Renewable Energy Standards Need Reform to Sustainably Support an Energy Transition

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Executive Summary

Key federal and state policies supporting renewable power—federal tax credits and state Renewable Portfolio Standards (RPS)—reward quantity over value of energy output. Quantity-based supports have helped renewable power technologies secure a foothold in the market, but these policies can contribute to price volatility and reliability concerns as penetration rates for intermittent renewable resources grow higher. While the challenges discussed here are associated with intermittent renewable resources, these challenges are not inherent to the technologies. Instead, the challenges arise from policies rewarding quantity of output over value to consumers.

Because these policies supplement rather than displace market incentives for power production, changing market incentives mitigate some potential volatility and reliability concerns. As a part of the grid becomes saturated with wind or solar, market prices fall in these locations at times output is highest. Incentives to invest in the area are reduced. Still, the price volatility and potential reliability concerns can be avoided by adapting RPS policies to better fit consumer and public policy goals.

An easy fix goes relatively far: shift RPS requirements from an annual matching obligation to an hourly matching obligation. Such a change directly encourages renewable technologies capable of delivering power where and when consumers most want it. Complementary moves to a broader "clean energy standard" and to locational matching obligations if they are currently not present will further improve existing RPS regulations. Such changes support innovation and will drive investments into zero- or low-emission resources that produce power when and where consumers want it.

Introduction

The brief rolling outages in California of August 2020 are suggestive of challenges to come elsewhere as the electric power industry is pressed into relying more on renewable resources without full consideration of impacts to the broader electric system. As much as 50 percent of the power generated in California mid-day came from renewables on August 14 and 15, 2020, during a heat wave covering most of the Western United States. As solar power declined in the evening the contribution from renewables dropped below ten percent. Consumer demand tends to increase during early evening hours in summer, and insufficient power generation was available to meet demand for a few hours on each day.[1] California grid operations had to rely on rolling outages to avoid uncontrolled blackouts.

Key federal and state policies supporting renewable power reward quantity over value of energy output. Quantity-based supports have helped renewable power technologies secure a foothold in the market, but as the penetration of intermittent wind and solar generation grows they can contribute to price volatility and reliability concerns. Policies targeting high percentages of renewable power production may face growing political opposition should they continue reliance on quantity-based policy supports.

1 This short summary obviously omits much. The California ISO, California PUC, and California Energy Commission have produced a detailed report in their Final Root Cause Analysis: Mid-August 2020 Extreme Heat Wave, January 13, 2021. https://www.energy.ca.gov/news/2021-01/caiso-cpuc-cec-issue-final-report-causes-august-2020-rotating-outages. The much longer lasting outages in Texas of February 2021 were due primarily to the freezing of gas wells and pipelines and discoordination between the gas and electric industries. Wind resources offline due to ice and extreme cold were only a small contributor to the overall energy failures. See Giberson, Michael, The 2021 Texas Power Crisis: What Happened and What Can Be Done to Avoid Another One? Reason Foundation Policy Brief, April 22, 2021. https://reason.org/policy-brief/the-2021-texas-power-crisis/

While the challenges discussed here are associated with intermittent renewable resources, these challenges are not inherent to these technologies. Instead, the challenge arises from policies rewarding quantity of output over value to consumers. Modern power systems operators have readily accommodated relatively large volumes of intermittent renewable resources—the California ISO served over 95 percent of consumers with solar and other renewable resources at the peak on April 24, 2021, and ERCOT in Texas served consumers nearly 60 percent wind energy on May 2, 2020.[2]

In most wholesale markets, power prices would drop when intermittent resources saturate an area. Market signals would slow down investment in these resources until complementary investments in transmission or other resources caught up. Strong quantity-based public policy incentives—often federal tax credits but at times state PTC policies—are sufficient to induce more investment in an area despite weak market signals. This paper describes how quantity-based policies can contribute to price volatility and reliability issues, discusses current market and policy initiatives aiming to overcome these issues, and explains how federal and state policies could be reformed to reduce these adverse consequences. The Basic Challenge: Cheap intermittent supply mismatched to consumer demand.

Federal policies have supported renewable power through a variety of policies, but the most substantial boosts to the renewable power industry have come through tax credits collected by wind and solar power projects.[3] Most U.S. wind power has been supported by Production Tax Credits (PTC) directly subsidizing energy output. Solar power has been predominantly supported by an investment tax credit, subsidizing the cost of installation rather than output directly, but the size of the subsidy is not linked to the value of the energy produced.

Many states employ Renewable Portfolio Standards (RPS) or Clean Electricity Standards (CES) to promote growth of renewable power (and other low-emission clean resources) to diversify the state's energy resource mix, promote domestic energy production, and reduce pollution and greenhouse gas emissions.[4] President Biden and Members of Congress have advocated similar but more extensive nationwide standards. Proposed nationwide standards would steadily increase to 100% "clean energy" requirements by 2035.[5]

Existing standards do not require a close matching of energy production to consumption, a feature that eases compliance now but will contribute to grid challenges in the future. Typically, a utility subject to RPS requirements must simply secure a REC produced sometime in the same year as the obligation was incurred. Allowing this sort of mismatch between renewable generation and the use of power was useful in getting the renewable power sector off the ground. As stringency of RPS policies grows higher the primary challenge is not just ensuring an adequate volume of clean electric power production, but also ensuring

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2 Sammy Roth, "California just hit 95% renewable energy. Will other states come along for the ride?" Los Angeles Times, April 29, 2021. Energy Information Administration, "Wind is a growing part of the electricity mix in Texas," Today in Energy, October 15, 2020.

