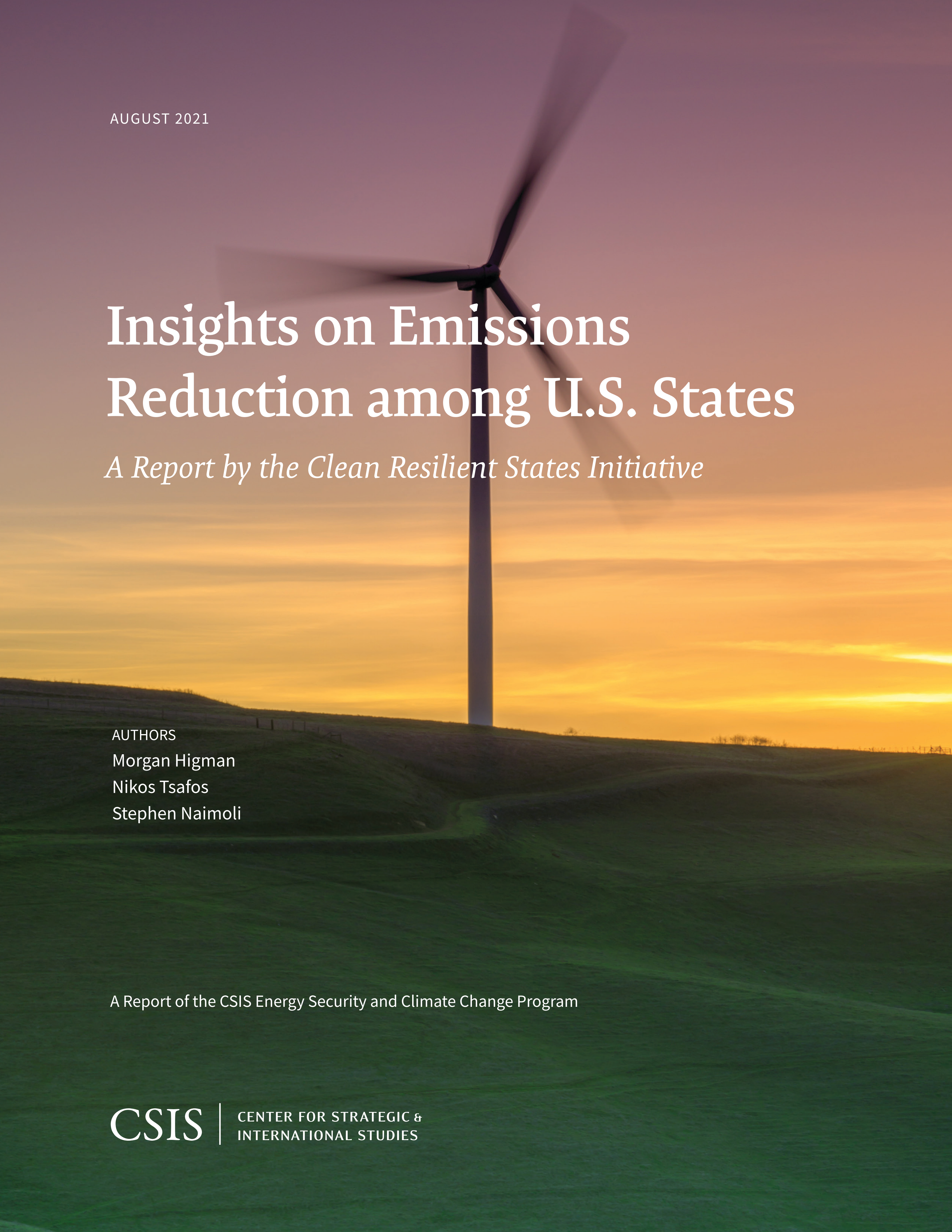

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A Report by the Clean Resilient States Initiative

AUTHORS
Morgan Higman
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A Report of the CSIS Energy Security and Climate Change Program

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About the Clean Resilient States Initiative

States often play a leading role in energy and climate policy, but their approaches vary, and the effectiveness of their policies is hard to gauge. The Clean Resilient States Initiative assesses the extent to which policies at the state level can reduce greenhouse gas emissions produced by the energy system, create economic opportunity in low-carbon energy, and enhance resilience to climate-related impacts.

The Clean and Resilient States Initiative explores the relationship between state-level policy and various outcomes in four papers and an associated database of policies. These resources will provide insights for policymakers and identify priorities for future research. This is the first paper in the series, looking at policies to reduce greenhouse gas emissions.

To support deeper analysis and ensure continuity over the four papers, a sample of 16 U.S. states was selected to study during the project. The selection process centered on three priorities: to include the largest energy users, to ensure diversity of regulatory environments, and to represent the different regions of the country. Each attribute has important implications for emissions reductions, economics, and resilience. The sampling strategy is described in an appendix.

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1

Introduction

From 2005 to 2018, the United States reduced its carbon dioxide (CO_2) emissions from the energy sector by 12 percent. However, this national average masks wide variation in performance across states.[1] In some states, declines in CO_2 emissions were dramatic: emissions fell by 37 percent in Maine, 34 percent in New Hampshire, and 28 percent in Alaska. However, in Wyoming and Washington, emissions changed little between 2005 and 2018, while in other states—Idaho, Nebraska, Arkansas, South Dakota, North Dakota, and Texas—emissions rose by double digits. What explains this variation? What policies, at the federal or state level, helped lower emissions? And what might policymakers learn from the states that succeeded in reducing emissions?

To answer these questions, the CSIS Energy Security and Climate Change Program investigated state-level policies that aim to reduce emissions or boost low-carbon energy. To enable deeper analysis, this report focuses on a sample of 16 U.S. states, consisting of the eight largest energy consumers and eight additional states that are representative of the country in terms of geography, economic structure, resource endowments, and energy systems (for more information on the sampling strategy, see the appendix). The authors were interested in the following questions:

- Which states reduced emissions the most and what drove those reductions?

1. Detailed state-level emissions data have been published only through 2018, so this analysis uses 2018 as the end point. "Energy-Related CO2 Emission Data Tables, Table 2: State energy-related carbon dioxide emissions by year, adjusted," U.S. Energy Information Administration, data released March 2, 2021, https://www.eia.gov/environment/emissions/state/.

- Did emissions fall across the energy system, or were they concentrated in some sectors (like power, industry, transportation, or buildings)?
- Was the reduction in emissions a product of policy, market forces beyond the control of policymakers, or exogenous factors?
- What policies did different states adopt in order to lower emissions and support low-carbon energy sources? Is there evidence that these worked?
- Are there any overarching lessons that can be drawn about what policies are most likely to reduce emissions? Or, in a narrower sense, what lessons can be learned about policy design?
- How much are states collaborating with each other as a way to reduce emissions?
- To what extent has federal policy complemented or inhibited state-level action?

This paper is structured in four sections. The first section describes some facts about greenhouse gas (GHG) emissions in the 16 states in the sample: where they fell, by what magnitude, and so on. The second section assesses how specific policies might have affected these outcomes. Given that the biggest reduction in emissions came from the power sector, the analysis is focused there. This report examines prominent policy instruments that support the decarbonization of the power sector, like direct regulation of emissions, market instruments, net metering and interconnection standards, renewable portfolio standards, and various financial incentives for renewable energy. The third section looks at questions of equity and environmental justice when it comes to reducing emissions. A final section presents the main conclusions from this analysis.

2

Measuring Success in Reducing Emissions

Measuring success in decarbonization can be a difficult matter. An obvious approach is to ask: Did a state reduce emissions in absolute terms? The reduction in absolute emissions is important because, in the end, what matters is removing CO_2 from the atmosphere, and bigger reductions make a bigger contribution to efforts to fight climate change. By that metric, five states alone accounted for more than a third of the total reduction in CO_2 emissions: Ohio, Pennsylvania, Indiana, Georgia, and New York (in that order).[1]

To measure the absolute reduction alone, however, is to focus predominantly on large states, which emit a lot of CO_2 and hence can reduce their emissions by a substantial amount. As a case in point: Ohio lowered its CO_2 emissions by roughly 65 million tons between 2005 and 2018. In contrast, Wyoming's total emissions in 2005 were around 64 million tons. In other words, Wyoming could decarbonize its economy entirely, and its overall contribution to the country's total drop in emissions would be about the same as Ohio contributed during the 13-year period under study. For that reason, it makes sense to think not only about absolute reductions but also about relative ones. By that measure, the leaders were Maine, New Hampshire, Alaska, and Maryland (if included, the District of Columbia would rank fourth).

There are several important caveats, however. The results observed are somewhat sensitive to the time span chosen. Examine the period from 2005 to 2017 instead, for example, and New Mexico has the eighth-highest percent reduction in CO_2 emissions in the country; expand the timeframe by a year into 2018, though, and New Mexico ranks 25th. This is an extreme case, but numerous factors could drive these kinds of variations: colder or warmer weather could influence demand in any given year, a major economic shock could lower demand, or a major investment could boost it. Absolute statements about success or failure are therefore best avoided.

History and past performance can also shape what a state can accomplish. California's emissions fell by just 5 percent from 2005 to 2018, a record that might seem at odds with California's reputation as a climate leader. But from 1990 to 2005, before this study period begins, California's emissions had risen by only 7 percent (compared to the national average of 19 percent). More importantly, California's per capita emissions were 44 percent lower than the U.S. average in 2018, and the state reduced its per capita emissions by about 14 percent from 2005 to 2018, while per capita emissions for the country as a whole stayed flat. Emissions totals alone rarely tell the whole story.

Other contextual factors matter, too. Geography and density can shape a state's transportation system: on a per capita basis, transportation energy use in Alaska is almost four times higher than it is in New York. A state's economic profile also impacts energy use: the industrial sector in Texas consumes almost twice as much energy as the entire state of New York. Climate impacts energy use as well: an average person in North Dakota consumes four times as much energy at home than an average person in Hawaii.[2] Resource endowments also shape what is possible: Oregon and Washington perform best in terms of how much CO_2 is emitted for each unit of energy consumed, largely because these states generate 60 and 71 percent respectively of their electricity from hydropower.[3] Conversely, the states on the other extreme of that spectrum—West Virginia and Wyoming—are big coal producers. Finally, accounting measures can affect outcomes: when a state generates electricity that is exported across state lines, the emissions from that electricity are attributed to the generator, not the consumer. Major electricity exporters, like Wyoming, North Dakota, and West Virginia, can be "penalized" by such accounting methods.

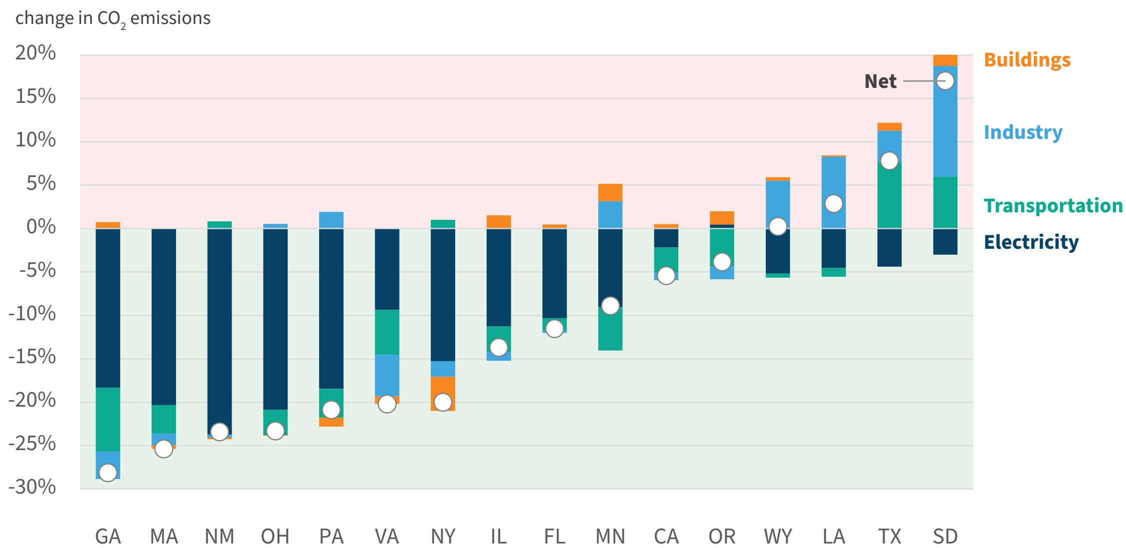
These factors are important in how performance is measured; at a minimum, they require that one speak about success in a limited fashion, always aware that different ways of looking at the data could yield different results. More fundamentally, one should bear in mind the importance of historical context, geography, resource endowments, economic structure, and other factors that shape state energy systems and the backdrops against which policy choices are made. As tempting as it is to draw a link between policy decisions and performance, one can never fully account for all external factors.

With these caveats in place, percent reduction in emissions was selected as the most important metric for success. Between 2005 and 2018, 12 of the 16 states in the sample reduced GHG emissions, while four did not (Wyoming, Louisiana, Texas, and South Dakota). The vast majority of these reductions came from the power sector, mirroring the performance of the country as a whole. This was true even in states where emissions went up overall: emissions from electricity fell, even if emissions from other sectors rose by a greater volume. Given the significance of this sector as the principal source of state emissions reductions, much of this report's analysis is focused in this area. (For a discussion of reductions in the industrial and transportation sectors, see the next section.)

2. This does not mean that climate is destiny—per capita energy use in the residential sector has declined by about 40 percent in California between 1973 and 2018.

3. That said, New Hampshire—which has the fourth-lowest carbon intensity per energy used—is in that spot because of nuclear power, not natural resource endowments.

Figure 1: Energy-Related CO_2 Emissions: Changes by State and Sector, 2005 to 2018



Source: "Energy-Related CO2 Emission Data Tables," U.S. Energy Information Administration, data released March 2, 2021, https://www.eia.gov/environment/emissions/state/.

3

Emissions Reductions from Industry and Transportation

CO_2 emissions from industry fell in a number of states in the sample, and often those declines were substantial: 34 percent in Virginia, 31 percent in Georgia and New York, 24 percent in Massachusetts, and 11 percent in Oregon (see Figure 1 above).[2] Generally speaking, there is a clear relationship between CO_2 emissions and energy use: the change in CO_2 emissions from 2005 to 2018 is predicted by the change in energy use in the same time period (the R-squared is 0.9379).[3] Explaining the decline in industrial energy consumption is harder, however, partly due to insufficient data on energy use by industrial subsectors. But there is strong circumstantial evidence to suggest that the observed change in energy use was largely the result of changes in industrial activity.

