WORLD RESOURCES INSTITUTE

WORKING PAPER

PUTTING A PRICE ON CARBON: A HANDBOOK FOR U.S. POLICYMAKERS

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EXECUTIVE SUMMARY

Putting a Price on Carbon: A Handbook for U.S. Policymakers is the first in a series of papers that the World Resources Institute will produce with the aim of providing a clear and comprehensive understanding of the key issues that will need to be addressed if the United States ultimately imposes a national price on carbon. *The Handbook* lays out what is already known about the design and effects of different approaches to pricing carbon, with a focus on carbon taxes and cap-and-trade programs.

We believe that pricing carbon should be a core element of the United States' long-term strategy for achieving significant reductions in greenhouse gas emissions in the coming decades. However, in writing the *Handbook*, we recognize that many who are, or could become, interested in carbon pricing might be motivated by the potential for benefits that are unrelated to climate change. Carbon price programs can be designed with an eye toward other possible policy goals, such as reforming the tax code to be more efficient. Even when carbon pricing is approached with non-climate priorities in mind, the emission reduction potential provides an insurance policy against the risk of significant climate impacts.

The *Handbook* provides an overview of carbon pricing—the types of decisions that need to be made in designing a program (including the political decisions about the use of revenue) and the expected economic impacts of alternative approaches. We conducted a thorough review of the literature, selecting a broad array of well-regarded and highly cited studies that represent a range of viewpoints. We expect this *Handbook* to be useful in the public debate in the United States on whether, how, and when to implement a national carbon price.

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Working Papers contain preliminary research, analysis, findings, and recommendations. They are circulated to stimulate timely discussion and critical feedback and to influence ongoing debate on emerging issues. Most working papers are eventually published in another form and their content may be revised.

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The Basics of Pricing Carbon

Greenhouse gas emissions impose costs on the global community via climate change. A carbon price shifts the burden of these costs from society as a whole to the entities responsible for the emissions, providing an incentive to decrease carbon emissions.

Pricing carbon increases the prices of goods across the economy in proportion to their carbon content, and thus in proportion to their effect on climate change. By raising the relative price of carbon-intensive goods (for example, fossil fuels), a carbon price encourages individuals and businesses to purchase less carbon-intensive alternatives.

A carbon price would lead to reductions in U.S. greenhouse gas emissions and create leverage to encourage other countries to reduce their emissions, both of which are necessary to prevent the more severe effects of climate change. In addition, reduced fossil fuel usage will provide "co-benefits" in the form of reduced emissions of other harmful air pollutants.

While pricing carbon implies higher prices for certain goods, the additional costs to individuals and businesses become an additional source of revenue that can either be returned to households or spent in other productive ways. Among other possibilities, carbon-pricing revenues can be used to promote economic growth, advance low-carbon technologies and other activities that help respond to climate change, and reduce adverse economic effects of the carbon price.

The following are some of the specific potential uses of carbon pricing revenues:

- **TAX CUTS.** The revenues from carbon pricing could be used to fund cuts in other tax rates. Taxes on labor and capital can reduce the income of individuals and businesses and decrease incentives to engage in productive activities such as work and investment. Such taxes differ from a carbon tax, which corrects for a market failure and reduces the incentive to emit harmful greenhouse gases.

- **RETURNING MONEY TO HOUSEHOLDS OR ELECTRICITY CONSUMERS.** Revenue from carbon pricing could be returned to households by sending them "lump sum" payments, which could be divided equally or by some alternative metric. This "tax-and-dividend" approach has gained popularity largely because of its perceived fairness and simplicity. Households could be provided with tax refunds or sent quarterly or annual checks. In California, some money from the cap-and-trade allowance auctions is returned to electricity customers in the form of rebates on their bills. These types of approaches could also ensure that low-income households receive at least as much in income as they spend on the tax.

- **DEFICIT REDUCTION.** Large national deficits can reduce economic growth rates by increasing interest rates, inhibiting (or "crowding out") private sector investments, and increasing future tax burdens to pay off the principal or interest on the debt. Carbon pricing revenues could be used to reduce annual deficits and thereby help to avoid such adverse economic effects.

- **INVESTING IN COMBATING CLIMATE CHANGE.** In addition to its potential to stimulate innovation in low-carbon technologies (for example, renewable energy), a carbon price can provide revenue to help promote the development and deployment of breakthrough technologies. In addition, carbon-pricing revenues can be used to invest in infrastructure that helps communities adapt to the effects of climate change that are now unavoidable (extreme weather, sea level rise, etc.).

- **TRANSITIONAL ASSISTANCE.** A portion of the revenues can be used to assist those likely to be most adversely affected by a carbon price. Job training can be provided to workers in industries with anticipated job losses (for example, coal mining). In addition, revenues can be disproportionately allocated to households and business in regions of the country that are most heavily dependent on the production or consumption of fossil fuels in order to smooth the transition to a lower carbon economy. Revenues can also be used to provide assistance to industries that might face increased competition from foreign competitors.

Many other ways are available to make use of carbon-pricing revenue. While many advocates strongly favor one or another particular approach to the use of revenue, existing or proposed carbon-pricing policies often include a mixture of approaches in accordance with the compromises and trade-offs required to pass such far-reaching legislation.

Carbon Taxes versus Cap-and-Trade

This *Handbook* focuses on the two main approaches to pricing carbon: carbon taxes and cap-and-trade programs. A carbon tax is a fee added to the price of goods in proportion to their carbon content. A cap-and-trade program entails setting a maximum level of carbon emissions, with emissions allowances issued by regulators up to this cap that can be bought or sold. Under a cap-and-trade program, the carbon price is equal to the market price of the emissions allowances.

If properly designed and implemented, both carbon taxes and cap-and-trade programs provide incentives to undertake the lowest cost abatement opportunities (those less expensive than paying the carbon price). In addition, carbon taxes and cap-and-trade programs require a number of similar decisions to be made in the design process.

While the effects of comparably stringent carbon taxes and cap-and-trade programs are virtually identical in theory, a number of practical differences exist between the two policy instruments. A carbon tax is in some ways simpler than a cap-and-trade program. A tax does not require the government to allocate or conduct auctions for emissions allowances, or monitor the trading of allowances, and regulated entities do not need to participate in auctions or secondary markets for allowance trading.

The major advantage of a cap-and-trade program is that the policy sets a firm limit on the quantity of emissions that will be allowed. Therefore, when climate change goals are stated in terms of emissions levels, the emissions cap can ensure the goal will be achieved. A carbon tax cannot guarantee a certain emissions path, but it will lead to a certain price pathway. Regulated entities might prefer that approach to the less stable prices of a cap-and-trade program, which can make business planning more difficult. To that end, cap-and-trade programs may include "ceilings" and/or "floors" on allowances prices to reduce price volatility.

Carbon-Pricing Policies and Proposals

While the concept of carbon pricing dates back to economic theory from the early 20th century, in practice, carbon-pricing programs were first developed in the early 1990s when four Scandinavian countries implemented taxes on carbon dioxide (CO_2) emissions. In the United States, the Clinton administration proposed a tax on the energy content of fuels that would have been similar to a carbon tax, but the proposal was controversial and withdrawn in 1993.[1]

Also in the 1990s, the United States implemented the Acid Rain Program, which put in place a cap-and-trade program for sulfur dioxide emissions in the United States.[2] While not focused on carbon emissions, the Acid Rain Program provided proof of concept for cap and trade, which has since been used for pricing carbon.

The European Union established its Emissions Trading Scheme in 2005, which is the world's largest CO_2 cap-and-trade program.[3] The EU-ETS went through a rocky initial phase, which saw prices collapse due, in part, to the over-allocation of allowances. However, the program has since achieved a stable market for allowances and meaningful emissions reductions, and has provided useful lessons for other cap-and-trade programs developed elsewhere.

Back in the United States, starting with the Climate Stewardship Act of 2003, Congress has seen numerous carbon pricing proposals, many with bipartisan sponsorship and support. The 111th Congress (2009 and 2010) was the high-water mark for these proposals, when the American Clean Energy and Security Act (ACES) cap-and-trade program (also known as "Waxman-Markey" after its two principal co-sponsors) was approved by the House of Representatives. While several companion bills were introduced in the Senate during that Congress, none moved to a floor vote. Additional carbon-pricing bills have been introduced in Congress since 2010, but none has been given serious consideration.

With little prospect of comprehensive federal action on climate change in the mid-2000s, many U.S. states began to plan their own state or regional cap-and-trade programs. The first was the Regional Greenhouse Gas Initiative (RGGI), a cap-and-trade program for CO_2 emissions from power plants, launched in 2009 by ten northeastern states (New Jersey has since withdrawn). Various western U.S. states and Canadian provinces created the Western Climate Initiative (WCI) in 2007 and jointly agreed on design principles for a regional cap-and-trade program. While the WCI was never able to implement the regional program, California and Quebec currently operate a linked cap-and-trade program that covers 85 percent of the emissions in each jurisdiction. Ontario recently announced its intent to establish a cap-and-trade program and link it with California and Quebec as part of the WCI.[4] In addition, WCI member British Columbia established a carbon tax in 2008 that is currently C$30 per ton of CO_2 across sectors representing 70 percent of total emissions.

Nearly 40 countries and over 26 sub-national jurisdictions have implemented either a carbon tax or a greenhouse-gas cap-and-trade program; these include seven pilot programs in China. Together, these programs cover approximately 12 percent of global greenhouse gas (GHG) emissions. In contrast to the situation a decade ago, if the United States were to establish a national carbon price it would no longer be a lone actor; instead, it would be joining a growing community of nations committed to reducing global greenhouse gas emissions with cost-effective climate-change policies.

Carbon Pricing Design Features

Establishing a carbon pricing program requires many decisions on policy structure and design. Some of the main design elements of a carbon-pricing policy are highlighted below. Each element is relevant to both a carbon tax and a cap-and-trade program.

- **SCOPE.** Scope refers to the portion of overall greenhouse gas emissions covered by the program. Determining a program's scope requires policymakers to decide: (1) whether the program covers only CO_2 or other greenhouse gases as well; (2) which economic sectors are covered by the program; and (3) whether all emitters or only those above a certain threshold of emissions are regulated. The broader the scope, the greater the emissions reductions that will be expected from a given carbon price. A broader scope also implies that a given quantity of emissions reductions will be achieved at a lower cost.

- **POINT OF REGULATION.** Carbon pricing can be applied at different points in the economy. Under an "upstream" approach, the carbon price is applied where the materials that will result in the emissions first enter the economy (for example, at the coal mine, the oil or gas drilling site, or the entry point of fuel imports). Such an approach enables a large fraction of energy CO_2 emissions to be covered while regulating relatively few entities. A "downstream" approach applies the carbon price at the point where the emissions actually occur. This is straightforward to implement for power plants and manufacturing facilities, but far more difficult for individual buildings, cars, and trucks. A program may also include a mixture of upstream and downstream approaches, or "midstream" approaches (for example, oil refineries and natural gas processing plants).

- **REPORTING AND VERIFICATION.** A key prerequisite for a successful carbon pricing policy is a robust emissions reporting and verification system. Reliable reporting systems are often already in place for other purposes. Because the addition of a carbon price creates direct economic consequences for both the covered entity—which wants to minimize its tax burden—and the government, verification of the emissions reports is essential. Different approaches to that verification are possible—from independent third party verification to self-certification with strong penalties.

- **SETTING THE PRICE OR CAP.** Carbon tax and cap-and-trade programs require setting pathways of prices or emissions caps. Setting the level of the tax or cap will likely require balancing a variety of political, economic, and environmental considerations. From a climate perspective, one can start from either consideration of emission targets or from estimates of the damages caused by GHG emissions. For non-climate policy priorities (for example, tax reform), setting the price might have more to do with the amount of revenue needed to serve those priorities. It is common to increase the stringency of a program gradually over time to allow businesses and consumers to adjust, and to maintain some flexibility to adjust the price or cap in the event that conditions change.

Various additional factors must also be considered. For example, allowing "offsets" (emissions reductions from entities that are not directly covered by the policy, for example, enhanced carbon sinks achieved by tree planting) can reduce the costs of a policy, but can also make the emissions reductions more difficult to verify.

Policymakers should also consider the broader policy context in which carbon pricing is introduced, including any complementary policies that might be needed to further reduce emissions or costs.

Economics of Carbon Pricing

The body of literature on the economic effects of carbon pricing programs is wide and deep. Economists have conducted both benefit-cost and economic-impact analyses to assess the effects of carbon taxes on society as a whole and on individual sectors, regions, and income levels. While there are serious limitations to economic models (see Section 6 for detail), economic theory and empirical results can nonetheless offer important lessons to policymakers as they design carbon-pricing programs.

Benefit-Cost Analysis

The most important finding of economic theory related to carbon pricing is also the most basic: when an activity such as emitting greenhouse gases causes harm that is not reflected in the prices of goods and services (what economists call a "negative externality"), pricing that activity leads to reductions in the activity and to overall gains in welfare. The price corrects for the market failure (the harm caused is internalized in the costs of the goods and services). Indeed, economic studies show that the optimal carbon price is potentially very large.[5]

Climate change is a challenging economic problem, in part because benefits are global in nature while policy costs are local. This dilemma has caused some to question the benefits achievable from a carbon price established by any single country. On the other hand, many nations and sub-national jurisdictions have already put a carbon price in place. The United States is responsible for a significant portion of global greenhouse-gas emissions, and U.S. adoption of a carbon price could help spur broader multinational action to combat climate change.

Comparisons of the benefits and costs of carbon pricing should take account of benefits unrelated to climate change. For example, reduced fossil fuel usage provides substantial "co-benefits" in the form of reduced emissions of other harmful air pollutants. In addition, the carbon pricing revenues can be used in a variety of ways to benefit the economy and boost economic growth.

For all these reasons, economists overwhelmingly support a well-designed national carbon tax. In 2012, a University of Chicago survey asked 40 prominent economists from across the political spectrum whether they would prefer the government to raise revenue through traditional income taxes or via a national carbon tax. Not one chose the income tax approach.[6]

Economic Impacts

While economists largely agree that many uses of carbon-pricing revenues can promote long-term prosperity, determining whether a carbon price will be beneficial to the U.S. economy in the short run is a more difficult question. A significant portion of the welfare gains will accrue outside the economy (if these gains are measured traditionally, using metrics such as national GDP) and will not be realized until far into the future. Nevertheless, because of the various non-climate policy objectives that can be achieved with the revenue from a carbon price, economists have found that at least some of the potential adverse economic consequences for specific sectors, regions, or groups can be offset. In fact, some economists have found that a properly designed carbon price can achieve net economic benefits, even before consideration of the climate benefits, which economists refer to as a "double dividend."[7]

The economic impacts of a carbon price (in terms of economic growth, employment, etc.) are highly contingent on how the revenue is spent. Economists have found that maximizing economic growth requires using the revenue to remove pre-existing "distortions" in the economy that serve to hinder growth.[8] For example, economic studies have shown that lower income tax rates (corporate and personal) would cause individuals to work more and corporations to create more jobs. Revenue can also be used to achieve many other objectives, such as investing in technologies that spur low carbon innovation and climate change adaptation, or providing transitional assistance to sectors, regions, and individuals that are most vulnerable to the higher prices and lower demand for carbon-intensive goods.

Recent studies have shown that neither the distributional consequences,[9] the regional disparities,[10] nor the effects on the competitiveness of U.S. industry[11] are as large as some have feared. Still, using a portion of the revenues to address either the actual or perceived "losers" from a carbon price may increase the fairness and political viability of the policy.

Next Steps

While we can't predict what the future may hold, conversations with policymakers, stakeholders, and others highlight several factors that could combine to increase the appeal of carbon pricing policies across the political spectrum in coming years. While views differ sharply on some of these, factors that might interest people of different political views include:

- Bipartisan support for tax reform;
- Successful carbon-pricing programs at the state and regional levels, including the potential for more programs spurred by compliance with the new EPA power plant standards;
- Increased awareness of the current and impending impacts of climate change;
- Stated goals for deeper greenhouse-gas emissions cuts; and
- Desire by some for an alternative approach to regulating carbon.

Cap-and-trade programs are already in place in the northeastern United States and California. However, following the failure of the U.S. Senate to pass climate legislation in

2010, talk in Washington D.C. about pricing carbon has shifted from cap-and-trade to carbon taxes. These discussions have involved a wide range of players, but have remained quiet and behind the scenes. A key question in coming years will be whether, and when, these discussions will again be considered part of mainstream political discussion.

We believe that pricing carbon should be a core element of the United States' response to climate change because of the massive environmental and economic benefits it can offer. Any such policy will result in winners and losers; it is therefore critical that any program be designed to recognize and address the potential for uneven distribution of benefits and costs. This paper highlights the major tools available for dealing with these concerns. These tools also provide the opportunity to satisfy a variety of political goals beyond emissions reductions. We hope that this working paper—and future issue briefs that will dive more deeply into many of the topics discussed here—will play a helpful role in the coming national conversation on these issues.

1. INTRODUCTION

Putting a Price on Carbon: A Handbook for U.S. Policymakers is offered in the expectation of continued debate in the United States over how to address climate change. While current policy actions focus on regulatory approaches, we believe that putting a price on carbon needs to be a core element of the United States climate policy in the long term. The *Handbook* is the first in a series of papers that the World Resources Institute will produce in coming years with the aim of providing a clear and comprehensive understanding of the key issues that will need to be addressed if the United States ultimately chooses to impose a national price on carbon. The *Handbook* sets out what is already known about the design and effects of different approaches to pricing carbon, with the main focus being on carbon fees or taxes and cap-and-trade programs.

The starting point for most discussions of a carbon price is its role in addressing greenhouse gas emissions and reducing the future effects of climate change. However, in writing the *Handbook*, we recognize that not all those who are or might become interested in carbon pricing are motivated by climate science and the need to reduce greenhouse gas (GHG) emissions in order to avoid the worst impacts of climate change. Carbon-pricing programs can be designed with an eye toward other policy goals, such as reforming the tax code to be more efficient. Viewed in this way, the potential for emissions reduction can be seen simply as a side benefit or an insurance policy against uncertain but potentially significant climate change impacts.

Because carbon pricing can aim at a variety of policy objectives, support for some form of pricing carbon comes from divergent points on the political spectrum. Though they disagree on the details, supporters include former Secretary of State George Schultz,[12] former Treasury Secretary Henry Paulson,[13] and former Republican Congressman Bob Inglis;[14] conservative economists such as Gregory Mankiw[15] and Art Laffer;[16] scholars at the American Enterprise Institute,[17] Resources for the Future,[18] and the Brookings Institution;[19] and organizations such as the Center for American Progress,[20] the Citizens' Climate Lobby,[21] and the Niskanen Institute.[22]

The *Handbook* provides an overview of carbon pricing—the types of decisions that need to be made in designing a program (including the political decisions about the use of revenue) and the expected economic impacts. This overview provides basic information aimed at improving understanding of important trade-offs inherent in pricing carbon (for example, between ease of implementation and comprehensiveness of coverage), though it is beyond the scope of the paper to attempt to resolve them. For those new to thinking about pricing carbon, the *Handbook* can serve as a basic primer. For those who have been deeply involved in prior legislative debates on climate legislation or in research and discussions of cap-and-trade programs or carbon fees and taxes, this *Handbook* provides a broad refresher and reference work. We expect that this type of reference work will be useful when public debate in the United States turns toward whether, how, and when to implement a national carbon price.

In writing this paper, the authors conducted a thorough literature review, selecting a broad array of well-regarded and highly cited studies that represent a range of viewpoints. Our exploration of carbon pricing was also informed by a number of conversations—many off the record—with carbon-pricing proponents from across the political spectrum. Future research by the World Resources Institute will explore in more detail some of the economic opportunities presented by carbon pricing, such as encouraging innovation, and how to evaluate and address some of the potential downsides, for example,

Box 1 | What is a "Carbon Price?"

In this *Handbook*, the term "carbon price" is being applied both broadly–to include all greenhouse gases—and narrowly—limited to two mechanisms that explicitly result in a price on carbon emissions.

A "carbon price" is sometimes understood to apply to carbon dioxide (CO_2) emissions only. In the context of this paper, we will refer generically to greenhouse gases as "carbon" so a carbon price can apply beyond CO_2. See section 3 for a discussion of policy design issues related to including greenhouse gases other than CO_2 in a carbon pricing system.

This *Handbook* focuses specifically on carbon taxes (or fees) and cap-and-trade programs. Both focus on greenhouse gas emissions, and result either directly or indirectly in an explicit price on carbon emissions. A carbon tax or fee would directly establish a price on carbon emissions in dollars per ton of emissions. While this price could be applied at the point of emissions, many proposals focus on applying the price "upstream"—at "chokepoints" where fossil fuels enter the broader economy—and are based on the carbon content of the fuels. A cap-and-trade program establishes the price indirectly by placing a limit on the total quantity of emissions that will be allowed. This limit is enforced based on tradable emission permits, typically called "allowances," that any emissions source must use to cover its emissions. Like a carbon tax, the cap could be applied downstream at the point of emissions, upstream where fuels enter the economy, or at points in the distribution system in between. The market for these allowances creates the carbon price in a cap-and-trade program.

Other types of programs can be used to place a price on carbon, including programs that are based on emission intensity (rather than actual emissions) such as the *Specified Gas Emitters Regulation (SGER)* program in Alberta, Canada.[a] In addition, a program such as a clean energy standard that includes trading provisions based on carbon intensity could also result in an effective price on carbon. Some discussions of carbon pricing also include consideration of fossil fuel and other energy subsidies, which can have an important effect on the relative cost of different fuels.

Note:
a. World Bank, *State and Trends of Carbon Pricing 2014*.

the potential for regional or income disparities that could arise from a carbon price.

This work is intended to seed an ongoing productive discussion and debate on the pros and cons of different approaches to pricing carbon. While the World Resources Institute sees reducing greenhouse gas emissions to reduce the impacts of climate change as a critical priority, the views and input of those interested in exploring a carbon price based on other priorities are welcome and needed to move the debate forward. We look forward to a wide-ranging and productive set of discussions in the coming years.

This paper explores how various design decisions and possible uses of carbon revenues can address other policy priorities in addition to climate change. The paper begins with an overview of carbon pricing (Section 2), followed by a brief history of experience with carbon pricing programs in the United States and elsewhere (Section 3). Section 4 then walks through the main decisions that must be made to design and implement a carbon-pricing program. Section 5 explores the various uses of revenue that have been tried or considered as part of different carbon pricing programs and proposals, and Section 6 provides a summary of the literature on the main economic impacts from carbon pricing. Conclusions are presented in Section 7. By providing clear analysis of what can be achieved through different approaches to pricing carbon, this paper hopes to guide thinking on how to design a proposal for pricing carbon to achieve multiple objectives.

2. THE BASICS OF PRICING CARBON

2.1. Why Price Carbon?

Pricing carbon can provide an economically efficient means of reducing greenhouse gas emissions and minimizing the disruptive risks of climate change. A carbon price provides a relatively simple and direct way to ensure that more of the costs of climate change are brought into the economic calculus behind investments and consumption, including resource and fuel use. It sends a price signal that could influence widely dispersed economic decisions, help guide future economic growth toward a lower carbon economy, and reduce the impacts of climate change over time.

Support for carbon pricing also comes from parties who might be motivated by policy priorities other than the need for action on GHG emissions, but who see the value of an insurance policy against climate risks. Policy priorities that can be addressed through some form of carbon pricing include:

- **REDUCING GREENHOUSE GAS EMISSIONS.** A carbon price can help reduce GHG emissions by internalizing the costs of climate change in economic decisions throughout the economy.

- **SPURRING INNOVATION IN CLEAN ENERGY.** By reflecting the cost of carbon in the prices for fuels and goods, a carbon price can send an economic signal that helps spur investment and innovation in energy sources and new technologies that are less carbon intensive.

- **REDUCING OTHER TAXES.** Revenue from pricing carbon can be used to reduce other taxes. This can be done in a revenue-neutral way that moves from taxing things we want more of (for example, employment or income) to taxing those we want less of (for example, GHG emissions). Options include reductions in payroll, personal income, or corporate income taxes in aid of broader tax reform.

- **RAISING REVENUE FOR OTHER PRIORITIES.** Carbon revenues can also help to address other policy priorities. For example, revenues could be directed to supporting research and development, adapting to climate change impacts, investing in infrastructure maintenance and improvements, or providing job training or other targeted support for industries or regions that are disproportionately affected by the carbon price.

In addition to these priorities, reducing GHG emissions can improve energy security, reduce direct energy costs, and help reduce other forms of pollution.[23] While various tools are available to address other forms of pollution directly, the reductions that result from a carbon price have the potential to provide meaningful local and regional public health and environmental benefits.[24]

2.2. Uses of Revenue

While pricing carbon implies higher prices for certain goods, the additional costs to individuals and businesses become an additional source of revenue that can either be returned to households or spent in other productive ways. Among other possibilities, carbon-pricing revenues can be used to promote economic growth or employment, to advance low-carbon technologies and other activities that help combat and prepare for climate change, or to reduce any potential adverse effects of the carbon price on specific groups.

The following summarizes some of the specific potential uses of carbon-pricing revenues:

- **TAX CUTS.** The revenues from carbon pricing can be used to fund cuts in income taxes, which increase incentives to work and invest, and therefore boost economic growth as a result. Taxes on labor and capital not only take money away from individuals and business, but also decrease incentives to engage in productive activities such as work and investment. Such taxes differ from a carbon price, which reduces the incentive to emit harmful greenhouse gases. The decision on which taxes to cut (for example, payroll, personal income, or corporate income taxes) may involve trade-offs between cost-effectiveness and distributional concerns.

- **RETURNING MONEY TO HOUSEHOLDS OR ELECTRICITY CONSUMERS.** Revenue from carbon pricing could be returned to households by sending them "lump sum" payments, which could be divided equally or by some alternative metric. This "fee-and-dividend" approach has gained popularity largely because of its perceived fairness and simplicity. Households could be provided with tax refunds or sent quarterly or annual checks. This approach could also ensure that low-income households receive as much in income as they spend on the tax. However, such payments are unlikely to boost economic growth as much as cutting tax rates, because they do not enhance incentives to work or invest.

- **DEFICIT REDUCTION.** Large national deficits can slow economic growth by increasing interest rates, reducing (or "crowding out") private sector investments, and increasing future tax burdens because of the need to pay off the principal or interest on the debt. Carbon-pricing revenues could be used to pay down the debt and therefore avoid such adverse economic effects. Just as reducing current tax rates can increase incentives to work and invest, reducing future tax rates through deficit reduction could have similar pro-growth effects.

