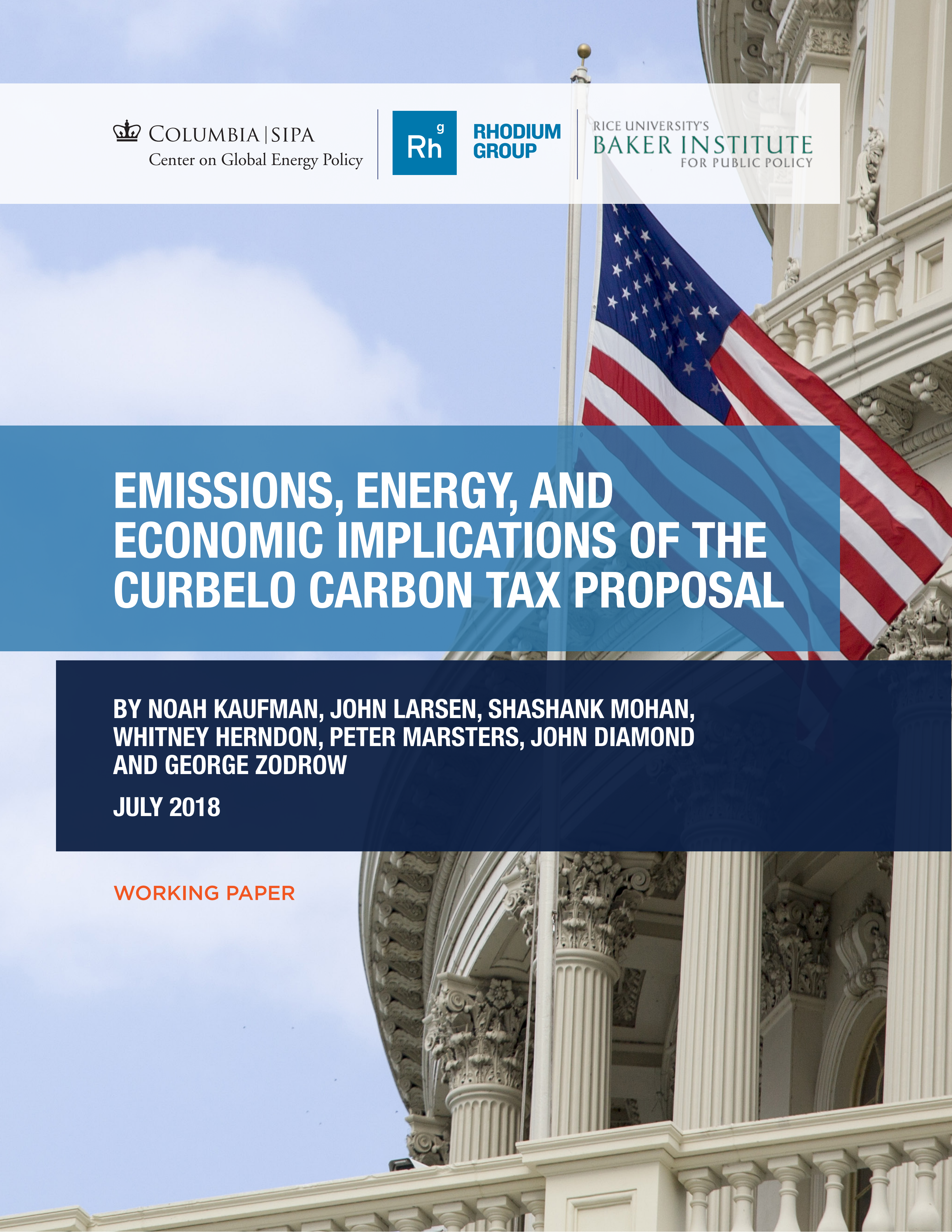

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EMISSIONS, ENERGY, AND ECONOMIC IMPLICATIONS OF THE CURBELO CARBON TAX PROPOSAL

BY NOAH KAUFMAN, JOHN LARSEN, SHASHANK MOHAN, WHITNEY HERNDON, PETER MARSTERS, JOHN DIAMOND AND GEORGE ZODROW

JULY 2018

WORKING PAPER

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This working paper was developed in response to a Congressional proposal, using the same models and methodologies described in reports prepared for CGEP Carbon Tax Research Initiative, which are available on CGEP's website. Unlike the CGEP Carbon Tax Research Initiative reports, given the relatively short timeframe available to conduct this analysis, this working paper has not been subject to CGEP's formal expert review process.

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TABLE OF CONTENTS

Executitve Summary 05

Background 06

Methodology for our Analysis 06

Greenhouse Gas Emission Implications 07

Energy Implications 09

Revenue Implications 12

Macroeconomic Implications 13

Impacts on Low-Income Households 14

Notes 16

EXECUTIVE SUMMARY

In July 2018 Representative Carlos Curbelo proposed legislation that would put a price on US carbon dioxide emissions ("Curbelo proposal"). A carbon price is widely viewed as a necessary part of a cost-effective national strategy to address the risks of climate change. This proposal is especially notable because Republicans, who currently control the US Senate, House of Representatives, and presidency, have not proposed national carbon pricing legislation in nearly a decade.

This paper, part of the Carbon Tax Research Initiative of the Columbia University SIPA Center for Global Energy Policy (CGEP), is a collaboration between scholars at CGEP, Rhodium Group, and the Baker Institute for Public Policy at Rice University. It presents the results of an independent analysis of the impacts on emissions, energy markets, revenues and the economy of the Curbelo proposal.

The Curbelo proposal would impose a tax on carbon dioxide emissions that starts at $24/ton of CO_2e in 2020, and it repeals the federal excise taxes on gasoline and diesel fuels. Analysis in RHG-NEMS provides estimates of the effects of these policy changes on the US energy system and greenhouse gases. The proposal would generate significant new government revenues that would be used to fund the US transportation system and provide dividends to low-income families, among other uses. Analysis using the Diamond-Zodrow dynamic computable general equilibrium model provides estimates of the effects of the price changes and revenue uses on the US economy and the welfare of low-income households.

