Comparing the economic impact of an expansion of regulatory CO_2 controls to a revenue-neutral, emissions-equivalent carbon tax

Prepared for the Alliance for Market Solutions

April 2017

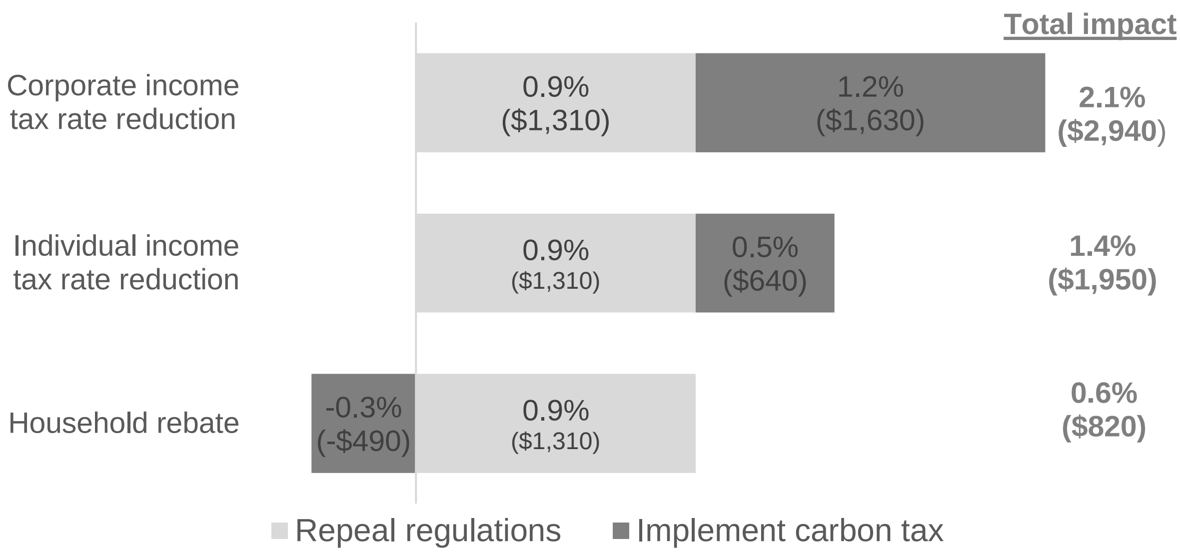
Building a better working world

(Page intentionally left blank)

Executive summary

This report compares the economic impact of the expansion of the rules and regulations for controlling CO_2 emissions (the “expansion of regulatory CO_2 controls”) in the United States to a market-based alternative in the form of a revenue-neutral, emissions-equivalent carbon tax. The report finds that a carbon tax, if substituted for the expansion of regulatory CO_2 controls, set to achieve the same reduction in CO_2 emissions, and whose revenues are used to finance a reduction in the corporate income tax rate, could increase gross domestic product (GDP) in the long-run by as much as 2.1% or, on average, $2,940 per household annually (in $2016) (Figure ES-1).[1] By contrast, the expansion of regulatory CO_2 controls are estimated to cost, upon full implementation, each household an average $1,310 annually in additional economic burden.

Figure ES-1. Long-run change in annual per-household GDP from revenue-neutral, emissions-equivalent carbon tax if implemented instead of the expansion of regulatory CO_2 controls, by use of carbon tax proceeds



Note: Expanded regulatory CO_2 controls refer to the regulatory expansion that occurred during the 2013-2016 period. Economic impacts are scaled to the size of the 2016 US economy. The long-run is defined as when the US economy has fully adjusted to the new policy. Approximately two-thirds to three-quarters of the impacts typically occur by year 10 in models of this type.

Expansion of regulatory CO_2 controls

The United States relies primarily on a set of rules and regulations to reduce CO_2 emissions. These rules and regulations typically target specific sectors or types of activities and mandate the use of different technologies and processes or otherwise place restrictions on the choices of consumers and producers.

Between 2013 and 2016 the Federal government expanded this set of rules and regulations and it is this expansion, not the pre-2013 baseline regulations, which are the subject of this analysis.

[1] For models of this type, roughly two-thirds to three-quarters of the long-run effect is generally reached within a decade.

Specifically, this report quantifies the economic and emissions impacts of the following (see Appendix A and Appendix B for more detail):

- **Expansion of Corporate Average Fuel Economy (CAFE) standards.** CAFE standards require that a manufacturer's model year of vehicles meet a fleet-wide average fuel efficiency level. CAFE standards apply to light-duty, medium-duty, and heavy-duty vehicles.
- **New Clean Power Plan (CPP).** The CPP aims to reduce CO_2 emissions in the power sector. The CPP will be implemented at the state level (starting in 2022), and each state is required to choose one of three approaches: (1) national emissions rate for each electricity-generating unit (in CO_2/MWh), (2) state-specific emissions rate for the state's overall electricity portfolio (in CO_2/MWh), or (3) state-specific mass-based limits (in CO_2/year).
- **Expansion of Renewable Fuel Standards (RFS).** RFS require that fuel distributors include a specific percentage of renewable fuels in their total sales.
- **Expansion of appliance and equipment efficiency standards (AEES).** AEES regulate more than 60 categories of appliances and equipment in both the residential and commercial sectors. The program sets energy efficiency standards for appliances and equipment to reduce energy consumption.

While the CPP explicitly targets reduced CO_2 emissions, CAFE standards, RFS, and AEES instead target reduced fossil fuel consumption through greater fuel efficiency (CAFE) and increased renewable fuel usage (RFS), and reduced energy consumption through greater energy efficiency (AEES). In this way, the rule-based policies reduce CO_2 emissions by targeting economic activity related to CO_2 emissions rather than explicitly targeting emissions reductions or, as in the case of the CPP, include only a portion of CO_2 producing economic activity.

To highlight the difference between the two approaches rather than in their timing, this report assumes that the expansion of regulatory controls goes into effect immediately. All dollar value economic impacts are scaled to the size of the 2016 US economy.

This report estimates the expansion of regulatory CO_2 controls to reduce CO_2 emissions by nearly 20%, but it also reduces GDP in the long-run by close to 1%, or about $1,310 per household annually (see Table ES-1). These economic impacts are primarily driven by the expansion of CAFE standards and implementation of the CPP.

Table ES-1. Economic impacts of the expansion of regulatory CO_2 controls relative to the pre-2013 regulatory baseline

Percent change from pre-2013 regulatory baseline

	2016-20	2021-25	2026-30	2031-35	Long-run
Overall CO_2 emissions reduction	-16.0%	-19.0%	-19.6%	-19.7%	-19.6%
GDP					
GDP, total	-0.4%	-0.7%	-0.9%	-0.9%	-0.9%
Consumption	-0.2%	-0.4%	-0.5%	-0.6%	-0.8%
Investment	-1.7%	-3.0%	-3.3%	-3.1%	-2.6%
Equivalent dollar measures (2016 $)					
GDP change per household ($)	-550	-1,030	-1,210	-1,250	-1,310
GDP change per ton carbon reduction ($)	-80	-130	-150	-150	-160

Note: Economic impacts are presented as the 5-year average over the time period denoted. All rule-based policies modeled include only the impacts of post-2013 expansion or implementation. The results presented in this table assume the CPP is implemented as 50% national emissions rate and 50% mass based, and this assumption is discussed further in the body of the report. The long run is defined as when the US economy has fully adjusted to the new policy. Approximately two-thirds to three-quarters of the impacts typically occur by year 10 in models of this type. Figures are rounded.
Source: EY analysis.

Revenue-neutral, emissions-equivalent carbon tax

After estimating the economic impact of the expansion of regulatory CO_2 controls, this report then compares the economic impact of the expansion of this set of regulatory policies to a market-based alternative in the form of a revenue-neutral, emissions-equivalent carbon tax. The carbon tax rate is set to achieve the same absolute reduction in CO_2 emissions as the expansion of the rule-based CO_2 controls.

The market-based carbon tax analyzed by this report is assumed to impose a uniform price on emitting CO_2 across the entire economy. A uniform CO_2 price would leverage the knowledge and behavior of consumers and producers, and the marketplace, to find the least costly way to reduce emissions, as compared to regulatory controls that are often less flexible and can sometimes mandate more costly ways to reduce CO_2 emissions.

Another important element of a revenue-neutral carbon tax is that it generates revenue, which creates opportunities inherent with the use of these revenues. The revenue could be used, for example, to reduce preexisting taxes, fund additional government spending or transfers, or reduce the federal deficit. Using the revenues to reduce existing policies that themselves are distortionary can provide additional economic benefits.