3 A summary of federal incentives is available at Cunningham, Lynn and Eck, Rachel. (2021). "Renewable Energy and Energy Efficiency Incentives: A Summary of Federal Programs," U.S. Congressional Research Service R40913, Updated August 9, 2021. https://sgp.fas.org/crs/misc/R40913.pdf

4 State programs are designated by a variety of names. This report will use the term RPS generically to refer to state RPS and similar state clean energy purchase obligation programs. CES will be used in cases in which the differences between a renewable-focused policy and the broader clean energy standards is important in context.

5 Recasting the clean energy program as a budgetary rather than regulatory initiative will significantly change the mechanism through which the effort will work. As federal clean energy proposals from the White House and members of Congress are currently under redevelopment, little is known other than general goals.

that electric power is available to consumers where and when consumers expect it. Mismatches between electricity availability and consumer demand contribute to the kind of reliability problems seen in California in August 2020.

In addition, as experience in Texas and elsewhere shows, price volatility increases in spot markets as the penetration of intermittent renewables increases.[6] Because solar and wind power feature near-zero marginal cost of production, any time they are plentiful they push prices toward zero. Sometimes power prices even go negative when excess renewable supplies mix with transmission constraints and inflexibility elsewhere on the grid. When consumer demand is high and wind or solar power are unavailable, prices shoot up. The addition of intermittent renewables tends to reduce average power prices slightly even as the volatility of spot prices gets bigger.[7] Price volatility increases risks for investors and makes planning more complicated.

The combination of greater price volatility and occasional reliability events associated with growing intermittent generation may boost opposition to clean energy policies. However, these challenges can be avoided. Technological advancement might produce a solution through cheaper energy storage. California already has substantial battery storage, and Texas, Illinois, Massachusetts, and Hawaii are seeing significant investment in the technology.[8] A policy change in how RPS compliance is measured can help smooth the path forward to a cleaner electric grid.

The recommended change seems simple, but it will go far toward addressing the potential challenges: shift RPS compliance obligations from annual to hourly matching. The change rewards renewable resources that produce when consumers want power, a characteristic increasingly valuable as dispatchable fossil-fueled resources on the grid decline in availability. Corporations including Walmart, Google, and Microsoft are among those who are voluntarily moving beyond annual-style matching for their clean energy goals, but these companies represent a small fraction of overall electric power use. State regulations should adapt to support voluntary hourly matching goals and consider transitioning any state RPS policies to hourly matching obligations.

Next, we take a closer look at state RPS policies and more carefully examine the market volatility and potential reliability issues that can be expected to grow as current policies become more stringent.

Renewable Portfolio Standards

RPS policies have developed into one of the primary policy tools used by states to promote the growth of renewable power generation. Iowa initiated the first RPS program in 1984 and now thirty states, three territories, and the District of Columbia have RPS requirements in place.[9] Seven states and one territory have renewable generation goals, but lack mandates. RPS requirements are credited as responsible for as

6 Winkler, J., Gaio, A., Pfluger, B., & Ragwitz, M. (2016). Impact of renewables on electricity markets–Do support schemes matter?. Energy Policy, 93, 157-167; Seel, J., Millstein, D., Mills, A., Bolinger, M., & Wiser, R. (2021). Plentiful electricity turns wholesale prices negative. Advances in Applied Energy, 4, 100073.

7 Winkler, et al. (2016).

8 U.S. Energy Information Administration, "U.S. large-scale battery storage capacity up 35% in 2020, rapid growth set to continue," Today in Energy, August 20, 2021. https://www.eia.gov/todayinenergy/detail.php?id=49236

9 This section draws upon National Conference of State Legislatures (NCSL), State Renewable Portfolio Standards and Goals, April 2021 (https://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx); and Barbose, G. L. (2021). US Renewables Portfolio Standards 2021 Status Update: Early Release. Lawrence Berkeley National Lab.(LBNL), Berkeley, CA.

much as one half of the installed non-hydro renewable energy capacity.[10]

RPS promote renewable power generation by requiring retail electric providers to purchase a minimum amount of renewable energy during a year. The obligation is generally set as a proportion of overall energy sold.[11] State targets range from 8.5 percent at present to as high as 100 percent zero-emissions energy by 2040.

Retailers demonstrate compliance by submitting Renewable Energy Credits (RECs) to the regulatory authority sufficient to cover the retailer's obligation.[12] For example, if an electric retailer sold 1,000,000 MWh of power to end consumers in a year in a state with a 15% RPS requirement, the retailer would demonstrate compliance through acquiring and submitting to the regulator 150,000 RECs. One REC represents the environmental benefits associated with one megawatt hour of electricity generated by a qualifying renewable resource.

