of fossil fuel plants, to mitigate harm and ensure that everyone derives the health and economic benefits of the transition to clean energy. For example, dozens of community organizations engaged in the development of Illinois's Climate and Equitable Jobs Act, creating comprehensive climate, clean jobs, and just-transition legislation (Collingsworth 2021). Cumulative impact assessments should go hand in hand with the involvement of communities in decisionmaking around just transitions, distributed generation, transmission, and other choices that will affect them directly.

The Road Ahead

The climate crisis demands strong action at all levels of society, and states are well positioned to help lead the nation in cleaning up the electricity sector and, through electrification, other key sectors as well. State policies for a clean energy transition also present opportunities to address issues and inequities within the existing power sector.

It is entirely feasible for states to commit to meeting 100 percent of the electricity consumption needs of their households, businesses, and institutions with renewable energy in the near term. This means accelerating state actions to improve public health, create more jobs in the energy sector, make energy more affordable, and reduce energy burdens—while cutting heat-trapping emissions. It also means dramatically ramping up the pace of installing solar panels, wind turbines, batteries, and transmission facilities. Simultaneously pushing to electrify cars, trucks, and home and business heating does increase the need for power-sector technologies, but it also drives substantial increases in benefits.

This analysis shows that the states that have declared their intention to lead the United States on a just energy transition can effectively address the power-sector piece of that transition, including significant electrification, in ways that bring a range of benefits to their residents. Even if they use only renewable energy to meet their requirements for 100 percent clean energy, these states can both meet electricity demands *and* lower energy costs.

The analysis also shows the importance of a *comprehensive* commitment to the clean energy transition. A focus on meeting only electricity consumption with clean energy leaves open the near-term possibility of new pipelines and fossil fuel plants, even if chiefly to supply states not committed to 100 percent renewable energy. Combining such commitments with a strong focus on deterring new fossil fuel investments will better position states, and the country as a whole, to meet the strong, economy-wide need to reduce heat-trapping emissions. Clean energy policies must focus on reducing the use of existing power plants fired by fossil fuels, retiring them faster, *and* constraining new investments in fossil fuel infrastructure.

Even so, states cannot count on equitably sharing the benefits and costs of the transition by default; policymakers must explicitly and proactively drive equity. The health benefits from reducing the use of power plants should accrue primarily to those who bear disproportionate burdens from plant siting and use. Black, Brown, Indigenous, immigrant, and low-income communities should have full access to the new jobs, economic development, and entrepreneurship initiatives that accelerated commitments to clean energy will yield. While renewable energy will likely lower costs overall, low- and moderate-income households should be particularly supported in accessing clean energy technologies and reducing their energy burdens. Similarly, communities now tied to fossil fuels need support in moving beyond that dependence. And through it all, frontline communities directly affected by changes in policy and practice should have power in decisionmaking processes.

In the absence of sufficient action and leadership from many on the national level, states are key to transitioning the United States to an equitable clean energy future, as well as to creating a roadmap for solutions that can be scaled nationwide. True leadership will recognize the importance of building clean energy, retiring dirty energy, and making sure that equitable outcomes are central to the transition.

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Acknowledgments

This analysis was made possible through the generous support of the Bezos Earth Fund, the Common Sense Fund, Energy Foundation, the Heising-Simons Foundation, The Joyce Foundation, The John D. and Catherine T. MacArthur Foundation, and UCS members.

For their thoughtful reviews and contributions, we thank Seth Mullendore (Clean Energy Group), Leslee Gutiérrez (COPAL), Samantha McDonald and Max Cox (Greenlink Analytics), Elena Itämeri and Subin DeVar (Initiative for Energy Justice), Chris Conry (100% Campaign),

Michelle Martinez (Michigan Environmental Justice Coalition), and Jackson Koeppel (Soulardarity), along with Marc Miller and David Gerratt (for editing and design assistance). At UCS we thank Anthony Eyring, Bill Cotter, Bryan Wadsworth, Camilo Esquivia-Zapata, Chris Bliss, Cynthia DeRocco, Heather Tuttle, Jeff Deyette, Jessica Collingsworth, Jiayu Liang, Julie McNamara, Lisa Nurnberger, Mark Specht, Meghan Hassett, Megy Karydes, Michelle Rama-Poccia, Mike Jacobs, Myles Haigney, Nicholas Iannaco, Steve Clemmer, and Youngsun Baek.

