



ACHIEVING U.S. EMISSIONS TARGETS WITH A CARBON TAX

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HIGHLIGHTS

- Adding an “emissions target mechanism” to a carbon tax will help to ensure that national emissions targets are achieved.
- Such a mechanism would involve a periodic evaluation of whether greenhouse gas (GHG) emissions levels are too high, and, if so, would ensure a policy change is triggered.
- The policy change may involve adjustments to carbon tax rates, increasing government spending in ways that reduce emissions, or activating a “back-stop” policy or regulation.
- Emissions targets can be achieved most cost-effectively when a carbon tax is supplemented by complementary policies.
- Policies that are likely to complement a carbon tax include those that support low carbon innovation, encourage energy savings from customers, target different emissions sources, or target different policy objectives.
- The importance of emissions target mechanisms and additional policies alongside a carbon tax depends on the tax rate and other details of the carbon tax policy.

CONTENTS

2	Executive Summary
5	1. Introduction
6	2. Emissions Target Mechanisms Alongside a Carbon Tax
10	3. Policies That Complement a Carbon Tax
17	4. Conclusion and Discussion
18	Endnotes
20	Bibliography

EXECUTIVE SUMMARY

A national carbon tax would decrease U.S. GHG emissions by providing a financial incentive to shift to less carbon-intensive behavior. Additional policies and mechanisms alongside a carbon tax can further decrease emissions and improve economic outcomes. This paper, the fourth in a series by World Resources Institute (WRI) on carbon pricing in the United States, provides an overview of how a carbon tax can fit into a broader strategy to achieve national GHG emissions targets by ensuring that emissions targets are achieved with sufficient certainty and by surrounding the tax with complementary policies that enable larger and more cost-effective emissions reductions.

Policymakers can add an emissions target mechanism to a carbon tax to help ensure that emissions targets are met.

The response of producers and consumers to a carbon tax cannot be predicted with certainty, so future emissions levels are uncertain. Some advocates of climate change policy are skeptical of carbon taxes due to the possibility that emissions levels under the tax may be higher than expected, jeopardizing national emissions targets. However, in two simple steps, policymakers can design a mechanism that can ease concerns of higher-than-expected emissions under a carbon tax.

The first step is a periodic evaluation of whether GHG emissions levels are too high, which involves setting the timing and benchmarks by which the emissions trajectory

is evaluated. Hypothetically, the policy could say that if the total annual emissions covered by the tax are above a benchmark, for example 4 gigatons (GT) of CO₂ after five years, the emissions trajectory is too high. To enable even greater control over emissions outcomes, policymakers can opt for more frequent evaluations, more complex benchmarks than annual emissions covered by the tax, and/or a benchmark that is relatively close to the emissions trajectory expected under the tax. If, instead, the tax is expected to drive emissions well below the benchmark, the mechanism is akin to an insurance policy against an unlikely high emissions outcome.

The second step is a policy change that is triggered when the evaluation deems emissions levels to be too high. This

policy change can come in many forms, which we separate into four categories:

1. *Automatic adjustments to carbon tax rates.* Greater emissions reductions can be achieved by increasing future carbon tax rates above originally planned levels. Switzerland's carbon tax does just that, and because 2016 emissions exceeded a benchmark prescribed in the legislation (73 percent of 1990 emissions), the tax rate will increase from \$87 to \$100 per metric ton in 2018 (Hafstead et al. 2017; World Bank 2017). Alternatively, the adjustments could shift all future tax levels upward by a certain percentage, so that, say, a 4 percent annual increase is raised to a 10 percent increase until emissions have fallen below the benchmark trajectory (Metcalf

2009). Under this approach, regulated entities would need to plan for multiple possible future tax levels, but they would still benefit from a predictable regulatory pathway; improving regulatory certainty can reduce compliance costs and boost innovation (Mordfin 2014).

2. *Increasing government spending in ways that reduce emissions.* If emissions levels are higher than expected, carbon tax revenues will also be higher than expected. The legislation could direct a government agency to use this “extra” revenue to fund activities that further reduce GHG emissions; for example, the revenue could fund changes in forest and agricultural practices or to capture methane leaks (Murray et al. 2017). Unlike an adjustment in the tax schedule, this policy change would not directly affect regulated entities. Similar to “offset programs” included in cap-and-trade policies, this approach requires a market for additional mitigation opportunities and strong monitoring and verification of emissions reductions, which is a challenge for many emissions sources (Murray et al. 2017). Another challenge could arise if the extra revenue is insufficient to reduce emissions to desired levels; in theory, policymakers could divert additional funding, but those funds would need to be diverted from another intended use or from increased debt, which could create significant political challenges.

3. *Activating a “back-stop” policy or regulation.* A carbon tax can be paired with an alternative policy that ensures sufficient emissions reductions and is implemented only when the evaluation deems emissions to be too high. While the federal government has broad authority to regulate greenhouse gas emissions, current federal regulations have not achieved emissions reductions that are as large and as certain as a strong carbon tax would achieve, which are prerequisites for a useful “back-stop.” The back-stop policy would therefore likely need to consist of additional policies or regulations passed alongside the carbon tax, such as a national cap-and-trade program or far more stringent versions of current federal climate regulations, which could significantly increase the political hurdles of passing legislation.
4. *A streamlined process for modifying the carbon tax based on new information.* Carbon tax legislation could include a process by which the policy is periodically reviewed and revised based on new information about climate science, the cost of the policy, and/or the actions of other countries. Aldy (2017) provides one detailed proposal, whereby changes to the future carbon tax levels proposed by the U.S. president would receive an expedited “up or down” vote in Congress with no amendments or filibusters, similar to the process for congressional approval of trade agreements.

Under Aldy’s proposal, if the president’s recommendation is voted down, the status quo carbon tax levels would remain. This approach provides flexibility to respond to changing circumstances, but also relies on future governments to act in good faith in developing and using new information to improve the policy.

None of these approaches would entirely eliminate the uncertainty in emissions outcomes, but the objective of the mechanism is to enable countries to credibly make and follow through on emissions pledges, not to achieve precise emissions outcomes.

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Additional policies alongside a carbon tax can further reduce emissions in a cost-effective manner.

The following are three major categories of policies that can complement a carbon tax as part of broader strategy to achieve a U.S. emissions target:

- *Policies, regulations, incentives, and infrastructure that support low-carbon innovation.* Technological progress occurs naturally in a market economy, and a strong and stable carbon tax is one important way to encourage innovation in low-carbon technologies. But, even with a carbon tax in place, the private sector will underinvest in the research, development, demonstration, and deployment (RDD&D) of emerging low-carbon technologies. Investors prefer short-term payoffs and minimal risk, and they make decisions largely based on their own expected financial gains, and not the much broader societal benefits that derive from the emergence of new and productive technologies. These barriers can be addressed with government-sponsored RDD&D, incentives for deployment of early-stage technologies, regulations, and infrastructure that encourage the emergence of low-carbon technologies.

The U.S. federal government has been involved in all stages of RDD&D in low-carbon technologies through grants, loans, subsidies, and the work of national laboratories and other government offices. Still, most experts recommend significantly increasing current funding levels for research and development

(R&D) of emerging low-carbon technologies (Newell 2015). Governments should be more cautious in supporting more mature technologies to avoid “crowding out” private sector actions, but targeted policies that encourage early-stage deployment (e.g., solar photovoltaic [PV]) and large-scale demonstration projects (e.g., carbon capture and storage [CCS]) have and will continue to be essential in enabling emerging low-carbon technologies to compete on a level playing field with high-carbon alternatives.

- *Policies that encourage energy savings from consumers.* A carbon tax encourages energy savings by increasing the price of energy, but a price signal alone is insufficient to induce consumers to take advantage of all cost-effective opportunities to improve energy efficiency. Consumers often lack incentives that reward long-run energy savings, sufficient information about energy efficiency opportunities, or the means to invest in new equipment (Gerarden et al. 2017).

