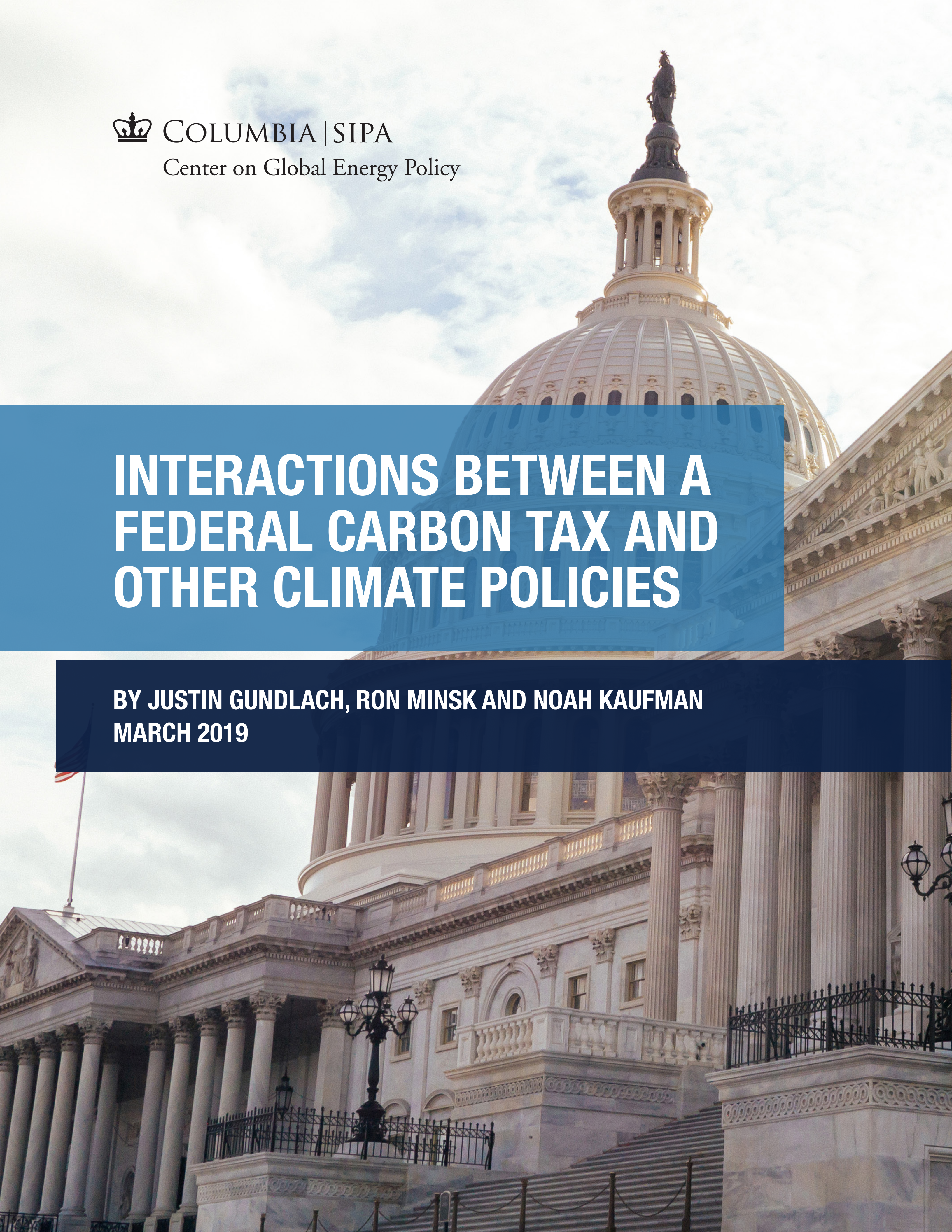

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INTERACTIONS BETWEEN A FEDERAL CARBON TAX AND OTHER CLIMATE POLICIES

BY JUSTIN GUNDLACH, RON MINSK AND NOAH KAUFMAN
MARCH 2019

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EXECUTIVE SUMMARY

Putting a price on carbon is a critical part of a low-cost strategy for reducing greenhouse gas (GHG) emissions, and a national carbon tax is a rare example of a climate change policy that has found bipartisan support in the United States. In 2018, legislation establishing a carbon tax was proposed by Democrats, Republicans, and bipartisan groups of US congressmen. However, while passing a carbon tax would certainly prove a significant step toward slashing emissions, simply adding a carbon tax to current policies is unlikely to achieve an emissions target at the lowest cost.

Designing a carbon tax that contributes to achieving greenhouse gas reduction targets effectively and efficiently will require an examination of whether other new policies are also needed and whether existing policies can or should be changed or eliminated. With more proposals expected in 2019, such an examination is critical to ensuring both sufficient emissions reductions and an efficient set of policies that keep costs in check for taxpayers.

As part of a broader carbon tax research program at the School of International and Public Affairs' Center on Global Energy Policy at Columbia University, we have developed a framework for considering the interactions between a federal carbon tax and other policies that influence greenhouse gas emissions. Toward the goal of helping to design better policies, we identify policies and programs that are "complementary" to a carbon tax or "redundant." A policy is defined as complementary if it

1. enables more cost-effective reductions of carbon dioxide emissions than a carbon tax would achieve on its own; or

2. reduces GHG emissions *and* achieves a separate policy objective more cost-effectively than a federal carbon tax would on its own.

Conversely, a policy is defined as redundant with a federal carbon tax if it leads to additional costs to society without achieving additional emissions reduction.

In developing this framework, we recognize that real-world policies often do not fall cleanly into either category and that neither specifying the framework nor making the categorizations is an exact science. It is often difficult to identify a policy's objective or evaluate its cost-effectiveness. In addition, the extent to which a policy complements a carbon tax depends on the nature of the carbon tax. Most obviously, with a lower carbon tax rate, fewer emission reductions would be achieved, and additional policies may be needed to make up the difference between the outcome and a science-based emissions reduction target.

The results of the work, highlighted in the following table, indicate a relatively large number of policies can complement a carbon tax, such as those that support innovation in low-carbon technologies, tackle behavioral barriers to more efficient energy use, or improve public infrastructure and address barriers to reducing emissions unrelated to the price-related barriers addressed by a carbon tax. Conversely, the paper identifies regulations that force entities that pay the carbon tax to take specific actions to reduce their emissions, such as Environmental Protection Agency regulations of stationary sources of carbon dioxide emissions under section 111 of the Clean Air Act, as redundant with the carbon tax. The paper does not recommend which policies should be eliminated, changed, or added but intends to provide policy makers with information that will help them make these decisions.

Figure ES1: The compatibility of a federal carbon tax and other policies that reduce emissions

<< Complementary				Redundant >>
Regulations of GHG emissions not covered by the carbon tax	Fuel economy standards	Subsidies for low-carbon technologies	State carbon pricing policies	Regulations of GHG emissions covered by the carbon tax
Regulations of local air pollutants		Renewable or low carbon fuel standards	Fuel excise taxes	
Removing fossil fuel subsidies			Renewable or clean electricity standards	
Energy efficiency standards and programs				
Funding innovation in low carbon technologies				
Public infrastructure supporting low carbon transportation and land use				

INTRODUCTION

A price on carbon would reduce greenhouse gas emissions by providing a financial incentive to shift away from carbon-intensive goods and services. For decades, economists have recommended a price on carbon as an important element of a cost-effective strategy to address the risks of climate change.

In recent years, there has been momentum to adopt a carbon tax, one of two primary policy alternatives to establish a price on carbon dioxide emissions (the other is a cap-and-trade policy). In 2018 alone, carbon tax legislation was proposed in the US Congress by a group of Democrats in May, by a group of Republicans in July, and by a bipartisan group in December. Still, the current leadership of the Republican party remains opposed to a carbon tax, making passage unlikely in the near term.

This paper assumes that the US Congress will consider implementing a carbon tax by the early 2020s. Given the difficulty and complexity that would be involved in negotiating and potentially enacting a federal carbon tax, it is important that policy makers have the information they need to thoughtfully design and consider proposals when the legislative window opens. The purpose of this paper is to explore one important aspect of future policy negotiations: the interactions between a carbon tax and other public policies that influence domestic greenhouse gas emissions levels.

Developing carbon tax legislation will involve negotiations not only over the details of the carbon tax itself but also over other policies that influence greenhouse gas emissions. That will include negotiations over (1) adding new policies and regulations alongside a carbon tax to reduce greenhouse gas emissions and (2) changing, suspending, or eliminating existing policies or regulations upon the implementation of a carbon tax. To make informed decisions, policy makers should understand how other policies interact with a federal carbon tax with respect to emissions, energy market, and economic outcomes.

In the remainder of this paper, we first summarize the universe of energy, transportation, and other policies that most directly influence domestic greenhouse gas emissions. Second, a framework is proposed for considering the interactions between these policies and a federal carbon tax. Third, we categorize existing policies and regulations using the framework described in the previous section.

We make various important assumptions to enable a relatively concise discussion. The federal carbon tax considered throughout the paper is purposely vague. We assume the carbon tax would cover only CO_2 emissions from the combustion of fossil fuels and industrial processes, but otherwise do not specify important aspects of policy design, such as the allocation of revenue. However, we note the important implications for policy interactions of a carbon tax that is set at a level that is "too weak" to reduce emissions to a desired level. We also assume that the primary (and possibly sole) purpose of the carbon tax would be to discourage activities that generate GHG emissions and thereby cause climate change and that its other effects (e.g., raising tax revenue, improving energy security) would be incidental.

We do not make any recommendations about which policies or regulations should be added, subtracted, retained, or changed with the implementation of a federal carbon tax. The purpose of the paper is to provide policy makers and other stakeholders with information that will help them make these decisions.

THE POLICY UNIVERSE AT ISSUE

While a major economy-wide policy like a carbon tax could be said to interact with a much broader array of policies,[1] the scope of this paper is limited to US domestic policies that influence GHG emissions in the energy and land use sectors and do not directly govern international trade.[2] This section summarizes those policies' supporting legal authorities and structures. It focuses first and primarily on federal policies but also notes several especially relevant state-level policies.

GHG Mitigation Authorized by the Clean Air Act

The Clean Air Act of 1963, as amended in 1970, 1977, and 1990,[3] regulates air pollutants emitted by mobile and stationary sources and is the most substantial source of climate change mitigation authority in the United States. Starting in December 2009 with its finding that GHG emissions cause or contribute to the endangerment of Americans' public health and welfare,[4] the Environmental Protection Agency (EPA) began issuing regulations that use the tools authorized under the Clean Air Act to reduce GHG emissions. This summary begins with a brief overview of the Act's relevant components. It then describes sectors and types of GHG sources regulated under the Act.

The Clean Air Act instructs the EPA to monitor ongoing scientific findings about pollutants' effects on public health and welfare, and to regulate—or update regulations of—those pollutants consistent with what good science demands.[5] In *Massachusetts v. EPA*, the Supreme Court confirmed that the authority of the Clean Air Act extends to six GHGs,[6] initiating a round of regulations to limit their emission. Technically, that case addressed only the question of whether the act covered GHGs emitted by motor vehicles, but because the regulation of pollutants from motor vehicle emissions under section 202 of the act triggers provisions in other sections of the act, *Massachusetts v. EPA* effectively knocked over the first in a line of regulatory dominoes that have continued to fall since. First, effective on December 29, 2009, the EPA required emitters to report their GHG emissions.[7] Next, in May 2010, the National Highway Transportation Safety Administration (NHTSA) and EPA issued a joint rule in which NHTSA revised the Corporate Average Fuel Economy (CAFE) standards by which it regulates fuel economy, and the EPA established its first ever regulations limiting CO_2 emissions from passenger- and light-duty vehicles for model years 2012–2016.[8] EPA and NHTSA have since issued similar standards: NHTSA for model years 2017–2021 (because the NHTSA's authorizing statute allows for the establishment of standards for only five years at one time) and EPA for model years 2017–2025,[9] and for heavy-duty vehicles as well.[10]

The next domino to fall was EPA's decision to include GHGs among the pollutants emitted by stationary sources regulated under the Prevention of Significant Deterioration (PSD) and Title V permitting programs,[11] which are intended to protect air quality from new or modified major sources of emissions. That inclusion means that new or modified major sources of emissions in "attainment areas" (i.e., areas in compliance with National Ambient Air Quality Standards for sulfur dioxide, lead, and other "criteria pollutants"), including power plants, refineries, cement production facilities, and the largest industrial facilities, must seek permits for GHG emissions as well as other pollutants and must adopt the "best available control technology" (BACT) to limit their GHG emissions.[12] Subsequent initiatives have included performance standards issued pursuant to Section 111 of the act, which regulates emissions from stationary sources, for several types of major new and existing sources of GHG emissions.[13] The last new area covered by the Obama administration was an endangerment finding for GHG emissions from aircraft, which is the first step toward regulating their GHG emissions.[14]

The EPA's Clean Air Act-based GHG regulations cover emissions from fossil fuel-fired electricity generating units (EGUs), cement plants and other manufacturing facilities, oil and gas refineries, solid waste landfills, waste incinerators, and vehicles regulations that address these sources:

- Performance standards for CO_2 emissions from new coal-fired power plants.[15]
- Performance standards for CO_2 emissions from existing fossil-fueled power plants.[16]
- Performance standards for emissions of methane and volatile organic compounds from new oil and gas production facilities.[17]
- With respect to on-road vehicles, NHTSA's CAFE and EPA's GHG emission standards set mandatory, fleet-wide targets for miles per gallon and GHG emissions per mile, respectively, while also giving credit for the deployment of plug-in hybrid electric and other zero-emitting vehicles, though President Trump recently proposed freezing the stringency of the standards in 2020. The EPA's standards also allow manufacturers to claim credits toward emissions compliance by upgrading air-conditioning systems—whether by substituting for refrigerants with a high global warming potential[18] or by improving system components in a way demonstrated to reduce the leakage of fluorinated gases.[19]

A last point about CAFE standards, which also is discussed below: although CAFE and GHG emission standards are codified in *federal* regulations, the Clean Air Act gives California authority to set its own standards, subject to a federal waiver, which has historically been granted.[20] Given the size of the California market for light-duty vehicles, and the fact that over a dozen states have exercised their rights under the CAA to adopt California's tighter standards, California effectively has an important role in the drafting of prevailing regulatory standards as long as regulators and automakers desire to have a single set of national standards. In August 2018, President Trump proposed revoking the waivers that establish California's GHG vehicle emission requirement.[21]

Section 115 of the Clean Air Act, unlike the provisions described above, has never been implemented.[22] It is unique in providing the EPA with authority to address international air pollution. Specifically, it authorizes the EPA to instruct a state's governor to revise the state's plan for complying with the Clean Air Act in a way that eliminates pollutants that the EPA has found to endanger public health or welfare in a foreign country, as long as that country has also been found to afford the United States essentially reciprocal rights under its laws.[23] Experts have argued that the EPA could use the authority in Section 115 to regulate GHG emissions, particularly given recent actions of other countries to regulate their GHG emissions.[24]

Another *potential* subject of regulation under the Clean Air Act deserves mention here: GHG emissions—particularly nitrous oxide (N_2O) and methane (CH_4)—from agricultural operations. The EPA regulates N_2O emissions from motor vehicles[25] and has sought to regulate CH_4 emissions from some oil and gas production activity but ignores such emissions from agricultural sources, even though manure from livestock alone accounts for roughly 7.7 percent of total annual US GHG emissions.[26] N_2O's global warming potential is estimated to be 298 times that of CO_2 over the first one hundred years after it is emitted, and CH_4's global warming potential is estimated to be twenty-five times that of CO_2[27] over the same time period.[28]

Incidental Mitigation of GHG Emissions by Non-GHG Pollution Controls Authorized by the Clean Air Act

National Ambient Air Quality Standards (NAAQSs) establish limits for the level of six of the most common pollutants ("criteria pollutants") that exist in outdoor ambient air, and National Emission Standards for Hazardous Air Pollutants (HAPs) govern toxic pollutants that are known to cause cancer or other serious health impacts. Those limits inform requirements for the use of up-to-date pollution control technology by emitters.