A 2008 OECD study found that taxes on capital, followed by labor taxes, are the most distortionary taxes for raising revenue. To contrast the potential benefits associated with the use of revenue from the revenue-neutral, emissions-equivalent carbon tax analyzed by this report, three alternative uses for the revenue are considered:

1. *Lower corporate income tax rate*, which would increase the after-tax return to investment, encourage more capital investment, contribute to higher labor productivity, and, ultimately, higher real wages and living standard in the United States.

2. *Across-the-board, proportional reduction in individual income tax rates*, which would increase the after-tax reward to work, possibly resulting in higher real wages or an increase in the US work force, and increase the after-tax return for savings and investment, through the lower investor-level taxes on dividends, capital gains, and interest income.

3. *Rebate to households*, which would offset some of the impact of the carbon tax on household incomes.

This report finds that, relative to the expansion of regulatory CO_2 controls, a revenue-neutral carbon tax with the same emissions reduction would significantly increase US GDP for each of the revenue uses considered (Table ES-2). This result ranges from $820 to $2,940 additional GDP per household annually in the long run.

Table ES-2. Economic impact of revenue-neutral, emissions-equivalent carbon tax implemented as an alternative to the expansion of regulatory CO_2 controls

	2016-20	2021-25	2026-30	2031-35	Long-run
CO_2 emissions change in all scenarios	-16.0%	-19.0%	-19.6%	-19.7%	-19.6%
Corporate income tax rate reduction					
Use of revenue					
Corporate income tax rate	19.9%	17.5%	16.8%	16.6%	16.2%
GDP					
GDP	0.7%	1.5%	1.8%	1.9%	2.1%
Consumption	-0.5%	0.2%	0.7%	1.0%	1.6%
Investment	6.7%	8.7%	8.9%	8.1%	6.2%
Equivalent dollar measures (2016 $)					
GDP change per household ($)	950	2,070	2,570	2,690	2,940
GDP change per ton carbon reduction ($)	140	260	310	320	350
Across-the-board, proportional individual income tax rate reduction					
Use of revenue					
Top individual income tax rate	37.6%	37.2%	37.1%	37.1%	37.1%
GDP					
GDP	0.5%	1.0%	1.2%	1.3%	1.4%
Consumption	0.2%	0.5%	0.8%	1.0%	1.3%
Investment	2.9%	4.5%	4.7%	4.3%	3.2%
Equivalent dollar measures (2016 $)					
GDP change per household ($)	780	1,450	1,740	1,820	1,950
GDP change per ton carbon reduction ($)	110	180	210	220	240
Household rebate					
Use of revenue					
Rebate per household ($)	1,130	1,340	1,380	1,390	1,380
GDP					
GDP	0.2%	0.4%	0.5%	0.5%	0.6%
Consumption	*	0.1%	0.2%	0.3%	0.5%
Investment	1.2%	2.4%	2.6%	2.4%	1.9%
Equivalent dollar measures (2016 $)					
GDP change per household ($)	220	570	720	760	820
GDP change per ton carbon reduction ($)	30	70	90	90	100

*Smaller in magnitude than 0.05% or $5.
Note: Economic impacts are presented as the 5-year average over the time period denoted. All rule-based policies modeled include only the impacts of post-2013 expansion or implementation. The results presented in this table assume the CPP is implemented as 50% national emissions rate and 50% mass based, and this assumption is discussed further in the body of the report. The long run is defined as when the US economy has fully adjusted to the new policy. Approximately two-thirds to three-quarters of the impacts typically occur by year 10 in models of this type.

Figures are rounded.
Source: EY analysis.

<u>Comparison of the rule-based approach to a revenue-neutral carbon tax</u>

This report finds that a revenue-neutral, emissions-equivalent carbon tax reduces the same amount of CO_2 for significantly less cost to the economy in terms of GDP than the expansion of regulatory CO_2 controls. The uniform price of CO_2 across the US economy leverages the knowledge and behavior of consumers and producers to find where it is least costly to reduce CO_2 emissions, as opposed to the location of emissions reductions being imposed by an often less flexible rule-based approach. Moreover, it can further benefit households by financing efficiency-enhancing tax relief, such as cutting business taxes and individual income taxes.

Impact	***Rule-based approach***	***Carbon tax***
Regulatory certainty	No	Yes
Ease of administration	No	Yes
Targets specific sectors or types of activities and mandates the use of different technologies and processes or otherwise places restrictions on the choices of consumers and producers	Yes	No
Provides incentives that leverage the knowledge and behavior of consumers and producers to find where it is least costly to reduce emissions across the US economy	No	Yes

This report also finds that the expansion of regulatory CO_2 controls will result in a net deadweight cost to the US economy and households. A more market-based approach, such as a revenue-neutral, emissions-equivalent carbon tax, has the potential to deliver the same reductions in CO_2 with less economic cost. Depending on the use of its revenues, over time a carbon tax that achieves the same reductions in CO_2 emissions as a rule-based approach could result in significant increases in GDP, particularly if the revenues are used to reduce otherwise distortionary taxes.

Contents

Comparing the economic impact of an expansion of regulatory CO_2 controls to a revenue-neutral, emissions-equivalent carbon tax

I. Introduction

The United States relies primarily on an extensive set of rules and regulations to reduce CO_2 emissions. These rules and regulations typically target specific sectors or types of activities and mandate the use of different technologies and processes or otherwise place restrictions on the choices of consumers and producers. This contrasts to the market-based approach of a carbon tax, which would place a uniform price on emitting CO_2 across the entire US economy. A uniform CO_2 price would leverage the knowledge and behavior of consumers and producers to find where it is least costly to reduce emissions, as compared to regulatory CO_2 controls that may be less flexible and can mandate more costly ways to reduce CO_2 emissions.

Between 2013 and 2016 the Federal government expanded this set of rules and regulations to further control CO_2 emissions. It is this expansion of regulatory CO_2 controls, not the pre-2013 baseline regulations, for which this analysis estimates the economic and emissions impacts.

This report uses the EY General Equilibrium Model of the US Economy ("EY GE Model") to compare the economic impact of the expanded regulatory CO_2 controls with a revenue-neutral carbon tax that achieves the same reduction in CO_2 emissions. This model captures the major features of the US economy and the key economic decisions of businesses and households affected by energy-related tax and rule-based policies. See Appendix A for more detail on the EY GE Model.

This report finds that a revenue-neutral, emissions-equivalent carbon tax would reduce the same amount of CO_2 for significantly less cost in terms of gross domestic product (GDP) than the expansion of regulatory CO_2 controls. That is, the results suggest that relying on the market-based approach of a revenue-neutral, emissions-equivalent carbon tax instead of the expansion of regulatory CO_2 controls would result in a much more efficient and less costly reduction of CO_2 emissions with significant net benefits for the US economy depending on the use of the carbon tax revenues.

Expansion of regulatory CO_2 controls

The expansion of regulatory CO_2 controls analyzed by this report include the following rule-based policies (see Appendix B for more detail):

This report analyzes a stylized version of the expansion of regulatory CO_2 controls embodied by the Federal government's introduction or expansion of the following rules from 2013 through 2016:

- *Expansion of Corporate Average Fuel Economy (CAFE) standards.* CAFE standards require that a manufacturer's model year of vehicles meet a fleet-wide average fuel efficiency level. CAFE standards apply to light-duty, medium-duty, and heavy-duty vehicles.

- *New Clean Power Plan (CPP).* The CPP aims to reduce CO_2 emissions in the power sector. The CPP is intended to be implemented at the state level (starting in 2022), and each state is required to choose one of three approaches: (1) national emissions rate for each electricity-generating unit (EGU) (in CO_2/MWh), (2) state-specific emissions rate for the state's overall electricity portfolio (in CO_2/MWh), or (3) state-specific mass-based limits (in CO_2/year).

- *Expansion of Renewable Fuel Standards (RFS).* RFS require that fuel distributors include a specific percentage of renewable fuels in their total sales.

- *Expansion of appliance and equipment efficiency standards (AEES).* AEES regulate more than 60 categories of appliances and equipment in both the residential and commercial sectors. The program sets energy efficiency standards for appliances and equipment to reduce energy consumption.

While the CPP explicitly targets reduced CO_2 emissions, CAFE standards, RFS, and AEES instead target reduced fossil fuel consumption through greater fuel efficiency (CAFE) and increased renewable fuel usage (RFS), and reduced energy consumption through greater energy efficiency (AEES). In this way, most of the rule-based policies reduce CO_2 emissions by targeting economic activity related to CO_2 emissions rather than explicitly targeting emissions reductions or, as in the case of the CPP, include only a portion of CO_2 producing economic activity.