Retailers obtain RECs through ownership of qualified generation resources, through power purchase agreements or other long-term contracts, or through spot REC purchases from generators or brokers. States implementing RPS policies create or authorize the establishment of a REC registry to manage the creation, transfer, and retirement (i.e. submission of a REC in compliance) of RECs. Typically, the RECs used for compliance must have been produced in the same year that the retail sale occurred causing the compliance obligation, but RECs "banked" from earlier years often may be used as well.

States differ on the precise list of qualifying generation technologies. Wind, solar, geothermal, biomass, and small hydro commonly qualify. Some states also recognize landfill gas, combined heat and power, fuel cells not relying on fossil fuels, and even energy efficiency. Some states have adopted clean-energy standards or zero-emission standards which include nuclear energy as a qualifying technology.

In addition to RECs used to satisfy RPS obligations, RECs are also used by companies, organizations, and some municipalities who voluntarily pursue clean energy goals beyond those required by state laws. Companies pursuing, say, a "100% clean energy goal" often seek to match their annual energy consumption with the purchase and retirement of RECs.

RPS programs supplement rather than totally displace electric power markets in areas where these are available.[13] The RECs created as part of RPS programs provide a secondary revenue stream that, along with energy market revenues and other subsidies, drive investment in new power plants in a way that allows compliance at low cost. Companies that are especially well-suited in achieving the desired outcomes

10 Barbose, G., Wiser, R., Heeter, J., Mai, T., Bird, L., Bolinger, M., Carpenter, A., Heath, G., Keyser, D., Macknick, J. and Mills, A. (2016). A retrospective analysis of benefits and impacts of US renewable portfolio standards. Energy Policy, 96, 645-660.

11 The RPS mechanisms in Texas, Iowa, and Kansas operate somewhat differently, but work in the same general way. See the NCSL survey for details on each state program.

12 This report uses the term RECs generically to refer to the credits or certificates representing the environmental value of electricity generated by qualifying resources. In some states the credits are termed Clean Energy Credits (CECs) or Zero Emission Credits (ZECs).

13 For emphasis, a "market-based approach to environmental regulation" is not a "free market approach" or a "deregulated" approach. "Market-based" signals only that the regulatory design divides responsibility for achieving policy goals between public sector and private sector such that decisions are made in the most effective arena. The public sector has the authority and responsibility to establish environmental goals, but the private sector is generally more effective at efficiently developing commercial enterprises. Market-based approaches seek to leverage both characteristics to advantage. A good general introduction to market-based approaches to environmental regulation is in Portney, P. "Market-Based Approaches to Environmental Policy: A 'Refresher' Course," Resources, June 15, 2020. https://www.resources.org/archives/market-based-approaches-to-environmental-policy-a-refresher-course/

may overproduce RECs which they then can sell, while companies poorly situated to produce RECs can purchase RECs to meet requirements.

However, as emissions reductions become the primary goal of regulatory efforts--as opposed to simply boosting renewable energy—some question whether technology-based policies, like RPS, are an effective approach. Further, as many private companies and industries are now voluntarily adopting their own stringent environmental standards, investment is now entering the market free from reliance on any government mandates. Some go as far as to argue that this may be the time to eliminate traditional RPS efforts altogether.

The Biden Administration and Democratic leaders in Congress have proposed national clean energy standards (CES) which may complement or displace state programs, depending on the details of the proposal. Should a federal CES be implemented with an annual compliance match requirement, it would likely enhance the challenges here. However, it remains uncertain when or even whether a federal CES will be enacted.

Current Views of Renewable Portfolio Standards

Public policies promoting the growth of renewable power generation either directly subsidize output or work to mitigate capital or operating costs. The investment tax credit (ITC) currently available to solar power projects is an example of policy aiming to mitigate capital costs.[14] The production tax credit (PTC) and existing state RPS policies are examples of policies that directly subsidize output. Both ITC and PTC policies are currently scheduled to phase out over the next few years, though supporters and beneficiaries of the subsidies have called for the programs to be extended or made permanent.

RPS programs have long been subject to the criticism that they are inefficient policies for securing reductions in carbon emissions. Work by Karen Palmer and Dallas Burtraw at environmental think tank Resources for the Future published in 2005 concluded RPS policies raise electricity prices and displace natural gas and coal emissions for standards up to 15 percent of power consumption.[15] At a standard of 20 percent the policy raised prices more dramatically and began to displace nuclear generation, securing modest environmental benefits while imposing high costs.

Much has changed in the last 16 years—the prices of solar power, wind power, and natural gas are all lower than in 2005, significantly so for solar and wind. Significantly more wind, solar, and natural gas generation is in the power sector fuel mix, and coal generation has been significantly reduced. These changes mean the cost of solar and wind expansion are smaller now than in 2005. Researchers associated with the Lawrence Berkeley National Laboratory and National Renewable Energy Laboratory (Barbose et al. 2016) estimated the compliance cost of RPS policies at about $1 billion a year for the period from 2010 to 2013, but found the costs were more than compensated for through the health effects of reductions in emissions.[16] In addition, they noted renewable generation put downward pressure on wholesale electric prices and reduced use of natural gas similarly reduced gas prices modestly.