EPA regulations addressing criteria pollutants and HAPs deserve brief consideration here because they incidentally reduce GHG emissions, and because the EPA has counted those incidental reductions of GHG emissions among the cobenefits to weigh in favor of promulgating such rules. Two key examples are the Cross-State Air Pollution Rule (CSAPR),[29] which addresses criteria pollutants that are emitted in one state and impair NAAQS compliance in another, and the Mercury Air Toxics Standard (MATS),[30] which tightens restrictions on emissions of mercury and other HAPs from coal- and oil-fired power plants. By ensuring that new or modified coal-fired power plants cannot operate without implementing substantial pollution controls. These regulations have helped to spur GHG emissions reductions indirectly by making coal plants less competitive in a world of low natural gas prices.[31] The EPA's cost-benefit justification for both regulations applied the social cost of carbon dioxide emissions (SC-CO_2) to estimate their climate change–related cobenefits.[32] For CSAPR, climate cobenefits accounted for 1.9 to 3.3 percent of the rule's $700 to $1.2 billion in total monetized benefits;[33] for MATS, it was 0.4 to 0.97 percent of the $37–90 billion total.[34] The GHG-reducing effects of these regulations of criteria pollutants and HAPs are small but not insignificant, and regulators included the benefits of GHG emission reductions in justifying them.

Energy Subsidies

The federal government subsidizes the production of several sources of energy, including renewables, nuclear fission, and fossil fuels. Estimates of the amounts of these subsidies vary widely.[35] The Energy Information Administration estimated that the federal government provided $29.3 billion in energy subsidies in 2013—including direct subsidies, loan guarantees, and tax preferences—and that about 70% of those went to renewables, 11% to natural gas and petroleum liquids, 8% to nuclear, and 5% to coal.[36] By contrast, a separate estimate concluded that annual federal subsidies for fossil fuels alone amounted to $17.2 billion in 2013–14.[37]

Renewable electricity generating facilities benefit from the federal Production Tax Credit (PTC—for wind, geothermal, closed-loop biomass, and other technologies) and Investment Tax Credit (ITC—for solar, fuel cells, small-scale wind, and other technologies).[38] The PTC, which provides facility owners with rebates based on the electricity they produce in their first ten years of operation, will phase out by 2020.[39] The ITC, which provides a rebate based on the amount invested in renewable facilities, will phase down by 2022.[40] The renewables sector, like the oil and gas sector, also benefits from the domestic manufacturing deduction, a tax preference available to an array of US industries.[41]

The 2005 Energy Policy Act established a PTC on the electricity produced during the first eight years of operation by advanced nuclear power facilities. In 2018 Congress extended this tax credit beyond 2020. To date, no nuclear facility has qualified for this tax credit. New and existing nuclear reactors also receive at least two forms of indirect subsidy: a liability insurance backstop, based on the Price-Anderson Act of 1957, as amended in 1975,[42] and support for waste disposal pursuant to the Nuclear Waste Policy Act of 1982, as amended in 1988 and 1992 (NWPA).[43] New reactors built since 2005 receive additional subsidies in the form of loan guarantees.[44] Some estimate that the value of Price-Anderson's indemnification of nuclear generators for accident-related damages above a statutory threshold (currently $500 million per reactor[45]) is zero; others—who take a different view of what qualifies as a subsidy—estimate that it is billions of dollars annually.[46] Estimates of the subsidy conferred by the NWPA are also wide ranging and reach as high as 5 to 18 percent of the market value of nuclear-generated electricity sold annually in the United States.[47] The values of loan guarantees for the construction of new, advanced reactors and reprocessing facilities are more easily calculated: Congress authorized up to $12.5 billion (reduced from an initial $20.5 billion), of which $8.3 billion was actually made available.[48]

Federal laws include several tax preferences available for activities related to the production, refining, and sale of coal, oil, and natural gas.[49] Unlike the PTC and ITC, the provisions of the tax code relevant here are generally permanent. The largest of them are: expensing intangible drilling costs, the domestic manufacturing tax deduction for oil and gas, and percentage depletion for oil and gas wells.[50] One subsidy for coal—the underpricing of leases on public lands relative to market rates for coal—was effectively suspended (for new leases) by the Obama administration when it suspended all new leases for the production of coal on federal land,[51] but this suspension was lifted by the Trump administration.

Finally, legislation in 2018 also expanded a tax credit for carbon capture, utilization, and storage, technologies that could be combined with fossil fuels or biomass to produce low-carbon electricity. The value of this tax credit depends on the type of storage, with CO_2 used for saline storage receiving $50 per tonne of CO_2 while CO_2 utilized in products (including EOR) receiving $35 per tonne of CO_2. The credits last for up to 12 years for projects started within a specified time period.

The "Gas Tax" and Other Federal Excise Taxes on Transportation Fuels

The current federal gas tax of $0.184 per gallon applies to gasoline with an octane rating of at least 75. The diesel tax, set at $0.244 per gallon, is applied similarly.[52] Since its creation in

1932,[53] the gas tax has flipped several times (in 1956, 1990, and 1996) from being, formally, a general-purpose source of federal revenue to today being chiefly a user fee that finances federal highways and their ancillary costs.[54] Recently, however, these taxes have not generated enough revenue to cover the costs of maintaining highway and mass transit systems,[55] and the short-term extensions passed by Congress since 2011 have not made up the gap.[56]

Comparable federal excise taxes are also assessed on other fuels, including those used in aircraft and watercraft: aviation gasoline, for instance, is taxed at a rate of $0.194 per gallon, kerosene at $0.244 per gallon.[57] Some of these taxes, like the gas tax, flow to trust funds such as the Sport Fish and Boating Restoration Trust Fund and the Airport and Airway Trust Fund.[58] No federal tax is assessed on fuels used in international marine shipping, or, since 2007, by railroads.[59]

The Federal Renewable Fuel Standard

The production and sale of biofuels, which derive from corn starch, corn stover (i.e., husks and cobs), sugarcane, or cellulose, have the following potential effects on GHG emissions: they can displace energy-equivalent but higher-emitting fossil fuels, they can cause fuel prices to rise or fall, and they can prompt land use changes that release GHGs from fertilizers or that would have otherwise remained stored in unused soil. An important limitation on these effects is the "E10 blend wall," an engineering-based 10 percent limit on the ethanol that can be substituted for gasoline without damaging many conventional engines,[60] though "flex fuel" engines can handle fuel containing up to 85 percent ethanol,[61] and many newer engines can handle fuel containing up to 15 percent ethanol.[62]

The federal Renewable Fuel Standard (RFS) requires transportation fuel distribution companies to blend specified volumes of renewable fuel into the nation's fuel supply. Parameters for renewable fuel composition, production volume, and lifecycle GHG emissions estimates were first established by the Energy Policy Act of 2005[63] and were then increased by the Energy Independence and Security Act (EISA) of 2007.[64] The EISA's parameters sort renewable fuels into four categories. All of them exclude fuels whose lifecycle GHG emissions are not at least 20 percent lower than those of conventional gasoline.[65] "Advanced biofuels" include those whose GHG lifecycle emissions are at least 50 percent lower than those of gasoline.[66] The EISA also places a fifteen billion-gallon cap, starting in 2015, on the annual volume of conventional renewable fuel (chiefly corn starch-based ethanol). Conventional ethanol arguably meets the 20 percent threshold but not the 50 percent threshold.

The RFS also makes an aspirational call for increased production of advanced biofuels from about 1.5 billion gallons in 2010 to 21 billion in 2022, at which time the statute delegates to EPA the authority to establish volumetric obligations.[67] For 2018, the EPA anticipates the production of 288 million gallons of cellulosic fuel (the EISA calls for 5.5 billion in that year), 95 percent of which will be biogas, and 4.29 billion gallons of all advanced biofuels (the EISA calls for 9.0 billion).[68] The production of cost-competitive sugarcane-based fuels is growing in Brazil, but their cost-effectiveness for US consumers varies with currency fluctuations and changes in trade policy in Brazil and here.[69] Cellulosic fuels do not rely on imports but cannot yet be produced cost-effectively in large quantities;[70] biodiesel has a less restrictive blend wall (20 percent instead of the 10 percent that limits substitutes for nondiesel biofuels), but diesel represents a limited slice of the US fuel market, and biodiesel's high production costs amid low oil prices are an obstacle to greater demand.[71]

While the program has prompted significant growth in the use of conventional ethanol made from corn, it has yet to induce the production of meaningful volumes of advanced biofuels, especially advanced liquid fuels.[72] Since 2010, the EPA has used its statutory authority under the EISA to waive these EISA-prescribed production volumes for cellulosic biofuels, but not for advanced biofuels generally; biodiesel and Brazilian sugarcane-based ethanol have made up the difference.[73]

Energy Efficiency Requirements

Federal energy efficiency (EE) laws have accumulated and been amended on an irregular basis since 1975[74] and now amount to a patchwork of mandates, incentives, and informational requirements, implemented through regulations issued by the Department of Energy (DOE), the EPA, the Federal Trade Commission, state governments, and other entities. Federal law addresses EE in buildings, industrial and commercial equipment, and consumer appliances.

Building codes remain the subject of state authority, and federal statutes do not impose EE performance requirements on new or existing commercial or residential buildings. Instead, federal law provides several forms of encouragement—chiefly technical support, tax credits, and subsidies[75]—to various actors. The Energy Policy Act of 1992 imposes one of the few federal requirements in this area: state governments must certify that they have determined whether EE improvements would result from adoption of the current American Society of Heating Refrigerating, and Air-Conditioning Engineers (ASHRAE) code for new commercial buildings and of the Council of American Building Officials' Model Energy Code for new residential buildings.[76] If EE improvements would result, then state governments must adopt the updated version.[77] Most states comply with this requirement, albeit at different paces, but some states do not.[78] The American Recovery and Reinvestment Act of 2009 conditioned receipt of State Energy Program (SEP) stimulus funds on each governor's assurance that his or her state would pursue a bevy of measures to improve EE, including implementation of the most up-to-date energy code for residential and commercial buildings.[79] All fifty governors provided such assurance and accepted receipt of SEP funds.

The key component of federal law relevant to EE in appliances and equipment is the Energy Policy and Conservation Act (EPCA) of 1975,[80] which was revised significantly in 1987[81] and amended by the EISA in 2007.[82] It instructs the DOE to adopt standardized assessments of energy use, water use, and energy efficiency for "covered products"[83] and also authorizes the DOE to set performance standards for those products' energy use based on the "maximum energy efficiency which is technologically feasible and economically justified."[84] DOE currently has testing procedures and standards in place for over sixty different products, ranging from clothes washers and dryers to televisions and ceiling fans to electric motors, which represent about 90 percent of home energy use, 60 percent of commercial building use, and 30 percent of industrial energy use.[85] The EPCA also instructs the Federal Trade Commission to issue a rule requiring disclosure via label of "the range of estimated annual operating costs or other useful measure of energy consumption" for those products.[86] The EPCA applies these requirements to both consumer products and appliances as well as commercial and industrial equipment.[87] The Energy Star program builds upon the EPCA's testing and reporting requirements and encourages the purchase of energy efficient products and homes through voluntary certification and labeling.[88]

Research and Development Funding

Economists often warn of underinvestment in private sector research and development (R&D)[89]—and clean energy technologies are no exception—because private sector entities do not recoup the full benefits associated with their R & D spending—some, like innovation and learning, accrue to society.[90] The federal government therefore supports R&D for nearly every type of energy source used in the United States, as well as for technologies that could change how energy is transmitted or that could capture CO_2 emissions for sequestration or utilization.

In fiscal year 2016, Congress appropriated $5.9 billion for R&D funded through the DOE.[91] Of that, $4.1 billion went to applied research: $2.1 billion to renewables and EE, $900 million to advanced nuclear, $600 million to fossil energy R&D (a category that includes both the development of methane hydrate for energy use and carbon capture, storage, and utilization (CCS/U)), and $200 million to electricity delivery and energy reliability.[92]

Agriculture

Agriculture, narrowly defined, accounts for 9–10 percent of gross national GHG emissions,[93] and the nation's lands absorb roughly the same amount of carbon dioxide each year (negative emissions).

Two types of federal interventions that address GHG emissions from agricultural sources do so indirectly. The first is a set of federal regulations and technical assistance programs. The US GHG Reporting Program does not generally require agricultural sources of GHGs to submit complete GHG inventories; only emissions from manure management at large agricultural facilities must be reported to the EPA.[94] Federal regulations also do not restrict GHGs emitted by agricultural fields, pastures, livestock, facilities, or operations—including concentrated animal feeding operations.[95] The main federal means of addressing agricultural sources of GHGs are programs that provide technical assistance and modest financial support for ecosystem and resources conservation and for particular farming practices with lower environmental impacts.[96] The US Department of Agriculture's Building Blocks for Climate Smart Agriculture and Forestry, announced in 2015, is a characteristic set of approaches: they are voluntary, not mutually contingent or coordinated, and modestly funded.[97] One of those building blocks, Livestock Partnerships, dovetails with another voluntary program: EPA's AgStar, which encourages farms to install anaerobic digesters to capture and extract GHGs (chiefly methane) from waste products, including manure.[98]

A second major federal intervention comprises subsidies for agricultural products, which affect GHG emissions indirectly. Farm subsidies often encourage emissions-intensive modes and patterns of food production and consumption.[99] Changes to agricultural practices could reduce those emissions substantially.[100] Farm subsidies do serve other policy goals, such as support for US farmers, ranchers, and other workers in the sector. In addition, the diverse range of agricultural sources might make them difficult to regulate. Still, several recent studies have, for example, explored the possibility of taxing beef to account for the methane emissions produced by livestock and the other GHG emissions related to the remainder of the supply chain. The Food and Agriculture Organization of the United Nations estimates that these represent almost two-thirds of agriculture-related anthropogenic GHG emissions, which themselves represent over 10 percent of all anthropogenic GHG emissions.[101] Of course, regulating agricultural emissions would present major political challenges.

State Laws

An exhaustive list of state and local laws and policies that would interact with a carbon tax is beyond the scope of this paper. However, this section addresses certain key state policies. Before describing those policies, it briefly summarizes the legal limits imposed on those state policies by the Constitution's dormant Commerce Clause (dCC) and Supremacy Clause.[102]

The dCC, a corollary to the Commerce Clause inferred by courts, prohibits states from (a) discriminating against commerce because it originates in another state, (b) regulating commercial activity in other states, or (c) imposing an "undue burden" on interstate commerce.[103] This is not a blanket prohibition on all state laws affecting interstate activities or activities in other states, however. Courts strictly scrutinize regulations that expressly advantage intrastate products or services vis-à-vis extrastate competitors or that regulate activities wholly outside a state's borders. Otherwise the courts apply a balancing test to challenged laws and regulations.[104]

The Supremacy Clause—"[t]his Constitution, and the Laws of the United States which shall be made in Pursuance thereof…shall be the supreme Law of the Land"—gives federal statutes preemptive authority over state law in several circumstances. Those are often referred to, in shorthand, as express preemption, field preemption, and conflict preemption. Congress can expressly vest a federal law with preemptive authority.[105] (Importantly, if a federal law pertains to an area traditionally regulated at the state level, then courts will presume that the federal law does not supersede the state law unless Congress has expressly said it does.[106]) Courts can also infer congressional intent to preempt a whole regulatory field on one of two bases: if Congress has legislated so comprehensively that no room is left for states to do more, or if "the federal interest is so dominant" that "the federal system" is assumed to preclude enforcement of state law in the same field.[107] Finally, even where Congress has not expressly preempted state law nor manifestly intended to occupy the whole relevant regulatory field, courts can still find that state law is preempted. If the state law "stands as an obstacle to the accomplishment and execution of [Congress's] full purposes and objectives,"[108] then courts can conclude that it conflicts impermissibly with federal law and must be preempted.[109]

A number of lawsuits have asked courts to determine the validity of the state-level policies described below under the dCC and/or federal statutes with potentially preemptive effects, like the Federal Power Act and Clean Air Act. By and large, courts have upheld these policies.[110]

Carbon pricing. California and the nine Regional Greenhouse Gas Initiative (RGGI) states have assigned prices to GHG emissions using cap and trade schemes.[111] Oregon explored a similar scheme in 2016 and will again in 2019;[112] voters in Washington State voted to reject carbon tax initiatives in 2016 and 2018;[113] and New York State and the New York Independent System Operator (NYISO) are developing a carbon charge on the wholesale sale of power.[114] Since 2015, California's cap and trade scheme has covered sources in California's electricity, industrial, transportation, and natural gas sectors, which altogether emit roughly 85 percent of the state's annual total GHG emissions.[115]

RGGI covers the 165 facilities located within RGGI-state borders that can generate at least 25 megawatts (MW) of electricity. In 2016, RGGI's cap on those facilities' emissions was about 1.1 percent of total U.S. emissions.[116] The cap, which is currently slated to decline by 2.5 percent annually until 2020, and which RGGI members have committed to reduce by a further 30 percent by 2030,[117] does not apply to other emissions, even from facilities with a capacity of 25 MW or greater located in non-RGGI states that export electricity to RGGI states. Most of the proceeds from RGGI auctions support investments in renewable energy facilities, EE, and other climate change mitigation efforts in RGGI states.[118] Notably, because RGGI does not account for the "leakage" of emissions from beyond its member-states' borders as a result of activity within their borders, it effectively allows members to meet their emission targets by importing electricity from areas outside the RGGI cap and thus "exporting" emissions. California's program does a better (though still imperfect) job of accounting for emissions associated with generation from both in-state and out-of-state sources and seeks also to avert the flight of industries or activity from in-state to avoid the emissions cap.[119]

Carbon-intensity restrictions. State laws also seek to restrict the carbon intensity of the electricity and transportation sectors by requiring the purchase of electricity or liquid fuels that meet particular standards. The most prevalent form for such restrictions is a renewable portfolio standard (RPS), variants of which have been adopted in 29 states and the District of Columbia.[120] Generally—though no two RPSs are exactly alike—retail utilities subject to an RPS must purchase some percentage of the electricity they sell from renewable sources. States have set widely varying target percentages and dates: Hawaii mandates 100 percent renewable power by 2045, Vermont 75 percent by 2032, and Pennsylvania 15 percent by 2020.[121] In most RPS states, utilities may meet that percentage requirement by purchasing either renewable energy or Renewable Energy Credits (RECs) from renewable generators. The FERC has disclaimed jurisdiction over REC markets, leaving their design and operation to states, so long as states do not bundle them with sales of wholesale capacity, energy, or ancillary services.[122] In sum, RPSs are thus an indirect, state-devised subsidy for renewable generators.

