for the

Hearing on

Building a 100 Percent Clean Economy: Solutions for the Power Sector

WRITTEN TESTIMONY OF KAREN PALMER, RESOURCES FOR THE FUTURE

Prepared for the Energy Subcommittee of the U.S. House Committee on Energy and Commerce

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Chairman Rush, Ranking Member Upton, and distinguished members of the Subcommittee:

Thank you for the opportunity to provide testimony to the Energy Subcommittee as part of the Committee's exploration of policy pathways to lead to a 100% net zero emission US economy in 2050.

My name is Karen Palmer, and I am a Senior Fellow and Director of the Future of Power Initiative at Resources for the Future (RFF). RFF is an independent, nonprofit research institution in Washington, DC. Its mission is to improve environmental, energy, and natural resource decisions through impartial economic research and policy engagement. RFF is committed to being the most widely trusted source of research insights and policy solutions leading to a healthy environment and a thriving economy. While RFF researchers are encouraged to offer their expertise to inform policy decisions, the views expressed here are my own and may differ from those of other RFF experts, its officers, or its directors. RFF does not take positions on specific legislative or regulatory proposals.

Summary of Testimony

This hearing is timely and takes place against the backdrop of a rapidly evolving power sector, shaped both by policy activities at the state and federal levels as well as market forces. States have continued to lead the way with increasing ambition, putting in place renewable and clean energy standards, cap-and-trade programs, and even ambitious legislative requirements to reach net-zero emissions by 2050. The costs of natural gas have decreased significantly as a result of improved extraction techniques, and the continued cost declines of utility-scale solar and wind along with storage have made them competitive without subsidy with coal and natural gas in some markets. Emissions from the power sector, as a result, are down 27% from 2005 levels[1].

Clearly there is momentum in the power sector towards a future with decreased emissions. However, the pace of the transformation is insufficient to meet the pace of reductions from the power sector required to keep US emissions reductions on a trajectory consistent with limiting global warming to 1.5 degrees Celsius[2]. Without further policy intervention, the vast majority of economic models indicate that the power sector will fall far short of the 100% net zero emission goal by 2050 put forward by Committee leadership that is consistent with this target.

In this testimony I offer three primary contributions. The first is a suggested set of criteria that the Committee consider in its evaluation of the merits of different policy options. The second is a discussion and comparison of a set of policy options that could be implemented to reduce power sector emissions or decarbonize it entirely. The options I discuss include carbon pricing, clean and renewable electricity standards, energy tax incentives, and clarification of existing regulatory authority. Finally, I highlight several potential challenges that are likely to need to be addressed to fully eliminate greenhouse gas emissions from electricity production.

Criteria for Evaluating Policy Approaches

As the Committee considers climate policy approaches, I suggest several criteria for the evaluation of such policies. The first criterion is the level and pace of emissions reductions, given the primary rationale of reducing US greenhouse gas emissions. The cost of the policy is important not only for the strength of the economy, but also because achieving reductions at less cost can allow for more ambitious policies. Equity and environmental justice considerations should assume a central place in climate policy conversations and include planning for a just transition for workers affected by a transforming energy system. International concerns, including both the need to maintain or improve international competitiveness and to leverage actions in other nations are vitally important. Technological innovation is a crucial policy outcome, not only to reduce US emissions but also to support reductions internationally. Finally, durability and adaptability should be incorporated into policy design, to help ensure that future policies can withstand changing economic circumstances and political winds.

Summary of Policy Options

Carbon Pricing

Economic theory, as well as experience, has shown that the most cost-efficient policy solutions are those that introduce a direct price on carbon emissions, for example through a carbon tax or a cap-and-trade program. An economy-wide price on carbon changes the relative cost of fuels by making fuels that have relatively greater emissions more expensive than those with relatively lower emissions, sending an

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[1] Energy Information Administration (2019). Monthly Energy Review Table 11.6. Available at: **https://www.eia.gov/totalenergy/data/browser/xls.php?tbl=T11.06&freq=m**

[2] IPCC (2018). Special Report: Global Warming of 1.5°C. **https://www.ipcc.ch/sr15/**

economic signal that percolates through the entire economy. This signal provides an incentive for all decision makers in the economy to look for ways to reduce emissions and provides them the flexibility to make decisions based on their own information and circumstances.

When applied to the electricity sector, either as part of an economy-wide policy or on its own, an important attribute of carbon pricing is that all emissions are priced consistently. Electricity generators of all types and efficiencies are therefore given an incentive to reduce their emissions in whatever manner makes economic sense, allowing significant flexibility for the power sector overall to reduce its emissions. In comparing climate policy options, with all else being equal, the greater the number of available options to reduce emissions, the lower the overall costs of the policy will be. Importantly, existing product markets, including wholesale electricity markets, can seamlessly incorporate changes in the relative prices of electricity generation alternatives driven by carbon pricing.

Carbon pricing policies can raise considerable revenue and how such revenue is used has a strong effect on the overall outcomes driven by the policy. Policy decisions made with respect to the use of carbon pricing revenues involve tradeoffs between, among other metrics, pure economic efficiency, overall emission reductions, and distributional outcomes, for example, how the costs of the policy are distributed across geographic regions, socioeconomic class, and economic sector.

Renewable Portfolio Standards

Renewable portfolio standards (RPS), which require retail electricity providers to sell a certain percentage of their electricity from renewable sources each year, have been widely deployed at the state level and have played an important role in deploying renewables and driving cost reductions. Most such policies currently in place have set relatively modest targets, but an RPS could be expanded to achieve net zero emissions by 2050 by requiring 100% renewable electricity. In comparison to more technology-inclusive and flexible policy requirements, however, renewables-only policies can be expected to have higher costs for the same level of emissions reductions. Extremely high levels of renewables penetration could also be expected to exacerbate some of the challenges I discuss later in my testimony.