Revenue-neutral, emissions-equivalent carbon tax

After estimating the impact of the expansion of regulatory CO_2 controls, this report then compares the economic impact of the expansion of regulatory CO_2 controls to a market-based alternative in the form of a revenue-neutral, emissions-equivalent carbon tax. The tax rate is set to achieve the same level of CO_2 emissions reduction as the rule-based expansion of regulatory CO_2 controls. The market-based approach of a carbon tax would place a uniform price on emitting CO_2 across the entire economy. A uniform CO_2 price would leverage the knowledge and behavior of consumers and producers to find where it is least costly to reduce emissions, as compared to the rule-based approach that is often less flexible and can mandate more costly ways to reduce emissions.

An important element of a carbon tax is that it generates revenue, which creates opportunities inherent in the use of the funds. The revenue could be used, for example, to reduce preexisting taxes, fund additional government spending or transfers, or reduce the federal deficit. Some of these uses may produce additional benefits by reducing preexisting distortions arising from, for example, high tax rates or possibly promoting economic activity with other societal benefits. If used to lower existing taxes, then, in addition to leveraging the knowledge and behavior of consumers and producers to reduce CO_2 emissions in the least costly way possible, an added benefit of the carbon tax is that the revenue it raises can be used to improve the efficiency of the economy, raising GDP and thereby resources available to households.

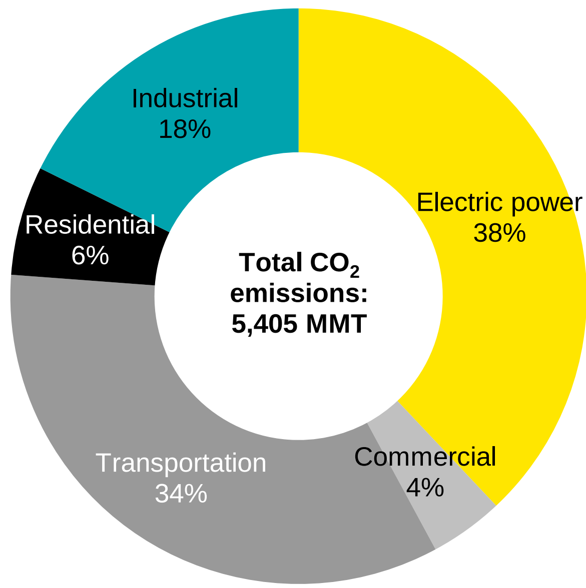
A 2008 OECD study found that taxes on capital, followed by labor taxes, are the most distortionary taxes for raising revenue.[1] To contrast the potential benefits associated with the use of revenue from the revenue-neutral, emissions-equivalent carbon tax analyzed by this report, three alternative uses for the revenue are considered:

1. Lower corporate income tax rate,
2. Across-the-board, proportional reduction in individual income tax rates, and
3. Rebate to households.

II. Expansion of regulatory and rule-based CO_2 controls

The regulatory and rule-based policies in place in the United States for CO_2 abatement and analyzed by this report generally target one of the major sources of CO_2 emissions in the US economy. Broadly, CAFE standards and RFS reduce transportation emissions (encompassing 34% of emissions) and AEES and the CPP reduce emissions related to the generation of electric power (encompassing 38% of emissions). An overview of US energy-related emissions by major type of economic activity is presented in Figure 1.

Figure 1. US energy-related CO_2 emissions, by major type of economic activity (2013)



Note: The transportation sector includes own-use vehicles. Figures are rounded.
Source: US Energy Information Administration.

Corporate Average Fuel Economy standards

The two classes of CAFE standards focus on increasing fuel efficiency for: (1) light-duty, and (2) medium-duty and heavy-duty vehicles. The light-duty CAFE standards apply to new passenger cars, pick-up trucks up to 8,500 lbs gross vehicle weight rating (GVWR), and sport-utility vehicles and minivans up to 10,000 lbs GVWR. CAFE standards for medium-duty and heavy-duty vehicles apply to new heavy-duty engines and trucks of 8,500 lbs GVWR and higher, including combination tractors, school and transit buses, and motor vehicles of 8,500 lbs GVWR or greater (except for those already covered by the light-duty vehicles regulations). Transportation emissions not covered by CAFE standards include the emissions of aircraft, boats and ships, pipelines, and rail.

Clean Power Plan

The CPP targets a reduction of CO_2 emissions from the power sector, specifically from fossil-fuel-fired EGUs. The CPP is intended to be implemented at the state level (starting in 2022) with each state required to choose one of three approaches: (1) national emissions rate for each

EGU (in lbs CO_2/MWh), (2) state-specific emissions rate for the state's overall electricity portfolio (in lbs CO_2/MWh), or (3) state-specific mass-based limits (in lbs CO_2/year).

The national emissions rate option requires specific rates of CO_2 emissions per MWh of electricity generation – in effect, with a separate rate for coal and gas EGUs – to be met by each individual EGU. In contrast, the state-specific emissions rate is a blend of the national emissions rates for coal and gas weighted to reflect each state's individual mix of electricity generated from each EGU type. For this approach, rather than each individual EGU meeting the national coal or gas emissions rate, the entire electricity portfolio of a state must meet the state-specific blended rate. The state-specific mass-based limits – estimated from the state-specific emissions rate option – set the maximum annual amount of CO_2 that a state can emit.

The CPP allows states considerable flexibility in how CO_2 emission targets are reached, including multi-state emissions rate or mass-based trading systems. Such trading mechanisms that allow the trading of emissions credits (for state-specific emissions rate) and emissions allowances (for state-specific mass-based limits) are market tools that enable CO_2-intensive industries to eliminate their carbon footprint in a cost-effective way. Businesses that face comparatively higher costs of reducing their CO_2-producing processes can trade emissions credits or allowances with firms that face comparatively lower costs of reducing their CO_2-producing processes, simultaneously reducing total CO_2 emissions while also allowing firms to account for their own unique costs of production.

Because the CPP has not yet been implemented, there is considerable uncertainty around how states will choose to comply. As such, the modeling of the CPP in this report includes three scenarios to generally bound the potential range of possible impacts. The scenarios include:

1. all states cooperate in creating a single, multi-state cap-and-trade program (relatively efficient),

2. all states choose to adopt the national emissions rate option without inter-industry trading (relatively inefficient), and

3. a 50-50 split of the previous two scenarios.

Additionally, these scenarios help illustrate how market-based approaches can more efficiently reduce CO_2. The market-based approach will be exemplified by the interstate and inter-fuel source trading implicit in the multi-state cap-and-trade system. Conversely, the adoption of the national emissions rate option with no inter-industry trading (e.g., between coal and gas) will be more representative of rule-based policies.

Only results for the third scenario (a 50-50 split of the first two scenarios) are included in the body of this report, but results for the other scenarios can be found in Appendix C.

Renewable Fuel Standards

RFS, enacted in the 2005 Energy Policy Act (RFS1) and later expanded upon in the 2007 Energy Independence and Security Act (RFS2), reduce CO_2 emissions by requiring fuel distributors to include a specific percentage of renewable fuels (including advanced biofuels, biodiesel, renewable diesel, biogas, and sugarcane ethanol) (“biofuels”) in their total sales. RFS2 is slated to increase the number of gallons of renewable fuel in domestic transportation fuels to 36 billion gallons by 2022. It requires that at least 16 billion gallons are from cellulosic biofuels and at most 15 billion gallons are from corn-starch ethanol.

Businesses obligated to comply with the RFS are refiners or importers of gasoline/diesel fuel. These businesses meet their compliance requirement, also known as a Renewable Volume Obligation (RVO), by either blending renewable fuels into transportation fuels or obtaining credits. The Environmental Protection Agency (EPA) calculates annual RVOs based on the Clean Air Act’s volume requirements and projected diesel and gasoline production for the year.

Appliance and equipment efficiency standards

The AEES program regulates more than 60 categories of appliances and equipment in both the residential and commercial sectors. The program sets efficiency standards for appliances and equipment to reduce energy consumption. There are four broad areas of affected appliances and equipment: (1) consumer products, (2) commercial and industrial products, (3) lighting products, and (4) plumbing products. Consumer products include dishwashers, refrigerators and freezers, and water heaters. Commercial and industrial products include computers, room air conditioners, electric motors, and walk-in coolers and freezers.

