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Resources


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A Note from RFF's President

Resources for a Climate Policy Toolkit

At Resources for the Future (RFF), we use economic insight to help improve environmental, energy, and natural resource decisions. A critical effort in this mission is to halt climate change and mitigate its impacts, including decarbonization of the global economy.

In the United States, we've found ourselves at a pivotal moment when decarbonization efforts are being taken seriously and pursued ambitiously. From corporate boardrooms and the halls of Congress to the White House and state agencies, emissions reduction goals and strategies are being developed and vetted. These plans will touch every corner of the economy. This moment brings tremendous opportunity—and responsibility—to design policies that both meet climate goals and underpin a thriving and equitable economic future. Hence, the issue of *Resources* you now hold in your hands (or view on your screen).

It's important to move both quickly and wisely in times of great change, with input from wide-ranging stakeholder communities and impartial data driving decisions. In this spirit, RFF has compiled a comprehensive collection of policy options for decarbonizing the US economy. The articles here summarize thousands of collective hours of research and analysis by RFF experts on this topic. We hope this "Federal Climate Policy Toolkit" can help lead the way to net-zero emissions as the federal government takes action on climate change.

The articles in this issue of *Resources* describe policy options for decarbonizing all major sectors of the economy and have been assembled from our Federal Climate Policy Toolkit explainer series, available at **rff.org/toolkit**. I wrote the first article as a summary of the primary policy instruments that the federal government can employ to reduce emissions; the article also describes how we can combine policies to reach climate goals most effectively, efficiently, and equitably. The subsequent articles get more specific: economy-wide policies; the power sector; the transportation sector; the industrial sector; the buildings sector; land use, forestry, and agriculture; and the oil and gas industry.

We hope this magazine—along with related materials that are digitally available on **rff.org** and **resources.org**—can serve as a reference for decisionmakers and staff in Congress, the administration, you, and your colleagues as we all work together to scale back emissions and help support a healthy environment and thriving economy. I look forward to collaborating with you.

All best wishes,

Richard G. Newell
President and CEO, Resources for the Future

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Combating Climate Change with Fair Analysis

Resources magazine recently spoke with Ambassador C. Boyden Gray, a lawyer, diplomat, former White House counsel, and Resources for the Future (RFF) board member. Below are excerpts from the conversation, which covers his love of the outdoors, how nonpartisan analysis helps policymakers, and more.

Supporter Spotlight

In this RFF Supporter Spotlight feature, we hear directly from donors about their commitment to issues in climate, energy, and the environment; how they make a difference; and why they support Resources for the Future—all in their own words.

***Resources* magazine: Why are you interested in climate, energy, and environmental policy?**

C. Boyden Gray: In the early 1980s, when I served in the government during the Reagan regulatory reform era, the biggest problem we had was how to balance environmental goals with economic growth. It was an intensive indoctrination into the world of clean air and clean water, which I hadn't had from my prior legal practice. I got to love the Clean Air Act and was a principal architect of the 1990 amendments.

That interest was supported by my upbringing—spending the summers of my childhood in the Blue Ridge Mountains in North Carolina, and then some of my adulthood on Mount Desert Island in Maine, where pollution was a major concern. The highest ozone readings on the East Coast tend to be taken on Mount Desert Island: in the old days, you'd fly in and see this ring of pollution around the perimeter. Now, that's all disappeared. So, the Acid Rain Program was a special interest to me, mostly because of the Blue Ridge and Maine.

You've been an RFF board member for much of the past decade and a supporter of RFF for over two decades. What continues to keep you engaged?

In my view, RFF is the most open-minded, fair source of analysis of what can be done—and how it can be done with the greatest efficiency and productivity. That's what attracted me, and that's what keeps me engaged. Climate change is going to be a difficult challenge for everybody; RFF has the background, the structure, and the history of dealing more honestly with these issues than any other group I know of.

> **"RFF is the most open-minded, fair source of analysis of what can be done—and how it can be done with the greatest efficiency and productivity. That's what attracted me, and that's what keeps me engaged."**

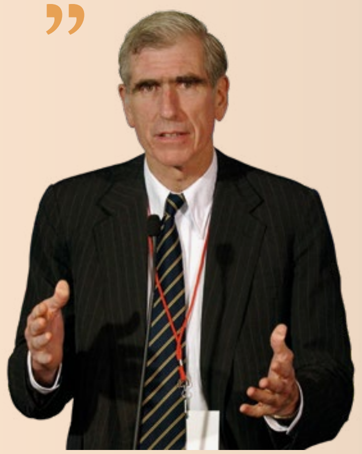


PHOTO C. Boyden Gray with former President George H. W. Bush
Courtesy of C. Boyden Gray

What do you see as the role of economics in achieving a healthy environment and a thriving economy?

Economics, fairly applied, is the best way to guarantee those twin objectives. To get the most bang for your buck, you've got to take the economics very seriously. If you look at emissions reductions from a cost-per-ton point of view, I think you can't go wrong. But you have to know what the cost per ton is, just as you have to know what the cost of carbon is—that's an example in which RFF has been a pioneer.

How can the nonpartisan analysis that RFF provides help decisionmakers in today's polarized political climate?

RFF has an opportunity to walk the tightrope, if you will—to get in between and get the best out of both sides. I think RFF's reputation as an honest broker is useful, and it's sought by both Republicans and Democrats, liberals and conservatives. The greatest calling card RFF has is its strict adherence to what the data show and not letting fashion or fad or passion dictate the result. That's why I think RFF has a great role to play—and a great responsibility, actually.

Drawing from your background in government and the private sector, how would you describe RFF's value to decisionmakers?

Regulatory agencies know that their ability to make progress depends on not overreaching, which creates a backlash. I think policymakers on both sides get comfort in knowing that, when they're dealing with data and conclusions from RFF, they're not likely to go wrong. The ability of RFF and the work it does to be evenhanded, nonpartisan, and nonideological—that's something people value a great deal. In this period of grappling with the enormous challenge of climate change, we'll greatly benefit if RFF can continue impartially presenting the facts that underlie where we should be going and how we can best get there.

Four Ways You Can Support RFF

1 Give through our website

Visit www.rff.org/donate to make a one-time donation, or to set up a monthly recurring donation.

2 Give through the mail

Send your check to Resources for the Future | 1616 P Street NW, Suite 600 | Washington, DC 20036

3 Give through a donor-advised fund

Donate through a DAF account at a community foundation or financial institution to support RFF while receiving favorable tax benefits.

4 Give through a will, trust, or gift plan

Include RFF in your estate plans to provide meaningful, long-lasting support.

Discover other ways to give at www.rff.org/donate/ways-giving or contact Tommy Wrenn at twrenn@rff.org

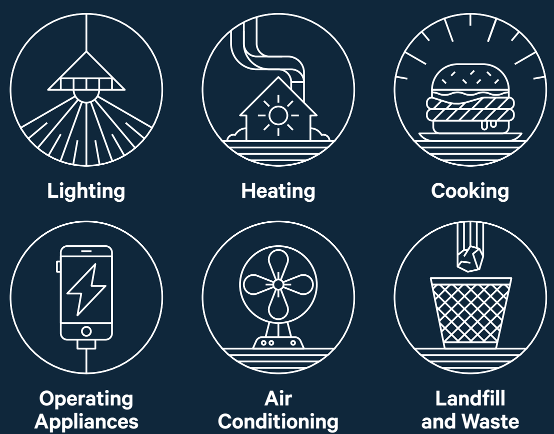
US Greenhouse Gas Emissions by Sector

To find strategies and solutions for reducing greenhouse gas emissions in the US economy, we first need to identify the sources and quantities of those emissions.

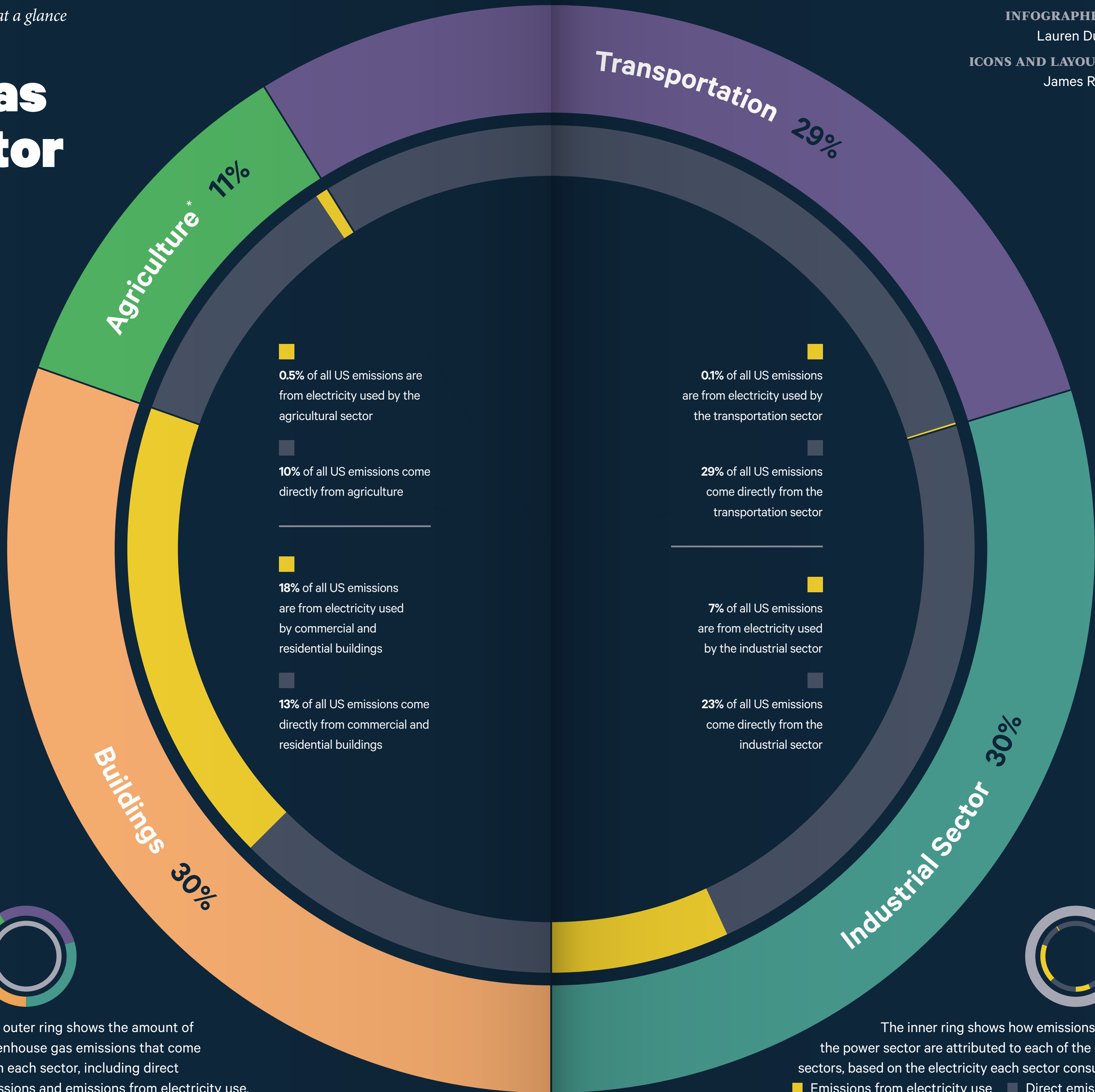
Agriculture* 11%

Discover strategies for reducing these emissions on page 44.

Buildings 30%



Discover strategies for reducing these emissions on page 38.



The outer ring shows the amount of greenhouse gas emissions that come from each sector, including direct emissions and emissions from electricity use.

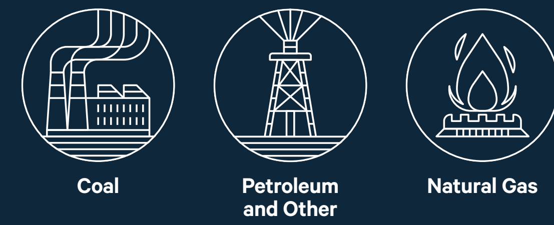
The inner ring shows how emissions from the power sector are attributed to each of the other sectors, based on the electricity each sector consumes.

■ Emissions from electricity use ■ Direct emissions

INFOGRAPHIC BY
Lauren Dunlap
ICONS AND LAYOUT BY
James Round

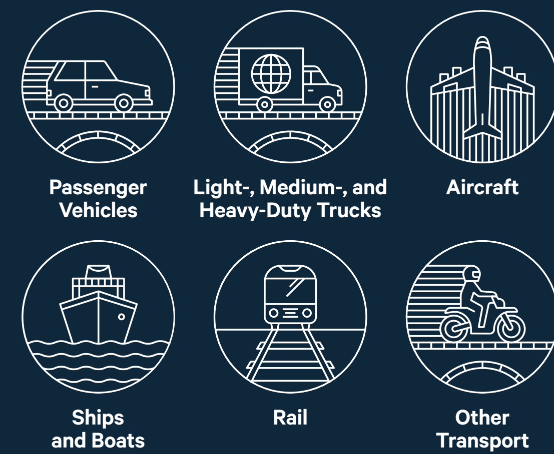
Power Sector

Power sector emissions come primarily from the combustion (burning) of natural gas and coal to generate electricity.



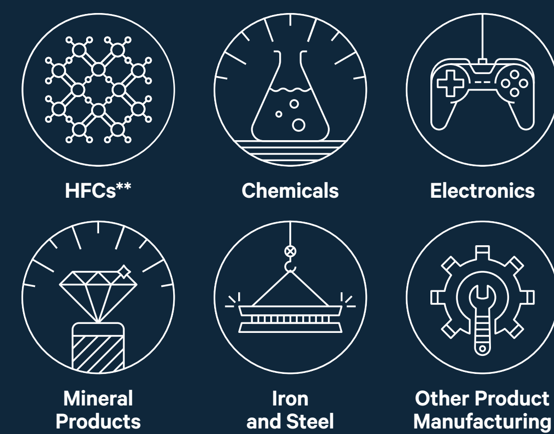
Discover strategies for reducing these emissions on page 18.

Transportation 29%



Discover strategies for reducing these emissions on page 24.

Industrial Sector 30%



Discover strategies for reducing these emissions on page 32.

* Land use and forestry remove carbon from the atmosphere (serve as a carbon sink)

** Hydrofluorocarbons

FEDERAL CLIMATE POLICY 101

Reducing Emissions

Various federal policy tools are available to reduce greenhouse gas emissions across the US economy and ultimately mitigate climate change. Key criteria can help policymakers weigh the value of these tools, taking into account innovation and ancillary effects such as air pollution and environmental justice.

TEXT Richard G. Newell
ILLUSTRATION James Round

DID YOU KNOW?

This issue of *Resources* assembles all eight digital explainers from RFF's new Federal Climate Policy Toolkit, available online at **rff.org/toolkit** as a series that describes in detail the policy tools that the US federal government can use to reduce emissions and atmospheric concentrations of greenhouse gases.

To minimize increases in the overall temperature of the planet and related impacts, the US federal government can use climate policy to reduce the amount of greenhouse gases in the atmosphere. Climate policy includes policies that help mitigate climate change and adapt to climate change.

This article lays out the primary policy instruments—in general terms—that can help reduce atmospheric greenhouse gases. This article also describes how such policies can be evaluated, highlighting a set of criteria that can help to determine how effective, efficient, and equitable a policy will be in achieving its climate goals.

Tools in the Climate Policy Toolkit

The United States emits billions of metric tons of greenhouse gases into the atmosphere every year—6.5 billion metric tons of carbon dioxide–equivalent in 2019. The visualization on pages 6 and 7 shows the breakdown of where these emissions originated, by economic sector. Major policy approaches under consideration for reducing greenhouse gases fall into three main categories: carbon pricing, technology subsidies, and performance standards. Carbon pricing policies provide a direct financial incentive to reduce emissions and can be implemented through a tax or fee (e.g., in dollars per ton), or through the establishment of a market-based cap-and-trade system.

Technology and innovation subsidies provide incentives for low-emissions technology deployment and innovation and can be implemented through tax credits or direct public funding. Performance standards require specific products or processes to meet certain minimum or average levels of technical performance (e.g., miles per gallon, tons of carbon dioxide per kilowatt-hour) and can range from being flexible, broad, and market based, to being prescriptive and site specific. Beyond these three major approaches, procurement policies, international agreements, and a wide array of other programs can play important roles in a comprehensive climate policy portfolio.

One of the most important attributes of individual climate policies is whether they are based principally on economic incentives, which leverage market forces to reduce emissions, or prescriptive regulatory approaches that rely on regulatory requirements and associated penalties. Many policies—particularly performance standards—fall on a continuum depending on their degree of flexibility across firms, locations, and technologies for meeting mandates. The different policy approaches can be and are used in combination.

> **"The United States emits billions of metric tons of greenhouse gases into the atmosphere every year—6.5 billion metric tons of carbon dioxide–equivalent in 2019."**

Carbon Pricing Policies

Carbon pricing policies require companies to pay a price for each ton of carbon emissions they release. This price, which generally escalates over time, changes the relative cost of fuels and products, increasing the price of high-emitting fuels and products relative to those with lower emissions.

Benefits and Challenges

- ✓ A carbon price is comprehensive and percolates through the entire economy, providing an incentive for all decisionmakers to find ways of reducing emissions (e.g., improving the boiler in a factory, buying a more efficient air conditioner at home).
- ✓ A carbon price provides businesses and households with the flexibility to make decisions based on their own information.
- ✓ Existing markets can seamlessly incorporate the value of reducing emissions in the prices of all goods and services.
- ✗ Explicit carbon pricing policies have faced significant political headwinds in the US Congress.