This analysis was based on three external data sources:

- First, the **Bureau of Economic Analysis** provides detailed data on value added by industrial subsector for the years 2005 and 2018 (in chained 2012 dollars), which allows one to see which sectors grew and which sectors declined.[4]
- Second, the **U.S. Energy Information Administration**'s (EIA) Manufacturing Energy Consumption Survey provides data on the energy intensity of different industrial sectors; in particular, Table 6.1 of the 2014 survey shows the energy used per dollar of value added.[5] This metric is helpful in understanding how industrial value added might impact energy consumption. Changes in the manufacture of coal and petroleum products, for example, will have a bigger impact than changes in the manufacture of machinery (39.3 thousand British thermal units per dollar of value added for the former versus 0.9 thousand British thermal units per dollar of value added for the latter).
- And third, the **EIA** provides data on refinery closures. Given that refineries are among the most energy-intensive industrial activities, this data can help corroborate changes in energy use.[6]

Looking at Virginia, for instance, the 34 percent reduction in industrial CO_2 emissions coincided with a 21 percent reduction in industrial energy use (direct energy use, excluding electricity from the grid). The value added of several energy-intensive sectors fell from 2005 to 2018, even though manufacturing value added as a whole increased for the state. The value added in coal and petroleum manufacturing fell by 71 percent as the state's only refinery closed; chemicals fell by 24 percent, textiles by 55 percent, and paper by 26 percent. A few energy-intensive sectors, like food and beverage manufacturing or primary metals, increased, but overall there seems to be strong support for the thesis that the decline in several key industrial sectors drove the reduction in energy use—and therefore in emissions.

This type of analysis was performed for the nine states where CO_2 emissions from industrial energy consumption fell between 2005 and 2018, and the conclusions were similar to Virginia: the decline in a few key sectors appears to have driven the decline in energy use and emissions. As such, there are not compelling policy measures in these cases that merited deeper investigation.

Declines in emissions from the transportation sector were less significant, but still material. In three states, the drop in CO_2 emissions from transportation were in the double digits: Louisiana (25 percent), Pennsylvania (15 percent), and Ohio (13 percent). In several others, the reductions were smaller (between 4 and 8 percent), while in a few states, emissions from the transportation sector rose between 2005 and 2018.

As with industry, there is an observable correlation between emissions and energy use (R-squared of 0.98). But it is harder to conclusively establish the effect of underlying activity on CO_2 emissions and energy consumption. The simplest measure to use is a state-level estimate of vehicle miles traveled, published by the Federal Highway Administration in the *Highway Statistics* series.[7] For some states, the prima facie link between the variables is plausible: in Texas, emissions went up by 15 percent, energy use by 19 percent, and vehicle miles traveled by 20 percent. South Dakota and Florida show a similar story.

However, the relationship is not always so clear-cut. In several states, changes in fuel use were driven largely by jet fuel.[8] In Louisiana, for example, CO_2 emissions from transportation fell by 25 percent while vehicle miles traveled rose by 11 percent. This appears, at first glance, to be a major disconnect, but the reduction in energy use is entirely attributable to a sharp decline in jet fuel: excluding jet fuel, energy use in transportation actually went up by 1 percent. Ohio is another state where the topline reduction in emissions is impressive (13 percent), but jet fuel is responsible for a large share of the change in energy use—excluding jet fuel, energy use in transportation fell by just 4 percent.

Simply comparing the years of 2005 and 2018 can also conceal a lot of variation for the period in between, and especially mask the effects of the 2007–2009 recession. In California, for instance, motor gasoline use fell by almost 13 percent from 2005 to 2012, but it has since risen by almost 4 percent. This broad pattern of a sharp drop to 2012 followed by stability or even a modest increase is seen in several other states: Georgia, Illinois, Massachusetts, Minnesota, New York, Ohio, and Virginia. Only in Pennsylvania is there a sustained decline observed throughout the study period, but vehicle miles traveled also declined there by 5 percent.

There are other trends that further dilute the success implied by the topline figures. Several states reported a sharp decline in residual fuel oil use for ships. In others, there was a sharp increase in gas used for pipelines, offsetting some of the emissions gains from the road transportation sector. There is also an increase in ethanol use across the board, which, by convention, is considered carbon neutral at the point of combustion.[4] Together, these changes make the apparent disconnect between energy use and vehicle miles traveled far less puzzling.

In summary, the reductions in CO_2 emissions from the industrial and transportation sectors might seem impressive at first glance, and they appear to be major contributors to the overall reductions in CO_2 emissions in certain states. On closer inspection, however, these changes seem to reflect some underlying economic shifts in industry and transportation. There are, surely, policy drivers at play here—including the blending of ethanol, continued gains in vehicle efficiency, and even vehicle electrification, although that was modest during the study period. But the data did not point to major success stories of the magnitude observed in the power sector.

4. Producing and burning ethanol results in emissions of CO2, but it is generally considered carbon neutral because CO_2 is absorbed as the biomass grows, which may offset the CO2 produced when it is burned.

4

Policies to Reduce Emissions or Boost Renewable Energy

States employ a number of policies to reduce emissions from the power sector. This paper focuses on six main instruments:

- Economy-wide emissions reduction targets
- Emissions performance standards
- Cap-and-trade systems
- Renewable portfolio standards
- Net metering
- Financial incentives

Of course, states do not always work alone. Multi-state coalitions, such as the Clean Energy States Alliance, pool their resources and knowledge to facilitate the deployment of low-carbon technologies in their states, like offshore wind and zero-carbon heating and cooling technologies.[9] The federal government also works with states, including by sharing knowledge and providing funding for collaborative projects. Through its national lab system, the U.S. Department of Energy builds partnerships with states to further technology development.

Though this paper is focused on state action, federal policy also matters. Major federal policies in place to encourage renewable energy development during the period under study for this report remain critical to this day. These include the 30 percent Investment Tax Credit for solar installations and the $0.015 per kilowatt-hour Production Tax Credit for wind farms. These credits likely bolstered actions taken by states and provided incentives in states that were not otherwise taking initiative. On the other hand, there was interference from the federal government during the study period as well. Most notably, the U.S. Environmental Protection Agency (EPA) under President George W. Bush refused to grant California a waiver to set fuel economy rules for vehicles.[10] More broadly, the Bush-era EPA was reticent to take action on reducing GHG emissions, and in 2003, the agency claimed it did not have the authority to regulate GHG emissions under the Clean Air Act.[11] However, this ultimately set the scene for future federal regulations: several states sued the EPA, leading to a landmark Supreme Court ruling that overturned the EPA's refusal and established that the federal government did have the authority to regulate emissions.[12]

Economy-Wide Emissions Reduction Targets

States often set an economy-wide target to reduce emissions relative to a baseline year—usually either 1990 or 2005, in line with the Kyoto Protocol or Paris Climate Agreement respectively. The ambition of these targets is partly shaped by the time of their adoption. Earlier adopters often initially committed to shorter time horizons, which have been increasingly "layered"—supplemented or replaced by steeper mid-century targets. By contrast, states that adopted targets more recently, such as Virginia and Louisiana, have moved straight to longer-term commitments.

Table 1: Emissions Reductions Targets: Selected States

Baseline	State	Adopted	Target (%)	Target Year	Source
1990	CA	2005	80	'50	Executive
		2016	40	'30	Statutory
		2018	NZ	'45	Executive
	OR	2007	75	'50	Statutory
	FL	2007	80	'50	Executive
	MA	2008	80	'50	Statutory
		2021	NZ	'50	Executive
	NY	2002	10	'20	Statutory
		2009	80	'50	Executive
		2019	40	'30	Statutory
		2019	85	'50	Statutory
2005	MN	2007	80	'50	Statutory
	PA	2019	80	'50	Executive
	IL	2019	28	'25	Executive
	NM	2019	45	'30	Executive
	LA	2020	NZ	'30	Executive
	VA	2020	NZ	'45	Statutory
No target	SD	-	-	-	-
	TX	-	-	-	-
	WY	-	-	-	-
	GA	-	-	-	-
	OH	-	-	-	-

Note: NZ = net-zero

Source: "U.S. State Greenhouse Gas Emissions Targets," Center for Climate and Energy Solutions, https://www.c2es.org/document/greenhouse-gas-emissions-targets/.

Table 1 includes economy-wide targets that were established through either statutory action or executive order. The former may be viewed as stronger policy commitments, because they often prescribe enforcement mechanisms to support emissions reductions, such as legislative authority to penalize (e.g., fine) non-compliant emitting firms.[13] Targets originating in legislation may also be less susceptible to political turnover. The case of Florida is illustrative of this point: Florida's governor authorized an emissions target and regulatory program in 2008, which was rolled back by his successor in 2012. Thus far, such backsliding on emissions targets is relatively unusual. However, Florida may serve as a cautionary tale for more recent emissions targets advanced by executive offices in states under split control, like Pennsylvania, Louisiana, and New Mexico.[14]

Even where emissions targets are less susceptible to retrenchment, challenges related to resource allocation and enforcement may pose barriers to enacting policies aimed at targeted emissions reductions, and some initiatives may simply fall short.[15] For this reason, it is important to view emissions targets not as significant achievements in and of themselves, but as a focal point for a broader policy platform.[16]

Emissions Performance Standards

Only a handful of states regulate power sector emissions through a performance standard, but these policies are associated with some of the largest reductions in CO_2 emissions at the state and power-plant level.[17] Performance standards impose a maximum threshold on emissions on the basis of pounds of carbon emitted per megawatt-hour of electricity (lbs. CO_2/MWh). Effectively, these standards penalize the most carbon-intensive sources of electricity—especially coal, whose emissions averaged about 2,100 lbs. CO_2/MWh during the study period.[18]

Emissions performance standards for electricity generation may be imposed at the point of electricity generation, at the point of procurement, or at both (see Table 2). Generally, standards also distinguish between baseload facilities, which provide the majority of electricity, and other facilities, which may ramp up or down according to demand. With the exception of Massachusetts's policy, these standards tend to focus on new or expanded plants, exempting those in operation at the time of standard adoption. Such exemptions are the subject of some criticism, as they can incentivize electric utilities to prolong operations of existing plants in order to avoid developing new ones that would be subject to more stringent emissions controls—a phenomenon observed across the United States after the imposition of the federal Clean Air Act Amendments of 1977.[19]

Table 2: Emissions Performance Standards by State: Selected States

	Year of Standard Adoption	Emissions Limit by Power Source*			
		Existing baseload plants	New or expanded baseload plants	New or expanded non-baseload plants	Long-term agreements for baseload power
MA	2001	1,800	-	-	-
CA	2006	-	1,100	-	1,100
OR	2007	-	675	675	-
	2009	-	-	-	1,100
NY	2012	-	925	1,450	-

*Emissions limits listed by maximum lbs. of CO_2 per megawatt-hour

Source: Data compiled by the CSIS Clean Resilient States Initiative.

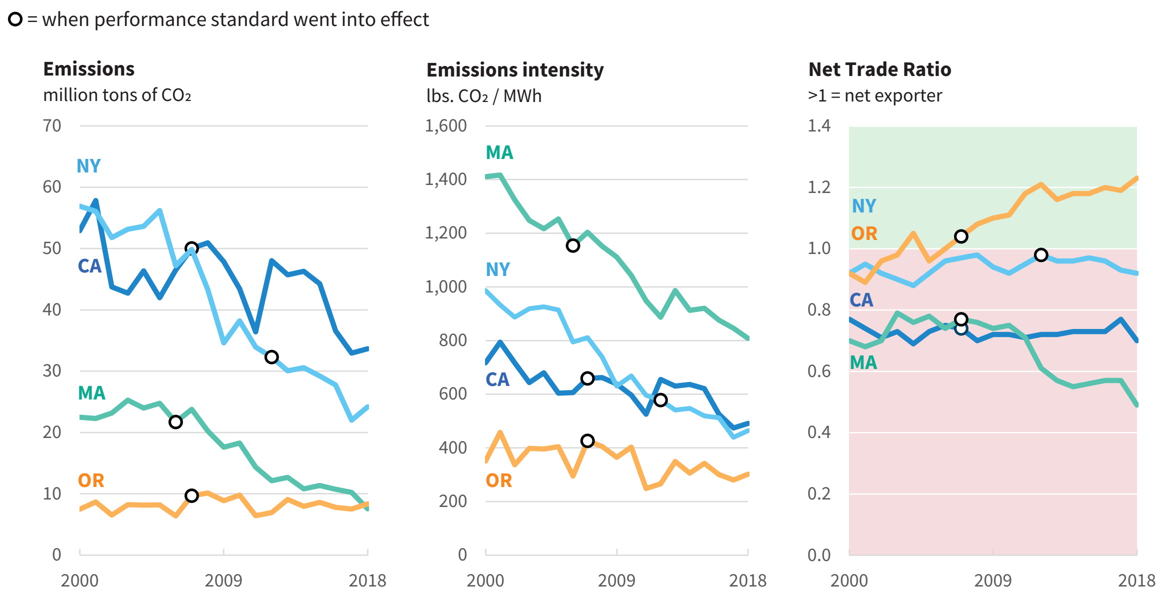
The impact of these policies can be most simply evaluated by examining patterns of emissions associated with fossil fuels in the power sector before and after the earliest compliance year in each state.[5] In Figure 2 below, the earliest compliance year is indicated by a bubble marker. A general decline in emissions and emissions intensity is apparent in the first two illustrations in Figure 2, even before performance standards take effect. As discussed previously, this trend is observed across most states within the study period.