III. Comparing the economic impact of the expansion of regulatory CO_2 controls to a revenue-neutral, emissions-equivalent carbon tax

Key takeaways

- *If implemented instead of the expansion of regulatory CO_2 controls, a revenue-neutral carbon tax with the same emissions reduction would result in significantly greater US GDP for each revenue use considered.*
  - *Using carbon tax revenues to reduce the corporate income tax rate would, in the long run, increase GDP per household by $2,940 annually and the size of the US economy would be larger by 2.1%.*
  - *Using carbon tax revenues for an across-the-board, proportional reduction in individual income tax rates would, in the long run, result in greater GDP per household of $1,950 annually and the US economy would be larger by 1.4%.*
  - *Rebating carbon tax revenues to households would, in the long run, increase GDP per household by $820 annually and the US economy would be larger by 0.6%.*

This report compares the economic impacts of the expansion of regulatory CO_2 controls with a revenue-neutral carbon tax that achieves the same reduction in CO_2 emissions. In particular, the regulatory expansion that has occurred since 2013 or is currently scheduled to occur is compared to a revenue-neutral, emissions-equivalent carbon tax.

To highlight the difference between the two approaches rather than their timing, this report assumes that the expansion of regulatory controls goes into effect immediately.[2] All reported economic impacts are scaled to the size of the 2016 US economy.

The economic impacts are estimated using the EY GE Model. This model is designed to capture the major features of US economy and the key economic decisions of businesses and households affected by energy and tax policy. It is an overlapping generations (OLG) model similar to models used by the Congressional Budget Office (CBO), EPA, Joint Committee on Taxation (JCT), and US Department of the Treasury to analyze changes in energy and tax policy.[3]

The EY GE Model includes a detailed modeling of industries, as well as their inter-industry linkages. Each industry differs in its relative use of capital, labor, and energy inputs, as well as in the CO_2 content of its outputs. Each industry is responsive to the price of capital, labor, and energy, and chooses the optimal mix based on relative prices and industry-specific characteristics. Businesses and households incorporate the after-tax return from work and savings into their decisions of how much to produce, save, and work. A technical description of the EY GE Model is provided in Appendix A.

An important element of a carbon tax is that it generates revenue, which presents opportunities for the use of the revenue. The revenue could be used, for example, to reduce preexisting taxes, fund additional government spending or transfers, or reduce the federal deficit. Some of these uses may produce additional benefits by reducing preexisting distortions arising from, for example, high tax rates or possibly promoting economic activity with other societal benefits. If used to lower existing taxes, then, in addition to leveraging the knowledge and behavior of consumers and producers to reduce CO_2 emissions in the least costly way possible, an added benefit of the carbon tax is that the revenue it raises can be used to improve the efficiency of the economy.

This report analyzes three alternative uses for the revenue raised from the revenue-neutral, emissions-equivalent carbon tax:

1. *Lower corporate income tax rate*, which would encourage more capital investment, contribute to higher labor productivity, and, ultimately, higher real wages and living standard.

2. *Across-the-board, proportional reduction in individual income tax rates*, which would increase the after-tax reward to work, possibly resulting in higher real wages or an increase in the US work force, and increase the after-tax return for savings and investment, through the lower investor level taxes on dividends, capital gains, and interest income.

3. *Rebate to households*, which would offset some of the impact of the carbon tax on household incomes.

Economic impact of the expansion of regulatory CO_2 controls

Table 1. Economic impact of the expansion of regulatory CO_2 controls to the pre-2013 regulatory baseline

Percent change from pre-2013 regulatory baseline

	2016-20	2021-25	2026-30	2031-35	Long-run
Overall CO_2 emissions reduction	-16.0%	-19.0%	-19.6%	-19.7%	-19.6%
GDP					
GDP, total	-0.4%	-0.7%	-0.9%	-0.9%	-0.9%
Consumption	-0.2%	-0.4%	-0.5%	-0.6%	-0.8%
Investment	-1.7%	-3.0%	-3.3%	-3.1%	-2.6%
Labor					
After-tax wages	0.4%	0.1%	-0.1%	-0.1%	-0.2%
Labor supply	0.1%	0.2%	0.2%	0.2%	0.3%
Equivalent dollar measures (2016 $)					
GDP change per household ($)	-550	-1,030	-1,210	-1,250	-1,310
GDP change per ton carbon reduction ($)	-80	-130	-150	-150	-160

Note: Economic impacts are presented as the 5-year average over the time period denoted. All rule-based policies modeled include only the impacts of post-2013 expansion or implementation. The results presented in this table assume the CPP is implemented as 50% national emissions rate and 50% mass based. The long run is defined as when the US economy has fully adjusted to the new policy. Approximately two-thirds to three-quarters of the impacts typically occur by year 10 in models of this type. Figures are rounded.
Source: EY analysis.

As displayed in Table 1, the expansion of regulatory CO_2 controls is estimated to reduce GDP over the long-run by close to 1%, or about $1,310 per household annually. Emissions of CO_2

would be reduced by nearly 20% relative to the pre-2013 regulatory baseline after the economy fully adjusts. The economic impact of the expansion of regulatory CO_2 controls is driven primarily by the expansion of CAFE standards and implementation of the CPP. The expansion of CAFE standards is estimated to be a particularly costly approach to reducing CO_2 emissions and accounts for approximately three-quarters of the long-run GDP impact.

Market-based alternative of a revenue-neutral, emissions-equivalent carbon tax

A key benefit of a revenue-neutral, emissions-equivalent carbon tax is that it leverages the knowledge and behavior of consumers and producers to find the least costly ways in which to reduce CO_2 emissions. In particular, rather than mandating that CO_2 emissions be reduced in a particular sector or via a particular restriction on the choices of consumers and producers, the carbon tax incentivizes consumers and producers to reduce emissions where it is least costly through a uniform, revenue-neutral CO_2 price. To the extent that the rule-based approach mandates reductions away from low-cost abatement opportunities, it will be less cost effective.

As seen in Table 2, this report finds that there are significant gains to the US economy from a revenue-neutral, emissions-equivalent carbon tax relative to the expansion of regulatory CO_2 controls. As a quantification of these gains, when carbon tax revenues are rebated to households – which does not improve economic efficiency via other tax rate reductions – GDP would increase in the long-run by 0.6%, or $820 per household annually. Because this use of proceeds does not improve efficiency through reductions in marginal tax rates it, in effect, isolates the benefit of leveraging the knowledge and behavior of consumers and producers in choosing where CO_2 emissions should be reduced.

There are even more significant economic benefits from the revenue-neutral, emissions-equivalent carbon tax when marginal tax rates are reduced. In particular, when used to reduce the corporate income tax rate the US economy would be larger by 2.1% in the long run relative to the expansion of regulatory CO_2 controls. Similarly, when used to fund an across-the-board, proportional individual income tax rate reduction the economy would be larger by 1.4% in the long run. In the long run, this amounts to an additional $2,940 in GDP per household (for a revenue-neutral reduction in the corporate income tax rate) and $1,950 (for a revenue-neutral across-the-board, proportional reduction in individual income tax rates) annually.

Table 2. Economic impact of revenue-neutral, emissions-equivalent carbon tax relative to the expansion of regulatory CO_2 controls

	2016-20	2021-25	2026-30	2031-35	Long-run
CO_2 emissions change in all scenarios	-16.0%	-19.0%	-19.6%	-19.7%	-19.6%
Corporate income tax rate reduction					
Source and use of revenue					
Carbon price ($/ton)	28	34	36	37	37
Corporate income tax rate	19.9%	17.5%	16.8%	16.6%	16.2%
GDP					
GDP	0.7%	1.5%	1.8%	1.9%	2.1%
Consumption	-0.5%	0.2%	0.7%	1.0%	1.6%
Investment	6.7%	8.7%	8.9%	8.1%	6.2%
Labor					
After-tax wages	-0.5%	0.7%	1.3%	1.6%	2.1%
Labor supply	0.1%	0.1%	0.1%	*	-0.1%
Equivalent dollar measures (2016 $)					
GDP change per household ($)	950	2,070	2,570	2,690	2,940
GDP change per ton carbon reduction ($)	140	260	310	320	350
Across-the-board, proportional individual income tax rate reduction					
Source and use of revenue					
Carbon price ($/ton)	27	32	34	34	34
Top individual income tax rate	37.6%	37.2%	37.1%	37.1%	37.1%
GDP					
GDP	0.5%	1.0%	1.2%	1.3%	1.4%
Consumption	0.2%	0.5%	0.8%	1.0%	1.3%
Investment	2.9%	4.5%	4.7%	4.3%	3.2%
Labor					
After-tax wages	1.4%	2.2%	2.6%	2.8%	3.1%
Labor supply	0.3%	0.3%	0.4%	0.3%	0.3%
Equivalent dollar measures (2016 $)					
GDP change per household ($)	780	1,450	1,740	1,820	1,950
GDP change per ton carbon reduction ($)	110	180	210	220	240
Household rebate					
Source and use of revenue					
Carbon price ($/ton)	27	32	33	33	33
Rebate per household ($)	1,130	1,340	1,380	1,390	1,380
GDP					
GDP	0.2%	0.4%	0.5%	0.5%	0.6%
Consumption	*	0.1%	0.2%	0.3%	0.5%
Investment	1.2%	2.4%	2.6%	2.4%	1.9%
Labor					
After-tax wages	-0.3%	-0.1%	*	0.1%	0.2%
Labor supply	-0.2%	-0.3%	-0.3%	-0.3%	-0.4%
Equivalent dollar measures (2016 $)					
GDP change per household ($)	220	570	720	760	820
GDP change per ton carbon reduction ($)	30	70	90	90	100

*Smaller in magnitude than 0.05% or $5.

