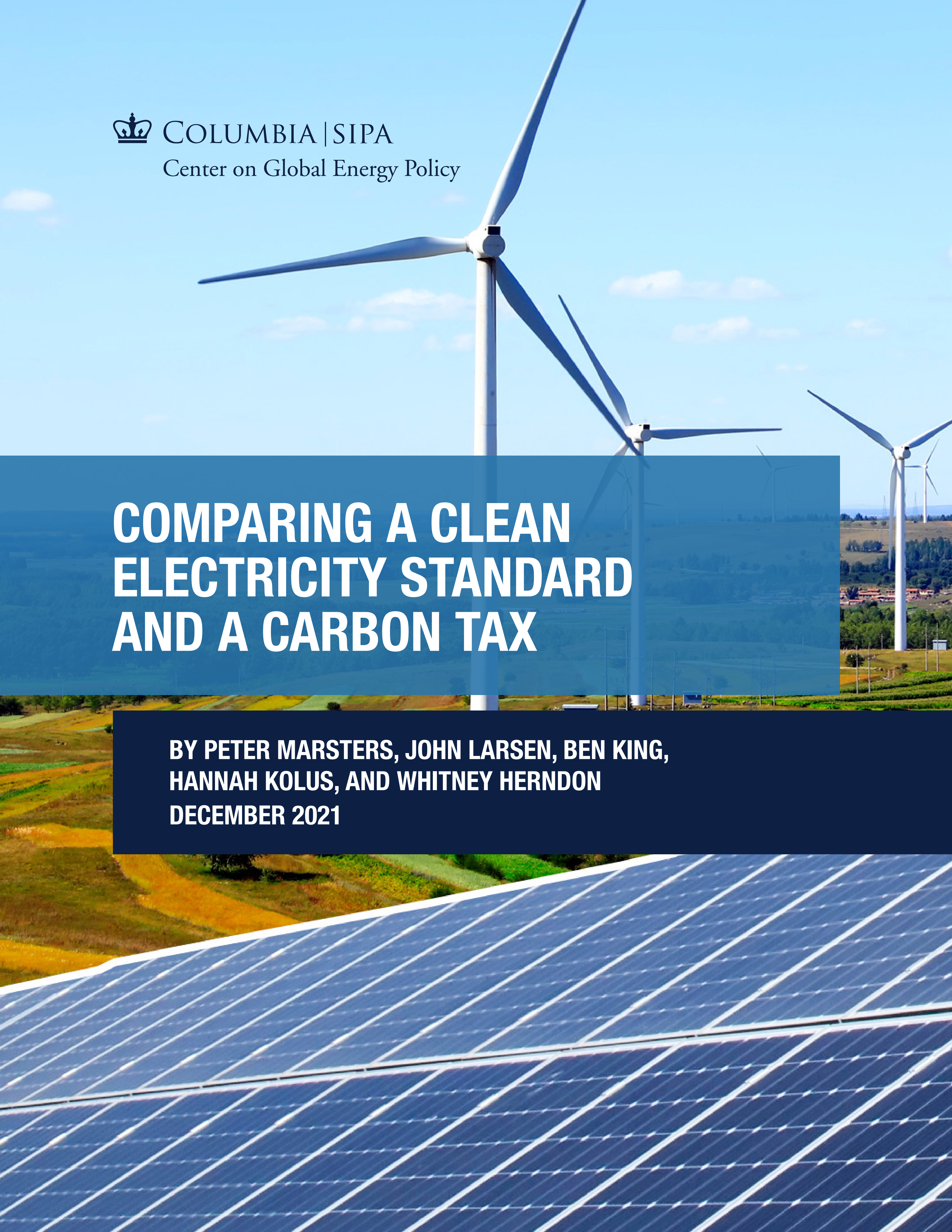

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COMPARING A CLEAN ELECTRICITY STANDARD AND A CARBON TAX

BY PETER MARSTERS, JOHN LARSEN, BEN KING, HANNAH KOLUS, AND WHITNEY HERNDON

DECEMBER 2021

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EXECUTIVE SUMMARY

As the United States commits to accelerating decarbonization as part of global efforts to combat climate change, the policies it enacts will govern its chances of success. These international ambitions are balanced against domestic realities: the effect of net-zero greenhouse gas strategies on households and the broader economy. Comparing different policy options against one another in terms of specific outcomes, such as emissions abatement and financial impact on consumers, is a useful exercise for policy makers. Because US congressional proposals have focused on two potential policy routes—an economy-wide price on carbon dioxide and other greenhouse gas emissions, and a sector-by-sector approach that starts with a clean electricity standard—this report models outcomes for these scenarios.

A carbon tax and clean electricity standard (CES) are similar policies in some ways. Both have the potential to drive large emissions reductions from the US power sector and beyond. If the CES is designed to be technology-neutral with tradable credits for clean electricity generation, both policies would operate as market-based mechanisms to encourage such generation. They also differ in significant ways, and this report, part of the Carbon Tax Research Initiative at Columbia University's Center on Global Energy Policy, uses energy system modeling to zero in on those differences to enable policy makers to better understand the advantages and drawbacks of each policy tool.

A variety of constructions even within a single tool—particularly a CES—can be employed. What type of generation is eligible for credit in a CES and how much credit each resource receives, for example, are in part products of political and policy trade-offs. For comparison purposes with an economy-wide carbon tax, this report primarily focuses on a single crediting approach that most closely resembles the incentives new and existing electric power generators could receive under a carbon tax (and is similar to the CES included in the Clean Energy Innovation and Deployment Act of 2020). And for CES comparison purposes, the authors construct a carbon tax pathway that closely approximates the annual and cumulative electric power CO_2 emissions of the CES.

Given the equal emissions-reduction ambitions of the two policies modeled in this report, the greatest trade-offs come down to price increases and revenues. The carbon tax raises consumers' electricity price more than the CES does, but also raises significant revenues that could be used, among other purposes, to offset increases in consumers' energy-related bills. Other findings from the report include the following:

- It takes a lower carbon tax rate to get to the same CES emissions outcome when clean energy technologies are relatively cheap. Under a mid-tech-cost CES scenario, the equivalent carbon tax rate starts at $14/ton in 2024 and rises to just over $18/ton in 2030. In the low-tech-cost CES scenario, the equivalent carbon tax rate starts at $9/ton and rises to just under $12/ton in 2030. These rates are far lower than any recent carbon tax proposal in Congress because the cheapest near-term abatement opportunities reside in the electric power sector.

- The CES could drive US power sector greenhouse gas (GHG) emissions down roughly 55 percent from 2005 levels by 2025, and down 62 percent by 2030, from 2,420 million metric tons (MMT) in 2005 to roughly 920 MMT in 2030. By design for this report, electric power sector emissions with the carbon tax are the same. But because the carbon tax modeled in this report is economy-wide, it could drive total US net GHG emissions down 27 percent by 2025 relative to 2005 levels, and 30 percent by 2030, from 5,999 MMT in 2005 to roughly 4,230 MMT in 2030.
- While the two policies result in a slightly different electricity generation mix, coal sees the most significant decline in both.
- Both policies substantially reduce conventional pollutants like sulfur dioxide (SO_2) and nitrogen oxides (NO_X), but SO_2 emissions are 23–54 percent higher and NO_X emissions are 7–16 percent higher under the CES on an annual average basis than under the carbon tax, which creates explicit disincentives for coal and to a lesser extent natural gas.
- Electricity prices increase more under the carbon tax because the tax is applied to all carbon dioxide emissions from electricity generation. In contrast, once generators achieve the mandated carbon intensity standard of the CES, their remaining emissions are effectively unregulated, so no costs are associated with these remaining emissions to be passed on to consumers. A carbon tax, however, brings in revenue that can be used in a number of ways, including offsetting any increases in electricity bills.
- The higher consumer prices under the carbon tax provide a stronger incentive for conservation of electricity than is found under the CES. The model shows electric retail sales to be 1 percent lower in the carbon tax scenario.
- Overall electricity generation is 1 percent higher in the CES scenario than in the carbon tax scenario, because the policy goal of the CES is to reach a certain carbon intensity level, providing incentives to both reduce emissions (the numerator of the fraction) and increase generation (the denominator).