- **ENCOURAGING INNOVATION IN LOW-CARBON TECHNOLOGIES.** While a carbon price can help stimulate innovation in low-carbon technologies (for example, energy efficiency or renewable fuels), additional support for innovation might be needed to mitigate the effects of climate change. Moreover, to the extent that the private sector "underinvests" in research and development because it cannot capture the public benefits of R&D, further government support might be required to promote the development of breakthrough technologies. Carbon-pricing revenues could be a source of such funding.

Box 2 | How a Carbon Price Works

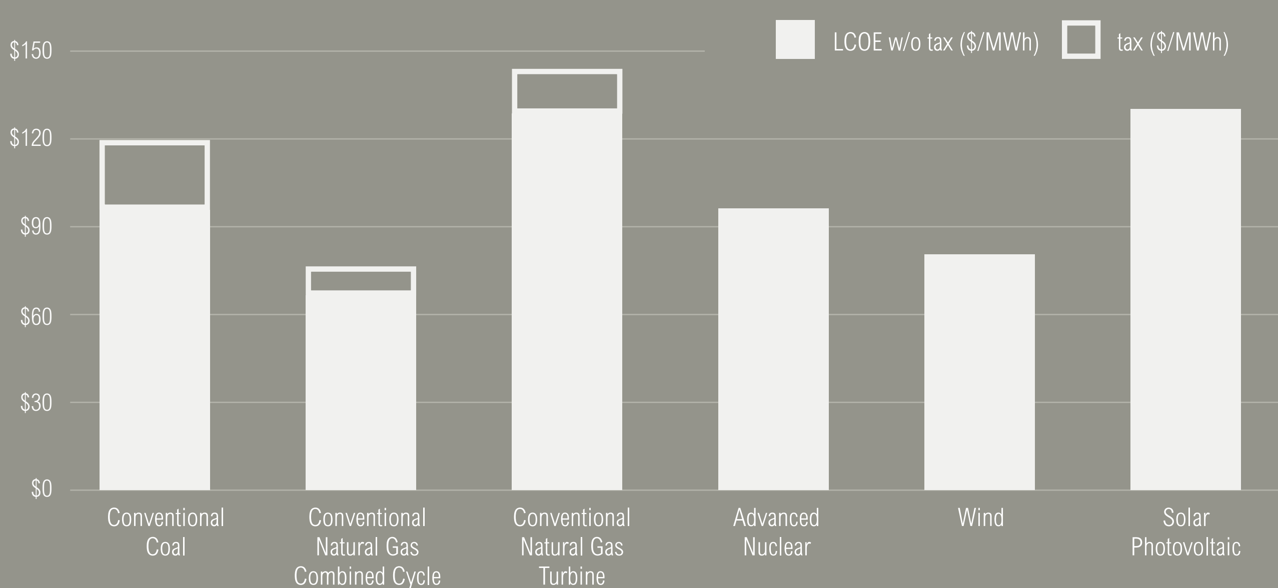
The impacts of climate change resulting from greenhouse gas emissions impose costs on society as a whole. Pricing carbon shifts these costs away from the broader society to those responsible for the emissions, while providing an incentive to reduce emissions.

Putting a price on carbon across the economy will increase the prices of goods and services in proportion to their carbon content, and so in proportion to their effect on climate change. The higher prices for carbon-intensive goods and services will encourage businesses and consumers to look for alternatives that meet their needs but have lower carbon-emission footprints.

As a simplified illustration of this type of shift, Figure 1 shows the impact of a carbon tax of $25 per ton of CO_2 on the levelized cost of electricity (LCOE). LCOE is a standard measure for comparing the lifetime costs of building and operating different electricity generation options, though it does not reflect the dynamics of wholesale electricity markets that drive electricity rates. The carbon tax reflects the relative impact of each fuel on CO_2 emissions, so the tax has a larger effect on carbon-intensive coal (the fuel that creates the highest carbon emissions per unit of energy when burned) than on less carbon-intensive natural gas, and no effect on non-carbon nuclear and renewable sources. The increased fuel prices—which now reflect the adverse effects of climate change—would then be passed on in full or in part in any products for which the fuels are an input.

These shifts increase the competitiveness of less carbon-intensive sources (see Figure 1). In addition, less efficient generation methods (such as the natural gas turbine) see a greater price increase than more efficient options (such as natural gas combined cycle).

FIGURE 1 | EFFECT OF CARBON TAX ON AVERAGE COST OF NEW U.S. ELECTRICITY GENERATION FOR PLANTS ENTERING SERVICE IN 2019 (2012 $/MWH)



Sources: "Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2014," U.S. Energy Information Administration, April 17, 2014, http://www.eia.gov/forecasts/aeo/electricity_generation.cfm. The tax increment is based on heat rates from EIA ("Table 8.2. Average Tested Heat Rates by Prime Mover and Energy Source, 2007-2013," U.S. Energy Information Administration, accessed April 13, 2015, http://www.eia.gov/electricity/annual/html/epa_08_02.html) and the emissions per Btu from EIA ("How Much Carbon Dioxide is Produced When Different Fuels Are Burned?," U.S. Energy Information Administration, accessed April 13, 2015, http://www.eia.gov/tools/faqs/faq.cfm?id=73&t=11).

Note: Levelized cost of electricity data in the figure are based on U.S. average levelized costs for plants entering service in 2019 from the 2014 Annual Energy Outlook.

- **CLIMATE CHANGE ADAPTATION.** While carbon pricing can help to mitigate the adverse effects of climate change, some impacts—according to the IPCC—are now unavoidable. For that reason, some proponents of carbon pricing support the use of revenues to invest in infrastructure that helps communities adapt to the impacts of climate change. Such investments could include increasing the resiliency of water, transport, and energy systems, as well as other infrastructure that is vulnerable to extreme weather, sea-level rise, and the other effects of a changing climate.

- **TRANSITIONAL ASSISTANCE FOR AFFECTED SECTORS, INDIVIDUALS, AND REGIONS.** By inducing changes in behavior and purchasing patterns, pricing carbon is likely to benefit certain industries and regions more than others. A portion of the revenues is often used to assist those who are likely to be adversely affected by a carbon price. Job training can be provided to workers in industries that experience job losses (for example, coal mining), and revenues can be disproportionately allocated to households and business in regions of the country that are most dependent on the production or consumption of fossil fuels. Revenues can also be used to provide assistance to industries that face increased competition from competitors in foreign countries without (or with lower) carbon prices.

Many other options are available. While many of those who support pricing carbon are champions of particular uses of carbon-pricing revenues, many carbon-pricing policies and proposals reflect a mix of approaches.

2.3. The Basics of Cap-and-Trade and Carbon-Tax Programs

Carbon taxes and cap-and-trade programs require a number of similar decisions to be made in the design process. These decisions often involve trade-offs: increasing the scope of a program beyond a certain level usually implies increasing the burden of administering it; programs with more stringent emissions targets will cause larger impacts on the economy; implementing mechanisms to "smooth" these economic impacts will generally increase either compliance costs or emissions.

A carbon tax is in some ways simpler than a cap-and-trade program, especially for the companies that would have to operate under the system. An emissions cap can ensure that emissions targets are met, while a carbon tax can ensure a stable trajectory of prices. Table 1 provides an overview of the main similarities and differences between the two systems,[25] while Section 4 provides a short primer on designing a carbon-price system.

Table 1 | **Important Design Features of a Carbon Tax Versus a Cap-and-Trade Program**

	CARBON TAX	CAP-AND-TRADE PROGRAM
What is the scope?	Both involve similar decisions regarding the choice of gases to regulate, which sectors to regulate, whether to allow relatively small emitters to remain unregulated, and where the regulation occurs (upstream, downstream, etc.). Such decisions often involve trade-offs between emissions reductions and feasibility and administrative burdens	
How is a carbon price established?	The price is the tax level	The price is the market price of emissions allowances (which can be estimated via modeling)
What emissions reductions can be achieved?	Depends on the response to the change in prices (which can be estimated via modeling)	Maximum emissions established by setting the trajectory of emissions caps

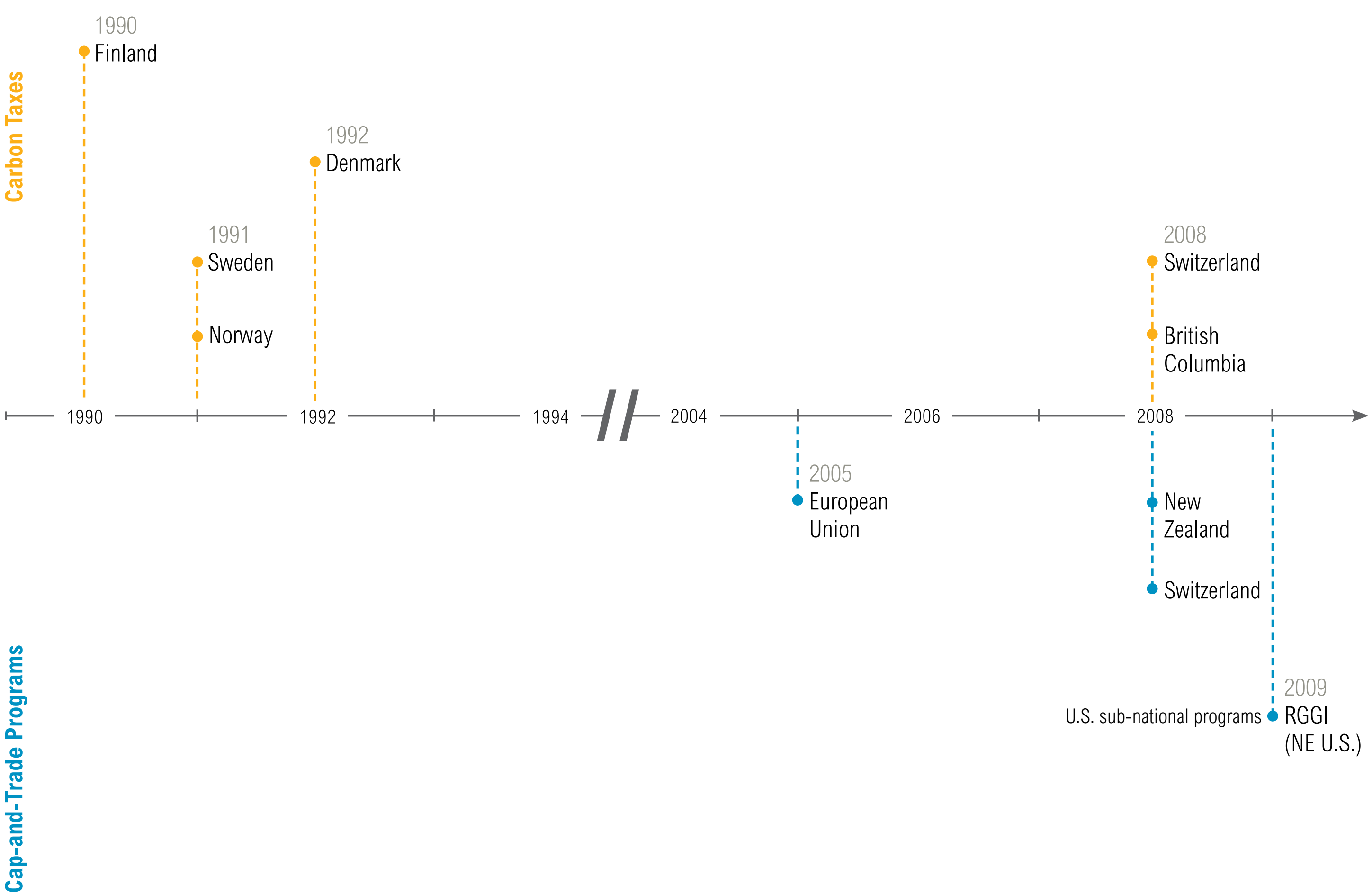
Table 1 | **Important Design Features of a Carbon Tax Versus a Cap-and-Trade Program (continued)**

	CARBON TAX	CAP-AND-TRADE PROGRAM
How do regulated entities comply?	Must report emissions (or a proxy for emissions such as fuel quantities) and pay the tax based on those emissions	■ Must report emissions (or a proxy) and surrender allowances based on those emissions ■ Obtain allowances by direct allocation, through purchase at auction, or in the secondary market ■ Participate in secondary market as buyer and/or seller of allowances ■ Bank allowances for future use or borrow for current use (if permitted under the regulation)
How much will it cost regulated entities to comply?	Future compliance costs based on emissions and established tax rates	■ Future compliance costs based on emissions and estimated allowances prices ■ Costs also depend on the degree to which allowances are allocated at no charge, versus bought at auction or on the secondary market
Can offsets lower compliance costs?	In theory, either policy could allow regulated entities to purchase emissions offsets (that is, verified emissions reductions from non-covered sources) in lieu of direct compliance, which will lower compliance costs. Offsets are more commonly seen as part of cap-and-trade programs	
Where will regulated entities reduce their emissions?	Where the cost of emissions reductions is less than the cost of paying the tax, taking into account the trajectory of future taxes	Where the cost of emissions reductions is less than the cost of buying (or the opportunity cost of not selling) allowances, taking into account the trajectory of expected future allowance prices
What is the role of markets, and which market protections are needed?	A carbon tax would not create a market that needs to be regulated	■ A mechanism for auctioning allowances (unless all are distributed at no charge) ■ A secondary market with proper oversight and regulation (a liquid secondary market that sends a transparent price signal to regulated entities is needed for an efficient program)
What happens to the revenue?	Both a carbon tax and a cap-and-trade program (assuming some degree of auctioning of permits) will generate revenue, and the government can stipulate how the revenue is to be spent (for example, reduced taxes, deficit reduction, spending on other programs). While the same alternatives will be available under either policy type, revenue amounts are likely to be more predictable under a carbon tax	
How does the system interact with complementary policies (for example, a Renewable Portfolio Standard)?	■ Complementary policies can achieve emissions reductions beyond those achieved by a carbon tax, for example, if a renewable portfolio standard requires more renewable power than would be deployed with the carbon tax alone ■ Complementary policies may be desirable, even within covered sectors, for example, to encourage innovation or deployment of new technologies in certain sectors	■ Complementary policies shift the location of emissions in the economy, but the cap establishes the maximum overall level of emissions for covered sectors ■ Complementary policies may be desirable even within covered sectors, for example to encourage innovation or deployment of new technologies in certain sectors

3. A BRIEF HISTORY OF CARBON PRICING

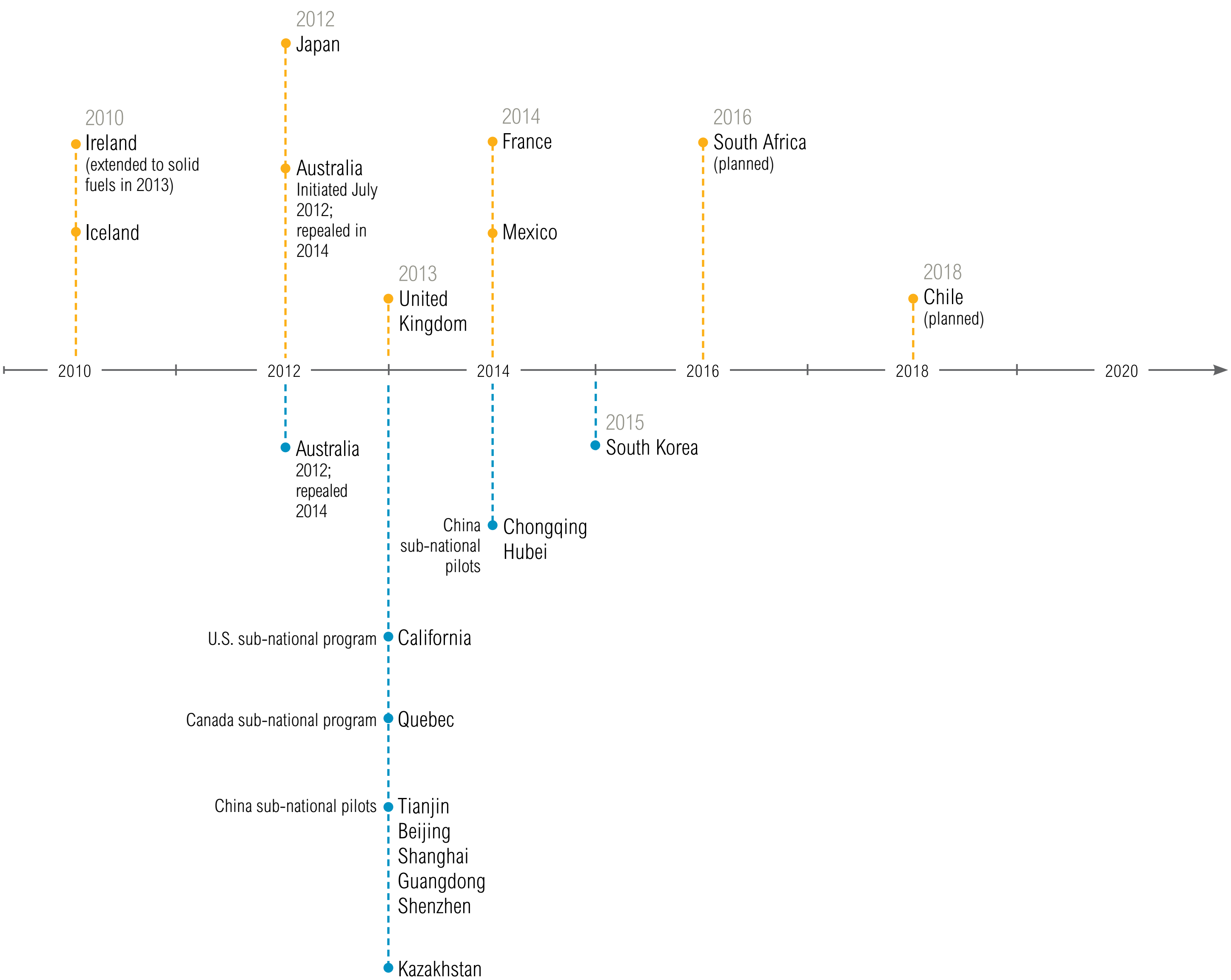
"Taxing carbon dioxide emissions may be an idea whose time is at hand in the United States, now that reducing greenhouse gas emissions has become an international imperative." These hopeful—but premature—words opened Gus Speth's foreword to *The Right Climate for Carbon Taxes*,[26] published by the World Resources Institute in August 1992, in the wake of the climate treaty signed by more than 150 nations in Rio de Janeiro that April. While the Clinton administration, as part of its first budget, proposed a tax on the energy content of fuels that would have had similarities to a carbon tax on energy,[27]

Figure 2 | **Timeline of Carbon Pricing Programs from Around the World**



that proposal was highly controversial and withdrawn by the end of 1993.[28] No serious proposals for a carbon tax or greenhouse gas cap-and-trade program were put before Congress for another ten years, though the 1990s did see the successful implementation of the acid rain cap-and-trade program (see Box 3). In the years since the Rio Earth Summit, however, many countries and sub-national jurisdictions have instituted carbon taxes or cap-and-trade programs. Figure 2 lists the carbon-tax and greenhouse gas cap-and-trade programs that since have been instituted around the world.

Figure 2 | **Timeline of Carbon Pricing Programs from Around the World (continued)**



Box 3 | Acid Rain Program: The Origin of Cap and Trade

A cap-and-trade program, limiting total emissions and enabling regulated entities to buy and sell emissions permits, is among the most prominent tools used to price carbon. The first major cap-and-trade system was the Acid Rain Program, passed by Congress in 1990 to reduce acid rain by regulating sulfur dioxide (SO_2) emissions from power plants. The majority of previous environmental regulations were "command-and-control," in that they designated emissions rates or equipment standards for regulated entities. In fact, many environmentalists were hostile to the concept of allowing polluters to pay for the right to pollute.

The cap-and-trade system at the heart of the Acid Rain Program arose from collaboration between the Environmental Defense Fund (EDF) and the Administration of George H.W. Bush.[a] Regulated power plants were allocated a fixed number of tradable allowances and had to surrender one allowance per ton of SO_2 emitted (and were heavily penalized if they did not). Power plants could buy allowances, sell allowances, or "bank" allowances for use in future years, but could not borrow allowances from future years' allocations. The emissions cap declined over time toward a long-term national goal of 7.6 million tons of SO_2 emissions, which was achieved three years ahead of schedule in 2007.

The great advantage of a cap-and-trade system is that it facilitates cost-effective emissions reductions. In theory, the plants with relatively low-cost opportunities to reduce emissions will do so and sell their unneeded permits (for a profit) to plants with higher cost opportunities, which will then avoid expensive emissions reductions. The Acid Rain Program was the first major test of this theory, and it was highly successful. The best estimates of actual program costs ($1.17 to $2 billion annually) were less than the projected costs of command and-control alternatives ($3.4 billion to $11.5 billion) and also less than EPA's initial projection for the Acid Rain Program ($1.9 to $5.5 billion).[b] Still, some people have argued that costs could have been even lower, were it not for informational barriers and other state and federal regulations that constrained power plants' abilities to select the low-cost abatement opportunities.[c]

Overall, the Acid Rain Program is widely seen as a success at many levels. Not only did it provide large environmental benefits at a relatively low cost,[d] it also paved the way for future cap-and-trade systems that have focused on carbon emissions. In 2005, the European Union's Emissions Trading Scheme became the first major cap-and-trade program for greenhouse gas emissions, and greenhouse gas cap-and-trade systems have since been established in the northeastern United States (the RGGI program) and in California.

Notes:

a. Conniff, R. August 2009. "The Political History of Cap and Trade." Smithsonian Magazine.[1-3] See: http://www.smithsonianmag.com/air/the-political-history-of-cap-and-trade-34711212/?page=2

b. Siikamäki J., D. Burtraw, J. Maher, and C. Munnings. March, 2012. "The U.S. Environmental Protection Agency's Acid Rain Program." Washington, D.C.: Resources for the Future. Working Paper.

c. Schmalensee R. and R. Stavins. August, 2012. "The SO2 Allowance Trading System: The Ironic History of a Grand Policy Experiment." Cambridge, MA: MIT Center for Energy and Environmental Policy Research.

d. Cost-benefit analyses have shown that the Acid Rain Program contributed benefits roughly 40 times the costs of the program. Interestingly, nearly 95 percent of the estimated benefits were related to the health impacts of sulfate particulates, which were not well understood until after the implementation of the program (Schmalensee and Stavins, 2012).

3.1. Carbon Pricing in the United States and Canada

Starting with the Climate Stewardship Act, introduced by Senators John McCain and Joseph Lieberman in 2003, Congress has seen numerous proposals to cap or tax carbon emissions, many of them with bipartisan sponsorship and support.[29] The 111th Congress (2009 and 2010) was the high-water mark for these proposals, with the passage in the House of Representatives of the American Clean Energy and Security Act (ACES), often referred to as "Waxman-Markey" for the names of its chief sponsors—then Representatives Henry Waxman and Ed Markey. This bill benefited from the many precursors in earlier Congresses. While several companion bills were introduced in the Senate during that Congress, none moved to a floor vote.

The debate and compromises that led to the passage of ACES in the House provide a useful set of lessons to consider in the context of future proposals to price carbon at the national level in the United States. Putting in place a significant carbon price will result in both winners and losers even if the policy provides net benefits overall. For the policy to succeed politically and work economically, it is critical that the program be designed to recognize and address, to the extent needed, the uneven distribution of benefits and costs that it could impose. Much of the negotiation and compromise that went into the House passage of ACES related to finding ways of addressing real or perceived costs of the program or finding benefits that could bring additional people into the coalition supporting the bill. This type of major policy initiative can only be put in place in the U.S. political system by finding ways to satisfy a wide variety of interests.

While additional bills have been introduced in Congress since then—including the American Opportunity Carbon Fee Act, by Senators Whitehouse and Schatz in November 2014,[30] and the Healthy Climate and Family Security Act of 2015 by Representative Van Hollen in February 2015[31]—as of this writing, none have been given serious consideration or a committee hearing.

With little prospect of comprehensive federal action on climate change in the mid-2000s, many states began working together, including several regional efforts to create multi-state cap-and-trade programs. The first of these was the Regional Greenhouse Gas Initiative (RGGI), a multi-state cap-and-trade program for CO_2 emissions from power plants. The discussions that led to RGGI were initiated in 2003, and the program was launched in 2009 by ten northeastern states (New Jersey withdrew in 2012, but New York, Delaware, Maryland, and the New England states remain in RGGI). RGGI covers approximately 20 percent of total GHG emissions in the participating states. In February 2013, the RGGI states completed a program review that lowered the 2014 emissions cap by 45 percent and made additional changes to the cap through 2020.

Box 4 | Carbon Pricing and the Clean Power Plan

In June 2014, EPA proposed the Clean Power Plan (CPP) to satisfy its obligation to regulate greenhouse gas emissions from existing power plants.[a] EPA proposed emissions rate standards, but provided states with significant flexibility to design their own implementation plans. After the CPP is finalized by EPA in the summer of 2015, states can propose implementation plans to EPA by 2016, with extensions available to 2017 (for single state plans) or 2018 (for multi-state plans).[b] EPA will also issue a final federal plan in 2016 for areas that do not submit a state plan. Within one year of a state plan being proposed, EPA will either approve the plan or institute its own plan before the compliance period begins in 2020.