Clean energy standards are similar to RPSs but generally encompass technologies like nuclear or large-scale hydropower.[123] New York's Clean Energy Standard provides nuclear power plants with Zero Emissions Credits (ZECs), defines the parameters for a ZEC's price, and requires retail utilities to regularly purchase ZECs.[124] (Illinois has a similar program.)[125] New York's program establishes no formal prohibition on participation by nuclear resources in other states (to avoid dCC limits), nor does it directly tether the value of ZECs to wholesale electricity prices (to avoid preemption by the Federal Power Act).[126] Instead, the New York Public Service Commission (NYPSC) defines eligibility broadly and establishes ZECs' value based on the SC-CO_2 (adjusted by the price of RGGI allowances) and a collar that is based on a blend of wholesale energy and capacity prices.[127] The Federal Court of Appeals for the Second Circuit recently affirmed the program's legality, finding that it was not preempted and that the parties challenging it lacked standing to bring a claim under the dCC.[128] (The Seventh Circuit recently affirmed a similar trial court decision upholding the Illinois ZEC program.[129])

EE resource standards (EERSs) and utility rate decoupling. Like RPSs, EERSs require utilities to substitute a lower-emitting alternative for some portion of electricity generation. Unlike RPSs, which require utilities to make or buy power using particular resources, EERSs require utilities to sponsor and otherwise encourage their customers to consume less of the electricity or natural gas that the utility sells.[130]

Legislation that directs public service commissions to decouple utility rates from volumes of energy sold aims to eliminate utilities' incentive to simply build more capacity and sell more energy.[131] In decoupled states, utilities receive compensation based on a set of performance measures[132] and thus have less reason to discourage or prevent their customers from investing in EE and conservation efforts—indeed, in some states, support for such investments is among the performance measures that determine utilities' compensation.[133]

Property-Assessed Clean Energy (PACE) programs. PACE programs support EE investments on private property by addressing several impediments: a lack of information about contractors and the performance of EE investments, uncertainty about rates of repayment from prospective energy savings, and a lack of low-cost financing to pay for EE-boosting retrofits.[134] PACE programs finance the cost of eligible energy-related investments to a property and pay them back over time through an assessment that attaches to the property, not the property owner. Lawsuits over how PACE funding affected federally backed mortgage loans interrupted nationwide adoption of PACE programs,[135] but such programs—for residential and commercial properties—persist widely.[136]

Fossil fuel extraction regulations and severance taxes. While states regulate aspects of the process of fossil fuel extraction and set severance tax rates to be charged for such extraction, their diversity in this regard has recently been illustrated by their varied approaches to the regulation of unconventional hydrofracture drilling ("fracking"), ranging from outright bans to the wholesale adoption of regulatory provisions drafted by the industry.[137] States' approaches to regulating coal mining must be consistent with provisions of the federal Surface Mining Control and Reclamation Act of 1977—and that act gives states "primacy" over implementation.[138] In addition to regulating drilling and mining for fossil fuels, state law also sets the rate at which such extractions are taxed. These rates vary; states adjust them actively and often rely on them for revenue.[139]

California's Preemption Waiver under the Clean Air Act. The Clean Air Act preempts state-level regulation of vehicular emissions to ensure that the national marketplace for automotive vehicles is not balkanized by diverse requirements.[140] But the act also instructs the EPA to grant California, which had emission standards in place that predated the Clean Air Act, a waiver of that preemption for more ambitious vehicular emissions standards that meet particular statutory criteria[141] and permits other states to adopt California's standards once that waiver has been granted.[142] Historically, California thus has not just set standards for itself, but it has helped other states with ambitious air quality goals to do so and has also presaged future CAFE standards. Under the Obama administration, California regulators were directly involved in developing national CAFE and GHG emission standards (which largely copied

California's standards at the time) to ensure that federal and state standards were a consistent part of a single national program so that automakers could manufacture a single national fleet.[143] A key issue arising from the Trump administration's effort to freeze the stringency of CAFE requirements nationwide at the model year 2020 level through 2026 is whether the EPA may revoke the waiver authorizing California to carry out its advanced clean car program, zero emissions vehicle mandate, and greenhouse gas standards.[144]

A FRAMEWORK FOR ASSESSING POLICY INTERACTIONS

Policy makers implementing a federal carbon tax should strive to develop a portfolio of public policies that reliably and effectively reduces greenhouse gas emissions while avoiding unnecessary regulatory costs and duplication. Doing so requires an understanding of how a federal carbon tax will interact with other energy, environmental, and climate policies.

This section provides a framework for policy makers to consider these interactions between existing policies and authorities and a federal carbon tax. It introduces a spectrum of policies ranging from "complementary" to "redundant" and describes the major factors that cause a policy to fit into one category or the other—or, often, somewhere in between.

Defining Complementary and Redundant Policies

We define a policy as "complementary" with a federal carbon tax if it satisfies either of the following two criteria:

Criterion 1: Cost-Effectiveness. A policy is complementary if, alongside a carbon tax, it enables more cost-effective reductions of carbon dioxide emissions than a carbon tax could achieve on its own—that is, it lowers the costs to society of achieving a long-run emissions target or enables larger emissions reductions without raising societal costs. Whereas a carbon price addresses one market failure that inhibits emissions reductions (i.e., leaving climate-damaging externalities costless), policies that satisfy this criterion generally address other market failures. For instance, a policy that subsidizes research and development focused on emissions-reducing technologies shares the ultimate objective of a carbon price but addresses a different market failure—namely, chronic private sector underinvestment in basic research on new technologies.

Criterion 2: Separate Objective. A policy is complementary if it reduces greenhouse gas emissions and achieves a separate policy objective (e.g., reducing local air pollution) more cost-effectively than a federal carbon tax would on its own.

At the other end of the spectrum, we define a policy as "redundant" with a federal carbon tax if it leads to additional costs to society without achieving additional emissions reductions.

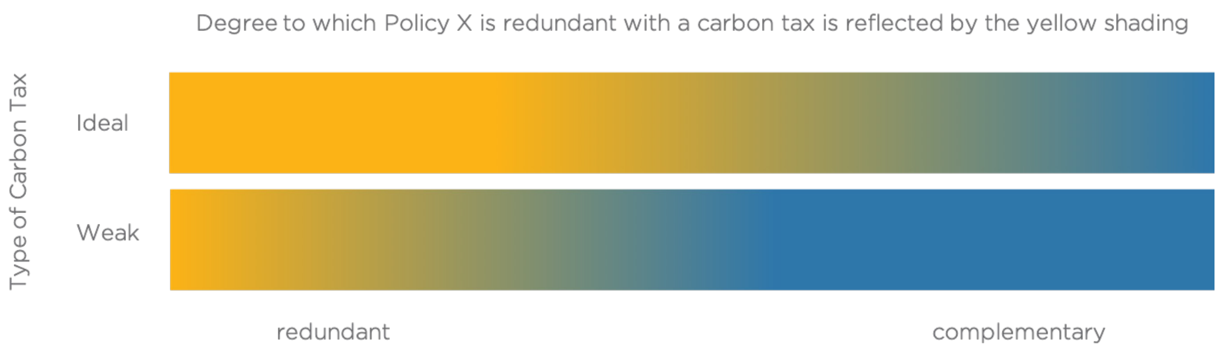
The Spectrum between Complementary and Redundant

Most real-world policies do not fall cleanly into either category. Instead, they exist on a spectrum in between the two categories.

Layering a policy on top of a federal carbon tax will often achieve additional emissions reductions (so it is not purely redundant), but it will not reduce the costs to society of achieving a given emissions outcome compared to using a carbon tax alone (so it is not purely complementary). The larger the incremental emissions reductions and the smaller the incremental costs, the more complementary the policy is to a federal carbon tax.

Identifying policy objectives is another complication, particularly because these objectives can evolve over time. Moreover, a policy that reduces greenhouse gas emissions may have multiple potential additional objectives. For example, a fuel excise tax may be less cost-effective at raising revenue compared to a federal carbon tax, but it may effectively address other driving-related externalities.

Figure 1: Policy Categorizations Depend on the Stringency of the Carbon Tax



The Importance of the Stringency of the Carbon Tax

The framework described above assumes that a federal carbon tax is designed to achieve the desired emissions or climate objective: for example, the carbon tax rates are set such that United States' emissions are likely to fall below target X by year Y.

However, if the federal carbon tax policy is not sufficiently stringent to achieve the desired objective (e.g., carbon tax rates are set too low due to political constraints), the spectrum of complementary and redundant policies "shifts," as shown illustratively in figure 1. A carbon tax that is "too weak" means that policy makers must either accept higher emissions levels or implement other policies to pick up the shortfall in achieving the desired emissions reductions, even if these emissions reductions come at a higher cost compared to a more stringent carbon tax. To the extent that policy makers chose the latter approach, a given policy is typically more complementary with a carbon tax policy with lower tax rates (or "weaker" carbon tax policies, more broadly).

Interpreting a Policy's Position on the Spectrum

This paper is designed to be useful to policy makers considering what policies to add, subtract, or change when implementing a federal carbon tax. As a general matter, complementary policies are better candidates to add alongside a federal carbon tax, and redundant policies are better candidates to eliminate upon the implementation of a federal carbon tax.

However, the typology described in this paper is not intended to be a specific road map for policy negotiations. First, policy makers may not wish to eliminate certain redundant policies if they are valuable "backstops" to ensure emissions reduction efforts proceed even if a change of political winds compromised the carbon tax after its passage. Second, policy makers may not wish to add certain complementary policies alongside a federal carbon tax if doing so has undesirable consequences apart from enabling more cost-effective emissions reductions. Third, the political challenges associating with adding, subtracting, or changing other policies may be high and therefore not worth jeopardizing the passage of federal carbon tax legislation over.

CATEGORIZING EXISTING POLICIES

This section examines the policies and regulations described in the second section and categorizes them based on the typology described in the third section. As discussed above, the typology is treated as a spectrum rather than a discrete set of choices, and circumstances that could change the categorization are noted where relevant.

The task of categorizing policies based on typology is subjective and difficult for several reasons. First, as noted above, it is often difficult to identify a policy's purpose. Many policies have multiple, even conflicting, purposes, and those purposes may have evolved over time, sometimes for more or less obvious reasons. This paper seeks to identify the policy's purpose(s) as could reasonably be argued by policy makers today and used as justification to maintain or adjust an existing policy. Second, it can be difficult to determine the cost-effectiveness of a policy's reduction of GHG emissions alongside a carbon tax, especially when the policy is intended to address multiple market failures related to climate change or other policy goals.

We find value in this exercise, despite its imprecision. When policy makers engage in serious discussions about a carbon tax, they will inevitably confront the challenge of determining how to evaluate existing and new policies alongside the carbon tax. In doing so, they will have to consider these same issues, confront these very questions, and be burdened by the same difficulties that we are addressing in this paper.

The purpose is to suggest a standard framework by which policy makers can consider how to treat existing and new policies and demonstrate how one might apply that standard to the existing policy framework. Given the inherent subjectivity of this exercise, we expect that readers may occasionally have different perspectives and welcome attempts to refine and improve upon the suggested framework and the manner in which it is applied.

Table 1 below provides an overview of the characterizations of new and existing policies. In the online version of this paper, summaries of the rationale for characterizations are provided in the table as well.

Figure 2: The compatibility of a federal carbon tax and other policies that reduce emissions

<< Complementary				Redundant >>
Regulations of GHG emissions not covered by the carbon tax	Fuel economy standards	Subsidies for low-carbon technologies	State carbon pricing policies	Regulations of GHG emissions covered by the carbon tax
Regulations of local air pollutants		Renewable or low carbon fuel standards	Fuel excise taxes	
Removing fossil fuel subsidies			Renewable or clean electricity standards	
Energy efficiency standards and programs				
Funding innovation in low carbon technologies				
Public infrastructure supporting low carbon transportation and land use				

Clean Air Act Regulations of Greenhouse Gas Emissions

Before categorizing the various individual GHG regulations under the Clean Air Act, a preliminary question is whether negotiators could segment these regulations or would need to take or leave them as an indivisible whole. Under current law, segmentation is not allowed: nothing in the statute authorizes the EPA to ignore pollutants if the act addresses their source—a point that the EPA has been loath to acknowledge in relation to emissions from aircraft and CAFOs.[145] But because a carbon tax would be adopted through legislation, such legislation could also amend the Clean Air Act to allow the EPA to implement regulations of some but not all sources subject to the Clean Air Act. Thus, the answer to the preliminary question is yes, the authorities could be segmented, even if current law does not allow for segmentation.

The potential segments considered here are: (1) Section 111(b) (new sources); (2) Section 111(d) (existing sources); (3) Section 115 (international air pollution); (4) the PSD program (new major sources or major modifications of existing sources in attainment areas); (5) Section 202 (road-based mobile sources), which undergird the CAFE and GHG emission reduction standards promulgated jointly by NHTSA and EPA; and (6) Section 231 (aircraft).

Clean Air Act Regulations to Reduce Carbon Dioxide Emissions: Mostly Redundant

The New Source Performance Standards (NSPSs) called for in Section 111(b) of the Clean Air Act prescribe technologies that new construction (or modification) of a given source type must incorporate into its design.[146] Similarly, EPA's application of the Prevention of Significant Deterioration (PSD) program requires certain facilities to implement a "best available control technology" to reduce greenhouse gas emissions. Section 111(d) is similar to Section 111(b), except that it applies to existing rather than new or modified sources.

Individually regulating the carbon emissions of facilities that are subject to a carbon tax is a textbook example of a redundant policy. These programs are designed explicitly to reduce carbon emissions, but if they inflexibly force regulated sectors or entities to achieve specific goals or take specific actions, they undermine the intent of enacting a carbon tax to reduce emissions cost-effectively.

This prescriptive approach also risks "picking" the wrong technology—EPA's acceptance in the 1970s of tall smoke stacks as a means of pollution control is one example of this sort of error.[147] Indeed, if Congress had passed one of the many federal carbon-pricing programs considered in the late 2000s, it is highly unlikely that the Obama administration would have pursued the regulation of CO_2 under Section 111 of the Clean Air Act.

To the extent that these regulations were intended to promote the deployment of certain emerging low carbon technologies that might otherwise struggle to get over the financial "valley of death" between technological development and commercial viability, they could complement a carbon tax. For example, regulators may decide that a technology like carbon capture, utilization, and storage (CCUS) is important for long-term decarbonization but unlikely to be sufficiently incentivized by a carbon tax in the near term; an NSPS requiring CCUS at certain facilities without other low-cost and low-carbon alternatives could be a deployment policy that complements a carbon tax. There are, however, other policies that policy makers could use to support the development of potentially transformative technology, including but not limited to direct government assistance, loan guarantees, or tax credits.