Performance Standards

Performance standards are a broad set of policies that set benchmarks that firms must meet. These standards can be applied in many different economic sectors. Examples of performance standards include clean electricity standards and renewable portfolio standards in the power sector (which set benchmarks for the amount of electricity that must come from low-carbon energy sources); fuel economy standards (miles-per-gallon standards), renewable fuel standards, low-carbon fuel standards, and zero-emissions vehicle standards in the transportation sector; emissions performance standards in the industrial sector; and appliance efficiency standards and building codes in the commercial and residential buildings sector.

Performance standards can be designed with widely varying degrees of flexibility and tradability across firms. On the most prescriptive end of the continuum are technology standards, which require firms and facilities to install and use specific types of technologies to reduce emissions. A good example of this prescriptive type of standard can be found in the US Environmental Protection Agency's New Source Review requirements for the construction of new or significantly upgraded power plants: to be granted a permit, these plants must include plans to install "Best Available Control Technology" for mitigating conventional air pollutant emissions.

More flexible performance standards generally do not dictate what technologies a firm should use to meet established benchmarks, instead allowing firms to do so in the most cost-effective ways they can. These policies typically consider a broad range of technologies as compliance options, sparking industry creativity with respect to how they meet the targets at lowest cost. Such standards may establish different benchmarks at the facility or firm level, or use tradability to offer flexibility for meeting benchmarks across a substantial portion of the economy. For example, clean electricity standards have been proposed that set targets for an increasing share of overall electricity sales to come from clean power, which would give rise to a national market for clean power credits.

Benefits and Challenges

- ✓ Performance standards increase the cost of low-performing technologies (e.g., a car with higher greenhouse gas emissions) relative to higher-performing technologies.
- ✓ Performance standards have less impact on consumer prices, compared with carbon pricing policies.
- ✓ Performance standards can be effective alone or when combined with carbon pricing policies.
- ✓ When designed carefully, performance standards can be cost-effective within a given sector.
- ✗ Performance standards lead to more expensive emissions reductions, compared to carbon pricing policies.

Technology Deployment Subsidies

Most technology deployment subsidies in the United States have taken the form of tax credits; other approaches include direct payments, loan guarantees, reverse auctions, feed-in-tariffs, and contracts for differences.

Tax credits provide a financial incentive that encourages a particular economic activity through the reduction of tax payments. In the clean energy context, tax incentives motivate companies and households to build, produce, or consume technologies and products that have low or zero emissions. For instance, a tax incentive might persuade people to buy electric vehicles rather than gasoline vehicles; encourage electric power from solar, wind, and other renewable power sources; or support the capture and underground storage of carbon dioxide.

Tax credits have been employed for years at the federal level. Examples include the Production Tax Credit and Investment Tax Credit for wind and solar power, and the federal tax credit for electric vehicles, which reduce the cost of building and deploying these technologies.

Benefits and Challenges

- ✓ Tax credits spur considerable private investment in initial deployment.
- ✓ Tax credits encourage technological innovation and learning-by-doing through deployment.
- ✗ Cost-ineffective way of reducing emissions over the long term, in part because tax incentives can require large amounts of public spending as deployment scales up.

Procurement Policies

Public procurement of goods makes up a sizable portion of the US and global economies—12 percent globally, by World Bank estimates. By establishing "green procurement" policies and programs, policymakers can encourage or require government agencies to purchase relatively sustainable goods (e.g., steel and cement, vehicles, office equipment). Given the size of the federal government, procurement at the federal scale can drive innovation investments, creating or bolstering markets for advanced technologies and high-performance products that otherwise would be less competitive. By establishing a "demand-pull" for the development of emerging technologies, government procurement creates a customer base and reduces the risk associated with investing in advanced energy technologies and other emissions reduction techniques.

> "The Paris Agreement and other international agreements are important policy tools for contributing to multinational climate strategies and for leveraging reciprocal action by other countries to reduce overall global emissions."

PHOTO
Former US Secretary of State John Kerry addresses delegates before signing the Paris Agreement
US Department of State

Public Funding for Innovation

Investing in research and development of advanced clean energy and emissions reduction technologies is a critical element of climate mitigation policy. Because the private sector often underinvests in long-term research, the federal government can—and frequently does—play a key role in providing foundational funding for the research and development of emerging technologies. The federal government can increase funding for this activity as a strategy for addressing climate change.

The government recently authorized billions of dollars of additional federal funding for clean energy research, development, and deployment via the Energy Act of 2020, which focuses on fostering energy innovation by modernizing US energy policies. The act establishes research and development programs for energy storage technology, hydrogen, carbon capture, and more.

International Agreements

The Paris Agreement on climate change is a legally binding agreement in which the countries that join must pursue significant efforts toward keeping global warming below 2ºC. The international popularity of the Paris Agreement can in large part be attributed to its flexibility: individual countries establish their own targets while being held accountable to amplify their goals over time. The Paris Agreement and other international agreements are important policy tools for contributing to multinational climate strategies and for leveraging reciprocal action by other countries to reduce overall global emissions.

DID YOU KNOW?

Benefits and Costs

When evaluating climate policy approaches, the overall benefits and costs of the policy to society are important to consider. In estimating the potential or actual benefits of a policy, several factors are critical, including the social cost of carbon and the co-benefits of the policy.

Social Cost of Carbon (SCC)
The SCC is a policy tool that enables decisionmakers to place a value on the benefits of a policy that reduces carbon dioxide emissions. The SCC does so by measuring, in dollar terms, the damage caused by one ton of carbon dioxide emissions released into the atmosphere. (Similarly, the social cost of methane and social cost of nitrous oxide measure the benefits of reducing these other potent greenhouse gases.)

Co-benefits
Co-benefits are ways in which a policy helps society beyond its principal motivation or purpose. For instance, if a carbon price is implemented to reduce greenhouse gas emissions and mitigate climate change, the same policy will also tend to reduce local air pollution. The benefits of reduced pollution, such as improved health outcomes for people breathing cleaner air, are co-benefits of the carbon pricing policy. Co-benefits are essentially a category of policy benefits, and it is important to consider them in benefit-cost analysis.

Cross-Cutting Criteria for Policy Evaluation

How can decisionmakers decide among the available tools for crafting climate policy, given the wide range of options available to them? Described below are various criteria for evaluating climate policy strategies.

Distributional Impacts and Equity

Policies have different effects on different subgroups of people, a phenomenon related to equity known as "distributional impacts." Increasingly, concerns about the distributional impacts of policies on different individuals, groups, communities, and regions assume a central place in the climate policy conversation. The equity impacts of a policy—its relative impacts on low-income and non-white communities compared to higher-income and white communities—are important for policy design and evaluation. Communities of color, low-income communities, and other environmental justice communities are most vulnerable to both the effects of a changing climate and the potential costs of climate policy. And many in these communities do not get the benefits that have accrued elsewhere.

Driving Technological Innovation

Technological innovation is a crucially important element of a comprehensive climate policy strategy, both domestically and internationally. Deep emissions reductions will depend heavily on improvements in the availability, cost, and performance of technologies that can reduce emissions while meeting other needs across multiple sectors. Innovation in carbon removal technologies—including direct air capture—also is necessary to compensate for hard-to-avoid emissions in a net-zero strategy, and to drive net-negative emissions if we surpass tolerable levels of atmospheric greenhouse gases.

Job Creation

As the US economy shifts away from fossil fuels and toward clean energy sources, employment patterns are changing—and workers and communities that depend on fossil fuel jobs could be negatively impacted. While measuring the employment-related impacts of any particular policy is challenging—as job losses may occur in one place and employment may increase in another—it is important for decisionmakers to evaluate the effects of policies on existing jobs, workers, and communities. It is also important to consider how policies can lead to job growth—and what complementary policies or programs might be needed to prepare people to fill new roles.

Policy Interactions

The United States already has established emissions reductions policies at both the federal level (e.g., tax credits for wind, solar, carbon capture, and electric vehicles; automobile standards) and the state level (e.g., renewable portfolio standards, cap-and-trade systems). New emissions reduction policies introduced in the United States therefore will come into force in combination with policies already on the books. To design a robust and cost-effective policy portfolio, it will be important to understand how policies interact and where new and existing policies complement each other.

Effectiveness in Achieving Emissions Reductions

A clear and obvious criterion for evaluating climate policy is the amount of emissions reductions achieved. If a policy does not reduce emissions—or, worse, if the policy leads to increased emissions—then it is not effective. The pace and cumulative quantity of reductions over time also is critical; for instance, a policy that leads to a small amount of reductions initially may lead to greater reductions later (e.g., through innovation), resulting in a significant overall effect.

International Competitiveness and Reciprocal Action

Maintaining and improving international competitiveness is important for the strength of the US economy and national employment. The effectiveness of various climate policy options depends on how US climate policy affects the competitiveness of US companies in world markets, the treatment of international imports, and international climate actions. Domestic policy can motivate actions by other nations; for instance, border tax adjustments can level the playing field and increase the cost of carbon-intensive imported goods, encouraging other countries to make less-carbon-intensive goods.

Durability

Climate change is not a short-term problem; to avoid its worst impacts, long-term and durable change is necessary. As political administrations and elected officials shift over time, federal policy can change drastically. The durability of law—in other words, the likelihood that regulations and statutes will remain robust as political power shifts—is a critical criterion by which to evaluate policy. Durable legislation and regulation provide more certainty for firms making important investment decisions, enabling a more consistent, stable environment in which to address climate change over the long term.

Cost-Effectiveness

The cost-effectiveness of a climate policy quantifies the cost of emissions reductions, per unit, generated by the policy (typically measured in dollars per ton of carbon dioxide or other greenhouse gas). For instance, if one policy costs $10 to reduce emissions by one ton and another policy costs $100 to reduce emissions by one ton, the first policy is more cost-effective. Cost-effective policies lead to a stronger economy because they don't waste resources and can achieve more ambitious emissions reductions for a given amount of resources spent.

Conclusion

Federal policy to reduce greenhouse gas emissions can take many shapes. Beyond the factors described above, three additional observations can guide the climate policy conversation. First, the climate is changing due to human activity—and fossil fuel use in particular. Reducing net greenhouse gas emissions to zero is critical to halting global temperature increases and related disruptions to the climate system. Second, technology, policy, and markets all are important in mitigating climate change. A technology-inclusive approach to emissions reductions that embraces a wide range of options is both necessary and available. Finally, technological advances have made clean energy and other emissions reduction options more feasible and affordable, which can pave the way for ambitious climate action.

To successfully mitigate climate change, the policy options above must balance the needs of different sectors and communities, encourage businesses and individuals to choose low-emissions options, and spur technological innovation.

> "To successfully mitigate climate change, the policy options above must balance the needs of different sectors and communities, encourage businesses and individuals to choose low-emissions options, and spur technological innovation."

Richard G. Newell *is the president and CEO of Resources for the Future.*

This article is available at **rff.org/toolkit** *as a published explainer titled "Federal Climate Policy 101: Reducing Emissions."*

FEDERAL CLIMATE POLICY 102

Economy-Wide Policies

TEXT
Marc Hafstead

Economy-wide federal climate policy options include approaches that cover all emissions from all sectors, such as carbon taxes and cap and trade, or an alternative strategy that combines various policy instruments to systematically tackle emissions sector by sector through a portfolio of regulations.

PHOTO
An aerial panorama of the downtown Los Angeles skyline at sunset
halbergman / Getty Images

The United States emits billions of metric tons of greenhouse gases into the atmosphere every year—6.5 billion metric tons of carbon dioxide equivalent in 2019 alone.

Federal emissions reduction policies can be designed to cover the entire economy or target specific sectors. Economy-wide policy options include carbon pricing, along with other comprehensive policy portfolios that combine sector-specific policies across the entire economy. This article provides an overview of economy-wide policy options, comparing pricing programs to a portfolio approach that seeks to reduce emissions, sector by sector, throughout the economy.

Carbon pricing is widely recognized as the most economically efficient approach to reducing carbon dioxide (CO_2) emissions, meaning that this approach achieves emissions reduction at the lowest possible cost to society. By giving all emitters the same incentive to reduce their emissions, a pricing mechanism can cost-effectively reduce emissions. However, many climate advocates and others do not think that carbon pricing should be the primary mechanism to reduce emissions. As an alternative to carbon pricing, a sectoral portfolio approach seeks to reduce emissions economy-wide, with a targeted approach for each specific source of emissions. Opponents of carbon pricing often favor the sectoral portfolio approach.

Economy-Wide Carbon Pricing

The Basics

Two forms of economy-wide carbon pricing are available: a carbon tax and a cap-and-trade program.

A carbon tax is a set price that each emitting entity must pay per ton of CO_2 they release into the atmosphere. A $3 tax per ton of CO_2 is equal to an $11 tax per ton of carbon, because carbon constitutes roughly 3/11 of the weight of CO_2.

A cap-and-trade program limits the total amount of CO_2 that can be emitted by a certain set of facilities. In a cap-and-trade program, the government issues a limited number of emissions allowances (also known as permits), each of which grants the holder the right to emit one ton of CO_2. Allowances can be distributed in various ways: they can be directly allocated to firms or facilities (a method called free allocation of allowances) or sold through auction markets. The limited, government-controlled supply of allowances "caps" the total amount of emissions. Allowances can be traded, and these sales and purchases (supply and demand) yield a market price for allowances—essentially the price of one ton of CO_2 emissions.

An economy-wide carbon price would cover all sources of energy-related CO_2 emissions from all sectors—power, transportation, industry, and buildings (commercial and residential). It could be implemented through an upstream price that requires fossil fuel producers to pay taxes or submit allowances for the carbon content of their fuels (e.g., oil wells or coal mines), a midstream price that requires the first purchaser of the fuel to pay for the carbon content of the purchased fuels through taxes or allowances (e.g., refiners would pay a tax that reflects the carbon content of each barrel of oil purchased), or a downstream price that applies directly to the emitter (e.g., coal-fired power plant, households, or firms).

Carbon taxes and cap-and-trade programs differ primarily by the type of certainty they provide. Carbon taxes provide price certainty, as entities subject to the tax know how much they'll have to pay per ton emitted—but simply setting a tax rate doesn't guarantee any particular level of emissions reductions. Cap-and-trade programs, on the other hand, set a cap on emissions and therefore provide quantity certainty—but price fluctuations under the trading market structure can provide a less solid basis for business planning decisions. Hybrid systems, however, can be used to reduce price or emissions uncertainty. Under cap-and-trade programs, price floors and ceilings have been proposed and utilized to prevent prices from being "too low" or "too high." Carbon taxes can also be designed to automatically adjust if actual emissions miss some predetermined emissions path.

Benefits and Challenges

- ✓ The flexibility of carbon pricing allows firms to choose the most efficient method to reduce emissions—or *not* reduce emissions—and it does not impose a one-size-fits-all policy across firms within a sector or across sectors.

- Carbon pricing equalizes the marginal abatement cost (the cost of avoiding one ton of emissions) across firms. This is a necessary condition to minimize the cost of reductions, and it allows for some sectors that can reduce emissions inexpensively (such as the power sector) to achieve greater reductions than those that cannot (such as the transportation sector).

- Both carbon taxes and cap-and-trade programs lead to price increases for energy- and carbon-intensive goods; for example, a $1 carbon tax will increase the price of gasoline by 1 cent per gallon, with all else kept equal. These price increases are salient to consumers—everyone sees changes to the price of gasoline—and can impact the competitiveness of energy-intensive firms (though policy design can offset some of the competitiveness issues).

- Some argue that economy-wide carbon pricing policies are unfair to lower-income households because they consume more energy as a fraction of their income than higher-income households. The impact of carbon pricing on lower-income households, however, depends on how the revenues are used. When revenues are returned to households in an equal dividend, many (if not most) households are better off than without a carbon price, because the dividend will exceed the increase in their energy costs. If revenues are used to reduce corporate taxes, however, the benefits primarily accrue to wealthier households.

- Most currently proposed carbon pricing policies are unlikely to drive significant decarbonization across all sectors of the economy, which leads some commentators to dismiss carbon pricing as an ineffective climate policy tool.

Key Considerations

- Stringency of the policy—either the level of the tax and how it escalates over time, or the amount of allowances and how they decrease over time.

- How the revenues are used, if any are raised—which can be as important as program stringency in determining the overall costs and how those costs are distributed. Tax swaps (using the revenue to reduce pre-existing labor, capital, or excise taxes) can reduce the overall costs of the policy. Dividends (direct payments to households) can offset increased energy costs for low-income households, and many studies find that most households would benefit from a carbon dividend.

- It may be possible to pursue a portfolio approach through existing legislative authority, such as the Clean Air Act (CAA). For example, the legal authority of the Obama-era Clean Power Plan—which was designed to force states to reduce the emissions intensity of their power sectors—is established in Section 111(d) of the CAA. Others argue that Section 115 of the CAA could be used to regulate greenhouse gas emissions, because the impacts of greenhouse gas emissions are global. However, any such rulemaking would face significant legal scrutiny and most likely would require the Supreme Court to weigh in on the legality of the rules, and there's no consensus that the CAA is a reliable vehicle for enduring and effective climate policy.

Past, Current, and Potential Economy-Wide Carbon Prices

Sixty-four carbon pricing initiatives currently exist across the world, in 46 national jurisdictions. Many of the policies are not true economy-wide policies and cover just a subset of emissions. The EU Emissions Trading System, for example, covers only 40 percent of Europe's emissions.

In the United States, no federal carbon pricing policies are in place, though several have been proposed in Congress. Several states and regions have implemented carbon pricing programs in some form, such as the Regional Greenhouse Gas Initiative and California's cap-and-trade program.