INTRODUCTION

Policies that encourage cutting greenhouse gas (GHG) emissions are essential to rapidly decarbonizing an economy. However, no single climate policy is a comprehensive decarbonization strategy. Proposals have targeted greenhouse gases both directly through, for example, carbon taxes or cap-and-trade strategies, and indirectly through, for example, regulating vehicle fuel efficiency or renewable electricity mandates. Currently, two main policies are being considered in the United States as the foundation for the next decade of decarbonization: (1) an economy-wide price on carbon dioxide (CO_2) and other greenhouse gas emissions and (2) a sector-by-sector approach that starts with a clean electricity standard (CES).

The purpose of this report is to identify key similarities and differences between a carbon tax and a CES. The authors assess an example of a carbon tax and a CES in which electric power CO_2 emission reductions are roughly equivalent. The intent is to derive directional insights from a comparison of results using energy system modeling to enable policy makers to better understand the advantages and drawbacks of each policy option.

A Price on Carbon

A carbon price is a fee on each unit of carbon dioxide or other greenhouse gas emissions released into the atmosphere and provides a financial incentive to use less emissions-intensive means of production and consume fewer emissions-intensive goods and services. An annually increasing fee could be applied to nearly all emissions sources from the US energy system and potentially additional industrial emissions sources as well, or the fee could instead be applied to specific sectors. As explained, a carbon price today creates a financial incentive to reduce emissions today; the expectation of a carbon price in the future creates an incentive to develop lower-carbon strategies for future use. Payments of the carbon price become government revenues, which can be used in a variety of ways.

Recent proposals to the US Congress have included implementing a carbon price by way of either a carbon tax or a cap-and-trade program, which would limit the total quantity of emissions per year.[1] As of 2020, 40 countries outside the US have a carbon price, and recently, Canada and the European Union have markedly raised their ambitions by increasing both the scope of their policies and the cost of emitting greenhouse gases.[2]

A Clean Electricity Standard

Instead of charging a fee for emissions, a CES is a mandate to achieve a specified emissions intensity standard (e.g., tons of CO_2 per megawatt hour [MWh] of electricity) such that an increasing portion of electricity is generated from carbon-free sources each year. A CES defines the technologies that are considered clean (such as renewables or nuclear) or perhaps relatively clean (such as natural gas). A CES typically enables the buying and selling of "clean electricity credits" that are created when a generator produces more electricity from clean sources than required. The ability to buy and sell credits creates a market incentive for cleaner generation. A CES is similar to a renewable portfolio standard, which mandates a certain amount of power be procured from renewable sources such as wind and solar, but a CES may also include electricity from nuclear and fossil fuels with carbon capture and sequestration.

DIFFERENCES IN POLICY DESIGN

A carbon price and a CES are similar policies in some ways. Both policies have the potential to drive large emissions reductions from the US power sector and beyond. If the CES is designed to be technology neutral with tradable credits, both policies would operate as market-based mechanisms that encourage electricity generation from relatively cleaner sources. Both policies have been proposed at the federal level but have been unsuccessful to date due to the considerable political hurdles facing stringent climate change policy in the United States.

A carbon price and a CES, as modeled in this study, differ in important ways as well. The CES modeled here would not regulate the carbon intensity of products in industries outside the power sector, and it would therefore avoid price impacts on gasoline and many other carbon-intensive products. Similar standards or other policies (e.g., a clean fuel standard) would be needed to regulate these products. Some experts argue that a sector- or product-specific approach can better enable international cooperation through a simpler, narrower international agreement or treaty.[3] Many also recognize that a single, sector-specific CES would need to be paired with other policies aimed at reducing emissions from sectors outside the CES regulation as part of a comprehensive program to address climate change. The authors, however, do not model these additional emission-reducing policies that may regulate sectors outside the electricity sector.

The carbon price modeled in this report is an economy-wide emissions tax, which provides several advantages over a sector-specific CES. While the majority of the near-term emissions reductions from a carbon price are likely to come from the power sector, which accounts for about one-quarter of US emissions, carbon prices would provide an incentive for emissions reductions and a long-term price signal on the majority of US emissions. The harmonization of policy incentives across sectors could avoid some unintended consequences, such as a CES lowering natural gas prices, which could increase emissions from buildings and industry. While the carbon price may lead to higher household electricity prices, as explained in the model results of this report, it also provides a source of government revenue that can be used to compensate households for those price increases (among other possible uses of the carbon-pricing revenue). Similarly, while the carbon price may lead to larger impacts on businesses with foreign competitors, due to increased costs, carbon-pricing policies typically include a mechanism, such as a border carbon adjustment, that would put domestic industries back on a level playing field with foreign competition.

How a CES and Carbon Tax Reduce Emissions

A CES drives electric power emissions reductions by mandating that load-serving entities (LSEs) such as investor-owned utilities procure an increasing share of clean electricity. This mandate establishes a value for clean generation that would not otherwise occur without a CES and establishes a new revenue stream for eligible generators through the sale of clean electricity credits to LSEs. Clean electricity credit revenue acts as a subsidy for these generators and encourages deployment. The lower the emissions intensity of an eligible generator relative to a specified benchmark, the greater the revenue for every MWh generated. As more low- and zero-emissions generation gets added to the electric system in response to the CES, fossil-fuel-fired generation is displaced and emissions decline. Because a CES is a sectoral policy, it does not directly impact GHG emissions outside the electric power sector.

In the electric power sector, a carbon tax drives emissions reductions by making fossil-fuel-fired generators more expensive to run. The more carbon intensive the generation, the bigger the carbon penalty. The increased costs on fossil generators reduces their competitiveness and increases wholesale electric prices when these generators are on the margin (i.e., when they are the generators with the highest marginal costs of production among the set of producing generators). Higher electric prices make low- and zero-emissions generators (that have little or no carbon tax liability) more profitable and result in more deployment. New clean generation and shifts from high-carbon-intensity generators to low-carbon intensity lead to declines in CO_2 emissions. An economy-wide carbon tax can drive emissions reductions outside the electric power sector in the same way. By increasing the price of fossil fuels, consumers can shift to low- and zero-carbon alternatives if they exist, leading to declines in emissions.

Some of these differences between a carbon price and a CES are due to the specific design of the policies, while others could be lessened by combining these policy tools with a broader strategy. For example, a CES could be combined with regulations in other sectors.

This paper compares the emissions and economic outcomes of specific CES and carbon tax policies to highlight the differences in policy tools. While the ambition of the modeled policies may differ from those that could end up in legislation (see Table 1 for examples of proposed legislation), this report focuses on comparing the trade-offs of the two policy tools. As such, the authors highlight results that are likely to scale with ambition.

