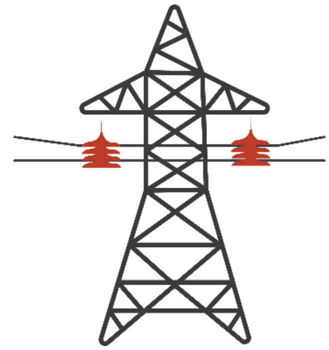
Policy Brief: Emerging Trends in Renewable and Zero-Emissions Electricity Standards



Numerous policies have been used in the United States at the state and federal level to encourage development of renewable electricity generation resources, from tax credits to tariffs – but one of the most successful has been the renewable portfolio standard, or RPS. An RPS establishes a target percentage of a jurisdiction's electricity that must come from eligible renewable resources. This target can be either a non-binding goal, as it is for a small number of states, or a binding requirement, as it is for most states with an RPS. According to Lawrence Berkeley National Laboratory, roughly half of the non-hydropower renewable energy development in the U.S. since 2000 can be attributed to RPS policies.[1]

Oregon established its RPS in 2007 with Senate Bill 838,[2] providing a requirement for the largest[i] utilities – Portland General Electric, PacifiCorp, and the Eugene Water & Electric Board – to provide 25 percent of retail sales of electricity from eligible renewable sources by 2025, with interim targets along the way. In 2016, the Oregon Clean Electricity and Coal Transition Plan (SB 1547[3]) increased the RPS requirement for the largest utilities to 50 percent by 2040. At the time, this placed Oregon in a small cohort of states with RPS targets of 50 percent or higher; since 2016, renewable energy policy has moved fast, with a number of states implementing higher RPS targets as well as 100 percent "clean" or "zero-carbon" standards.[4]

This section highlights recent trends in RPS design and targets in the U.S., describes different approaches various states have adopted in designing these programs, highlights interactions between RPS targets and clean electricity standards, and provides information on renewable energy policy actions that Oregon could consider in the future.

For more background on 100 percent renewable and zero-emissions electricity standards, see the Energy 101 section of this Biennial Energy Report.

Trends in RPS Targets and Clean Electricity Standards

As of May 2020, RPS policies are on the books in 30 states in the U.S. and in the District of Columbia. While most of these policies were enacted before 2008, there has been a flurry of activity in recent years by states making significant policy revisions to their RPS rules.

Increasing RPS Targets

Since January 2018, ten states and the District of Columbia have increased their RPS targets.[ii]

[i] Determined by the percent of Oregon's retail electricity sales the utility serves.
[ii] While some U.S. territories also have RPS and Clean Electricity Standards, they are not addressed in this paper.

Table 1: State RPS Target Increases Since January 2018

State	Previous RPS Target	New RPS Target
California	33% by 2020	60% by 2030
Connecticut	23% by 2020	44% by 2030
District of Columbia	25% by 2025	100% by 2032
Maine	40% by 2017	84% by 2030
Maryland	20% by 2022	50% by 2030
Massachusetts	1% annual increases	41.1% by 2030
New Jersey	22.5% by 2020	54.1% by 2031
New Mexico	20% by 2020	80% by 2030
Nevada	25% by 2025	50% by 2030
New York	30% by 2015	70% by 2030
Virginia	Voluntary Goal	100% by 2050

Table adapted from Barbose (2019) and Leon (2019)

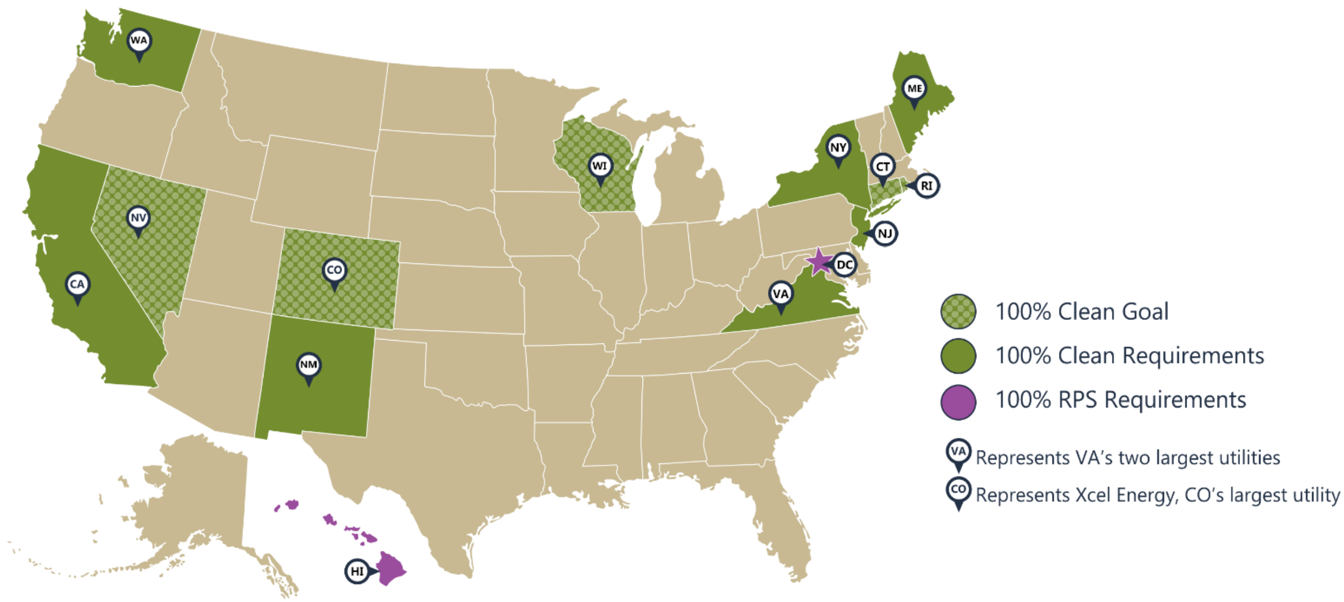
100 Percent RPS vs 100 Percent Clean Electricity Standards

One of the biggest recent trends in clean energy policies is the push for 100 percent clean electricity standards. States have gone about this via three main pathways: legislation, voluntary (non-binding) goals, and gubernatorial executive orders. Terminology indicating whether these pathways are binding or non-binding is not consistently applied across state programs. For clarity purposes, throughout this discussion, references are made to *goals* and statutory *targets*, where targets are legislatively codified and goals are either non-codified (as in the case with gubernatorial executive orders) or non-binding.

See Energy 101 section for more about renewable and zero emissions standards

While a 100 percent RPS requirement and a 100 percent clean electricity standard may seem interchangeable, there can be material differences between the implementation of the two. For example, many state RPS policies were originally enacted to incentivize the development of *new* renewable resources, which in practice left many older renewable resources ineligible, such as the Pacific Northwest's legacy hydropower. Some RPS policies have also excluded generation sources that are not traditionally considered "renewable" but that may be low-carbon or zero-carbon, such as nuclear power or fossil fuel-generated electricity with carbon capture and storage (CCS) technology. States can make legislative changes to their RPS programs to allow new generation sources, but given how mature many state's RPS policies are, and how complex they can be with carve-outs and tiers (see below for more information), some may determine it to be easier administratively to preserve the RPS policy as is and then add a complementary new clean energy standard.

Figure 1: 100% RPS and 100% Clean Electricity Goals by State (Data: EQ Research[5])



Below is a discussion of the 100 percent RPS or 100 percent clean electricity standard policies individual states have enacted, and a table summarizing the information is available below. Two jurisdictions now have 100 percent RPS targets: Hawaii and the District of Columbia.

The **District of Columbia** passed a Clean Energy Act in 2018 that established a requirement of 100 percent RPS by 2032. The district's current RPS has two tiers and allows for a small percent of annual compliance to come from Tier Two resources like hydropower (other than pumped storage), combustion of municipal solid waste, and generation from older, less efficient biomass facilities and/or those that use black liquor.

Hawaii also has a 100 percent RPS requirement by 2045. Current RPS-eligible resources include solar, wind, hydropower, biogas, geothermal, ocean energy, biomass, combustion of municipal solid waste, and hydrogen produced from renewable sources.

Other states have chosen instead to couple their RPS policies with a clean electricity standard that totals to a 100 percent clean electricity target (see Table 2). Following are details on each state with a 100 percent "clean" electricity target, including how each state chooses to define "clean" or "zero-carbon." Definitions differ across states and most states have not yet defined what resources will be eligible for the "clean" portion of the 100 percent standard. For that reason, information is provided for some states on resources eligible for the RPS.

Because it is not yet clear from the details included in the legislation or Governor's Executive Orders, some of the state targets outlined below potentially could be categorized as a 100 percent RPS policy instead of a 100 percent clean electricity standard because they will not add new resource eligibility beyond what's already allowed for RPS compliance. Those states include Maine, Nevada, Rhode Island, and Virginia.