> **“In the United States, no federal carbon pricing policies are in place, though several have been proposed in Congress.”**

Marc Hafstead *is a fellow and director of the Carbon Pricing Initiative at Resources for the Future.*

This article is available at **rff.org/toolkit** *as a published explainer titled “Federal Climate Policy 102: Economy-Wide Policies.”*

Portfolio of Sector-Specific Policies

The Basics

An alternative to economy-wide carbon pricing is to pursue a portfolio of sector-specific policies that systematically cover emissions from the power sector, transportation, industry, and buildings. The Green New Deal and the CLEAN Future Act are examples of a portfolio approach to emissions reductions. This type of approach would combine many of the different policy instruments discussed in the "Federal Climate Policy 101" article in this issue of *Resources*, and subsequent articles in this magazine provide further explanations for many of these policy tools.

Benefits and Challenges

- With the sectoral approach, it might be easier to pass a collection of smaller policies in individual sectors than to pass an economy-wide carbon price as one law or in multiple pieces of legislation.

- A sectoral approach gives assurance that targets will be met, which could persuade those who may be skeptical of the effectiveness of a carbon price. The opportunity to tailor different policies for each sector, or multiple policies for different parts of a sector, can allow policymakers to account for challenges faced by different sectors and take advantage of many different policy tools.

- Prices for energy or energy-intensive goods most likely would increase less than under a carbon price, which is beneficial for domestic production and employment. Further, price increases caused by sectoral policies may be less salient for the average consumer. For example, fuel economy standards increase the cost of new cars, but not everyone buys new cars; however, most people purchase gasoline regularly.

- A sectoral approach might be very expensive, as it does not equalize marginal abatement costs across sectors, resulting in expensive reductions from sectors that are particularly difficult to decarbonize.

- Sectoral approaches are unlikely to generate revenue for the federal government; therefore, no revenue accrues that can be used to mitigate impacts on disadvantaged communities, as is the case with carbon dividends. Some policy packages (e.g., the Green New Deal) address these concerns in different ways, such as through job creation programs and other measures aimed at more progressive policy. However, such programs require funding.

Key Considerations

- The types of policies pursued in each sector have important implications for the overall costs of this type of approach. Some policies, such as clean energy standards, may be nearly as cost-effective as a carbon price, while others may be much more expensive.

- A prescriptive sectoral approach requires regulators to decide ahead of time which methods of emissions reductions are both feasible and cost-effective, whereas other policies such as the clean energy standard or tradable performance standards offer similar types of flexibility to firms to decide how to reduce their emissions.

- Different policies vary in how much of the total emissions they cover; to be most effective, all (or nearly all) emissions need to be covered.

The rest of the articles in this magazine, which cover the major types of federal climate policy among the most important sectors of the US economy, dive deeper into the key considerations required for each set of sectoral policies.

Conclusion

Both carbon pricing policies and sectoral portfolios have benefits and challenges. A regulatory, portfolio approach to emissions reductions is likely to be much less cost-effective than an economy-wide carbon price, due to the inability to equalize marginal abatement costs across firms within and across sectors and the inflexibility of some regulatory approaches.

Carbon pricing at sufficiently high levels, however, may not be politically feasible: it has many detractors across the political spectrum, and most efforts to pass economy-wide carbon pricing in the United States at both the federal and state levels have failed to date.

California, however, has adopted an economy-wide carbon price through the Western Climate Initiative cap-and-trade scheme, along with myriad sector-specific policies, including a clean energy standard, a low-carbon fuels standard, and requirements for new buildings to be energy efficient and have solar capacity.

A final consideration is that opportunities exist to achieve emissions goals through a combination of these options. As in California, economy-wide carbon pricing and a sectoral approach are not mutually exclusive. The federal government could pursue a similar approach that combines carbon pricing with sector-specific policies, but with care to prevent redundancies across overlapping policies.

FEDERAL CLIMATE POLICY 103

Power Sector

Options for decarbonizing the power sector through federal climate policy include carbon pricing; clean electricity standards; renewable portfolio standards; tax credits; research, development, and demonstration; and direct regulations.

TEXT Kathryne Cleary and Karen Palmer

ILLUSTRATION James Round

Over the past few decades, carbon emissions from the power sector have declined, due in large part to reduced power generation from coal in favor of cheaper natural gas and low-carbon energy. Looking to the future, several states have pushed for aggressive electrical system decarbonization strategies by requiring 100 percent zero- or low-carbon (or "clean") energy within the next few decades.

The power sector (also known as the electricity sector)—which includes the electrical grid system of power plants and lines that generates and distributes electricity to consumers—was responsible for about 25 percent of US greenhouse gas emissions in 2019. Within the sector, coal-fired power plants produce 59 percent of emissions, natural gas power plants contribute approximately 37 percent, and the remainder of the emissions come from petroleum and other sources (Figure 1).

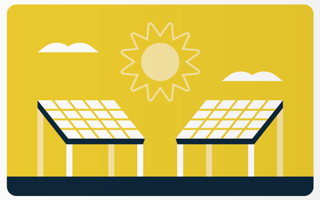
This article focuses on the tools that federal policymakers can use to reduce power sector emissions and mitigate the impacts of climate change. These tools include carbon pricing; clean electricity standards; renewable portfolio standards; tax credits; research, development, and demonstration; and direct regulations.

Emissions reductions in the power sector can come from three main sources: switching to cleaner fuels, improving the efficiency of existing power plants, and reducing electricity consumption. Future reductions in the sector likely will be achieved through a significant scale-up of renewable and zero-carbon resources, the use of carbon capture with existing fossil fuel resources, and reduced electricity demand due to efficiency improvements on the demand side. The policy options described below can be used to encourage each of these drivers of emissions reductions.

The Federal Climate Policy Toolkit

103

POWER SECTOR



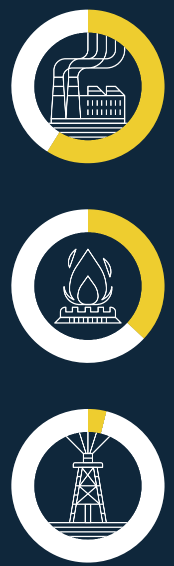
DID YOU KNOW?

Renewable Energy vs. Clean Energy

Renewable Energy
Refers to resources that can be replenished. Energy resources such as solar and wind are considered renewable because they rely on natural resources that cannot be used up. By contrast, resources like coal, oil, and natural gas take millions of years to be replenished; therefore, the supply of these resources is finite.

Clean Energy
Typically refers to resources that do not emit carbon dioxide. While most renewable resources also happen to be clean because they do not emit carbon dioxide, clean energy is a more inclusive term that extends beyond renewables and includes resources such as nuclear power.

FIGURE 1 **Power Sector Emissions**



Coal

59% of power sector emissions

15% of US emissions

Natural Gas

37% of power sector emissions

9% of US emissions

Petroleum and Other

4% of power sector emissions

1% of US emissions

Carbon Pricing

The Basics

Carbon pricing can take the form of either a carbon tax, which places a tax on each ton of carbon dioxide (CO_2) emitted, or a cap-and-trade policy, in which total CO_2 emissions from the power sector are capped and allowances to emit are traded in a market.

Benefits and Challenges

- ✓ Carbon pricing policies tend to be an economically efficient method of reducing greenhouse gas emissions, relative to other policy options for reducing emissions from electricity, because they directly target emissions.
- ✓ By increasing the cost of high-emitting power generation, carbon pricing encourages a transition away from carbon-intensive fuels in favor of lower-carbon fuels and can incentivize reductions in electricity consumption.
- ✗ Carbon pricing can be difficult to implement politically, due to resistance to new fees and corollary increases in retail electricity prices, as electric companies typically pass costs to ratepayers.

Key Considerations

- → How to use the revenues raised from the carbon price policy. Revenues could help offset the costs of the policy to consumers, either across the board or in a way that targets low-income consumers. Another option is to invest the revenues in other policy tools that further decarbonization goals, such as research and development for low-carbon technologies.
- → A carbon price that targets the power sector can discourage electrification of other sectors of the economy, because electricity becomes more expensive with the policy in place. As such, special attention to newly electrified vehicles, buildings, and other loads—such as through separate, lower electricity rates for electric vehicles—could be necessary, so that the carbon price does not discourage electrification.

Past, Current, and Proposed Carbon Pricing Policies

Several carbon pricing bills have been introduced in Congress, but historically, they have gained little traction. While no federal carbon pricing policy has come to fruition, several states have regional carbon pricing policies in place for electricity. For example, the New England states and California have had regional cap-and-trade programs for emissions from electricity in place for several years with success. The New York State grid operator also recently proposed incorporating a carbon price into its wholesale energy market.

PHOTO
Power lines in California
Pgiam / Getty Images

FIGURE 1 SOURCE
EPA Greenhouse Gas Inventory

> **“Several carbon pricing bills have been introduced in Congress, but historically, they have gained little traction.”**

Clean Electricity Standard

The Basics

A clean electricity standard (CES) (a type of clean energy standard) is a market-based policy that requires a minimum percentage of electricity sales to come from “clean” energy resources. This percentage requirement typically increases over time until it meets a goal, such as 100 percent clean electricity sales. While the definition of “clean” can vary from policy to policy, the term typically refers to low-carbon or carbon-free attributes and is technology inclusive, meaning that any technology that meets certain emissions requirements can qualify for credits. As such, a CES can encourage the use of zero-emitting renewables, nuclear, and fossil fuel plants fitted with carbon capture.

Benefits and Challenges

- ✓ Because a CES is technology neutral in its definition of “clean,” more technologies can compete to meet the standard, which lowers compliance costs relative to a more traditional Renewable Portfolio Standard (discussed below).
- ✓ A CES is structured similarly to Renewable Portfolio Standards used in most states today; therefore, a CES could be simpler to implement relative to other policy options.
- ✗ A CES *credits* clean electricity instead of *taxing* carbon-emitting electricity, and this crediting creates incentives to increase electricity generation. Therefore, the policy does not encourage energy efficiency or conservation to the same extent as a carbon price. Thus, a carbon tax can be a more efficient policy tool, because it encourages emissions reductions from both reduced electricity consumption and cleaner electricity generation, which can lower the costs of achieving carbon goals.

Key Considerations

- → How to set the federal standard, given existing state policies and existing resources. Some states, like California, already are pursuing 100 percent clean electricity portfolios, while others have not established clean energy policies and rely heavily on in-state fossil fuel resources for electricity generation. As such, a federal CES policy would have to ensure that the policy takes states' existing resource portfolios into account when establishing targets, to avoid a scenario in which polluting states bear most of the costs of compliance, which would result in a transfer of wealth from polluting states to cleaner states.

Past, Current, and Proposed CES Policies

A few CESs have been proposed at the federal level, but none has passed. For example, Senator Tina Smith (D-MN) and then-Representative Ben Ray Luján (D-NM) cosponsored the Clean Energy Standard Act of 2019 that requires 96 percent of electricity sales to come from clean sources by 2050. RFF analysis of the bill finds that the policy would have reduced emissions from electricity by about 10 billion metric tons, or by 61 percent, between 2020 and 2035. Other proposals, including the CLEAN Future Act and the Clean Energy Innovation and Deployment Act, have been introduced as well.

While no federal CES currently exists, some states have implemented versions of a CES. Massachusetts, for example, implemented a CES in 2017 that requires 80 percent of electricity sales to come from clean energy resources by 2050.

Renewable Portfolio Standard

The Basics

A renewable portfolio standard (RPS) is a market-based policy that requires a portion of electricity sales to come from renewable energy sources, with the requirement typically increasing over time. An RPS is similar to a CES in that renewable energy generators earn renewable energy credits for every megawatt-hour of electricity generated, which can be traded.

Benefits and Challenges

- ✓ RPS policies are already quite popular. Twenty-nine states and the District of Columbia have put in place a mandatory RPS, and an additional eight states have put in place a voluntary RPS. As such, the design and implementation of a federal RPS could be relatively straightforward in a substantial portion of the country.
- ✗ An RPS policy limits compliance to renewable technologies only and does not credit other carbon-free technologies such as nuclear plants; thus, an RPS may be more costly than a CES or carbon price in reducing emissions.
- ✗ Limiting the number of technologies that comply with the policy can make it more difficult to achieve ambitious targets; thus, this type of policy is limited in its ability to significantly reduce emissions.

Key Considerations

- → How to set the standard.
- → How to treat existing clean resources under the policy.
- → How to ensure equitable impacts among states in the transition away from fossil fuels.
- → How to treat diverse regions in a federal policy, given that a federal RPS can result in higher compliance costs for regions that are further behind in their pursuit of clean energy.

Past, Current, and Proposed Renewable Portfolio Standards

As stated above, the RPS is a popular policy tool among US states. These policies vary significantly in terms of stringency; some policies have modest goals, while others require 100 percent renewable energy within the next few decades.

Some federal RPSs have been proposed. In 2019, for example, former Senator Tom Udall (D-NM) introduced a bill that would have required 50 percent of electricity generation in the United States to come from renewable sources by 2035. Thus far, no federal RPS policies have passed in Congress.

Research, Development, and Demonstration

The Basics

Funding for research, development, and demonstration (RD&D) is a form of innovation policy that can support nascent or undeveloped technologies when the private market is not sufficient. This policy tool can help new technologies reduce costs and ultimately achieve commercial operation.

Benefits and Challenges

- ✓ RD&D can reduce the costs of nascent clean energy technologies and help enable a smooth transition to a decarbonized electric system.
- ✓ RD&D can lead to more clean technologies becoming commercially viable—and enable the discovery of new technologies and forms of energy, such as hydrogen—which could both improve grid operations in the future and lead to lower costs of meeting emissions goals, as more technologies compete to provide carbon-free electricity.
- ✗ This policy option poses some risk, as RD&D may not lead to the desired technological advances and cost reductions.

Key Considerations

- → RD&D funding is limited.
- → Funding should be allocated wisely among promising projects, consistent with decarbonization goals.
- → Research progress should be carefully monitored.
- → Clear information remains unavailable about which technologies will be most successful in driving down emissions.

Past, Current, and Proposed RD&D Funding

RD&D funding has been used frequently in the past to promote several technologies, including renewables such as solar and wind that are now competitive in the market. The Energy Act of 2020, passed as part of the omnibus spending bill in December 2020, is an example of using federal RD&D spending to promote decarbonization of the grid. Some aspects of the legislation increase funding for geothermal, carbon capture and storage, direct air capture, advanced nuclear, and energy storage technologies. These technologies offer grid benefits and services unlike other resources used today; they have the potential to better support grid reliability and could reduce the costs of achieving carbon goals. These technologies can complement intermittent renewable resources to better integrate these resources into the grid, and they can enable fossil fuel plants to participate in a low-carbon future with carbon capture technology.

> **“Tax credits, such as those available for wind and solar projects, can take the form of an up-front credit on an investment or a credit on energy generation from a particular resource.”**

Tax Incentives

The Basics

The tax code can be used to promote investment in clean energy technologies. Tax credits, such as those available for wind and solar projects, can take the form of an up-front credit on an investment or a credit on energy generation from a particular resource. These types of incentives can improve the economics of renewable projects by reducing the high costs of building new power plants. Tax credits also can be used to encourage a variety of investments, including the development of low-emitting technologies and transmission investments needed to integrate renewables into the grid.

Benefits and Challenges

- ✓ Tax credits have successfully encouraged investment in nascent technologies like wind and solar. Since renewable energy resources typically have very low operating costs but high up-front costs, tax credits that address these up-front costs can help a project attract financing from tax equity investors and improve the likelihood of its establishment.
- ✗ While tax credits can be effective at encouraging investment in clean resources, they do not work directly to reduce emissions or total electricity generation. As such, they are not as efficient at reducing emissions as a carbon price or CES policy.

Key Considerations

- → Whether to make tax credits technology specific or technology neutral. A technology-neutral approach could be more cost-effective relative to a technology-specific approach. However, the latter approach can promote investment in a particular technology that society might value.

Federal Energy Regulatory Commission Orders

The Basics

The Federal Energy Regulatory Commission (FERC), which regulates wholesale electricity transactions, can help enable a clean energy transition in a few ways. FERC could direct regional grid operators to account for the cost of carbon emissions in wholesale energy markets, so that the lowest-carbon resources are used first to meet electricity demand. FERC also could promote decarbonization by redesigning wholesale markets to better enable long-term investment in renewables and complementary resources such as energy storage. Lastly, FERC could take a more active role in encouraging regional transmission planning and investment, to facilitate long-distance transmission of power from wind- and solar-rich regions of the country to population centers that consume electricity.

Benefits and Challenges

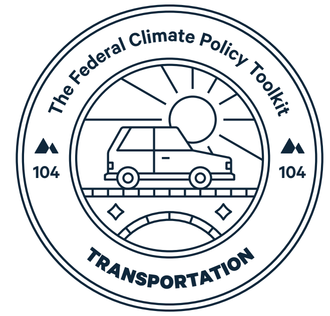
- ✓ Regulatory changes from FERC can complement legislative efforts and improve the efficacy of a carbon pricing policy.
- ✗ Although FERC has signaled that the agency is open to carbon pricing, the agency still needs a state or federal policy directive before implementing carbon pricing in the markets.

Key Considerations

- → Determination of FERC's legal authority to oversee carbon pricing through tariff approval.
- → How best to design wholesale markets to enable deep decarbonization of the power sector.

Kathryne Cleary *is a senior research associate and* **Karen Palmer** *is a senior fellow and director of the Future of Power Initiative at Resources for the Future.*

This article is available at **rff.org/toolkit** *as a published explainer titled “Federal Climate Policy 103: The Power Sector.”*



▸▸ FEDERAL CLIMATE POLICY 104

Transportation

The primary existing policies and policy options for reducing emissions from the transportation sector include renewable fuel standards and low-carbon fuel standards, programs that promote the use of alternative-fuel vehicles, and more.

TEXT Benjamin Leard
ILLUSTRATION Peter Greenwood

The transportation sector—which includes economic activity from all forms of travel—is the largest source of greenhouse gas (GHG) emissions nationally, accounting for 29 percent of the total GHG emissions in the United States in 2019.