Table 1: Select CES and carbon tax policies in the 116th/117th Congress

Proposed legislation	Policy tool	Ambition	Link
CLEAN Future Act	Clean electricity standard	Requires all retail electricity suppliers to obtain 100% clean electricity by 2035	https://energycommerce.house.gov/newsroom/press-releases/ec-leaders-introduce-the-clean-future-act-comprehensive-legislation-to
Clean Energy Innovation and Deployment Act	Clean electricity standard	100% zero-emissions electricity no later than 2050	https://www.congress.gov/bill/116th-congress/house-bill/7516
Energy Innovation and Carbon Dividend Act	Price on carbon	Starts at $15 per ton rising at 10 per year	https://www.congress.gov/bill/116th-congress/house-bill/763

METHODOLOGICAL APPROACH

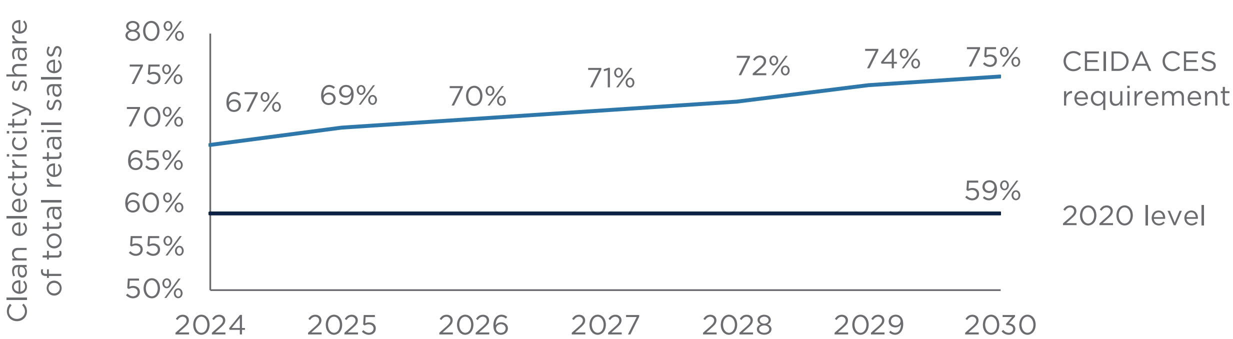
This report uses a modified version of the National Energy Modeling System constructed by the Energy Information Administration and maintained by Rhodium Group (RHG-NEMS) to analyze the impacts of these carbon tax and clean electricity standard proposals on US greenhouse gas emissions. RHG-NEMS has a detailed representation of the supply and demand sides of the US energy system including the electric power sector. It also projects all six major GHG emissions following widely used accounting protocols.

As a starting point for this analysis, the authors use Rhodium's Taking Stock 2020 "V" scenario to characterize current policy.[4] This scenario incorporates all state and federal policies on the books through May 2020 as well as the impacts of the COVID-19 pandemic and associated recession on energy demand, assuming the US economy follows a roughly V-shaped recovery. In this scenario, the authors use midlevel cost and performance assumptions for clean energy technologies, and wholesale natural gas prices are projected to hover in the range of $2.25–$2.50/million British thermal units on an average annual basis through the 2020s.

Clean Electricity Standard Scenario

The first policy scenario examined in this report is a clean electricity standard based on Title II of the Clean Energy Innovation and Deployment Act (CEIDA) of 2020, sponsored by Representative Diana DeGette (Democrat, Colorado).[5] The proposal imposes a requirement that all load-serving entities increase the amount of zero-emitting electricity they sell to retail consumers over time. Based on the authors' interpretation of the bill, the requirement amount starts at 67 percent of retail electric sales in 2024 and increases linearly to 75 percent of retail sales in 2030 and 100 percent in 2050 (Figure 1).

Figure 1: CEIDA clean electricity standard target



Note: The 59 percent clean energy in 2020 includes the partial crediting of natural gas generation.

Source: Rhodium Group analysis.

The authors chose the CEIDA in part because its crediting approach most closely matches the incentives created by a carbon tax. To mimic the electric power market incentives of a carbon tax, CES crediting must produce the same relative difference in costs of production between less-emitting generators and conventional coal, the most carbon-intensive generation on the grid. A new coal steam plant has an emission rate of roughly 0.820 metric tons per MWh.[6] Under a carbon tax, any zero-emitting generator, whether it's already online or will come online in the future, benefits the same. In the CEIDA CES, any such generator gets full credit toward meeting a given year's CES target. This includes all hydro-, nuclear, and renewable power plants currently online as well as any future capacity additions.

The CEIDA CES proposal also allows any electric generator to qualify and receive credit based on its CO_2 emissions rate relative to a benchmark of 0.820 metric tons per megawatt hour, creating similar cost differentials as a carbon tax. For example, a typical natural gas combined cycle (NGCC) unit emits roughly 0.450 metric tons per MWh. That translates to an NGCC receiving 45 percent of a CES credit for every MWh it generates. The same generator equipped with 90 percent carbon-capture equipment would receive 95 percent of a credit. Meanwhile, no existing or new uncontrolled coal steam plant has a carbon intensity lower than 0.820 metric tons per MWh, so they receive no credit. This is effectively the same as a carbon tax, where all coal plants see a penalty relative to other generators unless they are equipped with carbon capture.

The CES in the CEIDA does contain price floors and price caps on the value of clean electricity credits. The authors do not consider these policy elements in this analysis since such mechanisms distort the ability to conduct an apples-to-apples comparison with a carbon tax. Other titles in the CEIDA include tax incentives for the electrification of buildings and transportation and for clean electricity deployment as well as other programs. This report only considers the CES contained in Title II of the proposal.

In practice, what generation is eligible for credit in a CES and how much credit each resource receives is a product of political and policy trade-offs. CES proposals put forward in Congress over the past decade contain a variety of crediting approaches across multiple dimensions. These include differentiation between existing and new resources, different treatment for biogenic fuel combustion, the inclusion or exclusion of nongeneration resources such as energy efficiency, different benchmarks for crediting fossil fuel generation, and for some, special treatment for certain technologies through bonus crediting or carve outs.

Crediting

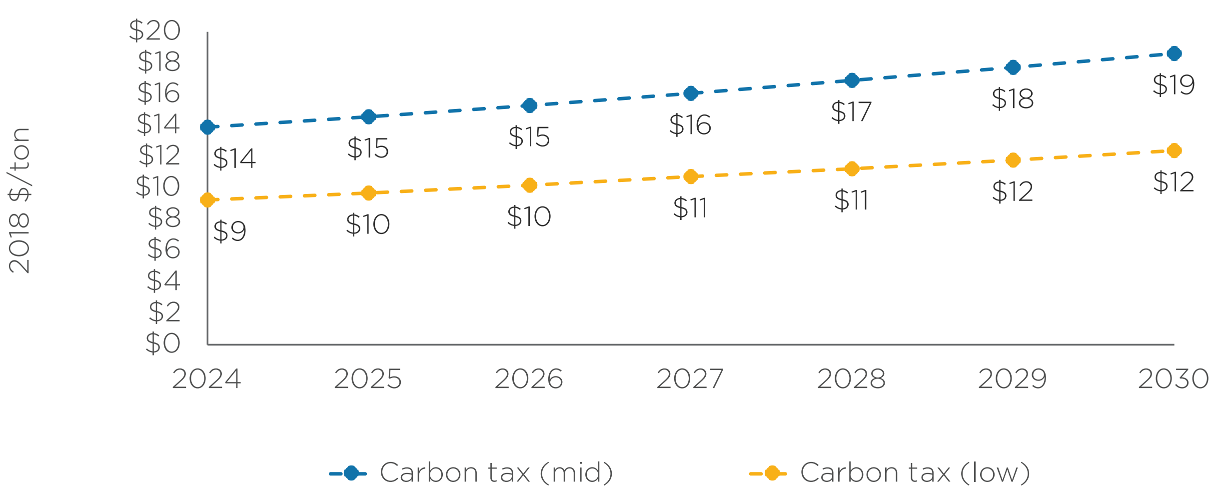
Within a CES, the crediting approach is central to determining which generating technologies will benefit from the program and by how much. There is no standard approach to crediting or a single proposal that receives consensus political support. Different crediting approaches can shift relative incentives for certain types of generators in the US electric system now and into the future. Some researchers have found that these shifts can have real impacts on total costs, generation mix, conventional pollutant emissions, and ratepayers.[7] An assessment of the pros and cons of different crediting approaches is outside the scope of this analysis. Instead, this report primarily focuses on a single crediting approach that most closely resembles the incentives new and existing electric power generators receive under a carbon tax. The CEIDA employs such an approach, though any deviation from this approach may make sense for policy or political reasons. The authors use the CEIDA crediting framework to enable a focus on the directional difference in outcomes between a carbon tax and CES rather than the policy design elements of either instrument. The stakes of CES crediting are high. For example, some researchers have found that different crediting approaches can lead to as much as a 26 percent difference in public health benefits from conventional pollutant emissions reductions associated with a CES.[8]