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14 The ITC currently allows a credit against federal taxes in the amount of 26% of the investment in solar property. Other technologies also have access to the ITC. See DSIRE, "Business Incentives Investment Tax Credit (ITC)" for more. https://programs.dsireusa.org/system/program/detail/658.

15 Palmer, K., & Burtraw, D. (2005). Cost-effectiveness of renewable electricity policies. Energy Economics, 27(6), 873-894.

16 Barbose, et al. (2016). See footnote 10 above.

More recently, in a 2020 paper titled "Do Renewable Portfolio Standards Deliver Cost Effective Carbon Abatement?" economists Michael Greenstone and Ishan Nath observe that many of the costs of renewable energy generation resulting from RPS policies are in the nature of indirect system costs.[17] These costs arise from additional transmission expenses, expenditures related to displacement of what would otherwise be productive generating resources, and the costs of managing the grid to compensate for the intermittent nature of wind and solar resources. The authors find reductions in carbon emissions at costs estimated at $58-$298 per ton avoided.[18] The authors report some evidence of reductions in sulfur dioxide emissions, but mixed or no evidence of an effect on other emissions.[19]

Differences between the Greenstone and Nath methods and goals and those of Barbose et al. make direct comparison difficult. Both make some attempts to get beyond direct compliance costs to encompass indirect system costs and benefits. Greenstone and Nath find higher indirect system costs and weaker evidence for indirect environmental benefits while Barbose et al. report modest indirect system costs and clearer evidence for environmental benefits.

Because RPS is a market-based regulatory policy, relying on incentives to private investors to enhance the efficiency of the program, all assessments note that increasing stringency comes with higher per unit added costs in the short run.[20] This effect is a natural consequence of the market-based approach: investors pursue the best opportunities first and are driven to invest in lower quality resources as the stringency of RPS policies increase. In practice RPS policies along with other subsidies have supported a great deal of wind energy generation, much of it in the central plains states, and some solar power in the southwest. Special solar-directed RPS requirements have also promoted solar power in New York, New Jersey, and a few other states.

Weakness in current policies a growing problem

The annual nature of the RPS compliance obligation gives rise to the weakness that is the focus of this report. The effect is not particularly noticeable in today's power markets, though the California rolling blackouts of August 2020 are suggestive of the concern. The weakness only becomes relevant as the stringency of RPS policies becomes higher.

Researchers associated with Google, Microsoft, and other corporations pursuing private 100% clean energy goals have seen this weakness and are adapting their own purchase policies to help adapt. These companies are a relatively small share of overall electric power consumption, so state (and potentially federal) policies will drive market results. As RPS obligations rise to 40 or 50 percent, the challenges created by this weakness will become readily apparent.

The key factor is this: under the current annual matching obligation electricity retailers need only secure RECs produced within the same year as the power consumption. The renewable power used to produce the REC submitted in compliance need not be from the same time and place as the retail electricity sale

17 Greenstone, M., & Nath, I. (2020). Do Renewable Portfolio Standards Deliver Cost-Effective Carbon Abatement? University of Chicago, Becker Friedman Institute for Economics Working Paper (2019-62).

18 p. 31.

19 pp. 30-31.

20 Longer term effects on costs are much more difficult to assess. Some speculate that policy-driven expansion of renewable energy investment promotes cost-reducing "learning by doing" and economies of scale effects. Long term trends of decreasing costs for both wind and solar power installations give some credence to such speculation.

that generated the obligation. Obligations created serving summer afternoon peak loads can be satisfied by submitting RECs generated in the middle of a windy Spring night, or even with RECs produced a few months later in the year.