States are likely to adopt a variety of approaches to implementing the CPP, including pricing carbon. In its proposal, EPA describes both "rate-based" and "mass-based" (that is, cap-and-trade) performance standards as alternative compliance mechanisms. Under either approach, a system of tradable emissions allowances could reduce the total costs of compliance by incentivizing those with high-cost abatement opportunities to purchase allowances from those with low-cost abatement opportunities. States and regions with pre-existing cap-and-trade programs are likely to continue these programs to comply with the standard (namely, California, and RGGI in nine northeastern states), and additional states may take an interest in carbon pricing as an implementation option.[c]

While not explicitly mentioned by EPA, various commentators have called for the use of carbon taxes as an additional CPP compliance alternative.[d] By increasing the relative price of carbon-intensive electricity generation, a carbon tax would lead to an increase in low-carbon generation or investments in energy efficiency, and thus a reduction in overall emissions rates. Using economic modeling (just as it would for other compliance strategies), a state could show that its planned carbon tax would likely achieve the required emissions rate standard. Carbon taxes are relatively easy to administer because they do not require states to allocate emissions allowances, conduct auctions, or monitor allowance trading. Carbon taxes also provide predictable and stable price signals to regulated entities, and a large source of government revenue that could be used to counteract the cost of the tax to constituents. Perhaps most importantly, carbon taxes (as well as cap-and-trade programs) are more cost-effective than emissions rate standards (even with multi-state trading programs), so enabling states to utilize carbon taxes could significantly lower the compliance costs of the CPP.[e]

Notes:

a. "Clean Power Plan Proposed Rule," U.S. Environmental Protection Agency, accessed April 13, 2015, http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule.

b. "Fact Sheet: Clean Power Plan & Carbon Pollution Standards Key Dates," U.S. Environmental Protection Agency, accessed April 13, 2015, http://www2.epa.gov/carbon-pollution-standards/fact-sheet-clean-power-plan-carbon-pollution-standards-key-dates.

c. See "Power Plan Hub," E&E Publishing, accessed April 13, 2015, http://www.eenews.net/interactive/clean_power_plan.

d. Wara, M, A. Morris, and M. Darby. October, 2014. "How the EPA Should Modify Its Proposed 111(d) Regulations to Allow States to Comply By Taxing Pollution." Washington, D.C.: Brookings Institution.

e. Fischer, C. 2001. "Rebating Environmental Policy Revenues: Output-Based Allocations and Tradable Performance Standards," Washington, D.C.: Resources for the Future. Discussion Paper 01-22.

The revisions recommended through the program review are intended to strengthen the program in the years ahead.[32]

In 2006, California passed the Global Warming Solutions Act (AB 32), which required it to reduce emissions to 1990 levels by 2020. The following year, western states (including California) and Canadian provinces created the Western Climate Initiative (WCI) and began a regional discussion on the design and implementation of a multi-sector cap-and-trade program. WCI grew to include seven states and four Canadian provinces, who jointly agreed on design principles for a regional cap-and-trade program.[33] However, California and Quebec are the only jurisdictions that have implemented the program to date. They now operate a linked cap-and-trade program that covers 85 percent of the emissions in each jurisdiction. Ontario recently announced its intent to establish a cap-and-trade program and link it with California and Quebec as part of the WCI.[34] British Columbia (BC) remains a member of WCI but does not have a firm plan for joining the linked cap-and-trade program. BC did establish its own economy-wide carbon tax in 2008 that is currently set at C$30 per ton of CO_2 across sectors representing 70 percent of total GHG emissions in the province.

Similar discussions among states and provinces in the Midwest to form a regional cap-and-trade program were initiated in 2007, but did not progress far and were suspended in 2010. (See Box 4 for discussion of the potential for carbon pricing as a state implementation measure under EPA's Clean Power Plan, which is establishing carbon dioxide standards for existing power plants.)

Since the failure of the Senate to pass climate legislation in 2010, talk in Washington about pricing carbon has shifted from cap-and-trade—now considered a political non-starter–to carbon taxes. These discussions have involved a wide range of players, but have remained quiet and behind the scenes. A key question in coming years will be whether, and when, these discussions will again be considered part of mainstream political discussion.

3.2. Carbon Pricing Systems Around the World

While no national carbon price has been established in the United States, almost 40 other countries and over 26 sub-national jurisdictions have implemented carbon-pricing programs. Total GHG emissions in the jurisdictions with these programs represent more than 22 percent of global GHG emissions, with the programs themselves covering approximately 12 percent of global emissions.[35]

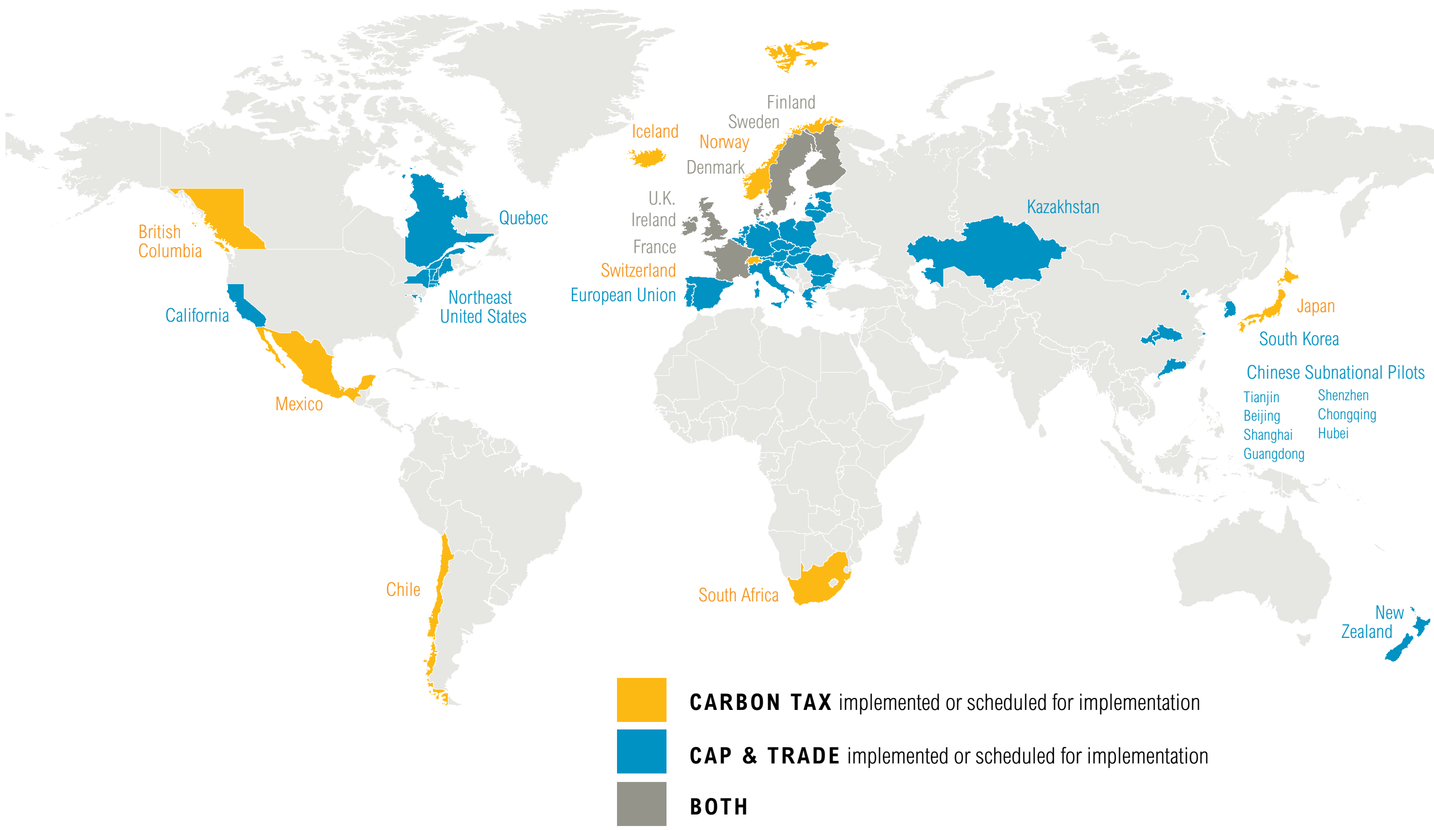
The longest-running programs are the carbon taxes established by Denmark, Finland, Norway, and Sweden in the early 1990s. National carbon taxes have also been established in recent years in France, Iceland, India, Ireland, Japan, Mexico, Switzerland, and the United Kingdom, while South Africa and Chile have approved carbon taxes that have not yet taken effect. In addition, British Columbia has enacted a carbon tax at the sub-national level.

The largest greenhouse gas cap-and-trade program is the European Union's Emissions Trading System (or EU ETS), initially established in 2005. Other national programs are operating in New Zealand, Switzerland, and Kazakhstan, and one began operation in the Republic of Korea in 2015. Sub-national cap-and-trade programs are also operating, with an electric sector program in nine states in the northeastern United States, linked multi-sector programs in California and Quebec, and seven municipal and provincial pilot programs under way in China. China has begun planning[36] a national-level emissions-trading system that is expected to be phased in starting in 2016.[37] While significant work remains to be completed, once fully operational the Chinese program could be the largest GHG trading program in the world.

Figure 3 shows the current and planned carbon tax and cap-and-trade programs from around the world, and Appendix A provides summary information about those programs. Not included in this summary are systems based on carbon intensity, such as the program in Alberta, Canada, or offset programs such as the Clean Development Mechanism (CDM).

In addition to these government programs, many businesses in the private sector are already accounting for substantial future carbon prices in their planning decisions. As shown in a recent report by CDP (formerly known as the Carbon Disclosure Project), a growing number of multi-national corporations representing a diverse set of industries and interest have disclosed using an internal carbon price, including BP, Duke Energy, Google, Royal Dutch Shell, Wal-Mart, Walt Disney, and Wells Fargo, among many others.[38]

Figure 3 | **Carbon Pricing Programs Around the World**



4. KEY DESIGN FEATURES

Establishing a carbon-pricing program requires many design decisions, including which gases and sectors are covered, which entities within the relevant sectors are required to comply, and the overall stringency of the program. While these elements are described separately below, design decisions require consideration of the interactions among these elements.

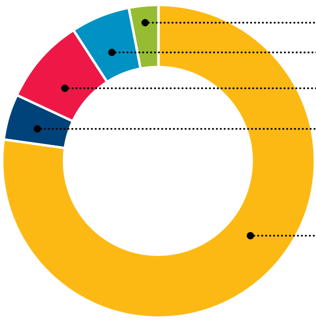
The policymakers involved with these decisions will also need to balance various criteria that can sometimes conflict. These range from comprehensive coverage of emissions, administrative ease in implementation, minimizing the economic costs and maximizing benefits, addressing differing impacts across population groups and regions, and achieving other goals, possibly unrelated to climate.

This section highlights some of the main choices facing policymakers who are considering either a carbon tax or a cap-and-trade program. Two of the most critical choices are the scope of the program and setting the price or cap levels. This section also discusses the importance of reporting and verification, and concludes with an examination of the possible interaction between a carbon-pricing program and complementary policies.

4.1. Scope

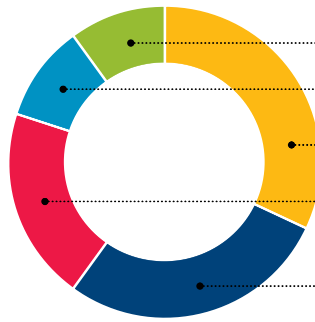
Scope refers to the share of total greenhouse gas emissions covered by the program. One element of scope involves the greenhouse gases to be included—just CO_2, or other gases such as methane and hydrofluorocarbons (HFCs) as well? The second element is which sectors of the economy are covered. Several existing programs only cover one sector, such as the RGGI program in the northeastern United States that only includes electricity generation, while others are multi-sector, such as California and the EU ETS. The third element is the point of regulation—where and how emissions from different sectors are covered. This might be "upstream," using fuels as a proxy for the emis-

Figure 4 | **Greenhouse Gas Emissions by Gas in the United States, 2012**



Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2012. U.S. Environmental Protection Agency, April 2014. Accessible at: http://epa.gov/climatechange/ghgemissions/usinventoryreport.html

Figure 5 | **Greenhouse Gas Emissions by Sector in the United States, 2012**



Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2012. U.S. Environmental Protection Agency, April 2014. Accessible at: http://epa.gov/climatechange/ghgemissions/usinventoryreport.html

sions that result from fuel combustion, "downstream" at point sources of emissions, or somewhere in between. The final element is whether and how to address imports and exports in the program.

For any carbon-pricing program, the broader the scope, the greater the emission reductions that will be expected from a given carbon price, since more emissions will be covered. A broader scope for a cap-and-trade program also means that a greater variety of sources will fall under the cap, leading to lower overall compliance costs because there will be more low-cost emission reduction opportunities covered by the program.

4.1.1. Which Gases to Include

Decisions over which greenhouse gases to include in a carbon pricing program involve trade-offs between the comprehensiveness of the program (that is, the fraction of total GHGs covered) and the ease of implementation (the ability to quantify the emissions being taxed or capped through direct measurement or accurate estimation). For each gas, two key factors to consider are (1) the contribution of the gas to total greenhouse gas emissions; and (2) how difficult it would be to measure and regulate the gas.

CO_2 is the most important greenhouse gas (GHG), representing over 70 percent of total GHG emissions globally and over 80 percent in the United States.[39] Other key greenhouse gases include methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen trifluoride. Because CO_2 is the primary GHG, some carbon-pricing systems focus only on this gas. Many of the most important sources of CO_2, especially those based on fossil fuel combustion, are also generally easy to measure or estimate, making them well suited for inclusion in a carbon pricing system. As seen in Figure 4, a program that included only energy-related CO_2 would have covered 77 percent of total U.S. emissions in 2012.

Other gases can be included in the system, allowing coverage of a larger portion of an economy's GHG emissions. Including these gases requires careful consideration of their relative contributions to climate change. These contributions are typically based on the "global warming potential" (GWP), which compares gases in terms of CO_2-equivalent (CO_2e) units.[40] These estimates can be made based on considerations of the heat-trapping properties of the gases and the time the gas remains in the atmosphere. GWPs have been regularly updated in recent decades, which can complicate the design of a pricing program.

The ease of implementing the program is in large part contingent upon the extent to which the emissions can be readily quantified or accurately estimated. In some cases, proxy measures, such as the carbon content of fossil fuels, provide a solid basis for quantifying the ultimate CO_2 emissions. On the other hand, methane and N_2O are second and third in terms of greenhouse gases emissions in the United States, but quantifying or accurately estimating methane and N_2O emissions from agricultural sources is difficult, so those sources are less likely to be included in a carbon-pricing program.

For each gas, policymakers must determine whether the benefits of the incremental emissions reductions are worth the difficulties associated with including the gas in the program.

4.1.2. Choice of Sectors

A key determinant of the portion of an economy's greenhouse gases that is covered by a carbon-pricing system is the choice of economic sectors to be included. One tradeoff is between the ability to quantify emissions—whether directly or through proxy measures such as the carbon content of fossil fuels—and comprehensiveness. For example, the electricity-generating sector already reports its GHG emissions.[41] As shown in Figure 5, the electric sector in the United States is responsible for about one third of total GHG emissions.[42] Limiting a system to this sector would miss a significant portion of overall emissions. An alternative approach, included in many proposals, is to limit the program's scope to energy-related CO_2 emissions, which can readily be covered through assigning responsibility for emissions to the point in the supply chain where the fuels that will result in the emissions first enter the economy.

There will be different advantages and disadvantages to inclusion of other sectors in a carbon-pricing system, and political considerations will also come into play in deciding which sectors to include. A carbon-pricing program could also begin with a limited scope and expand to include a more comprehensive set of sectors or gases after the program is initially established. Table 2 summarizes the key aspects of different sectors that affect their inclusion in a carbon-pricing system.

Table 2 | **Characteristics Relevant for Decisions on Inclusion in a Carbon Price System**

SECTOR	
Energy CO_2	■ Readily addressed based on carbon content of fuels and applying the program upstream, where fuels enter the economy ■ Would not require direct emissions reporting from individual sources in different sectors ■ Would cover 78 percent of total emissions in the United States
Electricity Generation	■ Easily identified emission sources that are already subject to environmental regulations and GHG reporting
Industry	■ Many emission sources are large facilities that already report GHG combustion and process emissions ■ Numerous smaller industrial sources may be difficult to track and monitor, so might be better addressed through more upstream approaches
Transportation	■ Significant emissions from many small and difficult-to-measure sources so program might be better directed upstream where transportation fuels are produced or distributed
Residential/ commercial	■ Significant emissions from many small and difficult-to-measure sources so program might be better directed upstream where relevant fuels are produced or distributed (or through complementary policies)
Forestry/ agriculture	■ Significant source of emissions and potential source of sequestration ■ Many emission sources and carbon sinks are dispersed and difficult to monitor, so proxy measures might be needed to estimate net emissions
Non-CO_2 gases	■ Some non-CO_2 GHGs are significant source of emissions in some industries ■ Many emissions result from a large number of sources that may be difficult to monitor, so might be better directed upstream (that is, where the gas first enters the economy)

4.1.3. Point of Regulation

Different approaches can be taken to allocating responsibility for paying the tax or surrendering allowances. At one end of the spectrum is an upstream approach in which responsibility for the emissions is applied when the materials that will result in the emissions first enter the economy. In the case of energy-related CO_2 emissions, this means that responsibility is applied to energy producers: the entities that mine coal, produce gas and oil, or import fuels. CO_2 emissions from each ton of coal, barrel of oil, or cubic foot of natural gas can be readily estimated because one molecule of CO_2 results from every atom of carbon in the fuel (generally speaking). The cost added to the fossil fuel will generally be passed along to the end users of the energy and, for manufacturers, will be incorporated into production costs. This approach allows a very large fraction of energy-related CO_2 emissions to be covered in a system that requires relatively few responsible parties to play a direct role.

At the other end of the spectrum, a downstream approach would apply responsibility at the point where the emissions actually occur. Large point sources like power plants and steel manufacturing plants are major emitters of CO_2 because they burn large quantities of fossil fuels. Tapping them as the point of regulation captures the major emitters who are responsible for a very large fraction of energy-related CO_2 emissions. This approach may provide a useful point of regulation for a program like RGGI, which is limited to the electricity-generating sector. However, following this path is more difficult for distributed sources such as residential and commercial building heating systems or cars and trucks. In these cases, an intermediate point may be more appropriate. For example, emissions from combustion of natural gas in household and small-scale commercial use can be captured by making gas utilities responsible for the emissions embedded in their product. A system can include a mix of these approaches. For example, California's cap-and-trade program initially covered large industrial sources directly (downstream), but has since expanded to include distributed use of natural gas by homes and smaller businesses through the utility distribution companies (midstream).

In a downstream program, it might be simpler to establish an emissions threshold below which sources are not included. Policymakers must decide whether the expected emissions reductions from sources with emissions below the threshold are sufficient to make the costs associated with regulating these smaller sources worthwhile.

The decisions of whether and how to set thresholds are generally based on what proportion of total emissions are associated with "large" emitters, and these decisions will differ by sector. In many sectors, such as electricity generation or cement manufacturing, the most significant emitters will also be responsible for the great majority of emissions and will already be reporting emissions. In this case, including all facilities in a carbon-pricing program would greatly increase the number of facilities covered—including many that are below emission thresholds for reporting requirements—without significantly increasing the amount of emissions included in the program. Other industries, like food processing or pulp and paper, have more small- and medium-sized facilities and companies, indicating that lower emissions thresholds for inclusion (or no thresholds) might be appropriate.

Regulating fuels as they enter the economy is one way to address emissions from smaller sources without attempting to regulate them directly. However, even an upstream system will require consideration of whether and how to apply thresholds.

4.1.4. Imports and Exports

A pricing program might also attempt to address emissions associated with imports from countries that do not have a carbon price in place (or have a lower carbon price) to avoid putting U.S. producers and manufacturers at an unfair disadvantage. The benefits and controversy surrounding such "border tax adjustments" are discussed in more detail in Section 6.2.3.

For energy imports in an upstream carbon price system, applying a border tax adjustment is relatively straightforward, because the carbon price can be applied at the point of import and a credit can be applied at the point of export of domestically produced energy.

Addressing emissions associated with imported goods outside the energy sector is more complicated. "Embedded emissions," that is, the emissions generated during manufacture and transport, are a significant concern for energy-intensive, trade-exposed industries. The industries that might potentially be affected are an important part of the U.S. manufacturing base, but represent a relatively small portion of the U.S. economy.[43] See Section 6.2.3 for a discussion of the impact of carbon pricing on industrial competitiveness.

As more carbon-pricing programs are established around the world, this issue may recede in importance, but for now it remains one of the potential political concerns that must be understood when designing any carbon-pricing program in the United States.

4.2. Setting the Price or Cap

Different approaches can be taken to setting the level of a carbon tax or emissions cap. From a climate perspective, one can start from either consideration of emission targets or estimates of the damages caused by GHG emissions. For those whose primary interests lie in non-climate policy priorities, such as tax reform, setting the price might have more to do with the amount of revenue needed to serve those priorities. In designing a pricing program, it is also important to recognize that the price or cap is normally not going to be a single number but rather a trajectory—an increasing tax rate or declining cap over a period of years or decades. In any case, setting the level of the tax or cap will likely require balancing a variety of political and economic considerations, such as attempting to ease the economic transition by starting at a relatively low price but allowing the price to increase over time to ensure significant emission reductions.

The United States has put forward emissions targets for 2020 (17 percent reduction from 2005 levels) and 2025 (26 to 28 percent reductions from 2005). These goals could provide the basis for the trajectory of emissions caps, and modeling could be used to estimate the resulting carbon price or to suggest an appropriate carbon tax trajectory. Longer-term targets, for example for 2030 or 2050, could be used as well. However, translating between carbon prices and emissions levels over the long term—whether determining the emissions effects over time of a given carbon-tax system or the prices that would result from a given carbon cap—is complicated by the uncertainties involved in modeling long-term developments in economic and energy systems. (See text box "The Limits of Economic Modeling" in Section 6.)

In theory, setting a carbon price based on damages caused by climate change aims to ensure that the full costs of climate change are incorporated into the prices of carbon-intensive goods and services. The United States and other countries have estimated the "social cost of carbon" (SCC) to gain insight into a key economic question–what damage does an incremental ton of emissions create?[44] The SCC attempts to identify and quantify the major impacts of climate change from around the globe and for centuries into the future. These impacts, which affect public health, the environment, and infrastructure, must be translated into monetary terms and discounted to present values in order to determine the "cost" of the incremental ton of emissions in today's dollars. In the United States, the Office of Management and Budget has directed agencies to use a range of SCC estimates in quantifying the benefits of reducing carbon emissions as part of their regulatory impact analyses. However, the resulting SCC estimates are highly imprecise, due to the major uncertainties surrounding the impact estimates, and also incomplete, because sufficient information to translate certain damages into monetary values is lacking.[45]

For policymakers who are not motivated primarily by the need to address climate change, the amount of revenue needed for particular policy purposes, such as paying for reductions in payroll or corporate tax rates or providing funding for infrastructure, provides an alternative approach for determining the level of the carbon price. Getting the level of the price and its trajectory over time right would still require modeling; while the price could be set with certainty for a carbon tax, the effect of the price on future emissions, and thus on future revenues, would need to be modeled. In addition, if the emissions levels were to fall more quickly than the price were to rise over time, the result would be declining revenues. Net government revenue would also be affected in either type of program by the extent to which tax payments or allowance purchases were deductible business expenses.

4.2.1. Changes in the Carbon Price over Time

Typically, the program will include an increasing price or declining cap that changes over time. With a price that starts at a relatively low level and increases in a predictable way over time, the immediate economic effects of the policy on existing activities are muted, because industries and consumers can adjust gradually to the carbon price. The signal sent throughout the economy—continued emissions will be increasingly costly in future years—is clear and can shift investment and other economic activity that need to take into account future costs and revenue streams. For example, when British Columbia introduced its carbon tax, it established the tax at C$10 per ton CO_2e for the first year (2008), increasing at C$5 per year until it reached C$30 in 2012.[46] A decreasing cap works in the same way, though with uncertainty over the future prices that companies and consumers will face.

In establishing a carbon-price trajectory, policymakers will need to balance the competing objectives of maximizing emissions reductions (accomplished with a faster rise in prices) and tempering the near-term economic effects of the program (accomplished with a more gradually increasing price).

In addition, emission reductions may prove either more or less expensive than anticipated, with the result that the economic and environmental outcomes differ from predictions. For example, in the case of both the EU ETS (after its initial phase) and RGGI, shifting levels of economic activity and (in the case of RGGI) reduced natural gas prices meant that the emission levels have been below the caps. The EU ETS and RGGI have since moved either to lower their caps in future phases or delay the auctioning of allowances to address the unanticipated low level of emissions.[47] Conversely, if emission reductions are more expensive or otherwise more difficult to achieve, a tax might result in fewer emission reductions than expected or a cap-and-trade program might experience higher allowance prices. Unanticipated circumstances can also lead to very high prices in a cap-and-trade program or minimal emission reductions resulting from a carbon tax.[48]

Anticipating such circumstances argues for including an adjustment mechanism in the original program design to minimize the potential for disruptive, unplanned changes or a cost-containment mechanism (see below). In terms of an adjustment mechanism, for example, the program rules might call for monitoring progress and determining whether the price/cap trajectory needs to be adjusted at established points along the way.

4.2.2. Cost-Containment Mechanisms

Price stability provides an important measure of confidence for those investing in emission reductions and clean technology. In the case of a carbon tax, this is an inherent aspect of the program—the design establishes the price of carbon emissions over time. Cost-containment mechanisms can address concerns regarding severe price fluctuations in a cap-and-trade program. If prices rise too high or too quickly, they could result in significant economic harm; if they drop too low, they will not provide the desired price signal for low-carbon investment. As with most program design choices, the decisions as to whether to include cost containment mechanisms typically involve trade-offs, which are discussed below for offsets and price ceilings/floor.

OFFSETS

Offsets are documented emissions reductions that occur outside the regulated sectors, and can be used by regulated entities in lieu of reducing emissions covered by the system. Offsets can reduce program costs (because a regulated entity will utilize offsets when they are less expensive than covered emissions reductions) while achieving the same level of emissions reductions.

Offsets can also provide a way to bring into the program sources that are difficult to address directly. For example, overall emissions from agricultural are often difficult to quantify, but it might be easier to quantify (and verify) the emissions reductions from specific actions, such as improved manure management. Offsets have been included in most cap-and-trade programs, but they have often been controversial because of concerns about whether the offsets really represent emissions reductions that would not have happened anyway.[49] Accurately measuring, reporting, and ensuring the quality of offsets is essential. They must result from actions that would not have been taken without the ability to sell the offset credits, and the emissions reductions must be real, permanent, quantifiable, and verified.[50] The decision as to whether to include offsets typically involves weighing the tradeoff between lower compliance costs and the certainty of achieving the environmental objectives. Including offsets undermines certainty when there are concerns over the validity of the associated emissions reductions.

Offsets are more often associated with cap-and-trade programs than with carbon taxes, but they can be incorporated into either type of program. Under cap-and-trade, the offset credits can be used to cover emissions in the same way as allowances. Under a carbon tax, regulated entities can be allowed to use offsets to reduce the quantity of emissions (or amount of fuel or other proxy for emissions) on which the tax is assessed. In either case, the system would need to include rules for establishing definitions of valid offsets and limits, if any, on their use.