California increased its RPS requirement to 60 percent by the end of 2030 and added a requirement that all retail electricity be from either RPS-eligible renewables or "zero-carbon" sources by the end of 2045. The legislation, SB 100 (2018), does not define "zero-carbon resources," but in planning for implementation, the state is considering two scenarios:[6]

- RPS+ scenario, where resources eligible for the RPS, plus large hydropower, nuclear, and natural gas with carbon capture and storage would be considered eligible "zero-carbon resources;" and
- No Fossil Fuel scenario, where resources eligible for the RPS plus large hydropower and nuclear would be considered eligible "zero-carbon resources."

Colorado, in 2019, codified the non-binding goal of its largest utility, Xcel Energy, to provide customers with electricity generated from 100 percent "clean energy resources" by 2050. The legislation defines clean energy resources as those that generate or store electricity without emitting carbon dioxide into the atmosphere, including those already eligible for the state's RPS: solar, wind, geothermal, biomass, small hydropower, coal mine methane,[iii] and pyrolysis (but not combustion) of municipal solid waste. Colorado has not identified what other resources, if any, beyond RPS-eligible resources, could be considered clean energy resources.

Connecticut's Governor-signed Executive Order No. 3 in 2019 requires state agencies to analyze pathways and provide recommendations for meeting a 100 percent "zero carbon" goal for the electric sector by 2040, but it does not make the goal binding, does not define "zero carbon," and does not list eligible resources. Instead, it tasks the state with analyzing pathways and strategies for reaching this non-binding goal. The state's RPS allows for resource eligibility according to tiers, with Tier 1 resources like solar, wind, geothermal, some hydropower, etc. providing the bulk of compliance. Tier II and Tier III resources may only be used for a small slice of annual compliance and include combustion of municipal solid waste and combined heat and power as eligible resources.

Maine passed legislation in 2019 requiring that 100 percent of electricity consumed in the state must come from "renewable" resources by 2050. The bill did not define renewable resources so it is not clear whether only currently RPS-eligible resources would be considered. If that's the case, this legislation would be categorized as a 100 percent RPS target instead of a 100 percent clean electricity standard. Maine's RPS-eligible resources include solar, wind, geothermal, biomass, combustion of municipal solid waste, some hydropower, and fuel cells.

Nevada's SB 358 (2019) requires the state to generate 50 percent of its electricity from renewable resources by 2030 and provides a non-binding goal of 100 percent of electricity sold by providers in the state from "zero carbon dioxide emission resources" by 2050. "Zero carbon" resources are not defined in the legislation, nor are the policies needed for compliance. Currently, the Nevada RPS allows for solar, some hydropower, wind, geothermal, biomass, and combustion of municipal waste.

New Jersey's 2018 Clean Energy Act increased its RPS requirement to 50 percent by 2030 and the Governor's 2018 Executive Order No. 28 added a 100 percent "carbon-neutral" electricity standard by 2050. The state hasn't yet codified what sources of electricity will meet the threshold of carbon neutral, but the Governor's Executive Order required that the state's 2019 Energy Master Plan provide a blueprint for meeting the 2050 target. This plan outlined the state's intent to model scenarios to inform decisions on how New Jersey can meet the 100 percent clean energy standard at the least possible cost. Currently, New Jersey's RPS allows for some hydropower and combustion of municipal solid waste to meet the Class Two requirements, which is 2.5 percent annually.

[iii] Coal mine methane and synthetic gas created from the pyrolysis of municipal solid waste are only eligible resources for the Colorado RPS if the PUC determines the resulting electricity is greenhouse gas neutral.

New Mexico passed its Energy Transition Act in 2019, which requires that 100 percent of all retail sales of electricity in the state be supplied by "zero-carbon resources" by 2045. The Act defines "zero-carbon resources" as those that "emit no carbon dioxide into the atmosphere as a result of electricity production"[7] but does not list eligible resource types.

New York, in 2019, passed legislation requiring a 70 percent RPS by 2030 and that the "statewide electrical demand system will be zero emissions"[8] by 2040. Resources that would meet the definition of "zero emissions" are not enumerated in the bill.

Rhode Island's Governor signed Executive Order 20-01 in January 2020, which requires the state's energy office to conduct analysis to develop viable pathways to meeting 100 percent of the electricity demand with "renewable energy resources" by 2030. The state energy office must submit an implementation plan to achieve the goal to the Governor by December 31, 2020, which should include initiatives that could be launched in 2021. It's not clear whether this plan will suggest expanding the state's current definition of renewable resources, which includes solar, wind, kinetic or thermal ocean energy, small hydropower, biomass, landfill gas, and fuel cells using an RPS-eligible energy source.

Virginia's Governor signed Executive Order 43 in 2019, which directed state agencies to develop a plan for producing 100 percent of the state's electricity from "carbon-free sources" by 2050. The following year, the Virginia Clean Economy Act was passed, creating the state's first RPS policy while also codifying the 100 percent "carbon-free" electricity by 2050 requirement from the Governor's 2019 Executive Order. It's difficult to categorize Virginia as having a 100 percent RPS or a 100 percent clean electricity standard as the legislation defines "zero-carbon electricity" as electricity generated by a generating unit that does not emit carbon dioxide as a by-product from the generation of electricity, but then provides for an RPS requirement of 100 percent by 2050 to be met with RPS-eligible resources that include solar, wind, some hydropower, combustion of municipal solid waste, landfill gas, or biomass.[iv]

Washington state passed a clean electricity standard in 2019 requiring all retail electricity sales be "greenhouse gas neutral" by 2030, and by 2045, 100 percent of retail sales of electricity must be from either RPS-eligible renewables or from "non-emitting" resources. The bill defines "non-emitting" resources as distinct from RPS-eligible resources but do not emit GHGs as a byproduct of electricity production. The difference between the 2030 target and the 2045 target is that, for the period between 2030 and 2045, utilities may meet up to 20 percent of their compliance with a combination of flexibility measures, including electricity produced from the combustion of municipal solid waste.

Wisconsin's Governor signed Executive Order No. 38 in 2019, creating an Office of Sustainable and Clean Energy and tasking it with achieving a goal of ensuring all electricity consumed in the state is 100 percent "carbon-free" by 2050. The Executive Order does not define "carbon-free" and the Office has not yet released any guidance. At this time, the Wisconsin RPS includes as eligible resources solar, wind, tidal or wave energy, geothermal, biomass, hydropower, fuel cells powered by renewable energy, thermal energy, and pyrolysis (but not combustion) of municipal solid waste.

[iv] Facilities that generate electricity from combustion of municipal solid waste or landfill gas must have been in operation as of January 1, 2020 and may not use waste heat from fossil fuel combustion or woody biomass as fuel to be RPS-eligible. Biomass facilities must have also been in operation as of January 1, 2020 and are limited in the amount of their qualifying annual generation.

Table 2: Select State RPS and Clean Electricity Standard Details

State	Year	Pathway	Target	Mechanism	Type	Labels Used	Eligible Resources	Notes
CA	2018	Legislation	100% by 2045	RPS + CES	Binding	carbon free	TBD	State agencies must submit plans by Jan 1, 2021 for achieving goal.
CO	2019	Legislation	100% by 2050 for Xcel Energy	RPS + 100% pledge	Non-binding	clean energy resources	TBD	Xcel service territory covers about 60% of the state's electricity load.
CT	2019	Executive Order	100% by 2040	TBD	Non-binding	zero carbon	TBD	
DC	2018	Legislation	100% by 2032	RPS	Binding	renewable	Tier 1 Resources: solar, wind, qualifying biomass, biogas, geothermal, ocean, fuel cells. Tier two resources: hydropower, waste-to-energy, less efficient biomass, black liquor.	Unclear whether Tier Two resources will be eligible after 2020.
HI	2016	Legislation	100% by 2045	RPS	Binding	renewable	Solar, wind, biogas, hydropower, biomass, geothermal, ocean energy, combustion of municipal solid waste, and hydrogen from renewable sources.	

State	Year	Pathway	Target	Mechanism	Type	Labels Used	Eligible Resources	Notes
ME	2019	Legislation	100% by 2050	RPS + CES?	Binding	renewable	Includes solar, wind, biomass, geothermal, combustion of municipal solid waste, some hydropower, fuel cells.	Unclear whether RPS will be only mechanism to implement.
NV	2019	Legislation	100% by 2050	RPS + CES?	Non-binding	zero carbon	TBD	Legislation includes non-binding goal of 100% by 2050 but no pathway to implement.
NJ	2018	Executive Order	100% by 2050	RPS + CES	Binding	carbon neutral	TBD	NJ will model scenarios for meeting the 100% target.
NM	2019	Legislation	100% by 2050	RPS + CES	Binding	zero carbon	TBD	
NY	2019	Legislation	100% by 2040	RPS + CES	Binding	zero emissions	TBD	
RI	2020	Executive Order	100% by 2030	RPS + CES?	Non-binding	renewable	TBD	State agency to provide analysis of 100% goal, but does not require entities to meet goal.
VA	2020	Legislation	100% by 2050 for two largest utilities	RPS + CES?	Binding	carbon free zero carbon	TBD	State to produce plan to implement by July 1, 2020.
WA	2019	Legislation	100% by 2045	RPS + CES	Binding	non-emitting	TBD	
WI	2019	Executive Order	100% by 2050	RPS + CES	Non-binding	carbon free	TBD	State agencies, utilities to achieve goal of 100% by 2050.