The Curbelo proposal leads to the following economy-wide net greenhouse gas emissions compared to 2005 levels:

- 27–32 percent reductions by 2025
- 30–40 percent reductions by 2030

More than two-thirds of these emission reductions occur in the electric power sector. Such economy-wide emission reductions would outpace the United States' nationally determined contribution to the Paris Agreement of 26–28 percent reductions by 2025. By contrast, under current policy, economy-wide net GHG emissions would fall to 18–22 percent below 2005 levels in 2025.

The Curbelo proposal has the following implications for the US energy market and economic outcomes, compared to a scenario in which current policies remain in place through 2030:

- Annual federal government revenues increase by $57 billion–$72 billion in 2020 and $63 billion–$106 billion in 2030 (all monetary results are in 2016 dollars).
- Natural gas production is 2–3 percent higher in 2020 and 5–8 percent lower in 2030.
- Crude oil production is not significantly affected, and gasoline and diesel prices increase by less than 10 cents per gallon.
- National average electricity prices are 8 percent higher in 2020 and 5–10 percent higher in 2030.
- Per capita energy expenditures will increase by about $275 in 2020 and by $186–$278 in 2030, in all years remaining more than $1,000 lower than the recent historical peak in 2008.
- National macroeconomic outcomes decline modestly, including reductions in annual gross domestic product of between 0.1 and 0.2 percent in the 2020s.
- The effects on gross domestic product do not increase over time; they remain at about 0.2 percent.
- The lowest-income households benefit from the Curbelo proposal; the 10 percent of carbon tax revenues used for transfers/dividends are more than sufficient to offset the higher energy prices.
- Younger workers, those who have not yet entered the workforce, and retirees fare better than middle-aged workers.

BACKGROUND

In January 2018, CGEP launched its Carbon Tax Research Initiative, a collaboration between scholars at Columbia University and outside experts. The goal is to produce clear and objective analysis that enables the thoughtful consideration of federal carbon tax policy in the United States. Thus far, studies have been released on major design decisions, energy and emission implications, macroeconomic effects, and distributional outcomes associated with a federal carbon tax, which can be found on the website of the initiative.

In July 2018, Representative Carlos Curbelo released the Modernizing America with Rebuilding to Kickstart the Economy of the Twenty-First Century with a Historic Infrastructure-Centered Expansion Act ("Curbelo proposal"). The Curbelo proposal places a carbon tax on all fossil fuel combustion and additional non-fossil fuel emission sources starting at $24/ton of CO_2e in 2020 and rising at 2 percent above the rate of inflation annually. The proposal contains a provision to adjust the tax rate upward if specific emission reduction targets are not achieved. The carbon tax applies to imported fossil fuel but not exports, and a border tax adjustment applies to the export and import of certain energy-intensive products. Tax credits are provided for non-emissive uses of taxed fuels and for permanent sequestration of taxed emissions.

The proposal abolishes the excise taxes on gasoline, diesel, and aviation fuels and provides certain limitations on the federal government's authority to regulate greenhouse gases under the Clean Air Act, including EPA regulations of stationary sources but not including vehicle greenhouse gas emissions standards. Revenues from the carbon tax are allocated to increasing the funding of the federal Highway Trust Fund and to grants to states to distribute to low-income households, among various other uses.

METHODOLOGY FOR OUR ANALYSIS

To assess the emission and energy market implications of the Curbelo proposal, this analysis includes a range of scenarios in RHG-NEMS, a version of the National Energy Modeling System developed by EIA and maintained by the Rhodium Group. RHG-NEMS produces economy-wide projections of the US energy system as well as projections of all major greenhouse gas (GHG) emissions consistent with the Environmental Protection Agency's GHG inventory.

Energy technology and market assumptions use EIA's *Annual Energy Outlook 2017* (AEO 2017) reference case as a starting point. The analysis includes use a range of assumptions on technological costs and deployment of key technologies, including electric vehicle batteries, renewable generating technologies, and the uptake of high-efficiency appliances and devices. It also includes additional low-carbon technologies beyond those included in AEO 2017, such as the availability of carbon capture and storage for industrial facilities and renewable natural gas.[1] Historical GHG data used in this analysis is sourced from EPA's 2017 GHG inventory. Consistent with EPA's 2017 inventory, we use the 100-year global warming potentials and upstream methane emission rates for fossil fuel production and distribution from the Intergovernmental Panel on Climate Change's *Fourth Assessment Report*.

As a basis for comparison, this analysis constructs a current policy scenario that modifies AEO 2017 to reflect relevant policy developments in place as of June 2017. This scenario incorporates a range of energy and environmental outcomes that reflect the uncertainties surrounding the cost and deployment of low-carbon technologies, as described above. This scenario assumes US carbon sequestration from land use, land use change, and forestry follows the optimistic path considered in Rhodium Group's 2017 *Taking Stock* report.[2]

This analysis includes all provisions contained in the Curbelo proposal unless otherwise noted below. It assumes all measures take effect in 2020 and continue throughout the projection period. For non-fossil CO_2 emissions subject to a tax, the analysis assumes no abatement of these emissions occurs as a direct consequence of the proposal. For CO_2 emissions from fossil fuel use, the tax is applied in RHG-NEMS to all covered fuels, and the model solves for the lowest-cost path to provide energy services throughout the US economy. All state and federal policies not revoked or revised by the proposal remain in place. Climate policy in the rest of the world remains unchanged. The provision of the Curbelo proposal that calls for tax adjustments if emission targets are missed is not modeled, though this analysis provides information regarding the prospects that this provision will be triggered.