PRICE CEILINGS AND FLOORS

A price ceiling limits how high (or how fast) allowance prices can rise, and a price floor limits how low they can fall. Used together, they form a price collar. These mechanisms are relevant only for cap-and-trade programs, and make those programs more like a carbon tax by increasing certainty about future prices. For example, the California cap-and-trade program includes a price floor that is implemented as a minimum price on the auction of its allowances. The floor was initially set at $10 per ton of CO_2e, increasing annually at the rate of inflation plus five percent.

A program might include a ceiling, a floor, or both. The purpose of the ceiling is to prevent economic disruption from very high carbon prices or from prices that rise too quickly. In general, a price ceiling will result in higher emissions over time, since the primary response to hitting the ceiling is likely to be an increase in the supply of allowances. A price floor can be used to prevent the collapse of the carbon price, ensuring that clean energy investments will at least be supported by a known minimum carbon price.

The drawback of price ceilings and floors is that they create inefficiencies in the markets for emissions allowances. Buyers and sellers might both wish to trade at a price higher than the ceiling or lower than the floor, but they are prohibited from doing so. Policymakers must determine whether the benefits noted above are worth the costs of these market inefficiencies.

4.3. Reporting and Verification

A key prerequisite for a successful system is a robust reporting and verification system. Such a system needs to be appropriate to the point of implementation; it is critical to have accurate and verified reporting of the emissions tied to the entity in the system that is responsible for them. An upstream approach involves reporting the production and imports of fossil fuels (often already done for other purposes) and translating the fuel report data into equivalent emissions. Similarly, downstream or intermediate approaches mean that reporting must accurately tie the emissions to the responsible entity.

Because the addition of a carbon price creates direct economic consequences, verification of entities' emission reports is essential. Different approaches to verification are possible, from independent third party verification to self-certification with strong penalties. To provide confidence that those covered by the program are providing consistent and accurate information, the reporting must be complete, accurate, consistent, transparent, and without material misstatement.[51] Piggy-backing on existing reporting systems to the fullest extent possible simplifies implementation for both business and the government. In designing a carbon-pricing program, policymakers must determine how to develop a system for reporting and verification that is accurate and reliable while also minimizing administrative and regulatory burdens to the extent possible.

4.4. Complementary Policies

A price on carbon can be a key element of a broader climate policy because it provides significant signals throughout the economy that encourage a shift to lower carbon energy and products. However, additional programs and policies will likely be needed to help provide a cost-effective path to deep greenhouse gas emissions reduction in the coming decades.

4.4.1. Addressing Emissions and Sources Outside the Program Scope

A carbon-pricing program is unlikely to address all sources of greenhouse gas emissions, because some emissions are too dispersed or hard to measure to be included in a program without overburdening administration. To reduce greenhouse gas emissions throughout the economy, additional approaches can encourage or require emission reductions from sources not covered by the carbon price. Such approaches might include offset programs allowing crediting of emission reduction activities, direct regulation, investments in R&D, or incentive programs.

4.4.2. Energy Efficiency

Energy efficiency has many well documented market barriers, such as split incentives between building owners and tenants, up-front costs, and lack of information, which hamper the achievement of the full range of cost-effective opportunities.[52] Applying a carbon price will strengthen the market signals and provide incentives for additional energy efficiency, but will not eliminate market barriers. For this reason, many programs that currently provide incentives to efficiency might still be needed, even with a carbon-pricing system in place. Carbon revenues, however, could provide significant additional funding to help support or expand such programs over time; this has been the case with the RGGI program. The Analysis Group has shown that, in the first three years of RGGI's operation, RGGI added $1.6 billion in net present value to the economies of the participating states, in large measure thanks to spending auction revenues on energy efficiency programs.[53]

4.4.3. Regulations and Standards

Market mechanisms such as a carbon tax or cap-and-trade program are often considered more cost effective in achieving emission reductions than more traditional regulations and standards, assuming that relevant markets (especially for energy efficiency and innovation) are functioning close to the competitive ideal.[54] For policymakers who view a carbon price as a means to other policy goals, avoiding these types of regulations and standards might be seen as a goal of implementing a carbon price.

However, in certain circumstances, a carbon price might be less effective at reducing greenhouse gas emissions than alternative policies; markets are not perfect, and in some cases prices will not be effective. For example, even a low carbon price applied uniformly across the U.S. economy would likely achieve significant power sector reductions, where significant low-cost opportunities are available, but a higher carbon price would be required to have meaningful effects in the transportation sector. The relatively low rate of fleet turnover slows the rate at which changes in vehicle technology lead to emission reductions, and shifting from gasoline and diesel to lower carbon fuels will require both vehicle and fueling infrastructure changes. Given that vehicle technology, fueling infrastructure and purchase patterns have little near-term response to a carbon price, pairing a carbon price with continued strong vehicle and alternative fuel standards is likely to prove a more effective approach to achieving deeper medium-term emission reductions, with the added benefit of reducing reliance on oil imports.

Similarly, a major near-term response to a carbon price in the electricity sector in the United States would likely be the increased use of natural gas. This could provide significant emission reductions for the next decade, but if deeper reductions are desired in the medium to long term, a continued shift to use of zero- and near-zero emissions sources, for example, renewables, nuclear power, and coal plus carbon capture and sequestration, is likely to be needed. Continued support through standards and other policies for these technologies might be a means to achieving such medium- to long-term emission reductions.

4.4.4. Investing in Enabling Technologies

Many emission reduction opportunities depend on other technologies that are not likely to be stimulated by a carbon price because of the same market barriers that hamper energy efficiency investments. For example, technical upgrades to the national grid would enable an increased contribution of power from distributed electricity generating sources, including renewables. A carbon price by itself is unlikely to provide sufficient incentive for investment in the grid, because any benefit from increased distributed power generation does not tend to accrue to parties investing in the grid. Public investment in infrastructure and enabling technologies might be able to unlock significant emission reduction opportunities across the economy.

4.4.5. Research and Development

Achieving the deep emission reductions needed by mid-century will require significant technological innovation and advancement. Increased support for research and development is likely to speed the development and deployment of new and improved technologies that may significantly reduce the cost of achieving the long-term emission goals. See Section 5.3.2, below, for further discussion on using revenues from a carbon-pricing program to support innovation in emissions-reduction technologies.

5. COMMONLY PROPOSED USES OF CARBON PRICING REVENUES

According to the Environmental Protection Agency, U.S. greenhouse gas emissions in 2012 were more than 6.5 billion metric tons of carbon dioxide equivalents.[55] A carbon tax, or a cap-and-trade program with allowance auctions, therefore has the potential to raise well over $100 billion per year at a moderate price of about $15 per ton, depending on its initial level and scope (for reference, in 2013 the corporate income tax brought in roughly $273 billion of revenue).[56] In an economy with a gross domestic product of nearly $17 trillion, this is a relatively small but far from negligible sum.[57] For a Congress looking for new sources of revenue to finance tax reform or avoid cutting politically popular tax expenditures, a carbon price could receive some unlikely support—potentially even from those who are not focused on reducing GHG emissions, but who see a carbon tax as more palatable than other taxes or as a potential substitute for regulations.

How any revenue gets spent will, of course, be decided by the legislative process. Yet, because it is one of the most critical and politically contentious elements of carbon-pricing policy design, with implications for individuals, companies, and the economy, this paper examines some of the most commonly proposed uses of revenue.

Policymakers have no shortage of competing priorities from which to choose, and each presents a wide range of advantages and disadvantages. Many revenue uses could potentially provide a "double dividend" of reduced greenhouse gas emissions and improved economic efficiency. Indeed, previous analysis by WRI and others indicates that well-designed policies to combat climate change can enhance economic growth.[58]

While the prospect of significant new revenue can bring many people to the table for a conversation, disagreements over how to slice the pie can make the resulting discussions difficult. For example, some proponents[59] of a carbon tax insist on a revenue-neutral offsetting of the carbon tax with an attendant reduction in other taxes, while others[60] advocate for returning revenues to households, reducing the deficit, or spending the money on other priorities.

Different stakeholders have differing views of revenue neutrality. Many conservatives would consider a carbon tax to be revenue neutral only if all revenues were used to reduce other taxes, with the federal government seeing no net increase in tax revenues, and no new spending.[61] Proponents of a fee-and-dividend policy, on the other hand, view their approach as revenue neutral as well, in that all carbon-tax revenues are returned to households rather than used by the government for other purposes.[62]

In this section, we'll review many of the most commonly suggested uses of revenues from a carbon tax or allowance auctions under cap-and-trade, including:

- Reducing "distortionary" taxes such as payroll, corporate and personal income taxes;
- Reducing government deficits;
- Investing in job training;
- Returning the revenue to households or electricity consumers;
- Addressing regional disparities;
- Investing in economic competitiveness;
- Investing in technologies that enable communities to adapt to climate change; and
- Investing in clean technology innovation.

For each alternative, we provide an overview of the economic and political strengths and weaknesses, and real world examples, where available. We have grouped these revenue uses by their primary intended effect but, as illustrated in Table 3 below, spending revenue can have a wide array of economic impacts.

5.1. Encourage Economic Growth

5.1.1. Reduce Distortionary Taxes

Economists typically single out several categories of taxes —such as those on labor, investment, and capital—as being "distortionary;" that is, they serve to discourage things like work and investment, which are encouraged elsewhere in the tax code and by other policies. Using some or all of the revenue from a carbon tax to reduce these distortionary taxes, including payroll and corporate and personal income taxes, can result in increased economic growth and output.

Economists from across the political spectrum are among those most keen to use carbon tax revenue to offset distortionary taxes elsewhere.[63] Doing so, they argue, would make the tax code more efficient, and would reduce disincentives to work and invest. Among the taxes most cited as ripe for reduction are payroll taxes and those on corporate income. The former are more regressive than the tax code as a whole—in 2014, only the first $117,000 of income was subject to Social Security payroll taxes—and they increase the cost of labor, discouraging employers from additional hiring and reducing the incentive to work. Taxes on corporate income are passed through to customers, employees, or shareholders, and are an inefficient means of taxing any of these groups. They can also discourage companies from investing and establishing or keeping their operations in the United States, which nominally has the highest marginal corporate income tax rate in the developed world.[64] However, the effective tax rate—what companies actually pay—is typically far less than this statutory rate, for a variety of reasons.[65] Using carbon-tax revenue to reduce either, or both, of these taxes can pay dividends throughout the economy, including greater economic growth and increases in overall employment.

Such a "revenue-neutral tax swap" is among the most common policy proposals from advocates of carbon taxes. Typically, in these proposals, most or all of the revenue from the carbon tax goes toward reducing other taxes, so there is no increase or decrease of revenue to the government. Generally speaking, most studies on the topic have found that, while reducing taxes on either labor or capital can offset at least some of the negative effects on economic output from a carbon tax, reducing the top tax rate on capital would be most effective at reducing the inefficiency caused by the tax system. For example, McKibbin et al. (2012) found that implementing a tax on carbon and reducing the marginal tax rates on capital would result in greater economic growth in the coming decades than would be the case in a business-as-usual scenario.[66] But the authors found that cutting marginal tax rates on labor instead would result in a small net negative effect on total economic output. And Carbone et al. (2012) found that cutting taxes on capital was more beneficial than cutting taxes on labor or consumption from an economic growth standpoint (though with no provision for issues of distributional equity), and this finding applied to both present and future generations.[67]

While reducing capital tax rates might be the most efficient use of revenue, studies have found that reducing tax rates on labor can offset at least a significant portion, and perhaps all, of the potential adverse economic impacts of the carbon tax. For example, a 2011 OECD study found that when "revenues [from allowance auctions of an emissions-trading program] are used to reduce taxation on labor, the pace of employment growth would accelerate…without any loss of purchasing power for workers."[68] According to Lawrence Goulder, an economics professor at Stanford University, the greater the inefficiency in the current tax system, the more likely it is that using carbon-tax revenues to cut labor taxes will lead to an increase in overall employment and economic growth.[69] See Section 6 for more details on the economic effects of reducing distortionary taxes.

5.1.2. Reduce Deficits

Interest payments on the national debt can potentially crowd out other investments, dampening economic growth and output. Some economists argue that future tax rates will need to increase in order to make interest payments and pay down the debt, and that the expectation of future tax increases will discourage work and reduce savings.[70] Some carbon-tax advocates therefore argue that policymakers have good incentive to use revenues from the tax to reduce annual deficits and pay down the debt, leading to long-term economic growth.[71] (For more discussion of the economic impacts of using carbon-tax revenue to reduce the national debt, see Section 6).

Much like reducing distortionary taxes, proponents of using carbon-tax revenue to address the national debt are trading one tax for another—in this case, offsetting a potential future tax increase, or allowing for a potential future tax reduction (government deficits can be rolled over forever, so whether to raise taxes to pay down the debt can be as much a policy question as an economic one). Although the issue of the rising national debt has faded somewhat after the deficit peaked in fiscal year 2011, many policymakers are still weighing the available options for long-term solutions to a potentially destabilizing fiscal problem.[72]

Ireland implemented a carbon tax in 2010, covering most of the carbon dioxide emissions from sectors not already included in the European Emissions Trading Scheme. Following the 2008 fiscal crisis, the decision was made to institute a carbon tax in lieu of other austerity measures and tax increases, and use much of the revenue to reduce annual budget deficits. In the years since its implementation, the carbon tax has contributed to a dramatic slowdown in the growth rate of the Irish national debt and has led to a reduction in emissions from covered sectors.[73, 74] While the circumstances under which the carbon tax was first implemented were extraordinary, this case nevertheless illustrates the way in which a carbon tax can help address national debt.

5.2. Ease Transition Costs for Individuals, Sectors, and Regions

5.2.1. Invest in Job Training

By inducing changes in behavior and purchasing patterns, a carbon price will, over time, benefit some industries (renewable energy, energy efficiency, clean vehicles, etc.) at the expense of others, especially coal and oil production. While such structural shifts in the economy may not significantly affect overall employment, and are a regular part of growth and economic shifts, policymakers may nonetheless decide to enact measures to ensure those that are adversely affected by a carbon tax are able to transition quickly and find new jobs. Federal support for job training programs,[75] spending on education, and other uses of carbon tax revenues can limit the impact of a carbon tax on employment in particular industries, or accelerate a transition to clean energy jobs.[76] In some cases, new initiatives for displaced workers can build upon existing federal programs.[77]

Some studies have found benefits to both short-term and long-term job training programs. Low-cost, short-term programs—those designed to get a person back to work as quickly as possible—have been found to reduce the time spent unemployed and increase job stability, and they are cost effective in the near term. Participants in long-term

Box 5 | **British Columbia's Carbon Tax—Proving Emissions Reductions and Economic Growth Can Co-Exist**

The Canadian province of British Columbia provides a real-world example of a carbon tax that reduces other taxes and is intended to be revenue neutral. British Columbia implemented a carbon tax of C$10 per metric ton of CO_2 equivalent in July 2008, which increased by C$5 per year to C$30 per metric ton in 2012; the tax will remain at C$30 per metric ton through 2017. The tax was designed to be revenue neutral, as the province anticipated using the revenues from the carbon tax to reduce a range of personal and business taxes. Those measures include providing a tax credit for low-income households, reducing the two lowest personal income tax bracket rates by five percentage points, and cutting the general and small business corporate income tax rates by two percentage points.[a] In its first few years, however, the tax was actually revenue negative, in part because the price on carbon reduced demand more than anticipated, leading to carbon-tax revenues that were lower than the province had projected. British Columbia therefore took in less money from its carbon tax than it cut from other taxes.

A 2013 analysis of British Columbia's carbon tax found that it has been successful in reducing greenhouse gas emissions without adversely affecting economic growth. In the five years following implementation, per capita greenhouse gas emissions fell 18.8 percent relative to the rest of Canada, while GDP growth kept pace with the rest of Canada. Moreover, the province's personal income tax rates are now the lowest in the country, and its corporate tax rates are among the lowest in North America.[b] British Columbia therefore provides an example of one way in which governments can reduce distortionary taxes, address regressivity, and reduce emissions–all while ensuring that no income group is made worse off. We should note, however, that some observers question British Columbia's suitability as an example for a carbon tax in the United States, especially given the differences in sources of electricity generation between the two regions.[c]

Notes:

a. British Columbia Ministry of Finance. February, 2012. "Budget and Fiscal Plan, 2012/13-2014/15." Available at http://www.bcbudget.gov.bc.ca/2012/bfp/2012_Budget_Fiscal_Plan.pdf

b. Elgie, S., and J. McClay. 2013. "BC's Carbon Tax Shift After Five Years: Results." Sustainable Prosperity. July. Available at: http://www.sustainableprosperity.ca/dl1026&display

c. See, for example, Marlo Lewis, "Why British Columbia's Carbon Tax is Not Applicable to America," OnPOINT, September 16, 2014, https://cei.org/sites/default/files/Marlo%20Lewis%20-%20Why%20British%20Columbia's%20Carbon%20Tax%20Is%20Not%20Applicable%20to%20America_0.pdf.

training programs, which are aimed at giving workers the skills they need to succeed in a new field, benefit from even more job stability and higher lifetime earnings.[78] On-the-job training programs have also proven cost effective. A study of 16 trades across the Canadian economy found that employers received C$1.47 in benefits for every C$1 invested in apprenticeship programs.[79]

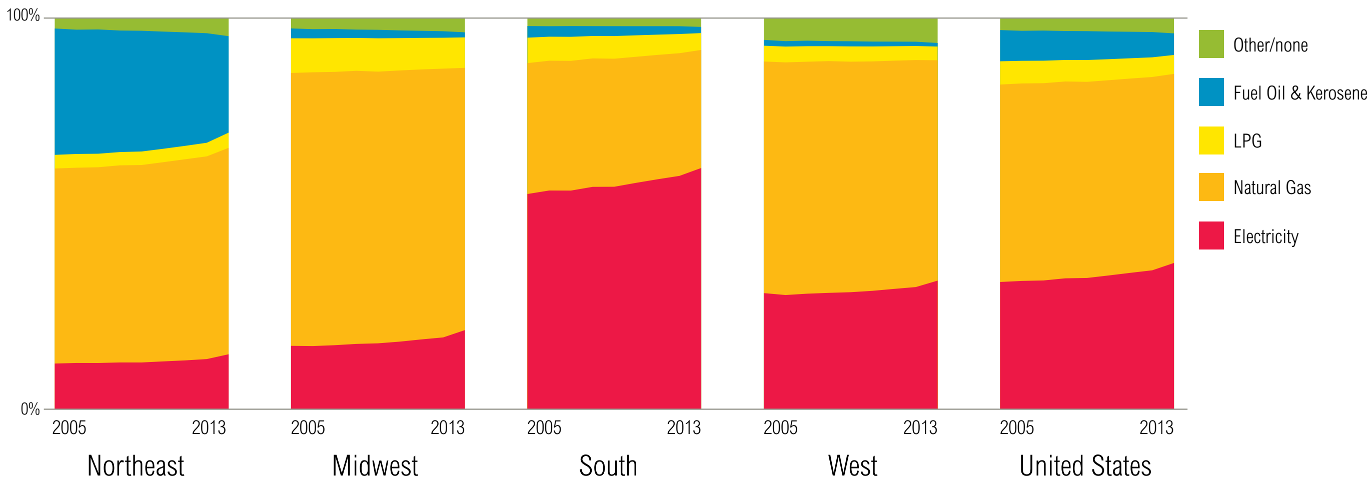
There are few examples of existing carbon-pricing policies that re-invest revenues into job-training programs, but the recently enacted carbon tax in Chile may prove instructive as it is implemented. In September 2014, as part of a broader tax reform, Chile enacted a $5-per-ton tax on carbon emissions from power plants in order to reduce its fossil fuel imports and encourage renewable energy development. It has been proposed that, when it goes into effect in 2018, most of the revenues from the carbon tax, and other tax increases, will go toward education initiatives. While this policy will not likely pay immediate economic dividends, Chile views it as a long-term investment in the economy and a way to reduce economic inequality. It will be a case study to follow in the years to come.[80]

5.2.2. Return Money to Households or Electricity Consumers

The notion of sending a quarterly or annual check to households to offset the increase in commodity prices resulting from a carbon tax—known as "fee-and-dividend"—has grown in popularity in recent years, largely because of its perceived fairness and simplicity. By dividing carbon-tax revenues equally amongst all consumers, programs ensure that lower income households receive as much or more in revenue as they spend on the tax, and a sizeable fraction of households would be net winners on a monetary basis.[81] Unlike proposals to reduce other taxes, fee-and-dividend programs do not have to contend with the problem of declining carbon-pricing revenues that must still fund permanent tax cuts. Also, by giving revenues to individuals or groups, policymakers can potentially increase public support for continued carbon pricing and make such a policy more "sticky," because any reduction in price or repeal of the policy would reduce or eliminate those dividends.[82]

However, some commentators do not agree that implementation would be so straightforward. Many also disagree with the characterization of this as a revenue-neutral option. Providing dividend checks would likely involve at least a small amount of new spending and growth of government to determine and distribute the dividends. Fur-

Figure 6 | **Primary Home Heating Fuel, by Census Division**



Source: "Everywhere but Northeast, Fewer Homes Choose Natural Gas as Heating Fuel," U.S. Energy Information Administration, September 25, 2014, http://www.eia.gov/todayinenergy/detail.cfm?id=18131.

thermore, a policy that provides equal dividends to every individual could support the perception that a carbon tax would affect some states and regions more than others, though these regional disparities may be overstated (see additional discussion in Sections 5.2.3 and 6.2.2).

Various methods can be used to administer rebate checks in a fee-and-dividend program. Existing federal programs that disburse money, such as Social Security or the Temporary Assistance for Needy Families program, can supplement households' monthly checks with carbon-tax revenues. For non-participants in those programs, the government can send a monthly check, or give annual tax refunds. All of these means of returning revenues carry various administrative burdens and costs.

Several examples of redistributing revenues to households may be instructive to policymakers. In 2008, Switzerland implemented a carbon tax on hydrocarbon fuels, which applies to all individuals and those companies that do not participate in the national cap-and-trade program. Revenues are redistributed to taxpayers in the form of lower health insurance premiums for individuals, and are returned to companies based on their total payroll. While few studies have analyzed the economic impacts of Switzerland's carbon tax, since its implementation in 2008 Switzerland has kept pace with, or exceeded, other developed countries in a variety of economic indicators.[83]

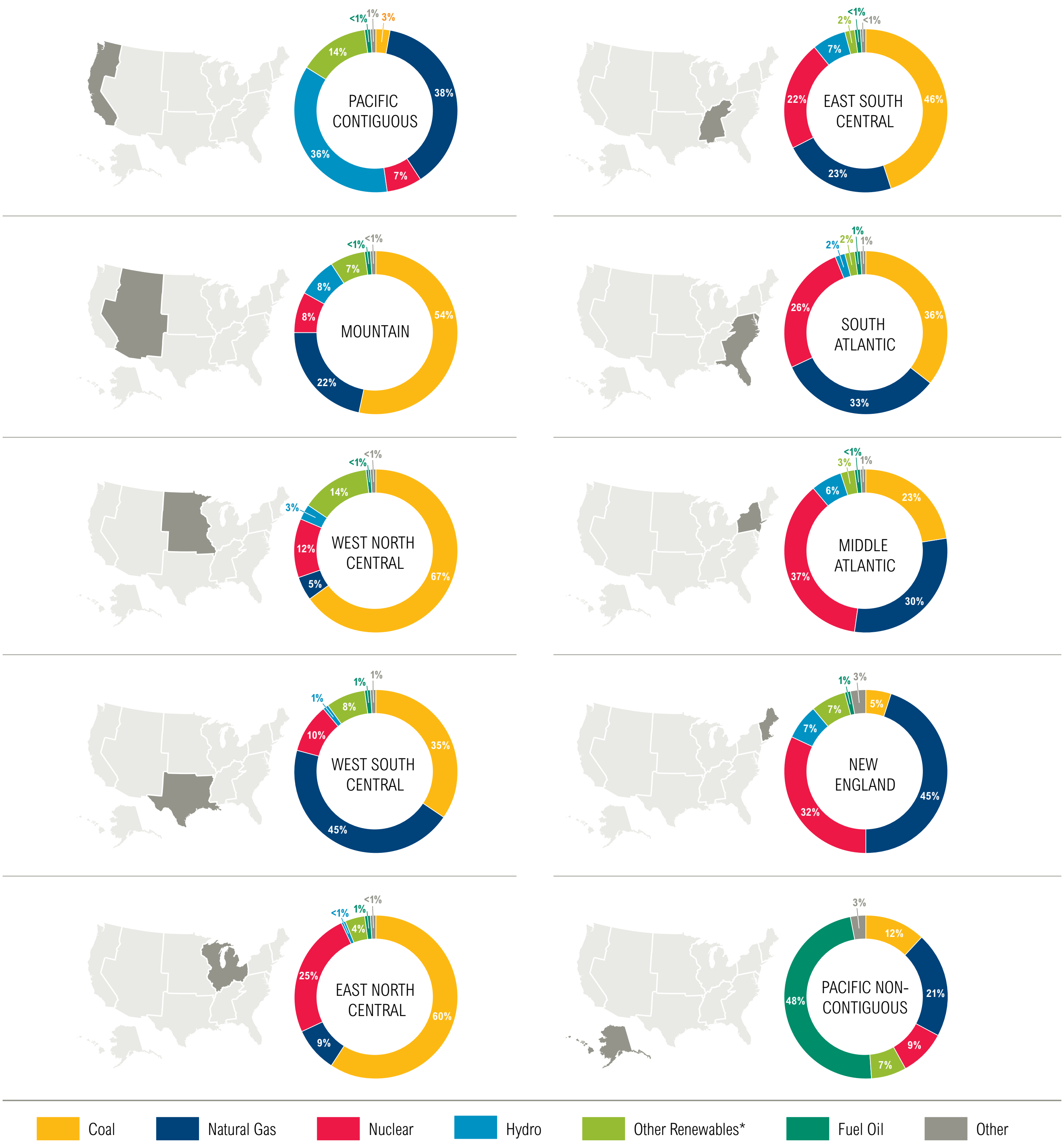
In the United States, there is precedent for recycling revenues to households, though as part of very different programs. The Alaska Permanent Fund returns a portion of that state's oil revenues to its citizens every year. And California is recycling some of the revenue from its allowance auctions back to households in the form of semi-annual rebates on electricity bills, administered by the investor-owned utilities (IOUs) in the state, as directed by the California Public Utilities Commission. The revenue for the rebates comes from a reverse auction of allowances that were distributed to investor-owned utilities under the cap-and-trade program rules.