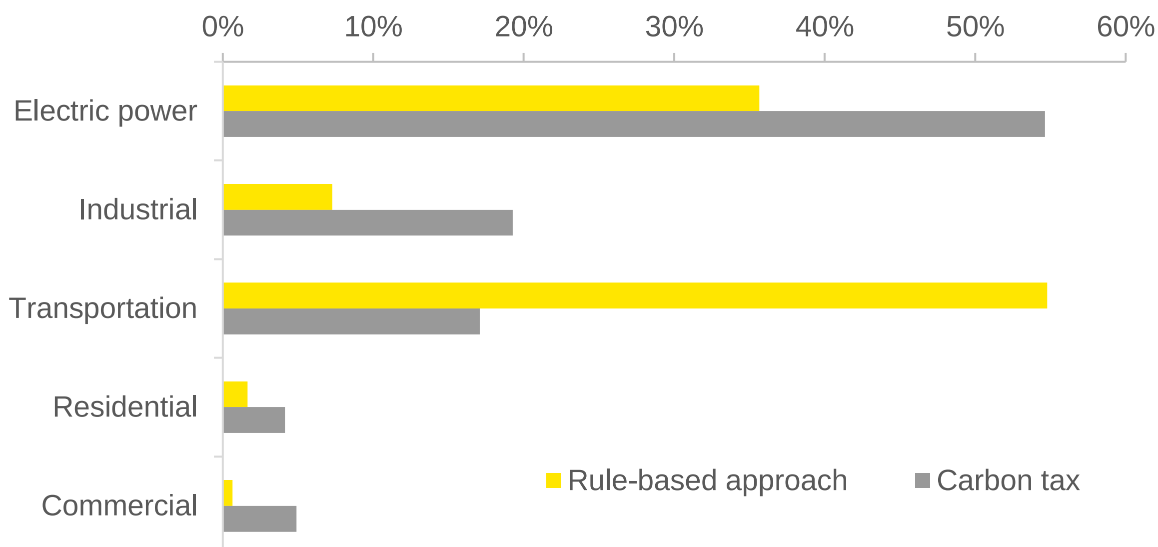
Note: Economic impacts are presented as the 5-year average over the time period denoted. All rule-based policies modeled include only the impacts of post-2013 expansion or implementation. The results presented in this table assume the CPP is implemented as 50% national emissions rate and 50% mass based. The long run is defined as when the US economy has fully adjusted to the new policy. Approximately two-thirds to three-quarters of the impacts typically occur by year 10 in models of this type. Figures are rounded.

Source: EY analysis.

Comparative evaluation

This analysis suggests that the expansion of regulatory CO_2 controls mandates more costly emissions abatement than lower cost abatement opportunities that are available. This is in large part due to the most costly of the rule-based policies, CAFE standards. As displayed in Figure 2, whereas in the expansion of regulatory CO_2 controls more than one-half of all emissions reduction occurs in transportation, this declines to less than one-fifth when consumers and producers are allowed to reduce emissions where it is least costly to do so. In contrast, the CPP – the second most costly of the expansion of regulatory CO_2 controls – mandates emissions reductions in the electric power sector where this analysis suggests there are relatively low-cost emissions abatement opportunities. In particular, under the revenue-neutral, emissions-equivalent carbon tax, more than half of all emissions reductions occur in the electric power sector. Notably, the appliance and energy efficiency standards also contribute to the electric power sector's emissions reductions. More disaggregated results can be found in Appendix D.

Figure 2. Share of CO_2 emissions reduction in revenue-neutral, emissions-equivalent carbon tax relative to the expansion of regulatory CO_2 controls, by sector



Note: Carbon tax scenario in which revenues are rebated to households is displayed. The transportation sector includes own-use vehicles. Each set of bars sum to 100%.
Source: EY analysis.

IV. Caveats and limitation

Any modeling effort is only an approximate depiction of the economic forces it seeks to represent, and the economic model developed for this analysis is no exception. Although various limitations and caveats might be listed, several are particularly noteworthy:

- **Estimates based on stylized depiction of US economy.** The general equilibrium model used for this analysis is, by its very nature, a stylized depiction of the US economy. The model was developed to capture the key details important to analyzing the impacts of the expansion of regulatory CO_2 controls relative to a revenue-neutral, emissions-equivalent carbon tax, but makes simplifying assumptions around many details of the economy.

- **United States is assumed to be on a fiscally sustainable path.** The model used for this analysis assumes that the United States is on a fiscally sustainable path under current law and remains on a fiscally sustainable path after the policy change, when neither may necessarily be the case.

- **Estimates limited by calibration to the 2013 US economy.** This model is calibrated to represent the US economy in 2013 and then forecast forward, but, because any particular year may reflect unique events and also may not represent the economy in the future, no particular baseline year is completely generalizable.

- **Preexisting distortions of rule-based policies enacted prior to 2013 are not modeled.** AEES, CAFE standards, and RFS were all first enacted prior to 2013 and the economic distortions associated with these policies prior to 2013 are not modeled. Thus the deadweight loss associated with further expansion of these rule-based policies may be understated.

- **Estimates are limited by available public information.** The analysis relies on information reported by government agencies (primarily the Bureau of Economic Analysis, US Energy Information Agency, and the EPA).The analysis did not attempt to verify or validate this information using sources other than those described in the report.

V. Summary

This report finds that a revenue-neutral, emissions-equivalent carbon tax reduces the same amount of CO_2 for much less cost to the US economy measured in terms of GDP than the expansion of regulatory CO_2 controls. The uniform price of carbon across the US economy leverages the knowledge and behavior of consumers and producers to find where it is least costly to reduce CO_2 emissions, as opposed to the location of emissions reductions being imposed by an often less flexible rule-based approach. Moreover, a carbon tax can further benefit households by financing efficiency-enhancing tax relief, such as cutting individual income and business taxes.

The United States has already enacted CO_2 abatement policies in the form of the scheduled expansion of the regulatory CO_2 controls. The results of this report, however, suggest that by instead relying on the market-based approach of a revenue-neutral, emissions-equivalent carbon tax, a much more efficient and less costly reduction of CO_2 emissions could be achieved, resulting in a net benefit for the US economy.

Appendix A. EY General Equilibrium Model of the US Economy

The EY GE Model was used to compare the macroeconomic impacts of the expansion of regulatory CO_2 controls with those of a revenue-neutral, emissions-equivalent carbon tax. This model, which is an OLG computable general equilibrium model, is similar to the economic models used by the, CBO, EPA, JCT, and US Department of the Treasury for estimating the potential economic and welfare impacts of various environmental and tax policies.[4]

Behavioral responses are modeled in a general equilibrium framework whereby representative firms and individuals incorporate changes in current and future prices when deciding how much to produce, save, and consume in each period. In this framework, individuals are assumed to be responsive to changes in the prices of consumer goods. Thus, as the price of carbon-intensive consumer goods increase, consumers substitute their consumption to other goods and services. Similarly, firms optimize the mix of capital, labor, and energy used in production, which can be affected by regulatory and tax policies.

An overview of the model follows:

Production

Firm production is modeled with the constant elasticity of substitution (CES) functional form in which firms choose the optimal level of capital and labor subject to the gross-of-tax cost of capital and gross-of-tax wage. The model includes industry-specific detail through use of differing costs of capital, factor intensities, and production function scale parameters. Such a specification accounts for differential use of capital and labor between industries as well as distortions in factor prices introduced by the tax system. The cost of capital measure models the extent to which the tax code discriminates by asset type, organizational form, and source of finance. Estimates of the cost of capital generally follow the formulation from Hall and Jorgenson (1967), expanded by Fullerton and Mackie (1987), and described in detail by Gravelle (1994) and Mackie (2002).