The outputs from RHG-NEMS are used as inputs to the Diamond-Zodrow (DZ) computable general equilibrium model, developed and run by John Diamond and George Zodrow at the Center for Public Finance of the Baker Institute for Public Policy at Rice University. Their model simulations provide estimates of the economic effects of the Curbelo proposal.

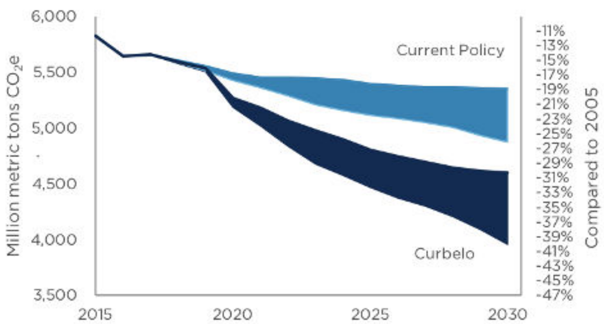
DZ is a computable general equilibrium (CGE) model designed to estimate the short- and long-run macroeconomic and distributional effects of tax reforms in the United States. In addition to estimating the effects of policies in terms of broad aggregate macroeconomic variables, DZ is designed to track the effects of tax policy changes across current and future generations and across income groups within each generation. Diamond and Zodrow (2018) uses the DZ model to analyze various potential federal carbon taxes in the United States, and versions of DZ have been used in analyses of tax reforms by the US Department of the Treasury and the Joint Committee on Taxation and in a number of recent tax policy studies.[3]

The economic analysis in this paper simulates the effects on the national economy of the Curbelo proposal compared to a current policy scenario that includes the effects of the Tax Cut and Jobs Act enacted in 2017. Inputs to this analysis include the outputs of the Rhodium Group's analysis of the energy market impacts of the Curbelo proposal in RHG-NEMS, including estimates of the revenue from the tax changes and changes in prices caused by the carbon tax for a bundle of consumer goods. These price changes are converted to the analogous price increases for the consumer/producer goods in the DZ model using a process described in Diamond and Zodrow (2018). While the analysis in RHG-NEMS produces a range of emission and energy market outcomes, the economic analysis uses the most conservative estimates of technological progress from the Rhodium Group analysis, which correspond to the high end of the emissions and revenue ranges.

GREENHOUSE GAS EMISSIONS IMPLICATIONS

The Curbelo proposal drives US economy-wide net greenhouse gas (GHG) emissions down to 27–32 percent below 2005 levels by 2025 and 30–40 percent below 2005 levels by 2030 (figure 1). The range reflects technological uncertainty. The bill represents a departure from current policy, in which emissions are between 18 and 22 percent below 2005 levels in 2025 and 19–26 percent below 2005 levels by 2030. If emissions under the Curbelo proposal indeed fall within these ranges, the provision in the proposal that adjusts the tax rate if cumulative emission targets are missed will not be triggered.

Figure 1: US economy-wide net GHG emissions



Source: Rhodium Group analysis

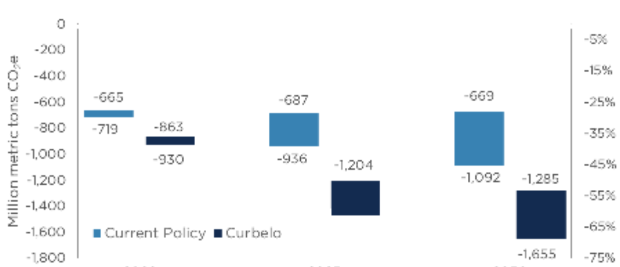
More than two-thirds of the emissions reductions relative to 2005 under the Curbelo proposal occur in the electric power sector. Emissions in the electric power sector decline rapidly once the tax is in place and fall to 54–69 percent below 2005 levels by 2030 (figure 2). These reductions are significantly greater than the 27–45 percent reductions from 2005 by 2030 in the current policy scenario. Among other factors, the large and abrupt shifts in the power sector are due to available and relatively low-cost abatement opportunities, such as shifting dispatch from carbon-intensive coal generators to lower-carbon natural gas or zero-emitting generators.

Emissions from other sectors also decline under the Curbelo proposal, but less than in the electric power sector. Some sectors, such as buildings and transportation, tend to be slow to respond to a carbon tax because of relatively small tax-induced changes in prices, slow stock turnover, and other nonprice barriers. Because the Curbelo proposal abolishes the fuel excise tax, it leads to small changes in transportation fuel prices and GHG emissions in that sector. Finally, some emissions are not subject to the carbon tax and in turn are little changed from current policy.

Taken together, emissions from the rest of the US economy outside the electric power sector decline slowly under the Curbelo proposal to 11–17 percent below 2005 levels by 2030. Still, emissions are lower than the 8–9 percent reduction from 2005 levels under current policy in that year.

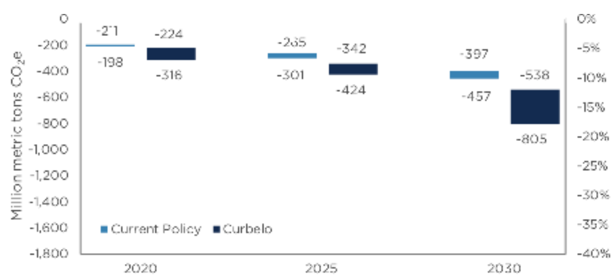
Our projections reflect some uncertainty in future emission outcomes, but the actual uncertainty is broader in scope. For example, our analysis includes a forecast of technological improvements across the energy sector but does not capture any acceleration in innovation in low-carbon technologies caused by the carbon tax.[4] The analysis assumes consumers will respond to the carbon tax as they respond to similar day-to-day price changes, while empirical evidence suggests the response may be stronger, perhaps owing to the greater visibility or permanence of a price-induced policy change.[5]

Figure 2: US electric power sector emissions reductions from 2005



Source: Rhodium Group analysis

Figure 3: US emissions reductions from 2005 from all sectors except electric power



Source: Rhodium Group analysis

Finally, climate change is a global phenomenon, so it is important to consider the effect on emissions outside the United States, even though such impacts are beyond the scope of this analysis. A carbon tax on imports may encourage trading partners to implement similar policies, and a federal carbon tax in the United States could change the landscape of international climate negotiations and might encourage other countries to take stronger actions to reduce emissions.