Modeling the future is uncertain. A key question when considering the impacts of a CES or carbon tax is the cost and performance of clean-energy technologies. The cheaper these technologies are, the lower the cost to consumers under either policy. To gain a broader understanding of the impacts of technology development, the authors consider two CES scenarios: one that assumes midlevel-tech costs for renewable energy and carbon capture and one that assumes low-level-tech costs.

Carbon Tax Scenario

For CES comparison purposes, the authors construct a carbon tax rate pathway that closely approximates the annual and cumulative electric-power CO_2 emissions of the CES. While electric-power CO_2 emissions under the CES are essentially the same regardless of technology cost assumptions, those same assumptions yield different carbon tax rate pathways to achieve the same emissions. Put another way, it takes a lower carbon tax rate to get to the same CES emissions outcome when clean energy technologies are relatively cheap. Under the midtech-cost CES scenario, the equivalent carbon tax rate starts at $14/ton in 2024 and rises to just over $18/ton in 2030 as shown in Figure 2. In the low-tech-cost CES scenario, the equivalent carbon tax rate starts at $9/ton and rises to just under $12/ton in 2030.

Figure 2: Carbon tax rates



Source: Rhodium Group analysis.

The authors take the carbon tax rates from each tech-cost scenario and apply them to all energy-related CO_2 emissions across the US energy system. It is worth noting that these carbon tax rate pathways are far lower than any recent or current carbon tax proposal in Congress. This makes sense when considering that the cheapest near-term abatement opportunities reside in the electric power sector.[9] It doesn't take that high of a carbon tax to achieve similar power-sector emissions to the CEIDA CES. That does not mean that a low carbon tax is an effective long-term decarbonization policy on its own. What it does mean is that for the purposes of conducting a comparison between a CES and a carbon tax, these carbon tax rates are appropriate.

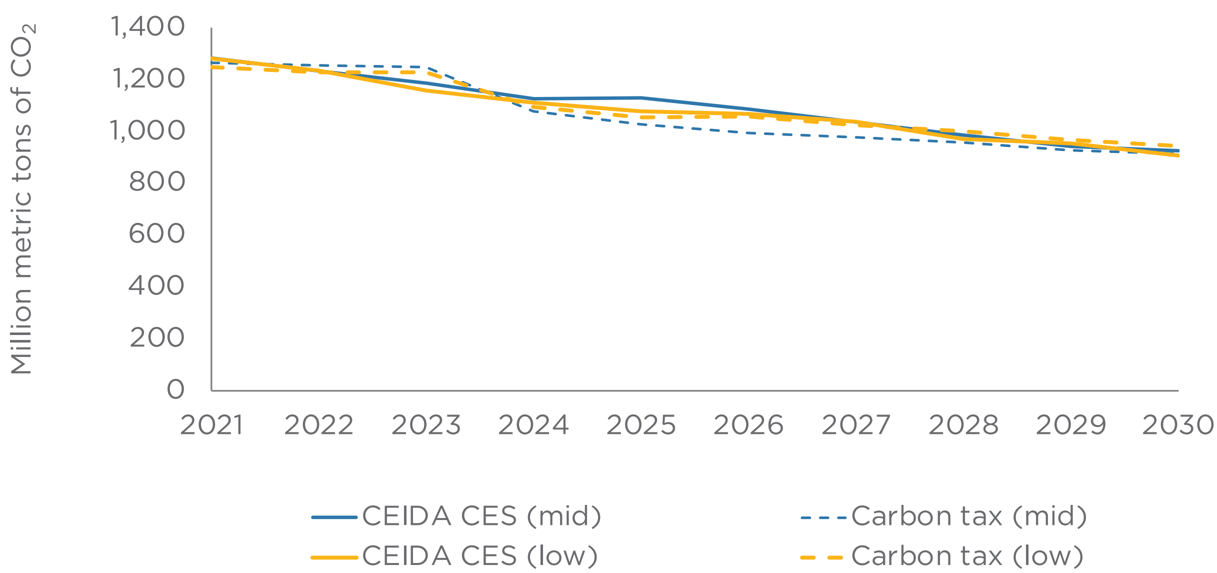
RESULTS FROM COMPARATIVE ANALYSIS

In this section, the authors present and discuss results from modeling a CES and a comparable carbon tax under two sets of technology cost assumptions. Throughout, the authors focus not on the magnitude of differences in outcomes between a CES and a carbon tax but instead examine the direction of results to identify key differences and similarities between policies. In some instances, the magnitude of the impact of the carbon tax and CES is small, due mostly to the modest near-term ambition of the policy scenarios considered.

Greenhouse Gas Emissions

As discussed, a CES causes emissions to fall by mandating an increasing portion of clean electricity, thus leaving less electricity demand for carbon-emitting generators to satisfy. As long as electricity demand does not grow rapidly (and in recent years, US electricity demand has not done so), the smaller portion of carbon-emitting electricity will lead to lower emissions.[10] The authors find that the CEIDA could drive US power-sector GHG emissions down roughly 55 percent from 2005 levels by 2025 and down 62 percent from 2005 levels by 2030 (Figure 3), from 2,420 million metric tons in 2005 to roughly 920 tons in 2030. By design, electric power sector emissions with a carbon tax are the same as shown in Figure 3.

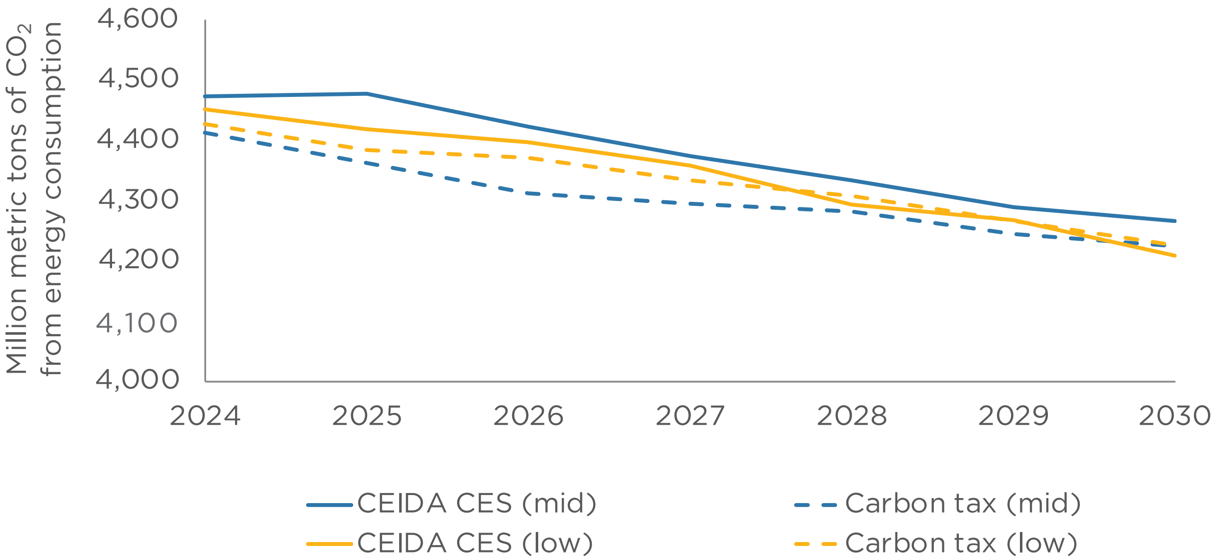
Figure 3: Power sector emissions in CEIDA CES and carbon tax



Source: Rhodium Group analysis.