Removing RPS Carve-Outs, Adding New Ones

Carve-outs are a common design element of RPS programs and are often used to support emerging renewable electricity technologies by requiring that utilities meet a certain percent of their annual RPS compliance requirement with that technology. As technologies become commercialized, the need for support from a carve-out should lessen. This has been the case for solar, which was the technology most often supported by RPS carve-outs in earlier years. Between 2010 and 2018, the costs associated with a utility-scale one-axis PV solar installation have fallen by 80 percent;[9] since 2016, Ohio, New Jersey, and Nevada have phased out their RPS solar carve-outs.[10] Colorado shifted its solar carve-out into a broader distributed generation carve-out, which includes rooftop solar and other small, distribution system devices that provide decentralized electricity generation. Oregon's RPS does not have a solar carve-out but it does offer a credit multiplier for solar generators in operation before 2016 and between 500 kW and 5 MW so that each kilowatt hour (kWh) counts as two kWh.[11] Credit multipliers are meant to increase the value of a specific type of resource since the generation is given "extra credit" for each unit of electricity delivered.

While the costs for familiar renewable energy technologies like solar and onshore wind have fallen, technologies like wave energy and offshore wind are still very expensive as compared to other generation options and thus prime candidates for carve-outs. For example, the Energy Information Administration calculates the levelized cost of offshore wind to be nearly three times the cost of onshore wind for resources entering service in 2023 ($117/MWh versus $42.8/MWh).[12] In 2018, three states (New Jersey, New York, and Maryland) added or increased offshore wind RPS carve-outs.

Critics of carve-outs contend that the added costs associated with requiring utilities to meet the RPS with more expensive technologies will raise the overall cost of RPS compliance. This is of special concern in states with RPS cost caps, such as Oregon, and in general as the costs of compliance may increase as states reach higher levels of installed renewable energy. Additionally, multipliers can have an unintended consequence of reducing the overall amount of renewable generation built as certain generators can earn double credit for each kWh. This could potentially result in states achieving significantly fewer kWh generated from renewables (up to half as much) in the absence of the double credit. As an example, 8 percent of compliance with Michigan's RPS in 2017 was met with renewable energy certificates (RECs) associated with a credit multiplier.[13]

Clean Peak Standards

As the percent of variable renewable energy increases in a state's electricity mix, the value of renewable energy becomes increasingly tied to *when* it is available to the grid. For example, an oversupply of solar energy in the middle of the day, well beyond what's needed to meet demand, can lead to low or even negative wholesale electricity prices and/or a reduction in the amount of electricity generated over what could have been produced because of curtailment. In this scenario, every extra unit of renewable energy is worth less than the last one and its environmental benefit is lower as it's replacing other renewable energy or relatively efficient fossil fuel-generated electricity. However, renewable energy is much more valuable at times of peak demand, when relatively dirtier, less efficient fossil fuel-powered "peaker" plants are commonly used to meet that demand. Having a higher percentage of renewable electricity delivered during peak times can not only reduce GHG and other emissions but can also deliver significant savings to ratepayers.

Clean Peak Standards are an emerging policy option to address the time value of renewable energy delivery to the grid. A clean peak standard builds on an RPS by requiring that a certain percent of electricity delivered to retail customers during designated peak times must be from eligible renewable resources. This essentially turns an RPS that was a straight procurement policy into one that includes capacity requirements.

Both California and Arizona have considered adding clean peak standard policies to their RPS, but Massachusetts was the first (and so far, only) state to enact such policy, in 2018.[14] The program will function as a market mechanism with the goal of sending a price signal for investment in energy storage technologies that can address peak demand. Eligible resources will receive Clean Peak Energy Certificates for each unit of electricity delivered during the designated peak periods, which will then be used by utilities to demonstrate annual compliance with the standard.

The Massachusetts statute defines the following as eligible resources for the clean peak standard:

- *New* RPS-eligible resources;
- Existing RPS-eligible resources paired with *new* energy storage capabilities;
- New stand-alone energy storage resources that will be charged primarily by renewable resources; and
- Demand response resources.[15]

Figures 2 and 3 show how the Massachusetts clean peak standard is designed to shift more renewable resources to times of peak demand. Figure 2 shows a forecasted typical winter week in 2030 without a clean peak standard. Very little, if any, of the generation from solar (in yellow) or offshore wind (in light blue) occurs during the predicted times of peak demand on some of the days (red circles). Massachusetts would have to maintain generation from oil or gas to meet these peak loads, despite cost or decarbonization goals. However, Figure 3 shows how the clean peak standard would incentivize shifting the output from renewable resources to times of higher demand, primarily through energy storage.

Figure 2: Massachusetts Electricity Generation and Demand During a Winter Week in 2030 Without the Clean Peak Standard[16]

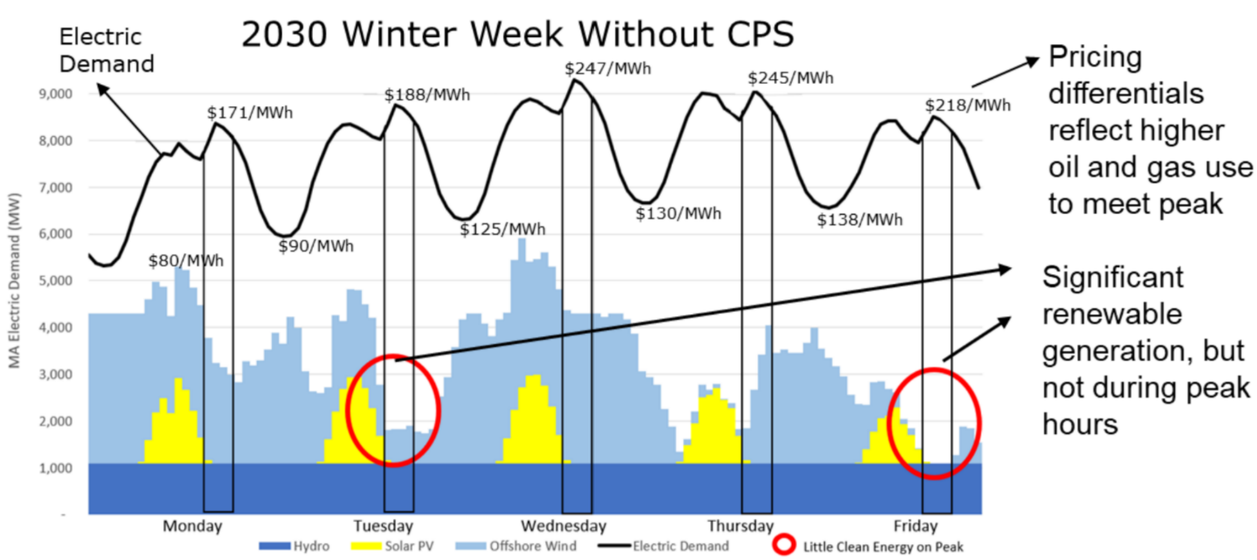
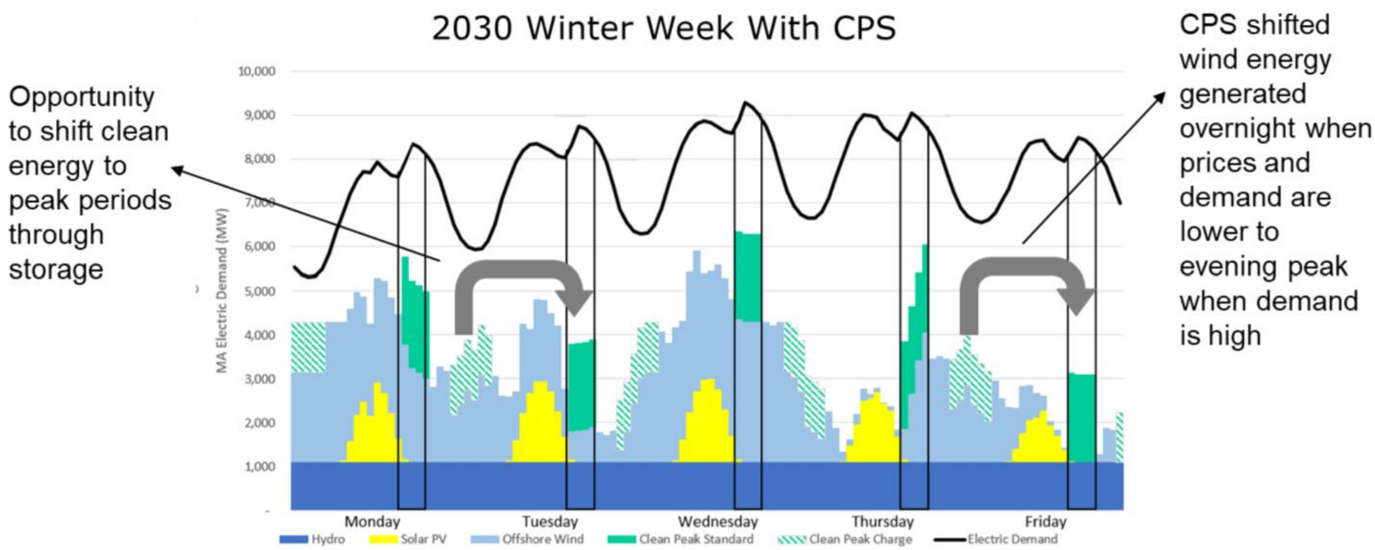