Clean Energy Standards

An alternative policy approach that builds on the structure of a traditional renewable portfolio standard but is more technology-inclusive, is a clean energy standard (CES). A clean energy standard requires that a certain percentage of electricity sales be met through “clean” zero- or low-carbon resources, such as renewables, nuclear energy, coal or natural gas fitted with carbon capture, and other technologies. RFF modeling of proposed CES policies has shown that a CES can put the power sector well on its way to full decarbonization with modest effects on nationally averaged electricity rates.

Provided it is well-designed, a clean energy standard can provide a very similar set of relative incentives for power generation as carbon pricing and can approach its economic efficiency. Unlike carbon pricing, however, clean energy standards typically do not raise revenue. Economic modeling and theory have also shown that clean energy standards will increase retail electricity rates by less than an equivalent carbon pricing policy that does not use its revenue for electricity rate reduction. An important effect of the application of both renewable and clean energy standards is that they may depress the clearing prices in wholesale electricity markets, with implications for the profitability of generators not receiving clean energy credits.

Tax Incentives

The myriad of tax incentives available to various forms of clean energy are, individually and collectively, far less efficient at reducing emissions than carbon pricing, but have still played an important role in deploying clean electricity projects and bringing down the costs of renewables. There are opportunities to improve upon the existing ad-hoc nature of the credits by rationalizing such tax incentives to become technology-neutral and long-lasting, providing greater certainty for investment in current and developing technologies.

Regulatory Authority

The federal government, under the Clean Air Act, is required to regulate greenhouse gas emissions from both stationary and mobile sources, though the full suite of regulatory tools by which it can do so are in dispute. An alternative to specifying in legislation the details of any of the above policy mechanisms would be for Congress to specify more broadly the level of emission reductions to be achieved, reaffirm that the Clean Air Act is a mechanism that can be used, and clarify both the relevant sections of the statute and that carbon pricing and other market mechanisms would constitute valid approaches.

Challenges to Electricity Sector Decarbonization

Decarbonizing the electricity sector raises some challenges to traditional approaches to electricity system operations and wholesale electricity markets that will need to be addressed as part of the transition to a fully decarbonized system. These challenges are not insurmountable and potential solutions have institutional, technical and regulatory components.

Among the potential challenges, is that a high penetration of renewables can be expected to drive wholesale energy prices to zero in many hours of the day, reducing incentives for investment in new generation. Markets may need to be altered in order to promote new investment while delivering power reliably and at low cost to consumers. In addition, maintaining a reliable grid with a high penetration of intermittent renewables will likely require a build-out of bulk energy storage and more flexible electricity demand activated by greater time varying prices, which will require changes in retail electricity rate design. Newly electrified loads may be a particularly amenable source of flexible demand that can help with renewables integration due to their distributed energy storage potential. However, targeting electricity sector emissions in isolation from the rest of the economy could discourage electrification of other sectors, which is considered a viable decarbonization method for transportation and buildings. Simultaneous efforts to address carbon emissions from these other sectors can make a clean electricity sector more viable.

Full Testimony

The US electricity sector is evolving rapidly, shaped both by policy activities at the state and federal levels as well as market forces. States have continued to lead the way with increasing ambition, putting in place renewable standards, standards for clean energy, cap-and-trade programs, and even ambitious legislative requirements to reach net-zero emissions by 2050. The shale boom has led to a sustained period of decreased costs for natural gas, which has, in turn, led to the retirement of many coal plants. Over the past decade, non-hydroelectric renewable generation has more than tripled, partly due to policy and declining costs. Since 2009, the unsubsidized levelized costs of utility-scale solar and wind have come down by 88 percent and 69 percent, respectively. Costs for energy storage are similarly falling, with a 35% decrease in one year since early 2018, making renewables plus storage competitive with coal and natural gas in some markets[3]. New technologies that facilitate carbon capture and storage are being tested at scale. A number of large utilities have, in response to these changing conditions and the need to address climate change, set targets of getting to 100% zero emissions by midcentury.

The combination of these activities has resulted in a decrease in emissions from electricity generation, which have dropped by over 27% since 2005[4]. While historically most of the emissions reductions have been from fuel switching from coal to natural gas, a growing portion are from deployment of renewables. In 2017, nearly 50% of emissions reductions in the power sector relative to 2005 were attributable to increases in non-carbon generation[5].

Clearly there is momentum in the power sector towards a future with decreased emissions. However, the pace of the transformation is insufficient to meet the pace of reductions from the power sector required to reach the level of reductions necessary to keep US emissions reductions on a trajectory consistent with limiting global warming to 1.5 degrees Celsius. Without further policy intervention, the vast majority of economic models indicate that the power sector will fall far short of the 100% net zero emission goal by 2050 put forward by Committee leadership that is consistent with the 1.5-degree target.

Criteria for Evaluating Policy Approaches

In a recent response[6] to the Energy and Commerce Committee's request for comment on policy considerations for reaching 100% net zero emissions by 2050, a number of my RFF colleagues and I provided suggested criteria for evaluating climate policy choices. These suggested criteria, summarized

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[3] Bloomberg (2019). Battery Power's Latest Plunge in Costs Threatens Coal, Gas. Available at: **https://about.bnef.com/blog/battery-powers-latest-plunge-costs-threatens-coal-gas/**

[4] Energy Information Administration (2019). Monthly Energy Review Table 11.6. Available at: **https://www.eia.gov/totalenergy/data/browser/xls.php?tbl=T11.06&freq=m**

[5] Energy Information Administration (2018). US Energy-Related Carbon Dioxide Emissions, 2017. **https://www.eia.gov/environment/emissions/carbon/pdf/2017_co2analysis.pdf**

[6] **https://www.rff.org/publications/testimony-and-public-comments/comments-key-considerations-united-states-climate-policy/**

here, are economic, political, and human. While the list below does not address every possible criterion a policymaker might want to consider, it is useful to keep in mind these crucial measures:

The level and pace of emissions reductions is at the heart of climate policy design, given the primary rationale of reducing US greenhouse gas emissions.