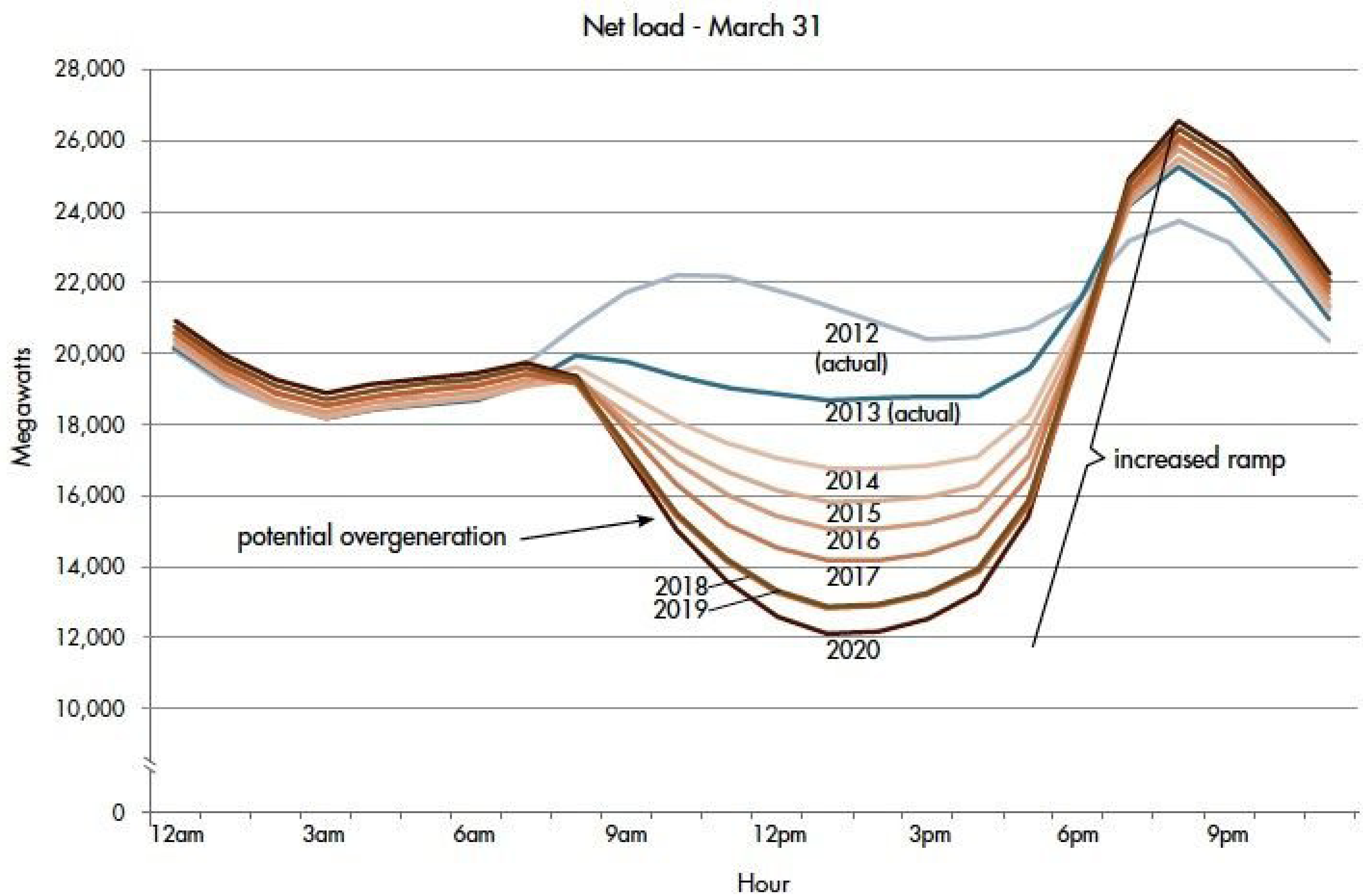
There is a geographical piece to the gap, too, if compliance obligations are satisfied by renewable generation that is not reliably deliverable from the physical renewable resources providing the RECs. For example, consider the city of El Paso at the far west tip of Texas, connected electrically to the Western Interconnection instead of the ERCOT interconnect that covers most of the state. If the local electric utility satisfies all RPS obligations by purchasing RECs generated within ERCOT, it is supporting the growth of renewable resources that will never be physically able to supply the city (absent a major investment in transmission, not currently contemplated). The ERCOT system gets the price variability and potential reliability concerns associated with higher levels of intermittent resource integration while REC purchases allow the El Paso electric company to get credit for supporting renewable energy.

Because the production and consumption of electricity covered by the RPS need not closely match in time and place, the mismatch between renewable generation and consumer power consumption will grow as the stringency of the RPS increases. Renewable power generators get a REC revenue stream based on the quantity of power produced. In the windy plains states wind energy naturally fits the bill, and most wind energy resources produce the most during Spring nights. In the sunny southwest solar increasingly dominates, producing the most during Summer afternoons. The renewable power generated may match consumer or not, the REC revenue remains the same.

The mismatch can be seen in the so-called "California Duck Curve," a chart comparing total power consumption over a day to the energy consumption net of intermittent wind and solar energy production within the California ISO.[21] See Figure 1 below for an illustration. This net energy consumption must be met by a combination of dispatchable generation resources, in California mostly hydropower, natural gas generation, and power brought in from other Western states. Given the state's extensive solar power capacity, midday solar production creates the "belly" of the duck, and dispatchable generation must ramp down in the morning and more rapidly up late afternoon to match peak consumer demand. It was a lack of dispatchable resources on August 13 and 14, 2020 that pushed the California grid operator into rolling outages to avoid a system failure.

21 See California ISO, "What the duck curve tells us about managing a green grid," The duck curve is not the product of only the California RPS, but the RPS does "feed the duck" so to speak.