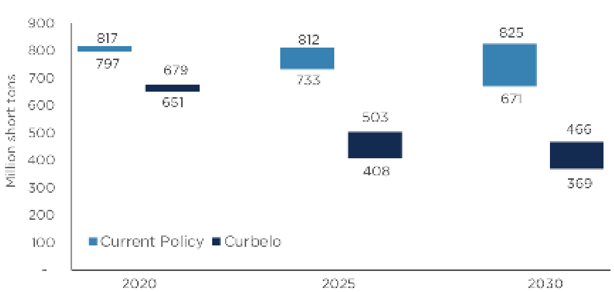
ENERGY IMPLICATIONS

Generally speaking, the carbon tax contained in the Curbelo proposal would cause the US economy to shift from carbon-intensive energy sources to low- and zero-carbon energy sources. The pace and extent of these shifts would depend on a host of factors, including the carbon intensity of the energy sources and characteristics of the markets in which they compete. This section describes our estimates of the effects of the Curbelo proposal on energy production, prices, and expenditures in the United States.

Energy Production Implications

Coal production is reduced by approximately 50 percent relative to current policy by 2030 under the Curbelo proposal (figure 4). In the United States, coal is used primarily in the electric power sector, where a host of cost-effective low- and zero-carbon alternatives are available. Coal production under the Curbelo proposal is 369 million–466 million short tons in 2030 compared with 671 million–825 million in the current policy scenario.

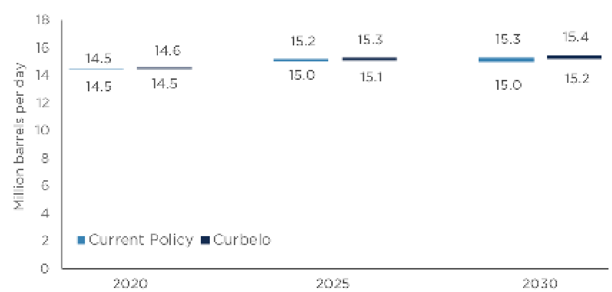
Figure 4: US coal production



Source: Rhodium Group analysis

By contrast, the Curbelo proposal leads to little change in US petroleum production relative to current policy (figure 5). With no substantial effect on petroleum prices (as discussed below), demand, or international trade, petroleum production is essentially unchanged. Production increases from approximately 14.5 million barrels per day in 2020 to slightly more than 15 million barrels per day in 2030 in both the current policy and Curbelo proposal scenarios.

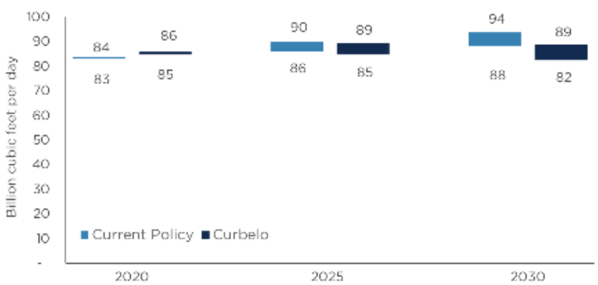
Figure 5: US petroleum production



Source: Rhodium Group analysis

The Curbelo proposal results in a small increase in natural gas production in the first few years after the carbon tax is implemented, but production is lower in 2030 relative to current policy. When the tax is first applied in 2020, shifts in electric power generation away from coal and toward natural gas lead to an increase in production of 2 bcf (billion cubic feet) per day in 2020 (figure 6). In response to the carbon tax, more renewable generating capacity comes online throughout the 2020s, displacing natural gas in the electric power sector. Meanwhile, renewable natural gas not subject to the tax becomes cost competitive and begins to take market share away from conventional fuels. All these factors lead to natural gas production of 82–89 bcf per day in 2030 under the Curbelo proposal, which is 5–6 bcf per day lower than in the current policy scenario and 9–16 bcf per day higher than 2017 production.

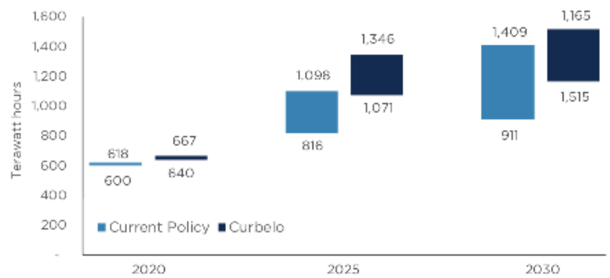
Figure 6: US natural gas production



Source: Rhodium Group analysis.
Note: Values do not include renewable natural gas production

Electricity generation from zero-emitting sources increases under the Curbelo proposal compared to current policy. Generation from nonhydroelectric renewable sources, such as wind, solar, and geothermal, is roughly the same between scenarios in 2020, the first year of the tax (figure 7). Over time, renewable generation increases under current policy to between 911 and 1,409 TWh in 2030. Renewables increase faster under the Curbelo proposal, reaching 1,165–1,515 TWh in the same year (as discussed below). Nonhydro renewables provide between 23 and 36 percent of total retail electric sales in 2030 under current policy and between 29 and 40 percent under the Curbelo proposal. (Note that retail electricity sales are also lower under the Curbelo proposal, as consumers respond to higher prices from the carbon tax.) We also find the Curbelo proposal prevents the early retirement of up to 4 GWs of existing nuclear capacity through 2030.