Over the past 30 years, emissions from the transportation sector have grown by about 24 percent. Most modes of transportation depend heavily on fossil fuels for energy: passenger vehicles largely burn gasoline, delivery trucks typically use diesel fuel, and aircraft rely exclusively on jet fuel. Each of these fuels is derived from crude oil, causing the transportation sector to be a large source of GHG emissions.

Policymakers have developed a series of major federal regulations for reducing transportation emissions. Instead of relying on a single climate policy, such as a carbon price, the United States has a patchwork of emissions regulations in the transportation sector. This article reviews current policies and policy options for emissions reductions in the sector, including fuel economy and GHG standards, programs to promote the use of alternative-fuel vehicles, GHG standards for airplanes, and renewable and low-carbon fuel standards.

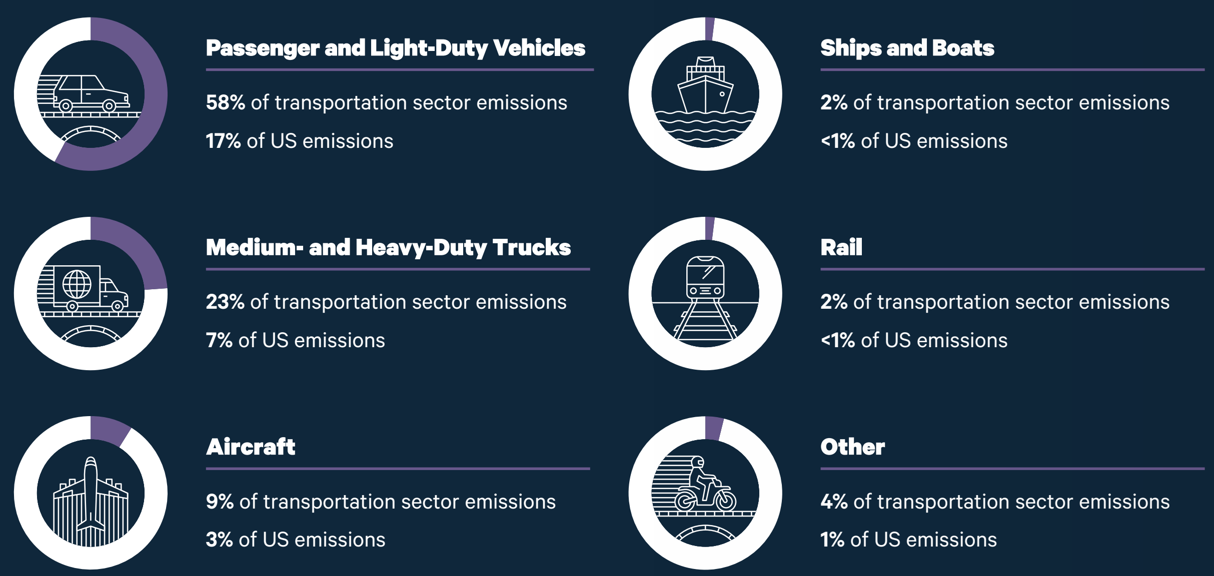
The future trajectory of transportation emissions is uncertain. Prior to the COVID-19 pandemic, transportation sector emissions were expected to grow, primarily due to expected increases in vehicle travel, especially heavy-duty vehicles. But as the economy recovers from the pandemic, it's hardly a given that households and businesses will revert to past behavior. Anticipated innovation, such as automated driving, creates additional uncertainty about future transportation demand.

Decarbonizing transportation requires burning less fuel derived from crude oil, which can be achieved by reducing either the number of miles driven (vehicle miles traveled, or VMT) or the amount of fuel used per mile traveled. In the 50 years prior to the COVID-19 pandemic, VMT increased dramatically as growing median household income increased demand for travel, goods, and services. Policies that raise the per-mile cost of driving, such as gasoline tax hikes, tend to have little effect on reducing VMT because driving is a necessity for many households; as a result, the demand for VMT is generally price inelastic, which means that changes in the cost of travel do not greatly affect demand.

Because reducing VMT through policy is difficult, transportation sector decarbonization efforts have largely focused on reducing the amount of fuel used per unit of VMT. Technology is currently available for reducing the amount of fossil fuel per unit of VMT—in particular, by adding fuel-saving technology to gasoline engines or by adopting battery electric vehicles. These technological innovations have provided a wide variety of avenues for companies to achieve regulatory goals. According to the US Environmental Protection Agency (EPA), carbon dioxide emissions have decreased 23 percent, and fuel economy has increased by 29 percent, or 5.6 miles per gallon, since 2004. But expanding the technology throughout the transportation sector presents challenges, because cars, trucks, airplanes, and ships last for a long time and can take decades to be replaced by new, more fuel-efficient vehicles.

While a carbon pricing program is known to be a cost-effective method for reducing GHG emissions, this policy option may not be politically viable at the scale needed to decarbonize the transportation sector. A carbon price may be effective at reducing emissions in other sectors; however, reductions in transportation emissions due to a carbon price are likely to be smaller than those due to the policy options outlined below.

FIGURE 1 **Transportation Sector Emissions**



> **"Decarbonizing transportation requires burning less fuel derived from crude oil, which can be achieved by reducing either the number of miles driven or the amount of fuel used per mile traveled."**

FIGURE 1 SOURCE
Inventory of US Greenhouse Gas Emissions and Sinks

Fuel Economy and Greenhouse Gas Standards

The Basics

Fuel economy and GHG standards can be used to reduce emissions from light-, medium-, and heavy-duty vehicles, which collectively emit more than 80 percent of all GHG emissions from the transportation sector. Fuel economy standards require manufacturers to achieve a minimum average miles per gallon for the vehicles they sell, and GHG standards require reductions in average vehicle lifetime emissions below a certain limit. The two sets of standards essentially regulate the same thing. By directly increasing fuel economy and reducing GHG emissions from new vehicles, these standards reduce fuel use per mile traveled.

Benefits and Challenges

- ✓ Fuel economy and GHG standards reduce the amount of fuel that's required to travel a set distance.
- ✓ Standards do not require a reduction in travel.
- ✓ Standards save consumers money, as drivers tend to spend less money on gas for each mile traveled.
- ✓ Fuel economy standards have garnered support from both consumers and policymakers, making this policy option politically viable.
- ✗ Fuel economy and GHG standards create a rebound effect for light-, medium-, and heavy-duty vehicles alike: some vehicle owners decide to drive their vehicles more as their vehicles get better fuel economy, which increases emissions.
- ✗ Standards are expected to increase the price of new vehicles, prompting potential car buyers to hold on to their used, less fuel-efficient cars for longer. This prolonged use delays the scrappage of older, fuel-inefficient vehicles, which erodes intended GHG reductions.
- ✗ Standards generally are a less efficient way to reduce transportation emissions compared to a carbon price, because of the downsides detailed above.

Key Considerations

- Designing effective and economically efficient fuel economy and GHG standards requires providing vehicle manufacturers with as much flexibility as possible. Currently, the standards allow manufacturers to earn, buy, and sell credits to each other, similar to an emissions trading program, which has likely reduced the cost to comply with the standards. However, the prices of credit transactions are not currently reported, which could make credit trading more difficult for companies and could hinder investments in fuel-saving technology.
- Overlap between the fuel economy and GHG standards for light-duty vehicles. These standards effectively regulate the same thing, but they have several key differences that make it difficult for manufacturers to comply with both cost-effectively. Cost-effectiveness can be improved by reducing or eliminating discrepancies, or more radically, by eliminating one of the programs—most likely the fuel economy program.

Past, Current, and Proposed Policies for Fuel Economy and GHG Standards

Corporate average fuel economy and GHG standards currently are in place to regulate and reduce emissions from passenger vehicles, while separate standards are used for medium- and heavy-duty vehicles. Cars, being lighter weight, traditionally have higher fuel economy standards and lower GHG standards than those that apply to trucks.

In 2020, the Trump administration replaced the 2021–2025 Obama standards with the Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule. The Biden administration plans to review the Trump administration's rollback with an executive order.

Programs that Promote Alternative-Fuel Vehicles

The Basics

The US transportation sector currently is shifting away from relying on fossil fuels to using electricity. Alternative-fuel vehicles—including electric vehicles and hydrogen fuel cell vehicles—are at the forefront of this transition. Federal and state policies currently promote the adoption of electric and hydrogen fuel cell vehicles, including federal income tax credits and Zero Emission Vehicle programs.

Federal Income Tax Credits for Plug-in Hybrid and Electric Vehicles: Because they do not produce tailpipe emissions, electric vehicles (EVs) could completely decarbonize passenger vehicle travel. For this reason, the United States currently subsidizes the purchase of EVs through a federal income tax credit.

Zero Emission Vehicle Programs: Zero Emission Vehicle (ZEV) programs require automakers to sell a certain number of electric and fuel cell vehicles, typically determined as a fraction of total vehicle sales. These key policies aim to increase the market share of EVs in select states.

Benefits and Challenges

- ✓ Tax credits increase EV sales by reducing the effective sales price of EVs and plug-in hybrids, which displaces sales of gasoline vehicles.
- ✓ ZEV programs (which target automakers) increase the number of alternative-fuel vehicles sold, which leads to emissions reductions—if these vehicles replace higher-emitting vehicles on the road.
- ✓ In areas of the country with a relatively clean electricity grid, an increase in EV sales reduces GHG emissions. As the power sector decarbonizes, this benefit will be amplified.
- ✓ ZEV programs allow manufacturers to meet regulatory goals on their own terms, through credit trading and other flexible compliance measures. Arguably, this flexibility could increase market competitiveness and decrease overall EV prices.
- ✗ An increase in the number of EVs could increase emissions through the production of electricity, even as vehicle emissions fall. Therefore, using clean sources for electricity production will be a vital part of reducing emissions.
- ✗ The tax credits are regressive—the federal tax credit currently applies only to the purchase of new EVs, which tend to be bought by relatively wealthy households.
- ✗ EV tax credits compensate some households for EV purchases that they would have made anyway, reducing the impact of the tax credit. One countermeasure could be to create a rebate rather than a tax credit, which is considered more equitable and would decrease the overall price of an EV at the point of sale.
- ✗ While ZEV programs do not directly affect used vehicles, households are likely to respond to higher-priced ZEVs by holding on to their used vehicles for longer. The used vehicle fleet takes decades to turn over, which will delay the impact of new ZEVs on fleet-wide vehicle emissions.

Key Considerations

- → Tax credits for hybrid vehicles and EVs could be redesigned as a more cost-effective and equitable strategy for increasing EV adoption. The current design of the tax credit tends to favor high-income buyers, who are more likely to be able to claim the full tax credit. An alternative design of the credit could follow California's Clean Vehicle Rebate Project, which offers a direct rebate instead of a tax credit and limits eligibility based on household income. This strategy could help attract lower-income households, likely leading to an increase in "additional" EV sales—sales that would not have occurred had the subsidy not been available—and increase the number of EV sales sold per dollar spent under the program.
- → The uncertainty of technological innovation and future costs when designing ZEV programs.
- → The benefit of clear information on credit prices when designing ZEV programs.
- → The need for flexibility and consistency when designing ZEV programs.

Past, Current, and Proposed Alternative-Fuel Vehicle Programs

Federal tax credits entitle car buyers to a credit of up to $7,500 for the purchase of a new EV or plug-in hybrid vehicle. After a manufacturer sells 200,000 EVs, the tax credit for cars from that manufacturer decreases and eventually reaches zero. At that point, new buyers do not receive a credit for purchasing a vehicle from that manufacturer. The credit has completely phased out for the two largest sellers of EVs—Tesla and General Motors—while Nissan, Ford, and Toyota are expected to surpass the cap within the next year or two (Figure 2).

Twelve states have ZEV programs: California, Colorado, Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, Vermont, and Washington. Because about 30 percent of new car sales in the United States occur in these states, these ZEV programs stand to significantly influence emissions from the US transportation sector.

On September 23, 2020, California announced an executive order that would ban the sale of new internal combustion engine vehicles in California after 2035, which effectively amounts to a 100 percent ZEV requirement. In October 2020, Senator Jeff Merkley (D-OR) and Representative Mike Levin (D-CA) introduced similar federal legislation.

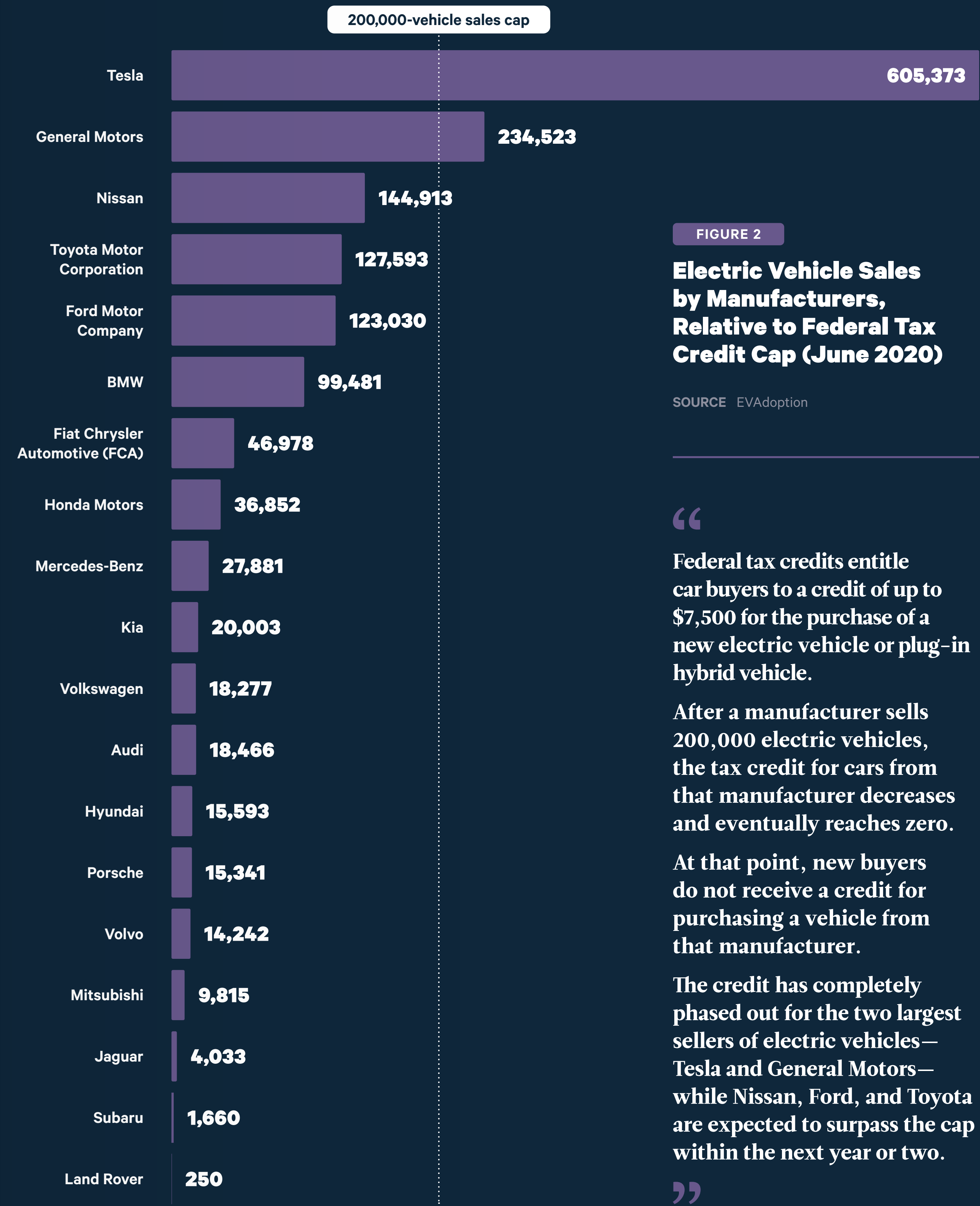


FIGURE 2

Electric Vehicle Sales by Manufacturers, Relative to Federal Tax Credit Cap (June 2020)

SOURCE EVAdoption

> "Federal tax credits entitle car buyers to a credit of up to $7,500 for the purchase of a new electric vehicle or plug-in hybrid vehicle.
>
> After a manufacturer sells 200,000 electric vehicles, the tax credit for cars from that manufacturer decreases and eventually reaches zero.
>
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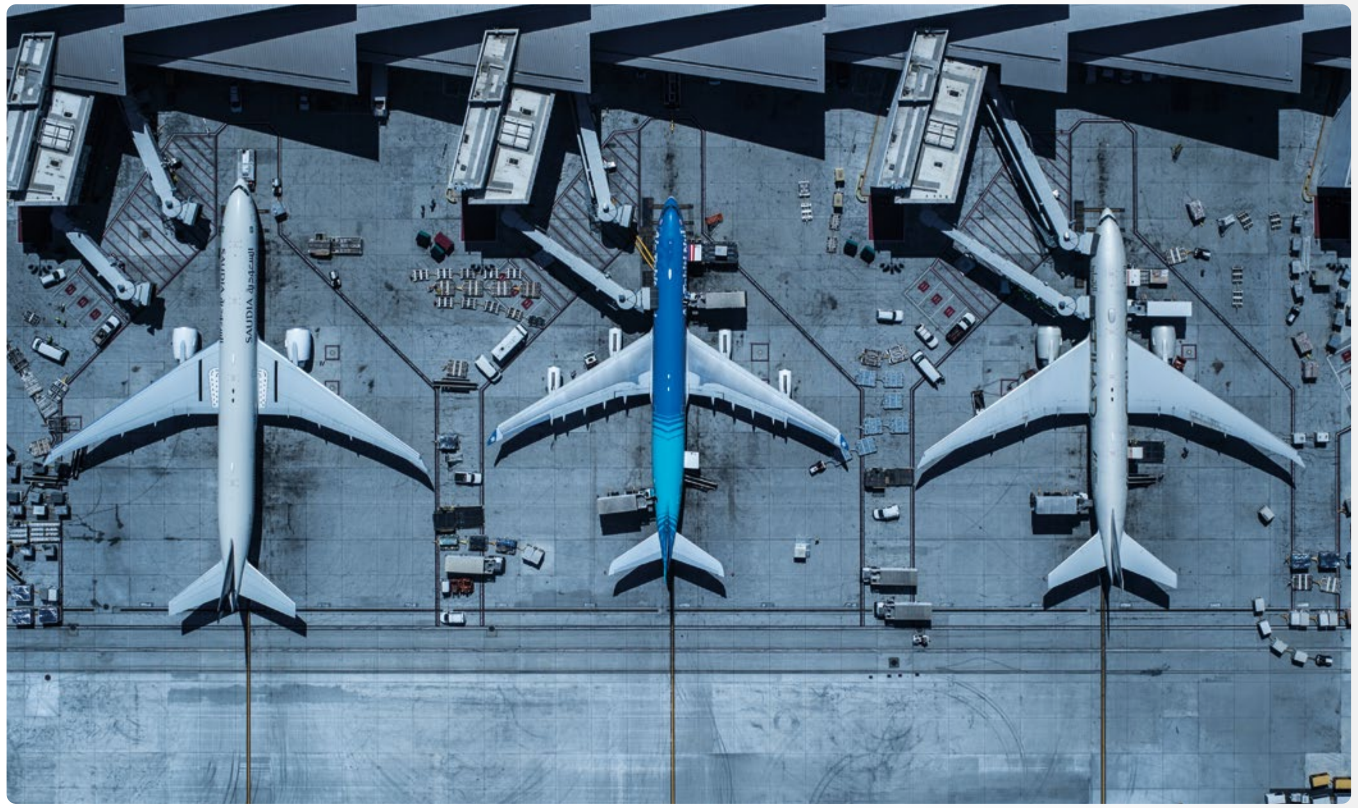

PHOTO Planes at the Los Angeles International Airport
Michael H / Getty Images

Greenhouse Gas Emissions Standards for Airplanes

The Basics

Aircraft represent the third-largest source (9 percent) of transportation-sector GHG emissions (Figure 1). The primary source of energy for flight is jet fuel, which is derived from crude oil. GHG standards, similar to those implemented for other vehicles, are the primary policy tool for reducing aircraft emissions. These standards reduce emissions by requiring certain new airplanes to reduce the amount of fuel consumed when traveling a set distance.