One difference between a CES and a carbon tax is sectoral coverage. Outside the electric power sector an economy-wide carbon tax, as modeled here, is still relevant as it is applied to all fossil fuel emissions across the economy. The CES only applies to the electric power sector. Due to this difference in application, the authors find that the corollary carbon tax proposal could drive US economy-wide net GHG emissions down 27 percent by 2025 relative to 2005 levels and down 30 percent by 2030, from 5,999 tons in 2005 to roughly 4,230 tons in 2030 (Figure 4).

Figure 4: Economy-wide emissions in CEIDA CES and carbon tax



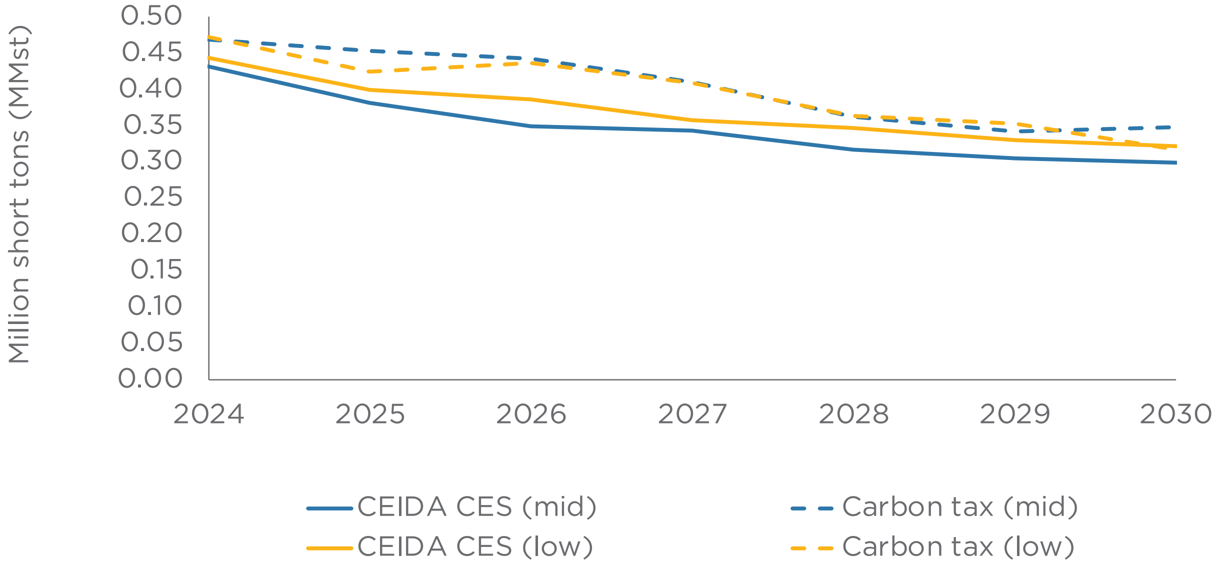
Source: Rhodium Group analysis.

When considering the pros and cons of carbon taxes and CESs, these results show that at least in the electric power sector, both policies can deliver comparable emissions reductions. From an economy-wide perspective, a carbon tax does achieve more total emissions reductions than a CES.[11] As mentioned previously, increasing the ambition of these policies will increase the costs and emissions reductions.

Conventional Pollutants

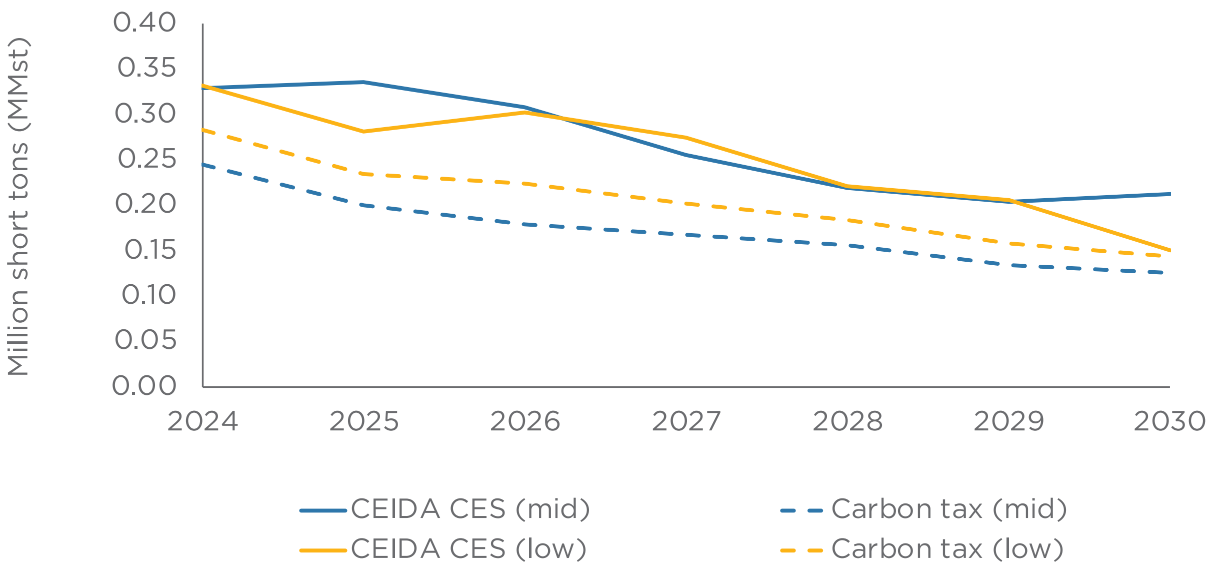
Due to the different generation profiles of a carbon tax and a CES, conventional pollutants differ depending on the policy choice. Both policies significantly reduce conventional pollutants such as sulfur dioxide (SO_2) and nitrogen oxides (NO_x), as shown in Figures 5 and 6. SO_2 emissions are 23–54 percent higher and NO_x emissions are 7–16 percent higher in a CES on an annual average basis compared to a carbon tax due to the higher percentage of coal power generation. Coal is the largest source of conventional pollutants in the electric sector. The explicit disincentive directed at coal and to a lesser extent gas under a carbon tax leads to more conventional pollutant reductions compared to a CES, where clean generation is explicitly incentivized.

Figure 5: NO_x emissions



Source: Rhodium Group analysis.

Figure 6: SO_2 emissions



Source: Rhodium Group analysis.

These results show that when a carbon tax and CES are calibrated to achieve roughly the same CO_2 emissions, a carbon tax delivers more reductions in conventional pollutants than a CES does in the short term. As discussed in more detail below, this result of lower conventional pollutants under the tax is due to the tax leading to a larger reduction in coal-fired generation than is achieved under the CES.