Policies can help to overcome these market barriers by providing information, targeted financial incentives, or technology standards. A wide range of policies are currently on the books to support energy efficiency, including at the federal level (e.g., energy efficiency standards for appliances and equipment, and fuel economy standards for vehicles), at the state level (e.g., 20 states have binding mandates requiring utilities

to achieve specified levels of customer energy savings), and at the local level (e.g., cities like Austin, Texas, that mandate home energy audits). Energy efficiency policies that enable emissions reductions or other objectives at a relatively low cost are important complements to a carbon price.

- *Policies targeting “uncovered” emissions or intending to achieve nonclimate objectives.* A large majority of GHG emissions can be covered by a carbon tax with relative ease, including nearly all CO₂ emissions from energy use, which make up about 80 percent of U.S. emissions. However, the administrative burdens associated with covering certain categories of GHG emissions (e.g., methane leaks from fossil fuel systems) with a carbon tax may be sufficiently large that alternative policies are preferred, particularly in situations where emissions sources are highly dispersed and reductions are difficult to verify. For example, in 2016, the Environmental Protection Agency (EPA) issued performance standards requiring oil and gas producers to reduce methane emissions from new or modified equipment, using technologies and methods that the government would be able to monitor and enforce (U.S. EPA 2016).

Policies intended to achieve nonclimate objectives and reduce GHG emissions as a “cobenefit” can also complement a carbon tax. For example, regulations of conventional air pollutants like

particulate matter often cause significant GHG emissions reductions because they discourage an activity (e.g., burning coal for electricity in power plants without emission controls) that produces both types of emissions.

Policies that do not fall into these three categories are less effective complements to a carbon tax if they are likely to involve administrative and regulatory costs without achieving significant climate benefits. In particular, policies may be duplicative if they (1) address the same emissions sources and (2) do not have a major rationale aside from reducing GHG emissions (e.g., addressing a separate market barrier). Indeed, if a sufficiently strong federal carbon tax is implemented, some policies are likely to be partially or fully duplicative from a GHG-reduction perspective.

The benefits of mechanisms and policies alongside a carbon tax depend on the details of the tax. If carbon tax levels are relatively low, it is more likely that an emissions target mechanism will be triggered to achieve a given emissions target. Alternatively, stronger complementary policies may be needed because the carbon tax alone is not “pulling its weight.” For example, with a “weak” carbon tax that insufficiently encourages private sector investments in clean energy innovation, additional government support for R&D— from support for basic research to incentives for deployment of emerging technologies—could help fill this gap.

On the other hand, if carbon tax rates are sufficiently high to comfortably achieve emissions targets, a mechanism that kicks in when emissions are too high is unlikely to be triggered. Still, even an emissions target mechanism that is never triggered can be an important component of a national climate change strategy—after all, ensuring that emissions targets are achieved without such a mechanism may require higher carbon taxes or additional complementary policies, both of which could impose additional costs on regulated entities and taxpayers.

Assembling a coalition of lawmakers to pass strong federal climate legislation will require policies that stand up to environmental and economic scrutiny. Even among those inclined to support a carbon tax, some powerful voices (e.g., many in the environmental community) will push for greater emissions certainty and additional policies alongside the tax, while others (e.g., many in industry) will push for greater policy simplicity, regulatory certainty, and fewer duplicative regulations. Designing a policy that earns support from both groups will be a major political challenge. By combining a strong carbon tax with a simple emissions target mechanism and a targeted portfolio of complementary policies that focuses on areas where a carbon tax has limitations, policymakers can design a national climate strategy that achieves ambitious emissions targets cost-effectively, which should earn the support of all groups that wish to reduce the risks of climate change.

1. INTRODUCTION

In 2015, WRI published *Putting a Price on Carbon: A Handbook for U.S. Policymakers* (Kennedy et al. 2015), which provides a summary of the key issues associated with a national carbon price in the United States. Building on the general information provided in the handbook, WRI is publishing a series of issue briefs devoted to specific topics of importance. One describes the specific ways a carbon price would encourage emissions reductions across the U.S. economy (Kaufman et al. 2016). Another describes the regional and socioeconomic variation in the effects of a national carbon pricing policy and explains how distributional concerns can be alleviated using the carbon pricing revenue (Kaufman and Krause 2016). The objective of this third issue brief in the series is to describe how a carbon tax can fit into a broader national strategy to achieve national greenhouse gas (GHG) emissions targets.

A strong national carbon tax would significantly decrease U.S. GHG emissions. The Stanford Energy Modeling Forum recently evaluated various carbon taxes starting between \$25 and \$50 per metric ton in 2020 and gradually increasing thereafter, and found that all would enable the United States to achieve the Obama administration GHG emissions target of 26 to 28 percent below 2005 levels by 2025 (Barron et al. 2018). Nearly all economists support a carbon tax because the policy would encourage relatively low-cost emissions reductions, incentivize private sector innovation, and generate a stream of government revenues

(University of Chicago 2012).

Still, these benefits do not imply that a carbon tax alone is an ideal approach to achieving emissions targets. Well-designed policies and mechanisms alongside a carbon tax can further reduce emissions and improve economic outcomes.

The remainder of this paper describes the types of additional policies and mechanisms that can complement a carbon tax. Section 2 describes how to design a carbon tax to achieve emissions targets with sufficient certainty. Section 3 outlines additional policies that can complement a carbon tax as part of a broader national strategy to achieve GHG emissions targets cost-effectively.¹ In both sections, we describe the important interactions between the carbon tax rates and the need for additional policies and mechanisms. The intent of the paper is not to provide a specific policy roadmap or a comprehensive list of policies that affect emissions,² but rather to provide policymakers and other stakeholders with an overview on how to develop a broader strategy to achieve national emissions targets using a carbon tax as the primary tool.

Policies and mechanisms alongside a carbon tax can further reduce emissions and improve economic outcomes.

2. EMISSIONS TARGET MECHANISMS ALONGSIDE A CARBON TAX

We do not know the extent to which a carbon tax will reduce GHG emissions. We derive expectations largely from simulations in energy/economic models. Various modeling inputs that can significantly influence the effectiveness of a carbon tax at reducing emissions are highly uncertain, including the business-as-usual projections for the U.S. economy and energy system, as well as the responses of consumers, producers, and investors to the tax. WRI researchers have previously concluded that a carbon tax is likely to be more effective at reducing emissions than most models predict due to conservative estimates of both technological change as well as consumer/producer responses to the tax (Kaufman et al. 2016). Still, the range of possible emissions outcomes under a carbon tax is wide, and emissions may also be higher than expected. For example, unforeseen technological advancements in fossil fuel production could lead to higher-than-expected emissions trajectories.

This uncertainty in emissions outcomes has led to some skepticism about relying on carbon taxes as the centerpiece of a U.S. strategy to reduce emissions.³ Cap-and-trade programs, on the other hand, include limits on annual emissions, and thus can provide more certainty in emissions outcomes. But carbon taxes have many advantages as well, including a predictable carbon price level. Importantly, “hybrid policies” can combine elements of carbon taxes and cap-and-trade policies, and arguably ensure a sufficient degree of certainty in both price and emissions

outcomes.⁴ In this section, we first explain why policymakers may wish to modify a carbon tax to increase the certainty of emissions outcomes, and then describe various ways of doing so.⁵