Section 115, International Air Pollution: Mostly Redundant

Clean Air Act Section 115's interaction with a carbon tax is difficult to characterize because the language of the statute is broad, and no regulation has been drafted to implement it. Various experts have noted that a Section 115 program applied to carbon emissions could be drawn up in a way that closely resembles an economy-wide carbon price, perhaps in the form of a cap and trade program.[148] Because such regulations would be intended to reduce carbon emissions but would not increase the cost-effectiveness of achieving emissions reductions alongside a carbon tax, they are categorized as mostly redundant policies. However, it should be noted that this section of the Clean Air Act could also be used to regulate pollutants other than carbon dioxide, including other GHGs.

Section 202, Vehicle Emissions Standards and CAFE: Partly Complementary, Partly Redundant

The transportation sector is responsible for about 28.5 percent of US GHG emissions.[149] Achieving long-term national emission targets will require not only improvements in vehicle efficiency but also the large-scale deployment of one or more alternatives to the petroleum-fueled internal combustion engine, such as electric and hydrogen fueled vehicles.[150] Adoption of these technologies will require changes by drivers and vehicle manufacturers. Vehicle manufacturers are unlikely to make the needed risky investments in new technologies unless they are pushed to do so by policies and regulations, along with their competitors, to ensure that there is both a market for the technology and that they will not place themselves at competitive disadvantages.[151]

Since they were established in 1975, the CAFE standards have proven to be effective tools for increasing efficiency and spurring technological advancements. Indeed, the standards have significantly increased the efficiency of US-made vehicle fleets[152] and—indirectly—the Asian-made fleets that have long been marketed to US consumers.[153] They have also induced the adoption of new technologies a rate faster than the "natural" rate at which the automotive sector would otherwise have incorporated new fuel- and energy-efficiency improvements.[154] In fact, manufacturers receive special credits for the sale of alternative fuel vehicles—an approach that sacrifices average emissions intensity and average fuel economy in favor of technology adoption.[155] Whether this is an efficient means of encouraging alternatives to the traditional internal combustion engine remains an open empirical question.[156]

Categorizing the vehicle emission and fuel economy standards requires careful attention to the programs because there are two separate federal standards, administered by two different agencies, under different statutory authorities, established decades apart in response to different challenges. Yet because they each seek to achieve their goals by increasing vehicle efficiency, and because the EPA and NHTSA have worked to align the stringency of the EPA's GHG-reduction and the NHTSA's fuel-economy standards, they may appear to be one set of standards, though they are not, as each program establishes separate and distinct, legally enforceable targets.[157]

The CAFE standards, born in an era when dependence on foreign oil was viewed as a threat to our economic and national security, are intended primarily to reduce fuel consumption.[158] The statute has been modified over time to encourage the development of alternative fuel vehicles, both to reduce fuel consumption and to reduce carbon emissions.[159] If the purpose of CAFE standards is to increase fuel efficiency and reduce fuel consumption, primarily to enhance our national and economic security, they may complement a carbon tax because they address a different policy objective and are more efficient than a carbon tax at achieving that objective.

The EPA regulates vehicle carbon emissions pursuant to the requirements of the Clean Air Act, as interpreted in *Massachusetts v. EPA*. In contrast to the NHTSA's fuel efficiency standards, the EPA's standards were established in 2012, in an era of growing concern about climate change, specifically to reduce carbon emissions.[160] In doing so, it also intended that its regulations "encourage early adoption and introduction into the marketplace of advanced technologies to dramatically improve vehicle performance."[161] In fact, both the fuel economy and carbon emission reduction standards currently incorporate additional incentives to encourage the adoption of new technologies.[162] To the extent that these standards are intended as the primary tool for regulating vehicle carbon emissions and thus overcoming the externalities associated with these emissions, they are redundant with a carbon tax, which is a more efficient approach to internalizing the external costs of vehicle emissions.[163] However, by overcoming behavioral (i.e., nonprice) barriers to increased fuel economy and by spurring new technologies, these standards can increase the cost-effectiveness of achieving a given emissions target alongside a carbon tax.

Modifications of the CAFE standards may be appropriate if a carbon tax is implemented. Any modification of the standards should take into account the different enforcement authorities currently available to the NHTSA and EPA for their respective standards. Whereas the NHTSA is authorized only to impose modest fines for noncompliance, the EPA is authorized to rescind authorization to sell motor vehicles for noncompliance with carbon emissions requirements.[164] Negotiators would have to decide whether mothballing or eliminating the carbon emissions portion of the current program would also mean abandoning the EPA's stronger degree of enforcement authority or transferring that authority to the NHTSA.

There are policies other than CAFE that policy makers could use to promote fuel efficiency and to reduce oil consumption. The carbon tax could be supplemented by additional excise taxes to account for some of the other costs attributable to driving. And to the extent that transformative emission-reducing technology lacks funding to proceed through the research and development process to deployment, other tools may be useful, including but not limited to direct government assistance, loan guarantees, or tax credits.

Finally, EISA extended the NHTSA's authority to regulate fuel economy to medium- and heavy-duty vehicles, and the EPA's authority to regulate their emissions was confirmed in *Massachusetts V. EPA*. These regulations of medium- and heavy-duty vehicles were established in 2015.[165] Generally speaking, though medium- and heavy-duty vehicles are regulated separately from light-duty vehicles, the issues regarding that program are similar to the issues regarding light-duty vehicles.

Non–Carbon Dioxide Clean Air Act Regulations: Complementary

Clean Air Act regulations are primarily directed at emissions of air pollutants other than carbon, including particulate matter, sulfur dioxide, mercury, and many others. As noted above, these air pollution regulations have led to reductions in carbon dioxide emissions, for example, by reducing the amount of electricity generated by coal-fired power plants. As a general matter, these regulations are complementary with a carbon tax because they achieve their goal of reducing non-carbon emissions more cost-effectively than would a federal carbon tax.

The Clean Air Act is also used to regulate GHGs other than carbon dioxide, such as the regulations of methane emissions from oil and gas production facilities under Section 111. Assuming these emissions are not covered by a carbon tax, separately regulating these sources may complement a carbon tax by achieving additional GHG reductions and thus lowering the carbon tax required to achieve a given GHG emissions target.

One caveat relates to the cost-benefit analyses that federal government agencies have conducted over the past decade as part of the regulatory process of developing these non-carbon dioxide regulations. While no air pollution regulations are set directly based on the results of a cost-benefit analysis, it is conceivable that the indirect benefits of emission reductions have influenced these standards to some extent. With a carbon tax in place to address the adverse effects of emissions, that could reduce or eliminate the cobenefits of emission reductions ascribed by regulatory impact analysis to noncarbon air pollution regulations.

Tax Preferences and Subsidies for Energy

This subpart considers interactions with federal financial support for the three types of energy noted above: fossil fuels, renewables, and nuclear power.

Eliminating Subsidies for Fossil Fuel Production: Complementary

There is a direct conflict between a new carbon tax and an existing set of tax preferences that are intended to promote the production of fossil fuel, in that the government would be both subsidizing the production of commodities to encourage their production, the combustion of which was taxed to reduce their use. Continued existence of tax credits intended to lower the cost of fossil fuel production undermines a carbon tax, and eliminating them complements a carbon tax.

In 2018, the Congressional Joint Committee on Taxation identified eighteen distinct tax expenditures that apply to the production of fossil fuels.[166] This compilation of tax credits largely mirrors the list of thirteen federal tax provisions the federal government reported to the G20 in 2015 as subsidizing fossil fuel production.[167] Some of the largest tax credits that support oil and gas production are a century old. In the 1910s, as the use of automobiles spread and the demand for motor fuel began to grow, Congress and the Treasury established two tax preferences to assist oil and gas producers. In 1917, the treasury issued a ruling that allowed for the expensing of a wide range of intangible drilling costs (IDCs) related to the production of oil and gas.[168] This allowed for immediate deductions of costs that would otherwise be amortized and deducted from income over time.[169] This provision survives, and under current law, independent producers can deduct all of their IDCs, and major producers can deduct 70 percent and amortize remaining costs over five years.[170] In 1926, Congress created a deduction for percentage depletion, simplifying the initial depletion deduction that was first created in 1913.[171] This provision allows for the deduction from income of a percentage of gross receipts instead of a deduction that reflected the costs incurred to extract the resources.[172] Therefore, by design, depletion was not limited to the cost of the capital investment and did not require the value of depletion deductions to reduce the basis of the asset, effectively allowing a double deduction for some costs.[173] These tax provisions, amended versions of which remain in the tax code today,[174] were created at a different time in history, when, unlike today, the nation needed greater oil production to support economic growth. They also cost the government over $2 billion annually.[175]

Proponents of these and other subsidies for the production of fossil fuels often point to the ongoing economic and energy security benefits of increased domestic fossil fuel production, which are important considerations. For example, Secretary Perry proposed in 2017 a rule for consideration by the independent Federal Energy Regulatory Commission (FERC) that would allow for the full recovery of costs of fuel-secure generators, essentially mandating payments to selected coal and nuclear plants that would otherwise be uneconomic, in order to keep them operating when they otherwise might close in order to enhance grid resiliency,[176] a viewpoint that the FERC rejected after concluding that there was no evidence that grid resilience or reliability was undermined as the result of the potential loss of any particular fossil-fueled generators.[177] Moreover, the elimination of some subsidies for the production of coal, in particular, might exacerbate the challenges of coal-producing communities in the face of declining coal production. Given the contradictory nature of existing fossil fuel subsidies and a new carbon tax, policy makers ought to examine all of the costs and benefits of fossil fuel production and use and decide whether they want to promote fossil fuel extraction by subsidizing it or reduce it by taxing it. A policy to eliminate current subsidies would complement the establishment of a new carbon tax, and a discussion about the future of these subsidies would be a logical part of negotiations over carbon tax legislation.

To place the effect of eliminating the tax expenditures into context, one recent study of how the elimination of the three largest tax preferences for oil and gas production would affect oil and gas drilling activity, production, prices, and consumption found that repeal would have material effects on drilling but only modest effects on production, prices, and consumption.[178] As for GHG emissions impacts, the study estimated that repeal would likely yield less than a 1 percent reduction.[179] Moreover, their elimination would generate roughly $4 billion in tax revenue annually.[180] Another relevant consequence of eliminating fossil fuel subsidies after the election of a new president could be the opportunity to demonstrate the United States' leadership role vis-à-vis other G20 governments that have lately balked at making the fossil fuel subsidy reductions they committed to in 2009.[181]

The PTC and ITC for Maturing Clean Technologies: Once Complementary but Increasingly Redundant

Tax credits for wind and solar energy installations, both maturing technologies, and a carbon tax both encourage a shift from fossil fuels to lower carbon electricity generation. When Congress first adopted the PTC as part of the Energy Policy Act of 1992, it would arguably have suited this article's "complementary" category well: integrating intermittent renewable resources then presented significant technical and economic challenges that required ongoing support for research, development, and deployment[182] given the high barriers to entry and the regulatory thickets of the electricity sector—home of powerful incumbents and conservative.[183] Tax credits did not just close a gap between the price charged by carbon-emitting generation and renewables but also supported ongoing research to lower the cost of wind and solar generation, bolstered renewable generators as they supplied power, worked to undo the technical and institutional knots that limited grid integration, and developed viable business models through trial and error.[184] In that sense, they were policies to promote the innovation of nascent technologies by lowering the cost of deploying these technologies to help reduce power plant emissions.

Today, even if renewables are not yet fully competitive with traditional electricity generation in all places and at all times, and they still face ongoing challenges like the risk of a trade war with China[185] and uncertainty over how the FERC will treat clean energy resources in the evolving design of regional electricity markets,[186] they certainly are no longer fledgling technologies.[187] Nor are wind and solar energy technologies still explorers of an unmapped frontier.[188] In 2017, wind and utility scale solar represented 6.3 and 1.3 percent of total net power generation in the United States,[189] and wind and solar power are expected to represent 64 percent of all new generation capacity installed in the United States in 2019.[190] This progress arguably justified the steady reduction and eventual elimination of some of the tax credits that were passed by Congress in 2015, with most of the subsidies phasing out in the early 2020s.[191]

Accordingly, to the extent that they to remain in force, those tax credits would increasingly serve the same purpose as a carbon tax would—crediting renewables for generating power without emitting GHGs—only far less efficiently: the National Academies of Sciences calculated in 2013 that roughly $250 in tax revenue is lost for each ton of carbon reduced via the facilities incentivized by the PTC or ITC.[192]

As wind and solar technologies continue to rapidly progress, subsidies for their deployment become increasingly redundant with a carbon tax and therefore are better candidates for removal (as already current scheduled) with the implementation of a carbon tax.

The PTC and ITC for Nascent Carbon-free Technologies: Mostly Complementary

Tax credits have also been available in recent years for carbon-free technologies aside from solar and wide energy. Production tax credits have been available for power produced from advanced nuclear energy, open- or closed-loop biomass, geothermal, small irrigation, municipal solid waste, and marine and hydrokinetic energy.[193] Investment tax credits have been available to subsidize investments in solar energy for illumination using fiber optic distributed sunlight, small wind generators, combined heat and power systems, certain microturbines, fuel cells to generate power, or geothermal power or heat systems.[194] In 2018, Congress expanded a tax credit for CCUS technologies.

As with the tax credits that support the generation of conventional wind and solar power, the credits that support these technologies were established to support nascent, promising technologies that faced technical and economic challenges and regulatory barriers. Yet while the production of wind and solar power have matured, these other renewable technologies eligible for the credits remain largely expensive and uncompetitive, and they do not meaningfully contribute to the current power generation portfolio.[195] To the extent that these and other new and emerging technologies hold out the promise of reducing carbon emissions, but need support for continued innovation, these tax credits are one means of providing that support. Accordingly, while subsidies for wind and solar power are better candidates for removal over time, the continuation or extension of tax subsidies for other renewable technologies remains mostly complementary to a carbon tax, at least for the intermediate future.

Fuel Excise Taxes: Mostly Redundant

The existing federal excise taxes on gasoline, diesel, and other motor fuels primarily perform a revenue raising or user fee function—though political unwillingness to raise these tax rates over recent decades means that fuel excise tax revenues are now insufficient to fund the upkeep of the US transportation system.[196] If the fuel excise tax rate was increased so that it internalized the cost of carbon emissions from the combustion of gasoline and diesel fuel, it would arguably function as a corrective to the externality of climate change and therefore would be mostly redundant with a carbon tax. After all, the carbon tax would generate revenues that could be used to fund transportation infrastructure as well. Indeed, the carbon tax introduced in the House of Representatives by Representative Curbelo (R-FL) in 2018 proposed eliminating the fuel excise taxes and funding the federal Highway Trust Fund with the carbon tax.[197]

However, in addition to GHG emissions, the use of vehicles causes local air pollution, congestion, and other negative consequences that are not typically accounted for in the price of fuels or the cost of driving. To the extent that fuel excise taxes are established at levels that reflect the costs of these other negative consequences, in addition to the effects of GHG emissions, fuel excise taxes can be a complementary policy when combined with a carbon tax.

Federal Renewable Fuel Standard (RFS): Partly Complementary, Partly Redundant

Similar to fuel economy standards, the RFS is meant to serve multiple goals, including reducing the US transportation sector's dependence on petroleum, reducing GHG emissions from transportation, facilitating technology and infrastructure developments in support of biofuels' substitution for conventional gasoline, and providing support for the agricultural sector and rural communities by promoting the use of conventional and advanced biofuels. While all biofuels are arguably substitutes for gasoline, the 10 percent blend wall limits the amount of possible gasoline substitution and effectively requires different biofuels to compete for shares of that 10 percent. Also, different categories of biofuels are produced using different technologies and have very different lifecycle emissions profiles: conventional ethanol derived from corn starch may (but does not always) provide marginal emissions improvement over gasoline, cane ethanol typically emits at most half as much, and biodiesel and other advanced biofuels also reduce emissions by at least 50 percent, sometimes far more.[198] Reflecting the different challenges that different biofuels face in achieving production at scale, the RFS has different volumetric obligations for each category of fuel.