Figure 7: Nonhydro renewable electricity generation

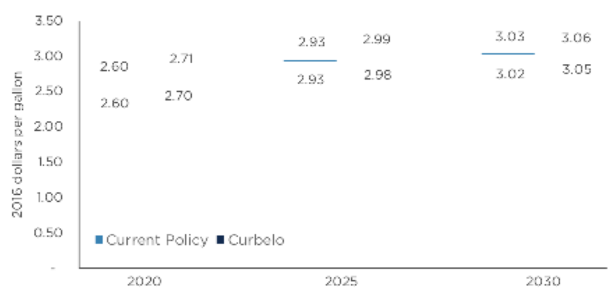


Source: Rhodium Group analysis

Energy Price and Expenditure Implications

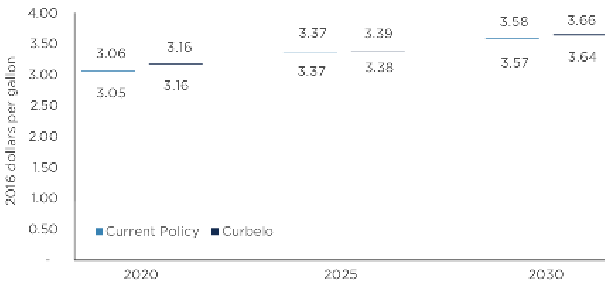
The carbon tax in the Curbelo proposal increases the cost of fuels and electricity and, in turn, increases total energy expenditures. At the same time, the repeal of the excise tax on transportation fuels reduces retail prices. On net, gasoline prices (figure 8) and diesel prices (figure 9) under the Curbelo proposal are no more than 11 cents/gallon higher than prices in the current policy scenario in any given year between 2020 and 2030, well within the bounds of historical monthly price variability.[6]

Figure 8: US average gasoline prices



Source: Rhodium Group analysis

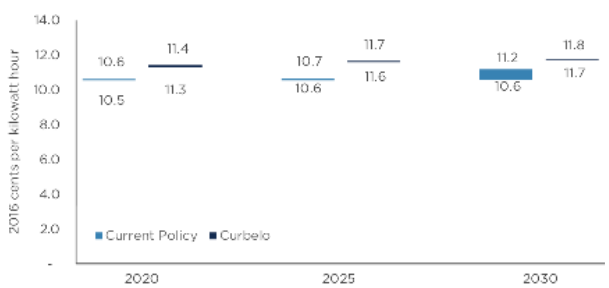
Figure 9: US average diesel prices



Source: Rhodium Group analysis

In the current policy scenario, national average electricity prices increase from a range of 10.5–10.6 cents per kWh in 2020 to 10.6–11.2 cents per kWh in 2030 (figure 10). Under the Curbelo proposal, the carbon tax increases wholesale electricity prices, and these increases flow through to retail rates. In 2020, average prices are 11.3–11.4 cents per kWh, 8 percent higher than in the current policy scenario. In 2030, average prices are 11.7–11.8 cents per kWh, 5–10 percent higher than in the current policy scenario.

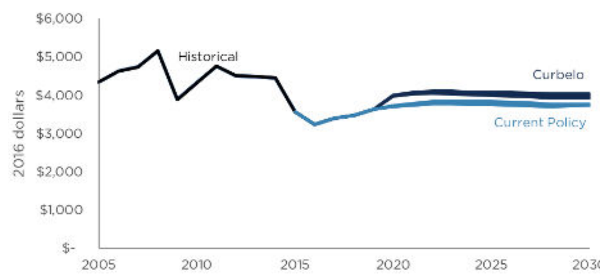
Figure 10: US average electric prices



Source: Rhodium Group analysis

The combination of the changes in energy prices and the changes in demand for energy in response to these price changes leads to changes in overall energy expenditures. We estimate per capita energy expenditures under the current policy and Curbelo proposal scenarios, representing total economy-wide energy costs divided by the US population. Under current policy, per capita energy expenditures are about $3,700 in 2020, rising slowly to between $3,747 and $3,759 in 2030. The Curbelo proposal increases per capita energy expenditures by approximately $275 in 2020 and by between $186 and $278 in 2030 compared to current policy. Notably, per capita expenditures under the Curbelo proposal remain more than $1,000 lower than the recent historical peak of $5,165, experienced at the height of the commodities boom in 2008.

Figure 11: US per capita energy expenditures



Source: Rhodium Group analysis

Similar to the emission projections, the estimated energy implications of the Curbelo proposal should be interpreted with the understanding that projecting energy systems over 12 years is an inherently uncertain exercise. The analysis does not capture potential consequences of the Curbelo proposal that could have important implications for energy market outcomes, including any increased stringency of climate policy in other countries, any accelerated innovation in low-carbon technologies, or any shifts in energy demand that are greater than our projections based on historical consumer responses to energy price changes.

REVENUE IMPLICATIONS

The payments of carbon taxes and fuel excise taxes are revenues to the government, and the analysis in RHG-NEMS provides an estimate of the additional government revenue from carbon tax payments and reduced government revenue owing to the repeal of the fuel excise taxes. The DZ model provides dynamic estimates of the effects of the Curbelo proposal on federal government revenue, taking into account the changes in demand, supply, and prices across the economy ("general equilibrium effects").

Turning first to the RHG estimates, the carbon tax generates roughly $110 billion–$120 billion per year in gross revenue from 2020 through 2030 (in 2016 dollars—see table 1). The Curbelo proposal allocates this carbon tax revenue to various uses, with 70 percent designated for the federal Highway Trust Fund (a portion of which replaces the revenues lost with the elimination of fuel excise taxes). 10 percent of carbon tax revenues are granted to states, which must transfer these grants to low-income households within their states. The remaining 20 percent of carbon tax revenues is allocated to new government spending on other programs.