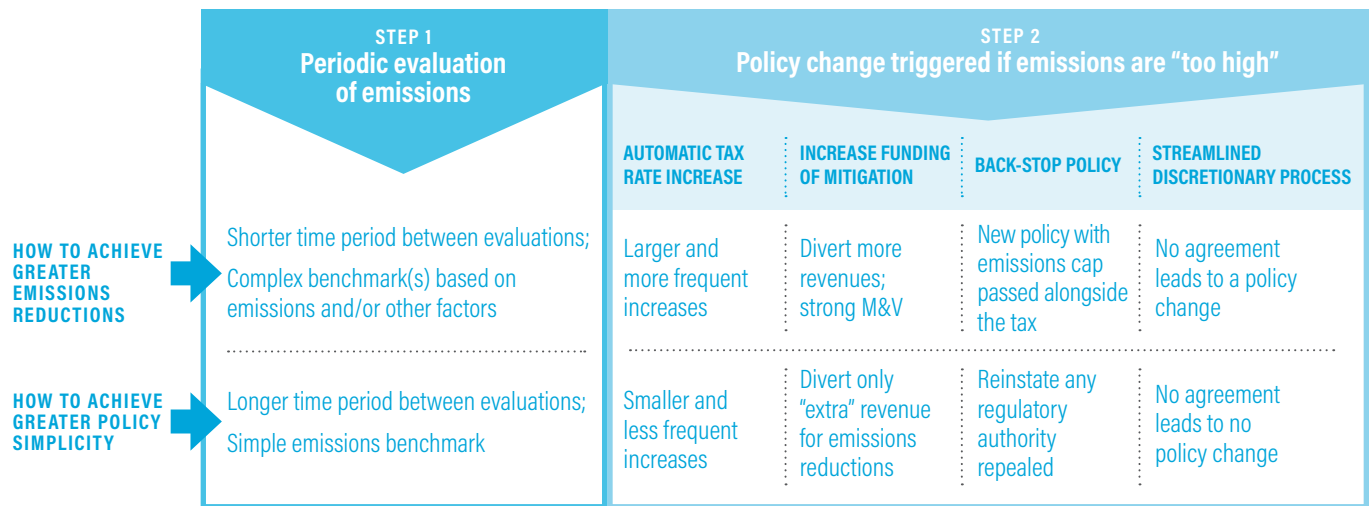
2.1 Rationale for adding an emissions target mechanism⁶ to a carbon tax

A primary benefit in aiming for a particular emissions trajectory is to enable the United States to set and deliver on targets in the context of the international effort to address climate change. Given the uncertainties driving global climate outcomes, some uncertainty in emissions outcomes is not necessarily a cause for concern, particularly if the uncertainty extends in both directions. In fact, some experts argue that carbon prices, calculated based on the benefits of avoiding carbon risks and the costs of reducing these risks, are a more appropriate and scientifically grounded policy objective than emissions levels, despite the difficulties of estimating these benefits and costs.⁷

Other experts argue that emissions targets are a more appropriate and practical policy objective, and national emissions targets are central to international climate negotiations under the United Nations Framework Convention on Climate Change (UNFCCC).⁸ Under this framework, a carbon tax that led to an emissions trajectory that is “too high” would be problematic for various reasons. First, given that current national emissions targets are insufficient to achieve the international goals for avoiding dangerous climate change (Levin and Fransen 2015), higher-than-expected emissions outcomes can aggravate the risks of climate

FIGURE 1

DEVELOPING AN EMISSIONS TARGET MECHANISM



Source: WRI.

change. After all, adverse outcomes like economic shocks may be correlated across countries. Second, unfulfilled climate change commitments could discourage other countries from making or acting on ambitious emissions reduction commitments of their own, further exacerbating the risks of climate change. In addition, such unfulfilled commitments to the international community may spill over and affect international cooperation in other realms. For example, the European Union (EU) has indicated that it will not sign trade agreements with countries that leave the Paris Climate Agreement.⁹

By adding an emissions target mechanism to a carbon tax, policymakers can reduce the likelihood of failing to achieve a national emissions target while retaining the most important advantages of a carbon tax policy. Such a mechanism would consist of the following two main components, summarized in Figure 1 and described in detail as follows:

1. A periodic evaluation of the emissions trajectory
2. A policy change intended to shift the emissions trajectory to a more satisfactory outcome

Component 1: A periodic evaluation of the emissions trajectory

The emissions trajectory under a carbon tax can be evaluated periodically to determine whether it is satisfactory or too high. Developing these evaluations requires policymakers to answer two key questions.

First, How often is the emissions trajectory evaluated? This decision involves a trade-off between greater emissions certainty and policy simplicity. With more frequent evaluations comes greater control over the emissions trajectory because “corrective” action can be taken more rapidly. Less frequent evaluations imply a less complex policy design, greater regulatory certainty for investors and regulated entities, and less chance

of “overcorrecting” when short-term emissions aberrations arise.¹⁰

Second, What benchmark is used to determine whether the emissions trajectory is satisfactory? At each evaluation date, the carbon tax legislation can include an emissions benchmark to which actual emissions levels are compared (though one could imagine more complex options¹¹). If emissions exceed the benchmark, a policy change is triggered. This benchmark can be set either in terms of annual emissions in the year of the evaluation, or as the sum of emissions over a multi-year period. An annual emissions benchmark has the advantage of aligning with national emissions targets, whereas cumulative emissions may be preferred under the rationale that climate change is caused by the accumulation of GHG emissions over time, and annual emissions levels may reflect an aberration from a longer-term trend.

The likelihood of triggering a policy change depends on how the benchmarks are set compared to expected emissions levels under the carbon tax: The further the benchmarks are set below expected emissions levels, the more likely the policy change will be triggered. For example, assume that under a given carbon tax policy, expected emissions in 2025 are 4 GT. If the emissions benchmark for 2025 were set below 4 GT, actual 2025 emissions with the tax in place would likely exceed the benchmark, meaning the policy change is likely to be triggered. Alternatively, if the emissions benchmark were set at 4.4 GT (the Obama administration target for 2025), the policy change is unlikely to be triggered, and the mechanism would serve more as an insurance policy in the event of a higher-than-expected emissions outcome.

In theory, an equivalent mechanism could be triggered if emissions are lower than expected. Because our focus is on mechanisms that reduce emissions, we consider such “two-sided triggers” to be beyond the scope of this paper.¹²

Component 2: A policy change intended to shift the emissions trajectory to a more satisfactory outcome

The second component is a policy change that is triggered only if the evaluation determines the emissions trajectory is too high. The policy change can come in various forms, which we separate into four categories.

First, with automatic adjustments to the carbon tax schedule. Increasing future carbon tax levels above the originally planned levels will lead to larger emissions reductions. The

legislation can stipulate changes to future carbon tax levels if, at the evaluation date, emissions are deemed to be too high. The design could be quite simple, with a base carbon tax trajectory shifting to a high trajectory if the mechanism is triggered, or with all future tax levels increasing by a certain percentage once the mechanism is triggered. The design could also be more complex, for example, with changes contingent on the degree to which the benchmark was missed. More complex designs enable greater control over the emissions level. Box 1 provides three examples of this approach. With automatic adjustments defined in the legislation, regulated entities may need to plan for multiple futures, but they would still benefit from a well-defined regulatory pathway. Improving regulatory certainty can reduce compliance costs and boost innovation.¹³

BOX 1

CARBON TAXES WITH AUTOMATIC ADJUSTMENTS TO THE TAX SCHEDULE

In 2009, economist Gilbert Metcalf proposed the Responsive Emissions Autonomous Carbon Tax (REACT), with the objective of achieving both short-run price stability and long-run emissions certainty (Metcalf 2009). REACT consists of an initial carbon tax rate, a standard growth rate for the tax, and periodic benchmarks based on cumulative emissions covered by the tax. When the benchmark target is exceeded, the annual growth rate of the carbon tax increases to a higher “catch-up rate” until cumulative emissions fall below the target. By choosing a higher catch-up rate, policymakers can increase the certainty of achieving an emissions target. In illustrative simulations, Metcalf (2009) used an initial tax of \$28 per ton, a 4 percent standard growth rate for the tax, and a 10 percent catch-up rate.

Building on the REACT proposal, Hafstead et al. (2017) introduced a Tax Adjustment Mechanism for Policy Pre-commitment, or TAMPP, which provides more general guidance to policymakers for designing a mechanism with automatic adjustments to the carbon tax levels, including far more complex options than in the REACT proposal. For example, the paper describes one option whereby the carbon tax level is a continuous function of the deviation of emissions from a benchmark, meaning that tax rates are increased by a larger amount if emissions are higher above the benchmark.