5.2.3. Address Regional Disparities

Some regions in the United States are more heavily dependent on the production or consumption of fossil fuels than others, and so will be differently affected by the implementation of a carbon price. A reduction in demand for coal, for example, could have adverse impacts on the coal-producing regions of Wyoming, West Virginia, and Kentucky, among other states.[84] Residents of states that get most of their electricity from coal would likely see their monthly electric bills increase in the near term. Many households in the Northeast, heavily reliant on heating oil, would see wintertime energy costs increase.[85]

However, recent analysis suggests that regional disparities in the consumption of carbon-intensive goods are not as great as once feared.[86] Regions that are more heavily dependent on one fossil fuel tend to be relatively less dependent on others—for example, while the Northeastern states burn more oil for home heating, their electricity mix is relatively less dependent on coal (see Figures 6 and 7).[87]

Figure 7 | **Electricity Generation Fuel Mix, by Region**



*Includes generation by agricultural waste, landfill gas recovery, municipal solid waste, wood, geothermal, nonwood waste, wind, and solar.

Source: "Different Regions of the Country Use Different Fuel Mixes to Generate Electricity," Edison Electric Institute, August 2014, http://www.eei.org/issuesandpolicy/generation/fueldiversity/Documents/map_fuel_diversity.pdf.

As Tufts University Economics Professor Gilbert Metcalf has found, returning carbon-pricing revenues to households via payroll tax reductions and Social Security can all but eliminate regional disparities while making all regions better off.[88]

Nevertheless, such concerns were a major sticking point in the debate surrounding how to apportion allowance revenue under the American Clean Energy and Security Act (ACES). To mitigate against increases in energy prices that would affect some regions more than others, the bill's authors devoted some allowance revenue to electricity and natural gas local distribution companies, as well as state programs that support home heating. The notion that some regions would be more adversely affected than others will likely be a contentious issue in any political debate surrounding a carbon price. This issue is discussed in more detail in Section 6, below.

5.2.4. Invest in Economic Competitiveness

Many industries, especially manufacturing, rely heavily on energy derived from fossil fuels as a primary input. There is concern that, if a price on carbon results in the prices of those fuels increasing to the point that it is cheaper for companies to relocate their operations elsewhere, some manufacturing jobs could be lost. While recent studies suggest that this may be less of a problem than previously thought (see Section 6.4), many advocates of a national climate policy call for measures to ensure that American industry remains competitive in the global marketplace. In a cap-and-trade program, this can be achieved by distributing free allowances to industries identified as vulnerable to competitive pressures because of the carbon price (often called energy-intensive trade-exposed industries).

Under a carbon tax, the most frequently discussed corresponding policy tool is a border adjustment, whereby imports from countries without equivalent policies are assessed a tariff based on the carbon content of their goods, and exports given a rebate of the tax paid in the manufacture of the good. If the trading partner has a climate policy in place that implicitly or explicitly prices carbon emissions equivalently to the U.S. domestic carbon tax, the border adjustment can be waived. If the trading partner has a climate policy that is less stringent than that of the United States, the border adjustment can be reduced accordingly. This creates difficult questions for regulators, such as how to quantify the effect of regulations that reduce emissions and how to determine the stringency of a suite of climate policies in other countries. Further discussion on border adjustments can be found in Section 6.2.3. We should also note that many of the United States' largest trading partners already have carbon-pricing policies in place. See Appendix A for more details.[89]

Of course, some portion of carbon-tax revenues can be returned to energy-intensive trade-exposed industries, as a means of sustaining international competitiveness (and if the corporate income tax rate is cut as part of a carbon-tax swap, many of these companies will already receive a tax break). As long as the revenue is not returned to these industries on the basis of their emissions, the price signal to encourage companies to reduce their emissions will remain. However, returning revenues to energy-intensive trade-exposed industries does not provide a way to address the fact that some other jurisdictions already apply a carbon price.

Denmark instituted a carbon tax in 1992 and, since 1995, has been returning a portion of revenues to various industries. In order to advance the goal of changing industrial behavior in order to reduce greenhouse gas emissions, the Danish government also provides a 25 percent reduction in a company's tax burden if it signs an agreement to take steps to reduce its energy use. The Danish carbon tax has proven effective at reducing emissions, especially from industry. Industrial emissions fell 23 percent in the decade following the implementation of the carbon tax, and per capita emissions in Denmark declined 15 percent between 1990 and 2005.[90]

Wind projects in Denmark also receive revenues from the country's carbon tax, which has helped the country become a global leader in wind power. Denmark is home to the wind turbine manufacturing operations of Vestas and Siemens, which together have nearly 20 percent of global market share,[91] and nearly 40 percent of Danish electricity consumption in 2014 came from wind power, the highest figure in the world.[92]

5.3. Support Related Goals

5.3.1. Respond to Climate Change

Some proponents of carbon pricing believe that revenue would be best spent on infrastructure that helps make communities more resilient to the impacts of climate change.[93] Such investments can serve a variety of purposes, including:

- Increasing the resiliency of water, transport, energy, and other forms of infrastructure that are vulnerable to extreme weather and other effects of a changing climate
- Reducing emissions and improving the resiliency of the electric grid by building out renewable energy and distributed generation infrastructure, and expanding smart grids
- Creating jobs through the spending of public money on needed investments in adaptation and resilience

Spending some carbon-tax revenues on adaptation allows for a carbon tax to address both the causes and effects of greenhouse gas emissions simultaneously.[94] The World Bank estimates that global investments to adapt to a changing climate will need to reach $70-100 billion per year through 2050—and even more if warming exceeds two degrees Celsius.[95] Estimates of adaptation costs in the United States vary widely, but could reach tens of billions of dollars per year by the middle of the century.[96]

Governments can also choose to spend revenues from a carbon tax on clean-energy initiatives designed to achieve additional emissions reductions, and possibly reduce the costs of complying with the carbon price. These initiatives can take the form of investments in renewable energy, demand-side or supply-side energy efficiency, building retrofits, or other measures designed to reduce the carbon intensity of energy use.

There are precedents for governments investing carbon-pricing revenues to help spur additional emissions reductions, though on a smaller scale. Germany currently devotes all revenues from its allowance auctions to domestic and international climate initiatives. These include "innovative projects" in Germany's industrial sector, other energy-saving domestic initiatives, and international climate finance to help spur emissions reductions in other countries.[97] In the United States, RGGI states devoted over 70 percent of allowance auction revenues to energy efficiency and renewable energy projects between 2009 and 2012—measures that RGGI estimates will avoid eight million tons of CO_2 emissions and save consumers more than $2 billion in energy savings.[98]

5.3.2. Encourage Investment in Clean Technology Innovation

By changing the relative prices of goods, and creating financial incentives to reduce emissions, a price on carbon can stimulate innovation. Alone or in conjunction with complementary policies (as discussed in Section 4.4), a carbon price encourages companies to develop new, cleaner, more cost-effective technologies and processes. As the Organisation for Economic Co-operation and Development has written:

> *"...environmentally related taxes can provide significant incentives for innovation, as firms and consumers seek new, cleaner solutions in response to the price put on pollution. These incentives also make it commercially attractive to invest in R&D activities to develop technologies and consumer products with a lighter environmental footprint, either by the polluter or by a third-party innovator... Even for firms that do not have the resources or inclination to undertake formalised R&D activities, the presence of environmentally related taxation provides increased incentives to bring in the latest technologies that have already been developed elsewhere."*[99]

It is highly unlikely that a low to moderate carbon tax would achieve the level of emissions reductions the Intergovernmental Panel on Climate Change (IPCC) recommends in order to prevent the worst impacts of climate change.[100] Therefore, some supporters of a carbon tax propose using some revenue to encourage innovation in technologies or practices that could help reduce greenhouse gas emissions.[101] The federal government already invests in research and development—the Department of Energy supports renewable energy, fossil energy, nuclear energy, and energy efficiency—and those programs have paid dividends in the form of technological advancement and lower costs to businesses and consumers.[102] But, while we can make significant emissions reductions with technology available today, in order to achieve much deeper emissions reductions by mid-century we will need either innovative breakthroughs or continuous improvements in the existing suite of technologies, or both.

Devoting some carbon-tax revenue to R&D can potentially help to reduce the long-term costs of complying with the tax and reducing emissions, in several ways. First, as reaffirmed in a pair of 2014 reports, both the public and private sectors often underinvest in innovation:[103]

> *"Financing for research and development in the power sector does not match the scale of the challenge [of reducing emissions]. Power company funds spent on research and development were only $280 million in 2011, or approximately 0.05 percent of power sec-*

Table 3 | **Revenue Options, and the Policy Goals they are Designed to Achieve**

		POLICY GOAL						
		Correct for Regressivity	Foster Economic Growth	Cut Taxes	Preserve or Create Jobs	Additional Emissions Reductions	Reduce Costs of Compliance	Revenue Neutrality
REVENUE OPTION	Reduce Distortionary Taxes	?[a]	✓	✓	✓	✗	✗	✓
	Reduce Deficits	✗	✓	✓	?[b]	✗	✗	✓
	Invest in Job Training	✗	✓	✗	✓	✗	✗	✗
	Return Money to Households	✓	?[c]	✗	?[e]	✗	✗	?[d]
	Address Regional Disparities	✗	✓	✗	✓	✗	✗	✗
	Invest in Economic Competitiveness	✗	✓	✗	✓	✗	✓	✗
	Respond to Climate Change Impacts	✗	✓	✗	✓	?[e]	✓	✗
	Encourage Investment in Innovation	✗	✓	✗	✓	✓	✓	✗

Notes:

a. If payroll or other labor taxes are cut, there could be a small improvement in the overall progressivity of the tax code, which could address income inequality in a modest way. If carbon tax revenues are used to reduce corporate income taxes, any such effect would be muted.

b. Depending on whether and how additional revenue is raised from alternative sources.

c. Proponents of a fee-and-dividend approach claim that it will foster economic growth, but the economic literature is divided on this. See Section 6 for more detail.

d. The revenue neutrality of returning all carbon-tax revenues to households in the form of dividends is in the eye of the beholder. Some proponents, such as Citizens Climate Lobby, believe fee-and-dividend to be revenue neutral (see https://citizensclimatelobby.org/carbon-fee-and-dividend/). Others disagree, pointing to the need to devote some revenues to the administration of the program, and the belief that dividends are a form of government spending and not tax reduction.

e. The evidence is mixed as to whether these revenue uses achieve the stated policy goals.

tor sales. By comparison, company funds spent on research and development were 11 percent of sales for pharmaceuticals, eight percent for computers and electronics, five percent for professional services, and three percent for general manufacturing."[104]

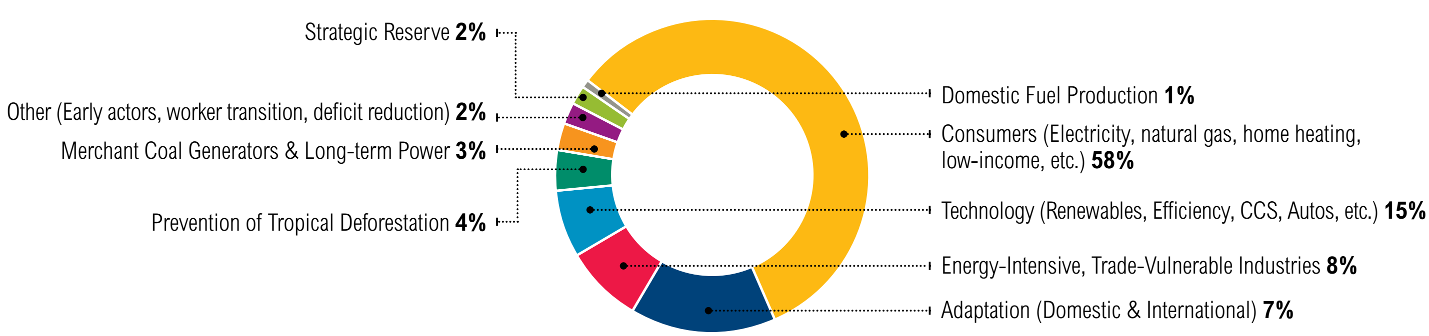
Government support of research, development, and demonstration of measures to reduce emissions from energy, transportation, agriculture, or other sectors can fill the gap created by private sector underinvestment, and help bring down the costs of breakthrough technologies. This, in turn, could help to drive more cost-effective emissions reductions and reduce the cost of complying with the carbon tax.[105] Polls suggest that public support for a carbon tax grows when revenue is used for R&D (though many polls do not ask respondents what level of tax they would be comfortable with).[106]

5.4. Mixing and Matching

Of course, policymakers will likely choose several options for using carbon-price revenues, and divide the money between them. In this way, a carbon-pricing policy can achieve (or contribute to achieving) a number of the goals outlined in this section. For example, in its analysis of a federal cap-and-trade program, the Center for Budget and Policy Priorities found that only 14 percent of allowance auction revenue was needed to ensure that the bottom quintile of the income distribution was not adversely affected by higher energy prices.[107] The 2009 ACES Act followed this guidance and devoted about 15 percent of allowance revenue to lower income households. To achieve a variety of policy goals, the bill's authors also proposed giving free allowances (or devoting allowance revenue) to electricity and natural gas distribution companies to protect consumers from higher energy prices, to energy-intensive and trade-exposed industries, to innovation and R&D, and for adaptation investments (see Figure 8).[108]

California is currently putting many of those principles into practice.[109] In addition to the semi-annual rebates on electricity bills mentioned above, the state is devoting some of its allowance revenue to transportation infrastructure (including high-speed rail and other mass transit), affordable housing, energy- and water-efficiency projects, support for low-income and minority communities, and several other smaller programs.[110] While distributing revenues across a variety of end-uses can diminish the effectiveness in achieving certain policy goals, it may allow a federal carbon-pricing program to address multiple priorities. See Table 3 for a summary of how various revenue options can satisfy one or more policy goals.

Figure 8 | **Cumulative Distribution of Allowances Under ACES, 2012-2050**



Source: "Distribution of Allowances Under the American Clean Energy and Security Act (Waxman-Markey)," Pew Center on Global Climate Change, August 2009, http://www.c2es.org/docUploads/policy-memo-allowance-distribution-under-waxman-markey.pdf.

6. ECONOMIC EFFECTS OF A CARBON PRICE

Like other climate and tax policies, pricing carbon will necessarily have economic impacts. The economic literature on a carbon tax's effects on economic growth and output, jobs, income, regional disparities, and industrial competitiveness is both deep and wide. These studies can tell us much about how a carbon tax can change an economy as it transitions from being highly dependent on fossil fuels toward a lower carbon future.

The design choices discussed in Section 4 help to determine the economic effects of a given carbon-pricing policy, among the most consequential decisions for policymakers in this regard is how to spend the revenues.

6.1. Macroeconomic Impacts

6.1.1. Effects of a Carbon Tax on Economic Growth

The effect of a carbon tax on economic growth depends greatly on the details of how the tax is designed, and especially on what is done with the resulting revenues. Studies have found that while some uses of carbon tax revenues would produce a net drag on economic growth, other uses would provide a net stimulus to the economy. Of course, as with all economic modeling, much depends on the modelers' assumptions (see Box 6 for further discussion on the limits of economic modeling). Here, we review the economic literature to see how the choices made by policymakers regarding the structure of the tax and the use of revenues will affect economic growth.

CARBON TAX POLICY PROPOSALS AND THEIR EFFECTS ON ECONOMIC GROWTH

Economists have undertaken considerable modeling and research on the economic impacts of various policy proposals and uses of revenues; those most commonly suggested are discussed in Section 5. Here, we'll review some of the economic literature to see how these revenue uses will impact growth.

REDUCING DISTORTIONARY TAXES. Using carbon tax revenue to "pay for" reductions in taxes on capital or labor can partially or fully offset the adverse effects of a carbon tax on economic growth, though there is disagreement among economists as to which of these uses of carbon tax revenue would lead to greater economic growth. Economists refer to taxes on capital and labor as distortionary, because they reduce the incentives to work and invest—generally, things that policymakers want to encourage in a healthy economy. By using carbon tax revenue to reduce existing tax rates on corporate income, personal income, or payroll taxes, policymakers can increase the incentives to work and invest while reducing the incentive to over-consume fossil fuels. For example, Parry et al. (2011) find that "if revenues are used to substitute for distortionary income taxes (either directly or indirectly through deficit reduction), economy-wide carbon taxes…may have (slightly) negative costs."[111]

PROVIDING DIVIDENDS. Carbon-tax revenue can also be recycled to households on a monthly, quarterly, or annual basis, either via a new federal program or through any of a number of existing programs; these programs include, but are not limited to, Social Security, Supplemental Nutritional Assistance Program (SNAP, also called food stamps), or via annual tax returns (further discussion of federal programs that could be used to return revenues to households can be found in Section 5.2.2). Most economists believe such a policy would reduce economic efficiency, at least in the near- to medium-term. For example, Lawrence Goulder and Marc Hafstead find that a lump-sum rebate is worse for economic growth than using revenues to reduce either personal or corporate income tax rates.[112] And, while a 2014 study by Regional Economic Models, Inc. (REMI) found that a "fee-and-dividend" approach would yield small net positive impacts on economic growth, this study was not peer-reviewed and some experts have taken issue with its assumptions and findings.[113]

FEDERAL DEFICIT REDUCTION. Large deficits are thought to act as a drag on the economy, because they crowd out private sector investment, and interest payments on the debt reduce the amount of money that the federal government can spend on more constructive purposes. And if interest payments rise (or are expected to rise) in the future, Congress may be forced to raise taxes to help defray those costs, further limiting output. Economists have modeled the potential economic effects of carbon taxes with revenues used for federal deficit reduction by assuming, for example, that tax increases to reduce the debt are inevitable, and carbon taxes can reduce the need for some of these future tax increases.

Carbone et al. (2013) find that a CO_2 tax of $30 per ton, with all revenue used as a "down payment" to bring the debt down to a sustainable level, would lead to very minor GDP reductions in the near term, and either minor increases or decreases following 2030, depending on the choice of debt reduction measures for which carbon taxes are substituted.[114] Similarly, McKibbin et al. (2012) find that, to achieve a given level of deficit reduction, a carbon tax reduces GDP slightly less than an equivalent tax on labor and slightly more than an equivalent tax on capital. They conclude that a carbon tax "offers a way to help reduce the deficit and improve the environment, and do so with minimal disturbance to overall economic activity."[115]

The potential advantages of reducing deficits are not present only at the federal level. Eisenberg et al. (2014) see similar benefits for states that use a carbon tax to comply with federal carbon-pollution standards for power plants, using that revenue to reduce state deficits and lower other tax rates.[116]

6.1.2. Effects of a Carbon Price on Employment

From an environmental standpoint, the primary goal of a carbon tax is to reduce greenhouse gas emissions; a well-designed tax will entail some restructuring of the economy as a result of reductions in the use of carbon-intensive fuels and the consumption of carbon-intensive goods. There is no consensus among economists on the effects of carbon pricing on overall employment levels in the near term, although it is well recognized that there will be "winners" and "losers" from different economic sectors, and most economists agree that any economic impacts will be limited in the long term. The non-partisan Congressional Budget Office (CBO) found that "[w]orkers and investors in fossil-fuel industries (such as coal mining and oil extraction) and in energy-intensive industries (such as chemicals, metals, and transportation) would tend to experience comparatively large losses in income under a carbon tax because demand for their products would decline."[117] However, the same analysis found that job losses would be offset over time by job gains in low-emitting energy industries (such as wind, solar, and nuclear) as well as the service sector and other industries that are comparatively less emissions-intensive. Further discussion on how a carbon tax affects employment in different regions and sectors can be found in Section 6.2, below.

In the aggregate, because a carbon tax would affect prices throughout the economy, there would likely be shifts in employment levels within industries, though the impact on overall employment levels depends on the size of the tax and what is done with revenue, and is likely to be small. In a 2010 review of the literature, CBO found that a "gradually increasing tax on greenhouse gas emissions or a cap-and-trade program ... would probably have only a small effect on total employment during the next few decades."[118] In addition, CBO found that initially "job

Box 6 | **Limits of Economic Modeling**

Economists build models that aim to simulate the conditions, operation, and behavior of real world economies. These models can be powerful tools to help economists understand and predict the behavior of economic actors, but they are necessarily simplifications, and have different strengths and weaknesses. They have some explanatory power, but they cannot predict the future.

Some of the discrepancy between predicted and actual costs of new rules is the result of changes made by affected entities to mitigate costs once those rules are implemented. Like models from other disciplines designed to mimic real-world conditions, economic models are premised upon the theories, assumptions, and policy design choices of their creators, and those theories and assumptions may be flawed, incomplete, or unproven. Moreover, given the wide range of views in the economics profession, there is likely to be another economist—and another model—with contrasting assumptions and vastly different results. In this paper, we strive to present an unbiased view of different modeling results, noting when those results are largely in agreement with each other and when they are not.

According to previous analysis by WRI and others, economic models also have a history of overstating the costs of environmental measures while undervaluing the benefits of action to address climate change.[a] We encourage readers to keep in mind that all the economic modeling results discussed in this section are estimates, and that changes to policy design that depart from what researchers have modeled, can have an impact on modeling results.

Economic models are also limited in their ability to reflect the benefits of preserving "natural capital," which includes resources such as forests, clean air, and clean water. When economic impacts are measured in terms of gross domestic product (that is, the total value of the goods and services in an economy), any degradation of natural capital will generally be unaccounted for. Economic models also typically fail to reflect the benefits of preserving other valuable resources (for example, minerals and fuels) or a stable climate. Thus the business-as-usual or reference scenarios may be more optimistic than reality, once the impacts of climate change are reflected.

Notes:
a. On the tendency of industry and EPA models to overstate the costs of environmental regulations, see http://pdf.wri.org/factsheets/factsheet_for_epa_regulations_cost_predictions_are_overstated.pdf. On the tendency for economic modeling to undervalue the benefits of acting on climate, see http://static.newclimateeconomy.report/wp-content/uploads/2014/08/NCE_Chapter5_EconomicsOfChange.pdf.

losses from the industries that shrink would lower overall employment in the economy and raise the unemployment rate," but over time most of these displaced workers would find jobs in less emissions-intensive industries and the economy would eventually return to full employment.[119] As discussed in Section 5, the OECD found that using carbon-tax revenue to reduce labor taxes would lead to faster growth in total employment than would be the case in the absence of such a tax swap.[120] In the long run, carbon taxes are expected to improve economic growth significantly by mitigating adverse effects of climate change, and overall employment tends to grow with the economy as a whole.

Rausch and Reilly (2012) argue for using tax revenue to offset either capital or labor taxes, to avoid spending cuts on social welfare programs, to pay down the deficit, or a combination thereof. They find that any of these suggested uses would lead to improvements throughout the economy, including greater private spending and employment.[121]

There is some agreement in the economic literature that a well-designed carbon tax will not have a significant, adverse effect on employment, if revenues are directed in ways that can partially or fully offset any job losses. Fossil fuel extraction, heavy manufacturing, and other emissions-intensive industries would be affected the most, and the transition could be difficult for many communities.[122] Job training programs and a steady and predictable rate of increase in the carbon tax rate could help mitigate any job losses, but those will likely take some time for their impact to be felt. Further discussion on how to mitigate negative impacts on heavy industry can be found in Section 6.2.3.

6.2. Distributional Impacts

6.2.1. Effects of a Carbon Tax on Income

A carbon tax increases the price of carbon-intensive fuels and, in the absence of any offsetting use of revenue, lower income households would bear a proportionally greater burden than higher income households because they tend to spend a higher proportion of their income on energy.[123] For example, CBO has found that a carbon tax of $28 per metric ton of CO_2 emissions would increase after-tax costs for the average household in the lowest quintile of the income distribution by 2.5 percent; for households in the top quintile, the carbon tax would increase after-tax costs by only one percent.[124] Marron and Toder (2013) found similar regressivity from a $20 per ton carbon tax—a 1.8 percent burden on the pre-tax income of the lowest quintile, but only a 0.7 percent burden on the top quintile.[125] At the extreme ends of the income distribution, the regressivity of a carbon tax is even more pronounced—Mathur and Morris (2012) found that an illustrative carbon tax of $15 per ton would account for 3.5 percent of income for households in the bottom decile, but only 0.6 percent in the top decile.[126]

Several studies—including Mathur and Morris (2012), Dower and Zimmerman (1992), and Hassett et al. (2007) —find that a carbon tax is comparatively less regressive when looking at impacts on consumption instead of income. For example, when measuring the effect of a carbon tax on consumption, Mathur and Morris estimate that the same $15 per ton tax would reduce consumption in the bottom decile by 2.1 percent, and in the top decile by 1.3 percent.

Due to this greater proportional burden on the poor than the rich, a carbon tax is considered a regressive tax, but this regressivity can be addressed through a variety of ways of returning revenues to lower income households. Williams et al. (2014) find that, while using carbon-price revenue to cut capital taxes improves economic efficiency, it exacerbates the regressivity of a carbon tax.[127] The authors found that using the revenue to provide dividends to households, however, would mean that the lower three quintiles of the income distribution would see a net benefit from the policy. Using revenues to reduce taxes on labor falls in between these two options, doing more to help lower income households than cutting capital taxes, but doing less than providing lump-sum dividends.