The cost of the policy is important not only for the strength of the economy, but also because achieving reductions at less cost can allow for more ambitious policies.

Increasingly, and for good reason, concerns about ***equity and environmental justice*** assume a central place in climate policy conversations. Disadvantaged communities are most vulnerable to the potential costs of policy and to the effects of a changing climate. Many in these communities feel they have not enjoyed the benefits or environmental improvements that have accrued elsewhere. Fortunately, there are important opportunities for joint reductions in greenhouse gases and conventional air pollutants.

Economic modeling can help project who bears the cost of various policy options across populations and sectors, providing decisionmakers with critical information to help mitigate these distributional impacts. A focus on equity also includes planning for a just transition for workers affected by a transforming, decarbonizing energy system.

Several ***international concerns*** should also be kept in mind when designing climate policy. First, maintaining or even improving international competitiveness is crucial. Second, domestic policy can be designed to leverage actions in other nations, which is critical in the face of a global challenge like climate change.

Technological innovation is a crucial policy outcome, not only to reduce US emissions but also to support reductions internationally. In an ideal world, US companies can benefit strongly in world markets from domestic policy actions taken to reduce carbon emissions.

Finally, it is valuable to consider lessons from previously enacted, large-scale environmental policies, as RFF Senior Fellow Dallas Burtraw, along with co-editor Ann Carlson (UCLA) and a range of contributing authors, recently did in their book *Lessons from the Clean Air Act*[7]. Their primary finding was the importance of building both ***durability and adaptability*** into policy design, to help ensure that future policies can withstand changing economic circumstances and political winds.

Policy Approaches to Decarbonizing the Electricity Sector

Though the Committee's hearing is focused specifically on decarbonizing the power sector, it is important to note that economists would favor policy approaches that are applied consistently across the entire economy. Economy-wide policy strategies are favored from an economic perspective because they have the potential to be cost effective, with market forces driving the economy to reduce

[7] Carlson, A., & Burtraw, D. (2019). *Lessons from the Clean Air Act: Building Durability and Adaptability into US Climate and Energy Policy*. Cambridge University Press.

emissions in whichever sector of the economy is least-cost. Both methods of pricing carbon that I discuss below, a carbon tax and cap and trade, would be applied most efficiently at the level of the whole economy, but are also highly cost-efficient tools when applied exclusively to the power sector.

In contrast to an economy-wide approach, other climate policy options would address emissions from a given sector of the economy, such as the electricity sector, transportation sector, buildings, industry, etc. From an economic perspective, sectoral approaches are often considered less efficient than carbon pricing. Sectoral policies, if designed appropriately however, can still provide a highly efficient means of driving emissions reductions.

Carbon Pricing

Economists often favor policy solutions that introduce a direct price on carbon emissions, which escalates over time. A price on carbon changes the relative cost of fuels by making fuels that have relatively greater emissions relatively more expensive.

A carbon price is viewed favorably for the following reasons:

- It percolates through the entire economy, providing an incentive for all decision makers in the economy to look for ways to reduce emissions, for example, by improving the boiler in a factory or buying a more efficient air conditioner at home.
- It provides firms with the flexibility to make decisions that make sense based on their own information.
- Existing product markets can seamlessly incorporate changes in relative prices of goods and services.

An important attribute of carbon pricing is that all emissions are priced consistently. A consequence of this consistency is that, for example, electricity generators of all types and efficiencies have incentives to reduce their emissions in whatever manner makes economic sense, providing significant flexibility for the power sector overall to reduce its emissions. In the design of policies to reduce emissions, with all else held equal, the greater the number of available options to reduce emissions, the lower the overall costs of the policy will be. Another important attribute of carbon pricing is that existing product markets, including wholesale electricity markets, can seamlessly incorporate changes in the relative prices of electricity generation. Carbon pricing would ideally be applied at the level of the full economy, but can also be efficiently applied to an individual sector such as the power sector as has been done in the Regional Greenhouse Gas Initiative.

In this testimony I focus on two specific types of carbon pricing: a carbon tax and cap and trade.

Carbon taxes and cap-and-trade programs primarily differ by the type of certainty they provide. Carbon taxes provide price certainty, as entities subject to the tax know how much they'll have to pay per ton emitted—but simply setting a tax rate doesn't guarantee a precise level of emissions reductions. Cap-and-trade programs, on the other hand, set a cap on emissions and therefore provide quantity certainty—but price fluctuations under the trading market structure can provide a less solid basis for business planning decisions. Hybrid systems, however, can be used to reduce price or emissions uncertainty. Under cap-and-trade programs, price floors, ceilings, and steps have been proposed[8] and utilized[9] to prevent prices from being "too low" or "too high." Carbon taxes can also be designed[10] to automatically adjust if actual emissions miss some predetermined emissions path.

Carbon Tax

A carbon tax, which sets a direct price that must be paid for each ton of carbon dioxide emitted, is perhaps the most straightforward way to introduce a price on carbon. There is significant economic evidence that a carbon tax will affect short-run behavior and long-run investments and will reduce emissions. For further background on carbon tax design see RFF's suite of summary resources[11].