Benefits and Challenges

- ✓ GHG standards can reduce aircraft emissions if set to a sufficient level.
- ✓ These standards may enable aircraft manufactured in the United States to remain competitive in international markets, if the policy aligns with international standards set by the International Civil Aviation Organization.
- ✓ GHG standards for aircraft could encourage innovation in a difficult-to-decarbonize part of the transportation sector.
- ✗ Similar to fuel economy standards for passenger vehicles, the rebound effect and delayed fleet turnover make this option an inefficient method of reducing emissions.

Key Considerations

- → How high to set the standard.
- → How to measure compliance.
- → Policymakers must consider current international standards and whether to align US standards with international policy or make US standards more or less stringent. While following international standards may be beneficial and affordable, some environmental groups and other critics have considered this option unambitious and insufficient to motivate significant GHG reductions.

Past, Current, and Proposed Greenhouse Gas Standards for Airplanes

In 2020, EPA finalized GHG emissions standards that apply to certain new commercial airplanes, including all large passenger jets. This final rule applies to manufacturers of new civil aircraft and requires certain new airplanes to meet a "fuel efficiency metric" based on the airplane's certified weight. These standards match the international airplane carbon dioxide standards adopted by the International Civil Aviation Organization in 2017.

> "In 2020, EPA finalized greenhouse gas emissions standards that apply to certain new commercial airplanes, including all large passenger jets. This final rule applies to manufacturers of new civil aircraft and requires certain new airplanes to meet a 'fuel efficiency metric' based on the airplane's certified weight."

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This article is available at **rff.org/toolkit** *as a published explainer titled "Federal Climate Policy 104: The Transportation Sector."*

Renewable Fuel Standards and Low-Carbon Fuel Standards

The Basics

The Renewable Fuel Standard (RFS) and Low-Carbon Fuel Standard (LCFS) are performance standards that require regulated emissions sources (such as fuel refiners, in the case of an RFS) to achieve a specified GHG emissions–related target. An RFS requires transportation fuel to contain a minimum volume of renewable fuels, such as biofuels. An LCFS limits a fuel producer's carbon emissions per unit of fuel produced.

Benefits and Challenges

- ✓ Performance standards tend to be more popular among consumers than other emissions reduction policies, in part because their costs are less obvious than explicit carbon price policies (e.g., a carbon tax).
- ✓ Tradable performance standards—which add a credit-trading aspect to performance standards—can be cost-effective, particularly for products with low elasticity of demand (e.g., vehicle miles traveled).
- ✗ Although they can be cost-effective, tradable performance standards generally are less cost-effective than a carbon tax, because standards target only a subset of actions that can reduce GHG emissions.
- ✗ Both the RFS and LCFS act as subsidies for production that can create GHG emissions. The RFS subsidizes ethanol production, the primary fuel used for compliance, which can generate net positive GHG emissions, depending on how it's produced. The LCFS subsidizes natural gas production, which creates GHG emissions as a byproduct when burned. Although ethanol and natural gas contain less carbon than the fuels they displace, these fuels can still generate GHG emissions.

Key Considerations

- → To ensure that RFSs reduce emissions, each renewable fuel must emit less than the petroleum that it replaces. This rule historically has been a controversial piece of the federal RFS program, because it requires estimating the GHG emissions of the renewable fuel itself, which poses empirical challenges due to the difficulty of tracking the origin of the fuel.
- → For LCFSs, whether to allow regulated entities to earn, buy, and sell regulatory credits. If an LCFS allows for these trades, policymakers should consider areas of potential overlap with other regulations that allow trading.

Past, Current, and Proposed Renewable and Low-Carbon Fuel Standards

As part of the Energy Independence and Security Act of 2007, the RFS requires transportation fuel sold in the United States to contain a minimum amount of renewable fuels. This minimum amount increases each year and is scheduled to be 36 billion gallons in 2022. The RFS regulates refiners and refined-petroleum product importers. It also includes a tradable credit system.

Although California implemented an LCFS in 2011, no federal LCFS is in place. A group of biofuel companies, agriculture representatives, and car companies have urged the Biden administration to adopt a nationwide "clean fuel standard," which would require reductions in the amount of GHG emissions emitted through the production, transport, and combustion of fuels.

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Industrial Sector

The complexity of the industrial sector means that we won't find any straightforward answers and approaches to decarbonization. A combination of pathways to reduced emissions likely is necessary—which could include incentivizing low-carbon processes, carbon capture, energy efficiency, waste reduction, decarbonizing the grid, and technological innovation. Policymakers can apply these pathways by prioritizing their approach based on the subsector, or the process, or the fuel that's involved.

TEXT
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> "The recent interest in hydrogen to dramatically decarbonize across many industrial sectors in the long term has distinguished it as a significant area of opportunity."

PHOTO
A petrochemical plant in Texas City
dszc / Getty Images

Reducing industrial emissions of greenhouse gases (GHGs)—primarily carbon dioxide (CO_2), but also nitrous oxide and methane—has received little policy attention compared to the power and transportation sectors, in spite of industry's large and growing carbon footprint. In 2019, the industrial sector produced 29.6 percent of all GHG emissions in the United States. The majority of industrial emissions (78 percent) comes directly from industrial processes, heating, and other uses, while about 22 percent are emissions that arise indirectly from the use of electricity within the sector. The industrial sector includes a diverse set of activities, such as manufacturing goods and producing materials like steel and cement.

The industrial sector encompasses a diverse set of products and processes with widely varying levels of emissions. Several mitigation pathways are possible—and likely necessary—to reduce industrial emissions:

- Incentivizing a shift away from high-carbon energy sources and high-carbon manufacturing processes toward lower-carbon energy sources (e.g., low-methane-emissions natural gas, decarbonized hydrogen, and biogas) and lower-carbon processes (e.g., electrification of production processes and heat sources).
- Encouraging industrial sources to capture their CO_2 emissions.
- Reducing energy use by increasing the energy efficiency of production processes and heat systems.
- Cutting material use and planning for the "circular economy" through product designs and manufacturing standards that reduce waste and one-time use.
- Decarbonizing the grid.
- Accelerating technological development that reduces costs or increases the efficacy of the other five pathways.

Policies can target one or more of these pathways—and some policies can operate on all six at once. For example, a carbon price applied to all industrial sources of CO_2 would encourage factory managers and company owners to find the cheapest ways of reducing emissions and avoiding carbon fees, thereby indirectly stimulating innovation. However, sufficiently high carbon prices to decarbonize the industrial sector may be politically infeasible. Also, most emissions policies operating directly on the industrial sector cannot sufficiently incentivize innovation, so policies promoting research, development, and demonstration (RD&D) still would be needed.

In addition to considering the mitigation pathways above, policymakers can think of industrial decarbonization in a few different ways:

- **By Subsector or Product**
  For instance, a piece of legislation may aim to reduce emissions from refineries or cement manufacturing, specifically.
- **By Process**
  Decarbonizing a process that's common to multiple industrial subsectors; for instance, a standard to improve boiler or motor efficiency, or a limit on emissions from blast furnace steel production.
- **By Fuel**
  For instance, regulations may restrict the use of coal, or tax credits could encourage the use of certain low-carbon fuels.

A variety of policy approaches to reduce industrial emissions along one or more of these pathways exist. While these types of policy options may be less efficient than an economy-wide carbon price, these alternatives nonetheless may be more politically feasible. This article examines several of the options.

The example of hydrogen is used throughout this article as a major opportunity for industrial decarbonization. Other opportunities exist, including energy efficiency; electrification; fuel switching from coal to gas; carbon capture, utilization, and storage (CCUS); and various industry-specific technologies. The recent interest in hydrogen for long-term decarbonization across industrial sectors has distinguished it as a significant area of opportunity, and thus is our focus in this article.

Tax Credits

The Basics

Tax credits enable emitters to pay lower taxes in exchange for reducing their emissions. Tax credits are flexible: they can be designed to reduce CO_2 emissions broadly, or they can be more targeted. Under a broad tax credit policy, industrial emitters can decide how to reduce their emissions. Alternatively, a credit program can favor specific technologies; for example, investment and production tax credits are available for solar power, wind power, and CCUS. Economists typically consider the designation of technological “winners” as economically inefficient, but tax credits that target certain technologies can create incentives for innovation in the private sector that ultimately will reduce the costs of the favored technologies.

Benefits and Challenges

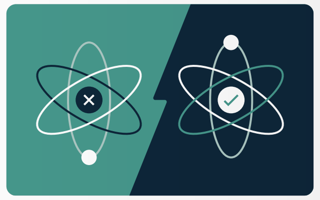
- ✓ Tax credits—a subsidy by another name—is far more popular than pollution taxes among most policymakers and regulated entities.
- ✓ Tax credits are a familiar federal policy with a decent track record (e.g., in stimulating renewables).
- ✗ Tax credits often are expensive.
- ✗ Tax credits tend to be narrowly drawn, potentially excluding promising options by “picking winners” when the credits target certain technologies.
- ✗ Tax credits may not be sufficient on their own. For example, even with a tax credit, low-carbon hydrogen production may not be economical.
- ✗ The most efficient tax credit would be based on actual reductions in CO_2 emissions, rather than the production volume or amount of money invested in renewables.

Key Considerations

- Who receives the credit and what they must do to receive it. For example, with decarbonized hydrogen, producers could receive a credit if they reduce the emissions associated with hydrogen production; or users who purchase decarbonized hydrogen could get a credit for replacing high-carbon hydrogen, fuels, and industrial feedstocks with lower-carbon alternatives; or both producers and users could receive a credit through two different credit systems.
- Coordination with other tax credits to avoid double-counting (such as with the 45Q program).
- The level of the credit—the amount of money awarded for the desired action—can be established in two basic ways: based on the social cost of carbon or based on the value that’s necessary to motivate the desired action.
- Who is eligible to receive the credit.
- Determining timelines, such as when production or investment must begin and when credits are available.
- Requirements for monitoring, reporting, and verification.

Past, Current, and Proposed Tax Credits

In the industrial sector, the 45Q tax credit for CCUS has led at least one industrial entity so far to develop a proposal to replace the production and use of gray hydrogen with blue hydrogen.



DID YOU KNOW?

Hydrogen Tax Credits

Hydrogen can be used as a fuel. Emissions benefits for switching to hydrogen from other fuels depend on the energy sources used to generate both the hydrogen and the fuel that hydrogen replaces.

Hydrogen is produced in a variety of ways. Most hydrogen in the United States is made by natural gas reforming (gray hydrogen) which uses high-powered steam on a methane source (e.g., natural gas) to produce hydrogen, carbon monoxide, and a small amount of carbon dioxide. Gray hydrogen is carbon intensive, consuming roughly 6 percent of the US natural gas supply. Emissions also are substantial, because carbon capture from the main hydrogen production processes—gray hydrogen and coal gasification (brown hydrogen)—is rare. Currently, hydrogen production emits 830 million tons of CO_2—more than 2 percent of global CO_2 emissions, all of which could be eliminated at no direct cost to users. ▸

▸ Unfortunately, methods of decarbonizing hydrogen by adding CCUS to hydrogen production processes (creating blue hydrogen) or powering electrolysis with carbon-free renewable or nuclear electricity (to make green hydrogen) are currently too expensive to allow decarbonized hydrogen to compete in the market without policy incentives. Of all the policies available in the near term to support production, a hydrogen tax credit may be most viable. Such a credit would permit eligible producers and industrial users to claim a deduction on their taxes. By setting the credit at a suitably high level, policymakers could help blue hydrogen become competitive for refineries and ammonia manufacturers, which already make gray hydrogen for their production processes. For example, a hydrogen tax credit could reflect the social cost of carbon; or match the established levels for 45Q, the CCUS tax credit program; or offer a larger credit to push decarbonized hydrogen even faster.

> **“Tax credits are flexible: they can be designed to reduce CO_2 emissions broadly, or they can be more targeted.”**

> **“Policies that encourage the adoption of energy-efficient technologies can both benefit the industrial sector and reduce emissions.”**

Energy Efficiency Standards

The Basics

Improving energy efficiency is a proxy, albeit imperfect, for reducing CO_2 emissions in the industrial sector. Energy-efficient technologies have promise for reducing the costs and environmental damages associated with energy use, but these technologies are not being leveraged to their full economic benefit by businesses or consumers. Policies that encourage the adoption of energy-efficient technologies can both benefit the industrial sector and reduce emissions. Two types of energy efficiency standards are commonly discussed:

- Prescriptive standards (also known as technology standards) require a particular energy-saving technology or process to be installed or used. Historically in the environmental field, prescriptive standards have been applied most often for reducing pollutants—but they could be applied to the industrial sector, as well.
- Performance standards limit the emissions or energy consumption per unit of product (e.g., amount of GHGs emitted per ton of cement manufactured). Performance standards do not require a specific technology or process.

Benefits and Challenges

- ✓ Reduced energy use.
- ✓ Lower GHG emissions.
- ✓ Lower conventional pollutant emissions.
- ✓ Reduced energy use often reduces operating costs, which can offset some or all of the higher capital costs.
- ✓ Energy efficiency standards generally are transparent, which simplifies enforcement.
- ✗ Increased capital costs of the products or processes covered by the policy.
- ✗ Potential reductions in performance.
- ✗ Prescriptive standards do not allow much flexibility for producers.
- ✗ Prescriptive standards can lock in particular technologies, which can forestall technological innovations.

Key Considerations

- Policies should be designed to address the specific causes of the energy efficiency gap. Root causes can include the market power of firms, limited information about new technologies, unobserved costs, not understanding a firm’s own energy operating costs, and an inability to capture the full benefits of RD&D.

Past, Current, and Proposed Energy Efficiency Standards

Energy efficiency standards are in place for appliances, which are relevant to the industrial sector and the buildings sector. The National Appliance Energy Conservation Act of 1987 established minimum efficiency standards for many common household appliances. The Energy Independence and Security Act of 2007 updated or enacted standards for 13 products.

Starting in the late 1990s, the US Environmental Protection Agency established Energy Star and other industry-oriented, nonregulatory, and voluntary programs that certify products (e.g., cement) which help reduce GHG emissions by reducing the amount of energy consumed per unit product. Typically, products with such certification sell for a higher price per ton and can be eligible for green procurement programs.

Tradable Performance Standard

The Basics

A performance standard is a policy that sets a benchmark that firms must meet, without specifying how the benchmark should be achieved. A tradable performance standard (TPS)—sometimes referred to as a “clean energy standard” for industry—is a flexible mechanism that encourages firms to use less carbon-intensive materials and employ production techniques that lead to lower emissions.

The “tradable” aspect of a TPS refers to the ability of firms to buy and sell credits with one another. Enabling tradable credits can improve overall cost-effectiveness and encourage innovation that in turn leads to lower emissions, as companies can make money from selling excess credits.

In principle, a TPS can be set for each industrial category or subcategory, requiring firms to meet emissions or other benchmarks based on the quantity or dollar value of product sold. Depending on the design of the system, a TPS for industry might allow trading within each sector and across sectors. Certain elements of existing cap-and-trade programs are carried over to TPSs. A TPS can create incentives for firms to reduce emissions, approximately similar to a cap-and-trade program that allocates emissions allowances in proportion to a facility’s output. Examples include California’s economy-wide cap-and-trade program and the European Union Emissions Trading System.