Each industry differs in its relative use of capital, labor, and energy inputs, as well as in the CO_2 content of its outputs. Each industry is responsive to the price of capital, labor, and energy, and chooses the optimal mix based on relative prices and industry-specific characteristics. The inclusion of inter-industry linkages is important for this type of analysis because CO_2 abatement policies have both direct and indirect effects that increase the costs of production. The direct effects are reflected in the increased costs created by the imposition of the policy on the use of CO_2-emitting industries. Indirect costs are incurred through the use of inputs or processes in production that have previously been subject to the policy. This means that even industries that are not directly impacted by a policy are subject to potentially significant cost increases through increased prices of intermediate inputs from other industries used in their production processes.

Consumers

The OLG framework is modeled with 55 generational cohorts. That is, in any one year the model includes a representative household optimizing lifetime consumption and savings decisions for each age 21 through 75 (i.e., 55 representative cohorts). For each generational cohort the endowment of human capital exogenously changes with age – growing early in life and declining later in life. This OLG framework is especially well-suited for estimating both the short-run transitional and long-run effects of a policy change.

The utility of representative individuals is modeled as a CES function allocating a composite good consisting of consumer goods and leisure over their lifetimes. Representative individuals optimize their lifetime utility through their decisions of how much to consume, save, and work in each period subject to their preference parameters and the after-tax returns from work and savings in each period. In determining their labor supply, representative individuals respond to the after-tax return to labor, as well as their overall income levels, in determining whether to work and thereby earn income that is used to purchase consumer goods or to consume leisure by not working.

Other features

The model includes a simple characterization of the government. The model includes a sector representing state and local governments as well as a sector representing the US federal government. Government spending is assumed to be used for either (1) transfer payments to representative individuals or (2) the provision of public goods. Public goods are assumed to be provided by the government in fixed quantities through the purchase of industry outputs as specified in a Leontief function. This spending is financed in the model by collecting taxes. All tax policy changes are assumed to be offset by a contemporaneous and offsetting change in government spending or taxes.

Appendix B. Policy descriptions and modeling approach – Expansion of regulatory CO_2 controls and the revenue-neutral, emissions equivalent carbon tax

The expansion of regulatory CO_2 control include the major policies introduced or expanded in the United States' rule-based CO_2 abatement regime in the 2013-2016 period. In particular, these policies are the expansion of: (1) CAFE standards, (2) RFS, and (3) AEES as well as the introduction of the CPP. Because the purpose of this analysis is to highlight the difference in approach (i.e., a rule- versus market-based approach) rather than timing, all rules introduced by these policies are assumed to be immediately in effect. For example, the CPP, which is intended to be implemented starting in 2022, is assumed to be fully in effect at the start of 2016. Additionally, note that no other policies in the United States' rule-based CO_2 abatement regime are modeled. Thus, any interactions of the policies modeled with any rule-based CO_2 abatement policies from before 2013 or after 2016 are not modeled. For example, CAFE standards, RFS, and AEES were all first enacted prior to 2013 and the economic distortions associated with these policies from prior to 2013 are not modeled.

Following the convention of recent environmental CGE models, rule-based policies (i.e., the addition of constraints in the constrained optimization choices of households and businesses) are modeled as (formally equivalent) revenue-neutral tax-subsidy combinations.[5] For example, the national emissions rate CPP scenario is modeled as revenue-neutral tax-subsidy combinations on the relevant power generation industries that reduce the emissions per unit of output (e.g., the coal national emissions rate standard was modeled via a revenue-neutral combination of a tax on the coal inputs to the coal power generation industry paired with a subsidy on coal power generation output). For modeling the carbon tax, because the emissions of CO_2 are explicitly traced through the economy in the EY GE Model, a uniform CO_2 price is imposed at the point of emission.

Reductions in the tax rate on wages are modeled by reducing the wedge between before- and after-tax wages in the model. All changes to capital taxation (i.e., the reduction in the corporate income tax rate or the reduction in taxation on income from capital gains, dividend, interest, and pass-through businesses) are all modeled through the user cost of capital formula discussed above.

Appendix C. Macroeconomic impacts with alternative CPP scenarios

Table C-1. Economic impacts of the expansion of regulatory CO_2 controls relative to the pre-2013 regulatory baseline (All states cooperate in creating a single, multi-state cap-and-trade program)

Percent change from pre-2013 regulatory baseline

	2016-20	2021-25	2026-30	2031-35	Long-run
Overall CO_2 emissions reduction	-15.6%	-18.6%	-19.2%	-19.3%	-19.3%
GDP					
GDP, total	-0.4%	-0.7%	-0.9%	-0.9%	-0.9%
Consumption	-0.1%	-0.4%	-0.5%	-0.6%	-0.8%
Investment	-1.8%	-3.0%	-3.3%	-3.1%	-2.6%
Equivalent dollar measures (2016 $)					
GDP change per household ($)	-510	-1,010	-1,200	-1,240	-1,300
GDP change per ton carbon reduction ($)	-70	-120	-140	-140	-150

Note: Economic impacts are presented as the 5-year average over the time period denoted. All rule-based policies modeled include only the impacts of post-2013 expansion or implementation. The long run is defined as when the US economy has fully adjusted to the new policy. Approximately two-thirds to three-quarters of the impacts typically occur by year 10 in models of this type. Figures are rounded.
Source: EY analysis.

Table C-2. Economic impacts of the expansion of regulatory CO_2 controls relative to a pre-2013 regulatory baseline (All states choose to adopt the national emissions rate option without inter-industry trading)

Percent change from pre-2013 regulatory baseline

	2016-20	2021-25	2026-30	2031-35	Long-run
Overall CO_2 emissions reduction	-16.5%	-19.6%	-20.2%	-20.3%	-20.3%
GDP					
GDP, total	-0.3%	-0.7%	-0.8%	-0.9%	-0.9%
Consumption	-0.1%	-0.3%	-0.5%	-0.6%	-0.7%
Investment	-1.7%	-3.0%	-3.3%	-3.1%	-2.6%
Equivalent dollar measures (2016 $)					
GDP change per household ($)	-480	-970	-1,160	-1,200	-1,260
GDP change per ton carbon reduction ($)	-60	-110	-130	-130	-140

Note: Economic impacts are presented as the 5-year average over the time period denoted. All rule-based policies modeled include only the impacts of post-2013 expansion or implementation. The long run is defined as when the US economy has fully adjusted to the new policy. Approximately two-thirds to three-quarters of the impacts typically occur by year 10 in models of this type. Figures are rounded.
Source: EY analysis.

Appendix D. Additional model results

Table D-1. Economic impacts of the expansion of regulatory CO_2 controls relative to the pre-2013 regulatory baseline (CAFE only)

Percent change from pre-2013 regulatory baseline

	2016-20	2021-25	2026-30	2031-35	Long-run
Overall CO_2 emissions reduction	-7.2%	-10.1%	-10.8%	-11.0%	-11.1%
GDP					
GDP, total	-0.2%	-0.6%	-0.7%	-0.8%	-0.8%
Consumption	*	-0.3%	-0.4%	-0.5%	-0.7%
Investment	-1.5%	-2.7%	-3.0%	-2.8%	-2.4%
Labor					
Job equivalents	0.8%	0.6%	0.5%	0.4%	0.3%
After-tax wages	0.4%	0.2%	*	*	-0.2%
Labor supply	0.1%	0.2%	0.2%	0.2%	0.3%
Equivalent dollar measures (2016 $)					
GDP change per household ($)	-340	-830	-1,020	-1,070	-1,140

*Smaller in magnitude than 0.05% or $5.
Note: Economic impacts are presented as the 5-year average over the time period denoted. All rule-based policies modeled include only the impacts of post-2013 expansion or implementation. The long run is defined as when the US economy has fully adjusted to the new policy. Approximately two-thirds to three-quarters of the impacts typically occur by year 10 in models of this type. Figures are rounded.
Source: EY analysis.