RFF has developed extensive modeling and other analytic tools for evaluating the effects of a carbon tax. These tools allow for the assessment of the effects of carbon tax policies across several key metrics, including annual emissions, annual revenues, cumulative emissions, consumer prices, economic growth, and the distribution of economic impacts. RFF researchers have used these tools directly to inform policymakers in carbon tax policy design and provide publicly accessible research that:

- Analyzes a number of policy proposals including the 2015[12], 2017[13], and 2019[14] versions of the American Opportunity Carbon Fee Act (Whitehouse-Schatz); the MARKET CHOICE Act[15] (Curbelo); and the Climate Leadership Council Carbon Dividends Plan[16].
- Assesses the level of tax required to meet the US obligation under the Paris Agreement[17].
- Evaluates the distributional effects[18] of various approaches to carbon taxes and recycling the generated revenues.

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[8] Flachsland, C., Pahle, M., Burtraw, D., Edenhofer, O., Elkerbout, M., Fischer, C., Tietjen, O., & Zetterberg, L. (2018). Five Myths About a European Union Emissions Trading System Carbon Price Floor. RFF Report. **www.rff.org/publications/reports/five-myths-about-european-union-emissions-trading-system-carbon-price-floor**

[9] Burtraw, D., Holt, C., Palmer, K., Paul, A., & Shobe, W. (2017). Expanding the Toolkit: The Potential Role for an Emissions Containment Reserve in RGGI. RFF Report. **https://media.rff.org/documents/RFF-Rpt-RGGI_ECR.pdf**

[10] Hafstead, M., Metcalf, G. E., & Williams III, R. C. (2017). Adding quantity certainty to a carbon tax through a tax adjustment mechanism for policy pre-commitment. *Harv. Envtl. L. Rev. F.*, *41*, 41.

[11] **https://www.rff.org/topics/carbon-pricing/carbon-tax/**

[12] Hafstead, M. & Kopp, R.J. (March 2016). Analysis of the American Opportunity Fee Act of 2015 (S. 1548). RFF Policy Brief No.15-01-REV. **https://media.rff.org/documents/RFF-PolicyBrief-15-01-REV_0.pdf**

[13] Hafstead, M. (July 2017). Projected CO2 Emissions Reductions under the American Opportunity Carbon Fee Act of 2017. RFF Issue Brief NO. 17-09. **https://media.rff.org/documents/RFF-IB-17-09.pdf**

[14] Hafstead, M. (April 2019). Projected CO2 Emissions Reductions under the American Opportunity Carbon Fee Act of 2019. RFF Issue Brief NO. 19-02. **https://media.rff.org/documents/RFF-IB-19-02_6.pdf**

[15] Hafstead, M. (July 2018). Considering a Carbon Tax-Gasoline Tax Swap: Projected Energy-Related US CO2 Emissions Reductions under the MARKET CHOICE Act. RFF Issue Brief NO. 18-08. **https://media.rff.org/documents/RFF-IB-18-08_final.pdf**

[16] Hafstead, M. (March 2019). Analysis of Alternative Carbon Tax Price Paths for the Climate Leadership Council (CLC) Carbon Dividends Plan. RFF Issue Brief NO. 18-07. **https://media.rff.org/documents/RFF-IB-18-07-rev_4evu2ny.pdf**

[17] Chen, Y. & Hafstead, M. (2018). Using a Carbon Tax to Meet US International Climate Pledges. *Climate Change Economics,* 10(1), 195002-195003.

[18] Goulder, L. H., Hafstead, M. A., Kim, G., & Long, X. (2019). Impacts of a carbon tax across US household income groups: What are the equity-efficiency trade-offs?. *Journal of Public Economics*, *175*, 44-64.

- Assesses the effects of a carbon tax on employment[19].

A result that is common to these and other analyses is that recently proposed carbon prices result in significant emissions reductions in the power sector over the business-as-usual case. For example, the 7 legislative proposals for carbon taxes put forward in the current Congress range in starting price from $15 to $55 per ton of carbon dioxide, yet all are projected to yield sufficient reductions in 2025 to meet the stated goals of the Paris Agreement.

An additional consideration in the implementation of a carbon tax is the level of uncertainty in emissions reductions resulting from a given price path of a carbon tax. RFF researchers have recently described in detail how a carbon tax might adjust automatically[20] to achieve an emissions target.

Cap and Trade

An alternate way to introduce a carbon price is through cap and trade, such as was implemented in the successful acid rain sulfur dioxide program. A carbon price is embodied in a trading program as the price of a tradable emissions allowance. Under cap and trade, the emissions goal is identified by the cap, but, in the absence of other policy constraints, the carbon price is set by the market as it adjusts to meet the annual limit on emissions. For further background on cap-and-trade design see RFF's suite of summary resources[21].

To date, cap and trade has been the dominant approach to putting a price on carbon in the United States and abroad. For example, in the United States, eleven states have enacted a carbon cap for all or some portion of their economies. This has allowed for considerable experience and evolution of the policy mechanism. Lessons learned from these experiences as well as further considerations for policy design are highlighted in the following resources:

- One of the longest running carbon cap-and-trade programs in the United States is the Regional Greenhouse Gas Initiative (RGGI). This Resources article[22], written on the occasion of RGGI's 10th anniversary, describes some of the more innovative features, including auctioning of allowances and the use of cost containment mechanisms.
- Cap-and-trade programs have moved away from free allocation of emissions allowances because of concern that windfall profits could result when firms receive allowances for free that have substantial economic value in the market. However, in some cases the introduction of an auction for allowances is politically or economically difficult to achieve. RFF's work described a consignment auction approach that was used in the sulfur dioxide trading program and elsewhere, in which allowances are conditionally allocated, but they must be sold in auction with revenue coming back to the original recipients. This design adds considerable transparency

[19] Hafstead, M. & Williams, R. (July 2019). Jobs and Environmental Regulation. RFF Working Paper No. 19-19. **https://media.rff.org/documents/WP_19-19_Hafstead_Williams_6.pdf**

[20] Hafstead, M., Metcalf, G. E., & Williams III, R. C. (2017). Adding quantity certainty to a carbon tax through a tax adjustment mechanism for policy pre-commitment. *Harv. Envtl. L. Rev. F.*, *41*, 41.