Figure 3: Massachusetts Electricity Generation and Demand During a Winter Week in 2030 With the Clean Peak Standard[17]



One consideration with a clean peak standard, and with energy storage as part of an RPS in general, is what resource is used to charge the energy storage device. These policies are meant to support renewable and zero-emission resources, which would be contradicted by providing financial benefit to fossil fueled-resources or unspecified power. The Massachusetts clean peak standard requires that eligible energy storage systems either be co-located with an RPS-eligible generating resource, have a contract to purchase electricity from an RPS-eligible generator, be charged at times when the electricity resource mix traditionally has the highest levels of renewable energy, or demonstrate an operational schedule that addresses power and flow concerns associated with variable renewable energy.

Some stakeholders have expressed concerns with the Massachusetts draft rules and suggest that in absence of stricter standards around pairing storage with renewable energy, GHG emissions during peak demand could *increase* under the clean peak standard. The state's Attorney General office provided comments on the draft rules that clean peak energy certificates should only be issued for storage charged by renewable resources, and suggested: additional metering requirements for co-located energy storage; purchase and retirement of renewable energy certificates for storage charged by contractually purchased renewable energy; and re-evaluation of the eligibility of storage based on charging at times of high renewable energy production (which may be impossible to select given market volatility) and based on provision of certain ancillary services.[18]

100 Percent RPS and 100 Percent Clean Electricity Policies – A Deeper Dive

As outlined above, state adoption of 100 percent RPS targets or clean electricity standards is a fast-growing trend. No two states have taken the same path to a 100 percent target, showing the diversity of options for implementing such policies. However, nearly all of these states have explicitly addressed the opportunities and challenges associated with meeting a 100 percent target, including reliability of electricity service, cost, and equity, among other considerations.

Opportunities with 100 Percent RPS and Clean Electricity Standards

Greenhouse Gas Emissions Reductions

As policies, 100 percent RPS and 100 percent clean electricity standards represent an opportunity to reduce greenhouse gas (GHG) emissions from the electricity sector. RPS policies have been considered implicit GHG emissions reduction policies given that the electricity required for an RPS will almost always be lower-carbon than the fossil fuel-generated electricity it replaces. However, when enacting original RPS legislation years ago, few state legislatures made GHG emissions reductions an *explicit* rationale for an RPS. It's a different story today, with legislative rationales for 100 percent RPS and clean electricity policies including not only GHG emissions reductions, but also increased air quality, reduced dependence on fossil fuels, and a transition to a more affordable and reliable energy system.

While 100 percent RPS or clean electricity standards can reduce GHG emissions as a stand-alone policy, they are especially useful as part of a larger decarbonization effort. Some studies have found that while renewable electricity is an important part of decarbonization, relying heavily or solely on an RPS or clean electricity policy could result in higher GHG emissions and higher costs than a policy that addresses carbon more comprehensibly.[19] [20] This is because an RPS or clean electricity policy requires procurement that can ignore the potential of other GHG emissions reduction contributions, like energy efficiency or electrification of thermal loads. Stand-alone policies can also introduce distortions into wholesale markets, such as negative pricing during times of high renewable output.[21] That said, some states have recognized that having an RPS policy on the books and simultaneously working on decarbonization via multiple pathways is a preferred alternative.

The "wedges" approach to decarbonization, first described in 2004,[22] looks at the total GHG emissions reductions needed to reach a specific GHG mitigation target[v] and then breaks that amount into numerous wedges that correspond to either specific policies (e.g., increasing fuel economy standards) or sectors (e.g., the electricity or transportation sector).

While Oregon does not yet have a comprehensive carbon pricing policy or a cap-and-trade program,[vi] the state established initial non-binding GHG emissions reduction goals back in 2007, with a reduction goal of at least 75 percent below 1990 levels of GHG emissions by 2050.[23] More recently, in March 2020, Governor Brown's Executive Order 20-04 established a new statewide reduction goal of 45 percent below 1990 levels by 2035 and 80 percent below by 2050.[24]

Governor Brown signed Executive Order 20-04 in March 2020, establishing a new statewide GHG emissions reduction goal of 80 percent below 1990 levels by 2050.

The Oregon Global Warming Commission conducted a wedges analysis for Oregon in 2015 and constructed a scenario (called Case 1) that included a number of the most cost-efficient measures that could reduce Oregon's GHG emissions and get it closer to meeting its 2035 emissions level target.[25] The combination of measures in Case 1 would result in roughly a 22 million metric tons of CO2e

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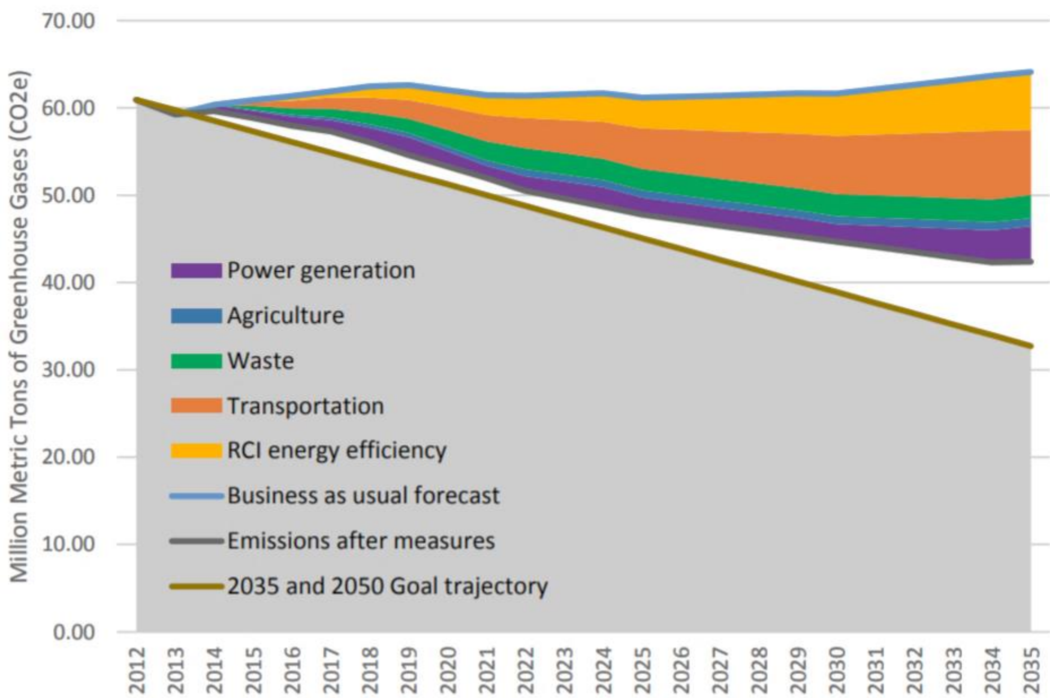
[v] Such as a target to hold the earth's atmosphere at a maximum parts per million concentration of GHGs, a target to maintain a maximum global temperature increase, etc.

[vi] Although, in 1997 Oregon became the first state to establish a price on carbon by requiring new plant's emissions to be 17% below the most efficient natural gas-fired facility operating in the country or pay for equivalent offsets.

(carbon dioxide equivalent)[vii] emissions reduction compared to business-as-usual in 2035, but would still leave Oregon about 10 million metric tons of CO2e short of achieving the 2035 GHG emissions reduction interim goal (see Figure 4). The wedge analysis was a comprehensive plan and Oregon's RPS was one of many actions and represented a big part of the "power generation" wedge reductions. While Case 1 falls short of Oregon's GHG emissions reduction goals, the analysis found that adding a gradually increasing carbon price to the Case 1 portfolio of measures would put Oregon back on track to meet the 2050 goal.