Switzerland’s carbon tax includes an automatic adjustment mechanism. The tax was initially set at 12 Swiss francs (CHF) per metric ton (about US\$11) of CO₂ in 2008, with gradual annual increases. The law specifies three milestone years—2012, 2014, and 2016—at which time the tax rate would increase if emissions levels were greater than given percentages of 1990 emissions. For example, because emissions exceeded 73 percent of 1990 emissions in 2016, the tax rate will jump from CHF 84 to CHF 96 per metric ton of CO₂ in 2018. If 2016 emissions had exceeded 76 percent of 1990 emissions, the tax rate would have increased to CHF 120 per metric ton in 2018 (Hafstead et al. 2017).¹⁴

Automatic adjustments to the tax level will not entirely remove emissions uncertainty, but the adjustments can be designed such that the likelihood of missing emissions targets is reduced to a level that is acceptable to policymakers. For example, simulations in energy/economic models can show the carbon taxes required to achieve emissions targets even when various influential and uncertain drivers of emissions evolve in ways that cause unexpectedly high emissions levels. The mechanism can then be designed so that tax rates increase to these needed levels if such a worst-case scenario were to arise.

Second, by increasing government spending in ways that reduce emissions.

Under a carbon tax, a regulated entity pays for each ton of CO₂ it emits. If emissions are higher than expected, payments of the carbon tax (and thus the government revenues from the tax) are higher than expected as well. The “extra” government revenue accrued from a carbon tax with higher-than-expected emissions can be used to fund activities that reduce GHG emissions in ways that complement a carbon tax. In the following section, we describe the types of policies that are likely to complement a carbon tax and that could make use of revenues to achieve emissions reductions under this approach. Unlike adjusting tax levels, this approach involves no changes in the burden faced by regulated entities (Murray et al. 2017).

While there are no existing examples of this approach, two programs provide useful experience. One is the Regional Greenhouse Gas Initiative (RGGI), a regional cap-and-trade program for the electricity sector in nine northeastern states. The participating states have invested a significant portion of their RGGI carbon revenues into energy efficiency programs that have helped reduce electricity demand and thus lower CO₂ emissions.

This approach also resembles “offset programs” commonly included in cap-and-trade policies, including in California and the European Union, which enable regulated entities to pay for reductions in emissions that are not covered by the policy, as opposed to either reducing or paying for their own emissions.¹⁵ But some offset programs have faced implementation challenges, including in the measurement of emissions reductions and in verifying that the emissions reductions claimed by offset projects were real and would not have occurred in the absence of the program (US GAO 2011).

In addition to these potential implementation challenges, there is no guarantee that that extra revenue from higher-than-expected emissions will be sufficient to fund the additional emissions reductions desired. Policymakers could divert additional funding to achieve a satisfactory emissions trajectory, but those funds would be diverted from

another intended use or derived from increased debt, which could create significant political challenges.

Third, by activating a “back-stop” policy or regulation. A carbon tax can be paired with an alternative regulation or policy that leads to more certain emissions reductions than the carbon tax. If the periodic evaluation deems that emissions are too high, this alternative policy would be triggered, forcing further emissions reductions.

The federal government can in theory use its authority to regulate GHG emissions to provide a back-stop to a carbon tax.¹⁶ However, existing authorities are unlikely to lead to emissions reductions that are as large and as certain as a strong carbon tax,¹⁷ which are prerequisites for a useful back-stop.

The back-stop policy could be passed alongside the carbon tax. It could take the form of an amendment to existing legislation such as the Clean Air Act, or new legislation that would establish a national emissions cap. This approach has the potential to provide a very high degree of certainty that an emissions target will be met, but it is also difficult to imagine gaining sufficient political support for such a policy. After all, some carbon tax supporters propose rolling back duplicative regulations when a carbon tax is implemented, and would likely balk at the idea of adding new ones.¹⁸

Emissions targets can be achieved even under “worst-case scenarios.”

Fourth, by providing a streamlined process for modifying the carbon tax based on new information.

Following the implementation of a carbon tax, any future federal government could pass subsequent legislation to modify the tax. In theory, when higher-than-expected emissions outcomes arise, the government could pass more stringent legislation. In reality, passing legislation is difficult—no national carbon price exists today despite the support of a majority of Americans¹⁹ and virtually all economists.²⁰ The challenges associated with modifying a carbon tax based on new information could be mitigated if the legislation were to provide a streamlined process for review and revision.

For example, Aldy (2017) proposes the following “structured discretionary approach”: Every five years, analyses are conducted by the EPA on the latest climate science, by the Department of Treasury on the effects of the carbon tax policy on economic and environmental outcomes, and by the State Department on the emissions mitigation efforts of other countries. Using these analyses, the president submits a recommendation to Congress with proposed adjustments to future carbon tax levels. That recommendation receives an expedited “up or down” vote with no amendments or filibusters, similar to the process for congressional approval of trade agreements negotiated by the executive branch. If the recommendation is voted down, under the Aldy proposal, the status quo carbon tax levels would remain in place.

Various alternatives to the Aldy proposal can be imagined. Instead of the status quo, the default outcome could be that automatic tax rate increases are triggered if emissions

exceed a benchmark. Instead of tax rate changes, a similar process could be used to modify elements of the policy other than the tax levels, such as changing how revenues are used. And instead of requiring a new congressional vote, the original legislation could perhaps delegate to a federal agency the authority to make changes to the carbon tax, although Congress has historically resisted delegating tax authority (Hines and Logue 2015).

A key advantage of this “revisit and revise” approach is that factors influencing a desired carbon tax level can change rapidly and unexpectedly, such as the progress in clean energy technologies in the last decade,²¹ and these changes have important implications on the costs and effectiveness of a carbon tax. However, this discretionary approach requires faith that future governments will propose a policy change based on objective studies conducted by future government agencies, rather than on other political objectives. Another drawback of this approach is the uncertainty it creates for regulated entities due to the unknown changes in the future to the carbon tax level.

2.2 The relationship between carbon tax rates and emissions target mechanisms

Policymakers can increase the likelihood of achieving an emissions target with a carbon tax policy by adding an emissions target mechanism, but they can also accomplish the same goal in another way: by taking that same carbon tax policy and increasing the tax rates. This relationship between carbon tax rates and emissions target mechanisms helps to illustrate the potential economic advantages of an emissions target mechanism. Higher

carbon tax rates impose additional costs on regulated entities and taxpayers. If a carbon tax policy with somewhat lower tax rates paired with an emissions target mechanism can achieve a national emissions target with comparable levels of certainty, this policy may avoid imposing those additional costs of higher tax rates.²²

As noted above, carbon tax rates also influence the likelihood that an emissions target mechanism is triggered. With higher carbon tax rates, there is a lower chance of emissions exceeding any given benchmark.

3. POLICIES THAT COMPLEMENT A CARBON TAX

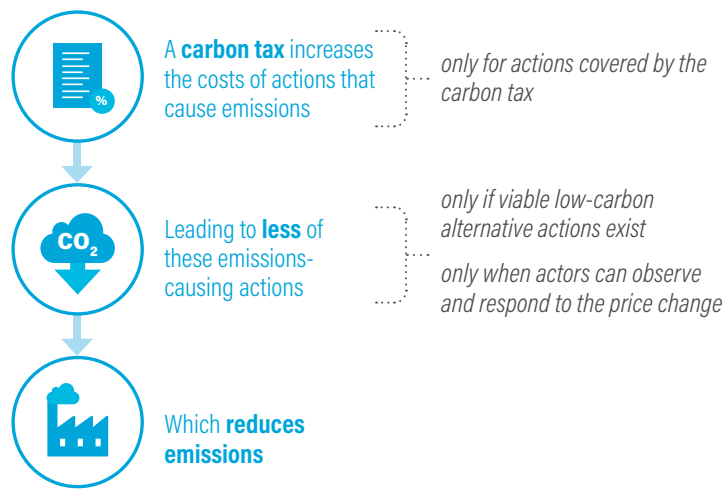
The previous section explained how a carbon tax can be relied upon to achieve a national emissions target. Still, for various reasons, emissions targets are likely to be achieved at a lower cost when a carbon tax is accompanied by additional policies as part of a broader national climate change strategy.²³

Figure 2 displays a high-level flow chart showing how a carbon tax works: It raises the relative price of carbon-intensive products and services, which reduces their use and in turn lowers emissions. But a carbon tax also has limitations at each step: the policy scope is limited, in that it does not address all GHG emissions or nonclimate concerns related to the same activities; it provides limited support for alternative low-carbon technologies; and finally, in some situations, producers and consumers do not respond well to price signals.