From the first two illustrations in Figure 2, performance standards appear to have made more directly observable impacts in Massachusetts and New York, given the continued and precipitous decline in emissions in these states following their implementation. In California, the standard may have had

5. A more nuanced measure is that of emissions at the power plant level, but the first year for which this data is uniformly available is 2011, considerably later than some of the policies discussed here.

effects initially, but these have proven inconsistent; in Oregon, the impact of the standard is even more nebulous. One consideration here is how compliance with standards is achieved. In Oregon, standard compliance may be achieved through carbon offsets, which allow power plants to exceed a state's performance standard and "make up" for the excess by investing in emissions-reducing projects, such as energy conservation improvements or planting trees. Offsets make it more difficult to evaluate policy effectiveness by observing power sector emissions, as was done here, which may explain why Oregon's policy appears ineffectual. More generally, evaluations of carbon offset programs routinely encounter difficulty demonstrating real, accurate, surplus, and permanent emissions reductions,[20] an observed shortcoming of Oregon's offset program in certain years and a potential pitfall of offsets as an overall compliance strategy. [21]

Figure 2: Power Sector Emissions, Carbon Intensity, and Net Trade: Selected States



Source: "Energy-Related CO2 Emission Data Tables," U.S. Energy Information Administration, data released March 2, 2021, https://www.eia.gov/environment/emissions/state/; "State Electricity Profiles," U.S. Energy Information Administration, data released November 2, 2020, https://www.eia.gov/electricity/state/.

In New York and Massachusetts, performance standards appear more effective, as they parallel declines in emissions from fossil fuels in the power sector. However, the standards in these states exclusively regulate emissions from in-state power generation, which creates the possibility of "leakage." Leakage occurs when regulation in one state pushes electricity generation activities—and associated pollution—to unregulated neighboring states. By observing net trade in electricity, the third illustration in Figure 2 provides some insight about instances of leakage. In New York, the emissions reductions do not coincide with a growing proportion of imported electricity, suggesting limited leakage as a result of the state's policy. By contrast, Massachusetts's emissions reductions coincide with growing dependence on imported electricity after the state's performance standard took effect, suggesting that reductions in the state are linked in part to leakage. The fact that Massachusetts has a more stringent policy than New York may help explain the different effects observed. Meanwhile, because Oregon and California impose performance standards on both in-state electricity generation and contracts for electricity procured beyond their respective borders, their policies reduce the possibility of leakage.

While emissions performance standards are conceptually among the most straightforward approaches to power sector decarbonization, this assessment suggests that realized impact is contingent upon more nuanced policy considerations. Ideally, policies should cover both electricity generation and procurement to mitigate leakage, and they should apply to existing as well as new or expanded facilities. Compliance by way of carbon offsets should be carefully considered, as this approach undermines the directness of policy impact and complicates evaluations of effectiveness.

While emissions performance standards are conceptually among the most straightforward approaches to power sector decarbonization, this assessment suggests that realized impact is contingent upon more nuanced policy considerations.

Though the performance standard is not without some noted limitations, it is distinctive for both its direct potential to mitigate emissions and its clear signal of decarbonization as a state policy priority. This policy approach has been slow to gain widespread adoption across states, owing to challenges of political feasibility. However, legal action by half a dozen states in 2010 resulted in a requirement that the EPA establish federal-level carbon emissions performance standards.[22] The resultant standards, published in 2015, were similar to some of the state-level standards described above, but they were met with legal challenges from another set of states and demands for revision from President Trump in 2017. These revisions, published in 2018, have again drawn legal action from states focused on emissions reductions, requiring additional modification by the EPA. This interaction between states and the federal government highlights the disputed nature of this policy approach, but it also reveals the significant role of states in shaping federal initiatives. As ambitions to reduce emissions accelerate at the state level and under the Biden administration, performance standards are likely to continue play a conspicuous—if contentious—role in climate and energy policy strategy.

Cap-and-Trade Systems

Cap-and-trade systems establish a limit on allowable emissions that decline over time. These programs usually distribute or auction off allowances to polluting firms that can then be traded to ensure compliance. They are generally considered more flexible than the performance standards described above, and they may create greater incentives for innovation in emissions control strategies and technologies. Most market-based mechanisms in the United States have been pursued regionally.

Across the United States, some regional attempts to create cap-and-trade programs have been more successful than others. The Western Climate Initiative (WCI), for example, began in 2003 as a coalition of Western and Southwestern states working to create a regional cap-and-trade system. Despite interest from various U.S. states, Canadian provinces, and Mexican states, political changes at the state level and the 2008 economic downturn led most parties to drop out.[23] Today, the program's only members are California and the Canadian provinces of Québec and Nova Scotia. The WCI links already-existing markets in the participating jurisdictions by allowing trading of allowances across them.[24] The Regional Greenhouse Gas Initiative (RGGI) cap-and-trade program, formed in 2005, has seen more success at retaining participating states. Although membership has changed over the years, the states participating as of July 2021 are Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. RGGI is structured similarly to the WCI, where programs in individual states add up to a regional market and auction program. A notable difference is that RGGI is restricted to the power sector.[25]

Not all collaboration efforts have endured. The Midwestern Greenhouse Gas Accord—signed in 2007 by the governors of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Ohio, Wisconsin, and South Dakota, as well as the premier of Manitoba—would have established a regional cap-and-trade program that covered electric power, transportation, industry, and buildings. Ultimately, political changes in most of these jurisdictions led to its functional dissolution in 2011.[26]

The cap-and-trade programs discussed in this section have proven useful at raising revenue to invest in other emissions reduction programs. From its inception through 2019, RGGI raised $2.8 billion from allowance auctions, most of which was invested in programs to increase energy efficiency, deploy low-carbon technology, or help low-income ratepayers pay their bills.[27] As of 2021, California has invested $14 billion from cap-and-trade auction proceeds in GHG reduction projects.[28] It is likely that these kinds of programs also incentivize some emissions reductions, but it is difficult to establish causality. A 2015 study of RGGI found that that emissions in the participating states between 2009 and 2011 would have been 24 percent higher without the program.[29] However, another study found that while the program reduced emissions in the region from 2004 to 2012 by reducing coal-fired generation, natural gas generation in the surrounding states increased to sell energy to the RGGI states.[30] This increase did not fully offset emissions reductions in the RGGI states, but it did indicate that the emissions likely “leaked” from RGGI states into their neighbors. In California, emissions have steadily declined (from 452 million metric tons of CO_2-equivalent in 2012 to 425 million metric tons in 2018), but the state has not evaluated how much of this reduction was attributable to the cap-and-trade program.[31] The only independent analysis estimates that, in 2015 and 2016, between 4 and 15 percent of the state’s emissions reductions were attributable to cap-and-trade.[32]

Despite the issues that the existing programs have gone through, regions are not abandoning cap-and-trade. Rather, a new effort is emerging. The Transportation and Climate Initiative (TCI), a partnership formed by several East Coast states in 2010, is working to create a cap-and-trade program for GHG emissions from transportation. In December 2018, the governments of Connecticut, Delaware, Massachusetts, New Jersey, Pennsylvania, Rhode Island, Virginia, Vermont, and the District of Columbia (all members of the TCI, along with Maine, Maryland, New Hampshire, New York, and North Carolina) announced their intent to contribute to this program, although the membership of the program is in flux.[33] Because each state needs to pass laws supporting the market, the governors that committed to the program must convince their legislatures to go along. As of this writing, the program is still in development.

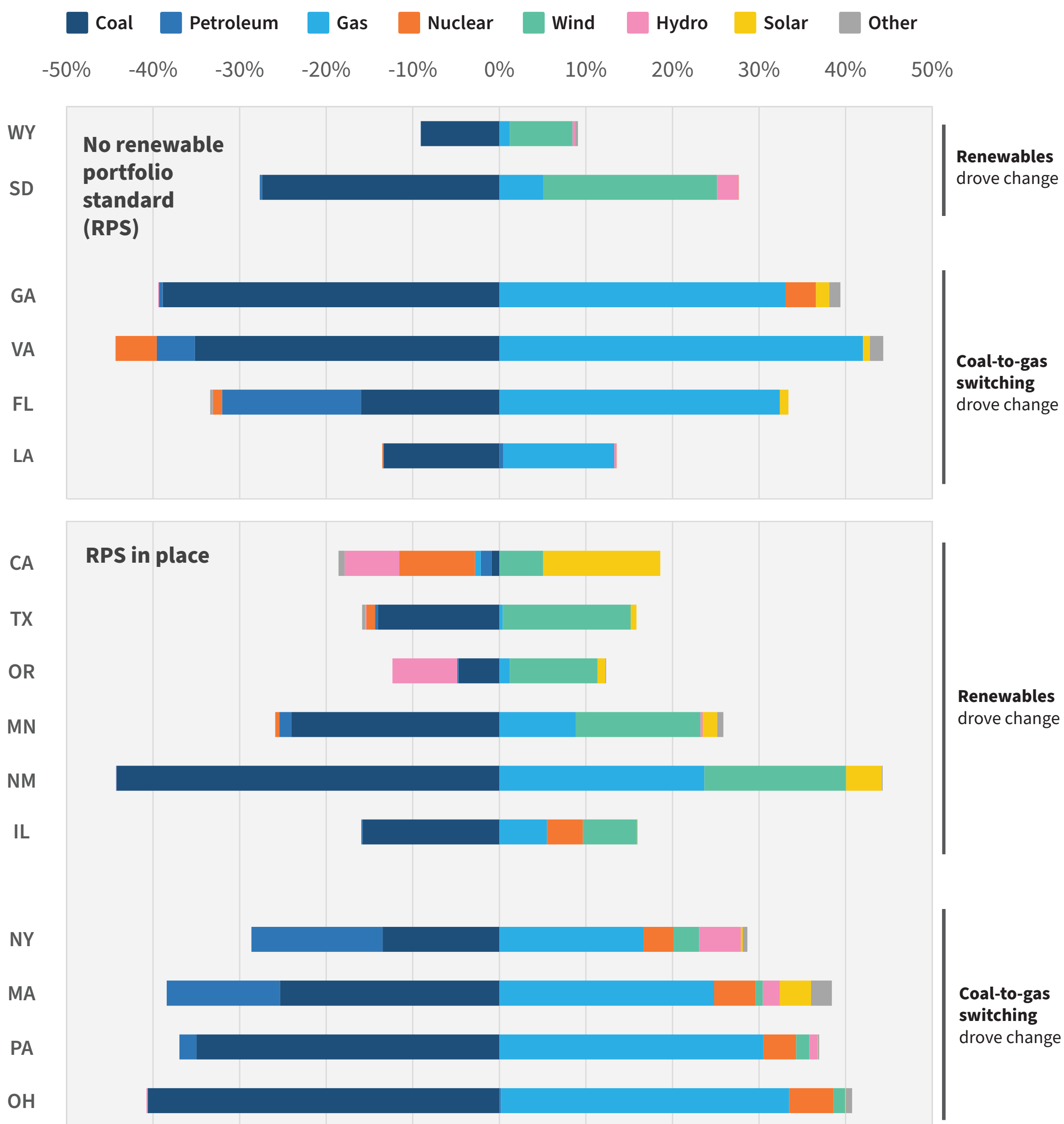
Overall, political conflicts can make it difficult to establish cap-and-trade systems. Although a few states have been able to avoid or overcome these conflicts and successfully establish programs, it is difficult to determine how successful those cap-and-trade systems have been at reducing emissions. In light of these challenges, many states have turned to alternatives that promote low- or non-emitting resources.

Renewable Portfolio Standards

Renewable portfolio standards (RPSs) are among the most common policy approaches to support renewable energy growth and emissions reductions. These standards require that utilities produce or procure a certain amount or percent of electricity from renewable or alternative resources. RPSs have supported electricity portfolio diversification, emissions reductions, and reductions in the carbon intensity of state power sectors.[34] However, not all states with an RPS have accrued benefits at the same rate, and some states have experienced renewable energy boons without an RPS.

Figure 3 below highlights how electricity generation has changed across states between 2005 and 2018. In this figure, states are grouped according to whether they had an RPS in place, and they are sorted according to the percent of added renewable energy. Some notable patterns emerge from Figure 3. First, Wyoming and especially South Dakota realized considerable renewable energy growth in the absence of an RPS. Second, among RPS states, some achieved markedly more renewable energy growth than others. These patterns are largely explained by RPS policy design, market contexts, and interstate trading effects.[35]

Figure 3: Electricity Generation: Changes in Market Share by State, 2005 to 2018



Source: "State-Level Generation and Fuel Consumption Data: Annual," U.S. Energy Information Administration, data released September 2020, https://www.eia.gov/electricity/data.php#generation.

Within the study period, selected states had a range of RPSs in place (see Table 3 below). This variation is most easily recognizable in different state targets and compliance schedules, which are simple and easy to conceptualize. For example, New York's 2006 reduction target was 29 percent by 2015, while New Mexico's 2007 target was 20 percent by 2020. This might suggest that New York had a more ambitious RPS, but a more substantive review of these targets suggests otherwise.

Each state's RPS uniquely defines which resources are deemed eligible for standards compliance. While every state includes solar and wind, some exclude certain technologies—such as biomass or hydropower—while others exclude sources of renewable generation that were already in operation prior to a given point in time. This is significant because the inclusion of mature and existing resources, particularly hydropower, may reduce the effectiveness of an RPS in promoting new renewable energy projects to displace fossil fuel resources and reduce power sector emissions.