[21] **https://www.rff.org/topics/carbon-pricing/cap-and-trade/**

[22] Palmer, K. & Burtraw, D. (2018). Marking a Decade of Climate Cap-and-Trade Policy Leadership in RGGI. Resources Article. **https://www.resourcesmag.org/archives/marking-a-decade-of-climate-cap-and-trade-policy-leadership-in-rggi/**

and stronger incentives for efficient outcomes. The approach suggested was adopted by Virginia, and an RFF article[23] described how this could work.

- Recently, in response to cost considerations, cap-and-trade programs have begun to adjust the size of their emissions caps. For example, RFF researchers worked with RGGI states to develop an "emissions containment reserve" (ECR)[24] that would provide several important benefits to help improve the functioning of the market for emissions allowances. The ECR has now been adopted[25].

Uses of Revenues Generated under Carbon Pricing Proposals

Carbon pricing proposals are often touted for the revenue they generate that can be used for other purposes. Though they impose their price on carbon in distinct ways, a carbon tax and cap and trade both convey a value on emissions that is evident in tax revenue or cap-and-trade allowance value. Past modeling along with analysis of recent US federal proposals imposing an economy-wide carbon price has shown that such value can total more than $1 trillion over a decade, with roughly 25-30% of such revenue attributed to the power sector[26]. How such value is allocated provides a substantial opportunity in policy design and largely determines distributional outcomes.

At a high level, there are five main types of proposals:

- Imposing a tax swap, for example, using carbon revenue to reduce other distortionary taxes such as corporate income or payroll taxes.
- Rebating dividends back to households.
- Using revenue to reduce the effects of the policy on retail energy costs, such as electricity rates.
- Spending on programs to accelerate emissions reductions or adapt to a changing climate ("green investment" strategies).
- Using revenue to reduce the federal deficit.

RFF and other organizations have conducted research[27] on the trade-offs related to various tax swaps, as well as with lump-sum rebates back to households across various income quintiles. A high-level result that is shared by many of these analyses is that, regardless of how revenues are recycled into the economy, even substantial carbon taxes that would dramatically reduce emissions are projected to result in only a minor drag on economic growth. For example, models indicate that under such policies,

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[23] Burtraw, D., & McCormack, K. (2017). Consignment auctions of free emissions allowances. *Energy Policy*, *107*, 337-344.

[24] Burtraw, D., Holt, C., Palmer, K., Paul, A., & Shobe, W. (2017). Expanding the Toolkit: The Potential Role for an Emissions Containment Reserve in RGGI. RFF Report. **https://media.rff.org/documents/RFF-Rpt-RGGI_ECR.pdf**

[25] Burtraw, D. The Next Big Thing in Carbon Markets? RGGI to Implement an Emissions Containment Reserve. Resources Article. **https://www.resourcesmag.org/archives/the-next-big-thing-in-carbon-markets-rggi-to-implement-an-emissions-containment-reserve/**

[26] Aldy, J.E., Brennan, T.J., Burtraw, D., Fischer, C., Kopp, R.J., Macauley, M.K., Morgenstern, R.D., Palmer, K.L., Paul, A., Richardson, N., & Williams, R.C. III. (November 2012). Considering a Carbon Tax: Frequently Asked Questions. RFF Issue Brief 12-09. **https://media.rff.org/documents/RFF-IB-12-09.pdf**

[27] Goulder, L. H., & Hafstead, M. A. (2013). Tax reform and environmental policy: Options for recycling revenue from a tax on carbon dioxide. RFF Discussion Paper No. 13-31. **https://media.rff.org/documents/RFF-DP-13-31.pdf**

US GDP would reach the same projected baseline level without the policy in 2035, delayed by less than a year[28].

Policy decisions made with respect to the use of carbon pricing revenues involve tradeoffs between, among other metrics, pure economic efficiency and distributional outcomes -- how the costs of the policy are felt, for example, across geographic regions, socioeconomic class, and economic sectors. From the standpoint of pure economic efficiency, using revenues to reduce other types of distortionary taxes such as the payroll tax, individual income, or corporate income taxes, provides the greatest overall benefit to the economy as measured purely in terms of overall economic productivity. Refunding the revenues via a per-capita dividend as has been featured in many recent legislative proposals, has been shown largely to offset the regressive nature of carbon pricing, making the bottom 3-4 quintiles indifferent or better off with the policy enacted than without. In comparison, using revenues to reduce the effects of the policy on energy prices, such as electricity rates, would do less to offset the regressive effect of the carbon price on low-income consumers, but would mitigate price increases for key energy inputs for energy-intensive commercial and industrial entities. By reducing the effects on prices directly, such a use of revenues would also reduce the level of energy efficiency, and in the case of a carbon tax also potentially decrease the overall level of emission reductions driven by the policy.

In comparison to the body of academic literature evaluating the use of carbon pricing revenue for tax-swaps and dividends, at the current time there is not the same depth of research on the efficiency and effectiveness of proposed green investment strategies. Given that, in several policy proposals, such investment strategies are put forward as critical elements for achieving target emissions reductions, understanding more about their utility moving forward will be vital for informing the design of such policies.

Renewable Portfolio Standard

As discussed above, pricing carbon—imposing a direct cost on each ton of greenhouse gas emissions emitted—is a policy tool favored by economists for its cost-efficiency in reducing emissions. In practice, however, policies to price carbon directly have proven difficult to put in place in the United States and elsewhere. Except for the Regional Greenhouse Gas Initiative, which caps emissions from electricity generators in nine northeastern states, and the AB32 cap-and-trade program in California, carbon pricing in the United States has yet to materialize.