In what follows, we explain each of these limitations in further detail, and we describe the types of policies that can successfully complement a

FIGURE 2

HOW A CARBON TAX WORKS ...AND WHEN IT IS LIMITED



Source: WRI.

carbon tax in each area.²⁴

3.1 Policies, regulations, incentives, and infrastructure that support low-carbon innovation

Innovation can enable emissions reductions to be achieved more rapidly and cost-effectively because technological progress in low-carbon technologies enables a less expensive shift away from high-carbon technologies. While innovation occurs naturally in a market economy, public policies can help to accelerate and channel that progress in beneficial ways (Palmer et al. 1995).

A strong and stable carbon tax is one important way to encourage innovation in low-carbon technologies, but an overall climate strategy can be more cost-effective with additional policies that enable technological progress. This includes the research and development of new technologies, incentives for demonstration and deployment of early stage low-carbon technologies, and a regulatory environment that

supports the emergence of cost-effective low-carbon technologies. We discuss each category in turn.

Research and development. The existence of a carbon tax increases the expected return on investments in low-carbon technologies, which means a carbon tax is likely to channel a larger portion of private sector R&D investments toward low-carbon technologies. It is therefore not surprising that, for example, patents of low-carbon technologies increased in Europe when an EU carbon price was first implemented (Calel and Dechezlepretre 2016), or that the oil company Statoil developed a new technology to store carbon in the ocean bed when Norway implemented a carbon tax (World Bank 2017).

However, even with a carbon tax in place, the private sector will underinvest in R&D. Investors make decisions largely based on *private* economic returns, and not the much broader societal benefits that come with increased innovation. Economists call these “knowledge

spillovers” because the work of one person or group to reduce the costs or increase the productivity of a product is replicated by others, making the entire economy more productive. Indeed, studies have found the return to society of R&D investments has been more than double the return to private businesses (Bazon and Smetters 1999; Jones and Williams 1998; Popp 2009). Private investors also prefer short-term payoffs with minimal risk, while the most important innovations often arise from long-term investments with many failures along the way. This underinvestment in private sector R&D is especially problematic in the energy sector, where large requirements for initial investments and low profit margins are typical. Indeed, R&D expenditures as a percentage of sales have historically been around 1 percent in the energy sector, compared to over 10 percent in other sectors like software (Nemet and Kammen 2007).

Direct government investments in R&D and policies that encourage R&D investments by the private sector and nonprofits can help to overcome the underinvestment problem. The U.S. federal government has been actively engaged in low-carbon R&D, including through offices such as the National Renewable Energy Laboratory and the Advanced Research Project Agency-Energy (ARPA-E), and specific initiatives like the SunShot Initiative for solar energy and the U.S. Department of Energy’s (U.S. DOE) carbon capture program, among many others.

Still, federal government energy R&D funding is only about \$4 billion per year, compared to \$78 billion for defense and \$34 billion for health care.²⁵ While the optimal level of

government support for R&D in low-carbon technologies (which would include more than just the energy sector) is impossible to measure with precision, Newell (2015) aggregates studies that have explored this question and concludes that along with a permanent tax credit for private sector R&D expenditures, about \$10 to \$15 billion per year of public funding is needed to finance “basic strategic research” related to climate change, which is more than double the current levels.

Recognizing this R&D funding gap, the Obama administration committed in 2015 to double U.S. funding for clean energy R&D over the next five years, with 21 other countries and the European Union making the same commitment.²⁶ However, the Trump administration has pursued funding cuts for clean energy R&D in its budget proposals.

Demonstration and Deployment. R&D alone is typically insufficient for a low-carbon technology to compete in the market on a level playing field. Early adopters of technologies provide benefits for those who come later through “learning-by-doing” (i.e., production costs fall as manufacturers gain experience) and “learning-by-using” (i.e., future producers have more information about the characteristics and success of the technology). Unless early adopters are rewarded for these wider benefits or the government takes on the role of early adopter, important low-carbon technologies may mature far too slowly from the perspective of society, or perhaps never mature at all.

For these reasons, federal, state, and

local governments have supported the demonstration and deployment of low-carbon technologies in recent years, including by providing tax credits or loan guarantees for emerging renewable energy sources like wind and solar power, and by investing in large-scale carbon capture and storage (CCS) demonstration projects like the Petra Nova coal power plant in Texas.

Whether government supports demonstration and deployment as valuable complements to a carbon tax depends on the specific policy and circumstance. For relatively mature technologies that do not require especially large or risky investments, government support may risk “crowding out” actions the private sector will take on its own, especially in the presence of a strong carbon tax. In addition, with support for individual technologies (as opposed to broader incentives), the government risks backing the “wrong” low-carbon product. This can lead to technological lock-in that stifles innovation in superior products (Jaffe et al. 2003). For example, the array of policies to support corn-based ethanol—including the Renewable Fuel Standard and other subsidies—have had a variety of unintended consequences, including inflated land and food costs. These ethanol incentives may not have meaningfully reduced emissions relative to fossil fuels, and have made investments in less subsidized but possibly superior alternative fuel sources less attractive (Searchinger et al. 2008).

Given these advantages and drawbacks, governments should be cautious in deciding whether and how to support more mature low-carbon technologies. Concerns of “crowd-

ing out” can perhaps be reduced if demonstration and deployment policies focus on more public-private partnerships and private sector incentives and less on direct government actions.

Supportive infrastructure and regulatory systems. Aside from the lack of a price on carbon, the infrastructure and regulatory systems in the United States present significant barriers to the penetration of low-carbon technologies—that are both unnecessary and economically unsound.

The regulation of the U.S. electricity system is one example (of many), where the regulatory structure is a barrier to the success of emerging low-carbon technologies. A detailed discussion of needed electricity reforms is beyond the scope of this paper, but reforms that can simultaneously promote low-cost and low-carbon electricity production may include the following:

- **Enabling the construction of long-distance electricity transmission lines.** Currently, interstate transmission projects can take over a decade to complete. If interstate transmission projects could be approved and built within a reasonable timeframe while ensuring appropriate environmental review, far more wind and solar energy could be produced in places with strong resources and delivered for use in urban demand centers (Klass 2017).
- **Creating a level playing field for energy storage, energy efficiency, and demand response.** When

demand for electricity exceeds supply, wholesale electricity markets are often designed to favor the solution of ramping up electricity generation from power plants, instead of (potentially lower-carbon) solutions such as reducing electricity demand or utilizing electricity that has been stored. Wholesale electricity markets and retail rate structures can be modified to enable electricity storage and demand reductions to compete on a level playing field (MIT 2016). Important steps in this direction include Federal Energy Regulatory Commission (FERC) Order 745, enabling “demand response” to be compensated at the same rate as generated electricity,²⁷ and California’s implementation of “time-of-use” rates (i.e., higher prices at times of the day when electricity is relatively costly) as the default electricity pricing structure starting in 2019.²⁸

- **Encouraging improved forecasts of renewable energy.** Improved forecasting of wind and solar electricity production increases their use on the grid and decreases the need for costly “back-up” generation. Better forecasts can be achieved by improving forecasting techniques and by shortening the duration between the commitment and the supply obligation (e.g., with “real-time” or “intraday” electricity markets). In addition, transferring the forecasting responsibility from the grid operator to the renewable energy producer could provide a more powerful incentive to develop improved forecasts (MIT 2016).

While the federal government has

an important role in regulating electricity, most grid regulation occurs at the subnational level; thus, that is where many important clean technology-enabling reforms will occur. Indeed, some U.S. states are embarking on processes to modernize their electricity grids, such as New York’s “Reforming the Energy Vision” (REV) initiative.²⁹

Other sectors have similar regulatory barriers, and some sectors lack infrastructure that would enable low-carbon technologies to compete on a level playing field. For example, gasoline and diesel vehicles benefit from a century of infrastructure built to support these technologies as opposed to alternative fuel vehicles.

Of course, implementing regulatory reforms and building infrastructure can be costly, but, assuming these costs can be kept relatively low compared to the long-run savings from a more efficient electricity system, such reforms are important complements to a carbon tax and would enable a given carbon tax to achieve additional emissions reductions more cost-effectively.