Table 3: Renewable Portfolio Standards in Selected States

		MA				CA			NY				NM		OR		TX	MN	PA	IL	OH		VA
Structure	Most Ambitious Target	4%	15%	80%	NZ	20%	60%	CF	25%	29%	70%	CF	20%	CF	25%	50%	6%	31.5%	18%	25%	12.5%	8.5%	100%
Structure	Earliest Compliance Year	2003	2009	2017	2020	2004	2016	2018	2004	2006	2016	2019	2007	2019	2011	2016	2001	2007	2007	2009	2009	2019	2021
Structure	Target Year	2009	2020	2050	2050	2017	2030	2045	2015	2015	2030	2040	2020	2045	2025	2040	2015	2020	2021	2026	2026	2026	2045
Structure	Est. Retail Rate Cost Cap	16%				n.s.			3%				2%		4%		3%	n.s.	8%	1%	2%		n.s.
Classes & Carveouts	Solar	-	1,600 MW	-	-	-	-	-	-	-	-	-	4%	-	-	-	-	1%	0.5%	1.5%	0.5%	-	6,700 MW by 2030
Classes & Carveouts	Onshore Wind	-	-	-	-	-	-	-	-	-	-	-	6%	-	-	-	-	24%	-	18.75%	-	-	6,700 MW by 2030
Classes & Carveouts	Distributed Generation	-	-	-	-	-	-	-	-	0.58%	2%	-	3% by 2015	-	-	8%	-	-	-	0.3%	-	-	1%
Classes & Carveouts	Offshore Wind	-	1,600 MW	5,600 MW by 2035	-	-	-	-	-	-	2,400 MW	9,000 MW	-	-	-	-	-	-	-	-	-	-	5,200 MW
Classes & Carveouts	Energy Storage	-	1,000 MWh by 2025	-	-	-	-	-	-	-	-	-	-	-	-	10 MW by 2020	-	-	-	-	-	-	-
Eligible Resources	Biomass	✓	✓	✓	✓	✓	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓	✓	✓	✓	✓
Eligible Resources	Geothermal	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	-	✓	✓	✓
Eligible Resources	Hydro	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓
Eligible Resources	New Hydro	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓	✓	-	✓	✓	✓
Eligible Resources	Landfill Gas	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Eligible Resources	MSW	✓	✓	✓	✓	-	-	-	-	-	-	-	-	-	✓	✓	✓	✓	✓	-	✓	✓	✓
Eligible Resources	Wave / Tidal	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-	✓	✓	✓	-	-	-	-	-	-
Eligible Resources	Nuclear	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-
Eligible Resources	Energy Efficiency	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	-	✓	✓	-
Eligible Resources	Oldest Qualifying Resources	1997				2004			1988				2004		1995		2001	2004	2001	1999	1998		1973

ACRONYMS & UNITS

NZ = net-zero
MW = megawatt
CF = carbon-free
MWh = megawatt-hour
n.s. = not specified

Note: Wind and solar resources are selected from the "Eligible Resources" section of this table for simplification/ease of interpretation, as solar and wind are eligible under all RSPs.

Source: "Summary Tables," DSIRE, NC Clean Energy Technology Center, https://programs.dsireusa.org/system/program/tables.

Returning to the example of New York, that state's original RPS target of 29 percent by 2015 required only 11 percent in additional resources, because it included existing renewable resources—and hydropower already accounted for about 18 percent of the state's electricity portfolio in 2006.[36] By some accounts, the inclusion of older renewable resources in RPSs creates demand to support ongoing maintenance and continued operation. However, failure to account for their inclusion in RPS targets can result in overestimations of a state's ambition or of its energy and emissions performance over time. In contrast to New York, New Mexico's 2007 RPS limited eligible technologies to those brought online no earlier than the first year the policy took effect, meaning that utilities could not count the 2 percent of wind energy already in place to fulfill their RPS obligations. This helps explain the appreciable differences in renewable energy growth among states with apparently similar RPSs.

Pennsylvania's Alternative Energy Portfolio Standard, which took effect in 2007, highlights a related caveat for RPS impact created by eligible resources. That state's RPS promotes two tiers of resources: one for renewable energy and a second for "alternative" (i.e., non-renewable) energy resources, including efficiencies achieved by demand side management, combined heat and power, and integrated gasification combined-cycle coal. Like the inclusion of existing renewable resources, inclusion of these technologies can result in lower renewable energy generation than a percentagebased target might suggest. These variations in policy design help explain growth differences in renewable energy generation among RPS states, but so do two other RPS policy attributes: cost containment and renewable energy credits (RECs).

RPSs typically include cost containment clauses—or "cost caps"—that allow for the suspension of RPS requirements if compliance is expected to result in significant price increases for consumers. While few states have fallen short of targets on account of cost constraints, this design feature also pushes utilities toward least-cost technologies for RPS compliance.[37] In the last decade and a half, this has resulted in an early and overwhelming reliance on onshore wind power for RPS compliance among states.[38] It is also important to note that RPSs do not necessarily require that utilities invest in renewable energy for compliance: most states also allow utilities to meet compliance through the purchase of RECs. An REC represents a megawatt-hour of electricity generated from a renewable energy system. Utilities can purchase RECs from other owners of renewable energy systems through a REC market in order to comply with their RPS obligations. REC markets generally include regional generation or delivery of electricity, which means RPS compliance in one state can be achieved by way of renewable energy procurement or development in another.[6]

In light of cost caps and REC compliance opportunities, the states that have most benefited from RPSs tend to feature greater resource potential (especially onshore wind) and fewer land-use constraints (which may arise owing to population density or existing infrastructure). Several states considered herein match this description, including Minnesota, Illinois, New Mexico, Oregon, and Texas. In these states, in-state wind capacity has, by and large, fulfilled RPS obligations. Conversely, RPS states with more limited renewable resource endowments have relied on RECs and out-of-state power procurement for RPS compliance.[7] Massachusetts is a case in point. There, in-state electricity generation accounted for no more than 30 percent of its RPS compliance in a given year between 2008 and 2017.[39] Massachusetts's experience can be understood as a case of policy "spillover": essentially, its RPS created renewable energy demand in neighboring states, especially Maine, which had the ability to supply abundant onshore wind power relatively cheaply.

Policy spillover explains why some states with no mandatory RPS have experienced rapid expansion in renewable energy generation: they have done so in response to demands from neighboring states with RPSs. Lawrence Berkeley National Laboratory suggests that 10 percent of all RPS capacity additions have been built in non-RPS states, amounting to an estimated nine gigawatts in South Dakota, Wyoming, and 11 other states.[40] This finding is supported by another study which indicates that, as an REC trading zone becomes larger, renewable energy deployment is concentrated in a few states—presumably where it is most cost-effective.[41]

A possible takeaway here is that states should establish in-state generation or procurement requirements as a condition of RPS compliance to ensure that renewable energy is "homegrown."

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6. State policies regarding RECs are nearly as diverse and multifaceted as those for RPSs. For an in-depth discussion, see Michael Gillenwater, "Redefining RECs—Part 1: Untangling attributes and offsets," *Energy Policy* 36, no. 6 (June 2018): 2109–2119.

7. This solution opens the door to another discussion about the role of measurement in state emissions reductions performance, as emissions associated with procured power generally "count" toward state emissions estimates but are not factored into the analysis here.

However, defining eligibility for RPS compliance solely on the basis of state boundaries may discriminate against interstate commerce and put states in violation of the Dormant Commerce Clause.[8] As a workaround, legal scholars have suggested that states reauthorize RPSs in language that emphasizes "legitimate, non-protectionist goals" such as environmental protection, electricity reliability, and resource diversity.[42] To date, this strategy remains untested.

A central opportunity for improving the impact of RPSs lies in aligning policy requirements with technologies that match state resources, particularly to promote technologies that are not yet cost-competitive. In the last decade, "carve-outs" for solar and distributed renewables have been incorporated into many RPS policies, mandating that utilities procure a small amount of renewable energy from these technologies. Carve-outs have earned some criticism for their price tag—amounting to as much as 40 percent of overall RPS compliance costs across all states in some years.[43] Nonetheless, few states have fallen short of targets on account of cost constraints, and carve-outs have contributed to substantial growth in solar power in the last decade. Credit multipliers have promoted similar goals under incentive-based rather than mandate designs, but empirical evidence finds that only carve-outs have had a statistically significant impact on renewable resource deployment.[44] In apparent recognition of their effectiveness, states are increasingly leveraging carve-outs to expand distributed generation and energy storage.[45] Offshore wind provides another recent example of aligning policy with state resources and nascent technologies. In 2016, Massachusetts became the first state to establish an offshore wind target, creating demand for a locally abundant resource. New York, New Jersey, and Virginia have subsequently followed suit, in recognition of the direct and long-term benefits of that resource in terms of in-state renewable energy growth potential.

A central opportunity for improving the impact of RPSs lies in aligning policy requirements with technologies that match state resources, particularly to promote technologies that are not yet cost-competitive.

Accelerating ambitions around renewable energy and emissions reductions are also motivating new policies that may prove more impactful on future performance. In particular, about a third of all U.S states have adopted targets for 100 percent carbon-free or net-zero electricity.[46] These policies have the advantage of explicitly mandating phase-outs of fossil fuel generation. For example, 2020 legislation in Virginia targets 100 percent renewable electricity by 2050, the retirement of most oil- and coal-fired generation units by 2025, and "all other electric generating units that emit carbon" by 2045, with a few exceptions.[9] Alongside these more recent and ambitious clean energy commitments, state

8. The doctrine has been summarized as "prohibition on discriminat[ion] between transactions on the basis of some interstate element.'" For a more in-depth discussion see Kevin Todd, The Dormant Commerce Clause and State Clean Energy Legislation, *Michigan Journal of Environmental & Administrative Law*, 189:9 (2020): 190–210. https://repository.law.umich.edu/cgi/viewcontent.cgi?article=1099&context=mjeal.

9. Utilities may petition state regulators for relief over grid reliability or security concerns.

eligibility criteria for clean or renewable technologies will continue to play an important role. A notable development is growing support for the inclusion of nuclear energy in clean energy plans, a zero-carbon resource that has historically been excluded from eligibility for RPS compliance. Five states—New York, Illinois, Ohio, Connecticut, and New Jersey—have enacted policies to support existing in-state nuclear generation through subsidies, though none has gone so far as to support new plant development.[47]

RPSs can motivate growth in renewables, but the effect is not always a one-for-one substitution of fossil fuel generation, nor a guaranteed local benefit, even when RPS compliance is fully achieved. States that have most benefited from RPSs in the last decade are those with abundant mature resources, especially wind. States that have experienced less renewable energy development from RPSs are likely to benefit from policy designs tailored to promote new renewable projects that align with local resources. Looking to the future, nascent technologies may offer greater and more competitive resource potential in these states. In the long term, the efficacy of the RPS policy approach requires not only high-level targets but also design features in the fine print that support robust, local renewable energy markets.

Net Metering

Net metering standards are often considered a foundational policy for small-scale renewable energy generation. These policies allow consumers to become "prosumers" by selling excess electricity generation to the grid. They reached near ubiquity following the federal Energy Policy Act of 2005, which required states to consider such standards.[48] Net metering policies have the benefit of specifically cultivating in-state renewable energy and can facilitate other desirable outcomes, such as reductions in energy demand and energy cost-burdens. Alongside these benefits, innovations in net metering policy design have supported not only diversification of electricity portfolios, but also diversification of energy ownership structures, creating new avenues of access to and demand for renewables.

Though states vary on the eligibility of technologies such as wind or small-scale hydropower for net metering, states with net metering policies uniformly include solar, and net metered systems across all states are overwhelmingly characterized by solar power. In 2018, net metered systems represented a greater proportion of total installed solar capacity than utility-scale generation in 18 states.[49] This pattern highlights the significance of net metering as a source of renewable energy development, as well as the unique suitability of solar power for distributed generation across a range of environments (e.g., urban and rural) and customer types (e.g., single homes and larger commercial developments).

Key net metering policy attributes account for the adoption of net metered systems within and across states by structuring customer opportunities for program participation and by highlighting the program's value (see Table 4 below). Traditionally, these attributes include limitations on the size of individual systems, aggregate net metered capacity, and the rate of compensation for net excess generation.

Table 4: Net Metering Policies in Selected States

	Net Metered Capacity - 2018 (MW)	Capacity Limits			Virtual Net Metering Allowed	Third-Party Ownership Allowed	Last Review of Rate Design	Net Excess Generation Rate
		Residential (kW)	Other (kW)	Aggregate*				
CA	8,181	1,000	1,000	5%	2008	2006	2015	Retail
MA	1,858	60	10,000	8%	2008	2008	2016	Less than retail
NY	1,390	25	2,000	5%	2011	2015	2014	Retail
PA	410	25	3,000	n.s.	2008	2012	2017	Retail, then reduced
FL	297	2,000	2,000	n.s.	-	2018	2017	Retail, then reduced
TX	215	-	-	-	2016	2011	-	-
OH	165	n.s.	n.s.	1%	-	-	2018	Less than retail
NM	150	80,000	80,000	n.s.	-	2015	-	Less than retail
OR	137	25	2,000	0.5%	2016	2008	-	Retail, then reduced
LA	136	25	300	0.5%	-	2016	-	Retail
MN	74	1,000	1,000	4%	2013	-	2016	Retail if < 40 kW, otherwise less
VA	69	20	1,000	1%	2017	2017	-	Retail
IL	67	2,000	2,000	5%	2016	-	-	Retail, then reduced
GA	19	10	100	0.2%	-	2015	2016	Less than retail
WY	6	25	25	n.s.	-	-	-	Less than retail
SD	0.7	-	-	-	-	-	-	-

*percent of utility's peak demand
n.s. = not specified

Source: "Summary Tables," DSIRE, NC Clean Energy Technology Center, https://programs.dsireusa.org/system/program/tables.

Rate designs for net excess generation shape the value of net metering participation. States with the most generous policies require that utilities compensate customers for excess renewable energy generation at the same rate as their retail electricity. Other states allow compensation structures that are lower than the retail rate some or all of the time. For example, in Virginia, customers are credited for excess generation at the retail rate on a 12-month cycle, after which they may opt to roll over credit indefinitely or to receive payment at a (lower) avoided-cost rate. Illinois customers are also credited the retail rate on a 12-month cycle, but excess credits are forfeited to the utility at the end of each year. In Wyoming, customers are only required to be compensated an avoided-cost rate, less than the retail rate for electricity. While there is evidence that rate structure matters in the adoption of net metered systems, the potential impact of net metering policies is more fundamentally shaped by capacity limits.[50]

Limitations on the size of individual systems and aggregate net metered capacity together delimit the scope of participation in state net metering programs. System limits affect the attractiveness of distributed generation investment across customer types. For example, Wyoming's 25-kilowatt (kW) system limit may suit the needs of individual homeowners, but it may hold little appeal for commercial or industrial customers. By contrast, Pennsylvania's policy accounts for this difference across consumer groups with tiered system limits for single-family residential systems and others, and Florida's blanket 2,000 kW system limit may be attractive to all user groups. Aggregate capacity limits affect how many customers ultimately benefit from net metering by reducing or eliminating compensation for excess electricity generation when the limit is reached. In short, higher limits of both kinds improve the potential impact of net metered systems and renewable energy generation, while rate designs improve the likelihood of realized impact by establishing a value for participation.