Eisenberg et al. (2014) suggest that, to offset regressivity, tax revenues could go toward safety net programs that benefit the poor.[128] While this study analyzed state-level carbon taxes as a means for complying with carbon pollution standards for power plants, the same approach could be used at the federal level. Existing federal programs that assist lower income families and individuals, and could be vehicles for distributing tax revenues to various constituencies, include Social Security, the Earned Income Tax Credit, Temporary Assistance for Needy Families, the Low Income Home Energy Assistance Program, and the Supplemental Nutritional Assistance Program (also called food stamps), among others. Other approaches include targeted tax cuts, such as the "environmental earned income tax credit" as proposed by Metcalf (2008), or including Social Security recipients in any payroll tax reduction (see Table 4) (Metcalf 2009).[129] Metcalf pro-

Table 4 | **Income Effects of a Carbon Tax, and Various Proposals to Reduce Regressivity**

	Change in Disposable Income ($)			Change as a Percentage of Income		
Income Group (decile)	**Carbon tax**	**Tax credit**	**Net**	**Carbon tax**	**Tax credit**	**Net**
1 (lowest)	-276	208	-68	-3.4	2.7	-0.7
2	-404	284	-120	-3.1	2.1	-1
3	-485	428	-57	-2.4	2.2	-0.2
4	-551	557	6	-2	2.1	0.1
5	-642	668	26	-1.8	1.9	0.1
6	-691	805	115	-1.5	1.8	0.3
7	-781	915	135	-1.4	1.6	0.2
8	-883	982	99	-1.2	1.4	0.2
9	-965	1035	70	-1.1	1.1	0
10 (highest)	-1224	1093	-130	-0.8	0.8	0

	Earned Income		Earned Income and Social Security		Lump Sum	
Income Group (decile)	**Net ($)**	**Net (%)**	**Net ($)**	**Net (%)**	**Net ($)**	**Net (%)**
1 (lowest)	-68	-0.7	112	1.4	166	2.1
2	-120	-1	125	1	128	1
3	-57	-0.2	114	0.6	120	0.6
4	6	0.1	70	0.3	103	0.4
5	26	0.1	54	0.1	108	0.3
6	115	0.3	66	0.1	26	0.1
7	135	0.2	35	0.1	-32	-0.1
8	99	0.2	-61	-0.1	-52	-0.1
9	70	0	-95	-0.1	-171	-0.2
10 (highest)	-130	0	-332	-0.2	-355	-0.2

Source: Metcalf, G. 2009. “Designing a Carbon Tax to Reduce U.S. Greenhouse Gas Emissions.” Review of Environmental Economics and Policy, Vol. 3, Iss. 1, Winter. Available at: http://reep.oxfordjournals.org/content/3/1/63.full.pdf+html

Note: Illustrative example using a carbon tax of $15 per metric ton (in 2005 dollars). Positive numbers represent an increase in income, and negative numbers represent a decrease in income. “Tax credit” refers to a proposal to use carbon tax revenues to reduce payroll taxes, up to the first $560 in taxes owed. “Earned income and Social Security” is a proposal whereby Social Security recipients also receive a $560 rebate. And “Lump sum” is the effects of a proposal to return all revenues to households in the form of per capita lump-sum rebates of $274.

poses reducing payroll taxes for individuals up to a certain level of income, while ensuring that workers with low income tax liability receive enough support to ensure they are not adversely affected.

Estimates of how much revenue is needed to offset much of this regressivity are more or less consistent across studies. Morris and Mathur (2014) find that ensuring the bottom 20 percent of households (those with incomes less than 150 percent of the poverty line) are not made worse off by a carbon tax would require about 15 percent of the revenue from the tax.[130] The analysis in Rosenbaum et al. (2009) of the Waxman-Markey cap-and-trade bill from 2009 found that the bill's provision that 15 percent of auction revenue be returned to low-income households would ensure that households in the bottom income quintile were made slightly better off, on average. A cap-and-trade program that auctions off all allowances functions in many ways like a carbon tax, so the findings are relevant to a carbon tax as well. For reference, CBO's analysis of the Waxman-Markey bill found that, in 2020, the bill's provisions for returning revenue to consumers meant that the average household in the bottom income quintile would see a net benefit of $125 per year. The other four quintiles would see a net annual cost, on average, as follows: second quintile $150, third quintile $310, fourth quintile $375, and top quintile $165.[131]

6.2.2. Regional Implications of a Carbon Tax

Gasoline, coal-fired electricity, and oil for home heating will all get more expensive under a carbon tax. Differing consumption patterns and fuel mixes in the electric grid between states and regions mean that a carbon tax will affect consumers differently depending on where they live. For example, the average driver in Wyoming drives nearly 22,000 miles per year—more than twice as far as drivers in Alaska and the District of Columbia.[132] In 2012, 92 percent of the electricity generated in Kentucky came from coal, while in Idaho that figure was less than one percent.[133] And carbon-heavy heating oil is a significant source of space heating in the Northeast, while much of the rest of the country relies much more heavily on less carbon-intensive fuels like natural gas, propane, or grid electricity to heat homes in wintertime (however, in states that are most heavily dependent on coal for electricity production, heating oil can be a less emissions-intensive method of home heating than grid electricity).[134] Nevertheless, as discussed below, some policy options for returning revenues to households can make all regions better off.

The Congressional Budget Office states that "[p]eople in regions of the country that rely on emission- intensive industries for their livelihood or that use the most emission-intensive fuels to produce power" are likely to bear a larger burden from the imposition of a carbon tax than others, and "[p]arts of the country that rely on fossil fuels or energy-intensive production for income would experience larger losses than other regions."[135] Policymakers concerned with such effects have tools at their disposal to offset any increases in energy prices. For example, ACES devoted 23 percent of revenue in the early years to local electricity and natural gas distribution companies, to combat higher prices for those commodities.[136]

Yet it is important not to focus just on electricity use, transportation costs, or any other single aspect of consumption, but rather to look at regional energy use and spending patterns more holistically. Morris and Mathur (2014) find that "regional analyses show that the burdens of a carbon tax as a share of income would not vary nearly as much as many fear," because different regions have different consumption patterns for carbon-intensive goods and fuels, but relatively similar consumption patterns for non-energy goods and services.[137] That said, they find that Wisconsin, Illinois, Ohio, Indiana, and Michigan could see a slightly higher burden from a carbon tax due to their high gasoline consumption and greater total energy consumption as a share of income.

Morris and Mathur are not alone in their conclusions, though the details do vary between studies. Metcalf also finds that a gradually increasing tax of $15 per ton CO_2 equivalent "does not appear to disproportionately burden one region of the country" after revenue is returned to households (Metcalf 2009). In analyzing the regional distribution effects of a carbon tax, Metcalf finds that, when revenues are returned via a payroll tax credit, there is a mere 0.6 percent difference in earned income between the hardest hit region (Alabama, Kentucky, Mississippi, Tennessee) and the regions least affected by the tax (the upper Midwest and the Mountain West). And when revenues are returned to households via a combination of payroll tax reductions and Social Security rebates, this income discrepancy drops to 0.4 percent, with all regions better off (see Table 5).

Hassett et al. found less in the way of regional effects in a 2009 study analyzing the impacts of a tax of $15 per ton of carbon dioxide emissions from fossil fuels when measured on a lifetime basis. The authors found that regional variation in the burden from the carbon tax was modest even

Table 5 | **Regional Distribution Effects of a Carbon Tax, With Two Proposals for Revenue Use**

	Earned Income and Social Security		Lump Sum	
Region	**Net ($)**	**Net (%)**	**Net ($)**	**Net (%)**
New England	-36	0.2	-65	-0.1
Middle Atlantic	-13	0.2	-18	-0.2
East North Central	-14	0.1	-37	-0.1
West North Central	52	0.5	-26	-0.2
South Atlantic	17	0.3	2	0.3
East South Central	-6	0.3	-75	-0.2
West South Central	-42	0.2	9	0.4
Mountain	46	0.5	34	0.4
Pacific	-4	0.2	59	0.6
10 (highest)	-332	-0.2	-355	-0.2

Source: Metcalf (2009).

Notes: Illustrative example using a carbon tax of $15 per metric ton (in 2005 dollars). Positive numbers represent an increase in income, and negative numbers represent a decrease in income. "Earned income and Social Security" is a proposal whereby Social Security recipients also receive a $560 rebate. And "Lump sum" is the effects of a proposal to return all revenues to households in the form of per capita lump sum rebates of $274. Regions are defined as follows: New England (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont); Middle Atlantic (New Jersey, New York, Pennsylvania); East North Central (Illinois, Indiana, Michigan, Ohio, Wisconsin); West North Central (Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota); South Atlantic (Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia); East South Central (Alabama, Kentucky, Mississippi, Tennessee); West South Central (Arkansas, Louisiana, Oklahoma, Texas); Mountain (Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming); and Pacific (Alaska, California, Hawaii, Oregon, Washington).

though their analysis did not look at uses of revenue, and that "variation across regions is sufficiently small that one could argue that a carbon tax is distributionally neutral across regions."[138]

Williams et al. (2014) found that, while a carbon tax would have a regionally diverse impact on electricity prices due to differing fuel mixes, those regional variations could be minimized through revenue recycling.[139] Using carbon-tax revenues to reduce taxes on capital would reduce the burden of the carbon tax, but do little to correct for regional disparities. A lump-sum rebate would be more beneficial for evening out the incidence of the carbon tax across regions but would lower overall welfare compared to a capital tax reduction. Reducing taxes on labor, however, nearly eliminated regional disparities in the incidence of the carbon tax, while providing much of the same economic benefit as reducing taxes on capital.

6.2.3. Impact of a Carbon Price on Industrial Competitiveness

Some emissions-intensive industries could see a decline in demand for their products under a carbon tax. Some of those industries, such as electricity generation, don't face competition from U.S. trade partners, simply because the vast majority of what is produced is not imported or exported.[140] Other emissions-intensive industries, however, such as steel, chemicals, and other large energy users, do face such competition, and higher prices on inputs could raise concerns that the United States will be a less attractive location for manufacturing and will lose international competitiveness, at least in the near term. However, these concerns may be unfounded, because many of the United States' largest trading partners already have carbon-pricing policies in place (see Appendix A for more information on those countries' policies).

A 2009 interagency report assessing the impact of a national cap-and-trade program on international competitiveness found that, on average, energy expenditures account for less than two percent of the value of U.S. manufacturing output, and that the majority of industries would not be noticeably adversely affected by a carbon price.[141] Meanwhile, only 44 of the 500 largest manufacturing industries qualified as trade-exposed, accounting for 12 percent of total manufacturing output and just six percent of manufacturing employment, although they were responsible for nearly half of all greenhouse gas emissions from manufacturing.

Even a small increase in energy costs could make a big difference in industries with tight profit margins, however, so it is important for policymakers to take steps to address the reduced competitiveness of some industries. Under a cap-and-trade program, allowances can be freely allocated to vulnerable industries to mitigate their trade exposure. Under a carbon tax, however, the most direct way to correct the disadvantage to these industries may be through a border adjustment. In this way, imports from countries without comparable carbon pricing policies would be subject to a tariff according to the carbon content of the good, and exports to such countries would have at least some of their tax burden reduced. Implicit in such a measure is an inducement to our trading partners to enact their own carbon-pricing policies. Harmonized policies would have the advantage of generating domestic tax revenues rather than tariff payments to other countries, and the potential for a more effective multi-country effort to reduce emissions. Metcalf (2010) asserts that a border adjustment under a carbon tax is more likely to be compliant with World Trade Organization (WTO) rules than similar measures under a cap-and-trade program.[142]

Border tax adjustments are not without risk and some measure of controversy. First, compliance with WTO rules is not a given, though the WTO has acknowledged that it is possible to design a border tax for environmental reasons without running afoul of its rules.[143] The border adjustment must be designed in such a way that it does not favor domestically produced goods, or imports from certain countries.[144] If a provision were written in a way that takes into account the carbon-pricing policies of our trading partners, many (though not all) experts believe a U.S. carbon tax could pass muster with the WTO, though it could be challenged by other countries.[145] Second, a border adjustment has the potential to spark trade disputes if some countries believe that they are being unfairly singled out and retaliate with import tariffs of their own.[146] Lastly, border adjustments can be burdensome to implement, because the carbon content of a vast array of imported goods will be so difficult to determine.[147]

7. CONCLUSION

In this *Handbook*, we have laid out the fundamental choices available to policymakers considering policies that put an explicit price on carbon emissions. Most of these decisions will be the results of political compromises, and there are a number of precedents in the recent past for cooperation on this issue. While we can't predict what the future might hold for carbon pricing and views differ sharply on some issues, a number of factors are in play that could increase the appeal of such a policy to different parts of the political spectrum in the United States in the coming years.

Bipartisan support for federal tax reform

The past five years have seen increasing calls for an overhaul of the federal tax code. Observers on both sides of the aisle, along with businesses and individual taxpayers, find it to be overly onerous and complicated, yet full of loopholes that allow individuals or companies to pay less than their fair share of taxes. The top marginal corporate tax rate is the highest in the developed world, yet a wide array of deductions means that the effective corporate tax rate is far lower, and closer to the average effective tax rate of other developed countries.[148] The tax code is also full of conflicting incentives; for example, fossil-fuel companies receive subsidies and targeted tax breaks, even as renewable-energy companies receive tax credits and subsidies for production and investment. All of these complications and inconsistencies in the tax code have led many in Congress to call for significant tax reform. In recent years, Republican and Democratic members of the Senate Finance Committee have discussed simplifying the tax code by replacing most or all energy subsidies and tax credits with a carbon tax or cap-and-dividend program.[149]

Stated goals for deeper reductions in GHG emissions

Under President Obama, the United States now has a plan in place to meet its near- and medium-term emissions reduction targets, and to continue driving reductions in emissions from the largest emitting sectors in the years beyond. However, analysis by WRI has shown that administrative actions alone are likely insufficient to meet our long-term emissions target of roughly 83 percent below 2005 levels by 2050.[150] In short, the United States will need a comprehensive, economy-wide climate policy, such as a carbon tax or cap-and-trade program, if the country is to achieve the level of reductions that the IPCC says will be necessary from developed nations to avoid the worst impacts of climate change.

Desire for alternative climate policies

A price on carbon is both a fiscal and an environmental policy. In addition to using revenues to “pay for” reductions in other taxes, as discussed above, some proponents advocate an economy-wide carbon price as an approach that is preferable to imposing sectoral emission standards, while others view such standards as important tools in their own right or as potentially complementary climate policies.

Bipartisan support for deficit reduction

While concerns about the national debt have subsided to some extent in the past few years, reducing long-term debt remains an issue with significant support from the general public and lawmakers on both sides of the aisle. A national carbon tax has the potential to raise hundreds of billions of dollars per year that could be used to improve the United States’ long-term fiscal situation.

Experience at the state level

In the absence of a national, economy-wide policy to reduce GHG emissions, some states have moved forward with their own carbon-pricing mechanisms. As discussed above, nine northeastern states operate a regional electricity sector cap-and-trade program, and California in 2012 initiated its own economy-wide cap-and-trade program. As of this writing, stakeholders in Massachusetts, Oregon, Vermont, and Washington, among others, are advocating for a carbon tax to raise revenue for transportation infrastructure or other purposes. And in response to the flexibility afforded them under the Clean Power Plan, many states are actively considering whether carbon pricing offers the least-cost way of complying with GHG emissions standards for power plants. Successful implementation of these policies at the state level could lessen resistance at the federal level for a similar carbon-pricing policy.

Increased awareness of climate-related impacts

From sea-level rise in Florida and Virginia, to increases in the frequency and severity of some types of extreme weather events, to protracted droughts in Texas and California, the United States is already seeing previews of what a warming planet holds in store. As climate impacts hit home, and their effects begin taking a toll on the economy, we might see public opinion become increasingly vocal on the need to act. A climate policy that puts a price on GHG emissions throughout the economy offers policymakers a proven, market-based solution to reduce the U.S. contribution to climate change and to raise revenues that can be invested in technologies that enable communities to better adapt to the impacts of climate change.

While none of these factors alone will likely be enough to move Congress to put a price on carbon in the coming years, their confluence suggests a gradual mounting of pressure that could turn the tide. The world and the American people are increasingly serious about the need to act to avoid the worst impacts of climate change.[151] A comprehensive carbon-pricing policy provides the opportunity to satisfy a variety of political goals beyond emissions reductions. We hope that this working paper—and future briefing papers that will dive more deeply into many of the issues raised here—can play a helpful role in the coming national conversation on these issues.

APPENDIX – GLOBAL CARBON PRICING SYSTEMS

Table A.1 | **Carbon taxes around the world**

COUNTRY	YEAR IMPLEMENTED	PRICE PER TON CO_2E	PORTION OF GHGS COVERED (%)	REVENUE USAGE[152]
Finland	1990	■ €35 ($48) for heating fuels ■ €60 ($83) for liquid traffic fuels	15	■ Reduce income taxes ■ Increase government revenue
Norway	1991	Nkr25 to 419 ($4-69) in 2014; depending on fuel type and usage	50	■ Increase government revenue
Sweden	1991	Skr1076 ($168)	25	■ Increase government revenue ■ Offset labor taxes
Denmark	1992	Dkr167 ($31 in 2014)	45	■ 40 percent used as environmental subsidy ■ 60 percent returned to industry
British Columbia	2008	C$30 ($28) in 2013/14	70	■ Designed to be revenue neutral through income tax reductions and tax credits ■ Revenue negative in practice - tax cuts and credits have exceeded carbon tax revenue
Switzerland	2008	SFr60 ($68) from 2014	30	■ Dividend redistributed proportionally to industry and consumers ■ Fund climate-friendly building renovations
Iceland	2010	Íkr1120 ($10)	50	■ Increase government revenue
Ireland	2010 (extended to solid fuels in 2013)	€20 ($28) from May 2014	40	■ Increase government revenue ■ Reduce the deficit
Japan	2012	¥192 ($2) from April 2014, increasing to ¥289 ($3) in April 2016	70	■ Invest in clean energy and energy efficiency

Table A.1 | **Carbon taxes around the world (continued)**

COUNTRY	YEAR IMPLEMENTED	PRICE PER TON CO_2E	PORTION OF GHGS COVERED (%)	REVENUE USAGE[152]
United Kingdom	2013	■ EU ETS price floor of £16 ($26.23) in 2013 ■ Effective tax in April 2014 of £9.55 ($15.75)	25	■ Reduce other taxes
Mexico	2014	■ Mex$10-50 ($1-4), depending on fuel	Unclear – initial bill included natural gas and would have covered 40 percent	■ Increase government revenue
France	April 1, 2014	■ €7 ($10) increasing to €14.5 ($20) in 2015 and €22 ($30) in 2016	Initial coverage: 35 percent	■ Fund energy transition plans
South Africa	Implementation planned in 2016	■ R120 ($12) in 2016 ■ Increasing by 10 percent per year through 2019, then subject to review ■ During 2016-19, a basic tax-free threshold will be established, making the maximum effective tax rate R48 ($5)	80	■ Likely to be a reduction in VAT or income taxes
Chile[a]	Goes into effect in 2018	■ $5 per ton ■ No detail on price increases	no data	■ Educational developments on climate change ■ Education system
Australia	Initiated July 2012; repealed in 2014	■ A$24.15 ($21.54) from July 2013	60	■ Revenue neutral: Reduce income tax and provide dividend to energy producers and consumers ■ Funded industry assistance programs

Source: State and Trends of Carbon Pricing 2014, World Bank, Washington D.C. 2014. Dollar values are based on exchange rates as of December 31, 2013.

Notes: a. Information from Reuters ("Chile becomes the first South American country to tax carbon," Reuters, September 27, 2014) and Point Carbon ("Chile passes carbon tax," Point Carbon,October 30, 2014).

Table A.2 | **National and Sub-National Greenhouse Gas Cap-and-Trade Programs Around the World**

JURISDICTION	YEAR IMPLEMENTED	EMISSIONS COVERED (%)	2013 PRICE PER TON CO_2E	COVERED SECTORS
European Union	2005	45	$9	Industry, electricity, aviation
New Zealand	2008	50	$1	Industry, forestry, transport, waste
Switzerland	2008	10		Electricity, buildings
U.S. Sub-national Programs				
■ Regional Greenhouse Gas Initiative (RGGI) – NE United States	2009	20	$3	Electricity
■ California (linked with Quebec)	2013	85	$11	From 2013: Industry, electricity; added in 2015: transport, distributed use of fuels
Australia	2012; repealed 2014	60	$21.54 (fixed price)	All large emission sources, including industry, large gas consumers, and landfills
Canada Sub-national Program				
Quebec (linked with California)	2013	85	$10	From 2013: Industry, electricity; added in 2015: transport, distributed use of fuels
Chinese Sub-national Pilots				
Tianjin	2013	60	$4	Industry, electricity, buildings
Beijing	2013	50	$9	Industry, electricity, buildings
Shanghai	2013	50	$5	Industry, transport, electricity
Guangdong	2013	42	$10	Industry, electricity
Shenzhen	2013	38	$11	Industry, electricity, buildings
Chongqing	2014	38		Electricity
Hubei	2014	35		Industry, electricity
Kazakhstan	2013	50		Industry, transport, electricity, agriculture
South Korea	2015 (planned)	60		Industry, electricity

Source: World Bank, State and Trends of Carbon Pricing 2014, unless otherwise noted.

Notes:
This table does not include Alberta (Canada) or Tokyo, Saitama and Kyoto (Japan), which have initiated trading systems based on emissions intensity.
California's program went into effect in 2012, but the first year for which covered entities had emissions obligations was 2013.
The portion of emissions covered in California and Quebec reflects the increase in scope at the start of 2015 to include transportation fuels and distributed use of natural gas and other fuels.
Australia's system, which has now been repealed, was initiated with a fixed price and was therefore, in its initial stages, a carbon tax.

BIBLIOGRAPHY

Acemoglu, D., P. Aghion, L. Bursztyn and D. Hemous. "The Environment and Directed Technical Change." FEEM Working Paper No. 93.2010. April 2010. http://ssrn.com/abstract=1668575

Amdur, D., B. Rabe and C. Borlick. "Public Views on a Carbon Tax Depend on the Proposed Use of Revenue." CLOSUP (Center for Local, State and Urban Policy), University of Michigan. July 2014. http://closup.umich.edu/files/ieep-nsee-2014-spring-carbon-tax.pdf

Bento, A. and M. Jacobsen. "Ricardian Rents, Environmental Policy, and the 'Double Dividend' Hypothesis." *Journal of Environmental Economics and Management* 53(1): 17–31 (2007). doi:10.1016/j.jeem.2006.03.006.

Bianco, N., K. Meek, R. Gasper, M. Obeiter, S. Forbes and N. Aden. "Seeing is Believing: Creating a New Climate Economy in the United States." World Resources Institute. October 2014. http://www.wri.org/publication/seeing-believing-creating-new-climate-economy-united-states

Bordoff, J. "International trade law and the economics of climate policy: Evaluating the legality and effectiveness of proposals to address competitiveness and leakage concerns." In: *Brookings Trade Forum* 2008 (1): 35-68. Brookings Institution Press, 2009.

Boyce, J. and M. Riddle. "Cap and Dividend: How to Curb Global Warming While Protecting the Incomes of American Families." Political Economy Research Institute. November 2007. http://scholarworks.umass.edu/cgi/viewcontent.cgi?article=1121&context=peri_workingpapers

British Columbia Ministry of Finance. February, 2012. "Budget and Fiscal Plan, 2012/13-2014/15." http://www.bcbudget.gov.bc.ca/2012/bfp/2012_Budget_Fiscal_Plan.pdf

Canadian Apprenticeship Forum. "It pays to hire an apprentice: calculating the return on training investment for skilled trades employers in Canada: a study of 16 trades, phase II: final report." Ottawa, Ontario. June 2009. http://apprenticeshippays.com/english_flash/PDFeng/CAF-Roti.pdf

Caperton, R. "A Progressive Carbon Tax Will Fight Climate Change and Stimulate the Economy." Center for American Progress. December 2012. https://cdn.americanprogress.org/wp-content/uploads/2012/12/CAPERTONCarbonTax.pdf

CDP (Carbon Disclosure Project). "Use of internal carbon price by companies as incentive and strategic planning tool: A review of findings from CDP 2013 disclosure." A White Paper from CDP North America. December 2013. https://www.cdp.net/CDPResults/companies-carbon-pricing-2013.pdf

Carbone, J.C., R.D. Morganstern, R.C. Williams III, and D. Burtraw. "Deficit Reduction and Carbon Taxes: Budgetary, Economic, and Distributional Impacts." Resources for the Future. August, 2013. http://www.weathervane.rff.org/RFF/Documents/RFF-Rpt-Carbone.etal.CarbonTaxes.pdf

Center on Budget and Policy Priorities. "Climate Change Policies Can Treat Low-Income Families Fairly and Be Fiscally Responsible." May 2008. http://www.cbpp.org/files/climate-brochure.pdf

Charnovitz, Steve. "Border Tax Equalization." DRAFT Paper Prepared for the Conference on Challenges Facing the World Trade System. 2014. http://indianeconomy.columbia.edu/sites/default/files/paper2-bordertax.pdf

Château, J., A. Saint-Martin and T. Manfredi. "Employment Impacts of Climate Change Mitigation Policies in OECD: A General-Equilibrium Perspective", OECD Environment Working Papers, No. 32, OECD Publishing, Paris. 2011. DOI: http://dx.doi.org/10.1787/5kg0ps847h8q-en

Clarke L., K. Jiang, K. Akimoto, M. Babiker, G. Blanford, K. Fisher-Vanden, J.-C. Hourcade, V. Krey, E. Kriegler, A. Löschel, D. McCollum, S. Paltsev, S. Rose, P.R. Shukla, M. Tavoni, B.C.C. van der Zwaan, and D.P. van Vuuren. "Assessing Transformation Pathways." In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 2014.

CBO (Congressional Budget Office). "Effects of a Carbon Tax on the Economy and the Environment." Congress of the United States. May 2013. http://www.cbo.gov/sites/default/files/44223_Carbon_0.pdf

CBO (Congressional Budget Office). "How Policies to Reduce Greenhouse Gas Emissions Could Affect Employment." Congress of the United States. May 2010. http://www.cbo.gov/sites/default/files/05-05-capandtrade_brief.pdf

CBO (Congressional Budget Office). "Federal Debt and the Risk of a Fiscal Crisis." Congress of the United States. July 2010. http://www.cbo.gov/sites/default/files/07-27_debt_fiscalcrisis_brief.pdf

Conniff, Richard. "The Political History of Cap and Trade." Smithsonian Magazine. August 2009. http://www.smithsonianmag.com/air/the-political-history-of-cap-and-trade-34711212/

Cosbey, A. "It Ain't Easy: The Complexities of Creating a Regime for Border Carbon Adjustment" September 2012. Entwined, August 2012. Available at SSRN: http://ssrn.com/abstract=2163203

Dower, R. and M.B. Zimmerman. "The Right Climate for Carbon Taxes: Creating Economic Incentives to Protect the Atmosphere." World Resources Institute. August 1992. http://www.wri.org/sites/default/files/pdf/rightclimateforcarbontaxes_bw.pdf

Eisenberg, S., M. Wara, A. Morris, M. Darby, and J. Minor. "A State Tax Approach to Regulating Greenhouse Gas Emissions Under the Clean Air Act." The Brookings Institution. May 2014. http://www.brookings.edu/research/papers/2014/05/22-state-tax-regulating-greenhouse-gas-clean-air-act-morris

Elgie, S. and J. McClay. "BC's Carbon Tax Shift After Five Years: Results." Sustainable Prosperity. July 2013. http://www.sustainableprosperity.ca/dl1026&display

Fischer, C. "Rebating environmental policy revenues: Output-based allocations and tradable performance standards." Resources for the Future. 2001. http://weathervane.rff.org/RFF/Documents/RFF-DP-01-22.pdf

Fischer, C. and R. Newell. "Environmental and technology policies for climate mitigation." *Journal of Environmental Economics and Management* 55 (2): 142-162 (2008). doi:10.1016/j.jeem.2007.11.001.