Figure 1: California Duck Curve



Source: California ISO via U.S. Department of Energy, "Confronting the Duck Curve: How to Address Over-Generation of Solar Energy," October 12, 2017. URL: https://www.energy.gov/eere/articles/confronting-duck-curve-how-address-over-generation-solar-energy

Other states face different combinations of consumer demand and intermittent power supplies, and few have quite the intensity of concerns as in California. Iowa generates a high proportion of its power from wind, but much of that power is readily exported to other states and gets balanced over a large area through participation in the Midcontinent ISO. Texas does not yet see similarly predictable reliability challenges, but some analysts warn of a "Dead Armadillo Curve" for Texas and a "Midwest Gator" in the years to come.[22]

RPS policies, along with some other policies supporting renewable energy development, promote quantity of output over quality. Such policies exacerbate the mismatch between intermittent renewable power output and consumer demand. While these policies may have been useful to spur renewable energy in its fledgling state, changing conditions mean these policies need updating. Current prospects for energy storage on the power grid are improving but not yet nearly enough to cover the gap. The gap—the difference between when power supported by RPS policies is put on the grid and when consumers most want that power—will get bigger as the stringency of RPS policies grows. See the appendix for an example that is

22 Webber, M. How Oil-Loving, Frack-Happy Texas Could Lead the Low-Carbon Future. Texas Monthly, September 2019. https://www.texasmonthly.com/articles/oil-frack-texas-lead-low-carbon-future-get-rich/; Twite, A. Forget the Duck Curve. Renewables Integration in the Midwest Is a Whole Other Animal. GreenTechMedia. June 21, 2018. https://www.greentechmedia.com/articles/read/renewables-integration-in-the-midwest-is-a-whole-other-animal#gs.5xd80m.

exaggerated to illustrate the point clearly.

The mismatch will necessarily disappear should an electric grid reach 100 percent clean energy. If every MWh of energy supplied comes from RPS-qualified production, then every consumer is always supplied by a resource able to deliver power to the time and place that consumer uses it.

The market-based nature of RPS compliance also works to mitigate some of the mismatch. Building additional wind resources at a location already saturated with wind power simply allows one wind resource to displace another: no additional wind resources end up on the grid and so no additional RECs are generated to provide an incentive to build. In addition, power prices will plummet during high wind periods in areas saturated with wind resources, so new resources would earn little revenue at the times its output is most available. Both power prices and potential REC revenue will encourage developers to find less saturated portions of the grid for new projects. The problem is that by the time these incentives to spread investments are strong, the market will already be experiencing greater price volatility and grid operators will already be facing the challenges of high penetrations of intermittent resources.

The pursuit of 24/7 Clean Energy and the Hourly REC

Critics of renewable energy policies have often criticized REC-based compliance as a sort of shell game.[23] Supporters of renewable energy make similar objections.[24] A company or city government can claim 100 percent reliance on renewable energy while remaining connected to a grid made reliable in large part due to the efforts of fossil fuel generators. Indeed, a company or city might declare itself 100 percent powered by renewable energy even while freely consuming electricity at times that renewable energy is not locally available in sufficient quantity to actually meet their usage.

Companies like Google and others pursuing stringent voluntary clean energy goals took the criticism seriously.[25] Their own analysis showed them that the low-quality, high-quantity approaches driven by RPS policies would lead power markets into a bumpy patch of increasingly volatile prices and potential reliability concerns. As an early step Google sought out RECs bundled with the underlying energy.[26] In Google's analysis a primary problem ahead resulted because the mix of resources encouraged by existing policies were not likely capable of always providing clean energy when and where they needed it. Their desire to take a leadership position in clean energy procurement drove them to seek out resources to match their power consumption on a "24/7" basis, that is for every hour, 24 hours a day, seven days a week.

M-RETS, a REC tracking and trading company based in Minnesota, has developed the capacity to link RECs to the hour of renewable power generation.[27] The advance allows corporate energy consumers

23 See, for example, Driessen, P. (2017) "Renewable Energy – By Royal Decree!" Townhall.com, November 4, 2017. https://townhall.com/columnists/pauldriessen/2017/11/04/renewable-energy--by-royal-fecree-n2404737

24 Roberts, D. (2015). "It's easy to buy green power. Making a difference is a little harder." Vox, November 16, 2015. https://www.vox.com/2015/11/16/9744620/support-renewable-energy

25 Google (2018). "Moving toward 24x7 Carbon-Free Energy at Google Data Centers: Progress and Insights." White paper available at https://storage.googleapis.com/gweb-sustainability.appspot.com/pdf/24x7-carbon-free-energy-data-centers.pdf; Google, (2020). "24/7 by 2030: Realizing a Carbon-free Future." White paper available at https://www.gstatic.com/gumdrop/sustainability/247-carbon-free-energy.pdf;

26 Google (2013). "Google's Green PPAs: What, How, and Why." September 17, 2013 (Revision 3; initially published April 21, 2011). https://static.googleusercontent.com/media/www.google.com/en//green/pdfs/renewable-energy.pdf

27 See Greenfact (2021). "Energy Traceability: The rising interest in hourly EACs." Greenfact.com, March 17, 2021. https://www.greenfact.

to better pursue voluntary "24/7" environmental goals. Google, which became the first purchaser of an hourly REC on the M-RETS platform, helped develop the product. EnergyTag, an independent industry-led initiative (which counts M-RETS, Google, Microsoft, and many others among its supporters), is working to define standards for the voluntary hourly-stamped REC market.[28]

Voluntary corporate efforts in the clean energy space allow for greater experimentation and more rapid innovation than is typically possible in federal and state government processes. Federal and state policymakers can take advantage of these efforts by considering whether government policies ought to change in response to developments emerging from voluntary clean energy action. There are two changes which public policymakers should consider. First, states should encourage the RECs used in state RPS compliance programs to become capable of supporting voluntary hourly and locational matching clean energy efforts. Second, states should consider whether their RPS compliance obligations should include hourly and locational matching requirements.