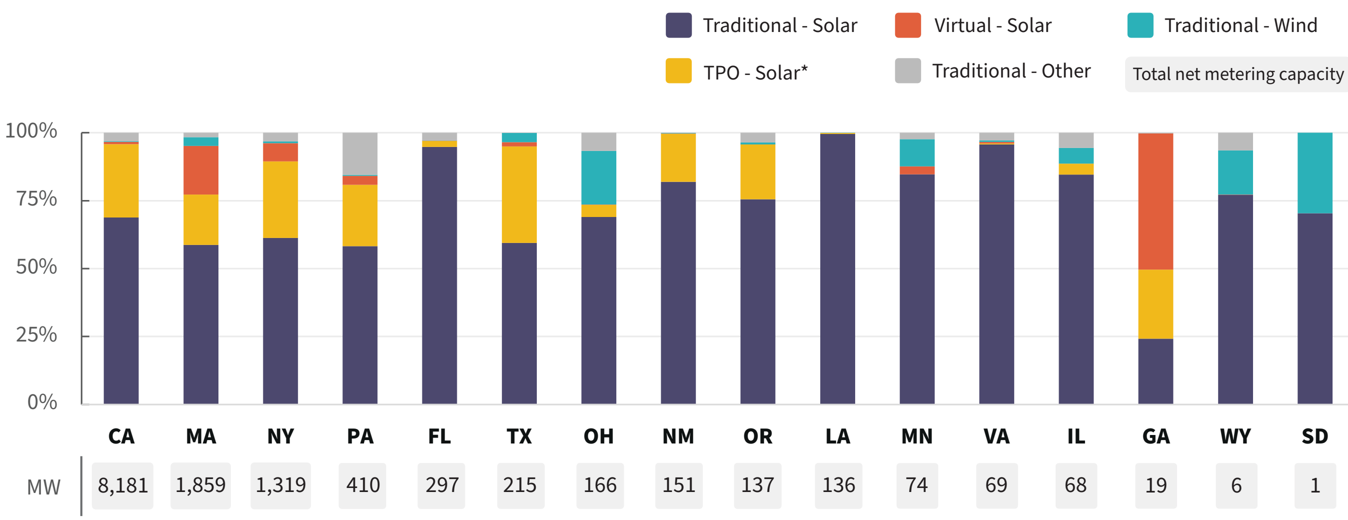
In the last decade, some states have expanded participation in net metering through two additional avenues: virtual net metering (VNM) and third-party ownership (TPO) models. These approaches can be written into existing net metering policies or developed in parallel with the goal of extending net metering participation and the penetration of distributed renewables. While neither has quite reached the prevalence of conventional net metering, each has taken hold across approximately half of all U.S. states, considerably expanding avenues for investment in distributed renewables. This is significant because net metering policies are somewhat regressive: they require that utilities compensate (i.e., subsidize) excess generation of those most capable of meeting the up-front capital costs and property requirements of traditional renewable energy ownership, and utilities distribute the cost of that subsidy across other ratepayers, including those unable to afford or host distributed renewables.

VNM programs (sometimes called group or neighborhood net metering) allow several customers to connect to a common, shared renewable energy system and to receive proportional compensation for their share of the generation. VNM works differently than the typical net metering arrangement, in which generated electricity flows back to a customer meter. In VNM, generated electricity feeds directly back to the grid, and the utility then allocates credits to individual utility accounts based on an allocation agreement. This approach arose in California in 2008 as part of the state's Multifamily Affordable Solar Housing (MASH) program, to help ensure that tenants—not just building owners—received the direct benefits of a building's solar system.[51] Since then, 20 states and the District of Columbia have adopted various VNM options.[52] These policies support a critical evolution in distributed renewables, providing access to renters and those otherwise unable to host an on-site system. In this way, VNM can improve inclusivity in net metering policies and renewable energy incentive programs. At the same time, VNM policies can create demand for, and improve the feasibility of, larger distributed renewables projects, thereby accelerating renewable energy deployment and decarbonization.

TPO also provides a novel avenue for the penetration of distributed generation. Under TPO models, a developer owns, operates, and maintains a customer-sited system, and the host customer pays a specific rate for system use or the electricity generated each month by way of a lease or power purchase agreement, respectively. This option is useful for customers who lack the upfront capital to purchase a distributed system, those who do not have the desire to own and maintain one, and those who cannot claim available incentives like tax credits (such as nonprofits). Under TPO models, such incentives and net metering compensation typically go to investors, while customers receive lower rates for renewable energy than may be incurred by direct investment. TPO models are not expressly allowed in about half of all states and face explicit legal barriers in at least six.[53] Restrictions on or ambiguity respecting TPO legality usually results from how states define utilities, with the language specifying that only regulated utility companies can sell electricity to end-use customers. Where supported by state-level policy or rulemaking, however, studies indicate that TPO creates additional demand for distributed solar, rather than replacing demand for traditional customer-owned systems.[54]

In light of these insights, one might conclude that states with higher system and aggregate limits for net metering, VNM, and TPO policy strategies are more likely to experience more rapid growth in distributed renewables and net metering participation. This conclusion is supported by empirical research and generally holds in terms of net metered capacity, depicted in Figure 4 below. [55] Among the selected states, the significance of VNM and TPO is evident in those that have accumulated the greatest net metered capacity: TPO solar accounted for about 27 percent of all net metered capacity in California (2,205 MW) and 28 percent in New York (392 MW). Likewise, VNM solar represented 18 percent of Massachusetts's net metered capacity (333 MW). States with lower limits on individual systems and those lacking either VNM or TPO have garnered less net metering capacity. Given that their other policy attributes are generally favorable, Minnesota and Illinois might be positioned to significantly benefit from TPO. In apparent recognition of this missed opportunity, Illinois adopted TPO in 2020.[56]

Figure 4: Net Metering by Type: Selected States 2018



*Third-party ownership

Source: "Annual Electric Power Industry Report, Form EIA-861," U.S. Energy Information Administration, https://www.eia.gov/electricity/data/eia861/.

While favorable net metering policies continue to support markets for distributed renewables, rising penetration rates are prompting some states to consider modifications to net metering excess generation rates. These modifications seek to balance incentives for adoption of renewables with grid impacts, resulting in new valuation models for net metered systems.[57] Generally, new valuation models account for attributes that have not traditionally been incorporated into rate design, such as collective benefits or added system costs. For example, in 2017, New York announced the development of a Value of Distributed Energy Resource (VDER) tariff approach. This variable compensation design accounts for the wholesale price of electricity in different locations, as well as the generation capacity, demand reduction potential, and environmental value of individual systems.[58] Similar "successor designs" are under consideration or development in several states. Though highly variable, many include new credit rates for excess generation, new customer charges, or the creation of a separate customer class for net metering customers.[59] There is some concern that successor designs will prematurely or unfairly reduce incentives for distributed systems in order to appease utility interests, which face mounting competition for electricity market share.[60] Given the relative recency of these developments, it remains to be seen how they will affect distributed system adoption and market growth.

Net metering policies play an important role in the decentralization and diversification of electricity portfolios and in expanding models of participation ownership and renewables consumption. The impact is historically small but is nonetheless direct, local, and steadily growing. Policy design features that support diverse and inclusive opportunities for participation are an important driver of renewable energy growth. Likewise, values reflected in this next generation of net metering policies are likely to have considerable bearing on the continued expansion of this category of renewables and its potential for power sector decarbonization.

Policy design features that support diverse and inclusive opportunities for participation are an important driver of renewable energy growth.

Financial Incentives

While the majority of states feature regulations that support basic renewable energy market access (e.g., net metering), cost constraints remain a primary barrier to the expansion of renewable energy.[61] Incentives that provide access to capital and improve project economics are frequently thought of as useful complements to regulatory measures. Like net metering, state-supported financial incentive programs have the benefit of explicitly prioritizing localized investment and generation.

Incentives come in a variety of forms, from tax-based credits and exemptions to financing mechanisms and direct subsidies. The number and type of incentives available differ dramatically across states, as do eligible beneficiaries (e.g., residential, commercial, or utility), technologies (e.g., solar or wind), and the monetary value of available incentives. What is perhaps the most comprehensive study of subnational financial incentives for solar development in the United States found no strong correlation between solar adoption and value of available incentives.[62] A possible explanation for this finding is that state resource endowments are an important determinant of incentive effectiveness, with resource-rich states requiring relatively modest incentives for significant development. Setting aside monetary value, incentives may be most impactful when narrowly tailored to support targeted beneficiaries (e.g., utility-scale or small-scale projects) and technologies. Here, several types of incentives available in the sample states during the study period are considered along these dimensions.

Select state incentives are detailed below (see Table 5), including type, eligible technologies (e.g., solar, wind, or other), and eligible beneficiaries (residential only, commercial and utility only, or both). Note that this table does not fully reflect the robustness of state efforts but depicts the availability of some of the most common incentive types across states. Moreover, the table does not reflect a count of available incentives. For example, New York offers multiple loan programs for solar technologies, which have been aggregated into one cell for brevity. In the table, states are organized according to the proportion of added renewable energy capacity they derive from different technologies.

Table 5: Incentives for Renewable Energy Development 2005 to 2018: Selected States

State		TAX-BASED				NON-TAX-BASED				ADDED CAPACITY		
		Sales Tax Credit	Corporate/Personal Tax Credit	Property Tax Credit	Production-Based Tax Credit	Production-Based Incentive	Rebate Program	Loan Program	Grant Program	%	MW	
TX	Solar	-	✓	✓	-	-	-	✓	-	8.3%	2,074	**Wind-driven growth**
	Wind	-	✓	✓	-	-	-	✓	-	**89.5%**	**22,439**	
	Other	-	-	✓	-	-	-	✓	-	2.2%	545	
	Eligibility	-	NR	B		-	-	NR	-	-	-	
IL	Solar	-	-	-	-	-	-	-	-	2.1%	98	
	Wind	✓	-	✓	-	-	-	-	-	**95.1%**	**4,543**	
	Other	-	-	-	-	-	-	-	-	2.9%	137	
	Eligibility	NR	-	NR	-	-	-	-	-			
OR	Solar	-	✓	✓	✓	✓	✓	✓	✓	12.2%	416	
	Wind	-	✓	✓	✓	-	-	✓	✓	**85.3%**	**2,913**	
	Other	-	✓	✓	-	-	-	✓	✓	2.5%	85	
	Eligibility	-	NR	NR	NR	NR	B	B	NR			
WY	Solar	✓	-	-	-	-	-	-	-	7.2%	97	
	Wind	✓	-	-	-	-	-	-	-	**89.8%**	**1,201**	
	Other	✓	-	-	-	-	-	-	-	3.0%	40	
	Eligibility	NR	-	-	-	-	-	-	-	-	-	
SD	Solar	✓	-	✓	✓	-	-	-	-	0.2%	2	
	Wind	✓	-	✓	✓	-	-	-	-	**99.7%**	**835**	
	Other	✓	-	✓	-	-	-	-	-	0.1%	1	
	Eligibility	NR	-	B	NR	-	-	-	-	.	-	
MN	Solar	✓	-	✓	-	-	-	✓	-	19.8%	805	**Diversified growth**
	Wind	✓	-	✓	-	✓	-	✓	-	**75.7%**	**3,086**	
	Other	-	-	-	-	✓	-	✓	-	4.5%	183	
	Eligibility	B	-	B	-	NR	-	NR	-	-	-	
NY	Solar	✓	✓	✓	-	-	✓	✓	✓	37.0%	1,211	
	Wind	-	-	✓	-	-	✓	✓	-	**55.5%**	**1,815**	
	Other	-	-	✓	-	✓	✓	-	-	7.5%	244	
	Eligibility	B	R	B	-	NR	B	B	NR	-	-	
NM	Solar	✓	-	✓	✓	-	-	-	-	32.6%	685	
	Wind	✓	-	-	✓	-	-	-	-	**67.3%**	**1,411**	
	Other	✓	✓	-	-	-	-	-	-	0.1%	2	
	Eligibility	B	B	R	NR	-	-	-	-	-	-	
PA	Solar	-	-	-	-	-	-	✓	✓	18.8%	313	
	Wind	-	-	✓	-	-	-	✓	✓	**69.4%**	**1,152**	
	Other	-	-	-	-	-	-	-	-	11.8%	196	
	Eligibility	-	-	NR	-	-	-	B	NR	-	-	
OH	Solar	✓	-	✓	-	-	-	✓	-	15.9%	199	
	Wind	✓	-	✓	-	-	-	✓	-	**59.5%**	**743**	
	Other	✓	-	✓	-	-	-	✓	-	24.5%	306	
	Eligibility	NR	-	B	-	-	-	B	-	-	-	
CA	Solar	✓	-	✓	-	✓	✓	✓	✓	**78.4%**	**17,935**	**Solar-driven growth**
	Wind	-	-	-	-	✓	-	✓	-	17.7%	4,040	
	Other	-	-	-	-	✓	-	-	-	3.9%	897	
	Eligibility	NR	-	B	-	B	B	NR	NR	-	-	
MA	Solar	✓	✓	✓	-	✓	✓	✓	-	**92.1%**	**2,169**	
	Wind	✓	✓	✓	-	-	-	✓	✓	6.6%	155	
	Other	✓	-	✓	-	-	✓	✓	✓	1.3%	31	
	Eligibility	R	B	B	-	B	B	NR	NR	-	-	
FL	Solar	✓	-	✓	✓	-	-	-	-	**78.6%**	**1,684**	
	Wind	✓	-	✓	✓	-	-	-	-	0.0%	0	
	Other	-	-	-	-	-	-	-	-	21.4%	458	
	Eligibility	B	-	B	NR	-	-	-	-	-	-	
GA	Solar	-	-	-	-	-	-	-	-	**69.0%**	**1,041**	
	Wind	-	-	-	-	-	-	-	-	0.0%	0	
	Other	✓	-	-	-	-	-	-	-	31.0%	468	
	Eligibility	B	-	-	-	-	-	-	-	-	-	
VA	Solar	✓	-	✓	-	-	-	✓	-	**60.8%**	**528**	
	Wind	-	-	-	-	-	-	✓	-	0.0%	0	
	Other	-	-	-	-	-	-	✓	-	39.2%	340	
	Eligibility	B	-	B	-	-	-	NR	-	-	-	
LA	Solar	-	-	✓	-	-	-	✓	-	16.1%	136	**Other**
	Wind	-	-	-	-	-	-	-	-	0.0%	0	
	Other	-	-	-	-	-	-	-	-	**83.9%**	**708**	
	Eligibility	-	-	R	-	-	-	R	-	-	-	

ELIGIBILITY KEY

R = residential
NR = non-residential
B = both

Source: "Summary Tables," DSIRE, NC Clean Energy Technology Center, https://programs.dsireusa.org/system/program/tables.