Benefits and Challenges

- ✓ A TPS is more flexible, compared to an energy efficiency standard.
- ✓ A TPS is generally more cost-effective, compared to an energy efficiency standard.
- ✓ A TPS rewards innovative firms for emissions reductions: reducing emissions generates compliance credits that can be sold to firms whose performance would otherwise fall short of the standard.
- ✓ A TPS comes with relatively lower costs overall, given that a TPS is less likely than a carbon price to harm industrial sector employment or cause emissions leakage. (Leakage happens when a regulation in one jurisdiction raises costs enough to shift economic activity and corollary emissions from a regulated area to an unregulated area.)
- ✗ Product price increases are small with a TPS, compared to a carbon price, which provides less incentive for consumers to shift away from emissions-intensive products and toward more environmentally friendly products.
- ✗ Applying multiple industry- or product-specific standards can increase production costs.

Key Considerations

- → Recent research reveals large differences between the highest and lowest energy-intensive production facilities in various industrial subsectors, including cement, bulk chemicals, and iron and steel. Thus, potentially large efficiency gains may be attainable, and a TPS is a plausible mechanism for achieving these gains.
- → How to manage the diversity of products and industries within the sector. The complexity can pose a challenge, particularly for subsectors with a wide variety of products, whereas establishing benchmarks for products that are relatively homogeneous—such as some cement products, basic steel, and bulk chemicals—may be less challenging. Strategies to allocate emissions allowances in cap-and-trade programs can be adapted to define TPSs for heterogeneous subsectors.

Past, Current, and Proposed Tradable Performance Standards

To date, application of TPSs to industry has been limited. A proposal by Representative Sean Casten (D-IL) would cover both the industrial sector and the electricity sector. The proposal would apply a clean energy standard to electricity generators and industrial thermal energy generators, requiring that energy producers meet certain emissions-intensity benchmarks for the energy they generate.

Another example of a TPS that spans sectors is California’s Low Carbon Fuel Standard. This policy regulates the carbon intensity of the full life cycle of transportation fuels, incentivizing carbon reductions in transportation, electricity, and the agricultural activities that fuel transportation.

China also has announced its intention to establish a TPS for the nation’s power sector and various industrial sectors.

> “Government funding for carbon-reducing technologies can help technologies mature, become less costly, and reach commercial scale.”

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This article is available at **rff.org/toolkit** *as a published explainer titled “Federal Climate Policy 105: The Industrial Sector.”*

Research, Development, and Demonstration

The Basics

Government funding for carbon-reducing technologies can help technologies mature, become less costly, and reach commercial scale. Research, development, and demonstration (RD&D) is particularly important for reducing industrial emissions, as some current industrial production processes offer few opportunities to reduce emissions.

Many policy options are available to help fund innovation. These policies can be classified as “supply-push” and “demand-pull” policies. Supply-push policies are traditional ways of issuing government-funded grants, such as ManufacturingUSA, or federal laboratories. Demand-pull policies aim to shape or stimulate the market for technologies by creating demand or reducing uncertainty in prices. Demand-pull policies include government green procurement policies; contracting guidance; market-creation mandates; and prizes, challenges, or milestone programs that better target RD&D.

Benefits and Challenges

- ✓ RD&D funding can lead to the commercial viability of advanced energy technologies and emissions-reducing technologies.
- ✓ RD&D can enable the discovery of new technologies.
- ✓ Related technological advances and discoveries could both reduce the industrial sector’s carbon footprint and make emissions reductions less costly, as more technologies compete to provide reduced-carbon (or carbon-free) products.
- ✗ The government must pay to fund RD&D, which drains government revenues.
- ✗ RD&D spending comes with inherent risks, as the efforts do not guarantee technological advances. That said, policies can be designed to minimize such risks.

Key Considerations

- → Ensure that funds are spent wisely.
- → Unclear which technologies and areas of development warrant the most investment, as future advances cannot be predicted.
- → Unclear which policies will be most beneficial.
- → Unclear which sectors will benefit most from RD&D investments.

Past, Current, and Proposed RD&D Funding

The Energy Act of 2020, which passed as part of the omnibus spending bill in December 2020, is an example of using federal RD&D spending to promote industrial decarbonization. This legislation increases funding for CCUS, direct air capture, advanced nuclear reactors, and energy storage technologies—all of which can help to decarbonize industry.

The US government supports a range of other initiatives to boost RD&D. For instance, H2@scale is an RD&D funding opportunity for cooperative agreements between the private sector and the US Department of Energy’s National Laboratories to develop and implement new technologies.

▶▶ FEDERAL CLIMATE POLICY 106

Buildings

TEXT
Kathryne Cleary
and Karen Palmer

PHOTO
The Manhattan skyline
Alexander Spatari / Getty Images

Emissions from commercial and residential buildings largely come from the use of electricity for lighting, air conditioning, and appliances, along with the direct use of fossil fuels for heating and cooking. Reducing emissions from the buildings sector through federal climate policy can be accomplished via two main avenues: improving energy efficiency and displacing fossil fuel use with electrical appliances that are powered by clean energy.

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“The vast number of residential and commercial buildings of varying ages and construction across different climate zones, as well as the diversity of energy-consuming appliances and devices inside them, makes designing policies to reduce emissions a daunting task.”

The buildings sector, which includes residential and commercial buildings, contributes about 12.5 percent of total US greenhouse gas emissions through the direct use of fossil fuels for heating, cooling, and cooking. When electricity use in buildings is included (emissions from electricity generation often are included in a separate category, as noted on pages 6 and 7), energy consumption in buildings contributes over 30 percent of US greenhouse gas emissions. Emissions from buildings have been on the rise in recent years and reached a new high in 2019. This article provides an overview of the tools available for policymakers to reduce emissions from buildings.

Buildings contribute to emissions directly and indirectly. Direct emissions primarily come from burning fuels like natural gas and oil for space heating, water heating, and cooking. Indirect emissions come from power plants that burn fuel to generate electricity, which then is distributed to homes and businesses and provides a broad range of energy services within the buildings.

Emissions from buildings can be reduced in two primary ways. The first is through improvements in energy efficiency, which reduce the amount of energy it takes to provide services (such as heating, cooling, or cooking) and thus reduces emissions. This method can reduce both direct and indirect emissions from buildings.

The second is to substitute clean energy technologies—such as electricity that's generated using clean sources—for appliances that use fossil fuels, which reduces direct emissions. Importantly, the emissions reductions from electrifying building appliances will depend on the extent to which the electricity system is decarbonized.

Reducing emissions from buildings can be challenging for a few reasons. First, the vast number of residential and commercial buildings of varying ages and construction across different climate zones, as well as the diversity of energy-consuming appliances and devices inside them, makes designing policies to reduce emissions a daunting task.

Second, many of the solutions that are currently available to reduce emissions from buildings involve reducing energy consumption through investments in energy efficiency, and these investments can carry significant up-front costs and uncertain energy savings.

Lastly, building owners have little control over their indirect emissions resulting from electricity production, other than the ability to reduce consumption or procure clean electricity, either directly from clean suppliers or by installing renewable energy.

The policy options that follow target reductions through both energy efficiency improvements and electrification.

Building Performance Standards

The Basics

A building performance standard (BPS) sets an energy performance target for buildings to meet with increasingly stringent goals over time. The performance target itself varies across policies and can be based on a variety of metrics, such as emissions, energy use, energy intensity, or emissions per square foot. These programs build on the requirements for building-level energy-use benchmarks and disclosures that have been implemented by many cities and some states to cover large commercial buildings.

A BPS policy can be designed to be market based and allow for trading: under this type of policy, buildings that reduce energy usage or emissions above their performance target can sell their excess savings to other buildings, where costs are higher to reduce energy use. This design, which is similar to emissions cap-and-trade programs used in the electricity sector, can improve the program's efficiency and reduce compliance costs.

Benefits and Challenges

- ✓ A BPS targets energy use or emissions performance directly, rather than setting efficiency standards for particular technologies. As a result, a BPS provides greater certainty that the program will yield emissions reductions relative to mandates for specific technologies or building designs.
- ✓ A program that allows trading is more flexible—and therefore more efficient—than one that requires all buildings to comply with the same standard. The ability to trade credits provides incentives for the buildings with the lowest abatement costs to reduce emissions beyond what the standard requires, while older, less efficient buildings can avoid or delay potentially costly investments in the early years.
- ✓ A performance-based policy like a BPS can encourage innovation and enable buildings to meet the requirement using innovative methods and technologies.
- ✗ A BPS can be administratively complex and costly due to the vast number of buildings it covers.
- ✗ BPSs typically are used to reduce emissions only in large commercial or residential buildings; they do not address emissions from single-family homes.

Key Considerations

- → Which buildings will be covered by the policy. The more buildings covered, the higher the administrative costs of the policy. For this reason, many existing BPS programs have thresholds that determine whether buildings are subject to the standard—usually minimum square footage requirements or minimum emissions levels. An RFF report on building performance standards highlights the trade-offs between using building size versus emissions to set this threshold. A size-based threshold is simple to implement and covers the same buildings over time, but this option can increase the administrative burden relative to emissions reductions achieved if the threshold ends up including low-emitting buildings. By contrast, an emissions-based threshold more efficiently targets high-emitting buildings, but this option requires establishing a method for estimating baseline energy use or emissions, which can be complicated.
- → Which metrics to use for evaluating building performance. An absolute standard—where buildings reduce emissions relative to their own benchmark—can be unfair to more efficient buildings, but this option can make trading simpler and enable greater program efficiency. An intensity standard, on the other hand, can be more equitable for buildings of different efficiencies, but this option can make trading more complicated.
- → Equity could be an important concern in policy design, as with any policy that involves trading. Buildings that take greater advantage of efficiency improvements to comply with the standard can benefit in many ways; for example, through lower energy bills for apartment residents and improved indoor air quality. Thus, it's important to ensure that benefits do not accrue solely to buildings in wealthier areas.

Past, Current, and Proposed Building Performance Standards

Currently, no national building performance standard is in place. Several cities in the United States have implemented or proposed building performance standards, which vary in design. Washington, DC, for example, enacted an energy intensity standard for privately owned buildings larger than 50,000 square feet (in the program's first round) and District-owned buildings larger than 10,000 square feet; the city does not allow trading to meet targets. New York City's building performance standard, which will begin compliance in 2024, requires that buildings larger than 25,000 square feet reduce their carbon-emissions intensity per square foot over time.

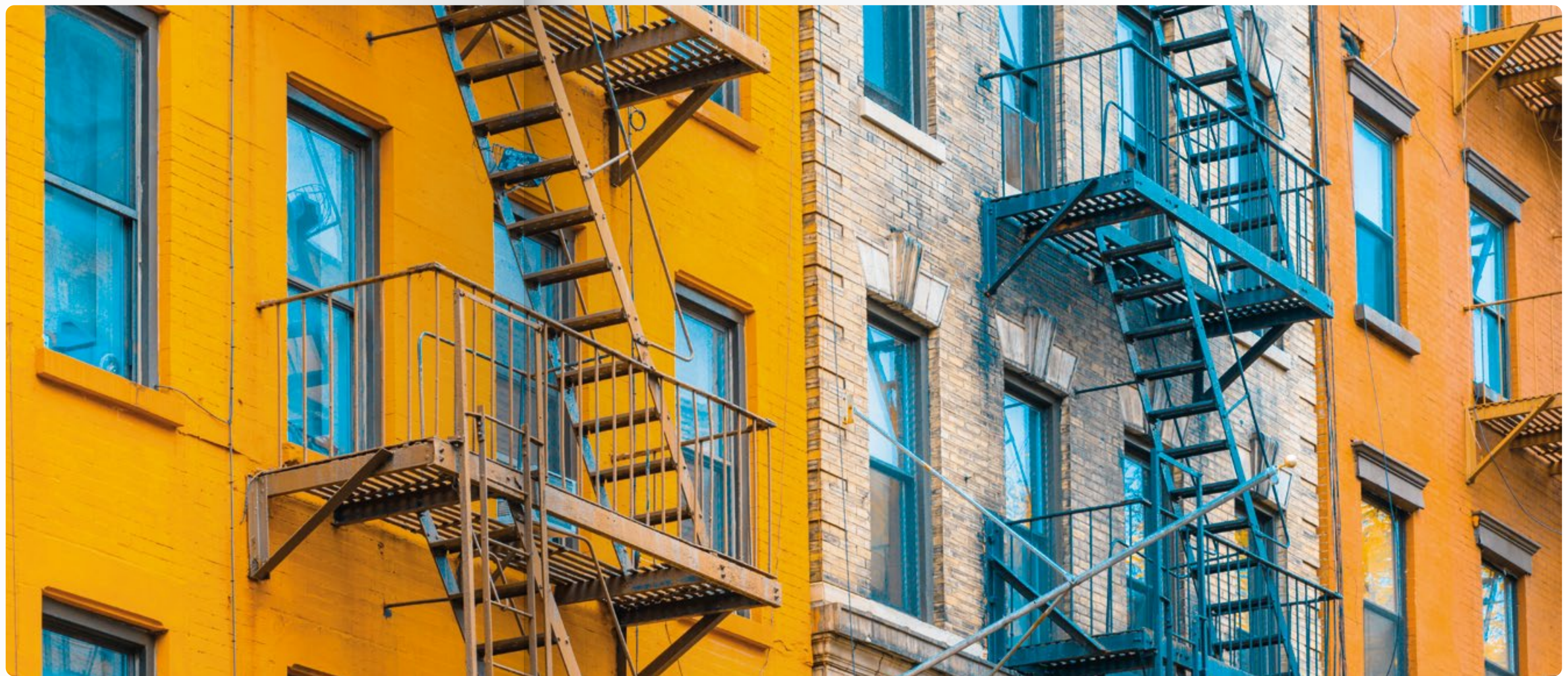


PHOTO
Apartment buildings in New York
Marco Bottigelli / Getty Images

“Building energy codes do not address energy use from existing buildings (apart from those being renovated), which still represent the majority of buildings and thus constitute the majority of emissions from the sector.”

Building Energy Codes

The Basics

Building energy codes require that new and renovated buildings adopt certain energy-efficient features in the building's design and construction. Building energy codes can include requirements for features such as the building envelope (walls, insulation, windows, and roof); heating, ventilation, and air conditioning systems (HVAC); and lighting. Notably, these requirements are for the design and construction of the building itself and not typically for appliances used inside the building, which are regulated under separate standards. (See “Appliance Standards” on page 43.)

Benefits and Challenges

- ✓ Building energy codes promise significant energy savings and associated reductions in the environmental impact of energy use in buildings, along with energy cost savings for building owners.
- ✗ Building energy codes do not address energy use from existing buildings (apart from those being renovated), which still represent the majority of buildings and thus constitute the majority of emissions from the sector.
- ✗ Building codes are limited in their potential energy savings, because codes do not necessarily affect how much energy is used by appliances within the buildings. Consequently, empirical studies of the long-term effects of these policies find mixed results.
- ✗ It's difficult to estimate energy savings because the calculation requires comparing actual energy use to hypothetical energy use—energy that would have been used without the code in place.

Key Considerations

- → Which code to adopt and how often to update the code. Most states use versions of building energy codes that are developed by two private organizations—the American Society of Heating, Refrigerating and Air-Conditioning Engineers and the International Code Council—while others, like California, have developed their own.

Past, Current, and Proposed Building Energy Codes

Most states have statewide building energy codes for commercial and residential buildings, and the few without statewide requirements typically have municipal requirements. The United States currently does not have a national building energy code in place.

Energy Efficiency Resource Standard

The Basics

An energy efficiency resource standard (EERS) requires that electric or natural gas utilities achieve an energy savings target—typically a percentage of sales—by a given future year, with incremental goals in the interim. Utilities meet their goals by encouraging customers to adopt more efficient equipment and, in some cases, providing incentives for customers to do so. If the program allows for trading, utilities can purchase certificates from others in the same state that represent electricity or natural gas not consumed.

Benefits and Challenges

- ✓ An EERS can be easier to administer because the policy is applied at the utility level, rather than at the individual building level.
- ✓ An EERS can reduce energy usage—and thus emissions—for a lower cost than if each building were required to reduce its own consumption, if the policy is market based and allows for trading among utilities in a given region.
- ✗ An EERS places the burden of compliance on energy suppliers, rather than consumers, and leaves utilities to figure out how to encourage their customers—the building owners—to reduce consumption. This approach raises concerns for how to treat decreases in energy consumption that result from reduced demand (due to factors such as economic recessions or business relocations), rather than increased efficiency.

Key Considerations

- → The design of an EERS requires the choice of a baseline to measure reductions against, given as a particular year's energy consumption or base average over a multi-year period. The policy's achievements will depend entirely on the energy use in the base year chosen: future targets will require more reductions if the initial base year has low energy consumption compared to other historical years.

Past, Current, and Proposed Energy Efficiency Resource Standards

More than half of US states currently have mandatory or voluntary energy EERSs in place for their electric or natural gas utilities (or both).

No standard has been adopted at the federal level thus far. In 2019, Senators Tina Smith (D-MN), Angus King (I-ME), and Jeff Merkley (D-OR) introduced the American Energy Efficiency Act of 2019, an EERS policy that would have required electric and natural gas utilities to reduce consumption by 22 percent and 14 percent, respectively, by 2035 relative to a baseline drawn from the average consumption of the three years prior to the first compliance year, but the bill did not pass.

Efficiency Subsidies

The Basics

Efficiency subsidies—which can be in the form of tax credits, rebates, or subsidized loans for efficient equipment or retrofits—provide government funding to reduce the up-front costs associated with energy-efficient technologies and building retrofits. By encouraging greater adoption of efficient technologies or encouraging consumers to pursue energy retrofits, subsidies can lead to reduced energy use in buildings.