Electric Rates and Bills

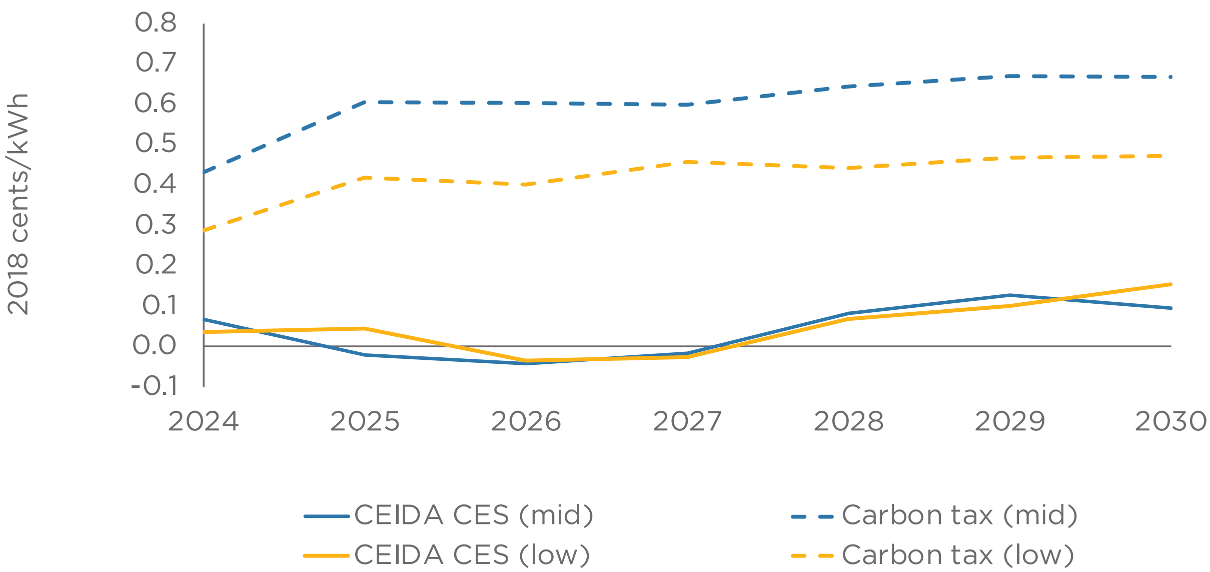
A climate policy is only effective if it causes a shift away from carbon-emitting generating sources (which supplied 62 percent of US electricity in 2019) that would not have occurred in the absence of the policy.[12] Producers will pass much of the cost of this shift on to consumers in the form of higher electricity prices. The price increases under a CES and carbon tax are shown in Table 2 and Figure 7. Given the low and falling costs of low-carbon generation sources, a mandate to gradually shift to more of these sources leads to relatively low additional costs to producers or consumers. Instead of subsidizing clean generation, a carbon tax adds cost to fossil generation. On net, differences between these two policies lead to higher rate and bill impacts under a carbon tax compared to a CES.

Table 2: Average impacts on retail electricity rates and energy bills, 2024–2030

	CEIDA CES	Carbon tax
Average monthly electric bill ($/month)	$95	$97–$99
Average retail rate ($/kilowatt hour)	$0.0999–$0.100	$0.104–$0.106
Base case retail rates	$0.099–$0.101	

Source: Rhodium Group analysis.

Figure 7: Electricity retail rate impacts



Source: Rhodium Group analysis.

It is important to note that both policies' costs will scale with their ambition to reduce greenhouse gases; more ambitious polices incur more costs. To understand why a CES encourages generation, recall that the policy requires generators to achieve a carbon intensity standard, which is commonly expressed as the following fraction: tons of CO_2 emissions / megawatt hour. The CES therefore provides incentives to reduce emissions (to lower the numerator of the fraction) *and* to increase generation (to raise the denominator of the fraction). Overall, electricity generation is 1 percent higher in a CES scenario compared to a carbon tax scenario. The increase in generation leads to an increase in capacity and costs. These results are indicative of the direction the differences are likely to take with higher ambition.

The price increases are larger under the carbon price. That's because the price is applied to all carbon dioxide emissions from electricity generation. In contrast, under a CES, once generators achieve the mandated carbon intensity standard, their remaining emissions are effectively unregulated, so no costs are associated with these remaining emissions to be passed on to consumers. Moreover, the carbon price does not provide an incentive for increasing electricity generation that offsets the price increase to some extent under the CES.

Lastly, another key difference between a CES and a carbon tax is that a carbon tax raises wholesale prices for all consumers so long as fossil generators are on the margin. A CES that relies on the crediting rates considered in this analysis leads to lower wholesale prices so long as CES-eligible generators (including uncontrolled natural gas) are on the margin because these generators reduce their bid prices based on the consideration of revenue from CES credit generation. In other words, CES credit revenue allows marginal generators to reduce their bid prices, leading to overall lower wholesale prices. These wholesale price reductions flow through to lower retail rates.

In the end, policy makers will need to weigh the trade-offs of higher electric bills under a carbon tax (along with higher energy bills for other fuels) and smaller electric bill increases from a CES against, as the authors discuss below, any need for new revenue for other policy purposes, which only a carbon tax can provide without additional tax increases elsewhere.

Carbon Price Revenue

Payments of the carbon price would become revenue to the US government. From 2024–2030, the carbon price would raise, on average, annual revenues of $47 to $69 billion for the low- and midlevel-cost cases, including $11 to $16 billion from the power sector. In general, if the carbon tax rate were increased, so too would the revenues.

Carbon pricing policies generate revenue, some of which can be returned to consumers. How much revenue is returned to consumers depends on the policy objective. For example, if the goal is to provide residential electricity customers with rebates that fully offset bill increases from a carbon tax, then $5.2–$7.5 billion in tax revenue will be required on an annual average basis, or roughly 11 percent of total revenue. If the goal is to compensate all electric consumers including commercial and industrial businesses, the total revenue required is $14–$19.8 billion a year on average, or 29–30 percent of revenue. If instead the goal is to compensate bill increases to a degree where the net outcome for residential consumers is comparable to the $0.5–$0.6 billion under the CES modeled in this report, that would require roughly 10 percent of total revenue (Table 3).

Table 3: Annual average change in consumer electric bills and share of carbon tax revenue required to offset it, 2024–2030 (in 2018 $billions)

	CEIDA CES (mid)	Carbon tax (mid)	CEIDA CES (low)	Carbon tax (low)
Residential consumers	$0.5	$7.5	$0.6	$5.2
Share of tax revenue	N/A	10.8%	N/A	11.2%
All consumers	$1.4	$19.8	$1.7	$14
Share of tax revenue	N/A	28.5%	N/A	30.0%

Source: Rhodium Group analysis.