From Table 5, it is clear that Texas, Illinois, Oregon, Wyoming, and South Dakota favored tax-based incentives and large-scale projects over the period under observation. Though solar projects were generally eligible for available incentives in these states, their added renewable energy capacity was dominated by wind. This pattern is not necessarily surprising, as wind is a significant natural resource in these states. Additionally, the wind market is generally more mature, so wind developers may be better positioned to capitalize on available incentives. As a result, solar development in these states may benefit from more targeted or exclusive incentives.

States that saw a greater proportion of added solar capacity tended to offer a more diverse array of incentives. This diversity includes more incentive types available to residential beneficiaries, who tend toward solar over other renewable technologies. The diversity of incentives in these states also includes a greater offering of incentives not grounded in taxes, such as rebates, grants, and loans. Non-tax-based incentives may attract investors with limited or no tax liability, such as nonprofits, political subdivisions (e.g., municipalities), and other institutions (e.g., higher education). Additionally, non-tax-based incentives are generally more effective in addressing high upfront costs, a persistent market barrier to small-scale projects and investors with limited income or credit.

The inclusion of more diverse and inclusive incentives may explain some of the greater proportional growth of solar in some states, particularly California and Massachusetts, and, to a lesser degree, New York and Minnesota. However, the coincidence of diverse incentives with greater proportional growth in solar is not uniform: renewable capacity additions in Florida, Georgia, and Virginia favor solar in spite of limited incentives or mandates. A possible conclusion here is that solar markets in these states may benefit considerably from relatively modest additional incentives, especially those inclusive of residential beneficiaries and those that are not grounded in taxes.

While incentive programs have almost certainly influenced renewable energy development across the board, incentive utilization data is not uniformly collected in all states. This means that insights about the impact of particular incentive designs, as well as their interaction with one another and with other types of policy, are somewhat limited and often draw from case-based or qualitative studies. In 2015, New Mexico published a novel impact study of its production-based tax incentive from 2003 and 2012.[63] The study noted that surveyed developers of solar and wind power tended to rank the state incentive third in factors most influential in getting facilities developed, behind both the Federal Renewable Energy Tax Credit and the state's RPS.[64] This suggests that a number of the renewable energy projects that received the tax credit may still have been built in its absence, highlighting the significance of incentives as a complement—rather than a substitute—for regulations. California reported similar findings in an evaluation of its 2007 solar initiative, suggesting that supportive net metering policies and TPO models enhanced the effectiveness of its rebate program.[65]

Deeper insights about the impact of various incentive designs—including their interaction with one another and with other types of policy—require greater transparency about program participation rates and verified project development. Oregon is a notable standout in this way, providing easily accessible (and exportable) information respecting availability, uptake, and outcomes associated with its renewable energy tax credits and grants as part of a broader initiative to support open government.[66] Though that data does not fully reflect the state's suite of renewable energy incentives, it provides a useful framework for states looking to develop a much-needed system for sharing data about incentive programs, utilization, and associated benefits.

This discussion has taken a high-level view of available incentives across states to assess how they coincide with renewable energy development. Table 5 above demonstrates some alignment of capacity additions with incentives by eligible technology and beneficiary groups, but there are distinct exceptions. The need for, and effectiveness of, these incentives is likely influenced by the quality of state resource endowments and the co-occurrence of policy mandates. While maturing renewable energy markets—particularly wind—may require fewer incentives over time, states are likely to continue offering incentives to attract and secure in-state development. Across states, financial incentives are also emerging as a lever to expand energy storage systems, electric vehicles and charging infrastructure, and other technologies that will support clean energy transitions.[67] In these burgeoning markets, as in more established markets for renewables, increased transparency and more uniform reporting of incentive uptake and outcomes across states could support needed evaluations and opportunities to verify and improve incentive impact.

Across state policies to promote renewable energy—including RPSs, net metering, and financial incentives—some key recurring themes emerge. Local resource endowments play a significant role in shaping observed outcomes. States that have experienced the greatest renewable energy development are generally those with greater wind resources. States with less of this potential have generally focused instead on the development of decentralized renewables and have achieved greater expansion of distributed solar power. While progress in renewable energy development is apparent across most states, renewable energy projects are not displacing fossil fuel generation one-for-one, so the impact on emissions reductions is limited. Some of the more recent and ambitious reduction targets set forth by states are in line with scientific assessments of what is required to slow the climate crisis, especially targets of net-zero emissions by mid-century. However, realizing decarbonization at this level is likely to require more impactful policy instruments. These include some of the evolutions in policy design described here, such as fossil fuel phaseouts in conjunction with RPSs, more inclusive models of renewables ownership and participation emerging in net metering policies, and continued market expansion supported by incentives.

5

Equity and Environmental Justice

As states increasingly prioritize climate action, there is mounting attention to who benefits from (and bears the costs of) energy transitions. While themes of equity and environmental justice have been threaded throughout this discussion in terms of access to and participation in renewable energy projects and incentives, here this policy imperative is considered directly.

Environmental justice is an evolving concept that can be difficult to measure. The official U.S. government perspective on environmental justice is that it constitutes "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies."[68] Petitions for environmental justice emerged amid the Civil Rights movement of the 1960s, and study of the phenomenon largely started with the work of Dr. Robert Bullard, who has shown that low-income communities of color suffer a disproportionate amount of environmental damage.[69] Historically, local pollution of water and air have been organizing points for environmental justice initiatives. Recent studies highlight that people of color continue to be disproportionately exposed to sources of fine particulate matter ($PM_{2.5}$) emitted directly from these kinds of combustion associated with the power and transportation sectors.[70]

It is difficult to establish a causal relationship between complex energy decisions and environmental justice outcomes, and this paper does not attempt to do so. However, several conceptual links can be established between decarbonization strategies and environmental justice outcomes. For example, one can reasonably expect that jurisdictions that reduce emissions by switching from coal to gas or renewable energy will experience decrease in air pollutants such as nitrogen oxides, sulfur dioxide, and $PM_{2.5}$. However, if the decommissioning of coal plants is not handled properly, abandoned contaminated sites can become local health hazards. Additionally, jurisdictions that rely on coal plants for employment are often far from job centers and subject to higher rates of poverty. Without some kind of support, transitions away from coal can cause these areas to suffer economically after the plants close.[71]

Household energy burden—typically measured as the ratio of electricity price to average household income—is an environmental justice issue as well. Since the hydraulic fracturing revolution, as coal plants have become less and less economic to operate and natural gas prices have plummeted, coal-to-gas switching has likely kept electricity costs down, which is positive for environmental justice outcomes.[72] At the same time, growing reliance on natural gas raises new concerns, and many environmental justice advocates argue that the extraction and transportation of natural gas imposes environmental costs on vulnerable communities.[73] The Federal Energy Regulatory Commission, which permits pipelines in the United States, is beginning to examine the issue as part of a renewed federal focus on environmental justice.[74]

Persistent barriers to renewable energy participation by historically excluded groups are another environmental justice concern. As previously discussed, several of the selected states have instituted programs to expand access to renewable energy technologies. Progressive state policies include VNM and TPO. In some states, direct incentives are also being employed to reduce the barriers associated with high capital costs. For example, California's 2006 Single-Family Affordable Housing Program provided a solar system rebate of $3 per watt to homeowners making 80 percent or less of their area's median income.[75] The state instituted a similar program in 2008 that provides between $1.10 and $1.80 per watt for multifamily buildings.[76] Massachusetts provides another example with its Mass Solar loan program, which was developed to foster a market for residential solar financing and to support solar for those with lower income or lower credit.[77] For the program, the state leveraged about $40 million in funding to provide loan support (paid directly to the loan principal), interest rate buy-downs, and a loan loss reserve, which ultimately supported 58 MW of solar installations. In spite of these successes, rooftop solar energy remains significantly limited in some low-income communities and in neighborhoods with low home ownership rates.[78] Additionally, research demonstrates that Black- and Hispanic-majority neighborhoods lag majority-White neighborhoods in solar energy adoption, even when controlling for income and home ownership.[79] These findings indicate that there remains much room for improvement in fostering environmental justice alongside other climate imperatives.

Sometimes, even programs that are supposed to help low-income communities can have unintended consequences that negatively impact vulnerable groups. For example, residential Property-Assessed Clean Energy (PACE) programs, available in three states, have caused several problems for homeowners. Cities with PACE programs designate private companies as program administrators, who then authorize contractors to market energy-efficiency improvements or renewable energy upgrades to homeowners. A customer pays for these upgrades through property taxes when a lien is put on their home. Unfortunately, the design of the program creates bad incentives for unscrupulous contractors: there is little to no oversight to ensure that contractors are behaving ethically, and there is little to no recourse for customers who have lost their homes because they were sold on upgrades they could not ultimately afford.

There are several instances of homeowners saying that contractors did not give them all the facts they needed to make informed decisions, including how much their property taxes would increase (sometimes by several thousand dollars per year) and whether the savings on their electricity bills would cover the cost.[80] Many of these were in low-income neighborhoods where unscrupulous contractors could prey on people who did not speak English or who did not have the time or expertise to examine lengthy contracts. In addition, an energy audit is not required, so homeowners have no way of knowing whether the upgrades suggested by the contractor are necessary.[81] In some particularly egregious cases, homeowners have even received PACE liens without ever hearing from a contractor—according to the state of California, one program administrator hired a fake construction company that allegedly falsified documents and even impersonated a real contractor to claim PACE projects that did not exist.[82] Because PACE programs do not have the consumer protections associated with traditional mortgages, customers are forced to fight in court and convince the lien issuers to release them.

As states have accelerated climate ambitions, equity and environmental justice have garnered greater policy attention, likely for several reasons: as an impetus for action, as a basis for particular policy choices or designs, and as a benefit to be realized. This discussion has focused on identifying the aspects of environmental justice that can complement or arise from policies with the primary policy goal of increased renewable energy deployment. Given the diversity and sometimes competing interests of different environmental justice imperatives, policymakers should take care to narrowly specify their intended outcomes. This practice will support more meaningful and much-needed evaluations of these policies and provide insights about how conceptualizations of environmental justice and realized progress unfold over time.

6

Conclusions

When it comes to reducing CO_2 emissions from the energy system, state performance has been highly variable. The country-wide reduction in CO_2 emissions since 2005 is a story of some states doing a lot, some states doing little, and other states increasing their emissions. It is important to tell granular stories in order to draw useful policy lessons for achieving decarbonization.

Most of the success of this story has come from the power sector. A few states have managed to reduce emissions from both industry and transportation as well, but these changes can largely be explained through shifts in economic activity rather than by ambitious policy design. As such, this research did not delve too deeply into policies engineered to reduce emissions from industry and transport because the analysis did not yield obvious success stories that merited a deeper investigation.

Market forces—chiefly a switch from coal to gas—were the main driver for the decline in emissions in half the sample, and those shifts were independent of state policies. In other words, for half of the states in the sample, the reduction in CO_2 emissions was something that happened to the state, rather than something that happened as a result of state action. The switch from coal to gas happened as much in states with aggressive policy targets, renewable portfolio standards, and other incentives, as in states with none of those things. This, in itself, is a sobering conclusion.

No overarching policy or strategy seemed to explain the reduction in CO_2 emissions across states. There is a tendency, in the literature and the public discourse, to applaud states with bold emissions targets, especially long-term ones; however, topline ambition may be a poor predictor of progress. Various other policy instruments—regulating emissions directly, cap-and-trade systems, renewable portfolio standards, net metering, and financial incentives—all played a role and contributed to reductions in emissions, but their independent effects were hard to isolate.

The country-wide reduction in CO_2 emissions since 2005 is a story of some states doing a lot, some states doing little, and other states increasing their emissions. It is important to tell granular stories in order to draw useful policy lessons for achieving decarbonization.

Four additional themes became apparent in this research. The first is that policy design really matters. It is well known that no two renewable portfolio standards are exactly the same. One could say the same for other policy initiatives: the direct regulation of emissions from power plants differed among states, net metering policies were highly variable in terms of coverage, and financial incentives were highly diverse in what they covered and how they tried to effect change. These realities reinforce the importance of granular work and careful design.

Careful policy design also matters because most states interact and trade energy and electricity with other states. There were several instances where policies in one state drove generation in another, either as a push factor, leading to leakage, or as a pull factor, where generation in one state was responding to incentives or market forces in another. While states have pursued regional initiatives when it comes to cap-and-trade programs, they rarely take a similar regional approach when it comes to other policy instruments. They probably should.

The role of the federal government was also hard to determine clearly. There were times when federal incentives played a major role in promoting renewable energy, even in states where few state-level incentives existed. Having a high-quality resource like wind or solar allowed states to develop local resources largely on the back of federal programs. Other times, the federal government was shown to be an obstacle to experimentation, impeding states' efforts to move faster to decarbonize. This pattern could be expected to continue, with the federal government sometimes supporting technologies that the states themselves are not supporting, sometimes working alongside states to promote specific goals, and other times acting as an obstacle to state ambition.

Finally, the state of knowledge and the focus on questions of equity and environmental justice is growing but still suffers from major gaps. There are some obvious ways in which decarbonization would intersect with environmental justice concerns. A reduction in pollution benefits some communities more than others, because those communities are more exposed to pollution to begin with; on the other hand, the growth in low-carbon energy technologies might first benefit affluent households, and policy interventions might be needed to ensure that these benefits accrue to others too. But while there is increasing emphasis on equity and environmental justice, for most of this study period from 2005 to 2018 these issues were incidental to the broader decarbonization story. That too should change.

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Appendix

State Sampling Strategy

To identify a diverse and representative set of 16 states for the Clean Resilient States Initiative, state selection focused on ensuring variation in state energy use, geography, and state regulatory environments for energy and emissions, in that order. To do so, the eight states with the largest annual energy use were selected: Texas, California, Louisiana, Florida, New York, Pennsylvania, Ohio, and Illinois, these states spanned every census region in the country (Northeast, Midwest, West, and South). An additional eight states were chosen to balance the first eight to ensure diversity in regulatory environments for issues of climate and energy.