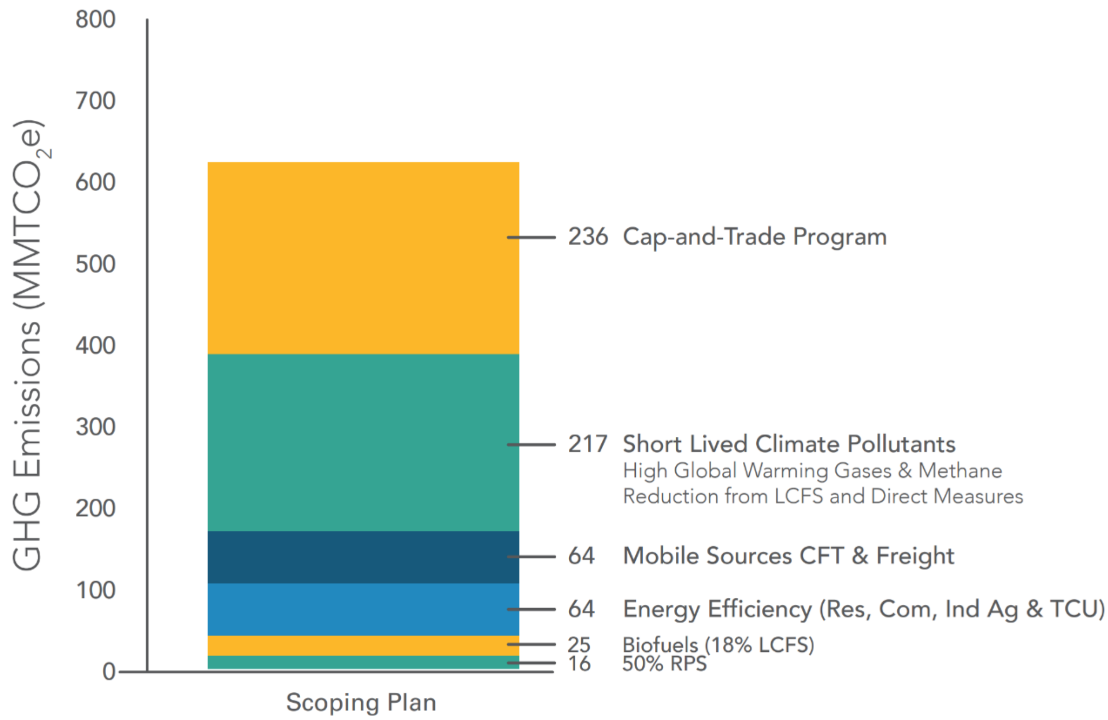
Figure 4: Case 1 Scenario for Reducing GHG Emissions in Oregon (Source: Oregon Global Warming Commission)



California launched its cap-and-trade program in 2013 and has repeatedly updated its RPS requirement in recent years, culminating in a 60 percent RPS and a 100 percent clean electricity standard, passed in 2018. In 2015, electricity generation represented 19 percent of California's annual GHG emissions and as part of its 2017 Climate Change Scoping Plan, the California Air Resources Board estimated that the then-current policy of a 50 percent RPS target would contribute 16 million metric tons of GHG emissions reductions from 2021 to 2030, but that was only a small portion of the overall GHG emission reductions needed.[26]

[vii] Each greenhouse gas has a different global warming potential, expressed over a period of years. For example, the global warming potential of methane is 21 over 100 years, as compared to 1 for carbon dioxide. This means that the emission of one million metric tons of methane is equivalent to the emission of 21 million tons of carbon dioxide over 100 years. Carbon dioxide equivalent allows discussion of greenhouse gases as a group.

Figure 5: Estimated Cumulative GHG Reductions by Policy/Program for 2021-2030 in California[27]



Valuation of "Clean" Resources Not Included in an RPS

The Pacific Northwest is blessed with abundant hydropower resources – in Oregon alone, hydropower provided over 43 percent of the electricity consumed in the state in 2018.[28] However, much of this hydropower is not eligible for the state's RPS. The goal of the Oregon RPS legislation was to promote "research and development of *new* renewable energy sources in Oregon"[29] (emphasis added). For this reason, aside from a few exceptions, only facilities that became operational on or after January 1, 1995, are eligible for participation in the RPS. The facility age requirement serves to incentivize the development of new renewable electricity sources, which is one reason why much of the existing hydropower in the region is not eligible for the RPS.

The section above enumerated the many different resources that states have deemed eligible to meet their "carbon-free" or "zero-emissions" electricity standards, such as a greater share of hydropower, nuclear, or fossil-fueled generation with carbon capture and storage. Not only does inclusion of these generating resources in a clean electricity standard provide them with additional value, but it can increase a state's likelihood of meeting the target without affecting reliability (see section below for more discussion on this topic).

Challenges with 100 Percent RPS and 100 Percent Clean Electricity Standards

When analyzing pathways to high renewable or 100 percent zero-carbon electricity systems, numerous studies have found that getting to 100 percent is technically feasible, but that the challenges (and costs) increase as one gets closer to 100 percent.[30] The reasons for this are that states need flexible zero-carbon resources to balance the grid, a major increase in the amount of regional transmission, gigawatts of energy storage, an overbuild of variable renewable resources and curtailment, or a mix of all of the above. Other challenges include building greater regionalization of infrastructure and markets, getting buy-in across stakeholder groups, and planning a long-term strategy for implementation that meets near-term goals without creating policy "lock-in," (e.g., a situation where policies that work in the near-term could also reduce the chances of long-term success).

It's important to note that, while they are not discussed here, energy efficiency and demand-side management are also two critical pillars in decarbonizing the electricity grid, especially given expected increase in electricity demand from beneficial electrification and electric vehicles.

Limited Options for Zero-Carbon Flexible Resources

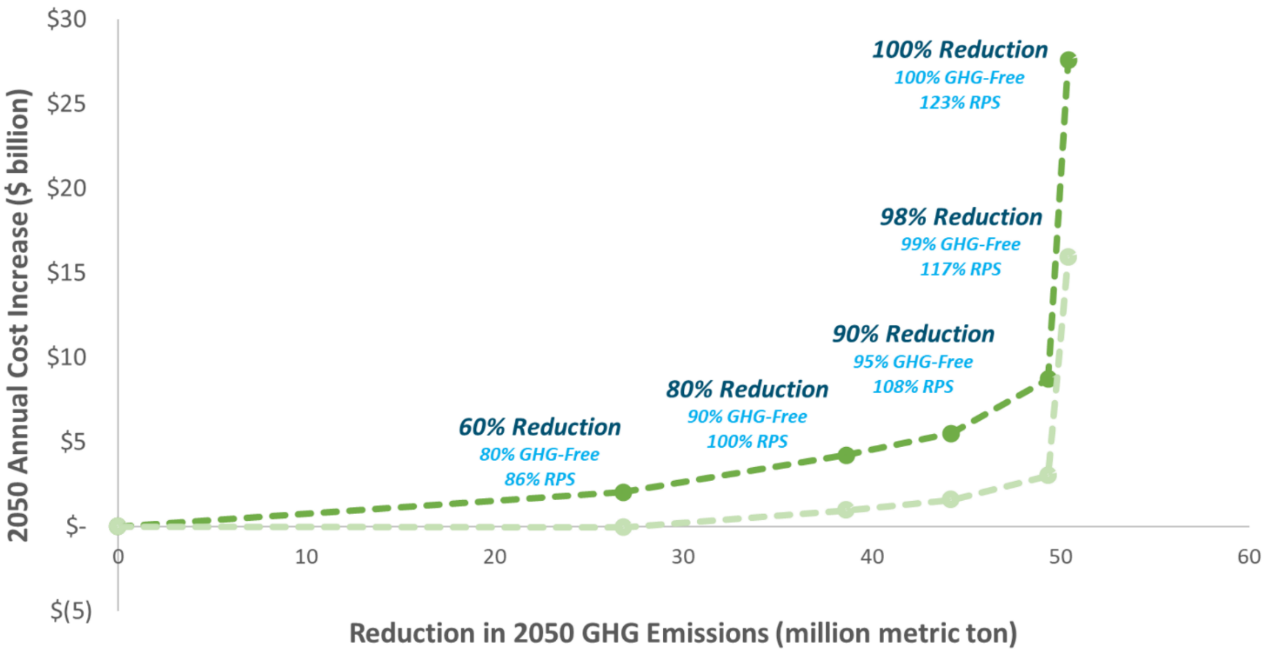
While many fossil fuel power plants take time to start up or shut down, most of them can provide electricity continuously once they are up and running and are often referred to as "baseload" generators, delivering "firm" power. "Baseload" has no industry-accepted definition but has come to mean facilities that are usually large in terms of megawatt (MW) output, designed to operate at or near capacity, and that provide some of the cheapest power when operating at high capacity. This is in contrast to many renewable electricity resources, which are more variable – solar panels only work when the sun is shining, and turbine blades only spin when there's wind.