Benefits and Challenges

- ✓ Efficiency subsidies can encourage the adoption of more efficient technologies or building weatherization, which can reduce energy consumption and emissions in buildings. By reducing the up-front cost to consumers, efficiency subsidies can increase access to efficient equipment for lower-income households.
- ✗ Because they are typically technology based rather than outcome based, efficiency subsidies cannot promise energy savings.
- ✗ Subsidies can be victim to the rebound effect.
- ✗ Subsidies can create a "free-rider" problem: they may subsidize purchases made by consumers who would have purchased energy-efficient appliances even without a subsidy. Consequently, efficiency subsidies can be less cost-effective relative to other policies.

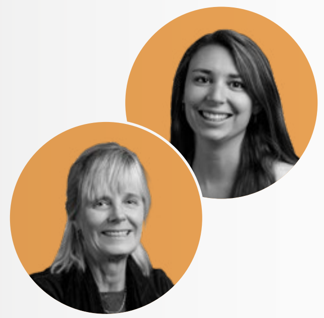
Key Considerations

- → Subsidy size. A subsidy is effective if it provides enough of an incentive for consumers to make the purchase. But a subsidy that is too large will cost too much relative to its emissions reductions.

Past, Current, and Proposed Appliance Subsidies

Many electric, gas, and water utilities offer subsidies in the form of rebates for energy-efficient equipment. (The Database of State Incentives for Renewables and Efficiency provides a list of rebates.) The federal government offers tax credits of up to $500 on certain appliances, along with subsidies for low-income households to weatherize homes. Other tax credits have been proposed at the federal level but have not passed. In 2019, Senator Ron Wyden (D-OR) and colleagues introduced the Clean Energy for America Act, which would have provided performance-based tax credits for new homes that are designed to be 25 percent more efficient than the 2015 International Energy Conservation Code baseline and existing homes that invest in energy-efficient equipment or energy retrofits.

"The federal government currently has appliance standards in place for appliances in 60 use categories. The US Department of Energy is required to revisit the standards every six years to make updates if necessary."



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This article is available at **rff.org/toolkit** *as a published explainer titled "Federal Climate Policy 106: The Buildings Sector."*

Appliance Standards

The Basics

Appliances contribute to building emissions through direct or indirect use of fossil fuels. Appliance standards, which require end-use technologies to achieve certain energy efficiency ratings or to use a certain fuel, are a policy option for reducing energy use in buildings. Appliance standards that improve energy efficiency include minimum efficiency standards for appliances like air conditioners, dishwashers, and washing machines, which can help reduce electricity or natural gas consumption. Additionally, appliance standards can encourage fuel switching to reduce emissions.

Recently, the strategy of increasing electrification standards for household appliances that typically use fossil fuels has been suggested to decarbonize home energy use. Such standards would require manufacturers to produce a minimum percentage of a particular type of appliance (e.g., water heaters, stoves) that relies on electric power, and for that percentage to increase over time.

Benefits and Challenges

- ✓ Appliance standards can produce substantial energy savings compared to a scenario without the required technology improvements—particularly when consumer use of the appliance is unlikely to vary with its efficiency rating. The federal government estimates that cumulative energy savings from appliance standards since 1987 will produce savings of nearly $2 trillion in the United States by 2030.
- ✗ Substantial uncertainty can revolve around associated energy savings. One unintended consequence of appliance standards is the potential for the rebound effect: because more efficient devices cost less to operate, consumers may use them more frequently than they would otherwise, which can undermine the energy and emissions goals of the standards. The extent of this rebound effect depends on how variable consumer use of the appliance may be.

Key Considerations

- → How to set standards, which for appliances are required by law to lead to a "significant conservation of energy" and can be interpreted differently by presidential administrations. Part of the standard-setting process is establishing a procedure that new appliance manufacturers must use to demonstrate that appliances comply with the standard.
- → For electrification standards, additional considerations may apply, such as requiring communications technology that could help align electrical charging times for devices with storage capacity, such as hot water heaters, with periods of abundant renewable energy supply.

Past, Current, and Proposed Appliance Standards

The federal government currently has appliance standards in place for appliances in 60 use categories. The US Department of Energy is required to revisit the standards every six years to make updates if necessary. To further reduce emissions, appliance standards can be expanded to cover additional types of equipment and devices, and existing standards can be strengthened.

FEDERAL CLIMATE POLICY 107

Land Use, Forestry, and Agriculture

A review of the federal policy options for increasing land-related carbon storage and reducing emissions from agricultural land uses and production activities.

TEXT James Boyd and David Wear
ILLUSTRATION Michael Crampton

The land sector in the United States contains a pool of carbon—carbon stored in soils, forests, and other vegetation—that is more than 50 times the nation's total annual greenhouse gas emissions as of 2019, with forests alone storing about 28 times those total emissions. This carbon pool has grown steadily over the past several decades, as the amount of atmospheric carbon absorbed by vegetation has exceeded the land sector's own emissions (e.g., through forest fires, conversions to other uses, or harvesting forests).

In 2019, the land sector removed nearly 800 million metric tons of carbon dioxide equivalent (MMT CO_2e) from the atmosphere—roughly equal to 12 percent of total US emissions. Accordingly, the land sector should be thought of as a "negative-emissions" sector.

In contrast, agricultural production activities generate net positive greenhouse gas emissions. In 2019, agricultural activities and electricity use accounted for about 11 percent of total US greenhouse gas emissions (see visualization on pages 6 and 7)—primarily in the form of methane from the digestive processes of livestock and manure management, along with nitrous oxide (N_2O) from agricultural soil management.

This article reviews the federal policy options for increasing land-related carbon storage and reducing N_2O and methane emissions from agricultural land uses and production activities.

> **"In 2019, the land sector removed nearly 800 million metric tons of carbon dioxide equivalent from the atmosphere—roughly equal to 12 percent of total US emissions."**

Land Use and Forestry

The size of the carbon pool in the land sector depends on land uses, land conditions, climate conditions, and land management practices. Forests account for the vast majority (96 percent) of the land sector's carbon sink, followed by green urban areas; agricultural areas account for the least, according to the Inventory of US Greenhouse Gas Emissions and Sinks. Shifts in land use to non-forest uses result in carbon emissions.

Land use patterns generally are stable on public lands, while land use patterns on private lands are more likely to change over time. Land use, conditions, and management also are likely to vary in response to changes in climate. Land use has changed since the 1980s in ways that affect greenhouse gas concentrations in the atmosphere.

Urban Growth
Growth in urban areas was a dominant land use trend between 1982 and 2012. New urbanization occurred in roughly equal portions on converted agricultural, forest, and range lands.

Declining Cropland
Cropland has declined overall—not only due to urbanization, but also in response to increased crop productivity and the US Department of Agriculture's Conservation Reserve Program (CRP), a federal land conservation program that has enrolled 24 million acres of cropland.

Forest Expansion
Between 1982 and 2012, forest use increased slightly. The transition of 17 million acres of forests to urban uses was offset by the transition of land from agriculture to forests. The expansion of forestland has strongly influenced growth in the land carbon sink since 1990, but future growth of forested areas is uncertain; for example, some projections indicate that the United States recently may have reached "peak forest area," and the most recent forest inventories show a slight decline in forests.

The largest transition in land use since the 1980s has been from agriculture to forests, followed by transitions from agriculture to CRP and urban uses, and forests to urban uses. US urban areas are net carbon sinks primarily because of growth in tree biomass. Rural lands converted to non-forest uses reflect positive emissions, whereas grasslands, croplands, and wetlands generated little net emissions over this time, indicating relatively stable land carbon pools.

Agriculture

On agricultural lands, carbon storage is more than offset by emissions from production activities. Emissions from the agriculture sector amounted to 618.5 MMT CO_2e (9.3 percent) in 2018, up 11 percent from 1990. The primary sources of these emissions are agricultural soil management, methane emissions from livestock (from digestive processes), and manure management.

Soil Management
Emissions from soil management vary as a function of crop type, production system, fertilization, and weather patterns. Soil management emissions increased by about 7 percent between 1990 and 2018, despite a reduction in cropland area.

Livestock
The digestive process in livestock accounts for the majority of methane emissions from agriculture. Emissions increased by 8 percent between 1990 and 2018. In 2018, beef cattle and dairy cattle produced 72 percent and 24 percent of livestock-related methane emissions, respectively.

Manure Management
Manure management produces substantial methane and N_2O emissions. Liquid-based management (anaerobic) systems generate much higher methane emissions than dry management systems. A 66 percent increase in methane emissions from manure between 1990 and 2018 reflects a shift toward larger, confined production operations with liquid-based systems.

Expanding the Carbon Sink and Reducing Emissions

The land sector in the United States provides a consequential carbon sink that could be enhanced by policies and market forces that shift land to more carbon-dense uses (particularly forests), reduce future forest losses, enhance carbon sequestration capacity, and transfer more harvested biomass to long-term storage in buildings and other products.

Recent research on natural climate solutions identifies afforestation and increasing tree densities as the most effective means to grow the land carbon sink in terms of carbon sequestration per unit area.

Atmospheric carbon reductions also can be achieved by changing agricultural practices, including retiring cropland, switching to low-emissions crop production systems (including conservation tillage), and adopting alternative technologies for manure management.

National carbon pricing programs (carbon tax and cap and trade) could have a significant effect on market forces and incentives in the land use sector. Such policies can be designed to strengthen the land sector's role as a carbon sink, given that land itself and land-based resource products like crops and timber are key components of the national economy. Recent research indicates that even relatively low carbon prices could incentivize substantial emissions reductions by encouraging the retirement of cropland and the adoption of digester technology for large, confined animal operations. Higher prices are needed to incentivize changes in crop production systems.

Beyond a carbon price, the four policy options described below could expand the US carbon sink and reduce emissions from agriculture.

Government Payments for Carbon Storage and Emissions Reductions

The Basics

Stored carbon is a commodity that, like crops and timber, can be purchased. However, because it is a public good, rather than a private good, markets alone generate little demand for carbon storage. Thus, without government intervention, landowners have little incentive to change management practices or shift to less carbon-intensive land uses. To correct this misalignment of incentives, the government can act as the purchaser. While carbon payments can be thought of loosely as subsidies, a more accurate description is that the government pays landowners for carbon storage services, such as planting trees, taking agricultural lands out of crop production, or shifting to no-till crop management.

Benefits and Challenges

- ✓ Payment programs can align the public benefit of increased carbon storage with public payments to landowners who make investments in the service.
- ✓ Payment programs can provide new revenue streams to rural farmers, forestry-based communities, and agricultural and forestry companies.
- ✓ Payment programs widely distribute the costs of carbon storage because they rely on general tax revenues as a funding source. Revenues can be supplemented by private-sector funds when private institutions wish to voluntarily purchase carbon storage offsets or credits.
- ✗ Payment programs can cause "leakage," which occurs when carbon payments lead to reduced emissions from one land use but also lead to *increased* emissions from other land uses. For example, when payments motivate landowners to shift row crops to forestry, other property owners may shift back to row crops, with a corresponding *reduction* in the net carbon stored.

Key Considerations

- → How to define and verify the delivery of stored carbon. Different land use types (e.g., specific tree species, cropping patterns) and management approaches (e.g., tilling, planting, thinning practices) need to be observable or verifiable and then mapped onto the specific amounts of carbon they store.
- → How to select the lowest-cost carbon storage options. Payment programs can use "reverse auctions," in which landowners reveal the minimum payment they require in exchange for changing their management practices or land uses. The government then selects projects based on the lowest-cost options for purchase, also known as "payment bids." In sum, a government-led commodity definition, auction, and payment infrastructure is required.

Current and Proposed Carbon Storage Payment Programs

Several existing programs serve a similar function that could be expanded and focused more directly on carbon sequestration. The CRP is one example, signed into law in 1985. For several decades, the federal and state governments also have administered subsidized tree-planting programs. This type of program could more strongly emphasize carbon storage and holds lessons for tree-planting legislation currently under consideration in Congress.

Under the Biden administration, a closely related policy proposal is for the US Department of Agriculture to establish a "carbon bank" using existing Commodity Credit Corporation authorities as a financing vehicle. Part of that proposal is to use a CRP-style reverse auction to solicit the lowest-cost carbon storage and emission mitigation activities from landowners.

Stimulate Demand for Wood Construction Materials

The Basics

Solid wood products used in construction represent 15 percent of the US land carbon sink. Using more wood products for building could significantly expand carbon storage by increasing demand for forest products (demand-side incentives). New mass timber technologies (such as cross-laminated timbers) greatly expand the potential use of wood in large buildings, especially in commercial applications. Moreover, because wood products are a substitute for concrete and steel, their use can lead to reductions in carbon emissions from the carbon-intensive concrete and steelmaking industries.

Three types of policies could stimulate demand for wood construction products: First, the tax code could provide tax credits to builders for using carbon-dense construction materials. Second, government procurement policies could be changed to benefit contractors who use carbon-dense wood products. Third, building codes could be modified to allow more wood-intensive construction.

Benefits and Challenges

- ✓ Demand-side incentives require amendments only to existing policy platforms—the tax code, government procurement policies, and building codes.
- ✓ The costs of tax credits and procurement incentives are transferred widely to the general taxpayer.
- ✓ The cost of modifying building codes falls on builders and building owners.
- ✓ Forest producers generally will benefit from all three policy types due to increased demand for timber, as will technological innovators in the mass timber production sector.
- ✗ Demand-side incentives could lead to forestry practices and forest harvest pressures that threaten the ability of forests to provide other important services, such as ecological habitats and water resources. However, these sustainability concerns—and the need for safeguards against them—accompany *any* carbon-focused land use policy.

Key Considerations

- → Tax credits and new procurement policies are not direct payments for carbon storage, but the public will pay for them via their effect on tax revenues and burdens. So, as with direct payments, ensuring the cost-effectiveness of these policies requires the measurement of the net carbon storage achieved relative to a baseline where wood products already are widely used in construction.

Current and Proposed Programs to Stimulate Demand

Existing tax code, procurement, and building code platforms at the federal, state, and local levels can be expanded to stimulate wood product demand. All of these wood construction incentives can be built into current federal infrastructure investment bills.

Building codes often restrict the height of wood buildings, for historical fire suppression and structural reasons. Modern wood production innovations have overcome many of those concerns, yet codes have not kept pace. The revised 2021 International Building Code includes revisions to allow for the use of mass timber in the construction of 18-story buildings with requisite fire protection and provides a model for new regulations. Updated building code standards could, on their own, stimulate demand at little cost.

Land Use Controls

The Basics

Another way to expand the carbon sink is to directly control land use via regulation. Urban land cover grew by 1.36 million acres annually between 1982 and 2012. This rate of urban growth is projected to continue, and US Department of Agriculture projections indicate that reducing the rate of urbanization could lead to large carbon storage benefits. For example, a 20 percent reduction in urban growth over the next 30 years is projected to augment carbon storage by about 40 MMT CO_2e per year through 2050.

Benefits and Challenges

- ✓ By design, land use controls restrict what property owners can do with their land, which may be desirable if the policy goal is to maximize land uses consistent with aggressive carbon storage goals.
- ✗ Restricting the right of owners to use their property as they wish is likely to generate significant political opposition.
- ✗ The costs of land use controls fall mainly on property owners via reduced property values.

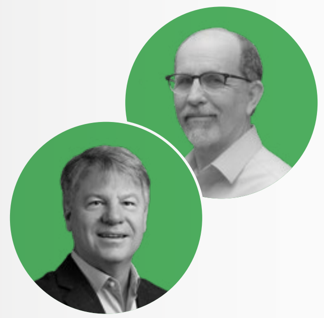
Key Considerations

- → One way to reduce the cost of land use regulations—and help ameliorate political opposition—is to establish a transferable development rights program. Rather than restricting land use uniformly, such a program would put a cap on development within a broad region, assign rights to development corresponding to that cap, and allow property owners to trade those rights among themselves. Like any cap-and-trade program, this strategy achieves an environmental goal at a lower total cost.
- → Another way to reduce the cost of land use regulations is through a no-net-loss policy. Rather than prohibiting conversion of forested land to urban development, these policies require landowners who deforest their land to pay for afforestation elsewhere. Payment could be made to private or government-developed forest banks—organizations that specialize in afforestation and forest restoration projects. This strategy allows high-value urban development to occur while funding relatively inexpensive forest gains elsewhere.
- → Local control of zoning makes land use controls challenging to deploy as a national strategy. Transferable development rights programs require a trading infrastructure to set the cap, allocate initial rights, and manage the transfer of rights among property owners. No-net-loss programs require measurement and verification that forest carbon losses are offset by corresponding gains purchased from an eligible forest bank—a doable, but challenging, technical and administrative task. Such market-based land regulation approaches would require new state or federal legislation.

Current and Proposed Land Use Control Programs

Transferable development rights programs have been established in several places throughout the United States. They tend to focus on preserving open and agricultural land uses—not necessarily forested land. Forest no-net-loss rules have been developed in Maryland and New Jersey and are a common component of city tree ordinances. Of particular relevance is the national experience with no-net-loss wetland regulations and mitigation banking programs established under the Clean Water Act.

> **“Urban land cover grew by 1.36 million acres annually between 1982 and 2012. This rate of urban growth is projected to continue, and US Department of Agriculture projections indicate that reducing the rate of urbanization could lead to large carbon storage benefits.”**



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This article is available at **rff.org/toolkit** *as a published explainer titled “Federal Climate Policy 107: Land Use, Forestry, and Agriculture.”*

Public Land Authorities

The Basics

More than 35 percent of US land is publicly owned and managed; therefore, changes on public lands can significantly influence carbon storage and emissions. Historically, agencies have not been directed to manage public lands with carbon storage in mind. New statutory authorities with a sequestration focus could expand the carbon stock of public lands in some areas and reduce emissions in others. Private commercial activities that take place on public lands, such as timber harvesting and livestock grazing, already are managed and regulated through frameworks that could be adapted to focus more on carbon storage. For example, grazing rules on public lands could be altered to more strongly emphasize carbon storage in root systems and soils, and forest management rules could be harnessed to reduce carbon emissions from wildfires.