3.2 Policies that promote energy savings from consumers

A carbon tax is a cost-effective way to reduce emissions when those responsible for the emissions can observe the price change and adjust their behavior in response. In situations where producers or consumers lack the ability either to observe or to fully respond to the price change, the effectiveness of a carbon tax at reducing emissions is limited. We focus here on one prime example: increasing the efficiency of energy consumption.

A carbon tax encourages improved

Cost-effective energy efficiency policies are important complements to a carbon tax.

energy efficiency by making energy more expensive; for example, when gasoline becomes more expensive, consumers will seek ways to purchase less of it. But a price signal alone is often insufficient to encourage consumers to take advantage of all cost-effective opportunities to improve energy efficiency, for the following reasons:³⁰

- **Information failures and asymmetries.** Consumers may have insufficient or inaccurate information about their energy use reduction opportunities, the energy efficiency characteristics of goods and services, or available incentives for efficient equipment and appliances.
- **Split incentives.** Those purchasing major appliances (e.g., landlords) may not be the same as those who pay the electricity bills (e.g., tenants). Other times, electricity users may pay a fixed rate or not pay for the electricity they use at all.³¹
- **Shortsightedness.** Consumers may make decisions based on near-term financial consequences rather than long-term cost-effectiveness.
- **Lack of investment capital**

and inefficient financial markets. Consumers may not be able to afford the upfront costs of smart investments in energy-efficient equipment, such as smart control systems in buildings.

Policies can help to overcome these market barriers by providing information, targeted financial incentives, or technology standards. Examples of prominent federal, state, and local actions intended to promote energy efficiency include (but are not limited to):

- U.S. DOE's Appliance and Equipment Standards Program, which covers more than 60 products, representing about 90 percent of home energy use, 60 percent of commercial building energy use, and approximately 30 percent of industrial energy use.³²
- U.S. Department of Transportation (U.S. DOT)/EPA's vehicle fuel economy standards that set fleet-wide targets for miles per gallon and GHG emissions per mile for both light and heavy-duty vehicles.
- EPA's Energy Star program, which encourages the voluntary certification and labeling of products and buildings that meet high energy efficiency standards (U.S. Congress 2005).
- Energy efficiency resource standards (EERS) that have been implemented by at least 20 states and require a minimum level of demonstrated energy savings each year (U.S. White House 2016).
- Property Assessed Clean Energy

(PACE) programs are state-level efforts to encourage low-cost financing and improved information about the existence and performance of potential energy efficiency investments.

- City-level programs, such as the Energy Conservation and Disclosure Ordinance in Austin, Texas, which requires energy audits of all homes listed for sale and provides information to homeowners regarding programs that can improve building efficiency (ACEEE 2014).

Policies to support energy efficiency are clearly important complements to a carbon tax, but given the long list of ongoing national, state, and local policies, a key question for policymakers designing a carbon tax is how this portfolio of existing policies compares to the ideal scale and scope of energy efficiency policies; for example, to what extent are more, less, or different energy efficiency policies needed alongside a strong carbon tax? The answers hinge largely on the cost-effectiveness of existing and potential future actions to promote energy efficiency.

Many empirical studies show energy efficiency gains at a relatively low cost. For example, U.S. DOE estimates that the reduced energy costs due to federal appliance and equipment standards have far outweighed the costs of implementing these standards (U.S. DOE 2018). Forecasts of the costs of energy efficiency programs as a compliance mechanism under the Clean Power Plan, largely based on evidence from existing programs, ranged from \$0.02 to \$0.07 per kilowatt-hour, lower than the average cost of generating electricity in most regions (Kaufman and Krause 2017).

Other recent empirical studies of

energy efficiency programs have found less optimistic results. For example, various studies have found that the actual energy savings achieved by energy efficiency programs have been far lower than estimates made prior to implementation, making the programs more costly than anticipated (Fowlie et al. 2018; Burlig et al. 2017). Nevertheless, an energy efficiency program need not achieve emissions reductions at "negative costs" to be a cost-effective approach to reducing emissions or achieving other objectives such as improved energy security. Indeed, achieving ambitious climate targets in the United States will require a massive increase in energy efficiency above today's levels—a reduction in energy use perhaps on the order of 20 percent, while satisfying the increased demand for energy services of a growing economy (U.S. White House 2016).

3.3 Policies targeting out-of-scope emissions or intending to achieve nonclimate objectives

In theory, it would be best if all sources of greenhouse gas emissions were "covered" by a national carbon tax, meaning that a producer or consumer responsible for each ton of carbon dioxide (or other GHG) would pay the tax associated with that emission. After all, a broader policy scope enables more low-cost emissions reduction opportunities and thus a more cost-effective policy. However, for certain categories of emissions, the administrative burden associated with carbon pricing may be sufficiently large that alternatives are preferred.

A large majority of GHGs can be covered by a carbon tax with ease, including nearly all CO₂ emissions from energy use, which make up about 80 percent of U.S. emissions (U.S. EPA 2017).³³ For other GHG

TABLE 1 GHG EMISSIONS AND SINKS THAT MIGHT NOT BE COVERED BY A CARBON TAX

Emissions Source/ Sink	% of U.S. Emissions ^a	Potential Problems with a Carbon Price	Other Policy Options	Existing Federal Policies
Methane and nitrous oxide emissions from agriculture and livestock	8%	Difficult to monitor/verify emissions reductions from dispersed and dissimilar emissions sources (e.g., soil, livestock)	Subsidies, technology standards, or other incentives for low-carbon alternatives (e.g., dietary restrictions for livestock, fertilizer regulations)	Various voluntary programs, such as USDA's ^b Building Blocks for Climate Smart Agriculture and Forestry and EPA's ^c AgStar
Methane from fossil fuel systems (e.g., oil and gas production, coal mining)	4%	Methane leaks are often dispersed and difficult to monitor	Technology or performance standards	EPA standards for oil and gas methane ^d
Methane and nitrous oxide from waste streams (e.g., landfills, wastewater)	2%	Difficult to monitor emissions and quantify emissions reductions	Technology or performance standards; programs on food waste	EPA standards for new and existing landfills
Hydrofluorocarbon (HFC) emissions from refrigeration and air conditioning	3%	Fugitive emissions may be difficult to monitor	Technology or performance standards; incentives for proper disposal, leak detection & repair	EPA regulations intended to stop the usage of certain HFCs and address HFC leaks
Sequestering carbon in forests and soils	-12%	Difficult to monitor and verify emissions and establish a baseline from which "increased sequestration" is measured	<ul style="list-style-type: none"> • Incentives and technical assistance to landowners; • encouraging compact urban development; • supporting improvements in crop yields, forest productivity, etc.; • forest restoration and expansion on federal lands 	<ul style="list-style-type: none"> • Voluntary USDA programs, including Building Blocks for Climate Smart Agriculture and Forestry; • HUD^e regional planning grants, etc.

Notes: State, city, and local policies are highly relevant as well. For example, urban development planning is largely at the city level, and cities have implemented policies such as urban growth limits and tradable development rights. A list of all state, city, and local policies that address these categories of emissions is outside the scope of this paper.

a. Percentage of gross U.S. emissions in 2015 (U.S. EPA 2017).

b. USDA = United States Department of Agriculture.

c. EPA = Environmental Protection Agency.

d. Under President Obama, EPA finalized standards for methane emissions from new and modified oil and gas facilities, which took effect in August 2016, and initiated the process of developing emissions standards for existing sources. Under President Trump, EPA attempted to suspend the implementation of the methane standards from new and modified sources, but in July 2017, the United States Court of Appeals for the DC Circuit rejected its attempt to do so. EPA has not continued the process of developing standards for existing sources.

e. HUD = Department of Housing and Urban Development.

Source: The elements of this table draw heavily from Metcalf (2009) and U.S. White House (2016).

emissions, policymakers should consider the trade-off between a broader policy scope and additional administrative costs.