RFS support for advanced biofuels, whose GHG emissions profiles are at least 50 percent lower than that of conventional gasoline, may be good complementary policies to a carbon tax for the same reasons that subsidies for renewable electricity technologies are good complements in the early stages of their development. At this point, they are nascent technologies that have not yet achieved production at commercial scale. For instance, in 2017, only ten million gallons of cellulosic ethanol (the fuel with the lowest emission profile) entered the US fuel supply of over 140 billion gallons of gasoline, 43 percent of which was imported, and 129 million gallons of other advanced fuels entered the fuel supply, of which over 55 percent was imported.[199] Given this poor track record, it seems clear that advanced renewable fuel technologies are still in need of further progress if they are to be produced in meaningful quantities. Moreover, given that the portions of the RFS that address advanced renewable fuels have not successfully brought advanced biofuels into the fuel supply, other or additional policy measures may be appropriate for this purpose and could better complement a carbon tax than the RFS.[200]

In contrast to the experience of advanced biofuels, nearly fifteen billion gallons of conventional ethanol entered the fuel supply, additional volumes were exported, and more could be produced and consumed domestically if not for the blendwall, which limits the space in the fuel supply for ethanol. Regulations that support biofuels with lifecycle emissions comparable to gasoline, which were left in place after establishment of a carbon tax, would conflict with a carbon tax in much the same way as tax preferences for fossil fuel extraction.[201] However, the conventional ethanol mandate of the RFS is a policy tool whose actual (if not stated) purposes include providing support for the agriculture sector and enhancing energy security, which are entirely separate policy goals. Policy makers should consider these benefits of the RFS with the downside of inhibiting other low carbon fuels entering the market, spurred by the carbon tax or otherwise.

An additional issue relates to the uncertain treatment of biofuels under a carbon tax. For example, if the lifecycle emissions from different sources of biofuels are not subject to carbon taxes of different levels, additional policies may be needed to encourage low-carbon biofuel production and discourage high-carbon production.

Energy Efficiency Requirements: Complementary

Of all the interactions considered in this article, the one perhaps examined most thoroughly elsewhere is that of a carbon tax and energy efficiency (EE) policies. Indeed, in 2011, the International Energy Agency addressed precisely the question of whether EE policies (e.g., labeling requirements, informational tools, and performance standards) address the same sources of market failure as a carbon tax.[202] Based upon a review of relevant empirical literature, the agency concluded that EE policies and carbon pricing overlap little and can be highly effective in tandem.[203] Energy efficiency policies address problems that cannot be addressed sufficiently by shifting market prices, such as principal-agent problems, unavailable energy performance information, and bounded rationality.[204] Carbon taxes also can mitigate the rebound effect from efficiency standards, which occurs when consumers increase the use of a more efficient appliance because of its lower operating costs.

Given that a carbon tax also encourages energy efficiency by raising the prices of carbon-intensive energy, it may be appropriate for policy makers to reconsider the appropriate structure and stringency of policies that promote energy efficiency when considering carbon tax legislation. But because efficiency policies can achieve incremental reductions in GHG emissions more cost-effectively than a carbon tax, they can clearly complement a carbon tax.

Support for R&D: Complementary

Support for innovation in low carbon technologies is also complementary with a carbon tax. While a carbon tax encourages private sector investments in low carbon technologies, a carbon tax by itself is insufficient to address the underinvestment in R&D resulting from the market failure of private entities not capturing the full benefits of their R&D spending. By leading to reduced costs and improved performance of low carbon technologies, R&D spending can reduce the costs of achieving long-run emissions targets.

A carbon tax is most complementary with early-stage research, development, and demonstration of new technologies, where the private sector is unlikely to make sufficient investments due to long time horizons and risks. Support for R&D can come is in the form of government programs, direct spending, public-private partnerships, tax credits, or other forms.[205]

Agriculture and Land Sector Policies: Complementary

In 2016, GHG emissions from agriculture activities represented 8.6 percent of U.S. emissions.[206] They were dominated by N_2O emissions from soil management practices and CH4 emissions from enteric fermentation.[207] Likewise, land use policies, including improved forest management practices, tree planting in urban areas, and the management of agricultural soils, landfilling of yard trimmings and food scraps, reduce GHG emissions and serve as a sink that removes GHGs from the atmosphere.[208] Because of administrative, technical, and political challenges, however, these sectors and practices are unlikely to be covered by a carbon tax. Therefore, policies that improve agriculture and land use policies to reduce emissions and enhance sinks are complementary to a carbon tax.

Infrastructure Improvements Related to Transportation and Land Use: Complementary

Infrastructure improvements is an extremely broad category of potential actions, and a separate study is needed for a comprehensive evaluation of such actions. For our purposes, it suffices to note that certain types of improvements in public infrastructure can enable more cost-effective GHG emissions reductions alongside a carbon tax. For example, with better mass transit systems or urban planning that enables more walkable or bikeable urban areas, households will be more likely to take advantage of financial incentives to reduce vehicle travel.

Such policies can arise at the federal, state, or local levels, and they can come in the form of government funding or process-related changes that direct private investments toward infrastructure and enable shifts to cleaner energy uses. Of course, infrastructure improvements can enable higher-carbon energy uses as well.

State Policies

In general, because climate change is a global phenomenon and it doesn't matter where GHG emissions take place, it is most efficient to concentrate action at higher levels of government. Therefore, it is logical to consider preempting state policy to address GHG emission with federal policy.

On the other hand, as Burtraw and Palmer (2015) observe, even with the implementation of a federal carbon tax, state and local governments still have an important role to play:

> In a unitary model of government, the introduction of a price signal is assumed to be transmitted instantly to decision makers at all levels of government so that permitting, land use planning, and other functions of government adjust accordingly. . . . But there is in fact little research to indicate how well this would occur. There are many reasons to think that price signals *may not be* transmitted efficiently through levels of government. . . . Even if a tax is used efficiently, it may not work

> as described in the conventional economic model. In particular, it may not, and we think it most certainly will not, affect all relevant margins of decision making in the economy from consumer behavior to the decisions of state and local governments.[209]

State and local governments can also be logical places for enacting some of the policies that best complement a carbon price, such as energy efficiency programs. Finally, state policies, particularly in California, have often served the role of "laboratories" for testing potential future federal policies. The complete preemption of state-level climate policies, carbon-pricing or otherwise, would therefore eliminate policies that could complement a carbon tax.

The following subsections characterize certain broad categories of prominent state policies that would interact with a federal carbon tax. It is not comprehensive, but rather considers a handful of important examples.

State Carbon Pricing Policies: Mostly Redundant

A federal carbon tax would be redundant with state laws that assign prices to GHG emissions, either in the form of a carbon tax or a cap and trade program. Given the cost-effectiveness of a uniform federal tax level, the preemption of state carbon pricing policies is a logical issue to arise as part of the consideration of carbon tax legislation.

However, there are significant caveats. First, state-level carbon prices could enable certain states to enact more stringent legislation than the federal policy, and some states might pursue that additionality after concluding that the federal tax is insufficient to help them achieve their own climate change–related goals.[210]

The second caveat is that preempting state carbon pricing policies would also redirect tax receipts from state to federal coffers and thereby deprive state-level energy transition policies of an important source of revenue.[211] Still, a state carbon price is not necessarily a more cost-effective way to accomplish revenue-raising goals. Similar to how carbon pricing revenues could be used for transportation infrastructure in lieu of revenues from fuel excise taxes, revenues from the federal carbon tax could be granted to states to compensate for losses from state carbon pricing programs.

Existing state carbon pricing schemes have steered clear of the legal limits mentioned above (though they have faced a number of legal challenges on other grounds).[212]

Low Carbon Fuel Standards: Partly Complementary, Partly Redundant

One component of California's implementation of its climate change law requires a 20 percent reduction in the average carbon intensity of motor vehicle fuels supplied or sold in California by 2030.[213] The California Air Resources Board expects that this will be accomplished by blending standard gasoline with ethanol or by replacing petroleum-based diesel with biodiesel.[214] Unlike the federal RFS, there are not separate categories and blending requirements for particular renewable fuels; instead, each fuel is measured based on its own life cycle emissions. As with the federal RFS, if a state RFS promotes mature fuel technologies with life cycle emissions profiles similar to gasoline, a low carbon fuel standard does not complement a carbon tax. In fact, it could provide a conflicting incentive for the use of a relatively high-carbon fuel.

However, the support for lower-carbon biofuels can be complementary with a carbon tax, particularly because the advanced biofuels with lower life cycle emissions profiles are typically fuels at an early stage of development, in need of additional government support to achieve commercial viability. In such cases, the state-level low carbon fuel standard could enable more cost-effective GHG emissions reductions by accelerating the development of nascent fuels, and it could also achieve a separate policy objective of promoting state biofuel industries.

Renewable Portfolio Standards and Clean Energy Standards: Mostly Redundant

Both renewable portfolio standards and clean energy standards (which include all forms of zero-carbon electricity, including nuclear energy) can be effective means of encouraging the deployment of zero-carbon electricity sources, but a carbon tax does the same and likely does so more efficiently from the perspective of reducing GHG emissions.[215] While a carbon tax discourages fossil fuel electricity generating sources in proportion to their carbon intensity, RPSs and CESs typically do not differentiate between electricity produced with natural gas, petroleum, or coal.[216]

Alongside a carbon tax, an RPS or CES would also reduce government revenues by directing money from emitting generators to zero-carbon generators (in payment for renewable energy credits [RECs] or zero emissions credits [ZECs]) instead of into federal coffers.[217] RPSs and CESs also do not directly increase power prices like a carbon tax (and may in some cases decrease prices[218]) and therefore do less to promote efficiency and conservation, and they do not “differentially disadvantage fossil technologies in relation to their emissions intensity.” For all of these reasons, RPSs and CESs arguably make poor complements to a carbon tax.

Still, the objectives of RPSs and CESs are often broader than achieving GHG reductions. They may be intended to spur specific technologies, particularly those produced within the state, to avert local economic disruption from facility closure and to promote local economic growth.[219] They also can reduce local air pollution from fossil fuel electricity sources and, in the case of an RPS, can reduce a state’s reliance on nuclear power. Policy makers may determine that these separate objectives, along with the additional GHG emissions reductions that an RPS or CES can cause alongside a carbon tax, are sufficiently important to retain these policies alongside a federal carbon tax.

Importantly, we take no position on whether or how federal carbon tax legislation could address state-level RPSs and CESs and whether to preempt them or otherwise blunt or sharpen their effects. Furthermore, we note that the design of RPSs and CESs—as well as of a carbon tax—can avoid redundancy. Recent activity in New York provides a useful pair of examples that highlight how redundancy might manifest and how to avoid it. The first example involves the New York ISO, which—as part of its development of a carbon adder for use in wholesale electric energy and capacity markets—has proposed a solution for the treatment of existing and future REC contracts under a carbon pricing regime.[220] In particular, NYISO’s draft decision acknowledges that a carbon adder would arguably cause some renewable generators to be “paid twice.” The other example involves New York State’s use of an Index Offshore Wind REC mechanism (Index OREC) in its procurement of offshore wind generation. That mechanism would adjust the amount paid to offshore wind developments with future market price changes,[221] including changes arising from the imposition of a price on carbon emissions in the electricity sector or more generally.

State Programs and Standards that Promote Energy Efficiency: Complementary

For all the same reasons described above for federal EE programs, state (and local) level programs to promote EE can also be valuable complements to a federal carbon tax because they can overcome behavioral barriers to low-cost reductions in energy use, therefore enabling a given emissions target to be achieved more cost-effectively.

The restructuring of electricity markets, which are primarily regulated at the regional and state levels, could also be valuable complements to carbon tax; for example, “decoupling” electricity utility revenues from their sales removes problematic incentives for overspending on generation and other capital assets. Improvements to the electricity system on the supply side can enable more cost-effective emissions reductions as well, such as easing the permitting process for long-distance (and particularly interstate) electricity transmission lines.

CONCLUSION

If Congress seriously considers carbon tax legislation, negotiations are likely to involve a host of policies in addition to the carbon tax, chiefly relating to energy, environmental protection, and land use. This paper identifies the most salient of those policies, introduces a framework for characterizing policies on a spectrum from complementary to redundant with a federal carbon tax, and discusses the placement of policies across this spectrum. These categorizations are meant to help inform policy makers and other stakeholders so that they can thoughtfully consider what policies to add, change, or eliminate as part of a political compromise to implement a carbon tax.

NOTES

1. See National Academies of Sciences, *Effects of U.S. Tax Policy on Greenhouse Gas Emissions*, 113–34 (William W. Nordhaus et al., eds., 2013) (examining emissions impacts of mortgage interest tax deduction and tax exemption of employer-sponsored health coverage).

2. Policies not considered here include the Minerals Leasing Act of 1920, which was recently the legal basis for regulatory limits on methane releases from mineral extraction operations. Bureau of Land Management, Waste Prevention, Production Subject to Royalties, and Resource Conservation, 81 Fed. Reg. 83008, January 1, 2017.

3. Clean Air Act of 1963, Pub. L. 88-206, 77 Stat. 392; Clean Air Act Amendments of 1970, Pub. L. 91-604, 84 Stat. 1676; Clean Air Act Amendments of 1977, Pub. L. No. 95-95, 91 Stat. 685; Clean Air Act Amendments of 1990, Pub. L. No. 101-549, 108 Stat. 2399; all *codified* at 42 U.S.C. §§ 7401–7626.

4. Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act, 74 Fed. Reg. 66496, December 9, 2009.

5. Clean Air Act §§ 109(d), 202(a)(1), 231(a)(2)(A).

6. Massachusetts v. EPA, 549 U.S. 497 (2007). The GHGs are: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

7. EPA, Mandatory Reporting of Greenhouse Gases, 74 Fed. Reg. 56260 (Oct. 30, 2009) ("The rule does not require control of greenhouse gases, rather it requires only that sources above certain threshold levels monitor and report emissions"), codified at 40 C.F.R. pt. 98 (authorized by Clean Air Act Section 114: Recordkeeping, inspections, monitoring, and entry).

8. EPA & NHTSA, Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule, 75 Fed. Reg. 25324, May 7, 2010. These standards, which largely copied those previously issued by California, are set in a joint rulemaking issued by the EPA and NHTSA. The EPA's authority for the rulemaking comes from the Clean Air Act; the NHTSA's comes from the 1975 Energy Policy and Conservation Act (EPCA), Pub. L. No. 94–163, 89 Stat. 871, December 22, 1975.

9. EPA & NHTSA, 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards; Final Rule, 77 Fed. Reg. 62624, October 15, 2012.

10. EPA & NHTSA, Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2, 81 Fed. Reg. 73478, October 25, 2016.

11. EPA, Action to Ensure Authority to Implement Title V Permitting Programs Under the Greenhouse Gas Tailoring Rule, 75 Fed. Reg. 82254, December 30, 2010; EPA, Limitation of

Approval of Prevention of Significant Deterioration Provisions Concerning Greenhouse Gas Emitting Sources in State Implementation Plans; Final Rule, 75 Fed. Reg. 82536, December 30, 2010; EPA, Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule, 75 Fed. Reg. 31514, June 3, 2010.

12. Like all rules issued by EPA in relation to GHG emissions, these rules, termed the "Timing and Tailoring Rules," were challenged in court. In 2014, the Supreme Court instructed the EPA to revise the scope of the rule's implementation of the PSD program slightly, *Utility Air Regulatory Group v. EPA*, 134 S. Ct. 2427, 2014, which the EPA has since done. See Prevention of Significant Deterioration and Title V Permitting for Greenhouse Gases: Removal of Certain Vacated Elements, 80 Fed. Reg. 50,199, August 19, 2015. As currently applied, the PSD program only limits GHGs emitted from "anyway" sources that would have been required to conduct New Source Review owing to their emission of some other regulated pollutant. Sources not subject to the PSD program for emission of a criteria pollutant are not now subject to that program for their emission of GHGs, even if those GHGs exceed the thresholds for program participation specified by EPA in the Tailoring Rule.

13. EPA, Standards of Performance for Municipal Solid Waste Landfills, 81 Fed. Reg. 59,331, August 29, 2016; EPA, Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Commercial and Industrial Solid Waste Incineration Units, 81 Fed. Reg. 40,955, June 23, 2016; EPA, Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources, 81 Fed. Reg. 35,823, June 3, 2016; EPA, Standards of Performance for Greenhouse Gas Emissions From New, Modified, and Reconstructed Stationary Sources: Electric Utility Generating Units, 80 Fed. Reg. 64,509, October 23, 2015; Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, 80 Fed. Reg. 205, October 23, 2015.

14. EPA, Finding that Greenhouse Gas Emissions from Aircraft Cause or Contribute to Air Pollution that May Reasonably Be Anticipated to Endanger Public Health and Welfare, 81 Fed. Reg. 18,399, August 15, 2016.

15. The Trump EPA's proposed revision of carbon emissions standards for new power plants would require new coal-fired plants to adopt high-efficiency steam cycles (e.g., supercritical) and would require nothing of new natural gas-fired plants. 83 Fed. Reg. 65,424, 65,430–31, December 20, 2018. The standards they aim to replace would require the use of carbon capture and sequestration technology for coal- but not natural gas-fired plants. 80 Fed. Reg. 205; see also Victoria R. Clark and Howard J. Herzog, *Assessment of the US EPA's Determination of the Role for* CO_2 *Capture and Storage in New Fossil Fuel-Fired Power Plants*, 48 Environmental Science & Technology 7723, 7723–29 (2014) (examining EPA's reasons for not imposing requirement on gas- as well as coal-fired plants).