Benefits and Challenges

- ✗ Political crosscurrents can obstruct amendments to public land management statutes and regulations.
- ✗ The list of governing rules is long and composed of agency-specific regulations and planning rules.
- ✗ Cross-cutting laws (e.g., National Environmental Policy Act, Clean Water Act, Endangered Species Act) can constrain land management and can be used to challenge changes to public land management statutes and regulations.

Key Considerations

- → How expanding carbon storage will affect forest health, other uses such as watershed protection and recreation, and the ecological services derived from these lands. In some cases, clear trade-offs exist; for example, if grazing is restricted, then declines will follow in terms of livestock yields, rancher profits, and lease revenues. Fire suppression to store more carbon could create a buildup of forest fuel that may lead to more damaging future fire events. Other less obvious trade-offs may be just as important, such as the impact of carbon-oriented vegetation management on species habitat and water resources.
- → The costs of enhanced carbon storage on public lands fall either on public agencies (i.e., taxpayers) or commercial interests using public lands. For example, afforestation investments (tree planting) could be funded by Congress, whereas the cost of changes to commercial harvest or grazing rules would fall more heavily on specific producers.
- → All of the values and uses of public lands are represented by stakeholders who are likely to lobby for their interests if policy is enacted to alter the current rules.

Past, Current, and Proposed Public Land Authorities

Federal lands are managed by specific agencies—including the Bureau of Land Management, Forest Service, Fish and Wildlife Service, and National Park Service—operating under their own statutory rules. These rules govern federal agency managers and commercial operators on public lands.

FEDERAL CLIMATE POLICY 108

Oil and Gas

The Federal Climate Policy Toolkit 108 108 OIL AND GAS

Burning fossil fuels increases the concentration of greenhouse gases in the atmosphere and causes climate change. Minimizing our reliance on fossil fuels will slow down climate change. Federal policies that reduce the production and consumption of oil and gas—and that eliminate methane leaks—will help.

TEXT Brian Prest

> **Oil and gas production involves drilling wells deep into the earth, facilitating the flow of fuels to the surface, transporting the fuels, and refining the fuels into final products.**

PHOTO
A pumpjack and refinery plant in Texas
dszc / Getty Images

US oil and natural gas consumption was responsible for more than 4 billion metric tons of CO_2 in 2019, together amounting to about 80 percent of energy-related CO_2 emissions in the United States. As the coal industry continues to decline, these two fuels will represent nearly all future energy-related emissions in the country.

While the other articles in this issue of *Resources* generally lay out federal climate policy options specific to end-use sectors—that is, where and how fuel ultimately is *used*—this explainer focuses on policies relevant to US oil and gas *production*.

Oil and gas production involves drilling wells deep into the earth, facilitating the flow of fuels to the surface, transporting the fuels, and refining the fuels into final products (such as gasoline, diesel, propane, and jet fuel). Emissions occur both when those fuels are burned and when the fuels are produced and transported, during which methane—the primary component of natural gas and a highly potent greenhouse gas (GHG)—leaks into the atmosphere. Hence, policies can reduce emissions either by reducing the production and consumption of oil and gas or by addressing methane leaks in the supply chain.

Eliminating Existing Tax Preferences for Oil, Gas, and Coal

The Basics

The tax code offers tax provisions and credits that benefit the fossil fuel industry specifically and encourage the production of fossil fuels. Policymakers can reduce emissions by eliminating some of these provisions, thereby reducing incentives for oil and gas production. Many provisions and credits favor oil and gas producers; the major ones are listed here:

- Accelerated tax deduction for intangible drilling expenses
- Accelerated tax deduction for resource depletion ("percentage depletion")
- Tax credits for enhanced oil recovery
- Tax credits for marginal oil and gas wells (wells producing fewer than 25 barrels of oil equivalent per day)

Together, these credits and preferences cost the government between $3 billion and $7 billion each year. Eliminating some or all of these tax breaks can lead to increased government revenue and decreased emissions.

Benefits and Challenges

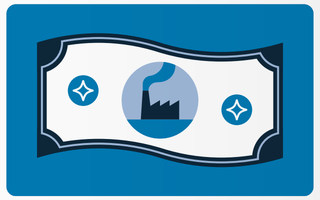
- ✓ Increases government revenue by several billion dollars annually.
- ✓ Can reduce emissions by reducing oil and gas production.
- ✗ Slightly increased energy prices, due to reduced supply of oil and gas. However, research finds that the effect on global oil production—and, accordingly, emissions and prices—would be modest.

Key Considerations

- Which tax credits and preferences to eliminate and which to keep.
- The accounting mechanisms that policymakers deem to be appropriate for the types of capital expenses incurred by oil and gas developers. This is in part a technical accounting question and in part a subjective determination about what type of tax treatment is deemed fair.

Past, Current, and Proposed Policies to Eliminate Tax Credits

Proposed bills from the 116th Congress that would eliminate these preferences include S. 4887, H.R. 7781, and H.R. 8411. All three bills would eliminate all the oil and gas tax preferences discussed above; the first two also would eliminate the refined coal credit.



DID YOU KNOW?

The Refined Coal Tax Credit

In addition to oil and gas tax credits, the federal government offers a tax credit of nearly $1 billion annually for "refined coal," which is coal that's chemically treated with the intention of reducing the amount of local air pollution it generates when burned. To claim the tax credit, coal refiners must demonstrate that sufficiently large pollution reductions are achieved (20 to 40 percent). However, RFF research has found that, in practice, the resulting emissions reductions fall significantly short of the targets established by the tax law. That research has led to an investigation by the US Government Accountability Office.

Eliminating the refined coal tax credit would save about $1 billion annually and reduce the use of refined coal, which in turn would mean that some coal plants may retire sooner or find more effective ways to reduce emissions to comply with air quality regulations. The refined coal tax credit is scheduled to expire at the end of 2021, though several bills have been introduced to extend the credit.

> **"When implementing a carbon tax, policymakers must choose where in the economy to impose it—essentially determining who directly pays the tax."**

> **"A midstream or upstream tax would apply to the 'embodied emissions' in the oil or gas—that is, the emissions that eventually are produced when the fuel is burned."**

Upstream or Midstream Carbon Tax

The Basics

Carbon taxes require companies to pay for each ton of GHG emissions they are responsible for, creating a financial incentive for companies and individuals to reduce their emissions. When implementing a carbon tax, policymakers must choose where in the economy to impose it—essentially determining who directly pays the tax. Policymakers can levy carbon taxes at any of the following points:

- **Downstream**, where the emissions occur, such as at a power plant or a gasoline pump when filling your fuel tank
- **Upstream**, at the point of production of fossil fuels, such as at a coal mine or oil well
- **Midstream**, somewhere in between, such as at an oil refinery

A midstream or upstream tax would apply to the "embodied emissions" in the oil or gas—that is, the emissions that eventually are produced when the fuel is burned. The cost of the tax would be paid directly by the taxed entity, but may be passed on to other entities, as well. For instance, some of the increased cost of an upstream tax would be borne by oil and gas producers, reducing production; however, to the extent that producers can raise their prices to cover additional expenses, some of the tax would be passed on to refineries (midstream) and utilities and consumers (downstream), reducing consumption. Reduced production and consumption alike lead to reduced emissions.

Benefits and Challenges

- ✓ An upstream or midstream carbon tax encourages cost-effective emissions reductions in the covered sector, generally similar to an economy-wide carbon tax.
- ✗ Emissions leakage. Leakage occurs when production shifts from an area with a tax to an area without the tax, or when consumers import fuels from foreign suppliers that are not subject to the tax. Leakage makes the tax less efficient and less effective at reducing emissions.

Key Considerations

- Leakage can be combated by imposing a border adjustment (import tax or export rebate) on the carbon content of imported (or exported) products, including oil and gas, so that domestic and foreign sources are treated equally. Imposing a border adjustment raises concerns, however, about ensuring that the adjustment comprehensively covers all related goods. For example, if the import tax applies only to crude oil but not to gasoline (which is made from crude oil), consumers may import the untaxed gasoline.
- Administrative ease. The structure of the supply chain may make it easiest to measure and apply a tax at a particular point. For example, the United States contains nearly one million operating oil and gas wells owned by thousands of companies (upstream), more than 100,000 gas stations (downstream), but only about 100 refineries (midstream). It may be easier to apply the tax at the level with the fewest entities, which in the case of oil is the midstream refineries.
- The preferred point of regulation may vary by fuel type; for example, scholars have argued that natural gas is best taxed downstream, because a large share of gas does not go through midstream processing, so would be missed by a midstream tax.

Past, Current, and Proposed Upstream or Midstream Carbon Taxes

Where carbon pricing has been implemented, it typically has been applied downstream for fossil fuels used at large stationary sources (like power plants) and midstream for oil refineries.

Reforming Federal Oil, Gas, and Coal Leasing Policy

The Basics

The federal government owns about 28 percent of US land and leases the right to extract fossil fuel from those lands to private developers. The emissions associated with the extraction and use of fossil fuels from federal lands are equivalent to about one quarter of US emissions annually.

Three policy reforms on this issue have received the most attention from policymakers: a ban on all new fossil fuel leasing, imposing "carbon adders" (akin to a carbon tax) on federal lands, and adjusting royalty rates (the share of fossil fuel revenues that the federal government receives).

Benefits and Challenges

- All three of the aforementioned policies would reduce emissions, with the amount of reductions depending on the stringency of the policy.
- Imposing higher royalties would generate new revenues for the government. These revenues historically have been shared with the producing states and could help support communities that depend on fossil fuels for their livelihoods, as the economy transitions away from fossil fuels.
- Because the policies would affect only the production from federal lands—not all US production—emissions leakage may occur; in other words, reduced federal production and emissions may be partially offset by increased production and emissions on nonfederal land within the United States and in other countries.

Key Considerations

- Policymakers must weigh key trade-offs, including emissions and revenues, given that fossil fuel leasing on public lands generates billions of dollars annually in royalty revenues for the federal government and the producing states.

Past, Current, and Proposed Leasing Reforms

The Obama administration issued a temporary moratorium on offshore oil and gas leasing, following the Deepwater Horizon oil spill, and later imposed a moratorium on federal coal leasing while it considered imposing carbon adders on new coal leases, potentially based on the social cost of carbon. In January 2021, the Biden administration took an analogous approach with respect to oil and gas leasing.

> **"The federal government owns about 28 percent of US land and leases the right to extract fossil fuel from those lands to private developers."**

PHOTO
An offshore oil platform on the California coast
VisionsofAmerica / Joe Sohm / Getty Images

Brian Prest *is a fellow at Resources for the Future.*

This article is available at **rff.org/toolkit** *as a published explainer titled "Federal Climate Policy 108: The Oil and Gas Industry."*

> **"Enforcing policies that penalize methane leaks requires those leaks to be tracked accurately. This means that regionally widespread yet accurate monitoring technology is necessary, but the most common monitoring technology is a handheld infrared camera, which is difficult to deploy at the necessary scale."**

Methane Policy: Leakage, Venting, and Flaring Regulations

The Basics

The primary component of natural gas is methane, a GHG about 30–90 times as potent as CO_2. Methane can leak into the atmosphere at multiple points in the oil and gas supply chain, such as through leaky pipes and valves. Additionally, methane sometimes is intentionally released (vented) or burned (flared) as part of the production process, both of which contribute to atmospheric GHG concentrations and waste natural gas. Though methane theoretically could be captured and used, it's often more practical for producers to dispose of the gas, because transporting gas to market can be difficult.

Benefits and Challenges

- Regulating methane emissions can reduce GHG emissions while ensuring that less natural gas is wasted.
- Capturing more gas for delivery to market means more royalty revenues for the owners of the resource, which includes both private landowners and the federal government.
- Although gas has value, the private value *lost* from flaring falls far below the social cost of emitting methane—in other words, companies have insufficient private incentive to capture the gas.
- Capturing excess gas is not always economical: many oil-heavy regions are in remote areas with limited gas pipeline capacity, so capturing the gas and delivering to market would require building new pipelines. The costly, unpopular alternative would be to shut the wells down completely and cease drilling, which would mean less energy production.
- Monitoring leaks at scale is costly and difficult. Methane leaks largely come from so-called "super-emitters"—infrequent but massive leaks; thus, the costs to install improved infrastructure may yield negligible benefits in emissions reductions at many wells that are not leaking to begin with, while the emissions reductions from other wells may be very large. Targeting heavily leaking wells in a timely way is difficult with existing technology.

Key Considerations

- Enforcing policies that penalize methane leaks requires those leaks to be tracked accurately. This means that regionally widespread yet accurate monitoring technology is necessary, but the most common monitoring technology is a handheld infrared camera, which is difficult to deploy at the necessary scale. Satellites increasingly are being deployed to improve monitoring; other approaches involve sensors on aircrafts or drones. Flaring is easier to detect, because the light produced by flaring is visible by existing satellites, but those data have not yet been explicitly incorporated into regulatory action.

Past, Current, and Proposed Methane Regulations

Many states have rules that limit the venting and flaring of methane, and the stringency of these rules varies from state to state and over time. At the federal level, the Obama administration issued regulations that restricted methane and other emissions from all new oil and gas wells, along with a Methane Waste Prevention Rule that limited venting and flaring from wells on federal lands and charged royalties on any such lost gas. These rules were rolled back by the Trump administration. Recent congressional proposals would reinstate Obama-era restrictions on new wells. In addition, the Methane Waste Prevention Act of 2021, proposed by Representative Diana DeGette (D-CO), would codify the Obama-era rule of the same name.

"Green" Gas Certification, Standards, and Markets

The Basics

By reducing methane leaks and taking other actions, gas producers can reduce emissions associated with the gas they sell. Creating certification programs to validate this low-methane-emissions gas, standards to mandate low-methane gas, and markets for "greener" gas can lead to emissions reductions without reducing the amount of gas that is produced and used.

"Green" gas standards would work by certifying gas that has relatively low emissions associated with it. Producers would get a certificate or credit that can be used to comply with the standards or sold to other companies that have more methane-intensive gas supply chains. This system could mirror a clean energy standard or renewable portfolio standard, as seen in the power sector.

Benefits and Challenges

- ✓ Creates incentives for operators to reduce their emissions and provides a standardized way to measure the methane intensity of different gas sources.
- ✗ Unclear whether sufficient market demand exists. If consumers are not willing to pay extra for green gas, operators will have little incentive to pursue certification.
- ✗ If certification is voluntary, only operators that are already low methane likely will opt in to claim credit, resulting in little to no reduction in emissions.

Key Considerations

- Designing a program to certify green gas requires widespread yet accurate measurement of emissions associated with gas production. However, methane monitoring is not straightforward. Improved satellite- or aircraft-based monitoring technology could facilitate this measurement.
- How frequently producers need to recertify. Because a single large leak can have a major effect on the overall "greenness" of a gas supplier, somewhat frequent certification may be necessary.
- Who designs and implements the green gas certification program. While standards would be set by the government (state, federal, or international), certification could be led by an industry coalition, nonprofits, or other stakeholders, and each option has different merits.

Past, Current, and Proposed "Green" Gas Policies

No federal standards for green gas exist yet, although some in the industry have begun voluntary efforts, such as ONE Future. Many other products have analogous certifications (e.g., fair trade coffee, Energy Star appliances). The US Environmental Protection Agency has used voluntary programs to reduce methane emissions, such as the Obama-era Methane Challenge Program and the Natural Gas Star Program (akin to Energy Star).

Some existing natural gas policies could be built upon to create a green gas standard or program. The Sustainability Accounting Standards Board requires member companies to disclose methane leaks in their US Securities and Exchange Commission filings. Finally, the Clean Energy Innovation and Deployment Act would encourage gas-fired power plants to demonstrate that their gas supply chain is clean, by providing credits for reducing emissions (i.e., provide greater financial incentives to produce clean energy) under a clean energy standard in the power sector.

DID YOU KNOW?

"Green" Gas Markets

Even without a policy in place, certifying lower-emissions gas could lead to environmental benefits. As explained by RFF researchers Alan Krupnick and Clayton Munnings, such certification could encourage upstream gas producers to reduce methane emissions in their supply chain and demonstrate that they're producing "green" gas. One incentive to do so could be consumers who are willing to pay a higher price for this lower-emissions gas. Even if this willingness to pay were small, some producers might enter a green gas market to bolster their reputation for social responsibility and attract climate-conscious investors.

For example, in 2020, the French company Engie backed out of a multibillion-dollar deal to purchase US-produced gas over concerns that the gas might be more methane intensive than alternative suppliers. Clearly, being perceived as more polluting can mean lost market share.

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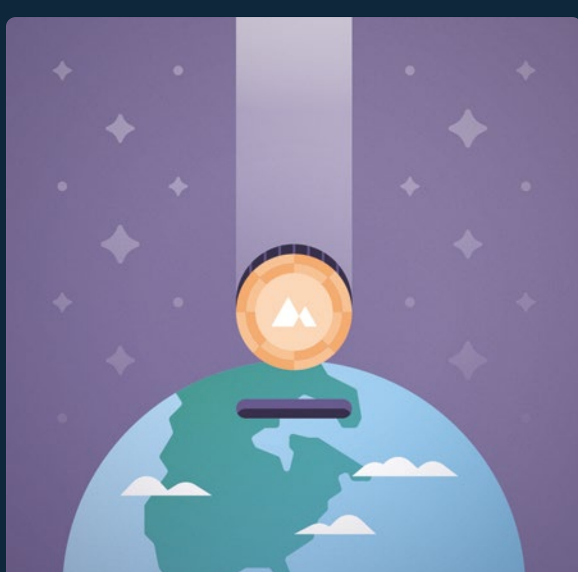

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