This analysis attempts to replicate the allocation of carbon tax revenues in the Curbelo proposal with the following inputs:

- 90 percent of the gross carbon tax revenue is allocated to increased government spending (about one-quarter of which replaces the spending lost due to the elimination of fuel excise taxes); and
- 10 percent is allocated as equal transfers (or dividends) to the 20 percent of households with the lowest income, which corresponds to the bottom three lifetime income groups in the DZ model.

Removal of the fuel excise taxes reduces federal revenue in 2020 by $35 billion, declining to a $24 billion reduction in 2030. The decline in fuel tax revenues between 2020 and 2030 is due to two factors: (1) the tax is not indexed to inflation, meaning the tax rate declines over time in real (inflation-adjusted) terms, and (2) consumption of fuels subject to the tax is projected to decline as vehicles become more efficient under current fuel economy standards and demand declines in response to the tax. Accounting for the carbon tax revenue and the lost excise tax revenue, the Curbelo proposal generates $874 billion–$946 billion in cumulative new federal revenue from 2020 through 2030.

The new carbon tax revenues and the lost fuel excise tax revenues are the two primary causes of changes in government revenues under the Curbelo proposal, but they are not the only factors affecting revenues. In particular, individuals and businesses throughout the economy would pay somewhat different amounts in other taxes (income taxes, payroll taxes, etc.) owing to the direct and indirect effects of the policy.

In estimating the budgetary consequences of such taxes on goods and services (sometimes referred to as "indirect" taxes), the Congressional Budget Office (CBO), the Joint Committee on Taxation (JCT), and the Treasury Department's Office of Tax Analysis (OTA) assume the government will receive roughly 20–25 percent less in revenue under new indirect taxes, because payments of these taxes on goods and services leave individuals and businesses with less income, and thus lower tax payments on that income.[7] A recent analysis by the Tax Policy Center (2018) uses its large-scale microsimulation model and estimates this "revenue offset" to be about 25 percent for a federal carbon tax. Under this standard assumption, additional government revenue from the Curbelo proposal would be about $57 billion–$58 billion in 2020, $64 billion–$72 billion in 2030, and $656 billion–$710 billion in cumulative revenue between 2020 and 2030.

The DZ model estimates significantly larger changes in total government revenue from the Curbelo proposal. Since it is a general equilibrium model, DZ projects changes in economic activity across the entire economy in response to the imposition of carbon taxes and the elimination of fuel excise taxes. The model captures the traditional revenue offset described above, which reduces government revenue by about 25 percent. In addition, it identifies a second significant effect on government revenue: shifts in capital and labor across sectors lead to higher wages and increased capital use in relatively highly taxed sectors, which increases government revenue.[8] The DZ model finds that total government revenues, measured in 2016 dollars, increase by $72 billion, $81 billion, and $106 billion in the first, fifth, and tenth years after enactment of the Curbelo proposal.

Table 1: Changes in federal government revenue (billions of 2016 dollars)

	First Year 2020	Fifth Year 2024	Tenth Year 2029
Carbon Tax Revenue	111 to 113	108 to 114	109 to 119
Lost Fuel Revenue	-35	-31	-25
Change in Total Government Revenue:			
With Standard 25% Revenue Offset	57 to 58	58 to 63	63 to 70
With Revenue Offset and Other General Equilibrium Effects	72	81	106

Source: Results from the RHG-NEMS and Diamond-Zodrow models

MACROECONOMIC IMPLICATIONS

Like any carbon tax policy, the Curbelo proposal would affect the US economy in a variety of ways. This section presents the results of an analysis in the DZ model that focuses on the economic effects of price changes caused by the policy, ignoring the effects of emissions reductions.

Table 2 displays the estimated impacts of the Curbelo proposal on key national macroeconomic variables. These effects are negative, meaning the economy grows more rapidly under the current policy scenario than under the Curbelo proposal. However, the effects are close to zero, indicating that the drag on economic growth caused by the increase in prices is roughly offset by the positive effects of revenue use.

Annual gross domestic product (GDP) is 0.1 and 0.2 percent lower under the Curbelo proposal in the 2020s.[9] Effects on total consumption and investment are also negative (and somewhat larger than the GDP impacts because most of the carbon tax revenues are allocated to increased government spending), although all effects are still less than 1 percent throughout the time horizon of the study.

The Curbelo proposal causes total employment to decline between 0.02 and 0.04 percent. Because the DZ model assumes full employment at all times, any changes in employment reflect changes in hours worked by a fixed number of employees as opposed to any changes in the number of jobs across the economy.

The impacts on macroeconomic variables do not increase over time. For example, GDP remains 0.2 percent lower under the Curbelo proposal in the "long-run," which is after approximately 150 years in the DZ model.[10]

Table 2: Macroeconomic impacts of the Curbelo proposal (percent annual changes from the current policy scenario to the Curbelo proposal scenario)

Variable	First Year (2020)	Fifth Year	Tenth Year	Long run
Gross domestic product	-0.2	-0.1	-0.1	-0.2
Total private consumption	-0.5	-0.4	-0.5	-0.8
Total private investment	-0.7	-0.3	-0.3	-0.3
Total employment (hours worked)	-0.04	-0.02	-0.02	-0.04

Source: Results from the Diamond-Zodrow model

These results should be interpreted cautiously, given the uncertain nature of all macroeconomic projections, and with the following specific caveats in mind:

- An economic impact analysis is not a cost-benefit analysis. The effect of a policy on economic growth does not imply the social costs of the policy exceed the benefits, or vice versa. In particular, various important impacts of a carbon tax, including its effect on environmental quality, are not accounted for in metrics like GDP.
- The economic effects of reduced air pollution and climate change are omitted. While they are difficult to estimate, studies have found large effects of reduced air pollution on labor participation and other economic variables.[11] The economic effects of climate change will also be large, but over the first decade of implementation, the differences between the current policy and Curbelo proposal scenarios are likely to be small.
- The current policy scenario assumes that no new policies or regulations are implemented to reduce emissions in lieu of a federal carbon tax, which may be unrealistic given growing concerns about climate change. Including these additional policies and regulations in the current policy scenario would likely improve the economic outcomes associated with Curbelo proposal owing to the relative cost-effectiveness of a carbon tax policy.
- The revenues are allocated primarily to the federal Highway Trust Fund to improve transportation infrastructure. The current policy scenario does not account for the deterioration of transportation infrastructure and any associated economic effects.