16. The Obama administration's Clean Power Plan—which was stayed by the Supreme Court in 2017 but is still technically before the D.C. Circuit Court of Appeals, and which the Trump administration has proposed to repeal and replace—treated power plants not as solitary facilities but as parts of an integrated electric grid and required "owner/operators" of one or more power plants (rather than individual power plants) to comply. 80 Fed. Reg. at 64,662, 64,677, 64,725.

17. Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources Reconsideration; proposed rule, 83 Fed. Reg. 52,056 (Oct. 15, 2018).

18. Global warming potential GWP refers to the effect of a given GHG in the atmosphere and is generally expressed as a coefficient relative to the effect of a unit of CO_2. Henry D. Jacoby, Anthony C. Janetos, et al., Ch. 27: Mitigation, in *Climate Change Impacts in the United States: The Third National Climate Assessment*, p. 651 (J. M. Melillo et al., eds. 2014). Fluorinated gases have especially high GWPs. Sulfur hexafluoride, for instance, has 22,800 times the GWP of CO2 over a 100-year timeframe. EPA, *Overview of Greenhouse Gases: Emissions of Fluorinated Gases*, https://perma.cc/5YPU-D78U (updated April 14, 2017).

19. Notably, the EPA's authority to make this crediting available to manufacturers is not in the Clean Air Act, but in the EPCA. 77 Fed. Reg. at 62,639 ("EPA is finalizing, under its EPCA authority, rules allowing the impact of air conditioning system efficiency improvements to be included in the calculation of fuel economy for CAFE compliance.").

20. Clean Air Act § 209; see also Denise A. Grab et al., Institute for Policy Integrity, "No Turning Back: An Analysis of EPA's Authority to Withdraw California's Preemption Waiver Under Section 209 of the Clean Air Act" (October 2018) (describing legal structure of waiver provision and history of its implementation).

21. See the SAFE Rule.

22. Justin Gundlach, "Section 115 in Practice," in *Section 115: How an Unsung Provision of the Clean Air Act Can Help the United States Tackle Climate Change* (Michael H. Burger ed., forthcoming) (describing EPA's and federal courts' engagement with Section 115, which has not included implementation).

23. Clean Air Act § 115(a)–(c).

24. See generally Michael Burger et al., Legal Pathways to Reducing Greenhouse Gas Emissions Under Section 115 of the Clean Air Act, 28 Geo. Envtl. L. Rev. 359, 2016.

25. Even that rule allows car manufacturers to treat CO_2 emissions as a proxy for N_2O rather than addressing N_2O emissions directly. 40 CFR § 86.1818-12, 2016.

26. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2013*, at 2-23, tbl. 2-10, April 15, 2015, http://bit.ly/1ZMQIod.

27. Ibid at ES-3.

28. Several petitions for rulemakings to regulate N_2O emissions from agricultural sources have been filed. See, e.g., Institute for Policy Integrity (IPI), *Petition for Rulemakings and Call for Information under Section 115, Title VI, Section 111, and Title II of the Clean Air Act to Regulate Greenhouse Gases*, February 19, 2013, http://bit.ly/2aApctz (seeking regulation of agricultural N_2O emissions under Clean Air Act Title VI and/or Section 111), Humane Society of the United States et al., *Petition to List Concentrated Animal Feeding Operations Under Clean Air Act Section 111(b)(1)(A), and to Promulgate Standards of Performance Under Clean Air Act Sections 111(b)(1)(B) and 111(d),* September 21, 2009, http://bit.ly/2aU6UEI.

29. The EPA issued CSAPR in 2011. EPA, Federal Implementation Plans: Interstate Transport of Fine Particulate Matter and Ozone and Correction of SIP Approvals, 76 Fed. Reg. 48,208, August 8, 2011. The D.C. Circuit rejected the rule. *EME Homer City Generation, L.P. v. EPA*, 696 F.3d 7 (D.C. Cir. 2012), but was reversed by the Supreme Court. *EPA v. EME Homer City Generation, L.P.*, 134 S. Ct. 1584, 2014. The D.C. Circuit's subsequent review of EPA's initial implementation of the rule upheld its key elements. *EME Homer City Generation, L.P. v. E.P.A.*, 795 F.3d 118 (D.C. Cir. 2015). The EPA has yet to finalize its proposed update of the rule with respect to ozone. The EPA, Cross-State Air Pollution Rule Update for the 2008 Ozone NAAQS; proposed rule, 80 Fed. Reg. 75,706, December 3, 2015.

30. The EPA issued the MATS rule in December 2011; it was published in the Federal Register in February of 2012. National Emission Standards for Hazardous Air Pollutants from Coal- and Oil-Fired Electric Utility Steam Generating Units and Standards of Performance for Fossil-Fuel-Fired Electric Utility, Industrial-Commercial-Institutional, and Small Industrial-Commercial-Institutional Steam Generating Units, Final Rule, 77 Fed. Reg. 9304, February 16, 2012. The D.C. Circuit upheld the rule, *White Stallion Energy Center, LLC v. E.P.A.*, 748 F.3d 1222 (D.C. Cir. 2014), but that decision was overturned by the US Supreme Court, which ordered the D.C. Circuit to decide whether to vacate or merely remand it to the EPA. *Michigan v. EPA*, 135 S. Ct. 2699, 2015. The D.C. Circuit did not vacate the rule but instead ordered the EPA to make a supplemental finding, which the EPA did. EPA, Final Supplemental Finding That It Is Appropriate and Necessary to Regulate Hazardous Air Pollutants from Coal- and Oil-Fired Electric Utility Steam Generating Units, 81 Fed. Reg. 24,420, April 25, 2016. The D.C. Circuit rejected challenges to the EPA's planned response to its order. *White Stallion Energy Center, LLC v. EPA*, Case No. 12-1101 et al., 2015 WL 11051103 (D.C. Circ. December 15, 2015) (remanding rule to EPA without vacatur and noting that "EPA has represented that it is on track to issue a final finding"). The Supreme Court then denied certiorari from that decision shortly after EPA had issued its Final Supplemental Finding. 136 S. Ct. 2463, June 13, 2016. The industry then filed challenges to EPA's Final Supplemental Finding with the D.C. Circuit. Petition for Review, *Murray Energy Corp. v. EPA*, Case No. 16-1127 (D.C. Cir. April 25, 2016). Before the court heard that challenge (though not before it was briefed), the Trump administration requested that the case be held in abeyance pending a review of the rule. The court granted that request in April 2017, Order, *Murray Energy Corp. v. EPA*, Case No. 16-1127 (D.C. Cir. April 17, 2017), and it remains in effect.

31. See Rafay Ishfaq et al., *Fuel-switch decisions in the electric power industry under environmental regulations*, 48 IIE Transactions 205, 206–07, 2016 (modeling effect of regulations on fuel-switching and plant closure decisions in a time of low natural gas prices).

32. 80 Fed. Reg. at 75,757 (reporting "Estimate Global Climate Co-Benefits of CO_2 Reductions for the Proposal").

33. EPA, Regulatory Impact Analysis for the Proposed Cross-State Air Pollution Rule (CSAPR) Update for the 2008 Ozone National Ambient Air Quality Standards (NAAQS), EPA-452/R-15-009, at ES-16, 6-27 to 6-35, November 2015. This calculation did not estimate benefits from the reduction of non-CO_2 GHG emissions. Ibid. at 6–34.

34. 77 Fed. Reg. at 9306, 9431–9432.

35. Compare D. Coady et al., International Monetary Fund, "How Large Are Global Energy Subsidies?" (2015), https://perma.cc/32LC-QS7S (treating untaxed externalities as subsidies), *with* ELI, Estimating U.S. Government Subsidies to Energy Sources: 2002–2008, September 2009, https://perma.cc/LTR9-264Q (not treating externalities as subsidies), *and* U.S. Energy Info. Admin. ("EIA"), Direct Federal Financial Interventions and Subsidies in Energy in Fiscal Year 2013, April 2015, https://perma.cc/8XD3-LZPZ (excluding various measures included by ELI).

36. EIA, pp. xix tbl. ES4, xxii tbl. ES6. (available here: https://www.eia.gov/analysis/requests/subsidy/archive/2013/pdf/subsidy.pdf)

37. Alex Doukas, OilChange International, "G20 subsidies to oil, gas and coal production: United States" 2–4, November 2015, https://perma.cc/69HF-EKPK.

38. These shorthand titles actually refer to the Renewable Electricity Production Tax Credit, the Business Energy Investment Tax Credit, and the Residential Renewable Energy Tax Credit.

39. Consolidated Appropriations Act, 2016, Pub. L. No. 114-113, Div. Q, 129 Stat. 2242, December 18, 2015.

40. Ibid.

41. See Doug Koplow, "The Domestic Manufacturing Tax Credit and the Oil and Gas Industry," EarthTrack Blog, April 1, 2011, https://perma.cc/RH8R-VPSW.

42. Price-Anderson Nuclear Industries Indemnity Act, Pub. L. No. 85-256, § 4, 71 Stat. 576 (1957), as amended by Pub. L. No. 100-408, 102 Stat. 1066, August 20, 1988, codified at 42 U.S.C. 2212i.

43. NWPA of 1982, Pub. L. No. 97-425, 96 Stat. 2201, January 7, 1983, as amended by P.L. 100-203, Title V, Subtitle A, December 22, 1987, Pub. L. No. 100-507, October 18, 1988, and Pub. L. No. 102-486, October 24, 1992, codified at 42 U.S.C. 10101–10270.

44. Energy Policy Act of 2005 tit. XVII; see also Mark Holt, Congressional Research Service, Nuclear Energy Policy 23–25, October 2014, https://perma.cc/53SD-GZVR.

45. 42 U.S.C. § 2210(c).

46. Compare Michael G. Faure and Tom Van den Borre, "Compensating Nuclear Damage: A Comparative Economic Analysis of the US and International Liability Schemes," 33 *Wm. & Mary Envtl. L. & Pol'y Rev.* 219, 2008 (concluding that Price-Anderson conferred no subsidy after 1975 amendments introduced retrospective premium payments), with Doug Koplow, Nuclear Power: Still Not Viable without Subsidies 84 (Union of Concerned Scientists, February 2011) (adopting estimated value of 0.1 and 2.5¢/kWh or $800 million to several billion dollars per year).

47. Ibid. at 104 tbl. 27.

48. Energy Policy Act of 2005, tit. XVII; see also Mark Holt, Congressional Research Service, Nuclear Energy: Overview of Congressional Issues 10 (November 2018); Congressional Budget Office, Federal Loan Guarantees for the Construction of Nuclear Power Plants 4 (August 2011) (noting initial Congressional authorization in 2008).

49. Staff of the Joint Committee on Taxation, Description of Present Law and Select Proposals Relating to the Oil and Gas Industry, JCX-27-11, May 11, 2011, https://perma.cc/6SRU-BVBH; Alan Kovski, Special Report: Tax Provisions Helping Oil and Gas Firms Take Much Criticism but Keep Paying Off, BNA Daily Environment Report No. 136, July 15, 2016 (listing the percentage depletion deduction and the domestic manufacturing deduction for coal and other hard mineral fossil fuels among those tax provisions that the Obama administration has grouped with tax preferences for oil and gas production). See also United States, Fossil Fuels Subsidy Reform: Progress Report on Fossil Fuel Subsidies, November 2014(identifying eleven US fossil fuel tax preferences and subsidies for consideration by G20).

50. Gilbert E. Metcalf, Council on Foreign Relations Discussion Paper: The Impact of Removing Tax Preferences for U.S. Oil and Gas Production 2–3, August 2016.

51. U.S. Bureau of Land Management, Order No. 3338, Discretionary Programmatic Environmental Impact Statement to Modernize the Federal Coal Program, January 15, 2016, http://on.doi.gov/1SpB6p4.

52. IRS, Publication 510: "Excise Taxes (Including Fuel Tax Credits and Refunds)," 5, February 19, 2016, http://bit.ly/2avg38i. States also charge taxes (excise and others) on gasoline and diesel. The average rates are $0.25 for gasoline and $0.27 for diesel; the range for gasoline varies from $0.0895 in Alaska to $0.514 in Pennsylvania. U.S. EIA, Frequently Asked Questions: *How much tax do we pay on a gallon of gasoline and diesel fuel?*, https://perma.cc/T9LR-3PU7 (updated November 25, 2015).

53. Revenue Act of 1932, ch. 209, Pub. L. No. 154, 47 Stat. 169, June 6, 1932.

54. James M. Bickley, "The Federal Excise Tax on Gasoline and the Highway Trust Fund: A Short History" (Washington, DC: Congressional Research Service, September 7, 2012). Ancillary costs include the cleanup of underground gasoline and oil storage tanks, paid for from the Leaking Underground Storage Tank Trust Fund.

55. Joseph Kile, Assistant Director for Microeconomic Studies, CBO, Before the Committee on Finance United States Senate, "The Status of the Highway Trust Fund and Options for Paying for Highway Spending," June 18, 2015, https://perma.cc/FTU2-3FVP.

56. Ibid. at 4 tbl. 1 (showing revenues credited to Highway Trust Fund), fig. 2 (showing growing shortfall out to 2025).

57. IRS, Pub. 150, supranote 52, at 4, 5, 8 (the list of fuel taxes includes aviation gasoline, gasoline blendstocks, diesel-water fuel emulsion, kerosene [including kerosene used for aviation], dyed diesel and kerosene, compressed natural gas, alternative fuels, fuels used in commercial transportation on inland waterways, and any liquid used in a fractional

ownership program aircraft as fuel).

58. Federal Aviation Administration, Fact Sheet: Airport and Airway Administration Trust Fund 4 (2016), https://perma.cc/3F3R-J3NM.

59. GAO-11-134, at 8.

60. Kelsi Bracmort, Congressional Research Service, *The Renewable Fuel Standard (RFS): In Brief* 7–8, January 16, 2015, https://perma.cc/GAQ9-V5Q7. Specially designed "flex fuel" engines can handle blends of up to 85 percent ethanol.

61. U.S. EIA, Annual Energy Outlook 2016, Table 46. Transportation Fleet Car and Truck Stock by Type and Technology, August 2016, https://perma.cc/9BLL-ZCYD (estimating that as of August 2016 flex-fuel vehicles comprise about 1.36 percent of the total US passenger- and light duty-vehicle fleet).

62. See US Department of Energy, Alternative Duels Data Center, "Fuel and Vehicles: E15," (undated) www.afdc.energy.gov/fuels/ethanol_e15.html.

63. Energy Policy Act of 2005, Pub. L. No. 109-58 (2005). As California's Air Resources Board has explained, the difference between ethanols for the purpose of a lifecycle emissions analysis is in how they came to be ethanol. *CAL. AIR RESOURCES BD., STAFF REPORT: INITIAL STATEMENT OF REASONS FOR PROPOSED RULEMAKING--PROPOSED RE-ADOPTION OF THE LOW CARBON FUEL STANDARD,* at III-62, January 2015, https://perma.cc/48A8-P5HT ("a gallon of ethanol made from corn grown and processed in the Midwest will, under a microscope or other analytical device, look identical in every material way to a gallon of ethanol processed from sugar cane grown in Brazil. Both samples of ethanol will have the same boiling point, the same molecular composition, the same lower and upper limits of flammability—in other words, both will have identical physical and chemical properties because both products consist of 100 percent ethanol. On the other hand, the corn ethanol made from the Midwest will have different carbon intensity than the sugar cane ethanol from Brazil. Thus, the relevant inquiry with carbon intensity is not so much what is contained in a fuel, but how that fuel was made, distributed and used.").

64. Energy Independence and Security Act of 2007, Pub. L. No. 110-140 (2007). EISA's relevant provisions amended the Clean Air Act by creating the Renewable Fuels Program as a subsection "o" of Section 211, codified at 42 U.S.C. § 7475(o).

65. Debate over whether ethanols made from corn starch should qualify as "renewable fuels" has raged for years. *BRENT D. YACOBUCCI & KELSI BRACMORT, CALCULATION OF LIFECYCLE GREENHOUSE GAS EMISSIONS FOR THE RENEWABLE FUEL STANDARD 10–16*, March 12, 2010, https://perma.cc/5F4Z-3FEC.