A broader discussion may be needed on whether traditional RPS policies remain necessary in today's energy economy. This paper only aims to evaluate current RPS policy to identify possible ways to make them more efficient and responsive to current market dynamics. Even should RPS policies be abandoned in pursuit of more effective public policy supports, a role will remain for hourly RECs to support corporate environmental goals.

Adding time and locational information to RECs will support innovation

At present most RECs need only be time-stamped to the year of the qualifying power generation because compliance obligations often only require annual matching. Requiring REC registries to include hourly and locational data would continue to allow RECs to be retired under current annual matching RPS requirements while supporting innovation and voluntary compliance efforts in the clean energy marketplace. There may be value in pushing beyond more refined time-stamping of RECs. Some voluntary efforts are hampered by lack of additional details about the precise environmental characteristics of the power generation associated with a REC. States' engagement with ongoing discussions may reveal additional areas through which RPS policies can support innovation in this area.

States should consider transitioning RPS obligations to hourly and locational matching

As states consider increasingly stringent RPS obligations, they should also consider requiring more granular matching of REC production and the energy consumption that gives rise to the obligation to acquire and retire the REC. Obviously, because the now-typical annual match drives investment in low-cost, relatively low-value renewable resources, moving to an hourly match would raise costs. The potential rate shock can be eased by at first requiring only a fraction of the RPS obligation to meet an hourly match, while the remainder of the obligation could be satisfied under current rules. Over, say, a ten-year period, the fraction of the RPS obligation requiring hourly matching could increase, steadily inducing investment

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com/News/1413/Energy-Traceability-The-rising-interest-in-hourly-EACs; M-RETS (2021). "A Path to Supporting Data-Driven Renewable Energy Markets." White Paper. March 2021. https://www.mrets.org/wp-content/uploads/2021/02/A-Path-to-Supporting-Data-Driven-Renewable-Energy-Markets-March-2021.pdf

28 See EnergyTag (2021). EnergyTag and granular energy certificates: Accelerating the transition to 24/7 clean power, White Paper. https://www.energytag.org/wp-content/uploads/2021/05/EnergyTag-and-granular-energy-certificates.pdf.

in clean energy resources capable of serving consumer demand for power at all hours and in every place consumers are willing to pay for it.

Complementary adjustments can also ease rate shock. For example, shifting from a purely renewable obligation to a broader clean energy standard will increase the range of possible technologies brought onto the grid.[29] Initial RPS policies were in part specifically intended to drive investment in renewable resources at a time when such technologies were relatively new to grid-scale projects. Now wind and solar resources are cheap enough in many places that they find robust demand without targeted state support. Policy needs these days are increasingly oriented to climate and other environmental goals as readily served by keeping existing nuclear power generation in operation or boosting hydropower as they are served by new renewable energy development.

Conclusion

State RPS policies have been credited with promoting a substantial amount of investment in zero- or low-emission electric power generation. But RPS policies along with federal incentives for renewable energy support projects regardless of the value of the power produced. Investment is driven into high-output renewable resources often mismatched with consumer power demands. As states raise the stringency of RPS policies, the mismatch between renewable resources supported and consumer demand threatens to produce greater price volatility in power markets and raises reliability concerns for grid operators.

A relatively simple fix in public policy goes far: shift RPS requirements from an annual matching obligation to an hourly matching obligation. Complementary moves to a broader "clean energy standard" and to locational matching obligations if they are currently not present will further improve existing RPS regulations. Such changes will support innovation and drive investments into zero- or low-emission resources that produce power when and where consumers demand it. Such shifts will raise the cost of regulatory compliance, but if such increases are projected to be significant then the requirements for hourly matching can be phased in over several years.

29 More on clean energy standards is here: Cleary, K. Palmer, K. and Rennert, K. (2019) "Clean Energy Standards." Issue Brief 19-01, Resources for the Future. January 2019. https://www.rff.org/publications/issue-briefs/clean-energy-standards/

Appendix

The two islands: An example

An example can make the point clearer. This example is an extreme case designed to illustrate the problem, but the effect revealed will be present in real world cases as RPS requirements become more stringent.

Imagine a state composed of two islands, call them East Island and West Island. They need not be actual islands for this example to work so long as they are electrical islands, which is to say they each lack transmission links to other areas. As electrical islands, all power generation and consumption must be balanced within each island. Assume similar populations and power consumption patterns in each. Also assume West has higher quality renewable resources. Finally, assume all renewable energy resources available are intermittent in nature.

The state imposes an annual RPS obligation that can be satisfied by RECs produced in either West or East islands. Initially power retailers in the state must acquire RECs equal to 5% of their annual retail sales, but over time that obligation will grow to 50%. Because the renewable resources are much better on West Island, assume all of the West demand for RECs and 80 percent of the East demand for RECs will come from resources on West Island.