To assess state regulatory environments, states were clustered based on likeness across four key variables: each state's highest emissions target, largest renewable portfolio standard (RPS), American Council on Energy Efficiency state score, and cumulative number of energy and emissions-related regulations and incentives as of 2018.[83] As depicted in Table 6 below, states in Cluster 1 are characterized by high ambition and performance across all variables. States in Cluster 2 did not have emissions targets in 2018, but they did have mandatory renewable portfolio standards in place. States in Cluster 3 featured the least supportive state regulatory environments for renewables and emissions reduction, based on the variables considered below.

Table 6: Regulatory Environment Clusters: Selected States

	Cluster 1		Cluster 2		Cluster 3	
	CA, MA, MN, OR, NY		IL, NM, OH, PA, TX		GA, FL, LA, SD, VA WY	
	Range	Mean	Range	Mean	Range	Mean
Largest Emissions Targets % reduction	75 – 100	83	-	-	-	-
Largest RPS % renewables penetration	31.5 – 100	66	5 – 25	16	-	-
ACEEE Score Index	35 – 43	36	14 – 28	19	5 – 18	11
Energy Efficiency & Renewables Deployment # of state regulations	17 – 63	31	7 – 21	12	6 – 20	10
Total U.S. States per Cluster # of states per index cluster	16		13		21	

Source: Authors' analysis based on multiple sources.

This selection strategy ensured that selected states vary on a range of pertinent attributes:

- Energy
- Emissions
- Population and economy
- Energy workforce & innovation
- Environmental justice
- Resilience

These attributes are briefly discussed below.

Energy: Because the sample includes the eight largest energy-using states, it slightly overrepresents large energy users, but includes a mix of net electricity exporters, importers, and nearly self-sufficient states.[84]

Emissions: Selected states are generally representative in terms of absolute emissions and emissions intensity, including some but not all outliers and a high concentration of closer-to-average performers.[85]

Population: State population is strongly correlated with energy use (.87) and carbon emissions (.83). Because the eight largest energy-using states are included, the sample slightly overrepresent more populous states. Population density tends to result in less carbon-intensive economies, supported in part by greater opportunities for energy efficiency. The 16-state sample reflects a range of state population sizes and densities, slightly underrepresenting densities observed in the Northeast.[86]

Economy: Economic contexts are intimately linked to state energy and emissions, as economic activity that requires greater energy intensity tends to result in greater carbon intensities and per capita emissions. Since energy transitions may be shaped by economic bases, the sample includes a diverse distribution of economic activity.[87]

Energy workforce & innovation: The sample states include varying degrees of renewables-related employment, as measured by the percent of all energy employment in each state. The sample also includes different levels of state energy research and development (R&D) investment, including state-level allocations for energy R&D as a percent of all state R&D funding and each state's average annual federal energy R&D funding allocation, as a percent of all federal energy R&D funding.[88]

Environmental justice: Among states, environmental justice is not uniformly defined or attended to in the same way as some of the quantifiable characteristics described above. For the sampling strategy, two metrics were selected to provide a baseline sense of population vulnerabilities and state attention to pertinent issues of environmental justice. The EPA Risk-Screening Environmental Indicators (RSEI) score accounts for the annual size of chemical releases, size and location of the exposed populations, and chemical toxicity across states. A lower score indicates lower potential concern within a state. The second measure is the energy burden of low-income households, as depicted by the cost of annual energy as percent of household income for households at 80 percent or less of the area median income.[89]

Resilience: Different state challenges associated with resilience are captured in part by the geographic variation in this sample as geography is an important dimension of climate hazards. As for state attention to issues of resilience, the selected states include 7 of 17 states with a designated resilience officer or office.[90]

This report's strategy was to select the eight largest states by annual energy use, then eight additional states that ensure equal geographic representation and varying regulatory environment. This strategy has the advantage of being relatively simple and effective in ensuring diversity and representativeness on a range of values that are useful and important to lessons learned about state progress in addressing emissions, economic benefits, resilience, collaboration, and environmental justice.

Table 7: Key Characteristics of Selected States and U.S. Average (2018)

		NORTHEAST			MIDWEST				SOUTH					WEST				
		MA	**NY**	**PA**	**IL**	**MN**	**OH**	**SD**	**FL**	**GA**	**LA**	**TX**	**VA**	**CA**	**NM**	**OR**	**WY**	**U.S.**
Regulatory Environment	Regulatory Groups *Index score*	1	1	2	2	1	2	3	3	3	3	2	3	1	2	1	3	-
Energy	Annual Energy Use *Billion btu/1000*	1,424	3,684	3,808	3,872	1,832	3,644	385	4,209	2,802	4,482	13,366	2,303	7,881	683	1,032	512	1,949
	Interstate Flow of Electricity *>1 = net exporter*	0.51	0.88	1.45	1.32	0.90	0.83	0.98	1.02	0.92	1.08	1.12	0.81	0.77	1.36	1.30	2.73	1.12
Emissions	Emissions *Mt. tons CO_2*	63.1	167.7	221.6	210.4	92.7	208.8	15.6	231.2	133.2	211.0	701.9	103.2	363.0	45.5	39.6	63.7	105.7
	Emissions *Mt. tons CO_2 per dollar of GDP*	130	112	314	270	274	348	321	256	245	914	412	213	139	538	186	1,650	284
Population & Economy	Resident Population *Millions*	6.9	19.5	12.8	12.7	5.6	11.7	0.9	20.9	10.4	4.6	29.0	8.5	39.5	2.1	4.2	0.6	6.4
	Population Density *Residents per square mile*	839.4	411.2	283.9	231.1	66.6	282.3	10.7	350.6	181.3	104.9	96.3	202.6	239.1	17.0	39.9	5.8	87
	GDP per Capita *GDP/resident population*	78.8	81.6	58.8	64.6	63.3	55.4	56.8	46.7	53.9	51.0	58.4	60.3	71.3	45.0	54.5	65.0	59.9
	Agriculture GDP *% of state GDP*	0.1	0.2	0.5	0.7	1.6	0.5	6.6	0.6	0.7	0.7	0.6	0.3	1.4	1.5	1.6	1.7	1
	Industry GDP *% of state GDP*	14.5	8.9	19.6	17.7	20.3	23.3	15.7	12.4	16.7	30.2	27.6	14.2	16.0	18.2	19.8	33.0	18.3
	Manufact. GDP *% of state GDP*	9.5	4.4	11.6	12.2	14.1	16.2	9.8	5.3	10.6	18.4	13.0	8.5	10.8	4.1	13.9	5.2	11
	Gov. and Services GDP *% of state GDP*	85.4	91.0	79.9	81.6	78.1	76.1	77.7	87.0	82.6	69.1	71.9	85.4	82.6	80.3	78.6	65.3	80.8
Energy Workforce & Innovation	Energy Employment *% of total employment*	2	1	2	2	2	2	2	1	1	7	5	1	2	5	1	12	2
	State Energy R&D *% of total state R&D*	18	11	6	0	0	15	1	0	33	8	0	1	38	2	10	4	13
	Share of Federal Energy R&D *% of total federal R&D*	5	8	2	5	1	3	0	2	2	0	3	3	15	2	1	0	2
Environmental Justice	EPA Env. Risk-Screening *Index score*	1	2	44	22	2	27	1	66	7	19	354	8	15	0	22	0	14
	Low-Income Energy Burden *% of income*	8	8	9	7	6	8	8	8	9	10	7	7	5	8	6	7	8
Resilience	Resilience Office(r)	-	✓	-	✓	-	-	-	✓	-	✓	-	✓	✓	-	✓	-	-
	Resilience Plan	✓	✓	✓	-	✓	-	-	✓	-	✓	-	✓	✓	-	✓	-	-

Source: Authors' analysis based on multiple sources.

Endnotes

1 “Energy-Related CO2 Emission Data Tables, Table 2: State energy-related carbon dioxide emissions by year, adjusted,” U.S. Energy Information Administration, data released March 2, 2021, https://www.eia.gov/environment/emissions/state.

2 “Industrial energy-related carbon dioxide emissions by state,” U.S. Energy Information Administration, data released March 2, 2021, https://www.eia.gov/environment/emissions/state/.

3 “State Energy Data System (SEDS): 1960-2019 (complete),” U.S. Energy Information Administration, data released June 25, 2021, https://www.eia.gov/state/seds/seds-data-complete.php.

4 “Interactive Data, Regional Data, GDP and Personal Income, SAGDP9N Real GDP by state,” Bureau of Economic Analysis, last updated March 26, 2021, https://apps.bea.gov/iTable/index_regional.cfm.

5 “Manufacturing Energy Consumption Survey: Ratios of Mfg. Fuel Consumption to Economic Characteristics,” U.S. Energy Information Administration, https://www.eia.gov/consumption/manufacturing/data/2014/#r6.

6 “Number and Capacity of Petroleum Refineries,” U.S. Energy Information Administration, data released June 25, 2021, https://www.eia.gov/dnav/pet/pet_pnp_cap1_dcu_nus_a.htm.

7 “Highway Statistics 2006 and 2019 (data for 2005 and 2018),” Federal Highway Administration, https://www.fhwa.dot.gov/policyinformation/statistics.cfm.

8 The data on product use come from “State Energy Data System (SEDS): 1960-2019 (complete),” U.S. Energy Information Administration, data released June 25, 2021, https://www.eia.gov/state/seds/seds-data-complete.php.

9 “Offshore Wind Accelerator Project (OWAP),” Clean Energy States Alliance, https://www.cesa.org/projects/offshore-wind-accelerator-project-owap/; “Building Decarbonization and Clean Heating/Cooling,” Clean Energy States Alliance, https://www.cesa.org/projects/building-decarbonization-and-clean-heating-cooling/.

10 Micheline Maynard, “E.P.A. Denies California’s Emissions Waiver,” *New York Times*, December 19, 2007, https://www.nytimes.com/2007/12/19/washington/20epa-web.html.

11 U.S. Environmental Protection Agency, “EPA Denies Petition to Regulate Greenhouse Gas Emissions from Motor Vehicles,” News release, August 28, 2003, https://archive.epa.gov/epapages/newsroom_archive/newsreleases/694c8f3b7c16ff6085256d900065fdad.html.

12 “Massachusetts v. EPA,” U.S. Department of Justice, https://www.justice.gov/enrd/massachusetts-v-epa.

13 John Basseches, “Private Power in the US States: Business Interests and the Design of State-Level Climate and Renewable Energy Policies” (PhD diss., Northwestern University, 2020).

14 “Partisan Composition,” National Conference of State Legislatures, https://www.ncsl.org/research/about-state-legislatures/partisan-composition.aspx.

15 Stephen Wheeler, “State and Municipal Climate Change Plans: The First Generation,” *Journal of the American Planning Association* 74 (October 15, 2008): 481–496.

16 William Drummond, “Statehouse Versus Greenhouse,” *Journal of the American Planning Association* 76 (July 30, 2010): 413–433.

17 Geoff Martin and Eri Saikawa, “Effectiveness of state climate and energy policies in reducing power-sector CO2 emissions,” *Nature Climate Change* 7, no. 12 (December 2017): 912–919.

18 “eGRID Data Files,” U.S. Environmental Protection Agency, https://www.epa.gov/energy/egrid.

19 Richard Revesz et al., “Grandfathering Coal: Power Plant Regulation Under the Clean Air Act,” *Environmental Law Reporter* 46, no.7 (July 2016), https://elr.info/news-analysis/46/10541/grandfathering-coal-power-plant-regulation-under-clean-air-act.

20 Charles Mason and Andrew Plantinga, “Contracting for Impure Public Goods, Carbon Offsets and Additionality” (NBER Working Paper 16963, National Bureau of Economic Research, Cambridge, MA, April 2011), https://www.nber.org/system/files/working_papers/w16963/w16963.pdf.

21 Anja Kollmuss, Michael Lazarus, Carrie Lee, and Clifford Polycarp, *A Review of Offset Programs: Trading Systems, Funds, Protocols, Standards and Retailers* (Stockholm: Stockholm Environment Institute, 2008).

22 “Regulation Database – New Source Performance Standards for GHG Emissions from Electric Generating Units,” Sabin Center for Climate Change Law, Columbia Law School, https://climate.law.columbia.edu/content/regulation-database-new-source-performance-standards-ghg-emissions-electric-generating.

23 Ruby Wincele, “Cap-and-Trade Ambition Renewed in 2019 After a Decade of Decline,” *Climate Xchange*, December 12, 2019, https://climate-xchange.org/2019/12/12/cap-and-trade-ambition-renewed-in-2019-after-a-decade-of-decline/.

24 Western Climate Initiative, *Design for the WCI Regional Program* (Sacramento, CA: Western Climate Initiative, 2010), https://wcitestbucket.s3.us-east-2.amazonaws.com/amazon-s3-bucket/documents/en/wci-program-design-archive/WCI-ProgramDesign-20100727-EN.pdf.

25 “Elements of RGGI,” Regional Greenhouse Gas Initiative, https://www.rggi.org/program-overview-and-design/elements.

26 Ruby Wincele, “Cap-and-Trade Ambition Renewed in 2019.”

27 Regional Greenhouse Gas Initiative, *The Investment of RGGI Proceeds in 2019* (New York: RGGI, Inc., 2021), https://www.rggi.org/sites/default/files/Uploads/Proceeds/RGGI_Proceeds_Report_2019.pdf.

28 “About California Climate Investments,” California Climate Investments, State of California, 2021, http://www.caclimateinvestments.ca.gov/about-cci.

29 Brian C. Murray and Peter T. Maniloff, "Why Have Greenhouse Emissions in RGGI States Declined? An Econometric Attribution to Economic, Energy Market, and Policy Factors," *Energy Economics* 51, issue C (2015): 581–589.

30 Harrison Fell and Peter T. Maniloff, "Leakage in Regional Environmental Policy: The Case of the Regional Greenhouse Gas Initiative," *Journal of Environmental Economics and Management* 87, issue C (2018): 1–23.

31 "Current California GHG Emission Inventory Data," California Air Resources Board, 2020, https://ww2.arb.ca.gov/ghg-inventory-data.