66. As California's Air Resources Board has explained, the difference between ethanols for the purpose of a lifecycle emissions analysis is in how they came to be ethanol. *CAL. AIR RESOURCES BD., STAFF REPORT: INITIAL STATEMENT OF REASONS FOR PROPOSED RULEMAKING--PROPOSED RE-ADOPTION OF THE LOW CARBON FUEL STANDARD, at III-62*, January 2015, https://perma.cc/3D78-BW3D ("a gallon of ethanol made from

corn grown and processed in the Midwest will, under a microscope or other analytical device, look identical in every material way to a gallon of ethanol processed from sugar cane grown in Brazil. Both samples of ethanol will have the same boiling point, the same molecular composition, the same lower and upper limits of flammability—in other words, both will have identical physical and chemical properties because both products consist of 100 percent ethanol. On the other hand, the corn ethanol made from the Midwest will have different carbon intensity than the sugar cane ethanol from Brazil. Thus, the relevant inquiry with carbon intensity is not so much what is contained in a fuel, but how that fuel was made, distributed and used.").

67. 42 U.S.C. § 7475(o)(2)(B)(i)(II).

68. Renewable Fuel Standard Program: Standards for 2018 and Biomass-Based Diesel Volume for 2019; Final Rule, 82 Fed. Reg. 58486, 58486-7, December 12, 2017. The National Research Council predicted this result in 2011. *LESTER B. LAVE ET AL., NAT'L RESEARCH COUNCIL, RENEWABLE FUEL STANDARD: POTENTIAL ECONOMIC AND ENVIRONMENTAL EFFECTS OF U.S. BIOFUEL POLICY 2 (2011).*

69. See Chris Prentice, *U.S. buyers scoop up Brazilian ethanol amid RIN revival*, Reuters, June 15, 2015, http://reut.rs/2fVgQ53.

70. Kelsi Bracmort, The Renewable Fuel Standard (RFS): Cellulosic Biofuels 18–19, January 2015.

71. Rosamond L. Naylora and Matthew M. Higgins, The political economy of biodiesel in an era of low oil prices, 77 Renewable & Sustainable Energy Revs. 695, 698–700, September 2017.

72. As California's Air Resources Board has explained, the difference between ethanols for the purpose of a lifecycle emissions analysis is in how they came to be ethanol. *CAL. AIR RESOURCES BD., STAFF REPORT: INITIAL STATEMENT OF REASONS FOR PROPOSED RULEMAKING--PROPOSED RE-ADOPTION OF THE LOW CARBON FUEL STANDARD*, at III-62, January 2015, http://bit.ly/1PHvupb ("a gallon of ethanol made from corn grown and processed in the Midwest will, under a microscope or other analytical device, look identical in every material way to a gallon of ethanol processed from sugar cane grown in Brazil. Both samples of ethanol will have the same boiling point, the same molecular composition, the same lower and upper limits of flammability—in other words, both will have identical physical and chemical properties because both products consist of 100 percent ethanol. On the other hand, the corn ethanol made from the Midwest will have different carbon intensity than the sugar cane ethanol from Brazil. Thus, the relevant inquiry with carbon intensity is not so much what is contained in a fuel, but how that fuel was made, distributed and used.").

73. See James H. Stock, The Renewable Fuel Standard: A Path Forward 9–10, April 2015 (tabulating difference between statutory volumes and volumes authorized by EPA rulemakings).

74. Energy Policy and Conservation Act, supranote 8; Energy Conservation and Production Act of 1976, Pub. L. No. 94-385, 90 Stat. 1142, August 14, 1976, codified at 42 U.S.C. §§ 12, 15b; National Energy Conservation Policy Act of 1978, Pub. L. No. 95-619, 92 Stat. 3206,

November 9, 1978, codified as amended at 42 U.S.C. §§ 8201–8284 and 42 U.S.C. §§ 12, 15; National Appliance Energy Conservation Act of 1987, Pub. L. No. 100–12, 101 Stat. 103, March 17, 1987; Energy Policy Act of 1992, Pub. L. No. 102-486, 106 Stat. 2777, October 24, 1992; Energy Policy Act of 2005, Pub. L. No. 1009-58, 119 Stat. 594, August 8, 2005; EISA; Emergency Economic Stabilization Act of 2008, 110–343, 122 Stat. 3765; American Recovery and Reinvestment Act of 2009, Pub. L. No. 111-5, 123 Stat. 138.

75. For a description of DOE's technical assistance program, see DOE, Office of Energy Efficiency & Renewables, "Building Energy Codes Program: State Technical Assistance," http://bit.ly/2aT7a7M (updated April 2, 2015). As for tax incentives, subsidies from utilities to customers for EE improvements are not taxable, 26 U.S.C. § 136, and tax credits are available to homeowners who install qualified EE-improving building envelope components (e.g., windows or insulation), id. § 25C(c), or heating or air-conditioning equipment. Id. § 25C(d)(3).

76. 42 U.S.C. §§ 6833(a), (b).

77. Ibid.

78. See DOE, Office of Energy Efficiency & Renewables, "Building Energy Codes Program: Status of State Energy Code Adoption," http://bit.ly/1SktOCx (updated July 2016) (commercial tab shows adoption of ASHRAE 2013/IECC 2015 code by seven states, of 2010/12 code by seventeen states and DC, of 2007/09 code by nineteen states, and of an earlier code or no code by thirteen states; residential tab shows adoption of IECC 2015 or equivalent code by four states, 2012 by ten states, 2009 by twenty-seven states, and earlier or no code by fifteen states).

79. ARRA § 410(a)(2); see also, e.g., Ted Strickland, Gov. of Ohio, Governor's Assurance under ARRA Title VI, Section 410, March 23, 2009, http://bit.ly/2akEBjf.

80. Energy Policy and Conservation Act of 1975, Pub. L. No. 94–163, 89 Stat. 871, December 22, 1975.

81. National Appliance Energy Conservation Act of 1987.

82. EISA §§ 142, 301, 303, 306–08, 310–12, 316, 321, 471, 531, 548.

83. 42 U.S.C. § 6293(b)(3). Examples include: "(9) illuminated exit signs, (10) low voltage dry-type distribution transformers, (11) traffic signal modules and pedestrian modules, (12) medium base compact fluorescent lamps, (13) dehumidifiers, (14) commercial prerinse spray valves, (15) refrigerated bottled or canned beverage vending machines."

84. Ibid. § 6295.

85. DOE, Office of Energy Efficiency and Renewable Energy, "Appliance and Equipment Standards Program," accessed on January 22, 2018, at www.energy.gov/eere/buildings/appliance-and-equipment-standards-program.

86. Ibid. § 6295©(2)(B).

87. See 10 C.F.R. pt. 430 (listing performance standards for consumer products based on EPCA authority); 10 C.F.R. 431 (listing test procedures and performance standards for commercial and industrial equipment, e.g., commercial refrigerators, freezers and refrigerator-freezers; commercial warm air furnaces; distribution transformers; electric motors; and pumps).

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89. Darren Acemoglu, Introduction to Modern Economic Growth 411–432, 497–536, 2008.

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91. CBO, Federal Support for the Development, Production, and Use of Fuels and Energy Technologies 9, March 29, 2017.

92. Ibid. 9 tbl. 2.

93. EPA, "Greenhouse Gas Emissions: Sources of Greenhouse Gas Emissions," https://perma.cc/8XES-KWTV (updated April 14, 2017); USDA Economic Research Service, "Agricultural Production and Mitigation," http://perma.cc/9N5Z-GBHY (updated October 14, 2016).

94. 40 C.F.R. §§ 98.2 (listing criteria for entities subject to mandatory GHG reporting), 98.360–98.368 (Manure Management), Appendix (animal population thresholds above which emissions must be reported: beef cattle, 29,300; dairy cattle, 3,200; swine, 34,100; poultry: layers, 723,600, broilers, 38,160,000, turkeys, 7,710,000).

95. See Complaint for Declaratory and Injunctive Relief, *U.S. Humane Society v. EPA*, Civil Action No. 15-cv-0141, (D.D.C. January 28, 2015) (alleging EPA may no longer delay in responding to petitions for rulemaking to address GHGs and other emissions from CAFOs).

96. These include the Conservation Reserve Program, the Conservation Stewardship Program (which includes Resource Conserving Crop Rotations program), the Agricultural Conservation Easement Program (includes Grassland and Wetland Reserve programs), and the Environmental Quality Incentives Program.

97. USDA, "Building Blocks for Climate Smart Agriculture and Forestry," April 2015, https://perma.cc/2Z3G-M968.

98. EPA, "AgSTAR: Biogas Recovery in the Agriculture Sector," https://perma.cc/F7YF-7U6P (updated January 11, 2017).

99. For a discussion of the emissions-intensity of several aspects of US agriculture, see "The White House, Climate Change and the Land Sector: Improving Measurement, Mitigation and Resilience of our Natural Resources," December 2015, https://perma.cc/4GVH-S9ZL.

100. See, e.g., Eva Wollenberg et al., "Reducing emissions from agriculture to meet the 2 °C target," 22 Global Change Biology 3859, December 2016, http://onlinelibrary.wiley.com/doi/10.1111/gcb.13340/epdf.

101. U.N. Food and Agriculture Organization, "Fact Sheet: Greenhouse Gas Emissions from Agriculture, Forestry, and Other Land Use," March 2014, http://www.fao.org/assets/infographics/FAO-Infographic-GHG-en.pdf; UNFCCC, News: "IPCC AR5: Key findings on implications for agriculture," August 2014, https://unfccc.int/news/latest-ipcc-science-on-implications-for-agriculture.

102. For a discussion of the factors that push state laws closer to (or keep them from) these legal limits, see Kate Konschnik and Ari Peskoe, *Minimizing Constitutional Risk in State Energy Policy: A Survey of the State of the Law*, 45 Envtl. L. Reporter 10434 (May 2015).

103. *Hughes v. Oklahoma*, 441 U.S. 322, 325-26 (1979).

104. See *Pike v. Bruce Church, Inc.*, 397 U.S. 137 (1970) (articulating test).

105. See, e.g., Federal Power Act § 201(b)(1), *codified* at 16 U.S.C. § 824(b)(1): The provisions of this Part shall apply to the transmission of electric energy in interstate commerce and to the sale of electric energy at wholesale in interstate commerce . . . . The Commission shall have jurisdiction over all facilities for such transmission for sale of electric energy, but shall not have jurisdiction . . . . over facilities used in local distribution or only for the transmission of electric energy in intrastate commerce, or over facilities for the transmission of electric energy consumed wholly by the transmitter.

106. *Rice v. Santa Fe Elevator Corp.*, 331 U.S. 218, 230 (1947).

107. *English v. Gen. Elec. Co.*, 496 U.S. 72, 79 (1990).

108. *Freightliner Corp. v. Myrick*, 514 U.S. 280, 287 (1995).

109. E.g., *Nantahala Power & Light Co. v. Thornburg*, 476 U.S. 953, 969 (1986) (North Carolina utility commission's electricity ratemaking conflicted with rates devised by Federal Energy Regulatory Commission pursuant to Federal Power Act).

110. Two recent and especially notable decisions of this sort relate to Zero Emissions Credits schemes that support the continued operation of uneconomic nuclear power plants in Illinois and New York. Elec. Power Supply Ass'n v. Star, 904 F.3d 518, 524 (7th Cir. 2018), reh'g denied (October 9, 2018) ("Those effects do not lead to preemption; they are instead an inevitable consequence of a system in which power is shared between state and national governments."); Coal. for Competitive Elec., Dynergy Inc. v. Zibelman, 906 F.3d 41, 54 (2d Cir. 2018) ("New York has kept the line in sight, and gone as near as can be without crossing it."). For a summary list of other cases that examine state energy laws under the dCC and preemption, see State Power Project, *State Cases: Summary of Proceedings*, https://statepowerproject.org/states/ (accessed December 27, 2018).

111. California Air Resources Board, Assembly Bill 32 Overview (2016), https://perma.cc/3XET-

NVRG; see also Global Warming Solutions Act of 2006 (setting statewide emissions reduction target and directing California Air Resources Board to implement programs to achieve "the maximum technologically feasible and cost-effective GHG emission reductions" in line with that target); Regional Greenhouse Gas Initiative, "Program Design," http://www.rggi.org/design/history; "Regional Greenhouse Gas Initiative, Memorandum of Understanding" (2005), https://perma.cc/EB4G-K37N.

112. Oregon Department of Environmental Quality, Draft Outline: Market Mechanism for Reducing Greenhouse Gas Emissions in Oregon (June 3, 2016), https://perma.cc/UJL9-BCAC.

113. See Office of the Secretary of State of Washington, "Initiative Measure No. 1631, An Act Relating to reducing pollution by investing in clean air, clean energy, clean water, healthy forests, and healthy communities by imposing a fee on large emitters based on their pollution," available at www.sos.wa.gov/_assets/elections/initiatives/finaltext_1482.pdf; see also description of the initiative at Ballotpedia, "Washington Initiative 1631, Carbon Emissions Fee Measure," available at https://ballotpedia.org/Washington_Initiative_1631,_Carbon_Emissions_Fee_Measure_(2018).

114. New York State Independent System Operator, "Carbon Pricing Draft Recommendations: A Report Prepared for the Integrating Public Policy Task Force," (August 2, 2018).

115. California Air Resources Board, Overview of ARB Emissions Trading Program (February 2015), https://perma.cc/NNQ3-XHEW.

116. Calculation based on RGGI & US GHG Inventory (2015).

117. RGGI, "RGGI States Announce Proposed Program Changes: Additional 30% Emissions Cap Decline by 2030," (August 23, 2017).

118. RGGI, "The Investment of RGGI Proceeds in 2015," at p. 3 (October 2017).

119. See Meredith Fowlie and Danny Cullenward, "Chapter 4: Emissions Leakage and Resource Shuffling," in Independent Emissions Market Advisory Committee Annual Report 25, 26–30 (October 2018) (discussing forms of leakage and California's policy responses to them); see also Danny Cullenward, *How California's carbon market actually works*, 70 Bulletin of the Atomic Scientists 1938 (2014).

120. Galen Barbose, Lawrence Berkeley National Laboratory, U.S. Renewables Portfolio Standards 2016 Annual Status Report 5 (April 2016), http://bit.ly/29CI8s6.

121. Ibid.

122. WSPP Inc., 139 FERC ¶ 61,061, 18–21 (2012).

123. See, e.g., 310 Code Mass. Regs. 7.75 (December 2017).

124. See Order Adopting a Clean Energy Standard (CES Order), New York Public Service Commission, Case Nos. 15-E-0302, 129–134 (August 1, 2016).

125. FEJA, Public Act 099-0906 (December 7, 2016), https://perma.cc/HRK5-75CU.

126. Coal. for Competitive Elec., Dynergy Inc. v. Zibelman, 906 F.3d 41, 46 (2d Cir. 2018) ("the ZEC program is not field preempted, because Plaintiffs have failed to identify an impermissible "tether" under *Hughes v. Talen Energy Marketing, LLC*, ––– U.S. ––––, 136 S.Ct. 1288, 1293, 194 L.Ed.2d 414 (2016) between the ZEC program and wholesale market participation; . . .").

127. CES Order at 51.

128. Coalition for Competitive Electricity v. Zibelman, 906 F.3d 41, 54 (2d Cir. 2018). As to the dCC claim, the court explained that because the plaintiffs owned no nuclear power plants outside of New York State, the plaintiffs suffered no injury from the fact that the program had thus far only benefited New York plants. Ibid. at 58.

129. Electric Power Supply Ass'n v. Star, Nos. 17-2433 & 17-2445 (September 13, 2018).

130. American Council for an Energy-Efficient Economy, State Energy Efficiency Resource Standards (EERS) (May 2016), http://bit.ly/2flob9c.

131. Richard Sedano, Regulatory Assistance Project, Presentation: "The Basics of Decoupling, A Superior Solution to the Throughput Incentive and remarks on EE Performance Incentives NCSL Webinar," 8–10 (February 12, 2015), http://bit.ly/2bkqMkO.

132. See Janine Migden-Ostrande et al., Regulatory Assistance Project, Decoupling Case Studies: Revenue Regulation Implementation in Six States 3–6 (June 2014), https://perma.cc/HLF5-28UC (providing background on decoupling and description of challenges of measuring its effects).

133. See ibid. 35–36 (discussing complementary EE policies employed in case study states).

134. For an overview of the logic and parameters of PACE programs generally, see American Council for an Energy-Efficient Economy, "Property Assessed Clean Energy (PACE)," https://perma.cc/HMC4-92AD (accessed June 1, 2017).