GATT (General Agreement on Tariffs and Trade). "The Text of the General Agreement on Tariffs and Trade." Geneva. July 1986. https://www.wto.org/english/docs_e/legal_e/gatt47_e.pdf

Gillenwater, M. and S. Seres. "The Clean Development Mechanism: A Review of the First International Offset Program." Pew Center for Global Climate Change. March 2011. https://ghginstitute.org/wp-content/uploads/2011/03/PEW8037CDMReport.pdf

The Global Commission on the Economy and Climate. "Better Growth, Better Climate: The New Climate Economy Report. Executive Summary." 2014. http://static.newclimateeconomy.report/wp-content/uploads/2014/08/NCE_ExecutiveSummary.pdf

Goodward J., and A. Kelly. "Bottom Line on Offsets." World Resources Institute. August 2010. http://www.wri.org/publication/bottom-line-offsets

Goulder, L.H. "Climate Change Policy's Interaction with the Tax System." Energy Economics 40(1): S3-S11 (2013). doi:10.1016/j.eneco.2013.09.017

Goulder, L.H. and M. Hafstead. "Tax Reform and Environmental Policy: Options for Recycling Revenue from a Tax on Carbon Dioxide." Resources for the Future. October 2013. http://www.rff.org/RFF/Documents/RFF-DP-13-31.pdf

Gravelle, J. "International Corporate Tax Rate Comparisons and Policy Implications." United States Congress Congressional Research Service. January 2014. https://www.fas.org/sgp/crs/misc/R41743.pdf

Green, K., S. Hayward and K. Hassett. "Climate Change: Caps vs. Taxes." *American Enterprise Institute for Public Policy Research*. No. 2. June 2007. https://www.aei.org/wp-content/uploads/2011/10/20070601_EPOg.pdf

Greenhouse Gas Protocol. "Policy and Action Standard: An accounting and reporting standard for estimating the greenhouse gas effects of policies and actions." World Resources Institute. 2014. http://www.ghgprotocol.org/policy-and-action-standard

Hassett, K., A. Mathur, and G. Metcalf. "The Incidence of a U.S. Carbon Tax: A Lifetime and Regional Analysis." *The Energy Journal, International Association for Energy Economics* 30 (2): 155-178 (2009). https://ideas.repec.org/a/aen/journl/2009v30-02-a08.html

Hibbard P., S. Tierney, A. Okie and P. Darling. "The Economic Impacts of the Regional Greenhouse Gas Initiative on Ten Northeast and Mid-Atlantic States." The Analysis Group. November 2011. http://www.analysisgroup.com/uploadedfiles/publishing/articles/economic_impact_rggi_report.pdf

Holmes, P., T. Reilly and J. Rollo. "Border Carbon Adjustments and the Potential for Protectionism." Climate Policy 11 (2): 883-900 (2011). doi:10.3763/cpol.2009.0071.

Holzer, K. and N. Shariff. "The Inclusion of Border Carbon Adjustments in Preferential Trade Agreements: Policy Implications." X Annual Conference of the Euro-Latin Study Network on Integration and Trade (ELSNIT). Milan, Italy. October 2012.

Horowitz, C., M.R. Enion, S.B. Hecht and A. Carlson. "Spending California's Cap-and-Trade Auction Revenue: Understanding the Sinclair Paint Risk Spectrum." Emmitt Center on Climate Change and the Environment, UCLA School of Law. March 2012. http://law.ucla.edu/~/media/Files/UCLA/Law/Pages/Publications/CEN_EMM_PUB%20Spending_CA_Cap_Trade_Revenue.ashx

Houser, T., R. Bradley, B. Childs, J. Werksman, R. Heilmayr. "Leveling the Carbon Playing Field: International Competition and US Climate Policy Design." Peterson Institute for International Economics and World Resources Insitute. May 2008. http://pdf.wri.org/leveling_the_carbon_playing_field.pdf

Interagency Working Group on Social Cost of Carbon. "Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866." Washington DC: United States Government. May 2013, Revised November 2013.

An Interagency Report Responding to a Request from Senators Bayh, Specter, Stabenow, McCaskill, and Brown. "The Effects of H.R. 2454 on International Competitiveness and Emission Leakage in Energy-Intensive Trade-Exposed Industries." Washington, DC: United States Government. December 2009. http://www.epa.gov/climatechange/Downloads/EPAactivities/InteragencyReport_Competitiveness-EmissionLeakage.pdf

Kejun, J., A. Cosbey and D. Murphy. "Embodied Carbon in Traded Goods." Prepared for the Trade and Climate Change Seminar, June 18–20, 2008, Copenhagen, Denmark. Winnipeg, Manitoba: International Institute for Sustainable Development. August 2008. http://www.iisd.org/pdf/2008/cph_trade_climate_carbon.pdf

Larsen, J. "Emissions Reductions Under Pollution Reduction Proposals in the 111th U.S. Congress." World Resources Institute. June 2010. http://www.wri.org/publication/emissions-reductions-under-pollution-reduction-proposals-111th-us-congress

Levin, K., B. Cashore, S. Bernstein, and G. Auld. "Overcoming the tragedy of super wicked problems: constraining our future selves to ameliorate global climate change." Policy Sciences 45 (2): 123-152. June 2012. doi: 10.1007/s11077-012-9151-0.

Lewis M. "Why British Columbia's Carbon Tax Is Not Applicable to America." Competitive Enterprise Institute. September 2014. https://cei.org/sites/default/files/Marlo%20Lewis%20-%20Why%20British%20Columbia's%20Carbon%20Tax%20Is%20Not%20Applicable%20to%20America_0.pdf

Mankiw, N.G. "Smart Taxes: An Open Invitation to Join the Pigou Club." *Eastern Economic Journal*. 35: 14–23 (2009). doi:10.1057/eej.2008.43.

Marron, D. and E. Toder. "Carbon Taxes and Corporate Tax Reform." Urban-Brookings Tax Policy Center. February 2013. http://www.taxpolicycenter.org/UploadedPDF/412744-Carbon-Taxes-and-Corporate-Tax-Reform.pdf

Mathur, A. and A. Morris. "Distributional Effects of a Carbon Tax in Broader U.S. Fiscal Reform." The Brookings Institution. 2012. http://www.brookings.edu/~/media/research/files/papers/2012/12/14%20carbon%20tax%20fiscal%20reform%20morris/14%20carbon%20tax%20fiscal%20reform%20morris.pdf

McKibbin, W., A. Morris, P. Wilcoxen and Yiyong Cai. "The Potential Role of a Carbon Tax in U.S. Fiscal Reform." Brookings Institution. July 2012. http://www.brookings.edu/~/media/research/files/papers/2012/7/carbon-tax-mckibbin-morris-wilcoxen/carbon-tax-mckibbin-morris-wilcoxen.pdf

Metcalf, G. "Designing a Carbon Tax to Reduce U.S. Greenhouse Gas Emissions." *Review of Environmental Economics and Policy* 3(1): 63-83 (2009). doi: 10.1093/reep/ren015.

Moore, F.C. and D.B. Diaz. "Temperature impacts on economic growth warrant stringent mitigation policy." Nature Climate Change 5: 127–131 (2015). doi:10.1038/nclimate2481

Morris, A. and A. Mathur. "A Carbon Tax in Broader U.S. Fiscal Reform: Design and Distributional Issues." Center for Climate and Energy Solutions. 2014. http://www.brookings.edu/~/media/research/files/papers/2014/05/22-carbon-tax-broader-us-fiscal-regulation-morris/05222014_carbon_tax_broader_us_fiscal_reform_morrisa_mathura.pdf

Moylan, A. "How to Tax Carbon." *The American Conservative.* October 2013. http://www.theamericanconservative.com/articles/how-to-tax-carbon/

Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestvedt, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura and H. Zhang. "Anthropogenic and Natural Radiative Forcing." In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 2013.

Nystrom, S. and P. Lucklow. "The Economic, Climate, Fiscal, Power, and Demographic Impact of a National Fee-and-Dividend Carbon Tax." Regional Economic Models, Inc. and Synapse Energy Economics, Inc. June 2014. http://dv7gcmvxe5e8l.cloudfront.net/wp-content/uploads/2014/09/The-Economic-Climate-Fiscal-Power-and-Demographic-Impact-of-a-National-Fee-and-Dividend-Carbon-Tax-6.9.14.pdf

OECD (Organisation for Economic Co-operation and Development). "Taxation, Innovation and the Environment." Executive Summary. Paris: OECD. 2010. http://www.oecd.org/env/tools-evaluation/46177075.pdf

Osikominu, A. "Quick Job Entry or Long-Term Human Capital Development? The Dynamic Effects of Alternative Training Schemes." *Review of Economic Studies* 80 (1): 313-342 (2013). doi: 10.1093/restud/rds022.

Parry, I. and R. Williams III. "Moving U.S. Climate Policy Forward: Are Carbon Taxes the Only Good Alternative?" Resources for the Future. February 2011. http://www.rff.org/RFF/Documents/RFF-DP-11-02.pdf

Pauwelyn, J. "Carbon Leakage Measures and Border Tax Adjustments Under WTO Law." March 21, 2012. Available at SSRN: http://ssrn.com/abstract=2026879

Pew Center on Global Climate Change. "Climate Policy Memo #4: Distribution of Allowances Under the American Clean Energy and Security Act (Waxman-Markey)." August, 2009. http://www.c2es.org/docUploads/policy-memo-allowance-distribution-under-waxman-markey.pdf

Rausch, S., and J. Reilly. "Carbon Tax Revenue and the Budget Deficit: A Win-Win-Win Solution?" MIT Joint Program on the Science and Policy of Global Change: Report No. 228. August 2012. http://18.7.29.232/bitstream/handle/1721.1/72548/MITJPSPGC_Rpt228.pdf?sequence=1

The Regional Greenhouse Gas Initiative. "Regional Investment of RGGI CO_2 Allowance Proceeds, 2012." February 2014. http://www.rggi.org/docs/Documents/2012-Investment-Report.pdf

Rosenbaum, D., S. Parrott, and C. Stone. "How Low-Income Consumers Fare in the House Climate Bill." Center on Budget and Policy Priorities. October 2009. http://www.cbpp.org/files/7-8-09climate.pdf

Schmalensee, Richard, and Robert N. Stavins. "The SO_2 Allowance Trading System: The Ironic History of a Grand Policy Experiment." *Journal of Economic Perspectives* 27(1): 103-22 (2013). DOI: 10.1257/jep.27.1.103

Siikamäki J., D. Burtraw, J. Maher, and C. Munnings. "The U.S. Environmental Protection Agency's Acid Rain Program." Resources for the Future. November 2012. http://www.rff.org/RFF/Documents/RFF-Bck-AcidRainProgram.pdf

Stavins, R.N., 1997. Policy Instruments for Climate Change: How Can National Governments Address a Global Problem? University of Chicago Legal Forum 1997, 293-329.

Sumner, J., L. Bird, and H. Smith. "Carbon Taxes: A Review of Experience and Policy Design Considerations." National Renewable Energy Laboratory, U.S. Department of Energy. December 2009. http://www.nrel.gov/docs/fy10osti/47312.pdf

Sussman, F., N. Krishnan, K. Maher, R. Miller, C. Mack, P. Stewart, K. Shouse, and W. Perkins. "Climate Change Adaptation Cost in the U.S.: What Do We Know?" *Climate Policy* 14 (2): 242-282 (2014). doi:10.1080/14693062.2013.777604.

Taylor, J. "The Conservative Case for a Carbon Tax." Niskanen Center. March 2015. http://1uad6j1oqspx17mxgkjacp15.wpengine.netdna-cdn.com/wp-content/uploads/2015/03/The-Conservative-Case-for-a-Carbon-Tax1.pdf

Thompson, T., S. Rausch, R. Saari and N. Selin. "A systems approach to evaluating the air quality co-benefits of US carbon policies." Nature Climate Change 4: 917–923 (2014). doi:10.1038/nclimate2342

United States Environmental Protection Agency. "Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2013." February 2015. http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html

Wara, M, A. Morris, and M. Darby. "How the EPA Should Modify Its Proposed 111(d) Regulations to Allow States to Comply By Taxing Pollution." Brookings Institution. October 2014. http://www.brookings.edu/~/media/research/files/papers/2014/10/28commentsonepa111dtaxingpollutionmorris.pdf

Western Climate Initiative. "Design Recommendations for the WCI Regional Cap-and-Trade Program." September 23, 2008, corrected March 13, 2009. http://www.westernclimateinitiative.org/component/remository/general/design-recommendations/Design-Recommendations-for-the-WCI-Regional-Cap-and-Trade-Program/

Williams III, R., H. Gordon, D. Burtraw, J. Carbone and R. Morganstern. "The Initial Incidence of a Carbon Tax Across U.S. States." Resources for the Future. October 2014. http://www.rff.org/RFF/Documents/RFF-DP-14-25.pdf

World Bank. "Economics of Adaptation to Climate Change, Synthesis Report." Washington, D.C.: The World Bank. January 2010. http://documents.worldbank.org/curated/en/2010/01/16436675/economics-adaptation-climate-change-synthesis-report

World Bank Group. "State and Trends of Carbon Pricing 2014." Washington, D.C.: World Bank. 2014. http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2014/05/27/000456286_20140527095323/Rendered/PDF/882840AR0REPLA00EPI2102680Box385232.pdf

ENDNOTES

1. Horvitz, P.F. June 9, 1993. “Clinton Retreats on Energy Tax in Fight Over Budget.” *The New York Times.* Also available at: http://www.nytimes.com/1993/06/09/news/09iht-plan_1.html.

2. Conniff, R. August 2009. “The Political History of Cap and Trade.” *Smithsonian Magazine.* See: http://www.smithsonianmag.com/air/the-political-history-of-cap-and-trade-34711212/?page=2

3. World Bank. May 28, 2014. *State and Trends of Carbon Pricing 2014.* Washington, D.C.: World Bank.

4. Ontario Office of the Premier, “Statement of Intent Between the Government of Ontario and the Gouvernement Du Québec Concerning Cooperation on Market Based Mechanisms,” April 13, 2015. Available at: http://news.ontario.ca/opo/en/2015/04/statement-of-intent-between-the-government-of-ontario-and-the-gouvernement-du-quebec-concerning-coop.html

5. Interagency Working Group on Social Cost of Carbon, United States Government. Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866. Revised November 2013. Available at: http://www.whitehouse.gov/sites/default/files/omb/assets/inforeg/technical-update-social-cost-of-carbon-for-regulator-impact-analysis.pdf

6. The University of Chicago Booth School of Business. December 4, 2012. *Carbon Taxes II.* Chicago: IGM Economic Experts Panel. Available at: http://www.igmchicago.org/igm-economic-experts-panel/poll-results?SurveyID=SV_8oABK2TolkGluV7

7. See, for example: Bento, A. and M. Jacobsen. 2007. “Ricardian Rents, Environmental Policy, and the “Double Dividend” Hypothesis.” *Journal of Environmental Economics and Management* 53(1): 17–31.

8. Carbone, J.C., R.D. Morganstern, R.C. Williams III, and D. Burtraw. August, 2013. “Deficit Reduction and Carbon Taxes: Budgetary, Economic, and Distributional Impacts.” Washington, D.C.: Resources for the Future. Available at: http://www.weathervane.rff.org/RFF/Documents/RFF-Rpt-Carbone.etal.CarbonTaxes.pdf

9. Mathur, A. and A. Morris. 2012. “Distributional Effects of a Carbon Tax in Broader U.S. Fiscal Reform.” Washington, D.C.: The Brookings Institution. Available at: http://www.brookings.edu/~/media/research/files/papers/2012/12/14%20carbon%20tax%20fiscal%20reform%20morris/14%20carbon%20tax%20fiscal%20reform%20morris.pdf

10. See, for example, Morris, A. and A. Mathur. “A Carbon Tax in Broader U.S. Fiscal Reform: Design and Distributional Issues.” 2014. Washington, D.C.: The Brookings Institution. Available at: http://www.brookings.edu/research/papers/2014/05/22-carbon-tax-in-broader-us-fiscal-reform-morris Additional studies are discussed in Section 5 of this paper.

11. Environmental Protection Agency. December 2, 2009. “The Effects of H.R. 2454 on International Competitiveness and Emission Leakage in Energy-Intensive Trade-Exposed Industries.” Washington, DC: Environmental Protection Agency. Available at: http://www.epa.gov/climatechange/Downloads/EPAactivities/InteragencyReport_Competitiveness-EmissionLeakage.pdf

12. Shultz, George P. March 13, 2015. “A Reagan Approach to Climate Change.” Washington Post. Also available at: http://www.washingtonpost.com/opinions/a-reagan-model-on-climate-change/2015/03/13/4f4182e2-c6a8-11e4-b2a1-bed1aaea2816_story.html

13. Paulson, Henry M. June 21, 2014. “The Coming Climate Crash: Lessons for Climate Change in the 2008 Recession.” *The New York Times.* Also available at: http://www.washingtonpost.com/opinions/a-reagan-model-on-climate-change/2015/03/13/4f4182e2-c6a8-11e4-b2a1-bed1aaea2816_story.html

14. See http://republicen.org/

15. See, for example, Mankiw, N. Gregory. “Smart Taxes: An Open Invitation to Join the Pigou Club.” *Eastern Economic Journal* 35, 14-23 (2009). Available at: http://scholar.harvard.edu/files/mankiw/files/smart_taxes.pdf

16. See, for example, Wolf, Amy. February 20, 2012. “Economist Arthur Laffer Proposes Taxing Pollution Instead of Income.” *Vanderbilt News.* Also available at: http://news.vanderbilt.edu/2012/02/economist-arthur-laffer-proposes-taxing-pollution/

17. See, for example, Green, Kenneth P., Hayward, Steven F., and Kevin A. Hassett. “Climate Change: Caps vs. Taxes.” *American Enterprise Institute for Public Policy Research Environmental Policy Outlook* No. 2, June 2007. Available at: https://www.aei.org/wp-content/uploads/2011/10/20070601_EPOg.pdf

18. See “Considering a U.S. Carbon Tax,” Resources for the Future, accessed April 13, 2015, http://www.rff.org/centers/energy_and_climate_economics/Pages/Considering-a-US-Carbon-Tax.aspx

19. See, for example, Morris, Adele C. and Aparna Mathur. May 2014. “A Carbon Tax in Broader U.S. Fiscal Reform: Design and Distributional Issues.” Washington, DC: Center for Climate and Energy Solutions. Available at: http://www.brookings.edu/research/papers/2014/05/22-carbon-tax-in-broader-us-fiscal-reform-morris

20. See, for example, “Idea of the Day: We Should Have a Progressive Carbon Tax,” Center for American Progress, December 6, 2012. Available at: https://www.americanprogress.org/issues/general/news/2012/12/06/47139/idea-of-the-day-we-should-have-a-progressive-carbon-tax/

21. “Carbon Fee and Dividend Explained,” Citizens Climate Lobby, accessed April 13, 2015, https://citizensclimatelobby.org/carbon-fee-and-dividend/

22. Taylor, J. March 2015. “The Conservative Case for a Carbon Tax.” Washington, DC: Niskanen Center.

23. See, for example, Thompson, T.M. et al. 2014. “A systems approach to evaluating the air quality co-benefits of US carbon policies.” *Nature Climate Change* 4, 917–923 (2014). Available at: http://www.nature.com/nclimate/journal/v4/n10/full/nclimate2342.html

24. For example, coal-fired power plants emit pollutants into the air and water that can be detrimental to human health and the environment. For more information, see http://www.epa.gov/cleanenergy/energy-and-you/affect/coal.html

25. For a more complete discussion comparing carbon taxes to cap-and-trade programs, see Goulder and Schein, "Carbon Taxes Versus Cap and Trade: A Critical Review." *Climate Change Economics* Vol. 4, No. 3, 2013.

26. Dower, R.C. and M.B. Zimmerman. August, 1992. "The Right Climate for Carbon Taxes: Creating Economic Incentives to Protect the Environment." Washington, D.C.: World Resources Institute. Available at: http://www.wri.org/publication/right-climate-carbon-taxes

27. The plan would have applied the tax to most forms of energy, including hydropower and nuclear power, but it would have exempted solar, wind and geothermal energy. For more information, see: Greenhouse, Steven. February 18, 1993. "Clinton's Economic Plan: The Energy Plan; Fuels Tax: Spreading the Burden." *The New York Times*. Also available at: http://www.nytimes.com/1993/02/18/us/clinton-s-economic-plan-the-energy-plan-fuels-tax-spreading-the-burden.html

28. Horvitz, P.F. June 9, 1993. "Clinton Retreats on Energy Tax in Fight Over Budget." *The New York Times.* Also available at: http://www.nytimes.com/1993/06/09/news/09iht-plan_1.html

29. For summaries and analyses of the various bills that were introduced between 2003 and 2010, see http://www.wri.org/publication/emissions-reductions-under-pollution-reduction-proposals-111th-us-congress

30. American Opportunity Carbon Fee Act, S. 2940, 113th Congress (2014): Introduced by Senators Sheldon Whitehouse and Brian Schatz. Available at https://www.govtrack.us/congress/bills/113/s2940

31. Healthy Climate and Family Security Act of 2015, H.R. 1027, 114th Congress (2015). Introduced by Representative Chris Van Hollen. Available at https://www.govtrack.us/congress/bills/114/hr1027

32. For more information on the RGGI program review, see "2012 Program Review," Regional Greenhouse Gas Initiative, accessed April 13, 2015, http://www.rggi.org/design/program-review.

33. "Design Recommendations," Western Climate Initiative, accessed April 13, 2015, http://www.westernclimateinitiative.org/the-wci-cap-and-trade-program/design-recommendations.

34. Ontario Office of the Premier, "Statement of Intent Between the Government of Ontario and the Gouvernement Du Québec Concerning Cooperation on Market Based Mechanisms," April 13, 2015. Available at: http://news.ontario.ca/opo/en/2015/04/statement-of-intent-between-the-government-of-ontario-and-the-gouvernement-du-quebec-concerning-coop.html

35. For data point on emissions in jurisdictions with pricing programs, see "What Does it Mean to Put a Price on Carbon?" June 11, 2014. The World Bank. Available at: http://www.worldbank.org/en/news/feature/2014/06/11/what-does-it-mean-to-put-a-price-on-carbon. For data on emissions covered by these programs, see World Bank, *State and Trends of Carbon Pricing 2014.*

36. China's economic planning agency, the National Development and Reform Commission (NDRC), has submitted regulations for a national-level emissions trading system to the State Council for approval. Kathy Chen and Stian Reklev. August 31, 2014. "China's National Carbon Market to Start in 2016—Official." *Reuters.* Also available at: http://uk.reuters.com/article/2014/08/31/china-carbontrading-idUKL3N0R107420140831.

37. Some provinces will be allowed to delay participation in the emissions trading system if they do not have the technical infrastructure to participate from the beginning. http://uk.reuters.com/article/2014/08/31/china-carbontrading-idUKL3N0R107420140831

38. CDP. December, 2013. "Use of internal carbon price by companies as incentive and strategic planning tool: A review of findings from CDP 2013 disclosure." New York, NY: CDP. See: http://big.assets.huffingtonpost.com/22Nov2013-CDP-InternalCarbonPriceReprt.pdf

39. WRI (World Resources Institute). CAIT 2.0, accessed April 13, 2015. http://cait2.wri.org/wri/Country%20GHG%20Emissions?indicator[]=Total CO_2 (excluding Land-Use Change and Forestry)&indicator[]=Total CH4&indicator[]=Total N_2O&indicator[]=Total F-Gas&year[]=2011&country[]=United%20States&country[]=World&sortDir=asc&chartType=pie

40. For a full discussion of global warming potential, see Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestvedt, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura and H. Zhang, 2013: Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Available at: http://www.climatechange2013.org/images/report/WG1AR5_Chapter08_FINAL.pdf

41. "Power Plants," U.S. Environmental Protection Agency Greenhouse Gas Reporting Program, accessed April 13, 2015, http://www.epa.gov/ghgreporting/ghgdata/reported/powerplants.html.

42. U.S. Environmental Protection Agency, U.S. Greenhouse Gas Inventory. http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html

43. Houser, T. et al. May, 2008. "Leveling the Carbon Playing Field." Washington, DC: Peterson Institute for International Economics and World Resources Institute. Available at: http://pdf.wri.org/leveling_the_carbon_playing_field.pdf

44. Interagency Working Group on Social Cost of Carbon, United States Government. 2013. "Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866." Technical Support Document. Revised November 2013. Available at: http://www.whitehouse.gov/sites/default/files/omb/assets/inforeg/technical-update-social-cost-of-carbon-for-regulator-impact-analysis.pdf

45. See, for example, Moore, F.C. and D.B. Diaz. 2015. "Temperature impacts on economic growth warrant stringent mitigation policy." *Nature Climate Change* 5: 127–131. Available at: http://www.nature.com/nclimate/journal/v5/n2/full/nclimate2481.html

46. British Columbia Climate Action Plan. 2008. Available at: http://www.gov.bc.ca/premier/attachments/climate_action_plan.pdf

47. For information on RGGI, see: http://www.eia.gov/todayinenergy/detail.cfm?id=14851. For information on EU-ETS, see: http://ec.europa.eu/clima/policies/ets/pre2013/index_en.htm and http://ec.europa.eu/clima/policies/ets/index_en.htm

48. No GHG cap-and-trade programs have had this experience to date, but the RECLAIM market for NOx emissions in Southern California experienced extreme increases in prices in 2000 and 2001 during the Californian electricity crisis. For a discussion of the lessons from RECLAIM's experience, see "Air Actions, California," U.S. Environmental Protection Agency, accessed April 13, 2015, http://www.epa.gov/region09/air/reclaim/

49. For an overview of the experience in the initial stages of the Clean Development Mechanism, the main offset mechanism set up under the UNFCCC, including its successes and its struggles, see Gillenwater, Michael and Stephen Seres, March 2011. "The Clean Development Mechanism: A Review of the First International Offset Program." Washington, D.C.: Pew Center for Global Climate Change. Available at: https://ghginstitute.org/wp-content/uploads/2011/03/PEW8037CDMReport.pdf

50. High quality offsets are real, permanent, additional, verifiable, and enforceable. For a full discussion, see Goodward, Jenna and Alexia Kelly, August 2010. "The Bottom Line of Offsets." Washington, DC: World Resources Institute. Available at: http://www.wri.org/publication/bottom-line-offsets

51. GHG Protocol, Policy and Action Standard, 2014. Washington, D.C.: World Resources Institute. Available at: http://www.ghgprotocol.org/policy-and-action-standard

52. For a discussion of market barriers, see the section on Reducing Electricity Consumption in Bianco et al, 2014. Available at: http://www.wri.org/publication/seeing-believing-creating-new-climate-economy-united-states

53. See Hibbard, Paul J. et al. 2011. "The Economic Impacts of the Regional Greenhouse Gas Initiative on Ten Northeast and Mid-Atlantic States." Boston, MA: The Analysis Group, November 15, 2011. Available at: http://www.analysisgroup.com/uploadedfiles/publishing/articles/economic_impact_rggi_report.pdf

54. Stavins, R.N., 1997. Policy Instruments for Climate Change: How Can National Governments Address a Global Problem? University of Chicago Legal Forum 1997, 293-329.