Table 1 displays major categories of GHGs aside from energy CO₂ emissions, potential challenges associated with pricing these emissions, and alternative approaches for reducing these emissions, as well as current federal

policies. Policymakers would need to weigh the advantages and disadvantages of including these various sources of GHG emissions and sinks under a carbon tax.

Once the determination has been made to regulate a source of GHG emissions separately, an alternative regulatory approach can often complement a carbon tax due to

the lack of overlap between the two policies. Perhaps the most common alternative policies are technology or performance standards, whereby the government requires regulated entities to make enforceable changes to equipment or methods that lead to emissions reductions. While such standards are typically less cost-effective than a carbon price to address energy CO₂ emissions, they

may be the most cost-effective option for emissions that cannot be easily covered by a carbon price. For some categories of emissions, other policy or regulatory tools may be preferred, including a focus on supporting innovation of low-carbon alternatives.

Specific analysis or guidance on which categories of U.S. emissions should be subject to a carbon tax is beyond the scope of this paper. However, a useful case study comes from the cap-and-trade program within the American Clean Energy and Security Act (commonly known as the Waxman-Markey Bill), passed by the U.S. House of Representatives in 2009 but never voted on by the Senate. Waxman-Markey's emissions cap covered between 85 and 90 percent of gross U.S. GHG emissions, including power plants, fuel producers, industrial sources, and natural gas distributors. Hydrofluorocarbon (HFC) emissions were covered under a declining cap under the larger bill but not by the main cap-and-trade program, and certain small emissions sources (less than 25,000 tons of carbon dioxide equivalent [CO₂e] emitted per year) were either left uncovered or subject to EPA performance standards. Emissions from agriculture and livestock were not covered at all, although some portion may have been included indirectly via emissions offset by provisions.³⁴

The same political constraints that have prevented the passage of a national carbon price could also lead to carbon taxes that are too weak to drive down emissions sufficiently.

A separate category of complementary policies to carbon tax are those that are intended to accomplish other societal objectives but reduce GHG emissions as a cobenefit. For example, regulations that limit air pollutants like particulate matter and mercury are primarily intended to protect human health, but because coal power plants are primary sources of these air pollutants and GHG emissions, air pollution regulations that require these plants to address those pollutants can also reduce GHG emissions. For example, the implementation of EPA's mercury and air toxic standard was one cause of the spike in coal plant retirements in the United States around 2015 (low natural gas prices and the falling costs of renewable energy were additional important causes).³⁵

3.4 The interaction between complementary policies and carbon tax levels

This section highlights policies that can complement a carbon tax under the strong assumption that taxes are set at optimal levels to achieve emissions targets. However, the same political constraints that have prevented the passage of a national carbon price to date could also lead to carbon taxes that are too weak to drive down emissions sufficiently (e.g., low tax rates, and lack of an emissions target mechanism).

To achieve emissions targets in such situations, the abovementioned complementary policies would need to be stronger because the carbon tax alone would not be "pulling its weight." For example, if a weak carbon tax leads to insufficient private sector investments in clean energy innovation, additional government support for clean energy RDD&D could help to fill this gap.

In addition, policies that would be unnecessary with higher carbon taxes may also be needed if carbon taxes are too low. The preferred details of such additional policies depend on the sector and emissions source, as well as the details of the carbon tax policy and political constraints. But, as a general matter, because these policies are substituting for higher carbon prices, policymakers should strive to develop policies that mimic the advantages of a well-designed carbon tax, which would include the following:

- Enabling markets to determine where, how, and when emissions reductions are achieved³⁶
- Minimizing costs of administration and regulatory complexity
- A stable and predictable regulatory process
- A broad policy scope
- Avoiding burdens on households and communities that cannot afford them

3.5 Duplicative policies

Policies that do not fall into the categories described above may be duplicative alongside a strong carbon tax, meaning they address the same emissions sources and do not have a major rationale aside from reducing GHG emissions (or, as economists would say, they do not address a separate market failure). Duplicative policies lead to additional administrative and compliance costs but are unlikely to provide significant climate or other benefits. Duplicative policies may still provide benefits as insurance, in the event a carbon tax is repealed or is inefficient, but, in general, avoiding duplication is a tenet of good policymaking.

Because of this potential for duplicative policies, some carbon tax proponents commonly suggest eliminating certain regulations as part of a package (or compromise) to pass carbon tax legislation. For example, one of the four pillars of the Climate Leadership Council’s proposal is “the elimination of regulations that are no longer necessary” alongside a rising carbon tax that starts at \$40 per metric ton, such as standards for stationary sources of GHGs under the Clean Air Act.³⁷

Removing duplicative regulations may be simple in theory, but it is complex in practice. Few existing policies are intended solely to reduce GHG emissions. For example, fuel economy standards for cars and trucks are intended not only to reduce emissions but also to reduce U.S. dependence on foreign oil and enable fuel savings.

Similarly, state clean energy (or renewable portfolio) standards are intended not only to reduce GHG emissions but also to reduce local air pollution and promote local energy sources. In such instances, policies are partially but not fully duplicative, and policymakers may consider whether adjustments to these policies are needed with the implementation of a federal carbon tax.

Of course, a policy need not be duplicative of a carbon tax to be a poor complement. Indeed, the most counterproductive policies for achieving GHG emissions targets are those providing incentives that conflict with a carbon tax. Subsidies that promote the use of fossil fuels (without CCS), which are in essence a negative carbon tax, are perhaps the clearest example of a policy with conflicting incentives. Other poor complements to a carbon tax are those providing incentives that conflict with other climate policies, such as mandatory parking requirements for new buildings that inhibit the move toward energy-efficient cities.

4. CONCLUSION AND DISCUSSION

This paper provides policymakers and other stakeholders with information about how a carbon tax fits into a broader policy strategy to achieve GHG emissions targets: first, by describing how a carbon tax policy can be modified to increase the likelihood that national emissions targets will be achieved; and second, by describing situations in which a carbon tax is limited in achieving cost-effective emissions reductions,

and how additional policies and regulations can complement a carbon tax in these areas.

If U.S. federal policymakers seriously consider a carbon tax, they will not be devising a national climate strategy that starts with a blank slate, but rather with a host of existing federal and subnational policies that address GHG emissions directly and indirectly. Some groups will push for additional policies on top of existing ones, and in some areas, there is compelling evidence suggesting additional government action is indeed needed even alongside a strong carbon tax (e.g., support for clean energy innovation). Other groups will push for the repeal of certain existing regulations with the adoption of a carbon price—for example, “regulatory rollbacks” is one of the four pillars of the Climate Leadership Council’s carbon tax proposal that was endorsed by prominent business leaders and corporations in early 2017.

Designing a policy that earns the support of groups that wish to keep policies and regulations (or add new ones) alongside a carbon tax, as well as groups that support removing existing policies and regulations will be a major challenge. By combining a strong carbon tax with a simple emissions target mechanism and a targeted portfolio of complementary policies that focuses on areas where a carbon tax is weakest, policymakers can design a national climate strategy that is both environmentally and economically sound, which should earn the support of all groups that wish to reduce the risks of climate change.