32 Lisa Song, "Cap and Trade Is Supposed to Solve Climate Change, but Oil and Gas Company Emissions Are Up," ProPublica, November 15, 2019, https://www.propublica.org/article/cap-and-trade-is-supposed-to-solve-climate-change-but-oil-and-gas-company-emissions-are-up.

33 "Transportation and Climate Initiative Statement," Transportation and Climate Initiative, December 18, 2018, https://www.georgetownclimate.org/files/Final_TCI-statement_20181218_formatted.pdf; David Abel, "Mass., Other States Near Historic Agreement to Curb Transportation Emissions," Boston Globe, December 15, 2020, https://www.bostonglobe.com/2020/12/15/metro/mass-other-states-near-historic-agreement-curb-transportation-emissions/.

34 Jung Eun Kim and Tian Tang, "Preventing early lock-in with technology-specific policy designs: The Renewable Portfolio Standards and diversity in renewable energy technologies," Renewable and Sustainable Energy Reviews 123 (May 2020); Ryan Wiser et al., *A Retrospective Analysis of the Benefits and Impacts of U.S. Renewable Portfolio Standards* (Berkeley, CA: Lawrence Berkeley National Laboratory, January 2016), https://www.nrel.gov/docs/fy16osti/65005.pdf; Geoff Martin and Eri Saikawa, "Effectiveness of state climate and energy policies in reducing power-sector CO2 emissions," *Nature Climate Change* 7, no. 12 (December 2017): 912–919.

35 Gireesh Shrimali, Steffen Jenner, Felix Groba, Gabriel Chan, and Joe Indvik, "Have state renewable portfolio standards really worked? Synthesizing past policy assessments to build an integrated econometric analysis of RPS effectiveness in the US" (DIW Discussion Papers No. 1258, German Institute for Economic Research, Berlin, 2018), https://www.econstor.eu/bitstream/10419/68450/1/734808526.pdf.

36 "Retail Renewable Portfolio Standard Case 03-E-0188," New York State, https://www3.dps.ny.gov/W/PSCWeb.nsf/All/1008ED2F934294AE85257687006F38BD?OpenDocument

37 Nancy Rader and Scott Hemplin, *The Renewables Portfolio Standard: A Practical Guide* (Washington, DC: National Association of Regulatory Utility Commissioners, 2001), https://www.energy.gov/sites/prod/files/oeprod/DocumentsandMedia/narucrps.pdf.

38 Wiser et al., *A Retrospective Analysis of the Benefits and Impacts of U.S. Renewable Portfolio Standards*.

39 Massachusetts Department of Energy Resources, *Renewable Portfolio Standard Annual Compliance Report* (Boston, MA: Massachusetts Department of Energy Resources, March 12, 2020), https://www.mass.gov/doc/rps-aps-annual-report-2017/download.

40 Galen Barbose, *U.S. Renewable Portfolio Standards Annual Update 2019* (Berkeley, CA: Lawrence Berkeley National Laboratory, July 2019), https://eta-publications.lbl.gov/sites/default/files/rps_annual_status_update-2019_edition.pdf.

41 Shrimali et al., "Have state renewable portfolio standards really worked?"

42 Ari Peskoe and Kate Konschnik, *Minimizing Constitutional Risk: Crafting State Energy Policies that Can Withstand Constitutional Scrutiny* (Cambridge, MA: Harvard Environmental Law Policy Initiative, October 18, 2017), https://statepowerproject.files.wordpress.com/2017/10/harvard-epi-minimizing-constitutional-risk-10-18-2017.pdf.

43 Barbose, *U.S. Renewable Portfolio Standards Annual Update 2019*.

44 Kim and Tang, "Preventing early lock-in with technology-specific policy designs," 213–243.

45 Edward Holt and Todd Olinksy-Paul, *Does Energy Storage Fit in an RPS? Clean Energy States Alliance* (Montpelier, VT: Clean Energy States Alliance, 2016), https://www.cesa.org/wp-content/uploads/Energy-Storage-and-RPS-Holt.pdf.

46 "Race to 100% Clean," Natural Resources Defense Council, 2020, https://www.nrdc.org/resources/race-100-clean.

47 Mark Morey, "Five states have implemented programs to assist nuclear power plants," *Today in Energy*, October 7, 2019, https://www.eia.gov/todayinenergy/detail.php?id=41534.

48 Energy Policy Act of 2005, H.R. 6, 109th Congress, Subtitle E. (2005).

49 "Annual Electric Power Industry Report, Form EIA-861 detailed data files," U.S. Energy Information Administration, data released August 3, 2021, https://www.eia.gov/electricity/data/eia861/.

50 Naïm R. Darghouth et al., "Net metering and market feedback loops: Exploring the impact of retail rate design on distributed PV deployment," *Applied Energy* 162 (July 2015): 713–722.

51 "Virtual Net Metering," California Public Utilities Commission, https://www.cpuc.ca.gov/General.aspx?id=5408.

52 "DSIRE [Database of State Incentives for Renewables and Efficiency]," NC Clean Energy Technology Center, 2021, https://nccleantech.ncsu.edu/renewable-energy-resources/dsire/.

53 Legal barriers usually lie in state definitions of "utility," which restrict power purchase agreements between third-party owners and prospective customers in Alabama, South Carolina, North Carolina, West Virginia, Kentucky and Arkansas, and until 2018, Florida. See "DSIRE," NC Clean Energy Technology Center.

54 Varun Rai, D. Cale Reeves, and Robert Margolis, "Overcoming Barriers and Uncertainties in the Adoption of Residential Solar PV," *Renewable Energy* 89, issue C (2016): 498–505.

55 Kathleen Marie Smith, Chris Koski, and Saba Siddiki, "Regulating net metering in the United States: A landscape overview of states' net metering policies and outcomes," *Electricity Journal* 34, no. 2 (March 2021); Kristen Ardani, Carolyn Davidson, Robert Margolis, and Erin Nobler, *A State-Level Comparison of Processes and Timelines for Distributed Photovoltaic Interconnection in the United States* (Golden, CO: National Renewable Energy Laboratory, 2015), https://www.nrel.gov/docs/fy15osti/63556.pdf.

56 Illinois Commerce Commission, *Petition for the Approval of the IPA's Revised Long-Term Renewable Resources Procurement Plan Pursuant to Section: 16-111.5(b)(5)(ii) of the Public Utilities Act* (Illinois Commerce Commission, February 2020), https://www2.illinois.gov/sites/ipa/Documents/Draft%20Revised%20Plan%20-%20Summer%202019/E-5_19-0995_FINAL%20ORDER%20Revised%20Plan%20Feb%202020.pdf.

57 Richard Revesz and Burcin Unel, "Managing the Future of the Electricity Grid: Distributed Generation and Net Metering," *The Harvard Environmental Law Review* 41, no. 1 (January 2017), https://www.researchgate.net/publication/303784934_Managing_the_Future_of_the_Electricity_Grid_Distributed_Generation_and_Net_Metering.

58 "The Value Stack," NY-Sun, New York State Energy Research and Development Authority, https://www.nyserda.ny.gov/All-Programs/Programs/NY-Sun/Contractors/Value-of-Distributed-Energy-Resources.

59 Tom Stanton, *Review of State Net Energy Metering and Successor Rate Designs* (Columbus, OH: National Regulatory Research Institute, March 2019), https://pubs.naruc.org/pub/A107102C-92E5-776D-4114-9148841DE66B/.

60 Ari Peskoe, "Unjust, Unreasonable, and Unduly Discriminatory: Electric Utility Rates and the Campaign Against Rooftop Solar," T*exas Journal of Oil, Gas, and Energy Law* 11 (2016): 101–110, https://ssrn.com/abstract=2735789.

61 Lazard, *Lazard's Levelized Cost of Energy Analysis—Version 12.0* (New York: Lazard, November 2018), https://www.lazard.com/media/450784/lazards-levelized-cost-of-energy-version-120-vfinal.pdf.

62 Brian Bush, Elizabeth Doris, and Dan Getman, *Understanding the Complexities of Subnational Incentives in Supporting a National Market for Distributed Photovoltaics* (Golden, CO: National Renewable Energy Laboratory, 2014), https://www.nrel.gov/docs/fy14osti/62238.pdf.

63 New Mexico Energy, Minerals & Natural Resources Department, *Economic Analysis of the New Mexico Renewable Energy Production Tax Credit* (Santa Fe, NM: 2015), https://web.archive.org/web/20210609104202/http://www.emnrd.state.nm.us/ECMD/CleanEnergyTaxIncentives/documents/REPTCFinalReportFeb2015.pdf.

64 45 facilities were contacted, 22 participated.

65 California Public Utilities Commission, *California Solar Initiative Annual Report to the Legislature* (San Francisco: California Public Utilities Commission, 2020), https://www.cpuc.ca.gov/-/media/cpuc-website/files/legacyfiles/2/6442465653-2020-csi-apa.pdf.

66 "Tax Credits & Energy Programs," Oregon Transparency., https://www.oregon.gov/transparency/Pages/Tax-Credits.aspx.

67 "DSIRE," NC Clean Energy Technology Center.

68 "Environmental Justice," U.S. Environmental Protection Agency, https://www.epa.gov/environmentaljustice.

69 Gregory Dicum, "Meet Robert Bullard, the Father of Environmental Justice," Grist, March 15, 2006, https://grist.org/article/dicum/.

70 Christopher W. Tessum et al., "PM2.5 Polluters Disproportionately and Systemically Affect People of Color in the United States," *Science Advances* 7, no. 18 (April 2021), https://advances.sciencemag.org/content/7/18/eabf4491.

71 Mark Haggerty, "Communities at Risk from Closing Coal Plants," *Headwater Economics*, March 2017, https://headwaterseconomics.org/energy/coal/communities-coal-plant-closures/.

72 Catherine Hausman and Ryan Kellogg, "Welfare and Distributional Implications of Shale Gas" (Brookings Papers on Economic Activity, BPEA Conference Draft, March 19–20, 2015), https://www.brookings.edu/wp-content/uploads/2016/07/2015a_hausman.pdf.

73 Kara Harris, "A Texas Town Takes on Fracking as a Racial Justice Issue," *Bloomberg*, August 28, 2020, https://www.bloomberg.com/news/articles/2020-08-28/racial-justice-concerns-spur-new-fracking-scrutiny.

74 Laura Lopez Nickerson and Stephen J. Humes, "FERC To Natural Gas Pipeline Industry: What About Environmental Justice?" *Holland and Knight*, February 25, 2021, https://www.hklaw.com/en/insights/publications/2021/02/ferc-to-natural-gas-pipeline-industry.

75 "California Solar Initiative - Single-Family Affordable Solar Housing (SASH) Program," DSIRE, NC Clean Energy Technology Center, March 8, 2021, https://programs.dsireusa.org/system/program/detail/3673.

76 "CSI Multifamily Affordable Solar Housing (MASH) Program," California Public Utilities Commission, https://www.cpuc.ca.gov/general.aspx?id=3752.

77 Lower income defined as ≤ 100% of the median household before 2016, ≤80% thereafter. Lower credit defined as Fair Isaac Corporation (FICO) score of ≤ 720.

78 "Low- and Moderate-Income Solar Policy Basics," National Renewable Energy Laboratory, https://www.nrel.gov/state-local-tribal/lmi-solar.html.

79 Deborah Sunter, Sergio Castellanos, and Daniel M. Kammen, "Disparities in Rooftop Photovoltaics Deployment in the United States by Race and Ethnicity," Nature Sustainability 2 (2019): 71–76, https://www.nature.com/articles/s41893-018-0204-z.

80 Rebecca Burns, "The Subprime Solar Trap for Low-Income Homeowners," *Bloomberg*, April 6, 2021, https://www.bloomberg.com/news/features/2021-04-06/the-subprime-solar-trap-for-low-income-homeowners?sref=B2BBHw9t.

81 "PACE Energy Efficiency Loans: Good Intentions, Big Risks for Consumers," National Consumer Law Center, September 2016, https://www.nclc.org/issues/pace-energy-efficiency-loans.html.

82 Mike Freeman, "San Diego clean energy lender Renovate America may lose PACE license amid fraud claims," *San Diego Union-Tribune*, June 4, 2021, https://www.sandiegouniontribune.com/business/story/2021-06-04/california-regulator-moves-to-revoke-pace-license-of-san-diego-clean-energy-lender-renovate-america-amid-fraud-claims.

83 "U.S. State Greenhouse Gas Emissions Targets," Center for Climate and Energy Solutions, https://www.c2es.org/document/greenhouse-gas-emissions-targets/; Galen Barbose, *U.S. Renewables Portfolio Standards: 2018 Annual Status Report* (Berkeley, CA: Lawrence Berkeley National Laboratory, November 2018), https://emp.lbl.gov/publications/us-renewables-portfolio-standards-1; "The 2018 State Energy Efficiency Scorecard," data released October 4, 2018, American Council for an Energy-Efficient Economy, https://www.aceee.org/research-report/u1808; "Summary Tables," DSIRE, NC Clean Energy Technology Center, https://programs.dsireusa.org/system/program/tables.

84 "Carbon dioxide emissions by state," U.S. Energy Information Administration, data released March 2, 2021, https://www.eia.gov/environment/emissions/state/.

85 "State Energy Data System (SEDS): 1960-2019 (complete)," U.S. Energy Information Administration, data released June 25, 2021, https://www.eia.gov/state/seds/seds-data-complete.php.

86 "State Population Totals and Components of Change: 2010-2019," U.S. Census Bureau, data released April 20, 2021, https://www.census.gov/data/tables/time-series/demo/popest/2010s-state-total.html.

87 "GDP by State," U.S. Bureau of Eocnomic Analysis, data released June 25, 2021, https://www.bea.gov/data/gdp/gdp-state

88 "Survey of State Government Research and Development," National Science Foundation, data released October 1, 2020, https://www.nsf.gov/statistics/srvystaterd/.

89 "Risk-Screening Environmental Indicators (RSEI): Explore RSEI Scores for Facilities, Counties and States," U.S. Environmental Protection Agency, data released January 20, 2021, https://www.epa.gov/rsei/rsei-results-map; "Low-Income Energy Affordability Data Tool,", U.S. Department of Energy, data released July 1, 2019, https://lead.openei.org/.

90 Authors' analysis based on multiple sources.

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