Early in the program the concentration of renewable resources in the West presents no special problem. Table A1 shows the base case and the implications of a 5% RPS. While on average just 5% of power generation must come from renewables, the better resource quality in the West results in more renewables investment and production there. The 5% RPS results in 9% of total generation in the West coming from renewables, and just 1% produced on East Island.

The 9% renewable generation in the West is an average for the entire year, but intermittent renewables and consumer demand tend to have seasonal and diurnal variability. At times when demand is low and renewable production high, renewable generation might represent 30 or 40% of total power on the West Island grid. If renewable generation lags when demand peaks, renewable generation may fall to near zero.

West Island, Table A1

No RPS	THERMAL GEN CAPACITY	RENEWABLE GEN CAPACITY
	1,826 MW	0 MW
	THERMAL OUTPUT	RENEWABLE OUTPUT
	12.00 TWh	0.00 TWh

5% RPS	THERMAL GEN CAPACITY	RENEWABLE GEN CAPACITY
	1,662 MW	411 MW
	THERMAL OUTPUT	RENEWABLE OUTPUT
	10.92 TWh	1.08 TWh

East Island, Table A1

No RPS	THERMAL GEN CAPACITY	RENEWABLE GEN CAPACITY
	1,826 MW	0 MW
	THERMAL OUTPUT	RENEWABLE OUTPUT
	12.00 TWh	0.00 TWh

5% RPS	THERMAL GEN CAPACITY	RENEWABLE GEN CAPACITY
	1,808 MW	46 MW
	THERMAL OUTPUT	RENEWABLE OUTPUT
	11.88 TWh	0.12 TWh

Table A2 shows how quickly challenges grow as the stringency of the RPS increases. At an RPS obligation of 25%, on average 45% of the power produced over the course of the year on West Island will come from renewables. Given typical variations in demand and renewable supplies, during low demand Spring nights and fast winds, the fraction of demand served by wind power could reach the technical maximum possible given grid limits and reliability requirements. Summer evenings as the sun goes down and winds typically slow may see renewables fall to near 10% or even 5% as West Island consumer demand is rising.

West Island, Table A2

25% RPS	THERMAL GEN CAPACITY	RENEWABLE GEN CAPACITY
	1,005 MW	2,055 MW
	THERMAL OUTPUT	**RENEWABLE OUTPUT**
	6.60 TWh	5.40 TWh

50% RPS	THERMAL GEN CAPACITY	RENEWABLE GEN CAPACITY
	183 MW	4,110 MW
	THERMAL OUTPUT	**RENEWABLE OUTPUT**
	1.20 TWh	10.80 TWh

East Island, Table A2

25% RPS	THERMAL GEN CAPACITY	RENEWABLE GEN CAPACITY
	1,735 MW	228 MW
	THERMAL OUTPUT	**RENEWABLE OUTPUT**
	11.40 TWh	0.60 TWh

50% RPS	THERMAL GEN CAPACITY	RENEWABLE GEN CAPACITY
	1,644 MW	457 MW
	THERMAL OUTPUT	**RENEWABLE OUTPUT**
	10.80 TWh	1.20 TWh

NOTES:

Assumes a constant 75% average capacity factor for thermal generation and a constant 30% average capacity factor for renewable generation.

Output values are annual totals constructed such that each island generates and consumes a total of 12 TWh of power each year.

The cheapest kind of fossil fuel generation to step into the gap when intermittent generation fails tend to be units with low capital costs and high operating costs. Low capital costs keep fixed cost recovery requirements low when the unit is not operating, an increasingly desirable feature for generation units spending most of the time on the sideline. But generators with low fixed costs tend to have high operating costs. As a result, when renewables are readily available in the West power prices will push toward zero, but when renewables fade power prices will jump up to the operating cost of the least efficient generator required to keep supply balanced with demand. Prices become increasingly volatile as reliance on intermittent resources increases.

We can take steps to make the example more realistic by assuming higher quality renewable resources in the East, or transmission links between East and West (or to other neighboring areas). Assuming some renewable resources are constant or dispatchable—like hydropower or geothermal—or that battery technology was available would help address price volatility and reliability issues. Even with these modifications, however, as stringency of the RPS reaches higher the mismatch effect creates challenges.

Market dynamics will mitigate some of the problems even in the extreme case

The extreme example neglects predictable power market dynamics. As more stringent RPS requirements boost intermittent power production on the West Island, wholesale power prices will be driven lower and REC prices will rise in the West to continue to drive investment in renewables needed for RPS compliance. The added capacity in the East will be much smaller by assumption, so less substantial market pressure on power or REC prices. As a result, likely market conditions would push a growing fraction of renewable investment to the East Island. Just incorporating modest market dynamics into the extreme example makes it less extreme.

Shifting RPS obligations from annual/anywhere to an hourly/deliverable matching helps too

If RPS policies required deliverability of resource to consumer load, then under the assumptions above East Island would have to build out its own renewable resources or invest in a transmission link to the West Island. Issues arising in the West due to investment driven by East Island compliance would be substantially reduced. If the RPS policies required hourly matching, then renewable developers would be driven to find and develop technologies capable of matching consumer demand.

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