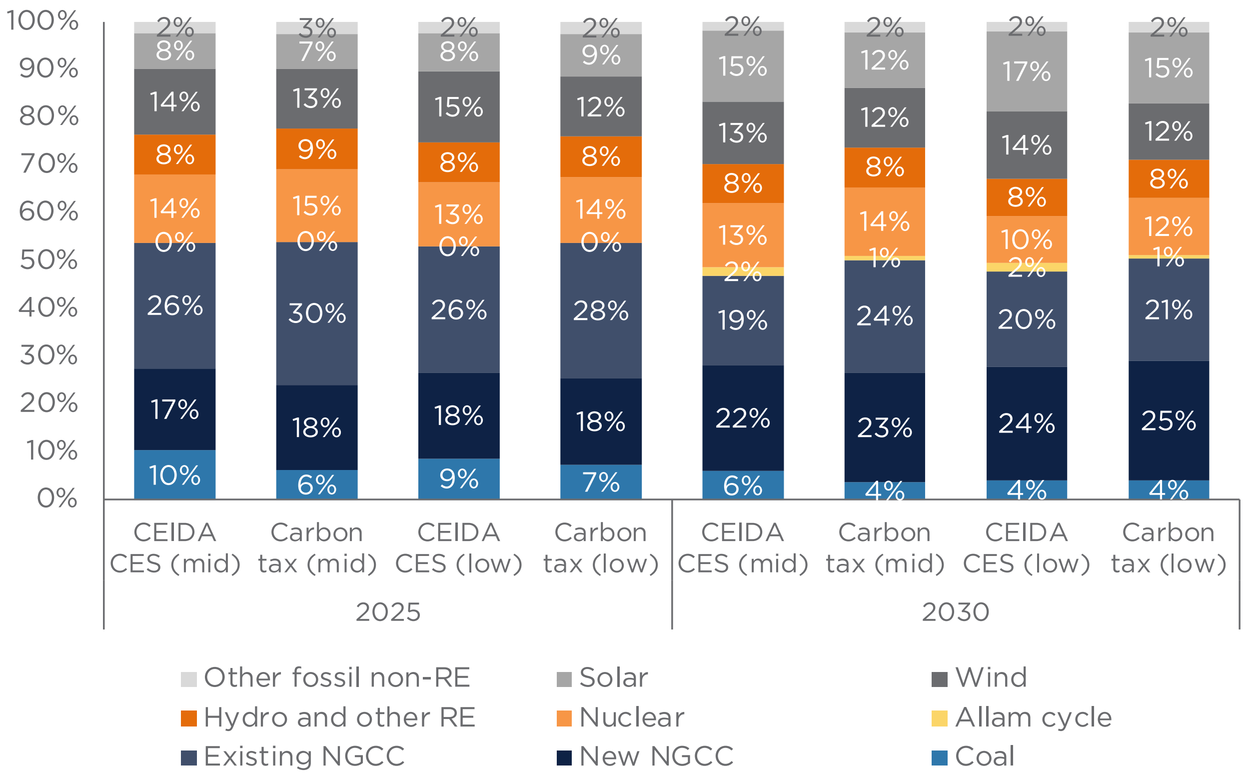
A big difference between a carbon tax and a CES is that a carbon tax results in revenue that can serve as a source of money to offset higher energy costs. Under a CES there is no such revenue. That leaves policy makers with the choice of raising revenue from other measures, borrowing money to compensate households, or leaving consumers to weather higher energy costs themselves. While the choice may seem stark, the relatively smaller electric bill impacts of a CES compared to a carbon tax may mean compensation isn't as important a factor with a CES, at least in the near term.

Electricity Generation

A benefit of a carbon price is that it provides a price signal to producers and consumers that encourages emissions reductions wherever and however they can be achieved at the lowest cost. Therefore, ignoring other market failures, the carbon price should lead to a portfolio of electricity generation sources that satisfies electricity demand at a low cost along a decarbonization pathway.

Like a carbon price, a CES provides a technology-neutral incentive to electricity generators. But the generation mix differs. As mentioned above, the CES encourages more electricity generation along with lower emissions—the combination of these two incentives leads to a different generation portfolio compared to the single incentive for emissions reductions from the carbon price. In addition, the higher consumer prices under a carbon tax provide a relatively strong incentive for the conservation of electricity compared to the CES. That means less electricity generation and thus a somewhat different generation mix under a carbon price, as shown in Figure 8. But overall, the model does not show major differences in generation mix between a carbon price and a CES.

Figure 8: Generation shares

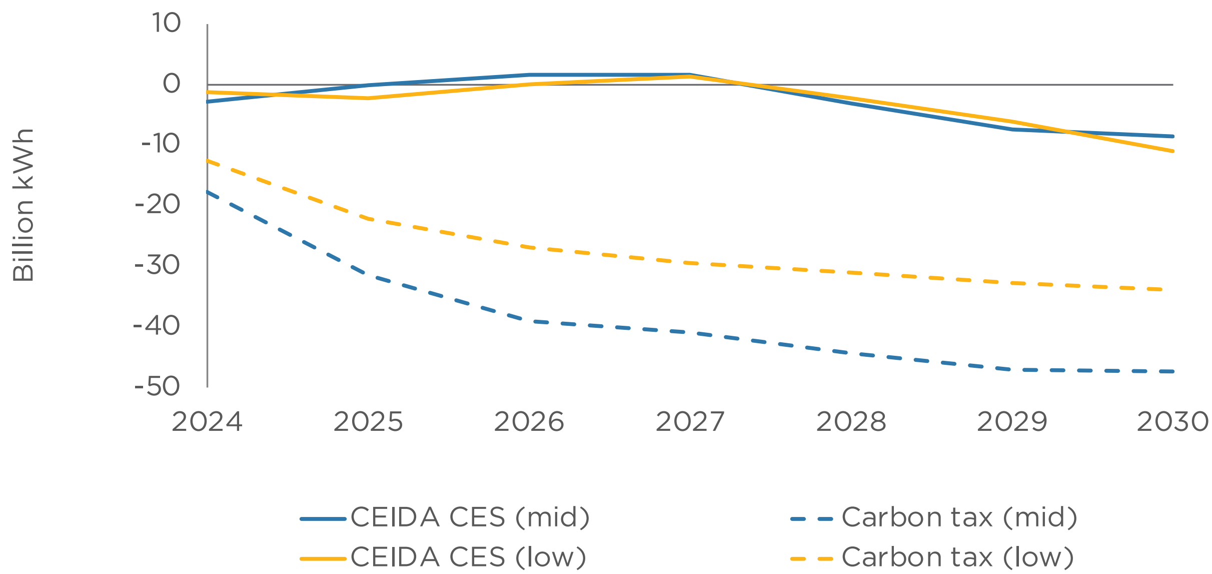


Source: Rhodium Group analysis.

Electricity Demand

Electricity demand is slightly lower under the carbon price than the CES because, as explained, the carbon price provides a larger incentive for conservation. In contrast, the CES provides a subsidy for increased electricity generation. The model finds electric retail sales to be 1 percent lower in the carbon tax scenarios (Figure 9).

Figure 9: Change in electric retail sales



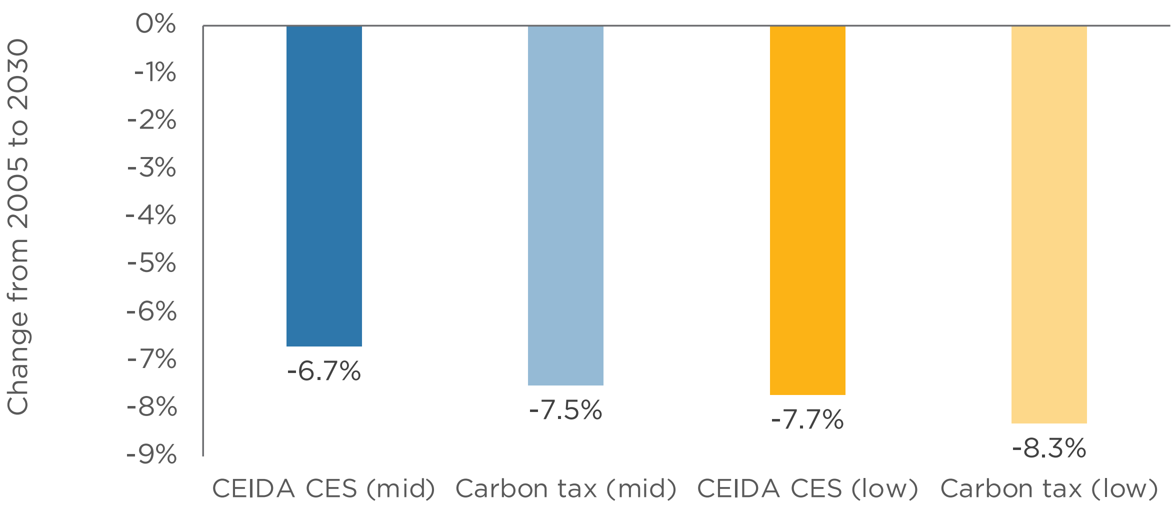
Source: Rhodium Group analysis.