The growing share of variable renewable resources in our electricity mix in the West has led to a discussion of "flexibility" when integrating intermittent renewables, where flexibility refers to a resource's ability to ramp generation up or down quickly to meet load requirements at all times, no matter the season or time of day. This is because the electric grid must be kept in balance at all times with respect to supply and demand; failure to maintain this balance can destabilize the grid and lead to brownouts, blackouts, and even safety threats. Unlike other forms of energy, such as liquid fuels, natural gas, or coal, it can be costly to store electricity in large quantities, at least with the technology available today. So, if electricity can't easily and/or cheaply be stored, then it must be produced it when it's needed, and that means flexible resources that can operate when variable renewable sources are not available or cannot fully meet demand are necessary.

Currently there are limited options for firm and/or flexible zero-carbon resources – namely geothermal, biomass, some hydropower, nuclear, and fossil fuel generation with carbon capture and storage (CCS) – and each has limitations. For example, geothermal generation is highly location-specific and expensive to develop; biomass can be limited by available feedstock; hydropower in the Northwest is primarily run-of-river and the amount of water available for electricity generation is dependent on a number of factors and other uses; and CCS technologies are as yet expensive and limited in deployment.

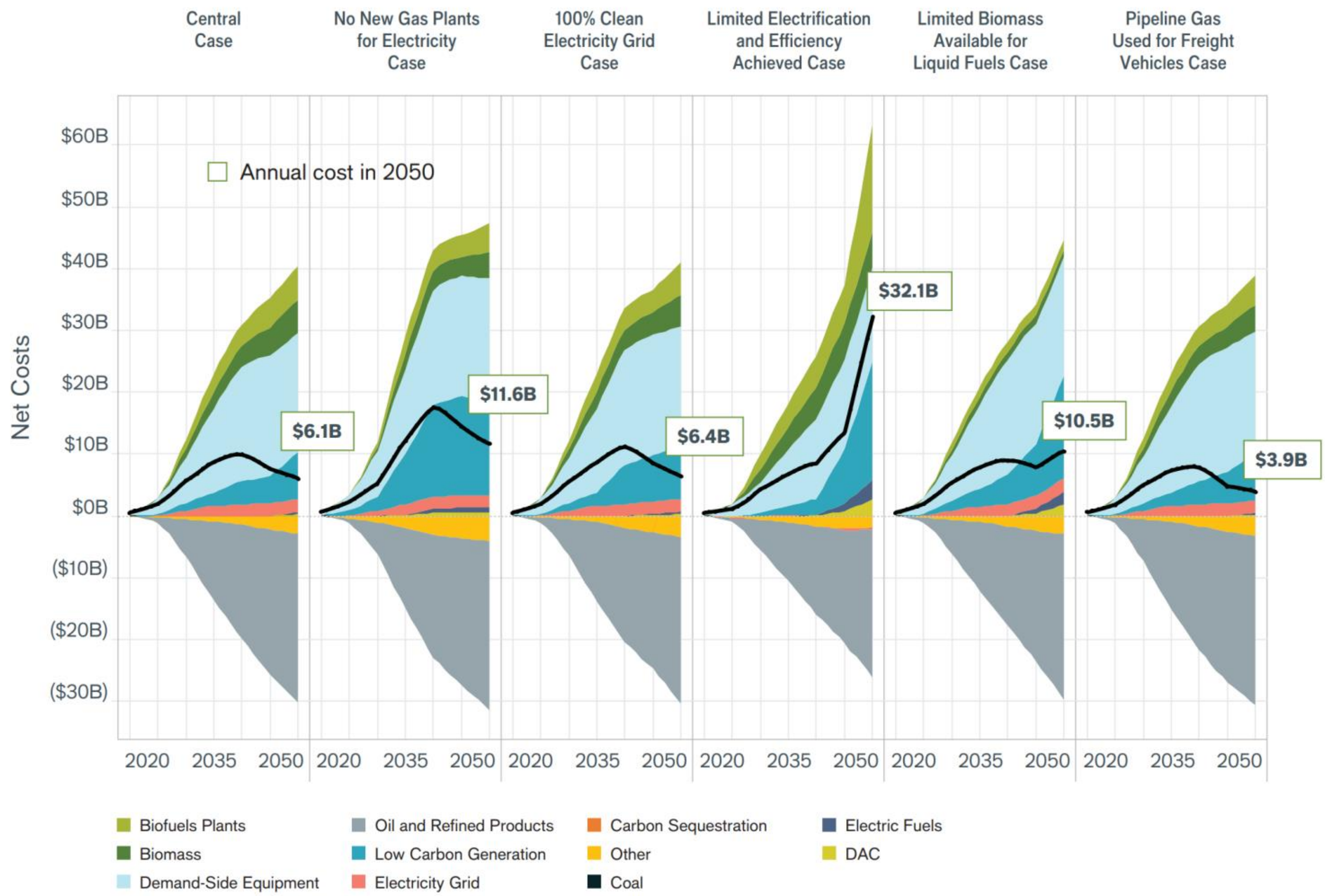
For this reason, recent decarbonization studies have recommended keeping a small percentage of existing or new natural gas generation capacity (with or without CCS) and not phasing out existing zero-carbon firm resources like hydropower or nuclear power. In its analysis of low-carbon scenarios for the Northwest, E3 found that a moratorium on new natural gas plants results in significant additional costs without a significant reduction in GHG emissions and suggested that natural gas generation may be key to meeting GHG emissions reductions goals "reliably and at least cost."[31] In another E3 study, this one looking at decarbonization pathways in the Northwest while maintaining resource adequacy, they again found that achieving 100 percent zero-carbon electricity with only wind, solar, hydropower, and energy storage to be "impractical and prohibitively expensive."[32] The study estimated the costs associated with various GHG emissions reductions, shown in Figure 6, and found that an additional $100 billion to $170 billion would be need to go from the 99 percent GHG-free electricity scenario to the 100 percent GHG-free scenario. This sharp cost curve is due to the significant renewable overbuild (and curtailment) required to ensure reliability in this scenario and the increasing amounts of energy storage needed to integrate all of that variable renewable energy.

Figure 6: Costs of Achieving Increasing Reductions of GHG Emissions in the Pacific NW (Source: E3, 2019)



Another study, this one from the Clean Energy Transition Institute, took an economy-wide look at decarbonization and found that while a "nearly" 100 percent clean grid is a critical component of decarbonization, the optimum, cost-effective electricity resource mix for the Northwest was one that retained 3.7 percent of gas-fired electricity generation (called the Central Case in the study).[33] However, the study also modeled a 100 percent clean electricity scenario, where gas-fired plants would be allowed to burn biogas and synthetic fuels, and found it was only nominally more expensive at $6.4 billion by 2050 (as compared to the Business as Usual scenario) than the Central Case scenario, which was estimated to cost $6.1 billion more by 2050 than business as usual (see Figure 7, below).[34] The difference in the costs of getting to 100 percent clean between the E3 study and the Clean Energy Transition Institute Study are due, in part, to the economy-wide focus of the latter study as opposed to just the electricity sector focus of the E3 study. The Clean Energy Transition Institute study found that "economy-wide decarbonization involving the fuel supply sectors and not just the electricity grid brings two benefits that make it easier to attain 100 percent clean electricity. First, flexible electric fuels increase load flexibility and make balancing the electricity system easier, and second, the clean synthetic gas that is produced can be used to generate electricity during challenging system-balancing conditions."[35] Here "electric fuels" refers to a process called Power-to-Gas, where electricity is used to create synthetic fuels. This is explained further in the next sub-section.

Figure 7: Annual Net Energy System Costs for Six Cases Compared to the Business as Usual Case (Source: Clean Energy Transition Institute)