In contrast, policies that promote renewable energy have been popular and widely implemented in states across the political spectrum. Nearly three-quarters[29] of US states have adopted either a mandatory or a voluntary renewable portfolio standard (RPS), a traditional approach that requires (or encourages, in the case of voluntary programs) that a certain percentage of a utility's sales come from eligible renewable energy technologies (including wind, solar, and geothermal). Although the percentage requirements or targets vary substantially across states, the overall goals of such RPS policies are typically to deploy zero-carbon renewable resources, reduce emissions, diversify the energy

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[28] RFF's Carbon Pricing Calculator, **https://www.rff.org/cpc/**

[29] Barbose, G. (2018). *US Renewables Portfolio Standards: 2018 Annual Status Report*. Lawrence Berkeley National Lab.(LBNL), Berkeley, CA (United States).

mix, and provide an incentive to induce market entry of technologies with the potential to create new jobs.

By allowing renewable energy production to generate renewable energy credits (RECs) that can be traded, an RPS provides a market-based solution to meeting renewable energy deployment goals. However, the narrow technological focus of an RPS, combined with generally low renewable targets that limit their ability to displace emitting generation, can curb the effectiveness of the RPS as a tool to reduce greenhouse gas emissions. One way to enhance the ability of this more traditional approach to reduce emissions is to expand an RPS into a more technology-inclusive clean energy standard.

Clean Energy Standard

A clean energy standard (CES), while lacking a universally accepted definition, typically refers to a technology-neutral portfolio standard that requires that a certain percentage of electricity sales be met through "clean" zero- or low-carbon resources, such as renewables, nuclear energy, coal or natural gas fitted with carbon capture, and other technologies. As with an RPS, eligible technologies are awarded credits per MWh of generation that can be traded, which provides an efficient, market-based solution to meet a standard.

A CES offers the potential to achieve an equivalent level of emissions reductions as an RPS at lower cost. Having a greater number of technologies in competition to reduce emissions can increase market efficiency and lower overall compliance costs for a given level of emissions reduction. In addition, the inclusion of a broad range of zero- and low-emitting technologies as compliance options for a clean energy standard can also increase ambition with respect to emissions reductions. A technology-neutral CES coupled with a more stringent target could therefore result in both higher emissions reductions and lower costs relative to a traditional RPS.

Previous research on CES design conducted by RFF[30] suggests that further efficiency gains are possible by using a credit system based on emissions rates rather than technology type. This credit system would encourage emissions reductions through changes in dispatch or investments at a facility, consequently further reducing emissions and lowering costs by allowing low-carbon technologies to participate. Under this construct, technologies would be compared on an emissions rate basis with a reference type of emitting generator, either a new coal plant or some type of natural gas plant, and would receive credits accordingly. Plants that emit at an equivalent or higher rate than the baseline plant would receive zero credits, while those with an emissions rate less than the baseline can earn partial credit. This structure brings a CES one step closer to providing incentives similar to those created by pricing carbon directly.

The changes that a CES will drive in power generation can be expected to affect electricity costs at both wholesale and retail levels. The magnitude of the effects will depend, among other factors, on the stringency of the policy target. The provision of credits to clean resources will likely create an incentive to expand energy supply and consequently lead to lower wholesale market prices. This effect notably differs from that of a carbon price, which would likely raise wholesale prices. The extent to which decreased wholesale market prices will lead to lower retail prices could vary with the policy target but would be especially likely when customers are served by a vertically integrated utility that generates

[30] Paul, A., Palmer, K., & Woerman, M. (2015). Incentives, margins, and cost effectiveness in comprehensive climate policy for the power sector. *Climate Change Economics*, *6*(04), 1550016.

more clean energy credits than it needs to comply with the standard. Conversely, as the target becomes more stringent and credit prices increase commensurately, retail prices would likely increase for electric utilities that are net purchasers of credits.

The idea of a federal clean energy standard is not new, and the concept has received bipartisan support. In 2010, Senator Lindsey Graham (R-SC) sponsored the *Clean Energy Standard Act of 2010*[31] which would have set a clean energy standard to 50 percent of electricity sales by 2050. Two years later, Senator Jeff Bingaman (D-NM) introduced the *Clean Energy Standard Act of 2012*[32] (CESA 2012) to the Senate Committee on Energy and Natural Resources which would have set a federal clean energy standard at 24 percent of electric generation in 2015, rising 3 percent per year until reaching 84 percent in 2035. Like Sen. Graham's bill, the list of eligible technologies included all non-emitting sources (renewables and nuclear) and several low-emitting sources (e.g., natural gas, waste-to-energy, and fossil fuel generation with carbon capture and storage) placed in service after 1991. Unlike the Graham bill, CESA 2012 used emissions-based crediting for low-emitting sources relative to a baseline with an emissions rate of less than 0.82 metric tons of carbon dioxide (CO_2) per MWh.

In the 116th Congress, Senator Tina Smith (D-MN) and Representative Ben Ray Luján (D-NM) introduced the *Clean Energy Standard Act of 2019* (CESA 2019), a clean energy standard for which the nationally averaged percentage requirement for clean electricity increases from approximately 51 percent of retail sales in 2021 to approximately 77 percent in 2035 and approximately 96 percent in 2050. Though there are a number of structural similarities to CESA 2012, key distinctions are CESA 2019's: higher annual targets; ineligibility of natural gas generators for crediting unless equipped with carbon capture and storage; eligibility of existing clean energy resources to receive full credit for clean generation; and the setting of targets at the level of the individual load serving entity based on their historical emissions.