55. See "National Greenhouse Gas Emissions Data," U.S. Environmental Protection Agency, February 2015, http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html

56. See "Historical Amounts of Revenue by Source," Tax Policy Center, February 4, 2015, http://www.taxpolicycenter.org/taxfacts/displayafact.cfm?Docid=203

57. See "Data: United States," The World Bank, accessed April 13, 2015, http://data.worldbank.org/country/united-states

58. The Global Commission on the Economy and Climate. September, 2014. "Better Growth, Better Climate." Washington, DC: Global Commission on the Economy and Climate. Available at: http://newclimateeconomy.report/

59. See, for example, George P. Shultz and Gary S. Becker. April 7, 2013. "Why We Support a Revenue-Neutral Carbon Tax." *The Wall Street Journal*. Also available at: http://www.wsj.com/articles/SB10001424127887323611604578396401965799658.

60. See, for example, "Carbon Fee and Dividend Explained," Citizens Climate Lobby, accessed April 13, 2015, https://citizensclimatelobby.org/carbon-fee-and-dividend/ and Richard W. Caperton. December 6, 2012. "A Progressive Carbon Tax Will Fight Climate Change and Stimulate the Economy." Center for American Progress. Available at: https://www.americanprogress.org/issues/green/report/2012/12/06/47052/a-progressive-carbon-tax-will-fight-climate-change-and-stimulate-the-economy/.

61. See, for example, Andrew Moylan. October 2, 2013. "How to Tax Carbon." *The American Conservative*. Available at: http://www.theamericanconservative.com/articles/how-to-tax-carbon/.

62. "Carbon Fee and Dividend Explained," Citizens Climate Lobby, accessed April 13, 2015, https://citizensclimatelobby.org/carbon-fee-and-dividend/

63. For example, Adele Morris from the Brookings Institution and Aparna Mathur from the American Enterprise Institute recommend using much of the revenue from a carbon tax to offset reductions in corporate and/or personal income taxes. See Morris and Mathur, 2014. Available at: http://www.brookings.edu/research/papers/2014/05/22-carbon-tax-in-broader-us-fiscal-reform-morris

64. "Taxation of Corporate and Capital Income (2014)," Organisation for Economic Cooperation and Development, accessed April 13, 2015, http://www.oecd.org/ctp/tax-policy/Table%20II.1-May-2014.xlsx.

65. U.S. Government Accountability Office. May, 2013. "Corporate Income Tax: Effective Tax Rates Can Differ Significantly from the Statutory Rate." Available at: http://gao.gov/products/GAO-13-520

66. McKibbin, W. J. et al. 2012. "The Potential Role of a Carbon Tax in U.S. Fiscal Reform." Climate and Energy Economics Discussion Paper. Washington, D.C.: Brookings Institution. Available at: http://tinyurl.com/btkd5xf.

67. Carbone, J.C., R.D. Morgenstern, and R.C. Williams III. 2012. "Carbon Taxes and Deficit Reduction." (Draft, May 2012.) Atlanta, GA: Georgia Tech. Available at: www.econ.gatech.edu/files/seminars/Williams.pdf

68. Chateau, J., A. Saint-Martin, and T. Manfredi. 2011. "Employment Impacts of Climate Change Mitigation Policies in OECD: A General-Equilibrium Perspective." Paris: Organization for Economic Co-operation and Development. Available at: http://www.oecd-ilibrary.org/environment/employment-impacts-of-climate-change-mitigation-policies-in-oecd_5kg0ps847h8q-en

69. Goulder, L.H. December, 2013. "Climate Change Policy's Interaction with the Tax System." *Energy Economics*, Vol. 40, Supp. 1. Available at: http://www.sciencedirect.com/science/article/pii/S0140988313002120

70. Congressional Budget Office. "Federal Debt and the Risk of a Fiscal Crisis." Washington, D.C. July 27, 2010. Available at: http://www.cbo.gov/sites/default/files/07-27_debt_fiscalcrisis_brief.pdf

71. See, for example, Richard W. Caperton. December 6, 2012. "A Progressive Carbon Tax Will Fight Climate Change and Stimulate the Economy." Center for American Progress. Available at: https://www.americanprogress.org/issues/green/report/2012/12/06/47052/a-progressive-carbon-tax-will-fight-climate-change-and-stimulate-the-economy/

72. "Historical Tables," White House Office of Management and Budget, accessed April 13, 2015, https://www.whitehouse.gov/omb/budget/Historicals.

73. "Government Deficit/Surplus, Debt and Associated Data," Eurostat, updated February 27, 2015, http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=gov_10dd_edpt1&lang=en

74. Frank Convery. 2013. "Budget 2013—Three Cheers for the Carbon Tax." Publicpolicy.ie. Available at: http://www.publicpolicy.ie/wp-content/uploads/Budget-2013-Three-cheers-for-the-Carbon-tax1.pdf.

75. See, for example: http://www.careeronestop.org/, http://www.jobcorps.gov/home.aspx, and http://www.valu.va.gov/Home/Index

76. Levin, K., B. Cashore, S. Bernstein, and G. Auld. 2012."Overcoming the tragedy of super wicked problems: constraining our future selves to ameliorate global climate change." Policy Sciences. Vol. 45, Iss. 2: 123-152. June. Available at: http://www.reshape.se/files/8514/2071/1788/Overcoming_the_tragedy_of_super_wicked_problems.pdf

77. See, for example: "Assistance for Coal Miners Who Have Been Laid Off, Work Force West Virginia, accessed April 13, 2015, http://www.wvcommerce.org/business/workforcewv/job_seekers/minelayoff.aspx and "Hiring Our Miners Everyday," Kentucky Career Center, accessed April 13, 2015, http://www.jobsight.org/jobseeker/coalminers.

78. Osikominu, A. 2013. "Quick Job Entry or Long-Term Human Capital Development? The Dynamic Effects of Alternative Training Schemes." *Review of Economic Studies*, (2013) 80 (1): 313-342. Available at: http://restud.oxfordjournals.org/content/80/1/313

79. Canadian Apprenticeship Forum. June, 2009. "It Pays to Hire an Apprentice: Calculating the Return on Training Investment for Skilled Trades Employers in Canada." Ottawa, Canada: Canadian Apprenticeship Forum. Available at: http://www.novascotia.ca/lae/Apprenticeshipboard/documents/CAF-FCA_ROTI_it_pays_to_hire_an_apprentice_ExecutiveReport_En_000.pdf.

80. Danielle Scalise. October 6, 2014. "Chile to Implement Carbon Tax Complimenting the Latin American Trend of Environmental Reform." *Panoramas.* Also available at: http://www.panoramas.pitt.edu/content/chile-implement-carbon-tax-complimenting-latin-american-trend-environmental-reform.

81. Boyce, J., and M. Riddle. November, 2007. "Cap and Dividend: How to Curb Global Warming While Protecting the Incomes of American Families." Amherst, MA: Political Economy Research Institute. Working Paper Series. Available at: http://scholarworks.umass.edu/cgi/viewcontent.cgi?article=1121&context=peri_workingpapers.

82. See Levin et al. (2012) for further discussion.

83. OECD. 2014. "Switzerland economic forecast summary November 2014." Paris. Organisation for Economic Cooperation and Development. Available at: http://www.oecd.org/economy/switzerland-economic-forecast-summary.htm

84. For U.S. coal production data, see "Coal: Production," U.S. Energy Information Administration, accessed April 13, 2015, http://www.eia.gov/coal/data.cfm#production

85. For household heating data, see "Household Heating Fuels Vary Across the Country," U.S. Energy Information Administration, October 28, 2011, http://www.eia.gov/todayinenergy/detail.cfm?id=3690.

86. See, for example, Morris, A. and A. Mathur. 2014. "A Carbon Tax in Broader U.S. Fiscal Reform: Design and Distributional Issues." Washington, D.C.: The Brookings Institution. Available at: http://www.brookings.edu/research/papers/2014/05/22-carbon-tax-in-broader-us-fiscal-reform-morris. Additional studies are discussed in Section 5

87. Edison Electric Institute. August 2014. "Different Regions of the Country Use Different Fuel Mixes to Generate Electricity." Washington, DC. Available at: http://www.eei.org/issuesandpolicy/generation/fueldiversity/Documents/map_fuel_diversity.pdf

88. Metcalf, G. 2009. "Designing a Carbon Tax to Reduce U.S. Greenhouse Gas Emissions." *Review of Environmental Economics and Policy*, Vol. 3, Iss. 1, Winter. Available at: http://reep.oxfordjournals.org/content/3/1/63.full.pdf+html

89. For more information on whether and how a U.S. carbon tax can be designed in order to comply with World Trade Organization rules, see Jennifer Hillman. July 25, 2013. "Changing Climate for Carbon Taxes: Who's Afraid of the WTO?" Washington, DC: The German Marshall Fund of the United States. Available at: http://www.gmfus.org/publications/changing-climate-carbon-taxes-who%E2%80%99s-afraid-wto; Pauwelyn , Joost, Carbon Leakage Measures and Border Tax Adjustments Under WTO Law (March 21, 2012). Available at: http://ssrn.com/abstract=2026879; and Steve Charnovitz. September 29, 2014. "Border Tax Equalization (Draft Paper Prepared for the Conference on Challenges Facing the World Trade System)." Available at: http://indianeconomy.columbia.edu/sites/default/files/paper2-bordertax.pdf .

90. Sumner, J., L. Bird, and H. Smith. December, 2009. "Carbon Taxes: A Review of Experience and Policy Design Considerations." Golden, CO: National Renewable Energy Laboratory. Available at: http://www.nrel.gov/docs/fy10osti/47312.pdf

91. "Global Market Share of the World's Leading Wind Turbine Manufacturers in 2013, Based on Sales in Gigawatts," Statista, accessed April 13, 2015, http://www.statista.com/statistics/272813/market-share-of-the-leading-wind-turbine-manufacturers-worldwide/.

92. "Wind Turbines Reached Record Level in 2014," Energinet.dk, January 20, 2015, http://energinet.dk/EN/El/Nyheder/Sider/Vindmoeller-slog-rekord-i-2014.aspx.

93. Caperton, R. 2012. "A Progressive Carbon Tax Will Fight Climate Change and Stimulate the Economy." Center for American Progress, December 6, 2012. Available at: http://cdn.americanprogress.org/wp-content/uploads/2012/12/CAPERTONCarbonTax.pdf.

94. For more information on the Green Climate Fund, see: http://unfccc.int/cooperation_and_support/financial_mechanism/green_climate_fund/items/5869.php and http://news.gcfund.org/

95. The World Bank. 2010. “Economics of Adaptation to Climate Change, Synthesis Report.” January. Washington, D.C.: The World Bank. Available at: http://documents.worldbank.org/curated/en/2010/01/16436675/economics-adaptation-climate-change-synthesis-report

96. Sussman, F., N. Krishnan, K. Maher, R. Miller, C. Mack, P. Stewart, K. Shouse, and W. Perkins. “Climate Change Adaptation Cost in the U.S.: What Do We Know?” *Climate Policy*, Vol. 14, No. 2: 242-282. Available at: http://www.tandfonline.com/action/showCitFormats?doi=10.1080%2F14693062.2013.777604&

97. http://www.bmub.bund.de/en/topics/climate-energy/climate-initiative/general-information/

98. http://www.rggi.org/docs/Documents/2012-Investment-Report.pdf

99. OECD (Organisation for Economic Cooperation and Development). 2010. “Taxation, Innovation and the Environment.” Executive Summary. Paris: OECD. Available at: http://www.oecd.org/env/tools-evaluation/46177075.pdf.

100. The IPCC estimates that, in order to keep warming to two degrees Celsius, global emissions must be approximately 80-95 percent below 2000 levels by 2050, though reductions would likely need to be even greater in developed countries. Global emissions of CO_2 would need to be net zero by 2070, and all greenhouse gases would need to be phased out by 2100. For more information, see: https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter6.pdf

101. See, for example: Jesse Jenkins. July 28, 2014. “When Politics Constrains Carbon Pricing, Part 3: Why Carbon Revenues Are Just As Important As ‘Putting a Price on Carbon.’” *The Energy Collective.* Available at: http://theenergycollective.com/jessejenkins/444186/when-politics-constraints-carbon-pricing-part-3-why-carbon-revenues-are-just-imp.

102. For example, federal support for new drilling techniques helped pave the way for the U.S. shale gas boom in recent years. See Box 1.1 of Bianco, N. et al. 2014. “Seeing is Believing: Creating a New Climate Economy in the United States.” Working Paper. Washington, D.C.: World Resources Institute. Available at: http://www.wri.org/publication/new-climate-economy.

103. The Global Commission on the Economy and Climate, *Better Growth, Better Climate,* Executive Summary. Available at: http://static.newclimateeconomy.report/wp-content/uploads/2014/08/NCE_ExecutiveSummary.pdf

104. Bianco, N. et al. 2014. “Seeing is Believing: Creating a New Climate Economy in the United States.” Working Paper. Washington, D.C.: World Resources Institute. Available at: http://www.wri.org/publication/new-climate-economy

105. See: Acemoglu, D. et al. and Fischer, C. et al.

106. Amdur, D., B. Rabe and C. Borlick. “Public Views on a Carbon Tax Depend on the Proposed Use of Revenue.” CLOSUP (Center for Local, State and Urban Policy), University of Michigan. July 2014. http://closup.umich.edu/files/ieep-nsee-2014-spring-carbon-tax.pdf

107. Center on Budget and Policy Priorities. May 12, 2008. “Climate Change Policies Can Treat Low-Income Families Fairly and Be Fiscally Responsible.” Available at: http://www.cbpp.org/files/climate-brochure.pdf

108. Pew Center on Global Climate Change. August, 2009. “Distribution of Allowances Under the American Clean Energy and Security Act (Waxman-Markey).” Pew Center, Washington, D.C. Available at: http://www.c2es.org/docUploads/policy-memo-allowance-distribution-under-waxman-markey.pdf

109. Horowitz, C., M.R. Enion, S.B. Hecht and A. Carlson. “Spending California’s Cap-and-Trade Auction Revenue: Understanding the Sinclair Paint Risk Spectrum.” Emmitt Center on Climate Change and the Environment, UCLA School of Law. March 2012. http://law.ucla.edu/~/media/Files/UCLA/Law/Pages/Publications/CEN_EMM_PUB%20Spending_CA_Cap_Trade_Revenue.ashx

110. For more information, see: http://www.arb.ca.gov/cc/capandtrade/auctionproceeds/budgetappropriations.htm

111. Parry, I., and R. Williams III. 2011. “Moving U.S. Climate Policy Forward: Are Carbon Taxes the Only Good Alternative?” Washington, D.C.: Resources for the Future. Available at: http://www.rff.org/RFF/Documents/RFF-DP-11-02.pdf

112. Goulder, L.H. and M.A. C. Hafstead. October 8, 2013. “Tax Reform and Environmental Policy: Options for Recycling Revenue from a Tax on Carbon Dioxide”. Washington, D.C.: Resources for the Future. Available at: http://ssrn.com/abstract=233821

113. Regional Economic Models, Inc. and Synapse Energy Economics, Inc. 2014. “The Economic, Climate, Fiscal, Power, and Demographic Impact of a National Fee-and-Dividend Carbon Tax.” Available at: http://dv7gcmvxe5e8l.cloudfront.net/wp-content/uploads/2014/09/The-Economic-Climate-Fiscal-Power-and-Demographic-Impact-of-a-National-Fee-and-Dividend-Carbon-Tax-6.9.14.pdf

114. Carbone, J.C., R.D. Morganstern, R.C. Williams III, and D. Burtraw. August, 2013. “Deficit Reduction and Carbon Taxes: Budgetary, Economic, and Distributional Impacts.” Washington, D.C.: Resources for the Future. Available at: http://www.weathervane.rff.org/RFF/Documents/RFF-Rpt-Carbone.etal.CarbonTaxes.pdf

115. McKibbin, W.J., A. Morris, P.J. Wilcoxen, and Y. Cai. July 24, 2012. “The Potential Role of a Carbon Tax in U.S. Fiscal Reform.” Climate and Energy Economics Discussion Paper. Washington, D.C.: Brookings Institution. Available at: http://tinyurl.com/btkd5xf

116. Eisenberg, S., M. Wara, A. Morris, M. Darby, and J. Minor. 2014. “A State Tax Approach to Regulating Greenhouse Gas Emissions Under the Clean Air Act.” Washington, D.C.: The Brookings Institution. Available at: http://www.brookings.edu/research/papers/2014/05/22-state-tax-regulating-greenhouse-gas-clean-air-act-morris

117. CBO (Congressional Budget Office). 2013.

118. CBO (Congressional Budget Office). May, 2010. “How Policies to Reduce Greenhouse Gas Emissions Could Affect Employment.” Washington, D.C.: CBO, Available at: http://www.cbo.gov/sites/default/files/05-05-capandtrade_brief.pdf

119. Ibid. According to CBO, “The length of time required for [the economy to return to full employment] would depend on a number of factors. One would be the ability of firms and workers to foresee and act quickly on the changes in prices and to implement the changes that would be required in their output, training, and other activities. Another factor would be the extent to which shrinking industries are concentrated in small communities in which other opportunities for employment are limited, requiring laid-off workers to relocate in order to find new employment. The U.S. economy has adjusted fairly quickly to past changes in the economic environment, including the changes brought about by the rapid development of computer and information technologies, which destroyed many jobs but created many others, and the increase in international trade, which shifted many manufacturing jobs out of the country but probably contributed to the growth of service jobs.”

120. Chateau et al., 2011.

121. Rausch, S., and J. Reilly. August, 2012. “Carbon Tax Revenue and the Budget Deficit: A Win-Win-Win Solution?” MIT Joint Program on the Science and Policy of Global Change. August 2012. Cambridge, MA: Massachusetts Institute of Technology. Available at: http://18.7.29.232/bitstream/handle/1721.1/72548/MITJPSPGC_Rpt228.pdf?sequence=1

122. For more information on the decline of coal-reliant communities in recent decades, see: http://www.washingtonpost.com/blogs/wonkblog/wp/2013/11/04/heres-why-central-appalachias-coal-industry-is-dying/

123. See, for example: Dower, R. and M.B. Zimmerman. 1992. “The Right Climate for Carbon Taxes: Creating Economic Incentives to Protect the Atmosphere.” Washington, D.C.: World Resources Institute. Available at: http://www.wri.org/sites/default/files/pdf/rightclimateforcarbontaxes_bw.pdf. Dower and Zimmerman find that poorer households spend as much as five times as much on energy as do richer households, when measured as a percentage of income

124. CBO (Congressional Budget Office). May 2013. “Effects of a Carbon Tax on the Economy and the Environment.” Washington, D.C.: Available at: http://www.cbo.gov/sites/default/files/44223_Carbon_0.pdf

125. Marron, D. and E. Toder. February, 2013. “Carbon Taxes and Corporate Tax Reform.” Washington, D.C.: Urban-Brookings Tax Policy Center. Available at: http://www.taxpolicycenter.org/UploadedPDF/412744-Carbon-Taxes-and-Corporate-Tax-Reform.pdf

126. Mathur, A. and A. Morris. 2012. “Distributional Effects of a Carbon Tax in Broader U.S. Fiscal Reform.” Washington, D.C.: The Brookings Institution. Available at: http://www.brookings.edu/~/media/research/files/papers/2012/12/14%20carbon%20tax%20fiscal%20reform%20morris/14%20carbon%20tax%20fiscal%20reform%20morris.pdf

127. Williams III, R., H. Gordon, D. Burtraw, J. Carbone, and R. Morgenstern. August, 2014. “The Initial Incidence of a Carbon Tax Across Income Groups.” Washington, D.C.: Resources for the Future. Available at: http://www.rff.org/RFF/Documents/RFF-DP-14-24.pdf

128. Eisenberg et al., 2014.

129. Metcalf, G. 2009. “Designing a Carbon Tax to Reduce U.S. Greenhouse Gas Emissions.” *Review of Environmental Economics and Policy*, Vol. 3, Iss. 1, Winter. Available at: http://reep.oxfordjournals.org/content/3/1/63.full.pdf+html

130. Morris, A. and A. Mathur. 2014. “A Carbon Tax in Broader U.S. Fiscal Reform: Design and Distributional Issues.” Washington, D.C.: The Brookings Institution. Available at: http://www.brookings.edu/research/papers/2014/05/22-carbon-tax-in-broader-us-fiscal-reform-morris

131. Rosenbaum, D., S. Parrott, and C. Stone. October, 2009. “How Low-Income Consumers Fare in the House Climate Bill.” Washington, D.C.: Center on Budget and Policy Priorities. Available at: http://www.cbpp.org/files/7-8-09climate.pdf

132. U.S. Department of Transportation, Federal Highway Administration. “State and Urbanized Area Statistics.” Available at: http://www.fhwa.dot.gov/ohim/onh00/onh2p11.htm Accessed on December 11, 2014.

133. U.S. Energy Information Administration. “Electricity: Detailed State Data.” Available at: http://www.eia.gov/electricity/data/state/ Accessed on December 11, 2014.

134. U.S. Energy Information Administration. “Household heating fuels vary across the country.” Available at: http://www.eia.gov/todayinenergy/detail.cfm?id=3690. Accessed on December 11, 2014.

135. CBO, 2013.

136. Pew Center, 2009. Available at: http://www.c2es.org/docUploads/policy-memo-allowance-distribution-under-waxman-markey.pdf

137. Morris and Mathur, 2014.

138. Hassett, K., A. Mathur, and G. Metcalf. 2009. “The Incidence of a U.S. Carbon Tax: A Lifetime and Regional Analysis.” *The Energy Journal.* Vol. 30, No.2. Available at: https://www.aeaweb.org/assa/2009/retrieve.php?pdfid=346

139. Williams III, R., H. Gordon, D. Burtraw, J. Carbone ,and R. Morganstern. October, 2014. “The Initial Incidence of a Carbon Tax Across U.S. States.” Washington, D.C.: Resources for the Future. Discussion Paper. Available at: http://www.rff.org/RFF/Documents/RFF-DP-14-25.pdf

140. For example, in 2012, the United States consumed 3.8 billion megawatt-hours of electricity. Of that total, less than 60 million megawatt-hours were imported from Canada or Mexico. See: http://www.eia.gov/electricity/annual/html/epa_02_02.html and http://www.eia.gov/electricity/annual/html/epa_02_13.html

141. EPA (U.S. Environmental Protection Agency). December 2, 2009. “The Effects of H.R. 2454 on International Competitiveness and Emission Leakage in Energy-Intensive Trade-Exposed Industries.” Washington, D.C.: EPA. Available at: http://www.epa.gov/climatechange/Downloads/EPAactivities/InteragencyReport_Competitiveness-EmissionLeakage.pdf

142. Metcalf, G.E. 2010. “Submission on the Use of Carbon Fees to Achieve Fiscal Sustainability in the Federal Budget.” *Submission to Commission.* Available at: http://works.bepress.com/gilbert_metcalf/86

143. See: “WTO Signals Backing for Border Taxes.” Financial Times, June 25, 2009. Available at: http://www.ft.com/intl/cms/s/0/1be7d034-61b6-11de-9e03-00144feabdc0.html#axzz3Vaj4M5MQ

144. For GATT rules, see: http://www.wto.org/english/docs_e/legal_e/gatt47_e.pdf

145. See, for example: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2026879 and http://www.gmfus.org/wp-content/blogs.dir/1/files_mf/1374767060Hillman_CarbonTaxes_Jun13_web.pdf For an alternate viewpoint, see: http://www.brookings.edu/~/media/events/2008/6/09%20climate%20trade/2008_bordoff.pdf. For a summary of challenges to WTO compliance, see http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2163203

146. See Holzer et al.

147. For a discussion of the challenges surrounding how to determine the carbon content of imported goods, see: http://www.iisd.org/pdf/2008/cph_trade_climate_carbon.pdf

148. Gravelle, J. January 6, 2014. “International Corporate Tax Rate Comparisons and Policy Implications.” Washington, D.C.: Congressional Research Service. Available at https://www.fas.org/sgp/crs/misc/R41743.pdf

149. See: http://www.finance.senate.gov/issue/?id=8b4a11ec-b93f-43bd-8f72-fbc4f4768989

150. Bianco, N. et al. 2013. For the United States’ commitment to reduce its emissions by 83 percent below 2005 levels by 2050, see: “United States Submission to the Copenhagen Accord, Appendix 1,” United States Department of State, January 28, 2010, http://unfccc.int/files/meetings/cop_15/copenhagen_accord/application/pdf/unitedstatescphaccord_app.1.pdf

151. See, for example: Coral Davenport and Marjorie Connelly. January 30, 2015. “Most Republicans Say They Back Climate Action, Poll Finds.” *The New York Times*. http://www.nytimes.com/2015/01/31/us/politics/most-americans-support-government-action-on-climate-change-poll-finds.html?_r=0

152. Source: Sumner et al., 2009.

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ABOUT WRI

World Resources Institute is a global research organization that turns big ideas into action at the nexus of environment, economic opportunity and human well-being.

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.