Table D-2. Economic impacts of the expansion of regulatory CO_2 controls relative to pre-2013 regulatory baseline (Mass-based CPP only)

Percent change from pre-2013 regulatory baseline

	2016-20	2021-25	2026-30	2031-35	Long-run
Overall CO_2 emissions reduction	-7.6%	-7.7%	-7.7%	-7.7%	-7.7%
GDP					
GDP, total	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%
Consumption	-0.1%	-0.1%	-0.1%	-0.2%	-0.2%
Investment	-0.2%	-0.2%	-0.3%	-0.3%	-0.3%
Labor					
Job equivalents	*	*	*	*	*
After-tax wages	*	-0.1%	-0.1%	-0.1%	-0.1%
Labor supply	*	*	*	*	*
Equivalent dollar measures (2016 $)					
GDP change per household ($)	-170	-190	-200	-200	-200

*Smaller in magnitude than 0.05% or $5.
Note: Economic impacts are presented as the 5-year average over the time period denoted. All rule-based policies modeled include only the impacts of post-2013 expansion or implementation. The long run is defined as when the US economy has fully adjusted to the new policy. Approximately two-thirds to three-quarters of the impacts typically occur by year 10 in models of this type. Figures are rounded.
Source: EY analysis.

Table D-3. Economic impacts of the expansion of regulatory CO_2 controls relative to pre-2013 regulatory baseline (Rate-based CPP only)

Percent change from pre-2013 regulatory baseline

	2016-20	2021-25	2026-30	2031-35	Long-run
Overall CO_2 emissions reduction	-7.9%	-7.9%	-7.9%	-7.9%	-7.9%
GDP					
GDP, total	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
Consumption	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
Investment	-0.1%	-0.1%	-0.2%	-0.2%	-0.2%
Labor					
Job equivalents	-0.1%	-0.2%	-0.2%	-0.1%	-0.1%
After-tax wages	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%
Labor supply	*	*	*	*	*
Equivalent dollar measures (2016 $)					
GDP change per household ($)	-230	-230	-230	-230	-230

*Smaller in magnitude than 0.05% or $5.
Note: Economic impacts are presented as the 5-year average over the time period denoted. All rule-based policies modeled include only the impacts of post-2013 expansion or implementation. The long run is defined as when the US economy has fully adjusted to the new policy. Approximately two-thirds to three-quarters of the impacts typically occur by year 10 in models of this type. Figures are rounded.
Source: EY analysis.

Table D-4. Economic impacts of the expansion of regulatory CO_2 controls relative to pre-2013 regulatory baseline (50-50 CPP scenario only)

Percent change from pre-2013 regulatory baseline

	2016-20	2021-25	2026-30	2031-35	Long-run
Overall CO_2 emissions reduction	-8.2%	-8.2%	-8.2%	-8.2%	-8.2%
GDP					
GDP, total	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
Consumption	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
Investment	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
Labor					
Job equivalents	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%
After-tax wages	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%
Labor supply	*	*	*	*	*
Equivalent dollar measures (2016 $)					
GDP change per household ($)	-230	-240	-250	-250	-250

*Smaller in magnitude than 0.05% or $5.
Note: Economic impacts are presented as the 5-year average over the time period denoted. All rule-based policies modeled include only the impacts of post-2013 expansion or implementation. The long run is defined as when the US economy has fully adjusted to the new policy. Approximately two-thirds to three-quarters of the impacts typically occur by year 10 in models of this type. Figures are rounded.
Source: EY analysis.

Table D-5. Economic impacts of the expansion of regulatory CO_2 controls relative to pre-2013 regulatory baseline (RFS only)

Percent change from pre-2013 regulatory baseline

	2016-20	2021-25	2026-30	2031-35	Long-run
Overall CO_2 emissions reduction	-0.3%	-0.2%	-0.1%	*	*
GDP					
GDP, total	*	*	*	*	*
Consumption	*	*	*	*	*
Investment	*	*	*	*	*
Labor					
Job equivalents	*	*	*	*	*
After-tax wages	*	*	*	*	*
Labor supply	*	*	*	*	*
Equivalent dollar measures (2016 $)					
GDP change per household ($)	*	*	*	*	*

*Smaller in magnitude than 0.05% or $5.
Note: Economic impacts are presented as the 5-year average over the time period denoted. All rule-based policies modeled include only the impacts of post-2013 expansion or implementation. The long run is defined as when the US economy has fully adjusted to the new policy. Approximately two-thirds to three-quarters of the impacts typically occur by year 10 in models of this type. Figures are rounded.
Source: EY analysis.

Table D-6. Economic impacts of the expansion of regulatory CO_2 controls relative to pre-2013 regulatory baseline (AEES only)

Percent change from pre-2013 regulatory baseline

	2016-20	2021-25	2026-30	2031-35	Long-run
Overall CO_2 emissions reduction	-0.4%	-0.7%	-0.9%	-1.0%	-1.0%
GDP					
GDP, total	*	*	*	*	*
Consumption	*	-0.1%	-0.1%	-0.1%	-0.1%
Investment	*	-0.1%	-0.1%	-0.1%	-0.1%
Labor					
Job equivalents	*	*	*	*	*
After-tax wages	*	*	*	*	*
Labor supply	*	*	*	*	*
Equivalent dollar measures (2016 $)					
GDP change per household ($)	-30	-50	-60	-70	-70

*Smaller in magnitude than 0.05% or $5.
Note: Economic impacts are presented as the 5-year average over the time period denoted. All rule-based policies modeled include only the impacts of post-2013 expansion or implementation. The long run is defined as when the US economy has fully adjusted to the new policy. Approximately two-thirds to three-quarters of the impacts typically occur by year 10 in models of this type. Figures are rounded.
Source: EY analysis.

Table D-7. Long-run impact on real after-tax income, by decile
Percent change from pre-2013 regulatory baseline

	Regulatory CO_2 control path	Carbon tax: corporate tax reduction	Carbon tax: individual tax reduction	Carbon tax: household rebate
1st decile (0-10)	-1.0%	0.0%	0.3%	2.0%
2nd decile (11-20)	-1.0%	0.3%	0.3%	0.2%
3rd decile (21-30)	-1.2%	0.5%	0.5%	-0.4%
4th decile (31-40)	-1.3%	0.6%	0.8%	-0.5%
5th decile (41-50)	-1.3%	0.8%	1.1%	-0.6%
6th decile (51-60)	-1.2%	1.0%	1.5%	-0.5%
7th decile (61-70)	-1.1%	1.3%	1.7%	-0.5%
8th decile (71-80)	-0.9%	1.5%	1.9%	-0.4%
9th decile (81-90)	-1.0%	1.5%	1.9%	-0.4%
10th decile (91-100)	-0.8%	2.8%	2.5%	-0.4%

Note: Change in real after-tax income is defined as the change in nominal after-tax income adjusted for changes in the price level. Income profiles are based on IRS microdata and data from the Bureau of Labor Statistics' 2015 Consumer Expenditure Survey. To estimate the change in income and price level, the results of the macroeconomic model by type of income (e.g., capital versus labor income) and type of consumption good were mapped to the specific annual income and expenditure patterns of each decile. The long run is defined as when the US economy has fully adjusted to the new policy. Approximately two-thirds to three-quarters of the impacts typically occur by year 10 in models of this type.
Source: EY analysis.

Appendix E. Inclusion of renewable energy and energy efficiency tax expenditures as part of rule-based approach for reducing CO_2 emissions

To be more fully representative of current policy, this report also considers the five largest tax expenditures (by revenue cost) focused on renewable energy or energy efficiency as part of the rule-based approach.[6] Although not rule-based policies, these tax expenditures are, similar to other policies included as part of the expansion of regulatory CO_2 controls, more targeted than a revenue-neutral carbon tax and, consequently, do not leverage the broad base of knowledge and behavior of consumers and producers to find where it is least costly to reduce emissions. This analysis assumes that all tax expenditures are permanent.

The renewable energy or energy efficiency tax expenditures analyzed by this report include:

- *Renewable electricity production tax credit.* The renewable electricity production tax credit (PTC) encourages the construction of new electricity generation facilities that use renewable energy sources. The PTC applies to electricity generated from renewable energy facilities for the first 10 years following construction. The PTC offers inflation-adjusted credits of $0.023 per kilowatt-hour (kWh) of electricity generated using wind, biomass, and geothermal resources, and $0.012 per kWh of electricity generated from solar energy, small irrigation projects, and municipal solid waste.

- *Credit for biodiesel and renewable diesel used as fuel.* The credit for biodiesel and renewable diesel used as fuel incentivizes the use and sale of biodiesel fuels. Biodiesel fuels include fuels produced using vegetable oils or animal matter that meet the industry specifications for use in standard diesel engines. The provision offers a $1.00 credit per gallon of biodiesel or biodiesel mixture used or sold at retail in the course of a trade or business. Also available is a $0.10 credit per gallon of agri-biodiesel produced and used or sold at retail. "Agri-biodiesel" refers to biodiesel derived solely from "virgin oils," such as corn, soybeans, sunflower seeds, canola, and animal fat.