135. Ian M. Larson, Keeping PACE: Federal Mortgage Lenders Halt Local Clean Energy Programs, 76 Missouri L. Rev. 599 (2011).

136. PACENation, "C-PACE Market Update Q1 2016," (June 2016) https://perma.cc/8NTQ-PTWH (providing snapshot of financing for project on commercial properties flowing through forty operating PACE programs in thirty-two states and DC); PACENation, Residential PACE Near You, http://pacenation.us/pace-programs/residential/ (visited June 1, 2017) (showing locations of PACE programs nationwide).

137. Amanda C. Leiter, *Fracking, Federalism, and Private Governance*, 39 Harv. Envtl. L. Rev. 107 (2015).

138. 95–87, 91 Stat. 445 (Aug. 3 1977), *codified* at 30 U.S.C. §§ 1201–1328; *see also Bragg v. W. Va. Coal Ass'n*, 248 F.3d 275, 289 (4th Cir. 2001), cert. *denied*, 534 U.S. 1113 (Jan. 22, 2002)

(contrasting SMCRA with "other cooperative federalism statutes").

139. U.S. EIA, "Major fossil fuel-producing states rely heavily on severance taxes," August 21, 2015, http://bit.ly/2aB0XLV (comparing severance tax revenues across mineral types and states).

140. Clean Air Act § 209(a).

141. Ibid. § 209(e). The most recent grant of a significant waiver related to the regulation of GHGs from vehicles was in 2013. California State Motor Vehicle Pollution Control Standards; Notice of Decision Granting a Waiver of Clean Air Act Preemption for California's Advanced Clean Car Program and a Within the Scope Confirmation for California's Zero Emission Vehicle Amendments for 2017 and Earlier Model Years, 78 Fed. Reg. 2,112 (Jan. 9, 2013).

142. Clean Air Act § 177 (authorizing other states to copy California).

143. See EPA, News Release: EPA and DOT Finalize Greenhouse Gas and Fuel Efficiency Standards for Heavy-Duty Trucks (August 16, 2016), https://perma.cc/QF6Z-HMLL ("The agencies have worked closely with the State of California's Air Resources Board in developing and finalizing the standards. All three agencies are committed to the goal of setting harmonized national standards.").

144. See Grab et al. (2018), at i ("Since the waiver provision was enacted in 1967, the EPA has granted more than fifty waivers for California, fully denied only one (a decision it subsequently reversed), and revoked zero.").

145. Aircraft endangerment finding; ABJ ruling denying M2D rest of case re undue delay on aircraft emissions; Complaint for Declaratory and Injunctive Relief, *Center for Biological Diversity v. EPA*, 1:16-cv-00681-ABJ (D.D.C.) (April 12, 2016) ("1. EPA has delayed unreasonably in (1) issuing an 'Endangerment Finding' for aircraft determining that carbon dioxide (CO2) emitted by aircraft engines causes or significantly contributes to air pollution which may reasonably be anticipated to endanger public health or welfare; and (2) promulgating regulations limiting such emissions. 2. Plaintiffs petitioned EPA to issue the endangerment finding and promulgate standards in 2007. EPA's delay in this matter so far exceeds eight years."); Complaint for Declaratory and Injunctive Relief, *U.S. Humane Society v. EPA*, Civil Action No. 15-cv-0141, (D.D.C. Jan. 28, 2015) (alleging EPA may no longer delay in responding to petitions for rulemaking to address GHGs and other emissions from CAFOs).

146. Notably, adoption of a particular NSPS incidentally sets a minimum performance standard for BACT applicable to that source category. 42 U.S.C. § 7479(3); *see also* EPA, PSD and Title V Permitting Guidance for Greenhouse Gases 20–21 (March 2011), https://perma.cc/UYD3-UCE4.

147. Richard L. Revesz and Jake Lienke, Struggling for Air: Power Plants and the "War on Coal" 85–86 (2016).

148. See Michael Burger et al., Legal Pathways to Reducing Greenhouse Gas Emissions Under

Section 115 of the Clean Air Act, 28 Geo. Envtl. L. Rev. 359, 362 (2016).

149. EPA, Sources of Greenhouse Gas Emissions: Transportation Sector Emissions, https://bit.ly/2QNTyMg (last updated April 12, 2018).

150. Chris Gearhart, National Renewable Energy Laboratory, *Implications of sustainability for the United States light-duty transportation sector*, 3 MRS [Materials Research Society] Energy & Sustainability: A Rev. J. 1 (2016); Anant D. Vyas et al., Transportation Energy Futures Series: Potential for Energy Efficiency Improvement Beyond the Light-Duty-Vehicle Sector, DOE/GO-102013-3706 (February 2013), https://perma.cc/U3YB-2ZZF.

151. See Stefan Ambec et al., *The Porter Hypothesis at 20: Can Environmental Regulation Enhance Innovation and Competitiveness?*, 7 Review of Environmental & Economic Policy 2, 4 (2013) (examining evidence supporting and challenging hypothesis that regulatory requirements can overcome market failures by pushing firms to make risky but profitable investments in new technologies, as first articulated by Michael Porter and C. van der Linde, *Toward a new conception of the environment-competitiveness relationship*, 9 Journal of Economic Perspective 97 (1995)).

152. US EPA, US Department of Transportation, and California Air Resources Board, Draft Technical Assessment Report: Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022–2025, EPA-420-D-16-900 [hereinafter TAR 2016], at 3-2, 3-3, 3-12 (July 2016); EPA, Greenhouse Gas Emission Standards for Light-Duty Vehicles Manufacturer Performance Report for the 2013 Model Year, EPA-420-R-15-008a (Mar. 2015), https://perma.cc/GL9R-CQ8Z (reporting that manufacturers consistently exceeded standards).

153. Antonio M. Bento et al., *The Impact of CAFE Standards on Innovation in the US Automobile Industry*, No. 206195, 2015 AAEA & WAEA Joint Annual Meeting, July 26–28 (2015), San Francisco, California, Agricultural and Applied Economics Association, https://perma.cc/P4RL-JCCE ("show[ing] that the changes in the rate of innovation is proportionate to the changes in the CAFE standards").

154. Id. at 9-10.

155. 75 Fed. Reg. at 62,811 ("EPA believes it is worthwhile to forego modest additional emissions reductions in the near term in order to lay the foundation for the potential for much larger 'game-changing' GHG emissions and oil reductions in the longer term."); see also Alan Jenn et al., *Alternative Fuel Vehicle Adoption Increases Fleet Gasoline Consumption and Greenhouse Gas Emissions under United States Corporate Average Fuel Economy Policy and Greenhouse Gas Emissions Standards*, 50 Environmental Science & Technology 2165 (2016), https://perma.cc/7CHB-XAJC.

156. National Research Council, Cost, Effectiveness, and Deployment of Fuel Economy Technologies for Light-Duty Vehicles 345 (2015) ("This incentive may drive additional deployment of PEVs. But this may not be the most cost-effective way to increase the number of alternative fuel vehicles in the long run."); Sanya Carley et al., "Rethinking

Auto Fuel Economy Policy Technical and Policy Suggestions for the 2016–17 Midterm Reviews. 45–47 (February 2016), https://perma.cc/VZ6Q-ZT6E (recommending critical examination of programs encouraging purchase of zero-emission vehicles).

157. In addition, although the NHTSA has been *authorized* to set fuel economy standards since the 1970s, only since EISA's passage has it been *required* to do so, and to "maximum feasible" levels. Pub. L. 110–140, title I, §§ 102, 104(b)(1), 121 Stat. 1498, 1503 (Dec. 19, 2007), codified at 49 U.S.C. § 32902(a), (f). That requirement for passenger and light duty vehicles expires in 2030. Ibid. § 32902(b)(2)(B).

158. President Gerald R. Ford, *Remarks at the White House Conference on Domestic and Economic Affairs in Hollywood, Florida* (February 25, 1975), www.presidency.ucsb.edu/documents/remarks-the-white-house-conference-domestic-and-economic-affairs-hollywood-florida.

159. See 49 U.S. Code § 32905; Alternative Motor Fuel Act of 1988, Public Law 100-494, 102 Stat. 2441, Sec. 2 (6)–(9).

160. EPA & NHTSA, Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule, 75 Fed. Reg. 25324, 25327 (May 7, 2010).

161. EPA, "Obama Administration Finalizes Historic 54.5 mpg Fuel Efficiency Standards/Consumer Savings Comparable to Lowering Price of Gasoline by $1 Per Gallon by 2025," August 28, 2012, archive.epa.gov/epapages/newsroom_archive/newsreleases/13f44fb4e2c2d39d85257a68005d0154.html.

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168. Stephen L. McDonald, Distinctive Tax Treatment of Income from Oil and Gas Production,

10 Nat. Resources J. 97, 99 (1970).

169. Ibid.

170. See 26 USC §§ 263(c), 291(b).

171. Revenue Act of 1926, Sec. 204(c)(2).

172. Ibid.

173. DePaul College of Law, The Depletion Deduction in the Oil and Gas Industry for Federal Income Tax Purposes, 3 DePaul L. Rev. 233, 235 (1954).

174. See 26 USC §§ 263(c), 291(b), 611–13.

175. United States Self-Review of Fossil Fuel Subsidies Submitted December 2015 to the G-20 Peer Reviewers, 2–3, 2015.

176. Department of Energy, "Grid Resiliency Pricing Rule, Notice of Proposed Rulemaking," 82 Fed. Reg. 46940, 46941, October 10, 2017.

177. Federal Energy Regulatory Commission, "Order Terminating Rulemaking Proceeding, Initiating New Proceeding, and Establishing Additional Procedures," 162 FERC, para. 61,012, 12, January 8, 2018.

178. Metcalf, supranote 50, at 1 (accounting for about 90 percent of the roughly $4.5 billion annually recovered by the oil and gas sector from tax preferences). Specifically, he projects the following results: (i) lower rates of drilling in the near term: 9 percent for oil, 11 percent for gas; (ii) lower rates of domestic production in the long term: 5 percent for oil, 3–4 percent for gas; (iii) higher prices over the long term: 1 percent for oil (global) and 7–10 percent for gas (domestic); and (iv) lower rates of consumption over the long term: less than 1 percent (global) for oil and 3–4 percent (domestic) for gas.

179. Ibid. at 18.

180. Ibid. at 19.

181. Ibid.; compare G20 Leaders' Statement, The Pittsburgh Summit, September 24–25, 2009, para. 24 (2009), https://perma.cc/JP97-2H9H ("To phase out and rationalize over the medium term inefficient fossil fuel subsidies while providing targeted support for the poorest."), with G20 Energy Ministerial Meeting Beijing Communique, Final draft 4:00 a.m. 29 June 2016, at 7–8 (2016), https://perma.cc/T5QP-SZF3 (reporting no agreement as to deadlines or quantitative targets for phase-out).

182. See, e.g., Pavlos S. Georgilakis, Technical challenges associated with the integration of wind power into power systems, 12 Renewable & Sustainable Energy Reviews 852, April 2008; Paul Denholma and Robert M. Margolis, Evaluating the limits of solar photovoltaics (PV) in traditional electric power systems, 35 Energy Pol'y 2852, May 2007.

183. See Benjamin K. Sovacool, *Renewable Energy: Economically Sound, Politically Difficult*, 21

Elec. J. 18, June 2008.

184. See Felix Mormann, Requirements for a Renewables Revolution, 38 Ecol. L.Q. 903 (2011) (surveying myriad barriers to entry and arguing that carbon pricing would not overcome them).

185. Brittany Renee Mayes, Ted Mellnik, Kate Rabinowitz and Shelly Tan, "Trump's Trade War Has Started: Who's Been Helped and Who's Been Hurt," *Washington Post*, July 5, 2018.

186. FERC has an ongoing proceeding examining issues related to electrical grid resilience; see Federal Energy Regulatory Commission, "Order Terminating Rulemaking Proceeding, Initiating New Proceeding, and Establishing Additional Procedures," 162 FERC, para. 61,012, p. 12, January 8, 2018.

187. Camila Stark et al., Joint Institute for Strategic Energy Analysis, "Renewable Electricity: Insights for the Coming Decade," p. 8, February 2015, https://perma.cc/UK8W-2UYG (illustrating that ranges of levelized cost of entry of competing generation sources varies across US jurisdictions); ibid., p. 42 ("The fundamental driver of rapid renewables deployment in the United States is that cost improvements are making renewable power generation cost competitive with fossil fuels.").

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189. EIA, Today in Energy: Electricity Generation from Fossil Fuels Declined In 2017 As Renewable Generation Rose, March 20, 2018.

190. EIA, New Electric Generating Capacity in 2019 Will Come From Renewables and Natural Gas, January 10, 2019, https://www.eia.gov/todayinenergy/detail.php?id=37952.

191. 26 USC § 45 (b)(5), (d); 26 USC § 48 (a)(2)(A)(i)(II).

192. National Academies of Sciences, Effects of U.S. Tax Policy on Greenhouse Gas Emissions (William W. Nordhaus et al. eds., 2013), p. 70.

193. See 26 U.S.C. § 45.

194. See 26 U.S.C. § 48.

195. EIA, Monthly Energy Review, p. 171, December 2018.

196. See, e.g., Ian Parry and Kenneth A. Small, "Implications of Carbon Taxes for Transportation Policies," in *Implementing a US Carbon Tax: Challenges and Debates*, 211, 221–22 (Ian Parry et al. eds. 2015).

197. United States House of Representative, Market Choice Act, 115 Cong. 2nd Sess. H.R. 6463.

198. EPA, Lifecycle Greenhouse Gas Emissions for Select Pathways, July, 2016.

199. EPA, RIN Trades and Price Information, accessed on January 10, 2018, available at www.epa.gov/fuels-registration-reporting-and-compliance-help/rin-trades-and-price-information.

200. Stock, supranote 73, p. 4 (recommending basic changes to RFS).

201. Id. at 19. However, the RFS's effect on energy security has been the subject of debate. Analyses that observe a drop in the international price of oil as a result of biofuels production suggest that, by promoting a "rebound" effect, the RFS undermines its goal of averting oil consumption by making oil cheaper to consume. See Madhu Khanna and Xiaoguang Chen, *Economic, Energy Security, and Greenhouse Gas Effects of Biofuels: Implications for Policy*, Am. J. Ag. Econ., June 2013, p. 2–3 (discussing empirical evidence showing that "[b]y reducing the demand for oil, these policies could lower the world price of oil, and lower the consumer price of gasoline and blended fuel in the United States and lead gasoline consumption to rebound positively and to decrease by less than the energy equivalent increase in biofuel consumption."). This is not an inevitable feature of policies that promote biofuels: unlike the RFS quantity mandate, the blend mandate codified in California's low carbon fuel standard (LCFS) will tend to reduce fuels' overall GHG-intensity while raising their prices, and therefore will generally not result in rebound. Ibid. p. 3.

202. Lisa Ryan et al., Energy Efficiency Policy and Carbon Pricing (International Energy Agency 2011), pp. 23–25, 32–33." (examining question in relation to appliances), 32–33 (buildings).

203. Ibid., pp. 23, 32.

204. Ibid., p. 24 ("Better information can thus facilitate [EE] improvements, and policies to increase information can enhance the effectiveness of price signals," such as a carbon tax would send to consumers).

205. For a fuller articulation of this point in relation to renewable energy technology more generally, see Richard G. Newell, "The Role of Energy Technology Policy Alongside Carbon Pricing," in *Implementing a US Carbon Tax*, International Monetary Fund, pp. 179–190" at 179-190 (2015); see also Robert N. Stavins, *Repairing the R & D Market Failure*, The Envtl. Forum, January/February 2011, p. 16, (describing the "R & D market failure" and observing that "[e]mpirical analyses have repeatedly verified the crucial point that combining carbon-pricing with R & D support is more cost-effective than adopting either approach alone.").

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208. Ibid., p. ES-21.

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213. California Air Resources Board, CARB Amends Low Carbon Fuel Standard for Wider Impact, September 27, 2018, https://ww2.arb.ca.gov/news/carb-amends-low-carbon-fuel-standard-wider-impact, visited January 8, 2018. Producers and importers are complying by blending lower-emitting ethanols with standard gasoline. The California Air Resources Board's life cycle emissions analysis of blended fuels takes into account the energy source used for ethanol production as well as the emissions resulting from transport of the fuel from the site of production to sale. Ethanols produced in the Midwest, even if they were chemically identical to ethanols produced in California, receive higher emissions ratings because their production draws to a greater degree on coal-fired power plants and they traveled farther.

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