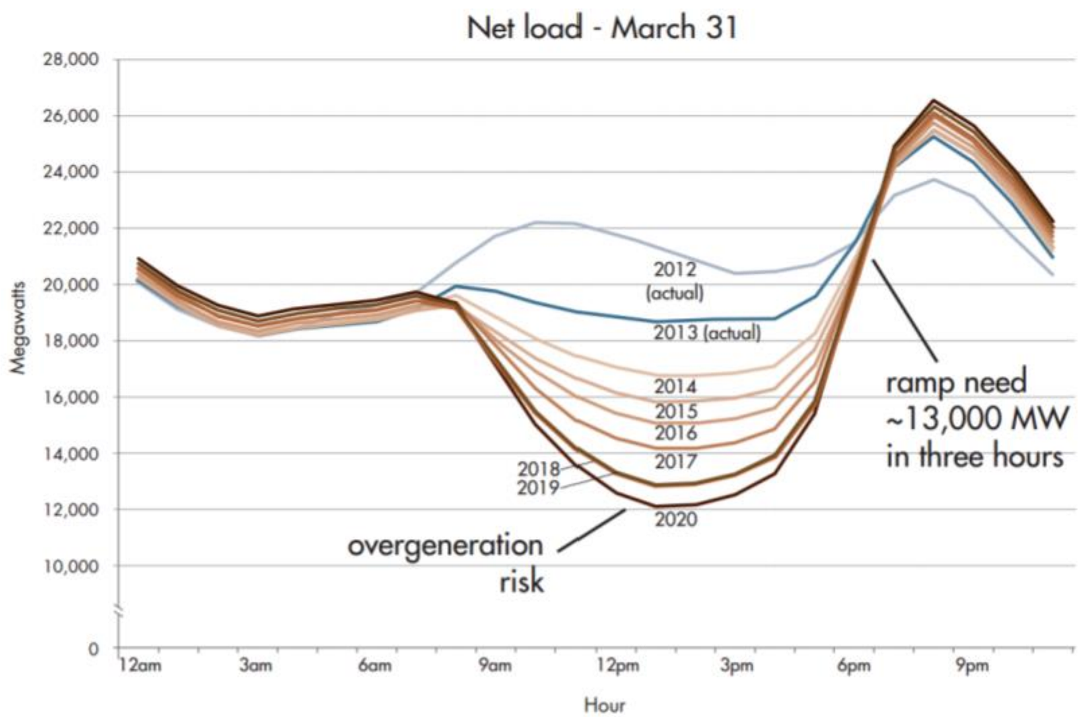
Finally, the recent 2035 study from UC Berkeley found that the U.S. can achieve a 90 percent clean grid by 2035 without coal or new natural gas plants with wholesale electricity costs about 10 percent lower that they are today.[36] The lower electricity costs in the 90 percent scenario are primarily due to the dramatically declining costs for wind and solar PV and, to a lesser extent, lithium ion battery storage, coupled with savings from no new natural gas generation facilities being built.[viii] The study's 90 percent scenario also results in significant environmental, health, and jobs benefits, but the study shows that achieving a 90 percent clean grid by 2035 is not possible without new policies to further support decarbonization. Perhaps one of the most important take-aways from the 2035 study is that existing technologies can immediately get us on the path to deep decarbonization of the electricity sector and better poised to meet future 100 percent targets.

[viii] While the study shows that wholesale electricity costs for the 90 percent scenario are lower than today's wholesale electricity costs, the costs in 2035 for the 90 percent scenario are 12 percent higher than the "no new policy" scenario in 2035 when environmental and social costs and benefits are not included.

Overbuilding and Curtailment

One option for integrating high levels of variable renewable energy is to overbuild and curtail, which refers to building more capacity than a system requires to meet peak demand and then to curtail[ix] those renewable resources at times of oversupply. The now-famous California duck curve graphically shows that the California Independent System Operator (CAISO) has a glut of solar power in the middle of spring and fall days (see Figure 8) and that as solar trails off towards evening, there is an increasingly steep ramp that must be met with flexible resources. Each line in the chart shows the net load, i.e., the demand for electricity minus wind and solar generation. The "belly" of the duck shows the period of lowest net load, where solar generation is at its highest, and that belly has grown as more solar has been added to the CAISO generation mix from 2012 to 2020 (estimated).[37]

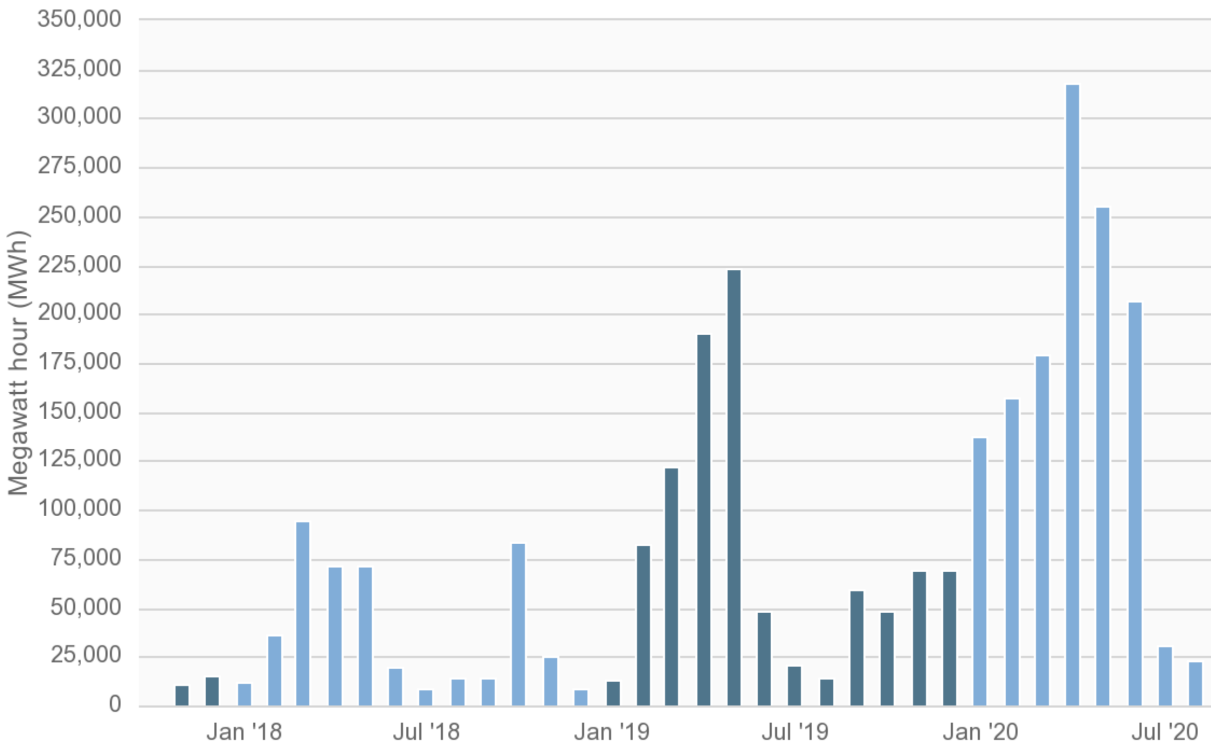
Figure 8: The CAISO Duck Curve (Source: Denholm)



The duck curve also highlights the overgeneration potential of variable renewable resources, which has increasingly resulted in curtailed electricity. When the system is in oversupply, CAISO's options are to use as much of the generation as possible, store what it can, export what it can, and then curtail the rest. Figure 9 illustrates the growing amount of energy curtailment in CAISO from 2018 to 2020.[38] In 2018, the most curtailment occurred in March – over 94,000 MWh. The highest curtailment for 2019 occurred in May and was more than double the March 2019 total at over 223,000 MWh. In 2020, curtailment was highest in April at 318,444 MWh, more than triple the highest curtailment number in 2018. As California's clean energy goals increase and the state adds more variable renewable energy to its mix, one can reasonably expect the curtailment numbers to continue to grow every year.

[ix] Curtailment refers to temporarily reducing the output of electricity from a generator from what it could have otherwise produced.

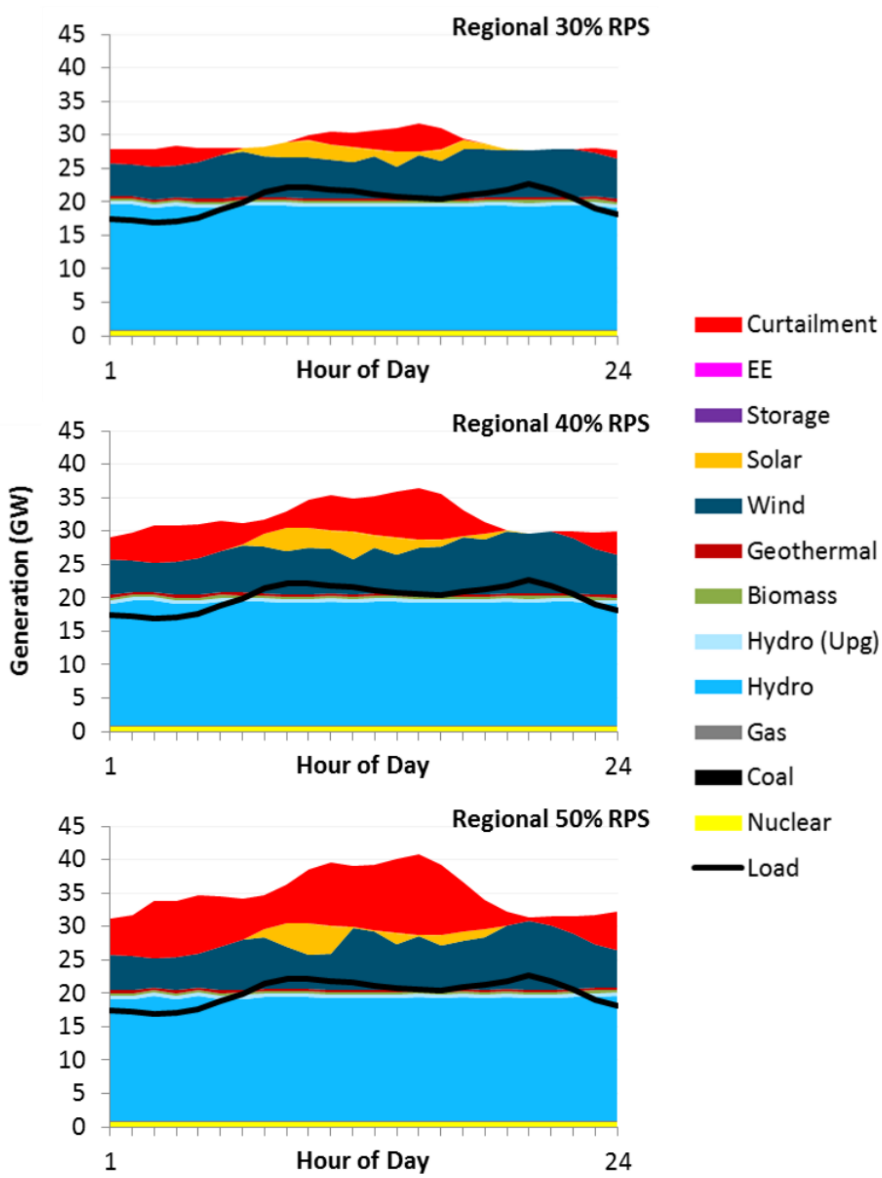
Figure 9: Wind and Solar Curtailments by Month in CAISO From November 2018 to August 2020 (Source: CAISO 2020)