- *Residential energy efficient property credit.* This credit encourages consumers to install energy-conserving property on or in their homes. Qualifying property includes solar hot water heaters, solar electric equipment, geothermal heat pumps, fuel cells, and wind turbines. The provision offers a credit of 30% of the cost of such property.

- *Wind, solar, geothermal, and fuel cell tax credit.* The wind, solar, geothermal, and fuel cell tax credit ("business energy investment tax credit," or ITC) encourages investment in renewable energy production equipment. The ITC is available for 30% of the amount invested in solar, fuel cell, and wind power equipment. A 10% ITC is available for investments in geothermal, microturbine, and combined heat and power system equipment.

- *Nonbusiness energy property credit.* The nonbusiness energy property credit offers a 10% credit for energy-efficient improvements to a taxpayer's existing principal home. The credit is capped at $500 for the taxpayer's lifetime. No more than $200 can be claimed for the purchase and installation of energy-efficient windows. Other qualifying property includes insulation designed to reduce heat loss or gain, exterior doors, and roofs with cooling technology. Because they apply to different types of property, the residential energy efficient property credit and the nonbusiness energy property credit can both be claimed by one taxpayer for the same home.

As the following tables show, these tax expenditures do not materially impact the emission reduction under the expansion of regulatory CO_2 controls (expansion of CAFE, new CPP, expansion of RFS, and expansion of AEES), nor materially impact on GDP relative to those regulatory controls.

Table E-1. Economic impacts of the expansion of CO_2 controls relative to pre-2013 regulatory baseline (including tax expenditures)

Percent change from pre-2013 regulatory baseline

	2016-20	2021-25	2026-30	2031-35	Long-run
Overall CO_2 emissions reduction	-16.2%	-19.2%	-19.7%	-19.9%	-19.8%
GDP					
GDP, total	-0.4%	-0.7%	-0.9%	-0.9%	-0.9%
Consumption	-0.2%	-0.4%	-0.6%	-0.6%	-0.8%
Investment	-1.7%	-3.0%	-3.3%	-3.1%	-2.6%
Equivalent dollar measures (2016 $)					
GDP change per household ($)	-560	-1,040	-1,230	-1,260	-1,320
GDP change per ton carbon reduction ($)	-80	-130	-150	-150	-160

Note: Economic impacts are presented as the 5-year average over the time period denoted. All rule-based policies modeled include only the impacts of post-2013 expansion or implementation. The results presented in this table assume the CPP is implemented as 50% national emissions rate and 50% mass based, and this assumption is discussed further in the body of the report. Also included are the five largest tax expenditures (by revenue cost) focused on renewable energy or energy efficiency. The long run is defined as when the US economy has fully adjusted to the new policy. Approximately two-thirds to three-quarters of the impacts typically occur by year 10 in models of this type. Figures are rounded.
Source: EY analysis.

Table E-2. Economic impact of revenue-neutral, emissions-equivalent carbon tax implemented instead of the expansion of regulatory CO_2 controls (including tax expenditures)

	2016-20	2021-25	2026-30	2031-35	Long-run
CO_2 emissions change in all scenarios	-16.2%	-19.2%	-19.7%	-19.9%	-19.8%
Corporate income tax rate reduction					
Use of revenue					
Corporate income tax rate	19.8%	17.4%	16.7%	16.5%	16.1%
GDP					
GDP	0.7%	1.5%	1.8%	1.9%	2.1%
Consumption	-0.5%	0.2%	0.7%	1.0%	1.7%
Investment	6.7%	8.7%	9.0%	8.2%	6.3%
Equivalent dollar measures (2016 $)					
GDP change per household ($)	970	2,090	2,590	2,710	2,960
GDP change per ton carbon reduction ($)	140	260	310	320	350
Across-the-board, proportional individual income tax rate reduction					
Use of revenue					
Top individual income tax rate	37.5%	37.2%	37.1%	37.1%	37.0%
GDP					
GDP	0.6%	1.0%	1.2%	1.3%	1.4%
Consumption	0.2%	0.5%	0.8%	1.0%	1.3%
Investment	2.9%	4.6%	4.7%	4.3%	3.2%
Equivalent dollar measures (2016 $)					
GDP change per household ($)	800	1,470	1,760	1,840	1,980
GDP change per ton carbon reduction ($)	120	180	210	220	240
Household rebate					
Use of revenue					
Rebate per household ($)	1,150	1,350	1,390	1,400	1,400
GDP					
GDP	0.2%	0.4%	0.5%	0.5%	0.6%
Consumption	*	0.1%	0.2%	0.3%	0.5%
Investment	1.2%	2.4%	2.6%	2.4%	1.9%
Equivalent dollar measures (2016 $)					
GDP change per household ($)	230	590	740	770	830
GDP change per ton carbon reduction ($)	30	70	90	90	100

Note: Economic impacts are presented as the 5-year average over the time period denoted. All rule-based policies modeled include only the impacts of post-2013 expansion or implementation. The results presented in this table assume the CPP is implemented as 50% national emissions rate and 50% mass based, and this assumption is discussed further in the body of the report. Also included are the five largest tax expenditures (by revenue cost) focused on renewable energy or energy efficiency. The long-run is defined as when the US economy has fully adjusted to the new policy. Approximately two-thirds to three-quarters of the impacts typically occur by year 10 in models of this type. Figures are rounded.
Source: EY analysis.

Endnotes

[1] See Asa Johannson, Christopher Heady, Jens Arnold, Bert Brys, and Laura Vartia, 2008, "Taxation and Economic Growth," OECD Economics Department Working Papers No. 620, Paris: Organisation for Economic Co-operation and Development.

[2] All future expansions in the regulatory controls are assumed to be in force as of the beginning of 2016. Note that even with this assumption there is still a phase-in for CAFE standards because they apply to new vehicles.

[3] See, for example, Shinichi Nishiyama, "Fiscal Policy Effects in a Heterogeneous-Agent Overlapping-Generations Economy With an Aging Population," Congressional Budget Office, Working Paper 2013-07, December 2013; Joint Committee on Taxation*, Macroeconomic Analysis of the "Tax Reform Act of 2014,"* February 2014 (JCX-22-14); Joint Committee on Taxation, *Macroeconomic Analysis of Various Proposals to Provide $500 Billion in Tax Relief*, March 2005 (JCX-4-05); Robert Carroll, John Diamond, Craig Johnson and James Mackie III, "A Summary of the Dynamic Analysis of the Tax Reform Options Prepared for the President's Advisory Panel on Federal Tax Reform," Office of Tax Analysis, US Department of the Treasury, May 25, 2006; Martin Ross, "Documentation of the Applied Dynamic Analysis of the Global Economy (ADAGE) Model," Research Triangle Institute, 2009; Richard Goettle, Mun Ho, Dale Jorgenson, and Peter Wilcoxen, "Energy, The Environment, and U.S. Economic Growth," In *Handbook of Computable General Equilibrium Modeling*, edited by Peter Dixon and Dale Jorgenson, 2013.

[4] See, for example, Shinichi Nishiyama, "Fiscal Policy Effects in a Heterogeneous-Agent Overlapping-Generations Economy With an Aging Population," Congressional Budget Office, Working Paper 2013-07, December 2013; Joint Committee on Taxation, *Macroeconomic Analysis of the "Tax Reform Act of 2014,"* February 2014 (JCX-22-14); Joint Committee on Taxation, *Macroeconomic Analysis of Various Proposals to Provide $500 Billion in Tax Relief*, March 2005 (JCX-4-05); Robert Carroll, John Diamond, Craig Johnson and James Mackie III, "A Summary of the Dynamic Analysis of the Tax Reform Options Prepared for the President's Advisory Panel on Federal Tax Reform," Office of Tax Analysis, US Department of the Treasury, May 25, 2006; Martin Ross, "Documentation of the Applied Dynamic Analysis of the Global Economy (ADAGE) Model," Research Triangle Institute, 2009; Richard Goettle, Mun Ho, Dale Jorgenson, and Peter Wilcoxen, "Energy, The Environment, and U.S. Economic Growth," In *Handbook of Computable General Equilibrium Modeling*, edited by Peter Dixon and Dale Jorgenson, 2013.

[5] They are shown to be formally equivalent in Donald Fullerton and Gilbert Metcalf, (2001), "Environmental Controls, Scarcity Rents, and Pre-Existing Distortions," *Journal of Public Economics* 80(2):249-67.

[6] See Congressional Research Service, "Energy Tax Incentives: Measuring Value Across Different Types of Energy Resources," March 19, 2015.