Our analysis provides only nationwide results, which mask regional variation. Studies of the regional effects of other carbon pricing policies have found that before accounting for any revenue uses, the western and northeastern regions of the country fare relatively well under a carbon tax, while the economic effects of a carbon tax tend to be worse in the more carbon- and energy-intensive southern and middle parts of the country.[12]

IMPACTS ON LOW-INCOME HOUSEHOLDS

A concern with any major tax legislation is its effect on low-income households. The Curbelo proposal, like any carbon tax, will increase the price of energy-intensive goods such as electricity, home heating fuels, and gasoline. While some low-income households (particularly retirees) are shielded from energy price increases in the near term because the payments they receive from Social Security and other government assistance programs increase with the price level,[13] others will struggle to afford any increase in energy-related expenditures.

As noted above, the Curbelo proposal allocates 10 percent of carbon tax revenue for transfers to low-income households. An individual is eligible for these transfers if he or she is at least 18 years old and lives in a household with income that is below 150 percent of the poverty line, among other requirements described in the proposed legislation. Based on studies of similar proposals,[14] we assume these transfers will be received by households in the bottom 20 percent of the US income distribution.

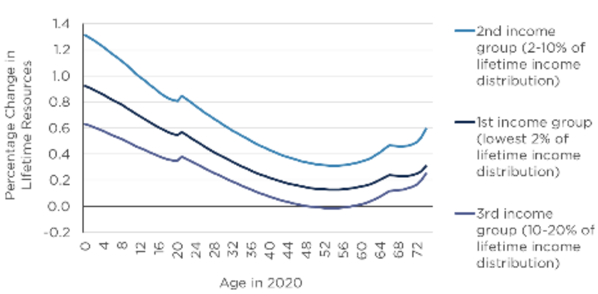
A key question is whether the positive effects of these transfers to low-income households are sufficient to outweigh the adverse effects of the price increases caused by the carbon tax (net of the price decreases associated with the elimination of fuel excise taxes). We use the DZ model to help answer this question.

Figure 12 displays the changes in welfare for a representative household at each age in the bottom three lifetime income groups in the

DZ model, which correspond to the bottom two lifetime income deciles, with the lowest decile split into the bottom 2 percent and the remaining 8 percent.[15] The welfare effects are positive for all representative households in the lowest two income groups (the bottom lifetime income decile) and for most households in the third income group (the second lifetime income decile), which indicates that the transfers are in almost all cases more than sufficient to offset the adverse effects of the price increases for these households.

The U-shaped pattern shown in Figure 12 indicates that younger workers, those who have not yet entered the workforce, and retirees fare better than middle-aged workers. This owes partly to the indexing of payments from government assistance programs like Social Security and other income transfers, which are most important when wages are relatively low during youth and old age. The DZ model indicates those unborn as of 2020 fare similarly to households of age zero in 2020 (not displayed in figure 12).

Figure 12: Impact of the Curbelo proposal on welfare of low-income households



Source: Results from the Diamond-Zodrow model

In addition to the uncertainties described above, these results should be interpreted with the following specific caveats in mind:

- The welfare effects do not incorporate the effects on households of increased government spending, which is how the majority of the carbon tax revenue is allocated under the Curbelo proposal. This is a limitation of DZ and most similar models.

  In reality, low-income households will benefit from additional government spending proposed in the legislation, including on transportation infrastructure, support for displaced energy workers, and various other government programs.

- DZ is a highly aggregated model of the US economy with four consumer goods.[16] It captures the impacts of the carbon tax–induced price increases, but it is not well suited for capturing differing impacts on households based on their differing consumption patterns.

- The effects on household welfare are in comparison to the current policy scenario and therefore do not include any impacts on low-income households of other regulations that might be enacted to reduce emissions in lieu of a carbon tax.

- Low-income households may disproportionately benefit from the reductions in air pollution caused by the Curbelo proposal, which are not reflected in our analysis.[17]

This analysis focuses on the welfare of low-income households because the Curbelo proposal specifically allocates a portion of the carbon tax revenues to these households. The results of the DZ model show reductions in welfare for middle- and higher-income households. These reductions increase with household income, with "long-run" welfare losses in excess of 0.5 percent of remaining lifetime resources. However, the DZ model does not account for the effects on household welfare of the revenues used for additional government spending (in excess of the funding for the federal Highway Trust Fund that was previously financed by fuel excise taxes), which all households will benefit from. Still, the government spending is likely to disproportionately benefit lower- and middle-income households, and thus would not be expected to reverse the qualitative nature of the distributional results from the DZ model.

NOTES

1. For a complete description of all input assumptions and model details, see John Larsen, Shashank Mohan, Peter Marsters, and Whitney Herndon, Energy and Environmental Implications of a Carbon Tax in the United States (prepared by the Rhodium Group for the Center on Global Energy Policy at Columbia University, July 2018), https://energypolicy.columbia.edu/our-work/topics/climate-change-environment/carbon-tax-research-initiative/carbon-tax-initiative-research.