RFF analysis[33] of CESA 2019 projected that, relative to a "no additional policy" baseline, the proposed Clean Energy Standard Act of 2019 would:

- Reduce power sector greenhouse gas emissions in 2035 by 61 percent, with cumulative emission reductions between 2020 and 2035 of approximately 10 billion metric tons of carbon dioxide (CO_2) equivalent;
- Increase generation by renewables from 30 percent to 56 percent of total generation in 2035;
- Avoid retirement of 43 GW of nuclear generation capacity as of 2035, which would increase nuclear generation from 10 percent to 18 percent of total generation in 2035.
- Reduce generation from fossil sources from 60 percent to 26 percent of total generation in 2035;
- Provide net benefits of $579 billion over the 2020–2035 time period;
- Prevent 30,000 premature deaths from air pollution in the US over the 2020–2035 time period; and
- Increase nationally averaged retail electricity rates by 4 percent in 2035.

[31] Clean Energy Standard Act of 2010, S.20, 111th Congress. (2010).
[32] Clean Energy Standard Act of 2012, S. 2146, 112th Congress. (2012).
[33] Picciano, P., Rennert, K., & Shawhan, D. (May 2019). Projected Effects of the Clean Energy Standard Act of 2019. RFF Issue Brief No. 19-03. **https://media.rff.org/documents/RFF-IB-19-03_CES_4.pdf**

In the discussion of climate policy design, energy efficiency is often highlighted as a critical and low-cost resource for reducing emissions. One commonly proposed approach to driving additional energy efficiency is to require additional energy efficiency deployment through a market-based policy referred to as an Energy Efficiency Resource Standard (EERS). Such standards have at times been incorporated directly within state and federal RPS and CES proposals and have also been proposed as standalone pieces of legislation. The trading mechanisms included in these policies assume robust measurement of energy savings from particular interventions and clear understanding of savings potential and their costs that could guide program development and creation of tradable energy savings credits used for compliance. Given the challenges of measuring and verifying energy savings attributable to utility programs, separating these policies into two different trading programs makes sense. Access to abundant high frequency data from smart meters and other smart devices combined with machine learning algorithms suggest new opportunities for the development of more credible estimates of baseline energy consumption and thus better measurement of energy savings from specific efficiency programs and measures in the future.

Tax Incentives

The myriad of federal tax incentives available to various forms of clean energy are, individually and collectively, far less efficient at reducing emissions than carbon pricing. Still, such incentives have played an important role in deploying clean electricity projects, reducing emissions, and bringing down the costs of renewables. Importantly, unlike carbon pricing, the US Congress has also been able to pass legislation both to enact and periodically extend such tax credits over time.

Two major criticisms of the tax credits are that they are often short-term in nature and periodically expire, and that they provide uneven incentives that are targeted at specific technologies. Both of these attributes hamper long-term investments in renewables as well as investments in new technologies for which the existing tax credits may not apply.

There are opportunities to improve upon the existing ad-hoc nature of the credits by rationalizing such tax incentives to become technology-neutral and long-lasting, providing greater certainty for investment in current and developing technologies. One potential approach would be to provide production and/or investment tax credits that are based upon the emissions-intensity of the energy delivered to the market. Such incentives would allow technologies to compete on the basis of emissions, could be set for a relatively long time-horizon to allow for stability in the investment climate for existing technologies, and would also provide clear rules for the road for incorporating new technologies. One proposal to implement this type of approach has been put forward by Senator Wyden and cosponsors in the *Clean Energy for America Act*[34].

Regulatory Authority

The federal government, under the Clean Air Act, is required to regulate greenhouse gas emissions from both stationary and mobile sources, though the full suite of regulatory tools by which it can do so are in dispute. An alternative to specifying in legislation the details of any of the above policy mechanisms would be for Congress to specify more broadly the level of emission reductions to be achieved, reaffirm

[34] Clean Energy for America Act, S.1288, 116th Congress (2019).

that the Clean Air Act is a mechanism that can be used, and clarify both the relevant sections of the statute and that carbon pricing and other market mechanisms would constitute valid approaches.

Challenges for Achieving 100 Percent Decarbonization in the Power Sector

Decarbonizing the electricity sector raises a number of challenges to traditional approaches to electricity system operations and wholesale electricity markets that will need to be addressed as we move toward a fully decarbonized system. In addition, an exclusive focus on electricity may slow decarbonization of other sectors of the economy. These challenges are not insurmountable and potential solutions have institutional, technical and regulatory components.

Regulation of the electricity sector varies by region. In regions that use wholesale markets to dispatch generators, set energy prices and procure new generation capacity, wholesale market restructuring or redesign may be necessary in order to accommodate and promote investment in new zero-carbon generators. Current wholesale electricity markets were designed to produce efficient dispatch for a largely fossil system with energy prices that reflect marginal costs largely attributable to fuel. Most renewable technologies have no fuel costs and therefore zero marginal costs; with a high penetration of renewables wholesale electricity prices will be zero in many hours of the day, thus not allowing generators to recover their fixed costs and discouraging investment.

If a regional market allows for shortage pricing, prices can rise substantially during the few hours of energy shortages and create opportunities for investors to earn revenues to cover fixed costs, if their generators are operating during those hours. This opportunity is limited by energy price caps, which exist today in most organized wholesale markets to protect consumers from high prices. Separate electric capacity markets were created to help fill the revenue gap but raise their own set of issues. Therefore, markets may need to be altered in order to promote renewable investment while also maintaining their intended purpose of delivering power reliably at the lowest possible cost to consumers. The best approach to doing this is the subject of ongoing discussion[35]. Changes to market design will require input from regional grid operators (RTOs) and the Federal Energy Regulatory Commission (FERC).