Overbuilding and curtailment represent real costs, not to mention the persistent challenges associated with siting new renewable installations. While the levelized costs of solar and wind power have reached parity with fossil-fuel generation in numerous jurisdictions – and are, in some cases, cheaper – overbuilding leads to a reduction in the marginal value of each next unit of variable renewable energy. Each new MW of variable renewable energy becomes less useful and less valuable than the one before it. This is because 1) an excess of variable renewable energy at times of peak generation can lead to near-zero wholesale electricity prices given the near-zero operational costs of these units; and 2) more overbuilding necessarily leads to more curtailment.

In its analysis of low-carbon scenarios for the Northwest, E3 found that increasing regional RPS targets could lead to an increase in both the magnitude and frequency of curtailment events.[39] When looking at a day with high hydropower supply, the study found that curtailment of available renewable generation went from 4 percent to 9 percent in the 20 percent regional RPS scenario versus the 50 percent scenario (see Figure 10). Curtailment patterns in California are driven by the high penetration of solar and coincide with the highest hours of solar output, differing from those seen in the Northwest, where instead curtailment is driven by combined high output from both hydro and wind resources, with less frequent but longer-lasting incidents, depending on the hydro conditions.

Figure 10: Increasing Renewable Curtailment Observed with Increasing Regional RPS Goals[40]



Again, an option for avoiding curtailment is deployment of energy storage, but given the current costs of energy storage technologies, some states are finding its cheaper to overbuild and curtail than to invest in large amounts of storage. For example, the Minnesota Solar Potential Analysis[41] found that in scenarios investigating getting to 70 percent solar by 2050, it would be more cost-effective to overbuild and curtail variable renewable resources rather than add long-duration or seasonal storage. However, the costs for lithium-ion storage systems are rapidly declining, which is already making storage cost-effective in a number of utility-scale applications.[42]

An alternative to battery storage for soaking up excess renewable electricity that would otherwise be curtailed is Power-to-Gas, or PtG, which is the process of using electricity to create synthetic fuels that can then be stored for later use in meeting thermal loads or in generating electricity. Power-to-Methane (PtM) can create carbon-neutral methane to be used in place of natural gas if the carbon dioxide used is from direct air capture and if the electricity used to power electrolysis is renewable. Power-to-Hydrogen (PtH) can generate carbon-neutral hydrogen gas if the electricity used to power the process is renewable. Not only do these fuels act as energy storage, but when injected into a pipeline system, the entire infrastructure can be imagined as one big battery. A study by the Finnish firm Wärtsilä analyzing California's path to 100 percent renewables found that if California maximized its use of PtG technologies, it could meet its 100 percent clean goal five years early while reducing GHG and particulate emissions and saving approximately $8 billion dollars as compared to the current path.[43]

Learn more about PtG in the Technical Review and Policy Briefs sections.

Though not detailed here, another option for addressing overgeneration of renewable resources is using demand response programs to shift demand from periods of high demand to periods where demand is lower.

Increased Transmission

Transmission refers to the delivery of high-voltage electricity across long distances to move power from where it's generated to where it's consumed. This not only allows for building generation facilities where the renewable resource is best, even when it's far from load centers, but also allows for smoothing out the variability of intermittent renewable energy. This is to say that the larger the area across which you're sharing power, the greater the likelihood that the sun is shining or the wind is blowing *somewhere*.

The ability to move renewable power over greater distances is why numerous studies on decarbonization include increased transmission as a key part of a *cost-effective* transition to zero-carbon electricity, though this may seem counter-intuitive given that new transmission infrastructure isn't exactly cheap. In a 2014 report for the Western Electricity Coordinating Council, Black & Veatch estimated the costs for new transmission lines in the West to range from $959,700 to $1.6 million per mile in 2014 dollars.[44] Despite these costs, the Clean Energy Transitions Institute study found the costs of decarbonization could be reduced by an estimated $11.1 billion over the 30-year study period if the Northwest and California electric grids were expanded and better integrated.[45] The reduced cost from building fewer generating or storage resources offsets the higher costs of transmission, leading to the cost savings.

Conclusions

The renewable portfolio standard is a mature procurement policy for renewable electricity and has been widely adopted by states in the U.S. As interest in aggressive decarbonization of our electricity supply grows, many states have used the RPS policy to drive GHG emissions reductions in the electricity sector, either by adding higher RPS targets, all the way up to 100 percent, or enacting 100 percent clean electricity standards that expand the list of eligible generating resources. States are also updating RPS policies to boost emerging technologies, like offshore wind, or to address complex issues like the GHG emissions associated with peak electricity demand. Finally, instead of supplanting RPS policies, GHG emissions reduction policies are increasingly being enacted alongside existing RPS programs, and RPS policies are considered an important part of a wider electricity, and economy, decarbonization plan.

With respect to implementation of 100 percent clean electricity standards, numerous studies[x] have shown that reaching a 100 percent target is feasible. Though questions remain as to how best to cost-effectively reach the last few percentage points on the road to 100 percent, the options for meeting targets up to 80-95, depending on the region, percent are relatively straightforward.

Numerous studies show that reaching 100% clean electricity standards is feasible.

[x] See References

Oregon's RPS: Looking Ahead

Oregon policymakers can draw a number of valuable conclusions from the recent RPS and clean electricity standard trends occurring in other states. Following are some ideas for consideration:

RPS + Price on Carbon

Numerous recent studies have found that a high or 100 percent RPS or clean electricity standard alone is not the most cost-effective way to reduce emissions from the electricity sector. Pairing an RPS or clean electricity standard with a price or cap on carbon allows for greater emissions reductions at lower cost.

Considerations for 100 Percent RPS or Clean Electricity Standard

Some Oregon stakeholders have signaled an interest in a 100 percent renewable or clean standard for the state's electricity sector. If the state chooses to pursue such a policy, the following are important questions to address:

- Is a 100 percent clean electricity target the right one for Oregon? Numerous studies show that leaving just a small margin for firm natural gas generation reduces costs while minimally affecting GHG reductions. Is there a role for natural gas electricity generation to play in a future clean electricity standard?
- How should the state define terms like "clean" or "zero carbon"? What resources should be eligible? Building a diverse portfolio of electricity generation options can reduce costs and threats to reliability.
- How can the costs to consumers be made as equitable as possible? The long-term costs of doing nothing are much higher than the costs of decarbonization, but there are also real costs associated with decarbonization, which is why the state needs to pay particular attention to protecting vulnerable Oregonians.
- How will the state approach medium-term and long-term planning in such a way that reduces costs to the consumer and successfully meets medium-term goals in a way that doesn't possibly preclude meeting longer-term goals?

Regionalization

Regardless of whether Oregon enacts an increased RPS, a clean electricity standard, or a carbon pricing policy, other states in the West have already done so and their policies will affect the supply and cost of electricity available to Oregon. Greater coordination in the West of energy markets and transmission infrastructure will help Oregon and other states to cost-effectively meet their policy goals.

New RPS Carve-Out

While carve-outs can affect the cost of compliance with an RPS, they also provide vital support to emerging new technologies that will be necessary in the coming years to meet decarbonization goals. Oregon policymakers may want to consider whether there are new technologies they wish to incentivize with this mechanism. For example, an RPS carve-out for offshore wind could help commercialize this new renewable generating resource. However, as described above, the benefits of an RPS carve-out would need to be weighed against the additional costs.

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