2. See the Rhodium Group website, https://rhg.com/research/taking-stock-2017-us-greenhouse-gas-emissions/.

3. For an analysis of a federal carbon tax and complete citations of related work involving the Diamond-Zodrow model, see John W. Diamond and George R. Zodrow, Dynamic Macroeconomic and Distributional Effects of a Carbon Tax under Alternative Revenue Recycling Options (prepared at the Center for Public Finance of the Baker Institute for Public Policy for the Center on Global Energy Policy at Columbia University, July 2018), https://energypolicy.columbia.edu/our-work/topics/climate-change-environment/carbon-tax-research-initiative/carbon-tax-initiative-research.

4. A carbon tax is likely to increase innovation in low-carbon technologies, but the magnitude of this effect is not well understood. One recent study finds that to reduce emissions by 30 percent in 20 years, the carbon tax rate needed is nearly 20 percent lower in a scenario that accounts for the innovation induced by the carbon tax. See Stephie Fried, "Climate Policy and Innovation: A Quantitative Macroeconomic Analysis," American Economic Journal: Macroeconomics 10, no. 1 (2018): 90–118, https://www.aeaweb.org/articles?id=10.1257/mac.20150289.

5. See, for example, Chad Lawley and Vincent Thivierge, "Refining the Evidence: British Columbia's Carbon Tax and Household Gasoline Consumption," Energy Journal 39, no. 2 (2018): 35–61, https://www.iaee.org/en/publications/ejarticle.aspx?id=3056; and Julius Andersson, "Cars, Carbon Taxes and CO_2 Emissions" (Centre for Climate Change Economics and Policy Working Paper No. 238, Grantham Research Institute on Climate Change and the Environment Working Paper No. 212, 2017), http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2017/03/Working-paper-212-Andersson_update_March2017.pdf.

6. See the US Energy Information Administration website, https://www.eia.gov/totalenergy/data/monthly/.

7. See the Congressional Budget Office website, https://www.cbo.gov/sites/default/files/cbofiles/ftpdocs/96xx/doc9618/01-13-25percentoffset.pdf.

8. The change in overall economic activity will also affect tax revenue in the DZ model, but as explained below, those effects are relatively small.

9. Note that previous studies of carbon taxes have shown that a key driver of the economic impacts of carbon taxes is the use of the revenue. For example, Diamond and Zodrow (2018) show that using carbon tax revenue in ways that increase incentives for growth (including lower taxes or deficits) can lead to higher projected GDP in the DZ model compared to a current policy scenario, although these positive long-term increases in GDP are less than 0.6 percent under all the carbon tax scenarios analyzed. Note that this implies that the changes in GDP reflect temporary changes – in the long run, GDP, like all other variables, grows at the exogenous growth rate.

10. The "long run" in the DZ model occurs when a steady-state equilibrium is reached. In carbon tax scenarios, over 90 percent of the long-run changes in macroeconomic outcomes generally take place within

50 years after enactment of the policy, although the simulations continue for at least 150 years to ensure that a true steady-state equilibrium (one in which all economic variables are growing at precisely the exogenously specified growth rate of the economy) is reached.

11. The primary intent of a carbon tax is to reduce carbon dioxide emissions, but it would also significantly reduce the emissions of particulate matter and other conventional air pollutants that have detrimental effects on human health (owing primarily to the reduction in coal production caused by the carbon tax). For a carbon tax starting at $25 per ton and increasing 5 percent per year, Woollacott (2018) estimates both the costs and cobenefits at the national level and finds that the marginal cobenefits offset over half of the marginal welfare costs to households from the tax. See Jared Woollacott, "The Economic Costs and Co-benefits of Carbon Taxation: A General Equilibrium Assessment," Climate Change Economics 9, no. 1 (2018): 1840006, https://www.worldscientific.com/doi/abs/10.1142/S2010007818400067.

12. Ross (2018) estimates the effects on GDP in 2030 of 10 US regions for a carbon tax that starts at $25 per ton and increases at 5 percent per year. The analysis considers three different revenue uses. Effects on GDP are most negative when revenues are used for "lump-sum recycling" (i.e., household rebates). In this scenario, 2030 regional GDPs decline between 0.0 and 0.6 percent below the baseline scenario, with the East North Central, West North Central, and Mountain regions faring worst. See Martin T. Ross, "Regional Implications of Carbon Taxes," Climate Change Economics 9, no. 1 (2018): 1840008, https://www.worldscientific.com/doi/abs/10.1142/S2010007818400080.

13. Don Fullerton, Garth Heutel, and Gilbert E. Metcalf, "Does the Indexing of Government Transfers Make Carbon Pricing Progressive?," American Journal of Agricultural Economics 94, no. 2 (January 1, 2012): 347–53, https://doi.org/10.1093/ajae/aar096.

14. Chad Stone, "The Design and Implementation of Policies to Protect Low-Income Households under a Carbon Tax" (Resources for the Future, September 2015), http://www.rff.org/research/publications/design-and-implementation-policies-protect-low-income-households-under-carbon.

15. The change in household welfare is measured using a metric called "equivalent variation," which is the percentage change in remaining lifetime resources, including the value of leisure but excluding the value of the inheritance/bequest, which is simply transmitted across generations and grows at the exogenous growth rate that is required in the initial equilibrium for a household to achieve the same level of lifetime utility as under the newly enacted carbon tax.

16. The DZ model has four consumer goods: a corporate good, a noncorporate good, owner-occupied housing, and rental housing. Consumption of "utilities," where much of the carbon tax–induced price changes takes place, is included in the two housing sectors.

17. Reduced air pollution is likely to improve health outcomes disproportionately in low-income communities where pollution mortality and morbidity rates are highest. See Michael Hendryx and Melissa M. Ahem, "Relations between Health Indicators and Residential Proximity to Coal Mining in West Virginia," American Journal of Public Health 98, no. 4 (2008): 669–71, https://ajph.aphapublications.org/doi/abs/10.2105/AJPH.2007.113472.

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