Achieving 100% decarbonization will also pose some technical challenges to traditional approaches to system operation. With some exceptions, such as nuclear power, most carbon-free energy technologies are renewables that rely on natural conditions, like wind or sunlight, as a fuel source and therefore produce power intermittently. As renewables grow to be the main source of electricity generation, grid reliability could become an issue during certain hours of the day or times of the year. Addressing the challenge of intermittency can be done on both the supply and demand side.

On the supply side, grid-scale energy storage such as batteries or other storage mechanisms like compressed air can accompany renewables to absorb excess renewable energy production during certain hours, provide power during times of low energy production, and to meet grid flexibility needs

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[35] Energy Innovation (2019). Wholesale Electricity Market Design for Rapid Decarbonization. **https://energyinnovation.org/publication/wholesale-electricity-market-design-for-rapid-decarbonization/**

as renewable production fluctuates. If unfavorable conditions persist for several days, such as extended periods without sunlight to power solar panels, then storage alone may not be sufficient for balancing grid operations. To address these contingencies, there may still be a need for low-carbon dispatchable generators, like natural gas plants, to be available to run if necessary. Consequently, removing all emissions from the power sector using just renewables may be very difficult, and the use of carbon capture and storage with some remaining fossil plants could be a more economical and practical approach to achieving net zero emissions in the power sector[36].

On the demand side, greater flexibility in timing of demand can be helpful to accommodate variable renewable generation. In every hour, electricity supply on the grid must balance electricity demand. Grid operators today largely take demand as given and adjust supply to meet fluctuations in demand; however, this approach to system operations will become more challenging as supply becomes more variable. Consequently, greater flexibility in demand will become increasingly important in enabling the integration of renewables. Time varying retail pricing can assist with this effort by discouraging electricity use during certain time periods and encouraging it during times of abundant renewable generation. Time shifting of electricity demand can be accommodated by smart appliances and software programs that limit the need for direct consumer engagement in real time. Certain types of load, including EV charging, electric water heating and building HVAC systems lend themselves to such flexibility and can act as a grid battery that charges during times of high renewables production[37] (or through pre-heating in the case of water and space heating) and allows for energy service consumption when needed.

Power sector-focused carbon policies can be effective at reducing emissions from this sector by encouraging energy efficiency, fuel switching to lower-carbon fuels, and deployment of clean energy technologies. However, if climate policy applies exclusively to the power sector and not the rest of the economy, it could discourage decarbonization more broadly. This unintended consequence would be particularly likely if electrification is among the most economic and viable methods for reducing emissions in these other sectors. Limiting electrification of cars and building energy use could foreclose options for integrating renewables identified above. Thus, simultaneous efforts to address other sectors can help make a clean electricity sector more viable.

Conclusion

I include three closing observations about how to make progress. First, policy outcomes are certain to involve a portfolio of these options and measures at the federal, state and local levels. This policy mix may be desirable for various reasons, such as to promote innovation, achieve ancillary benefits (from improved local air quality, for example), or to achieve distributional outcomes that seeks to offset particularly adverse consequences for low income communities, racial minorities or particularly hard hit local economies. It is important that policies be designed in anticipation of overlapping influence to maximize the effectiveness of the entire portfolio. One example of such a design is the move toward

[36] Jenkins, J. D., & Thernstrom, S. (2017). Deep Decarbonization of the Electric Power Sector Insights from Recent Literature. *Energy Innovation Reform Project*.
[37] Nguyen, H. N., Zhang, C., & Zhang, J. (2016). Dynamic demand control of electric vehicles to support power grid with high penetration level of renewable energy. *IEEE Transactions on Transportation Electrification*, *2*(1), 66-75.

price-responsive supply of allowances instead of a fixed emissions cap in cap-and-trade policies. This new form of cap-and-trade policy design, reflected in both RGGI and California's cap-and-trade program, allows for complementary policies to yield meaningful environmental improvements in addition to lower allowance prices in these programs.

Second, it is important to recognize that meeting the environmental challenge before us is not totally unprecedented. Though the greenhouse gas emissions reduction goals identified by Committee leaders are ambitious, so too were the targets under the Clean Air Act in 1970, which addressed multiple pollutants across the economy and for which technologies to achieve emissions reductions did not exist at the time. The achievements under the Clean Air Act were monumental. Since 1970, the nation has seen reductions of 86 percent in carbon monoxide pollution, 99 percent reductions in lead, 60 percent reductions in nitrogen dioxide, and 84 percent reductions in sulfur dioxide[38]. In addition, ozone pollution has fallen by 32 percent and over the 15 years since EPA started to regulate fine particulate matter, particulate pollution has fallen by 37 percent[39]. These dramatic declines in pollution have happened at the same time as the US economy has increased dramatically (16-fold since the early 1970s) and as the population has grown by roughly 150 percent.

Third, the policy choices that we make must be sufficiently forward looking to put us on the path toward our ultimate emissions reduction goals while at the same time accommodating new discoveries with respect to climate science and new technologies. As noted above, a recent book[40] sponsored by the American Academy of Arts and Sciences identified crucial features that enabled the Clean Air Act to be durable, adaptable and flexible in achieving its goals. While durability and adaptability may seem at odds, regular policy reviews have proven a strong point of the Clean Air Act and of regional climate policies such as the Regional Greenhouse Gas Initiative, and these reviews have arguably contributed to policy durability in both cases. Flexibility, particularly the reliance on market-based mechanisms, can be a mechanism to inform adaptability through making costs transparent. By driving the economy toward cost-effective solutions, market-based mechanisms can enable increasing environmental ambition over time, something that will be necessary to meet the climate challenge.

[38] Carlson, A., & Burtraw, D. (Eds.). (2019). *Lessons from the Clean Air Act: Building Durability and Adaptability into US Climate and Energy Policy*. Cambridge University Press.
[39] Ibid
[40] Ibid