Generally, the authors find that a carbon tax can amplify and reinforce market signals for energy efficiency while a CES does so only modestly. If policy makers want to incentivize investments in energy efficiency, a carbon tax is more effective toward this outcome on its own than a CES on its own. At the same time, a CES could be coupled with additional energy efficiency policies to achieve greater energy conservation. Of course, such additional policies would not be costless to the federal government, and assessing the relative efficiency of a CES plus additional energy conservation policies to an emissions tax is beyond the scope of this research.

Emissions Impacts outside of Electric Power

A key difference between the CES and carbon tax considered in this analysis is that the carbon tax is economy-wide while the CES focuses solely on the electric power sector. Economy-wide energy CO_2 emissions are consistently lower in the carbon tax scenarios than in the CES scenarios. The difference varies from year to year and technology assumptions but is as large as 115 million tons in a single year. When looking at emissions from all sectors except the electric sector, a carbon tax achieves emissions reductions of 7.5–8.3 percent below 2005 levels in 2030 (Figure 10), up to 1 percentage point more than the corresponding CES results.[13]

Figure 10: Energy CO_2 emissions from all sectors except electricity, 2030



Source: Rhodium Group analysis.

The authors find the vast majority of emission reductions catalyzed by a carbon tax occur in the electric power sector; an economy-wide approach can drive more abatement than a sectoral policy, but the overall difference is small in the absence of additional policy interventions.

Fossil Fuels

As far as fossil fuels are concerned, coal used for power sees the most significant decline in use in both scenarios. This has serious implications for communities dependent on the economic benefits of mining coal. Under a CES this transition away from coal is slightly more gradual, declining 60–69 percent compared to 2020 levels by 2030, than under a carbon tax, in which the decline is 69–72 percent by 2030. If policy makers want to avoid economic shocks to communities, they may prefer a more gradual decline as seen with a CES, giving time for a transition.[14] However, the carbon tax raises funds that could be used in transitioning coal communities.

Natural gas prices vary by about 4 percent across all scenarios. Both natural gas production and prices are higher in the carbon tax scenario, with production 1 trillion cubic feet higher per year on average as more coal generation retires and is swapped for natural gas. Petroleum demand will be higher in a CES versus a carbon tax: a carbon tax impacts the nonelectric transportation sector, and the increased prices from the tax will lower demand and production.

Border Issues

Any climate policy that increases the cost of consuming energy, including both a CES and a carbon tax, could make American products more expensive than those from countries without such policies. This increase in costs could lead to shifts in production overseas to countries that don't require firms to pay for pollution. To level the playing field, either domestic industries need to be subsidized or imported and exported products need to have prices equalized to the relevant market through either rebates or border adjustments. The exact amount will depend on the carbon content of the traded product multiplied by the carbon price or, in the case of a CES, the increased costs due to the policy. At low emissions reductions, price increases are unlikely to cause much incentive to move abroad; however, as ambition increases, additional policies such as border adjustments or output-based rebates could be examined.[15] Given that the European Union as well as other countries are discussing applying their domestic carbon prices to imported goods, policy makers should be aware of how US climate policies fit within an international pricing context.

CONCLUSIONS

In this analysis, the authors compared emissions and economic outcomes under a CES for the electricity sector alone and those under an economy-wide carbon tax. Both can be effective policy tools to reduce emissions in the US, with trade-offs. Given the equal emission ambition modeled in this report, the trade-offs come down to price increases and revenues. A carbon tax raises consumers' electricity price by more but also raises significant revenues that can be used, among other purposes, to offset increases in consumers' energy-related bills. A CES raises electricity prices by a lower amount but raises no revenues. In the long term, both policies can significantly reduce air pollutants; however, looking out to 2030, a carbon tax eliminates more coal and its associated pollution. Either policy can accelerate the decarbonization of the US energy system.

NOTES

1. Under cap and trade, this limit is enforced using tradable emissions permits that any emissions source must own to cover its emissions. The market for buying and selling these allowances creates the carbon price in a cap-and-trade program.

2. World Bank, *State and Trends of Carbon Pricing 2020* (Washington, DC: World Bank, 2020).

3. Scott Barrett, *Environment and Statecraft: The Strategy of Environmental Treaty-Making* (Oxford: Oxford University Press, 2003).

4. For more information on the scenario, see https://rhg.com/research/taking-stock-2020/.

5. Congress.gov, "H.R.7516—116th Congress (2019–2020): Clean Energy Innovation and Deployment Act of 2020," July 10, 2020, https://www.congress.gov/bill/116th-congress/house-bill/7516.

6. This figure assumes the heat rate of a new, ultra-supercritical coal plant as specified in the assumptions to the *Annual Energy Outlook 2020* from the EIA: https://www.eia.gov/environment/emissions/co2_vol_mass.php.

7. Paul Picciano, Kevin Rennert, and Daniel Shawhan, "Two Key Design Parameters in Clean Electricity Standards," Resources for the Future, February 2020, https://media.rff.org/documents/IB_20-03.pdf.

8. Picciano, Rennert, and Shawha, "Two Key Design Parameters."

9. John Larsen et al., "Expanding the Reach of a Carbon Tax: Emissions Impacts of Pricing Combined with Additional Climate Actions," Columbia University SIPA Center on Global Energy Policy, October 20, 2020, https://www.energypolicy.columbia.edu/research/report/expanding-reach-carbon-tax-emissions-impacts-pricing-combined-additional-climate-actions.

10. See section 7 of US Energy Information Administration, *Monthly Energy Review*, October 2021: https://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf.

11. When considering differences in CO_2 and conventional pollutant pathways, it's important to keep in mind that annual changes in emissions reflect the impact of policies as well as second-order market effects. And when comparing between scenarios, the cumulative differences can be just as important as annual differences. For example, in Figure 4, even though CEIDA low and carbon tax low emissions meet later in the time series, the carbon tax low emissions are consistently below the CEIDA low emissions for most of the time frame and in turn indicate that the carbon tax modeled in this analysis yields more emission reductions than the CES.

12. US Energy Information Administration, *Monthly Energy Review: August 2020*, August 26,

2020, https://www.eia.gov/totalenergy/data/monthly/archive/00352008.pdf.

13. Since results are compared to 2005 levels, some of the emission reductions from a carbon tax or a CES are actually due to declines in emissions from policies already in place and market trends. These policies and trends are the same across carbon tax and CES scenarios.

14. Noah Kaufman, "A Clean Electricity Standard's Weaknesses May Be Its Biggest Strengths," Columbia University SIPA Center on Global Energy Policy, May 8, 2019, https://www.energypolicy.columbia.edu/research/commentary/clean-electricity-standards-weaknesses-may-be-its-biggest-strengths.

15. Frédéric Branger and Philippe Quirion, "Would Border Carbon Adjustments Prevent Carbon Leakage and Heavy Industry Competitiveness Losses? Insights from a Meta-analysis of Recent Economic Studies," *Ecological Economics* 99 (2014): 29–39; Noah Kaufman, John Larsen, Ben King, and Peter Marsters, "Output-Based Rebates: An Alternative to Border Carbon Adjustments for Preserving US Competitiveness," Columbia University SIPA Center on Global Energy Policy, December 3, 2020, https://www.energypolicy.columbia.edu/research/commentary/output-based-rebates-alternative-border-carbon-adjustments-preserving-us-competitiveness.

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