ENDNOTES

1. In this paper, we use the term “cost-effective” to refer to achieving an objective (typically an emissions level) at minimal cost.
2. For example, the topic of border tax adjustments, or more broadly, how U.S. policy can affect international emissions, is beyond the scope of this paper.
3. For the case for cap-and-trade, see Natural Resources Defense Council: <https://www.nrdc.org/experts/david-doniger/adding-carbon-pricing-climate-protection-toolkit>. For the case for a carbon tax, see Harvard professor Greg Mankiw: https://scholar.harvard.edu/files/mankiw/files/smart_taxes.pdf.
4. A carbon tax directly establishes a price on carbon in dollars per ton of emissions, which is factored into the price of goods and services based on their carbon content. A cap-and-trade program establishes the price indirectly by placing a limit on the total quantity of emissions. This limit is enforced using tradable emission permits, typically called “allowances,” that any emissions source must own to cover its emissions. The market for these allowances creates the carbon price in a cap-and-trade program (Kaufman et al. 2016).
5. An analogous discussion on adding price certainty to a cap-and-trade program via price floors and ceilings is beyond the scope of this paper.
6. The Environmental Defense Fund has coined the term “environmental integrity mechanism” to refer to these mechanisms that provide greater levels of certainty in emissions outcomes under a carbon tax. See: <http://blogs.edf.org/markets/2016/11/03/ensuring-environmental-outcomes-from-a-carbon-tax/>.
7. This is the theory underlying the “Pigouvian” taxes; that is, when the full social cost of a market activity is not captured by the private costs, a tax equal to the social costs of the negative externalities is the most efficient public policy response. In the case of climate change, a global carbon tax would be set at an estimate of the social cost of greenhouse gas emissions to best internalize the external costs of climate change. For example, see Pearce (2003): <https://academic.oup.com/oxrep/article-abstract/19/3/362/440581>.
8. This includes Nationally Determined Contributions (NDCs), which are in the form of emissions targets in 2025 or 2030 for most countries, and a global emissions target of zero by the second half of the 21st century, per the 2015 Paris Climate Agreement.
9. For the EU’s stance on entering into trade agreements with countries that leave the Paris Climate Agreement, see: <https://www.forbes.com/sites/davekeating/2018/02/08/eu-tells-trump-no-paris-climate-deal-no-free-trade/>.
10. In theory, the decision could also be constrained by data availability, but since the U.S. GHG emissions inventory is released on an annual basis by EPA, and data on energy CO₂ emissions are released monthly by EIA, data are unlikely to be a major constraint in reality.
11. Certain examples of more complex metrics include the following: the legislation could stipulate multiple emissions benchmarks at each evaluation date that would trigger different policy changes; the benchmarks could be based on a broader definition of emissions than those covered by a U.S. carbon tax, or automatically factor in changes to national or global emissions targets; the benchmarks could be dependent on information about future expected emissions at the evaluation date, because evidence may indicate that emissions are off-course now but will not be for long (Murray et al. 2017). Including such additional factors could significantly increase the complexity of the policy.
12. See Hafstead et al. (2017) for further discussion of two-sided triggers.
13. On benefits of a well-defined regulatory pathway, see, for example, <http://review.chicagobooth.edu/magazine/fall-2014/the-price-of-policy-uncertainty>; and <http://pubs.acs.org/doi/abs/10.1021/es800094h>.
14. For more on Switzerland’s carbon tax law, see: <http://lenews.ch/2017/07/13/tax-to-rise-as-switzerland-misses-emissions-target/>, and <http://harvardelr.com/wp-content/uploads/2017/06/HELRF-4-Hafstead.pdf>.
15. Under a carbon tax, unlike cap-and-trade offset programs, revenues could also be used to fund additional emissions reductions from sources that are covered by the policy.
16. Due to *Massachusetts v. EPA* (Supreme Court 2007) and EPA’s Endangerment Finding (2009).
17. With the phrase “strong carbon tax” referring to policy with tax levels sufficient to exceed national emissions targets. Of course, a strong carbon tax is also not currently providing large or certain emissions reductions, but this discussion is based on the premise that such a tax will be implemented.
18. For further discussion on climate strategy and the carbon tax, see: <https://www.clcouncil.org/our-plan/>.
19. For public willingness to pay for a carbon tax, see: <http://iopscience.iop.org/article/10.1088/1748-9326/aa822a/meta;jsessionid=4726593E73933E34E5741FD56941EF51.c1.iopscience.cld.iop.org>.
20. For more on economists’ views on a carbon tax, see: <http://www.igmchicago.org/surveys/carbon-taxes-ii>.

21. On advantages of “revisit and revise” approach and factors influencing a desired carbon tax level, see: <https://www.energy.gov/revolution-now>.
22. To some extent, regulated entities would be expected to incur regulatory costs to prepare for the possibility of higher carbon tax rates, even if a mechanism is never triggered. However, these costs should still be lower than those incurred with a higher carbon tax rate in place, particularly if the probability that the mechanism is triggered appears relatively low.
23. While this paper focuses on a carbon tax, the additional policies described in Section 3 are also valuable complements to cap-and-trade programs, which is another form a national carbon pricing policy could take. Since a cap-and-trade program includes a maximum emissions trajectory, complementary policies addressing the same emissions sources could improve the cost-effectiveness of a national climate change strategy but would not reduce emissions further.
24. Note that while the previous section applied solely to a carbon tax, the policies discussed in this section can also complement a cap-and-trade program.
25. For federal government spending on energy R&D, see: <http://insideenergy.org/2016/12/07/the-uncertain-future-of-energy-rd/>.
26. For global initiative of 22 countries and the EU to accelerate global clean energy innovation, see: <http://mission-innovation.net/about/>.
27. For more on FERC Order 745, see: <https://www.utilitydive.com/news/what-the-supreme-court-decision-on-ferc-order-745-means-for-demand-response/413092/>.
28. For more on California’s rate restructuring plan, see: <https://www.utilitydive.com/news/inside-californias-rate-restructuring-plan-and-the-battle-for-fixed-charge/402117/>.
29. For more on electricity grid modernization at the state level, see: <https://www.utilitydive.com/news/the-top-5-states-for-utility-grid-modernization-and-business-model-reform/439550/>.
30. Examples are drawn from the United States Mid Century Strategy for Deep Decarbonization. See: unfccc.int/focus/long-term-strategies/items/9971.php.
31. Levinson and Niemann (2004) found that including electric utilities as a fixed rate in tenants’ rental contracts was associated with significantly greater energy use than when these electric bills were paid by the tenants themselves.
32. For more on U.S. DOE’s Appliance and Equipment Standards Program, see: https://energy.gov/sites/prod/files/2017/01/f34/Appliance%20and%20Equipment%20Standards%20Fact%20Sheet-011917_0.pdf.
33. For these emissions, a carbon tax imposed “upstream” (where the energy is produced or imported) would be relatively inexpensive to administer due to relatively few regulated entities and the ease of monitoring (Metcalf and Weisbach 2009). Simply put, because the carbon content of these fuels is relatively consistent, reliable measurements of the amount of fuel extracted/imported is all that is needed to reliably estimate the amount of carbon that will be released when it is burned.
34. Information gathered from Larsen et al. (2009) and the websites of C2ES (<https://www.c2es.org/>) and M.J. Bradley and Associates (<http://www.mjbradley.com/>).
35. For factors causing coal plant retirements in the United States, see: <http://www.mjbradley.com/sites/default/files/MJBAcoalretirementissuebrief.pdf>.
36. When U.S. EPA estimated the costs of market mechanisms versus prescriptive regulations across various pollutants and locations, it found market mechanisms to be less expensive in every case, and greater than 10 times less expensive in certain situations. See NCEE 2001, 25–27.
37. The Climate Leadership Council (CLC) is an international policy institute founded in 2017 with a proposal for a “carbon dividend” plan (a carbon tax with revenues returned in equal lump sum payments to American households) that has been endorsed by prominent Republican statesmen, business leaders, and Fortune 500 companies. World Resources Institute is a “strategic partner” with CLC but has not endorsed its proposal. See: <https://www.clcouncil.org/mission/>.

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Our Challenge

Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth's resources at rates that are not sustainable, endangering economies and people's lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Livable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

Our Vision

We envision an equitable and prosperous planet driven by the wise management of natural resources. We aspire to create a world where the actions of government, business, and communities combine to eliminate poverty and sustain the natural environment for all people.

Our Approach

COUNT IT

We start with data. We conduct independent research and draw on the latest technology to develop new insights and recommendations. Our rigorous analysis identifies risks, unveils opportunities, and informs smart strategies. We focus our efforts on influential and emerging economies where the future of sustainability will be determined.

CHANGE IT

We use our research to influence government policies, business strategies, and civil society action. We test projects with communities, companies, and government agencies to build a strong evidence base. Then, we work with partners to deliver change on the ground that alleviates poverty and strengthens society. We hold ourselves accountable to ensure our outcomes will be bold and enduring.

SCALE IT

We don't think small. Once tested, we work with partners to adopt and expand our efforts regionally and globally. We engage with decision-makers to carry out our ideas and elevate our impact. We measure success through government and business actions that improve people's lives and sustain a healthy environment.

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