Organizational affiliations are listed for identification purposes only. The opinions expressed herein do not necessarily reflect those of the organizations that funded the work or the individuals who reviewed it. COPAL, GreenRoots, the Michigan Environmental Justice Coalition, and the Union of Concerned Scientists bear sole responsibility for the report's contents.

Endnotes

1. http://www.usclimatealliance.org.
2. "Gas" in this document refers to what is traditionally called natural gas.
3. See, for example, "100% Clean Act" bills in Massachusetts (An Act Transitioning Massachusetts To Clean Electricity, Heating, and Transportation), Michigan's efforts to achieve carbon neutrality by 2050 in Executive Order 2020-182 and Executive Directive 2020–10, and the Minnesota House of Representatives' omnibus bill HF 1031, proposed in 2021.
4. ReEDS encompasses the 48 contiguous states and Washington, DC, analyzes electric sector changes in two-year increments, and assesses results for 17 specific points in time during each two-year period. See the technical appendix at www.ucsusa.org/resources/road-100-percent-renewables for more information.
5. The incorporation of rising electricity demand is based on the "High" electrification scenario from a multiyear, multi-stakeholder assessment of electrification options (NREL, n.d.a).
6. While electrification generally reduces overall energy use for given uses because electric technologies are inherently more efficient, the modeling did not incorporate specific policies aimed at increasing energy efficiency beyond those already in place.
7. Findings from our analysis are expressed in 2020 dollars.
8. The analysis did not examine the job changes resulting from increased electrification.
9. A job-year is defined as a full-time position held by one person for one year. A person holds a job for an average of four years (BLS 2020).
10. In a recent winter, 5.5 million US homes, mostly in the Northeast, used oil heating (EIA 2022).
11. While CO_2 is the primary heat-trapping gas, it is not the only one. Other emissions beyond the scope of this study include methane, which traps heat more than 80 times more effectively over a 20-year period, and which leaks from gas infrastructure, such as wells, transport pipelines, neighborhood pipeline networks, and even kitchen appliances (Lebel et al. 2022).
12. We modeled accelerating some likely coal plant retirements in Michigan by 2030. We also modeled prohibiting new combined-cycle gas plants, but allowing new gas-combustion turbines, which are used solely during periods of high electricity demand.
13. For more about implementing a US move to high levels of renewable energy, see Baek et al. 2021 and NREL, n.d.c.
14. Distributed generation (also called on-site generation or decentralized generation) refers to generation of electricity for use on site, rather than transmitting energy over the electric grid from a large, centralized facility (such as a coal-fired power plant) (EESI, n.d.).
15. According to a Lawrence Berkeley National Laboratory study, out of roughly 1.4 million residential rooftop solar adopters across the country, only 15 percent were households with annual incomes below $50,000 (Barbose et al. 2020). Tufts University and the University of California–Berkeley research shows that solar adoption has been limited among Indigenous people and people of color. Black-majority census tracts installed 69 percent less rooftop solar compared with no-majority tracts; Hispanic-majority census tracts installed 30 percent less (Sunter, Castellanos, and Kammen 2019).
16. Project labor agreements, pre-hire collective bargaining agreements with one or more labor organizations, establish the terms and conditions of employment for a specific construction project; they are described in 29 U.S.C. 158(f) (White House 2022).

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On the Road to 100 Percent Renewables

States Can Lead an Equitable Energy Transition

Renewable energy can provide leading states with 100 percent of the electricity they consume by 2035 even as electrifying transportation and heating increases demand, according to an analysis by COPAL, GreenRoots, the Michigan Environmental Justice Coalition, and the Union of Concerned Scientists. Replacing electricity generated by coal and gas plants with renewables decreases emissions of air pollutants, leading to 6,000 to 13,000 fewer premature deaths and 700,000 fewer lost workdays between 2022 and 2040. It also creates jobs, reduces household energy burdens, and significantly reduces heat-trapping emissions. Key recommendations of the analysis address rapidly moving away from fossil fuels and increasing investment in renewables, and ensuring that the benefits of the transition go to communities most affected by environmental racism and pollution as well as to workers and communities that depend on fossil fuels. While state action cannot substitute for national leadership, it, too, is crucial to a clean and equitable energy future.

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https://doi.org/10.47923/2022.14533